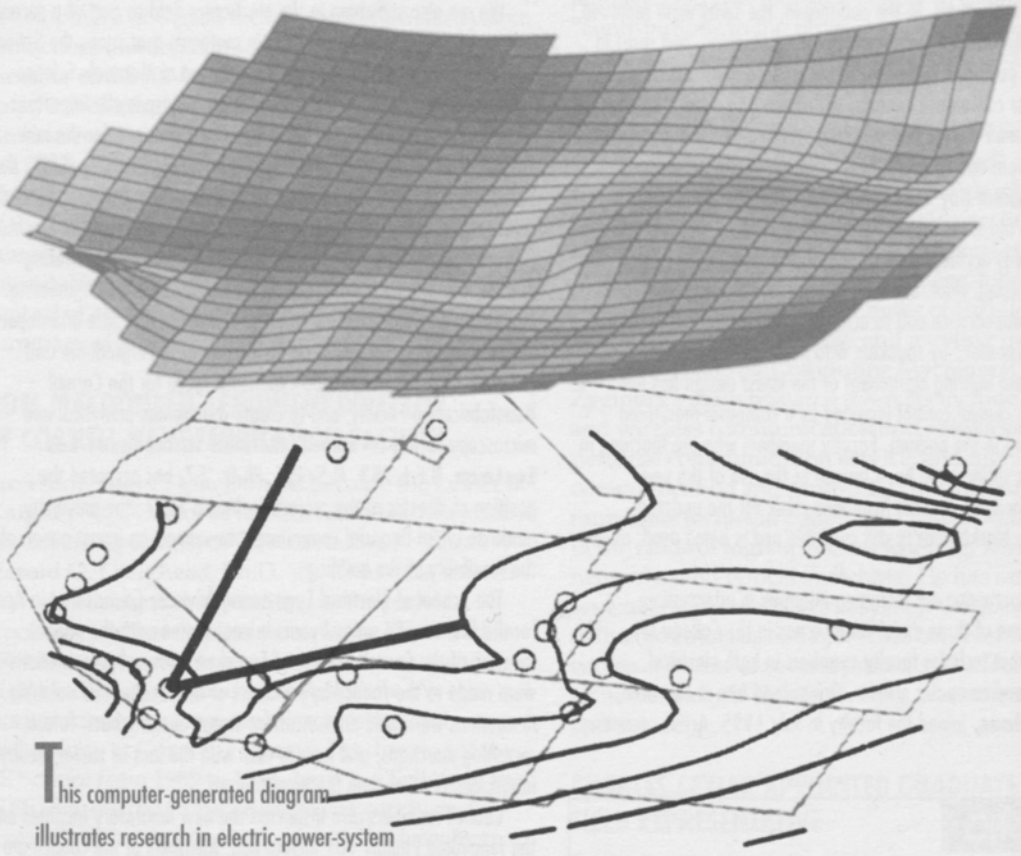
CONNECTIONS

A Report from the SCHOOL OF ELECTRICAL ENGINEERING • Cornell University

Electric-Power-Systems Research

in the School of Electrical Engineering



This computer-generated diagram illustrates research in electric-power-system analysis and protection performed by the Electric-Power-Systems Group in the EE School. **The diagram shows one frame of a moving picture of voltage-phasor angle changes that affected power flows in the western system breakup of December 14, 1994. All generators on a "contour" line have the same positive-sequence-voltage phasor angle with respect to an arbitrary reference. The upper portion of the figure is a three-dimensional representation of the same pattern of angular displacement. As the "movie" progresses, the unstable behavior leading to the blackout becomes readily apparent. Studies of this network have demonstrated prevention of the disturbance by modulation of power flow through high-voltage-direct-current transmission lines (the two bold lines in the figure). Control would be achieved by means of real-time data from phasor-measurement units in the system synchronized by precise timing input from the Global Positioning System. Professor Thorp's research is described on page 6. (Diagram courtesy of James S. Thorp.)**

This fifth edition of *Connections* features the challenging research of our Electric-Power-Systems Group, relates the history of electric-power engineering in the EE School, and considers the impact on this traditional field of the restructuring of the electric utility industry. The "Positive Feedback" section contains news of recent alumni activities. Other items of interest to alumni are listed in the table of contents below. Please fill out the information coupon on the last page of this newsletter, and clip and mail it to us. We want to hear what you are up to.

Simpson (Sam) Linke, editor

SPRING 1996

IN THIS ISSUE

Report from the Director

James S. Thorp

At the close of my second year as director, I am pleased to report completion of the renovation of Phillips 101. The construction, part of a multiyear College of Engineering plan, did not begin until the summer of 1995 because of the building permit delay I mentioned last year. Consequently, the room did not become available until February of 1996. The ceiling of the foyer received an attractive new treatment after the asbestos was removed, and the floor of the foyer was redesigned to make it suitable for access by handicapped individuals. In the auditorium, the seats were removed, returned to the original manufacturer for refurbishing, and reset in their original positions except for the first three rows, which were rearranged for conference seating, with tables, to allow the room to be used for small classes and seminars. An exit installed on the east side of the room opens onto a new sidewalk leading down to Phillips Hall from adjacent Hoy Road. Handicapped access was provided by replacing the old steps on each side with a reduced slope of one-to-twelve that was accomplished by raising the floor in the front of the room. New ceiling, floor, and wall treatments were installed to improve the appearance and to achieve acoustics that have been pronounced excellent by speakers who have used the room. Audiovisual and lighting equipment of the latest design has been installed with central control provided by a computer-monitored system housed in the podium. Faculty members who are teaching in the room this spring have been trained in the use of the new audiovisual facilities, but old-fashioned chalk for the updated artificial-slate blackboards is still available and is being used, as in the past.

We are continuing our recruiting initiative in information technology, one of three major thrust areas in the College of Engineering that includes faculty members in both electrical engineering and computer science. Our second hire in this area, **Zygmunt Haas,** joined the faculty in July 1995. Active recruiting is proceeding this year in an attempt to hire the remaining three faculty members designated for this area. In addition to the five-year GTE Foundation and the three-year AT&T Foundation grants that already support our efforts in information technology, a substantial new grant has been made by **David A. Duffield,** B.E.E. '63, M.B.A. '64, president of Peoplesoft, Inc., of Walnut Creek, California, to fund an electrical engineering/computer science laboratory in this discipline (see page 21).

We are also searching in the electronics field as part of a second College of Engineering thrust area in materials that spans the School of Electrical Engineering and the Department of Materials Science and Engineering. Laboratory resources are an especially important factor in successful hiring in this area. Plans continue for the new College of Engineering Research and Instructional Facility (ERIF) that include construction of a building to accommodate the research and safety requirements of faculty members from the schools of Electrical Engineering, Chemical Engineering, and Applied and Engineering Physics, and the Department of Materials Science and Engineering. The building is also planned to house a modern and safe interdepartmental laboratory for hands-on instruction of undergraduate and graduate students, to provide expansion space for the Cornell Nanofabrication Facility, and to create a materials analytical and microscopy facility for Cornell's Materials Science Center. **Les Eastman,** B.E.E. '53, M.S. '55, Ph.D. '57, has accepted the position of director of the project. In March 1996, the university made an initial financial commitment to support an investigation of the feasibility of the building.

The School of Electrical Engineering Advisory Council met in April for the first time in several years in conjunction with the annual meeting of the Cornell Society of Engineers. Several presentations were made to the council by members of the faculty, and valuable discussions were held on the current status of the school, future recruiting directions, and how to deal with the loss of senior faculty in disciplines other than the growth areas.

Council members also inspected the new laboratory facilities and the renovated Phillips 101 lecture hall. Members of the council are introduced in the centerfold of this issue of *Connections.*

We welcome **David A. Hammer,** Ph.D. '69 (applied physics), the J. Carlton Ward Professor of Nuclear Energy Engineering, who joined the EE faculty in July 1995. See page 3 for a summary of Dave's past accomplishments in the field of plasma physics.

Finally, I must not fail to mention the exciting interaction of the EE School with the flight of the Space Shuttle orbiter *Endeavour,* which was launched on January 11, 1996. Dr. **Daniel T. Barry,** B.S. '75 (electrical engineering), one of the NASA astronauts on the flight, carried an EE School banner into orbit and returned it to the school after the mission. We have a problem: how do we display this valuable artifact so it does not fall into the hands of some avid collector of rare items? Details of this momentous event are on page 22 of this issue.

—James S. Thorp
Professor and Director
School of Electrical Engineering

Enrollment and Graduation Statistics

UNDERGRADUATE PROGRAM

Year	*Sophs*	*Juniors*	*Seniors*	*Degrees*
93–94	—	103	111	120
94–95	125	112	110	106
95–96	120	116	104	*

M.ENG.(ELECTRICAL) DEGREES

August	*January*	*May*	*Total*
32	11	48	91
57	19	55	*
50	12	*	*

M.S./PH.D. PROGRAM

Year	*Applicants*	*Admissions*	*Total Enrollment*	*Degrees*
93–94	508	17	126	23 Ph.D.s, 11 M.S.s
94–95	556	13	117	20 Ph.D.s, 7 M.S.s
95–96	501	14	109	26 Ph.D.s, 9 M.S.s

Note: Students now affiliate with the EE School when the first term of sophomore math and physics is completed. These figures indicate that over the past three years, the undergraduate program has remained stable, the M.Eng.(Elec.) program has increased significantly, but the M.S-Ph.D. enrollment has declined somewhat.
*Not available at press time. Compared to the previous two years, the number of degrees to be awarded is expected to remain unchanged for undergraduates and increase for M.Eng.

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JIM THORP NAMED TO NATIONAL ACADEMY OF ENGINEERING

Professor **James S. Thorp,** B.E.E. '59, M.S. '61, Ph.D. '62, all in electrical engineering from Cornell University, the Charles N. Mellowes Professor of Engineering, and director of the School of Electrical Engineering, has been elected to the National Academy of Engineering "for contributions to the development of digital techniques for power system protection, monitoring, and control." Jim has been a member of the EE faculty since 1962. In 1976–77 he spent a sabbatical leave as a faculty intern with the American Electric Power Service Corporation, and in 1988 he was an Overseas Fellow at Churchill College, Cambridge University. Jim became a Fellow of the IEEE in 1989. His teaching and research interests are in the field of estimation and control of discrete linear systems with applications to the control of electric-power networks. (See page 6 for a summary of his recent research).

NOEL MACDONALD APPOINTED DIRECTOR OF CORNELL NANOFABRICATION FACILITY

Professor **Noel C. MacDonald** became the **Lester B. Knight** ['80] Director of the Cornell Nanofabrication Facility in September 1995, succeeding Professor **Harold G. Craighead,** Ph.D. '79. Following sixteen years in management positions in the physical electronics industry, Noel came to the EE School in 1984 as a professor of electrical engineering and director of the Semiconductor Research Corporation's Program on Microscience and Technology at Cornell. He served as director of the EE School from 1989 to 1994. Noel is a Fellow of the IEEE. For the past nine years he has conducted research in the new technology called microelectro-mechanical systems (MEMS). A specialist in electron-beam technology with emphasis on microelectronic application, he conducts research on the physical limits of nanomechanical systems in silicon, including new sensors and actuators. Recently his group announced fabrication of the world's smallest scanning electron microscope.

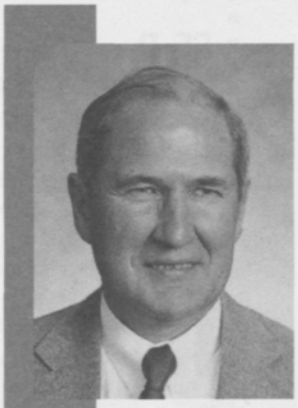
NEW EE SCHOOL FACULTY MEMBERS: DAVE HAMMER AND ZYGMUNT HAAS

Professor **David A. Hammer,** Ph.D. '69 (applied physics), the J. Carlton Ward Professor of Nuclear Energy Engineering, transferred from the Program in Nuclear Science and Engineering to the School of Electrical Engineering in July 1995. He joined the Cornell faculty in August 1977 and was director of the Cornell Laboratory of Plasma Studies from 1985 to 1995. Before returning to Cornell, Dave worked at the Naval Research Laboratory in Washington, D.C., from 1969 to 1976, was a visiting associate professor (part-time) at the University of Maryland from 1973 to 1979, and an associate professor at UCLA in 1977. His research interests are in the areas of plasma physics and controlled thermonuclear fusion. Dave is a Fellow of the American Physical Society and in January 1995 was named a Fellow in the IEEE for "contributions to the physics, technology and applications of intense pulsed electron and ion beams and dense z-pinch plasmas."

Zygmunt J. Haas, B.Sc. '79 (Technion) M.Sc. '85 (Tel Aviv University), Ph.D. '88 (Stanford), all in electrical engineering, joined the EE School faculty in August 1995 as an associate professor. From 1988 to 1994 he was a member of the technical staff in the AT&T Network Research department, followed by a year in the AT&T Wireless Center of Excellence. He is a Senior Member of IEEE and a voting member of the Association for Computing Machinery. Zygmunt's main research interests include mobile and wireless communication and networks, personal communication service, and high-speed communication and protocols. He is the author of numerous technical papers and holds twelve patents in the fields of high-speed networking, wireless networks, and optical switching. He has organized several communication subsystem workshops, delivered tutorials at major IEEE conferences, and serves as editor of several journals. His leisure activities include skiing, fencing, classical music, and traveling.

CHARLES SEYLER APPOINTED GRADUATE FIELD REPRESENTATIVE

Professor Charles E. Seyler, Jr., became coordinator of graduate studies in the EE School in 1995 succeeding Professor **Paul M. McIsaac,** B.E.E. '49. Charles received the Ph.D. in physics and astronomy from the University of Iowa in 1975. Following two years at the Courant Institute of Mathematical Sciences at New York University, he transferred to Los Alamos National Laboratory, where he worked as a research scientist in the controlled-fusion group. He joined the EE School faculty at Cornell in 1981 as an assistant professor, and became a full professor in 1993. His research interests are primarily in the physics of plasmas at high-altitude atmospheric levels as well as in earth-based laboratory fusion experiments. ■



NOEL C. MACDONALD

DAVID A. HAMMER

CHARLES E. SEYLER, JR.

ZYGMUNT J. HAAS

EE Power Field Revisited

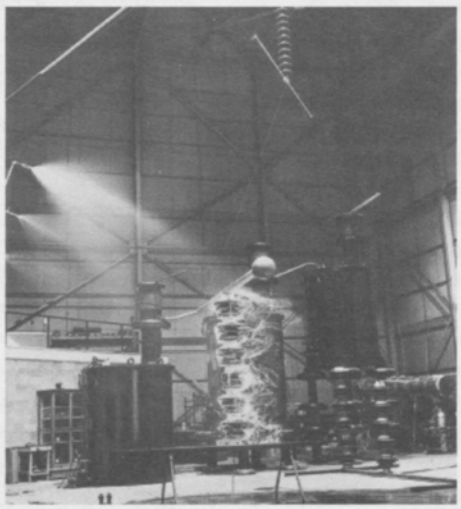


Photo A. (*above*) Early machinery experiment in Rand Hall.

Photo B. (*left*) High-voltage discharge experiment in Mitchell Street laboratory.

In the Cornell University *Register* of 1883, President Andrew D. White announced the establishment of a new course in electrical engineering and wrote, "the special studies of the course embrace the theory of electricity, the construction and testing of telegraph lines, cables, and instruments, and of dynamo machines, and the methods of electrical measurement, electrical lighting, and the electrical transmission of power." Subsequent announcements of curriculum content make it clear that for many years electrical engineering was almost exclusively power engineering.

Harris J. Ryan, class of 1887, was one of the first graduates of the new program. After a year in industry, Ryan returned to the campus and eventually became one of Cornell's most famous professors. He was a pioneer in the development of long-distance alternating-current transmission of power, and he modified cathode-ray tubes of the time by inserting horizontal and vertical deflection plates that allowed him to display ac wave forms and Lissajous figures. In 1906 he received a patent for this breakthrough invention that eventually led to the development of the cathode-ray oscilloscope. Ryan's original 10,000-volt ac transformer is still in the EE School's historical collection.

Following Ryan's departure to Stanford University in 1905, upperclass EE courses in design of dc and ac machinery and special topics such as the design of street-railway motors were taught by professors **Henry H. Norris** and **Vladimir Karapetoff.** The latter became famous in his own right during his thirty-five years as an EE faculty member, making voluminous contributions to machine theory, basic circuit theory, and power engineering. Apparently 1915 was a banner year in the history of the Cornell EE curriculum; Karapetoff initiated a course in the theory of electric machinery, assistant professor **Walter S. Ford** offered a course devoted exclusively to the transmission of electric energy, and assistant professor **William C. Ballard** taught a course in wireless telegraphy and telephony for the first time. In succeeding years Ballard taught additional courses in the new field of radio engineering, and in 1923, with instructor **True McLean,** he offered a "communication option" to seniors in electrical engineering, who could then choose between the new studies and those of the more traditional "power option." The first three years of the EE curriculum, however, were still common to both options. Perhaps half of each year's senior class elected to take the power-option courses, but all members of the senior classes were required to take machine theory and machinery laboratory courses considered to be basic to an electrical engineering education. These required senior courses remained in the curriculum until the early '60s.

When professor **Alexander Gray** was appointed head of the Department of Electrical Engineering in 1916, the year when the machine laboratory was established in the second floor of Rand Hall, the power engineering faculty consisted of professors Karapetoff, **Robert F. Chamberlain,** and **John G. Pertsch.** The School of Electrical Engineering became a separate entity in 1921 and Gray was named its first director. Upon his death that same year he was succeeded by professor **Paul M. Lincoln,** who came to Cornell with extensive industrial experience as a power engineer. When director Lincoln retired in 1937, the EE faculty numbered twenty men and included professors **L. A. Burckmyer, W. W. Cotner, M. G. Malti, Wilbur E. Meserve, M. G. Northrop, E. M. Strong,** and **Joseph G. (Jack) Tarboux,** all of whom initially taught courses related to power. Burckmyer became the formidable head of the famous "Rand Lab" (Photo A), Cotner moved to power electronics with **B. K. Northrop,** Malti became an advanced-circuit theorist, Meserve eventually developed the servomechanisms laboratory, M. G. Northrop specialized in ac machinery theory, Strong taught basic circuit theory, and Tarboux taught power equipment and electric-utility economics until he left Cornell in 1929 to become head of the Department of Electrical Engineering at the University of Tennessee. On a sabbatical leave from U.T. in 1936–37, Tarboux returned to the campus to complete his Ph.D. thesis research. With the assistance of **Lawrence B. Spencer** '34, he built a model of a 60 Hz 250-mile-long transmission line with distributed inductance and capacitance and used it in conjunction with two motor-generator sets in the Rand Hall laboratory to perform studies that were among the earliest investigations of power-system stability.

In 1938, **William A. Lewis,** a highly regarded graduate of Caltech with a strong industrial record at Westinghouse Corporation, became the director of the EE School and remained in that position until 1943, when he transferred to Illinois Institute of Technology, where he later became dean of engineering. During his stay at Cornell, Lewis, in cooperation with Corning Glass Works, established the High-Voltage Laboratory on Mitchell Street, taught courses in the transmission of electric power, and encouraged the faculty to undertake research in the power field. In this period, **Eric T. B. Gross** joined the power faculty as an assistant professor and taught ac machinery and circuit concepts applied to machinery until 1945, when he joined Lewis at I.I.T. for several years and then transferred to R.P.I., where he was the Philip Sporn Professor of Power Engineering until his retirement.

THE WAR YEARS

During the war years, **Paul D. Ankrum, William H. Erickson,** and **Robert E. Osborn** joined the power faculty, and members of the entire power group taught power-related subjects in the Naval V-12 Program. Circuit and machine-theory classes were held in Franklin Hall as in the past, and instrumentation and ac and dc machinery laboratories were conducted in Rand Hall and in an auxiliary machinery laboratory installed in the Old Heating Plant near the present site of Bard Hall. In 1945, Tarboux returned to the faculty as a professor of power engineering, and **Stanley W. Zimmerman** joined the faculty as professor of high-voltage engineering with responsibilities for teaching and research activities of the High-Voltage Laboratory (Photo B). This facility contained 750 kV transformers and a 3-million-volt surge generator used in artificial lightning studies. Unfortunately, in 1947 the laboratory was lost in an enormous fire that effectively ended the high-voltage research program. The building was rebuilt several years later and became one of the principal facilities of the Laboratory of Plasma Studies.

The large G.I.-Bill student enrollment, followed by a substantial increase in the regular student body, created a need during the late '40s for an expanded instructional staff in the EE School for both electrical and non-electrical engineering students. A curriculum for the latter group was developed by Erickson, who supervised the "service courses" staff and taught instrumentation and dc and ac machinery in the program before becoming assistant director and then acting director of the School. In 1959 Erickson became associate dean of the College of Engineering. The additional teaching demands on the EE School were met by a number of graduate-student instructors who eventually became long-term members of the EE faculty. Of this group, **Nelson H. Bryant, Simpson (Sam) Linke, Joseph L. Rosson,** and **Norman M. Vrana** began their academic careers in the power field. For a number of years Bryant, Linke, and Rosson joined Erickson in teaching machinery and basic electronics in the service courses before moving to regular EE instruction in instrumentation and machinery laboratories. Vrana and Ankrum were members of the Rand Lab staff with Burckmyer and Osborn until the mid '50s, when Vrana transferred to the computer field and Ankrum took up instruction in solid-state and power electronics. Bryant became a specialist in electronics and related instrumentation in the regular EE curriculum.

GRADUATE STUDY

Professor **Malcolm S. McIlroy** '23 joined the EE faculty in 1947, and under his influence interest in the power option shifted from undergraduate to graduate study. McIlroy was an enthusiastic investigator in the application of analog and digital computers to complex electrical networks until his untimely death in 1956. Although the senior courses in machine theory and laboratory were still part of the required curriculum, interest in power electives was low, particularly after Tarboux transferred to the University of Michigan in 1952. Graduate study was enhanced, however, by the acquisition of the Westinghouse Power Network Calculator in 1955 (Photo C), coincident with the move to Phillips Hall. Under the supervision of Linke, with Spencer as chief operator, the facility provided professional system-analysis services to several electric utility companies and was used as a laboratory tool by a number of senior and graduate students in elective power-system-analysis courses now taught by Linke. When it became apparent in the early '60s that power-system analysis would eventually be done by digital computer, the network calculator was decommissioned, and load-flow and stability studies were transferred to the university computer mainframe. Power alumni of the period may recall those early analyses of the

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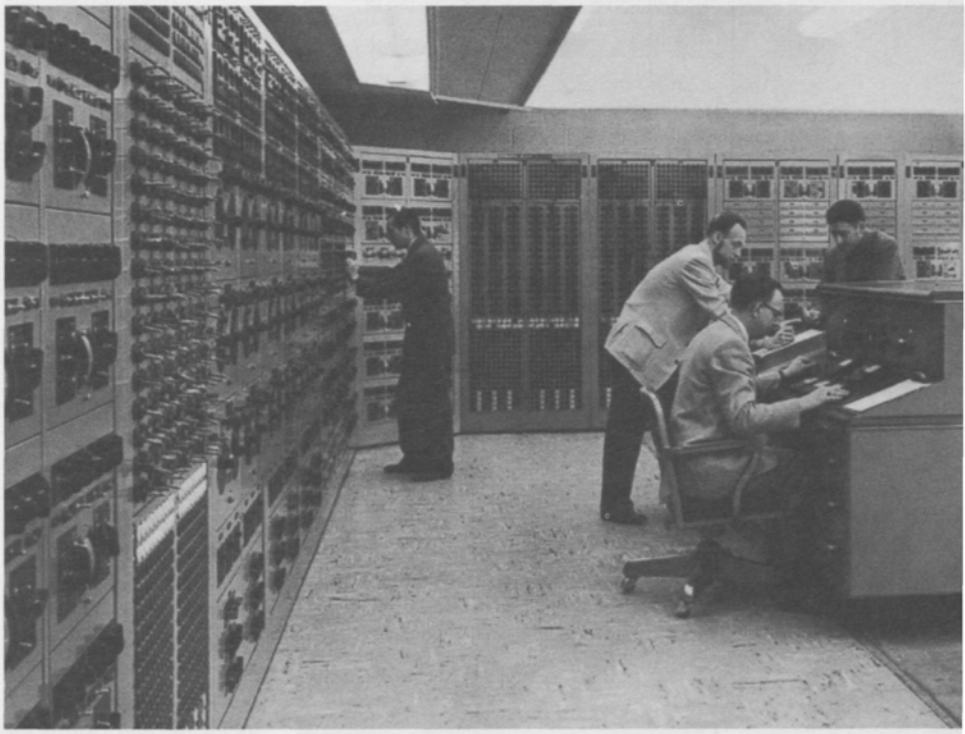


Photo C. The AC Power Network Calculator in Phillips Hall, c. 1955. *Left to right:* Garland Ching, Al Prochazka, Larry Spencer, Sam Linke.

THE ELECTRIC-POWER-SYSTEMS GROUP

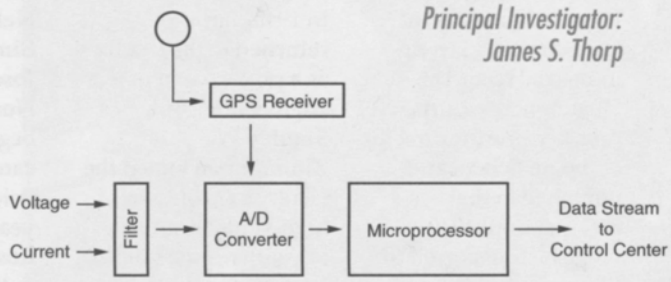
The Electric-Power-Systems Group in the School of Electrical Engineering consists of three full professors, **Christopher Pottle, Robert J. Thomas,** and **James S. Thorp** '59; an associate professor, **Hsiao-Dong Chiang**; a postdoctoral associate, **Ray D. Zimmerman,** Ph.D. '95; and affiliated graduate students. Experimental data from the Kettering Energy Systems Laboratory, algorithm development on the Phillips Hall computer network, and access to the Cornell Theory Center supercomputer in Rhodes Hall facilitate the group's theoretical and analytical studies of modern power systems.

Electric-power research in the EE School in past years dealt with the physical characteristics of electromagnetic machines and devices, high-voltage phenomena, and switching theory, coupled with traditional system analysis. Current research in the school is concerned with the complex problems of operation, control, and system security that will arise from the restructuring of the electric-utility industry. The proposed open-market mode of bulk-power transmission that will allow any generating company to sell power to any customer through the existing network, will have a profound effect upon both technical and economic performance of power systems throughout the country. Under the new mode of operation, traditional electric-utility responsibilities such as maintenance of system reliability and security, coordination of available generation to meet sudden demand, and response to sudden emergencies will require new approaches to power-system engineering. In the past few years, EE School researchers and their graduate students have made significant contributions to the development of solutions to these challenging new problems.

The principal areas of the Electric-Power-Systems Group research are described in the following four articles.

Digital Protective-Relay Research

Principal Investigator: James S. Thorp



Phasor-Measurement Unit (PMU): Data is transmitted to the control center at a rate of two to five cycles per 60 Hz phasor measurement. (Adapted from A. G. Phadke, "Synchronized Phasor Measurements in Power Systems," *IEEE Computer Applications in Power,* April 1993, Figure 3, page 12.)

System protection has always been a major concern of electric-power engineers. As power systems evolved into the large-scale networks typical of today's electric utilities, adequate protection was achieved by means of intricate electromechanical instruments that were sensitive to system variables such as voltage, current, and frequency magnitudes, direction of current and power flow, distance from a fault, and difference in current between two points. These protective relays, often characterized as "marvelous examples of the clockmaker's art," have operated satisfactorily for many years, but have always been limited by the necessity for fixed settings, frequent maintenance and testing, occasional faulty operation, and inability to communicate directly with the various elements of a protective assembly.

For the advanced requirements of present-day power-system operation, the relatively new and now well-established digital protective relays can perform all of the functions of the traditional analog relays, communicate with other components of the system, detect changes in the power network and take automatic corrective action, notify the control center if they cannot execute their scheduled functions properly, and carry out all of these actions with circuit components that are much more economical than their non-computerized counterparts.

Professor **James S. Thorp** has been a leader in research and development of digital techniques for power-system protection, monitoring, and control, including algorithms for digital protection, adaptive relaying, and real-time control of power systems using measurements obtained from microprocessor relays. In addition, he studies the complicated dynamical and chaotic behavior of power systems by means of the generation of fractals by such systems. Jim received the Ph.D. degree in electrical engineering at Cornell University in 1962, joined the EE faculty in that year, became a full professor in 1975, and is now the Charles N. Mellowes Professor of Engineering and director of the EE School. In 1976 he was a Faculty Intern at the American Electric Power Service Corporation in New York City, where he began his work on computer relaying for power systems. In 1988 he was an Overseas Fellow at Churchill College, Cambridge, England. In 1989 Jim became a Fellow of the IEEE and won the Best Professor Award of the Cornell Student Branch of the IEEE for the third time.

In research activities that have been vital to the successful birth of computer relaying, Jim has made important contributions to the understanding of expectations for the new field, and to development of several new protection and control techniques that take advantage of this new technology. He was the first power-system analyst to demonstrate that there are quantitative bounds on the performance of certain impedance relays that determine the distance to a fault. In a pioneering paper, he showed that the power system imposes an inherent limitation on the speed and reach of any impedance-type relay (whether analog or digital) because of the presence of unpredictable non-fundamental frequency components of voltages and currents in the system. He initiated the use of estimation theory in

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Power-System Simulation

Principal Investigator: Christopher Pottle

Alternating-current transmission and distribution of electric power and the subsequent development of complex networks established the need for power-system simulation. Initially, network problems were solved by dc models. Resistors represented inductive reactances, and ammeters were inserted at appropriate points to measure current distribution. Eventually, the comprehensive solutions required for system planning, protection, and stability were obtained from large ac network calculators that modelled the system with lumped resistors, inductors, capacitors, and adjustable sinusoidal voltage sources. Steady-state power flows, voltages, and currents were measured throughout the network. For transient studies, similar circuit configurations were used except that transmission lines had many pi-sections to allow examination of voltage and current pulses at intermediate points.

With the advent of the digital computer, analog calculators have been replaced by algorithmic solutions for the steady-state performance of equivalent circuits. Because of computational requirements, however, transient studies have been best performed on analog models known as transient network analyzers (TNA). Unlike the earlier transient calculators, these low-power simulators operate in real time and are controlled and probed by microprocessors and associated digital computers. Major changes in utility operation and limitations of current analog TNAs have prompted research on completely digital, real-time representations of power systems.

Professor **Christopher Pottle**'s primary research interest is in the direct implementation of time-consuming computer algorithms into parallel VLSI hardware with particular attention given to development of a real-time, completely digital, dynamic power-system simulator that combines appropriate algorithms with special-purpose hardware. He has been working on simulation techniques since 1965, when he developed a widely distributed computer program called CORNAP. Chris received the Ph.D. degree in electrical engineering from the University of Illinois in 1962, joined the Cornell EE School faculty in the same year as an assistant professor, and became a full professor in 1980. For several years he served as associate dean for computing in the College of Engineering. He has been a Fulbright scholar at the University of Erlangen-Nuremberg, Germany, and a visiting professor at Carnegie-Mellon University. He has spent sabbatical leaves at the General Electric Company's Electric Utility Systems Engineering Department and at the IBM Watson Research Laboratories. In the 1995 spring term he was the resident academic director of the Cornell Abroad Program in Hamburg, Germany. Chris is a Senior Member of IEEE, a member of the Association for Computing Machinery, and a member of the American Association for the Advancement of Science.

In recent years, microprocessor-based representations of power generators and loads have been added to the other digital accessories of the analog TNA. Consequently, a variety of power-system functions can now be studied in "real time," a simulation technique that requires events in the model to unfold at the same rate as they would in the physical system. This capability also allows a TNA to be used as:

- a fully dynamic simulator for training power-system operators in a manner equivalent to techniques used in aircraft-pilot training,
- a test bed for the design, verification, and testing of digital equipment for use in the bulk-power system; for example, in the application of digital relays,
- the basis of a model reference control scheme for operation of a specific power system.

The success of the digital interfaces with the analog TNA, and the availability of high-speed relatively inexpensive microprocessors have led to studies of the feasibility of changing the TNA from analog to digital format. With support from the National Science Foundation, Chris and his graduate student **Robert C. Durie** conducted research for several years on the development of a completely digital multiprocessor TNA that would also be completely extensible, that is, the amount of required computer equipment would be proportional to the number of buses in the system. In order to devise an accurate digital representation of the transmission lines in the power network, they employ the "method of characteristics," championed in 1969 by Hermann W. Dommell in the Electromagnetic Transient Program (EMTP), and known in Europe as Bergeron's method. The standard model differential equations for the lumped elements of a transmission line easily incorporate a lossless line with distributed inductances and capacitors and are solved by the trapezoidal integration rule with a step size of Δt. The actual lossy transmission line is approximated by a pure delay

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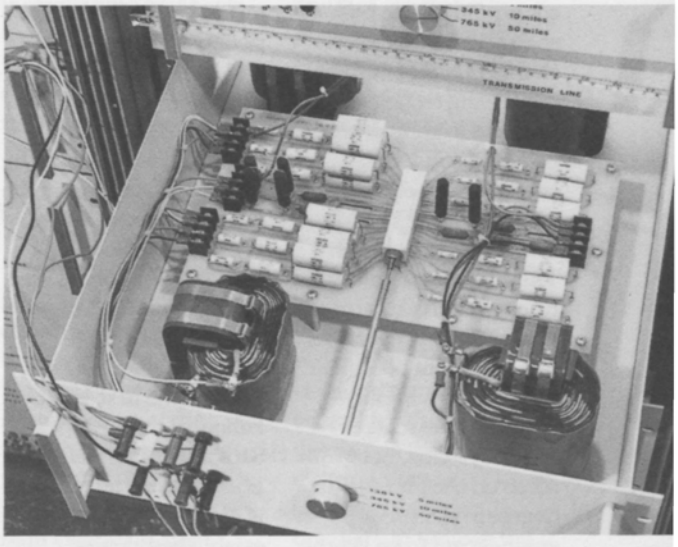
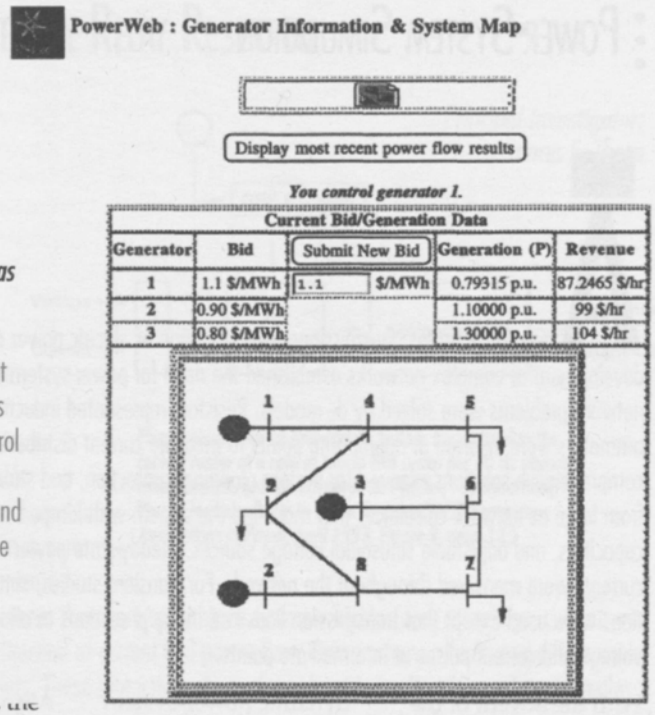


This three-phase analog pi-section model of a transmission line in the Kettering Laboratory TNA can be replaced by one transputer chip. (Photograph by William Mutch.)



Typical PowerWeb load-flow output for the test system. (Diagram courtesy of Robert J. Thomas.)

Principal Investigator: Robert J. Thomas

The American electric utility industry has an enviable long-term record of reliable performance that reflects the attention given by power-system engineers to the development and application of effective control procedures. In the late '40s, large utility interconnections were controlled, under both normal and emergency conditions, by dispatchers in power-control centers who gave directions to power-station operators over leased telephone lines. As the utility systems developed into today's complex networks, modern communication facilities and computerized economic-dispatch control equipment supplanted the outmoded methods of the past, but system dispatchers armed with these powerful modern tools remain important components of power-system operation. Automatic control of power systems, however, is certain to become a reality in the near future.

New techniques in power-systems management are being developed that will allow instant response to emergency conditions or rapid changes in demand through real-time monitoring and management of power flow on specific lines. These desirable conditions will be accomplished through employment of techniques such as the digital protective relays described on page 6 of this newsletter, and the Flexible AC Transmission Systems (FACTS) concept in which high-speed communication channels and computer-processing techniques are used to control high-powered solid-state switches in the power-system network.

Professor **Robert J. Thomas**'s academic and research interests are concerned with analysis and control of nonlinear systems with applications to large-scale utility systems. Bob received the Ph.D. degree in electrical engineering from Wayne State University in 1973, joined the Cornell EE faculty in the same year as an assistant professor, and became a full professor in 1985. Over the years, he has received three excellence-in-teaching awards. Bob has spent sabbatical leaves with the U.S. Department of Energy and the National Science Foundation (NSF) on electric-energy-systems concerns. For five years he was director of the Cornell component of the NSF-sponsored Education Synthesis Coalition for the development of high-technology methods for teaching engineering. During that period he also formed and directed the Engineering Multimedia Research Laboratory (EMRL). He has been the EE faculty advisor on the Cornell Hybrid-Vehicle Project since its inception. In 1994 Bob became a Fellow of the IEEE. In 1995 he spent three months in Washington, D.C., as the first Visiting Fellow at the American Society for Engineering Education. Currently he is director of the newly established Power Systems Engineering Research Center (PSERC) described on page 17.

In coming years, the complex bulk-power delivery system in this country is likely to become completely restructured. System loads are changing in character and increasing in magnitude and diversity, but environmental and economic constraints are being imposed on construction of new large-scale generation and transmission facilities. Consequently, growth in demand is being met by an increase in the interchange of power among utilities over existing transmission networks. In addition, an unprecedented element of competition has entered into utility operation because of new regulations that allow independent power producers to compete with utilities for customers and to have open access to existing transmission lines. Thus the concept of a neighborhood power company that provides both generation and localized service could disappear, and major utilities could become power-generating entities that sell their energy, in competition with the independent power producers, to operating companies and industries over existing transmission networks serving as the marketplace for the entire electric-utility business. The difficult technical and economic-dispatch problems introduced by these trends could cause individual utilities to approach their capacity limits and place the nation's supply of reliable electric energy in jeopardy, a contingency that can be averted by the application of modern system analysis and adaptive control to current systems to make them more efficient, more responsive to rapid changes, and more receptive to competition. The ability to maximize, measure, and price the manner in which electric energy will be transmitted and distributed is critical to the future of the industry.

Bob and his graduate students **Eric Sakk** and **Soam Archarya** and postdoctoral associate **Ray Zimmerman** in the PSERC effort have begun to apply power-control principles to the solution of the problems posed by the restructuring of the industry. As a part of that activity, a prototype of a real-time interactive distributed power-system simulator, known as "PowerWeb," has been designed and implemented on the Phillips Hall computer network. The simulator is available to anyone with access to the Internet, a world-wide-web browser, and the password. The initial nine-bus system includes three generators and three loads as shown in the figure above. Each generator may submit power and price bids for a given set of loads and a system operating point. The algorithm will perform a load-flow analysis and an evaluation of the economic-dispatch conditions (that is, run an optimal power flow), and provide a display of

the results in graphical and tabular form. As the prototype undergoes further development, the dimensions of the system will be increased, more complex loads will be added, an ability to focus on a small portion of a very large system will be incorporated, and capabilities will be included for on-line fault and stability studies as well as for immediate display of the impact of automatic-control activities on the system under study. The ultimate goal is to establish an expanded version of the simulator on the World Wide Web that will be available to anyone interested in studying the nature of competition in a restricted electric-power industry.

In accord with one of the goals of PSERC to challenge high-caliber EE students to study power-system engineering, Bob has conceived of a tournament that could become national in scale. The contest would be based on competitive student-compiled free-market bidding strategies for a future electric-power system operating under a fixed set of technical and economic constraints. Students at various institutions would use the PowerWeb to convey their bids in real-time with a real-time return of results. The school that can accumulate the most game revenue would win the contest. Bob would appreciate some feedback from interested alumni on this idea. Comments and suggestions may be sent to him via e-mail at *rjt1@cornell.edu*. ■

On-line Algorithms for Power-System Analysis and Control

Principal Investigator: Hsiao-Dong Chiang

In the mid '50s, power-system engineers recognized the potential of digital computers as an inevitable replacement for the well-established analog calculators, provided suitable algorithms for analysis could be written. Business-machine programmers in several forward-looking utility companies, as well as in associated industries, worked with system analysts to produce load-flow programs to run on the primitive card-programmed calculators of the time. With the advent of more advanced computers, power-system programming developed rapidly to produce algorithms for efficient load-flow studies, fault studies, transient-stability studies, and solutions for economic dispatch. Present-day computer power has allowed expanded versions of these algorithms to readily support studies of systems with 2,000 buses and 300 generators.

Power engineers now have robust facilities available for both static-security analysis of systems operating within normal ranges, and dynamic-security analysis of systems responding to major disturbances that have the potential to trigger blackouts. The principal characteristics of these analytical tools is that they all operate off-line and often require many hours of computational time. Proliferation of system interconnections, and new regulations that have established the open-market transmission system, are introducing dynamic-security problems that will require research on the development of algorithms that allow rapid on-line analysis.

Professor **Hsiao-Dong Chiang**'s research interests include the development of theoretical foundations and analytical tools for the analysis and control of physical systems such as power and control systems, and the use of this work to achieve valuable and practical results. In recent years he has given particular attention to the development of algorithms for on-line dynamic security and assessment and control of power systems. Hsiao-Dong received the Ph.D. degree in electrical engineering from the University of California at Berkeley in 1986, joined the EE faculty at Cornell in 1987, and was promoted to his current rank of associate professor in 1992. He received the Engineering Research Initiation Award in 1988 and the Presidential Young Investigator Award in 1989, both from the National Science Foundation. In 1990 he was selected by a Merrill Presidential Scholar as the faculty member who had the most influence on that student's education at Cornell. He was associate editor of *IEEE Transactions on Circuits and Systems* from 1990 to 1991, and associate editor for *Express Letters of IEEE Transactions on Circuits and Systems: Part I* from 1993 to 1995.

The threat to the dynamic security of a power system because of a disturbance that results in a transient-stability problem may be understood by reference to the simple case of a generator connected to an infinite bus. When a short circuit occurs in the system, the rotating masses of the turbine generator experience an accelerating torque that causes the generator power angle (described on page 16, column 1) to increase with respect to that of the infinite bus. The power regulator (throttle) setting of a turbine generator remains essentially constant throughout a transient-stability event. Since the power requirements of the system are reduced momentarily during the fault and the subsequent fault clearance, the available excess input power due to the constant regulator setting introduces accelerating energy into the rotor. As the power angle increases, the rotor absorbs decelerating energy from the system. If the accelerating energy exceeds the decelerating energy, the generator will go unstable. If the fault is not cleared in sufficient time, the accelerating rotor will cause the power angle to pass through 180° with respect to the reference bus. At that instant the voltages of the generator and the infinite bus oppose one another and create an "electrical center," a momentary zero voltage at a point within the system that is, in effect, a short circuit. If this behavior is now extrapolated to a system with many generators and many buses, the new short circuit may cause another generator to accelerate and cause still another virtual fault. In a worst-case scenario, a series of cascading short circuits could evolve into a major blackout. In order to maintain stability it is necessary to analyze the system to determine the critical clearing time at which to set relays and circuit breakers to remove the original fault.

$$E(\delta,\omega) = \frac{1}{2}M\,\omega^2 - P_m\,\delta - P_0\cos\delta$$

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Recent Faculty Accomplishments

Note: Most of the listed awards were announced at the College of Engineering Fall 1995 Awards Ceremony and Faculty Reception on October 2, 1995.

• Professor **Joseph M. Ballantyne** (optoelectronic devices and materials), director of the Semiconductor Research Corporation (SRC) interdisciplinary Program on Microscience and Technology at Cornell, and his group have demonstrated that their unique triangular waveguide diode-ring laser has the potential to become a very important laser source for optical communications. The devices set new records for diode-ring lasers of low cw room-temperature threshold current, high-output power, and spectral purity. Unique new ways have been developed to produce devices with unidirectional circulation and single-beam output.

• Professor **Toby Berger** (information theory and communications), the J. Preston Levis Professor of Electrical Engineering, and his students have extended analysis of the CEO Problem in multisite coding theory to encompass situations in which the observations are made by agents who are not necessarily statistically interchangeable. This study has profound unintuitive consequences on configuration of an information-gathering team under communication constraints. Toby and his students also recently announced the development of a signature-verification system that can reject most forgeries while still allowing for the minor variations in a person's real signature.

• Associate professor **Adam W. Bojanczyk** (computer engineering, parallel architecture, and algorithms for signal and image processing) was on sabbatical leave during the 1994–95 academic year. Together with Georg Heinig of the department of mathematics at the University of Chemitz, Germany, he investigated how to utilize transformations between different structures to preserve stability and computational complexity of fast solvers. Adam also worked with his graduate students to implement Space-Time Adaptive Processing (STAP) algorithms on massively parallel computers.

• Associate professor **Geoffrey M. Brown** (concurrent systems, communications protocols, and hardware synthesis) and his students have developed a working prototype of a reconfigurable data-acquisition card based upon field-programmable gate arrays along with a compiler and debugger for the concurrent programming language used to configure the card.

• Associate professor **Hsiao-Dong Chiang** (analysis and control of nonlinear systems with applications to electric-power networks), a member of the Cornell Electric-Power-Systems Group, has been awarded a U.S. patent for "On-Line Method for Determining Power System Transient Stability." With his graduate students **Cheng-Shan Wang** and **Jin-Cheng Wang** he has applied for two U.S. letters patents for innovative power-system analysis.

• Associate professor **Richard C. Compton** (millimeter and microwave integrated circuits) was on sabbatical leave during the 1994–95 academic year. The first half of his leave was spent with Martin Marietta Research Laboratories in Baltimore, Maryland where he served on the Federal Communications Commission Negotiated Rulemaking Committee that considered use of the 28-GHz wireless band. He spent the remainder of his sabbatical in Ithaca with the start-up company Avoca Laboratories.

• Associate professor **David F. Delchamps** (control and system theory) and his students have continued their investigation of nonlinear feedback systems that mix continuous and discrete variables. During the past year, with both descriptive and proscriptive goals in mind, explorations have been conducted on some novel approaches toward modelling such systems dynamically and computationally. David was a recipient of a 1995 Dean's-Fund Excellence in Teaching Award.

EE School Research Funding Summary

Total research funds expended in 1992–93
$12,077,185

Total research funds expended in 1993–94
$11,202,647

Percent decrease
7.24%

Total research funds for 1994–95 (as of June 30, 1995)
$11,848,956

• Professor **Lester F. Eastman** (compound semiconductor materials, devices, and circuits), the John LaPorte Given Professor of Engineering, continues his phased retirement with teaching duties in the fall term and research in the spring. His recent research is concerned with the design of a novel GaAs MODFET structure using InGaP barriers instead of AlGaAs. Devices have been fabricated that performed at a new state-of-the-art frequency response of f_{max} = 188 GHz with 0.25 μm gates.

• Professor **Donald T. Farley** (radiowave and upper-atmospheric physics), while on sabbatical during the 1995 calendar year at the Max Planck Institute for Aeronomie in Germany, participated in three international symposia as an invited lecturer, and worked on a book manuscript. With **Dave Hysell,** Ph.D. '92, he finished some experimental work that disproved a long-standing hypothesis about a particular plasma instability in the equatorial atmosphere. Don was the recipient of the Alexander von Humboldt Senior U.S. Scientist Research Award.

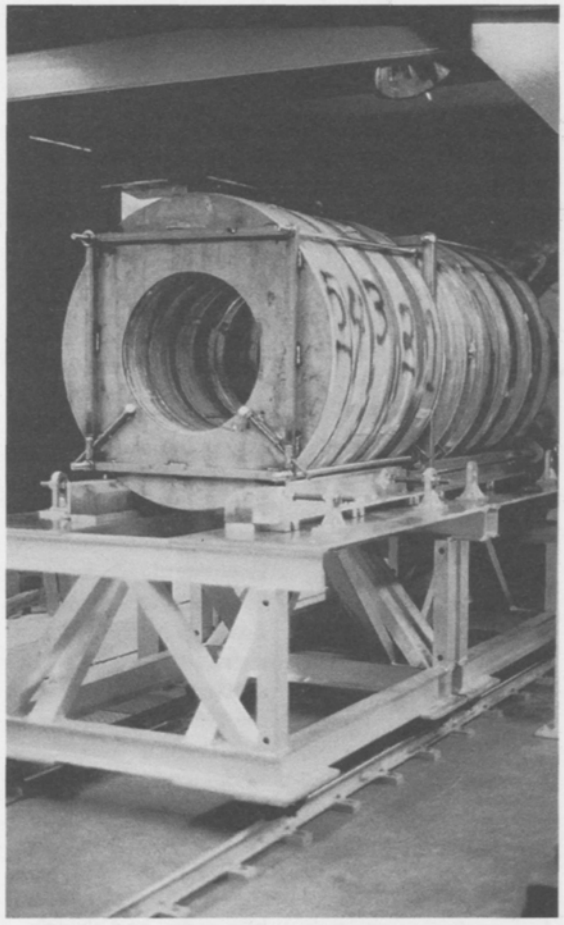
• Professor **Terrence L. Fine** (information theory, inference and decision making in the presence of uncertainty) initiated work on his forthcoming book, *Feedforward Artificial Neural Networks*, to be published in the Springer Monograph Series on Statistics. Completion of the volume is expected this year.

• Associate professor **Zygmunt J. Haas** (wireless communication and networks, mobile systems) and his associates investigated the capacity of cellular communications systems, with particular attention to how the reuse factor can be improved given the knowledge of the mobiles' locations. An evaluation was made of the number of channels required to support a cellular infrastructure with a given number of mobiles in each cell.

• Professor **David A. Hammer** (plasma physics, controlled fusion, intense ion beams), the J. Carlton Ward Professor of Nuclear Energy, with **R. N. Sudan** and associates in the Laboratory of Plasma Studies (LPS), reports the completion in 1995 of the Cornell Field-Reversed Ion Ring Experiment (FIREX), an alternate-concept experiment within the magnetic-confinement thermonuclear fusion program (see photo). David has been named a fellow of the IEEE "for contributions to the physics, technology and applications of intense pulsed electron and ion beams and dense z-pinch plasmas."

• Associate professor **Chris Heegard** (communication, information, and coding theory) is on sabbatical leave for the 1995–96 academic year. He plans to write a text/research book on modern digital communications that will emphasize the use of digital-signal processing techniques for modulation and error-control coding. He is also working on the development of a toolbox package for digital communications design in the MATLAB™ environment. Chris was named a fellow of the IEEE "for development and analysis of families of efficient channel codes."

• Assistant professor **Sheila S. Hemami** (application-specific compression techniques for packet networks, networking aspects of visual communications, and multirate coding and transmission) has developed multidimensional source-coding techniques that incorporate reconstruction requirements for image transmission over lossy packet networks, thereby enabling reliable digital-image reception when information is transmitted over unreliable links.



Early view of the magnetic structure of the LPS Field-Reversed Ion-Ring Experiment (FIREX), used in the research of professors Hammer and Sudan. The goal of the FIREX ion-beam accelerator is to produce a fully field-reversed ring with 1 MeV protons. The central component is an applied-B magnetically insulated ion diode of a type first employed at Cornell for ion-ring generation in the '70s. (Photograph by William J. Podulka and William Mutch.)

• Professor **C. Richard Johnson, Jr.** (adaptive control and signal processing), reports new results on behavioral characteristics of adaptive fractionally spaced equalizers, including frequency-domain description of convergence rate of decision-directed least-mean-square (LMS) algorithms, effects of loss of subchannel disparity on decision-directed LMS and constant modulus algorithms (CMA), and CMA error surface distortions with non-independent identically distributed sources.

continued on next page

• Professor **Michael C. Kelley** (upper-atmospheric and ionospheric physics) and graduate student and NSE/ATT Fellow **Clark Miller** have made a major breakthrough in upper-atmosphere electrodynamics. Several decades of observations were organized and compared with modern experiments designed for the Arecibo Observatory, and with computer simulations that they ran at Cornell. Atmospheric gravity waves generated by weather processes were found to generate large electrical potentials that magnify the effect of weather on both ionized and neutral gases in the thermosphere.

• Professor **Paul M. Kintner** (atmospheric plasma physics), while on sabbatical leave during the 1995 calendar year, directed the field campaigns for the launch of two sounding rockets and was the principal investigator for the payload of the January 1995 launch from Andoya, Sweden. Preliminary analysis of the data from the Andoya launch indicates that the source for the Van Allen radiation belts has been discovered. Paul also developed a laboratory course, EE 316, Global Positioning System: Theory and Design, that he is offering for the first time in the spring 1996 term.

• Associate professor **Ronald M. Kline** (history of technology and electrical engineering) has been appointed director of the Cornell Program on History and Ethics of Professional Engineering, endowed by Sue and **Harry E. Bovay, Jr.,** CE '37. Ron spent a portion of his sabbatical leave during the 1994–95 academic year doing research under a grant from the National Science Foundation for a book on the social history of the telephone, automobile, radio, and electric light and power in the rural United States.

• Professor **J. Peter Krusius** (solid-state electronics, semiconductor devices and systems, and electronic packaging), while on sabbatical leave during the 1995 spring term, taught an electronic-system packaging course at the Royal Institute of Technology in Stockholm, Sweden. He has completed development of physics for carrier relaxation in compound semiconductor thin films under femtosecond optical excitation. Peter also developed a new version of the junior-level course, EE 315, Electronic Circuits, that was offered for the first time in the 1995 fall term.

• Associate professor **Miriam E. Leeser** (VLSI design and computer engineering) is on leave of absence with the Department of Electrical Engineering at Northeastern University in Boston, Massachusetts.

• Professor **Richard L. Liboff** (physics of microsemiconductor devices and solid-state plasmas) has used a waveguide experiment to establish the existence of "field chaos" in electromagnetic fields. This form of chaos relates to confined propagating electromagnetic fields, and may play a role in the design of waveguides. The third edition of Richard's popular text, *Introductory Quantum Mechanics,* is in press, and the second edition of his text *Kinetic Theory* is under contract with Wiley Interscience.

• Assistant professor **Yu-Hwa Lo** (optoelectronic materials and devices, and integrated optoelectronic circuits) and his group have demonstrated first-time operation of long-wavelength vertical-cavity lasers with low-threshold currents. A patent has been filed on the innovative design and the invention has been licensed to a company. An earlier invention on thin-film direct-bonding technology has been substantiated by record-performance demonstration of several optoelectronic devices. Yu-Hwa was the recipient of the **Michael Tien** '72 Excellence in Teaching Award.

• Professor **Noel C. MacDonald** (microelectromechanical and nanoelectromechanical systems), the **Lester B. Knight** Director of the Cornell Nanofabrication Facility, began his 1994–95 academic-year sabbatical leave with a presentation on nanomechanisms at a Gordon Conference in Wolfeboro, New Hampshire, followed by four invited presentations at conferences in Maui, Hawaii; Quebec City, Ontario; Berlin, Germany; and Atlanta, Georgia. During the year, Noel made ten presentations of his work with **Y. Xu** and **S. Miller** on their production of the world's smallest micromachined scanning tunneling microscope, and gave over twenty-five talks on his group's micro-electromechanical systems (MEMS) research at conferences, universities, and industries, in this country and abroad.

• Professor **Paul R. McIsaac** (microwave theory and techniques) retired from his fourth term as graduate field representative in the School of Electrical Engineering, and returned to full-time teaching and research. Paul has been evaluating the port waveguide-to-resonant-cavity mode coupling factors in the scattering matrix representations of cavities as microwave junctions. Information relating to the waveguide-mode to cavity-mode coupling integrals can be determined based on the symmetries of the port waveguides and of the cavity junction.

• Professor **John A. Nation** (electromagnetic fields and waves) reports that the research of his group on ferroelectric cathodes continues to attract outside attention and, in part, has led to a new five-year U.S. Department of Defense contract to exploit this new technology. As part of his teaching activities, John has introduced computer simulation laboratory sessions into two courses in the core curriculum. In EE 303, Electromagnetic Fields

and Waves, students work on field problems in electrostatics and magnetostatics. In EE 304, Electromagnetic Fields and Applications, two lab projects are assigned: one, to find the nodes of an RF cavity, and the other, to design an electron gun.

• Professor **Thomas W. Parks** (signal theory and digital-signal processing) has developed a new approach to the design of multirate systems. The work is described in a paper with **R. Shenoy,** Ph.D. '91, and **D. Burnside,** Ph.D. '95, in the September 1994 *IEEE Transactions on Signal Processing.* Tom was a recipient of a 1995 Dean's-Fund Excellence in Teaching Award.

• Associate professor **Alfred Phillips, Jr.** (quantum mechanical devices, optical switches, and process modeling), and his students have developed a new field-effect transistor (FET) that is the first substantially new FET model in forty years. An improved semiconductor diffusion modeling system that is more accurate than a similar model at Stanford has been developed, and a simple but physically accurate mathematical model for electron tunneling between nanometer silicon tips has been constructed.

• Professor **Clifford R. Pollock** (lasers and optoelectronics), associate director of the School of Electrical Engineering and the Ilda and Charles Lee Professor of Engineering, has been concerned with administrative duties in the school with particular attention to the restoration of the computer staff. He was program chairman of the annual Optical Society of America Advanced Solid-State Laser Conference in 1995. Clif was the 1995 recipient of the **Stephen** '57 and Marilyn **Miles** Excellence in Teaching Award.

• Professor **Christopher Pottle** (computer engineering, parallel processors, VLSI technology), a member of the Cornell Electric-Power-Systems Group, was on sabbatical leave during the 1995 spring term when he was the resident acting director of the Cornell Abroad Program in Hamburg, Germany. This spring, Chris is teaching course EE 476, Digital Systems Design Using Microcontrollers. In keeping with current trends in computer applications, this new course emphasizes microcontrollers rather than microprocessors.

• Associate professor **Anthony P. Reeves** (parallel computer systems, computer-vision algorithms) and his students in computer-vision research have developed several mathematical models to represent the dynamic behavior of calcium ions in a biological cell. Tony has also revised course EE 308, Fundamentals of Computer Engineering, that now stresses the interaction between programming language requirements and computer organization.

• Professor **Charles E. Seyler, Jr.** (space-plasma physics, physics of relativistic electron beams), coordinator of graduate studies in the School of Electrical Engineering, has formulated and developed a theoretical/simulation model of an important class of plasma waves found in the auroral ionosphere-magnetosphere system, and compared the results in detail with Freja Satellite observations. Charles also developed course EE 114, An Introduction to Engineering Design, a new electronic-design course based on a team project: a fiberoptical transmitter-receiver system.

• Assistant professor **Yosef Y. Shacham** (VLSI technology, nanoelectronics, and process integration) is on a one-year leave of absence at the Technion Institute of Technology in Israel. Yosi has been studying the reasons for failures of electroless copper deposition and has invented an ultra-clean surface with the capability of nucleating a deflect-free laser on 200 μm silicon wafers.

• Associate professor **James R. Shealy** (development of compound semiconductors) and his students have developed a new technology for flat-panel color displays based on the combination of compound semiconductor materials synthesis with micromachining technology at Cornell. They have also devised a new technique for fabricating GaN using a process developed in the organometallic vapor-phase epitaxy (OMVPE) laboratory. Dick was elected as the 1995 Best Professor by the Cornell student branch of IEEE.

• Professor **Ravindra N. Sudan** (plasma physics), the IBM Professor of Engineering, and his associates report three major research results in the past year: (1) an understanding of the formation of current sheets in the solar corona which, in turn, are the basis of our understanding of solar flares; (2) a new insight into the Farley-Buneman instability that occurs in the equatorial ionosphere; and (3) a sorting out of the physics of the injection and formation of field-reversed ion rings.

• Professor **Chung L. Tang** (lasers, opto-electric devices, nonlinear and coherent optical processes), the Spencer T. Olin Professor of Engineering, has achieved femtosecond pulse generation to 5.2 μm for the first time. This breakthrough was accomplished in $KNbO_3$ crystal, also a first-time achievement. He has also demonstrated for

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ADVISORY COUNCIL

The EE Advisory Council was established by Professor John Nation in 1987, when he was the director of the School of Electrical Engineering. Council members include prominent Cornell EE alumni from other universities, research organizations, and industry, as well as several equally well-known non-alumni who have been active in EE School affairs.

The latest meeting of the council was held on April 11–12 of this year with an update on the current status of the school; a presentation by Professor Lester Eastman on the planned Engineering Research and Instructional Facility (ERIF); consideration of plans for faculty recruiting in two areas, information technology and electronics; and discussions of ERIF mandates for strengthening the school position in computer science. The current council members are identified on these pages.

WILLIAM DESTLER

William W. Destler, B.S. '68, Stevens Institute of Technology; Ph.D. '72 (applied and engineering physics), Cornell University, is dean of the Glenn L. Martin Institute of Technology and the A. James Clark School of Engineering at the University of Maryland at College Park. His research interests are primarily in the areas of high-power microwave sources and particle-beam technology, and he is the author or co-author of over 100 research papers on these and related topics. He has received many awards for teaching excellence, and in 1992 was named a University of Maryland Distinguished Scholar-Teacher. Dr. Destler is a Fellow of the IEEE and of the American Physical Society.

DAVID HODGES

David A. Hodges, B.E.E. '60, Cornell University; M.S. '61, Ph.D. '66 (both in electrical engineering from the University of California at Berkeley) is dean of the College of Engineering at Berkeley. His recent research has centered on semiconductor manufacturing systems. He was founding editor of the *IEEE Transactions on Semiconductor Manufacturing* and past editor of the *IEEE Journal of Solid-State Circuits*. With R. W. Brodersen and P. R. Gray, he received the 1983 IEEE Morris N. Liebmann Award for pioneering work on switched-capacitor circuits. Dr. Hodges is a Member of the National Academy of Engineering, and a Fellow of the IEEE and the AAAS.

WALTER BUTLER

Walter J. Butler, B.S. '66, Dublin University, Ireland; Ph.D.'70, McMaster University, Canada (both in electronics engineering) is vice president and general manager of the Microwave Electronics Division of Sanders, a Lockheed Martin company engaged in development, manufacture, and sale of advanced electronic systems and products in a broad range of defense electronics markets. He assumed his present position in July 1995 after serving since 1982 as general manager of the General Electric Company Electronics Laboratory in Syracuse, New York. Dr. Butler is a Senior Member of IEEE, a member of several professional associations, and a member of the American Association for the Advancement of Science (AAAS) and the American Society for Engineering Education.

DANIEL MILLER

Daniel H. Miller, B.S. '78, Cornell University; M.S. '79, Stanford University (both in electrical engineering), is a private investor and entrepreneur. He is a co-founder, member of the board of directors, and former executive vice president of TCSI Corporation in Berkeley, California, a leading provider of software products and services to the telecommunications industries and equipment manufacturers. Throughout the company's history, he played a key role in identifying and designing business and technical solutions that combined advanced telecommunications and computer technologies into products or systems of operational and economic value to TCSI's clients. Mr. Miller retired from his executive role in 1994, but remains an active consultant to the company. He is a member of the IEEE.

TIMOTHY COFFEY

Timothy Coffey, B.S.E.E. '62, Massachusetts Institute of Technology (M.I.T.); M.S. '63, Ph.D. '67 (both in physics from the University of Michigan) is director of research at the Naval Research Laboratory in Washington, D.C. His research involves the theory of nonlinear oscillations, electron-beam plasma interactions, and plasma processes in the earth's atmosphere. He has published over seventy-five professional papers and articles. He is the recipient of many awards, including the Presidential Rank of Distinguished Executive for the second time in 1994. Dr. Coffey is a Fellow of the American Physical Society, the Franklin Institute, and the Washington Academy of Science. In 1991 he was awarded the Fahrney Medal of the American Institute of Physics.

ROBERT NAFIS

Robert A. Nafis, B.E.E. '49, Cornell University; S.M. '65, M.I.T. Sloan School, retired in 1990 as president of Grumman Electronics. His forty-one-year career with Grumman Corporation began with duties as an automatic flight control and instrumentation-systems project engineer and progressed through various management positions to vice president for development in 1983. He became president of Grumman Electronics and chairman of Tachonics Corporation in 1985. Following retirement as president, he served as a senior management consultant to Grumman until 1993, engaged in private consulting through 1995, and retired to Ithaca, New York, in 1996.

VENKATESH NARAYANAMURTI

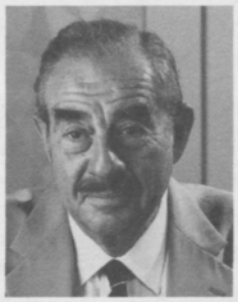
Venkatesh (Venky) Narayanamurti, Ph.D. '65 (physics), Cornell University, has been dean of the College of Engineering and professor of electrical and computer engineering at the University of California at Santa Barbara since 1992, following prior positions at Sandia National Laboratories and AT&T Bell Laboratories. His major research interests are in the areas of low-temperature physics, superconductivity, semiconductor electronics, photonics, and phonon optics. Dr. Narayanamurti is a member of the National Academy of Engineering, a Fellow of the American Physical Society, the IEEE, the Royal Swedish Academy of Engineering Sciences, the Indian Academy of Sciences, and AAAS. He also serves on several national advisory boards and professional committees.

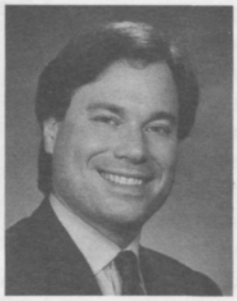
RODNEY ROUGELOT

Rodney S. Rougelot, B.E.E. '56, Cornell University, retired as president and chief executive officer of Evans & Sutherland Computer Corporation in December 1994, after twenty-two years with the company. He has published several papers on computer image generation. He is also a founding director of Recycling Resource LLC, a privately held company located in San Francisco, California; a member of several university advisory boards; a past director of the Image Society and of the American Defense Preparedness Association, and has served in senior executive positions for several simulation-industry trade organizations. Mr. Rougelot is a member of Tau Beta Pi, Eta Kappa Nu, Sigma Xi, and IEEE.

JOEL SPIRA

Joel S. Spira, B.S. '48 (physics), Purdue University, is founder, chairman, and chief executive officer of Lutron Electronics Company, Inc., in Coopersburg, Pennsylvania, the world's leading producer of electronic lighting controls for industrial, commercial, institutional, and residential applications. Credited with sixty-one U.S. patents, Mr. Spira is a member of the National Academy of Engineering, a Fellow of AAAS, a Senior Member of the IEEE, and serves on the engineering advisory committees of five universities. In April 1995, Mr. Spira was cited as one of Purdue University's distinguished graduates for outstanding invention.





ROGER STRAUCH

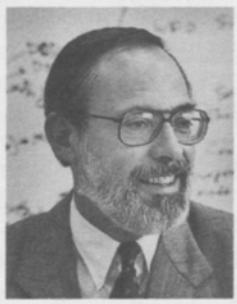
Roger A. Strauch, B.S. '78 (with distinction), Cornell University; M.S. '79, Stanford University (both in electrical engineering), is president, chief executive officer, and chairman of the board of directors of the telecommunications software company TCSI Corporation in Berkeley, California. He co-founded TCSI in 1983, and has served as the company's only CEO. Mr. Strauch is a member of the Cornell University Council, chairman of the Cornell School of Electrical Engineering Advisory Council, a member of the Industrial Advisory Board for the Department of Electrical Engineering and Computer Sciences at the University of California at Berkeley, and a member of the IEEE.

PETER WARTER

Peter J. Warter, B.S.E. '54 (with highest honors), M.A. '56, Ph.D. '62, (all in electrical engineering from Princeton University), professor of electrical engineering at the University of Delaware in Newark, Delaware, served as chairman of the Department of Electrical Engineering at Delaware from 1975 to 1994. His current research interests include computationally simple image-processing algorithms based on measurements of human visual system performance. In 1984–85, he was a visiting professor at the Computer Laboratory at Cambridge University in England. Dr. Warter, a member of the IEEE, has consulted with IBM Watson Laboratories, Texas Instruments, Xerox Corporation, Seimens, and Digital Products Corporation.

GEROLD YONAS

Gerold Yonas, B.S. '62 (engineering physics), Cornell University; Ph.D. '66 (engineering science and physics), the California Institute of Technology, is vice president of the Systems Applications Division of the Sandia National Laboratories in Albuquerque, New Mexico. His research interests and publications are in the fields of intense particle beams, inertial confinement fusion, strategic defense technologies, and technology transfer. He holds a U.S. patent for a relativistic electron-beam accelerator concept. He serves on many U.S. government and university advisory boards, and is the recipient of a number of awards including the Secretary of Defense Medal for Outstanding Public Service. Dr. Yonas is a Fellow of the American Physical Society and an Associate Fellow of the American Institute of Aeronautics and Astronautics.



The availability of PMUs for synchronized phasor measurements has prompted research by Jim and his graduate students leading to development of algorithms for microprocessor-based protection systems.

Protective Relays—continued from page 6

relay algorithm analysis. He has also been involved in the introduction of the concept of adaptive protection and control, in which measurements can be used to alter the characteristics of the protection system in response to changing system conditions. Jim has conducted seminars on his work in eight countries. Relays and monitoring systems based on his concepts and algorithms have been installed throughout the world.

Power transfer in an electric-power network, both in magnitude and direction, is directly related to the angular difference between the phasors at discrete points in the network. Consider two generators in the network connected by a transmission line. Both machines may be rotating at the same synchronous speed (3,600 rpm, for example) but if machine A is sending power to machine B, the shaft of A will be leading that of B by a specific angle, called the "power angle." In the analogous mechanical system, a shaft will have an angle of twist, called the "torque angle" when mechanical power is being transferred from one end to the other. If the torque angle becomes excessive, the shaft will break apart. For large angular differences in the electric system, the two generators may go "unstable," that is, they may pull out of synchronism. For many years power-system engineers have wanted to measure these "power angles" in real time, simultaneously, accurately, and continuously. Several years ago, Jim (together with professor Arun Phadke of VPI) invented a device, called a phasor measurement unit (PMU), that had the potential to meet these hitherto impossible requirements, provided that essentially simultaneous sampling of phasor angles over a wide geographical area could be achieved (see figure on cover page).

Accurate synchronization could not be obtained from timing signals broadcast by radio station WWV or the Loran C radionavigation system. Fortunately, the satellites of the Global Positioning System operated by the U.S. Department of Defense provide a common-access timing pulse that is accurate to within one microsecond at any location on earth. Since the angle extended during one microsecond of one 60 Hz cycle is only 0.0216°, the use of the timing pulse for synchronization of the PMUs introduces negligible error in measurement of phasor angles. At each installation during each 60 Hz cycle, the synchronized PMUs (see figure, page 6) make twelve accurate measurements of voltage and current phasors and calculate active power, reactive power, power frequency, and phase angle. The resultant "time-tagged" digital data stream is transmitted over rapid communication channels for reconstruction at local control centers. This precise data acquisition capability provides unprecedented potential for real-time monitoring, protection, and control of power systems.

The availability of PMUs for synchronized phasor measurements has prompted research by Jim and his graduate students leading to development of algorithms for microprocessor-based protection systems. Preliminary installations of PMUs have been made in the interconnection between Florida Power and Light and the Georgia Power Company, and in the Western Systems Coordinating Council (WSCC) network that is illustrated on the cover of this newsletter. Jim and his group are continuing to investigate the PMU control potential of the WSCC region by means of computer simulations at the Cornell Theory Center. Favorable results obtained thus far assure the eventual widespread adoption of these new techniques for power-system protection and control. ■

Power Simulation—continued from page 7

with ohmic losses lumped at each end. The computation and ancillary communication functions are achieved by a special microprocessor chip called a transputer, which attempts to optimize interprocessor communication. The extensibility feature is accomplished by assigning one or more transputers, as required, to each bus of the network being simulated so that the topology of the TNA is identical to that of the network. Ideal transformers in the network are represented by circuit equations for pure inductances that can also be integrated by the trapezoidal rule. Nonlinear transformers require more extensive mathematical techniques involving iterative procedures.

In order to test the completely digital TNA concept and to examine potential limitations on line length, an experimental study was performed on a nine-bus model of the WSCC system using the Inmos T800-20 transputer. The study found that a real-time digital TNA of arbitrary size is feasible, and that the architecture of the transputer is ideally suited to this application.

The T800 transputer, however, is not quite fast enough to be of practical value. The fundamental limitation on a real-time digital TNA is the travel time of the minimum possible line length as determined by the execution time, Δt, of one integration step. The study for the single-phase case resulted in an execution time of 58 μs for one integration step. In the integration process, the data computed in the nth time step is not available for use by other processors in the system until the n+2nd step. The net effect is to make the minimum line length equal to twice the distance calculated for one time step. Thus the line length that corresponds to an electrical travel time of 116 μs (at the speed of light) is 34.8 km (21.6 miles). For the three-phase case, the expected tripling in minimum line length is reduced to 52.9 miles because of further overlapping of communication and computation time. Power-system engineers are likely to find the line lengths of these preliminary studies to be unsatisfactory. Fortunately, new transputer-like processors are becoming available and are prompting further research with results indicating at least a fivefold increase in speed. ■

Faculty—continued from page 13

the first time an all-optical switch based on intracavity-coupled, in-plane, and vertical-cavity surface emitting lasers. Chung has been named a recipient of the 1996 Charles Hard Townes Award by the Optical Society of America for outstanding contributions to quantum electronics.

• Professor **Robert J. Thomas** (control techniques for large-scale networks, analysis of microelectromechanical systems), a member of the Cornell Electric-Power-Systems Group, is the director of the newly established Power Systems Engineering Research Consortium (PSERC). Bob reports that his undergraduate research group on hybrid electric vehicles won second place in the DASH event of the 1995 Clean Air race.

• Professor **James S. Thorp** (estimation and control of discrete linear systems as applied to control of electric-power networks), the director of the School of Electrical Engineering and a member of the Cornell Electric-Power-Systems Group, has continued his investigation of real-time control of the dc transmission lines in the WSCC network through phasor measurements using decision trees. The twenty-one phasor measuring units (PMUs) have been installed and the control algorithms have been tested in simulation on a 4,700-bus model of the WSCC. In addition, new techniques have been developed for simultaneous transmission of chaotic signals through a single channel. In January 1995, Jim was named the most recent Charles N. Mellowes Professor of Engineering.

• Professor **Hwa C. Torng** (computer architecture applied to design of intelligent communications networks) along with Dr. S. Vassilliadis, a senior engineer at the IBM Glendale Laboratory, edited *Instruction-Level Parallel Processor.* The volume was published in January 1995 by IEEE Computer Society Press and is now in its second printing. His new course, EE 546, Architectures of High-Capacity Networks, was taught in the 1995 spring term for the first time. H.C. was a recipient of the **Michael Tien** '72 Award for Excellence in Teaching.

• Professor **George J. Wolga** (quantum and solid-state electronics) has entered phased retirement. He supervised three Master of Engineering (Electrical) students in the development of model experiments for junior-year laboratory courses based on the commercial CD player. ■

PSERC:

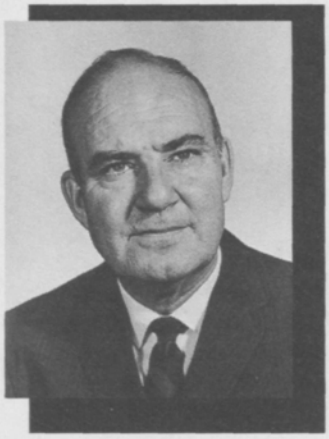
POWER RESEARCH CENTER ESTABLISHED

Two years ago, Cornell University, the University of California at Berkeley, the University of Illinois at Urbana-Champaign, the University of Wisconsin at Madison, Howard University, and Hampton University formed a consortium to establish a Power Systems Engineering Research Center (PSERC). Funding for the center is currently provided by the U.S. Department of Energy, the Empire State Electric Energy Research Corporation, the Electric Power Research Institute, participating institutions, and several electric utility companies. PSERC is currently negotiating with the National Science Foundation to become an NSF-sponsored center.

The purpose of the center is to help the electric-power industry achieve the high-performance capability necessary to meet the challenges created by recent legislation concerned with deregulation of the nation's electric-energy systems. PSERC will seek to advance education and research in the expanding field of electric-power systems, to address issues arising in an increasingly competitive electric-power marketplace, and to facilitate informed discussion of technical problems that stem from policy options affecting industry restructuring. Specific tasks to be addressed by the center include:

- Analysis of new transmission roles such as fast control of power flow
- Development of incentives for efficient expansion
- Evaluation of communication requirements
- Investigation of large-scale generation and delivery-system reliability
- Examination of information requirements
- Exploration of containment of dynamic disruptive system phenomena

Cornell is the lead institution in the center, and Professor **Robert J. Thomas** of the School of Electrical Engineering at Cornell is the director of PSERC. More information is available by visiting the PSERC website at *http://www.pserc.cornell.edu/PSERCServer.*



JOSEPH LINVILLE ROSSON

Professor emeritus **Joseph Linville Rosson** died at age seventy-five on April 1, 1995, in Memphis, Tennessee, after a long illness. Following four years as a cooperative engineering student, and graduation from the University of Tennessee in 1942 with the B.S.E.E. degree, Joe entered the Naval Reserve as an ensign and experienced his first contact with Cornell in the ninety-day naval commissioning program on the campus. After a tour of duty as an engineering officer aboard an LCT (L) 11, he was promoted to lieutenant and placed in command of an LSM (landing ship medium). With service in the Atlantic, Mediterranean, and Pacific theaters, Joe undoubtedly had many interesting adventures, but he seldom spoke of his war days except to say on a couple of occasions, "I ran a tight ship," a statement that boded well for his eventual stewardship of the EE School.

After the war, Joe returned home and became an instructor in mechanical drawing at the University of Tennessee Junior College at Martin, Tennessee, where he honed his considerable (and later well-known) skills as a blackboard artist. When he was an undergraduate at U.T., Joe had been deeply influenced by Professor **J. G. (Jack) Tarboux,** Ph.D. '37, who often spoke of his earlier days as a professor at Cornell. When Joe learned that Tarboux had returned to Cornell, he decided to apply to graduate school there and sought advice from his former professor. Joe's application was successful and in January 1947, he came to the EE School as an instructor and graduate student. He received the M.E.E. degree in June 1951, was appointed an assistant professor in July of that year, became an associate professor in 1957, attained full professorial rank in 1969, and retired as professor emeritus in 1986.

Joe's professional career can best be described as versatile. He was a dedicated teacher, a knowledgeable and conscientious advisor, an innovative researcher, an exceptional administrator and manager, and above all, an excellent engineer. His principal academic contributions to the EE School were in the electric-power field with a major emphasis on ac and dc machinery, and the application of feedback-control principles to machinery. For many years he was in general charge of the junior laboratory courses (the famous "Superlab"), and took direct responsibility for the development of instructional facilities for basic instrumentation and machinery experiments. When he was appointed assistant director of the EE School in 1965, he continued his teaching duties and also assumed responsibility for management of the advising program, typically designating himself as advisor to a substantial number of students. His door was always open and it was rare to find him alone in his office.

In 1957, prior to his assumption of administrative duties, Joe was designated as the university manager of an extra-high-voltage-underground cable testing program sponsored by the Association of Edison Illuminating Companies (See Photo D, page 20). In an outstanding exhibition of his engineering skills, he collaborated with electric utilities and cable manufacturing companies, coordinated the construction and installation of operating facilities and designed all of the test and measurement systems. In addition, he trained more than sixty students to operate the field facilities on twenty-four-hour schedules. When the project was completed in 1964, Joe published a complete report of the work in *IEEE Transactions on Power Apparatus and Systems*. The cable test was considered to be a landmark event and Joe was the recipient of many compliments and commendations from both utility and cable-industry officials.

Joe was appointed associate director of the EE School in 1975. In addition to his teaching and advising duties he was responsible for course and staff scheduling, the budget, nonacademic staff, student-faculty and EE-alumni relationships. He had an extraordinary talent for obtaining the willing cooperation of individuals who were essential for a specific task. Joe would look intently at his intended participant and say, "I need a ramrod." He always got the desired collaboration. Just as in the Navy, he ran a tight ship and served as an invaluable right-hand-man for the several

Cornell president Frank H. T. Rhodes is at the wheel of the Alfa Romeo. Joe Rosson is second from the right.

directors of the school who held office during Joe's twenty-one-year administrative tenure.

In 1968, Joe became the advisor of a long-term Master of Electrical Engineering project for the design of an electric vehicle for urban and suburban transportation. Over the years, more than seventy students participated in all aspects of development and manufacture of five prototype electric vehicles, three of which were licensed for continuing study and evaluation. In 1970, a Cornell team won first place in the National Clean Air Race, and in 1977, another Cornell team won the Emission Award in the Urban Vehicle Design competition. The famous 1975 "fire-engine-red" Alfa Romeo electric replica is shown in the photo.

The welfare of his students was always uppermost in Joe's mind both in and out of the classroom. Stories of his help, encouragement, sound advice, and wise counsel always emerge whenever alumni remember him, both in conversation and in written accounts. For quite some time Joe probably did not know that his students lovingly referred to him as "Papa Joe." His students always expected that he would deal with them in his office with a stern expression which they invariably would not take very seriously. On one occasion, however, an advisee was able to take a candid photo that showed Joe behind his desk, lighted cigarette in hand, with an uncharacteristic smile lighting his face. Sometime later, on his birthday, Joe came to his office, early as usual, and found a copy of the *Cornell Daily Sun* on his desk. After perusing the first page, he opened the paper and was startled to find a full-page image of his smiling face with a huge caption at the top: HAPPY BIRTHDAY PAPA JOE!

Joe had this big resonant voice that he could use very emphatically. Students meeting with him for the first time in his office, or in the lab, were in for a memorable experience. Joe would explain something, and looking at them fiercely, "eye-to-eye" (one of his favorite expressions), he would say, "Are you with me? Are you with me?"—After a meeting or two with this tough customer, the students would realize that they were dealing with a man who had a heart of pure gold. That is why Joe's thousands of students and advisees will always remember him with such deep affection, as will all his friends and colleagues.

WILLIAM F. BROWN

William F. Brown, retired supervisor of technical services in the EE School, died on January 12, 1996, in Ithaca, New York, at the age of seventy-three. He retired in 1987 after forty years of service. During World War II he flew sixteen missions in the "Flying Tigers" 308th Bomb Group of the 14th Air Force, and received six battle stars. Bill will be long remembered by EE faculty members and colleagues for his careful execution of daily tasks and his cheerful good-humored attention to all who came to his shop for assistance.

ERNESTE GOODMAN COTTRELL

Mrs. **Erneste Goodman Cottrell**, wife of the late professor emeritus **Casper L. Cottrell,** died on January 23, 1996, in Ithaca, New York, at the age of ninety-three. A resident of Ithaca for fifty-nine years, Erneste was a graduate of Vassar College in 1923, and did her masters work in physics at Cornell. In early years she participated in the activities of an EE faculty wives group in the School, and later contributed to many other areas of life in Ithaca, including the Salvation Army, the League of Women Voters, the Human Rights Commission, the Meals on Wheels Program, and years of service to the Episcopal Church. Her many friends will long remember her spirited devotion to these essential elements of community obligation.

JANE BLAKESLEE SMITH

Mrs. **Jane Blakeslee Smith,** wife of the late professor emeritus **Howard G. Smith,** died in a tragic automobile accident on April 9, 1995, in Ithaca, New York, at the age of eighty-five. A resident of Ithaca since 1925, Jane graduated from Cornell in 1931 with a Bachelor of Arts degree. She shared in the activities of the EE faculty wives group for many of her early years of association with the EE School, performed a particular service as a volunteer teacher of English to foreign-born wives of graduate students on the campus, and took part in a variety of other Cornell and community-related programs. She will be fondly remembered by her many friends for her interest in bridge clubs, and her willing contributions to many areas of community concern. ■

▼ *Papa Joe Fund*

In the past year since the announcement of Professor **Joe Rosson**'s passing, the many contributions that have been made to the "Papa Joe Fund" reflect the high esteem in which he was held by everyone who knew him. When Joe retired in 1986 as an emeritus professor, the fund was established in Joe's honor in recognition of his dedicated service to the EE School. At the time, Joe requested that the proceeds from the fund be used to support the work-study program for EE undergraduates. The Papa Joe Fund has been incorporated into the **Joseph L. Rosson Memorial Fund,** with the proceeds to continue to be used in accordance with Joe's original wishes. Alumni who would like to contribute to the fund should contact professor **James S. Thorp** in care of the School of Electrical Engineering, Room 224, Phillips Hall.

Power Revisited—continued from page 5

STEECO system (the fictitious Southern Tier Electric Energy Company) that were performed with punched cards and twenty-four-hour turnaround time. Eventually, the punched-card input was replaced by the now-familiar keyboards and monitors, but turnaround was still a problem unless students chose to appear at the Upson Hall terminals in the early-morning hours.

In the early '60s, the traditional machine theory and laboratory courses were removed from the required curriculum and offered as electives by Osborn. Also in this period, the mathematically oriented generalized theory of electrical machines was introduced into the curriculum by **Ravindra N. Sudan** in two elective courses, one on machines in the transient and steady-state, the other on unified theory of electromechanical systems. Sudan had studied electrical machines at the Imperial College, London, and received the Ph.D. degree from the University of London in 1955. After industrial experience in England and India, he came to the EE School as a research associate in 1958 and joined the faculty as an assistant professor in 1959. Following several years of activity with the power group that included research on vacuum circuit breakers and vacuum electrical breakdown physics, Sudan turned his attention to plasma physics and thermonuclear fusion and began his distinguished career in that discipline.

The rebuilt high-voltage-laboratory building on Mitchell Street, now converted into an energy-research laboratory, served in the early '60s as the staging area for a three-year 500 kV underground cable testing and dielectric-research facility erected near the laboratory (Photo D). The project was sponsored by the Edison Electric Institute and conducted by Rosson and Osborn. The study produced information on cable design and dielectric materials that received worldwide attention and commendation by electric utilities and the cable manufacturing industry.

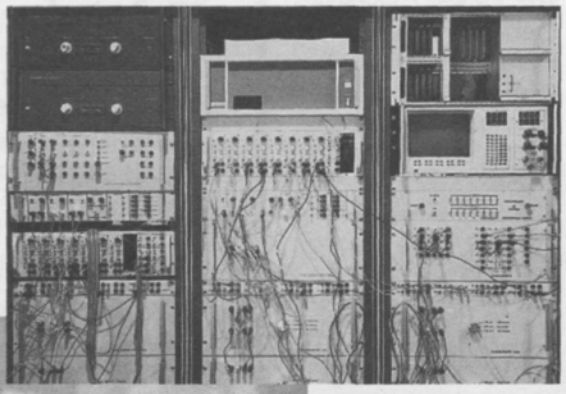
BLACKOUT SPARKS INTEREST

Faculty and student interest in power increased following the historic 1965 Blackout in New York City. Responding to the apparent need for advanced techniques for control and protection of the expanding power-system networks, and to the potential for the application of digital computers to power-system operation and control, professors **James S. Thorp** '58, **Christopher Pottle,** and **Robert J. Thomas** applied their expertise to problems in the power field and encouraged graduate students to undertake thesis research in the discipline. Together with Linke, Rosson, and other members of the EE faculty with related interests, the Cornell Program in Power Systems was formed and research proposals were submitted to suitable energy agencies. The program was enhanced by the receipt of a $250,000 grant from the Kettering Fund for the establishment of a power-system laboratory in Phillips Hall to be known as the Eugene W. Kettering Energy Systems Laboratory (Photo E), in memory of the late **Gene Kettering,** a member of the EE class of 1930. The principal component of the new laboratory was a transient network analyzer (TNA) that was designed by members of the power group and constructed for the most part by **Charles R. Strohman** '77. The TNA was augmented and controlled by a VAX 750 digital computer that could be accessed in the laboratory proper and also by remote terminals in Phillips Hall. This latter feature was of great benefit to the students who were studying the STEECO system, since instant access and instant turnaround removed the tedium and delays associated with the university mainframe computer.

In recent years the TNA has been relocated in Rhodes Hall (the Theory Center building) and the now obsolete VAX 750 has been replaced by several workstations connected to the Phillips Hall computer network. The facility continues to be used by Thorp and his graduate students for testing new protective-relay concepts, and associate professor **Hsiao-Dong Chiang,** who joined the power group in 1987, conducts some of his research in the Kettering Laboratory. In a manner reminiscent of the old power network calculator days, the TNA has also been used occasionally by several commercial companies for special relay studies.

The traditional EE School association with the power field continues, although, in keeping with advanced technical requirements and the current overhaul of the structure of the utility industry, it now takes on different forms. Activities of individual members of the Electric-Power-Systems Research Group are described in articles that appear elsewhere in this newsletter.

—Sam Linke
professor emeritus
electrical engineering



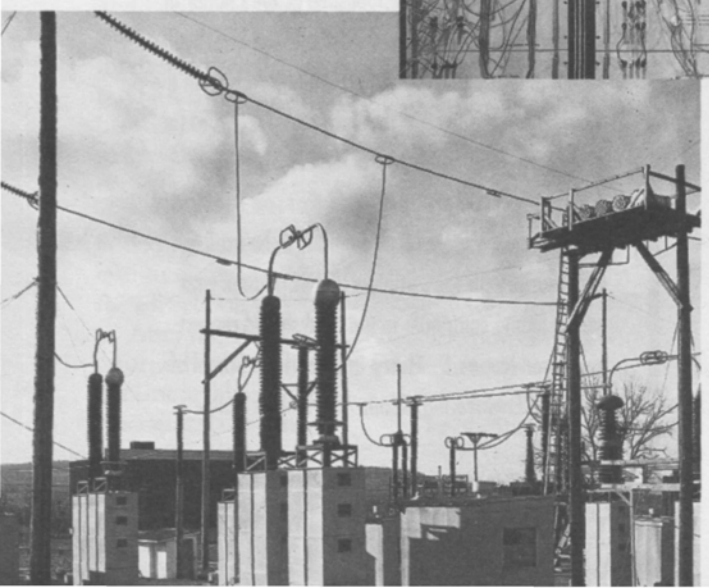


Photo D. (*below*) Extra-High-Voltage-Cable test site.

Photo E. (*right*) View of a portion of the Kettering Power Systems Laboratory TNA. (Photograph by William Mutch.)

Algorithms—continued from page 9

System analysts recognize that adequate dynamic-security assessment for proposed new system configurations will require fast and reliable on-line approaches. Traditional transient-stability studies based on assumptions of many possible fault contingencies generally require many hours of off-line computation and tend to give conservative results. Point-by-point numerical integrations of the non-linear transcendental "swing equation" are performed for each generator in the system. In contrast to this time-domain approach, system stability may be determined by means of "direct" methods that evaluate the physical exchange of accelerating and decelerating energy in the system. These methods determine whether or not the system will remain stable once the fault is cleared by comparing the energy in the system when the fault is cleared to a critical energy value.

Direct methods avoid time-consuming step-by-step solutions, and also provide a quantitative measure of the degree of system stability. This additional information makes direct methods very attractive when the relative stability of different plans must be compared or when stability limits must be calculated quickly.

Direct methods have a long developmental history spanning five decades, but until recently were thought by many to be impractical. Hsiao-Dong has been instrumental in making direct methods practical for large-scale power systems. He is the first system analyst to establish both the theoretical framework and corresponding practical implementation of an energy function for direct methods of stability analysis.

Hsiao-Dong has been studying direct methods for several years and was recently awarded a U.S. patent for a direct procedure that evolves from basic Lyapunov function theory applied, for example, to a simple energy function of a one-machine-infinite-bus power system (see equation on page 9). His method introduces the concept of a controlling unstable equilibrium point (u.e.p.) at the fault location and determines if the fault-on trajectory (tendency toward stability) at clearing time lies within the stability region of a desired stable equilibrium point of its post-fault system. Rather than attempting to estimate the entire stability boundary of the post-fault system, the method focuses on approximating the relevant part of the stability boundary to which the fault-on trajectory is heading. This systematic procedure is called the BCU method for "**boundary** of a stability region based on **controlling** the **unstable** equilibrium point." In the BCU method, energy relations and stability boundaries are expressed mathematically in terms of energy functions.

Hsiao-Dong has since developed a generic BCU method that would be applicable to all existing power-system-stability models. In 1993, under the sponsorship of the Electric Power Research Institute, the BCU method demonstrated its capability for on-line transient-stability assessments using real-time data at two utilities: the Northern States Power Company and Ontario Hydro.

The speed, accuracy, and on-line analytical capability of the BCU method allow system controllers to assess potential disturbances quickly and predetermine the time to take corrective action. Since on-line BCU results are less conservative than those of traditional off-line studies, application of the new procedure will also allow power systems to be operated at higher capacity levels without jeopardizing system safety. ■

Teaching and Research Grants

A generous new grant to the College of Engineering has been made by **David A. Duffield,** B.E.E. '63, M.B.A. '64, president of Peoplesoft, Inc., of Walnut Creek, California. This donation supplements last year's five-year GTE Foundation and three-year AT&T Foundation grants to the college in support of its interdisciplinary efforts in telecommunications and information technology. The grant will fund an electrical engineering/computer science laboratory for these rapidly expanding new areas of study.

In addition, approximately one million dollars has been received by the EE School in the past academic year in support of faculty research and special projects. Major equipment and cash gifts have been received from AT&T, Eastman Kodak, GTE, Hewlett-Packard, Intel, Lockheed, Martin Marietta, Motorola, Raytheon, and Schlumberger. These commendable grants from corporations and foundations, coupled with equally generous gifts from many individuals, aid the recipients in their teaching and research and make it possible for the EE School to maintain a leading edge in the discipline.

A Distinguished Power-Field Alumnus

William J. Balet received the B.E.E. degree from Cornell University in 1959, and was employed as an electrical engineer at Consolidated Edison Company of New York, Inc., for twelve years. In 1965, immediately following the memorable Northeast Power Blackout, he was assigned to the U.S. Federal Power Commission (FPC) to join in an evaluation of that major outage and to assist in the preparation of a landmark report on the event. In 1971, he accepted a position with the FPC, where he served for three years as assistant chief of the Bureau of Power. In 1974, he was appointed planning manager of the New York Power Pool, a post he held until 1979, when he was promoted to his present position of executive director.

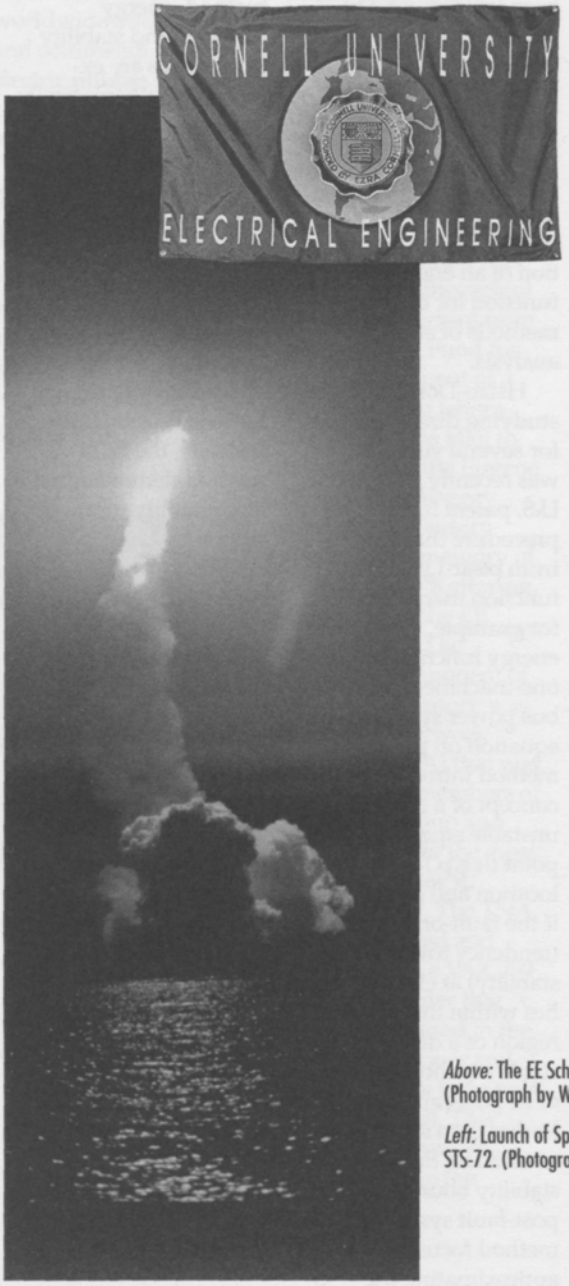
The New York Power Pool is an association of the seven investor-owned utilities and the New York Power Authority in New York State. The pool's function is to coordinate the planning and operation of the bulk-power system of the state. In addition, the pool assists in the coordination of planning and operation of the New York system with the systems in neighboring states in this country and in the provinces of Ontario, Quebec, New Brunswick, and Nova Scotia. As executive director, Bill is responsible for the operation of the Power Pool Control Center in Guilderland, New York, and its 100-member technical support staff. At present, he is deeply involved with the impact on the New York Power Pool of the current restructuring of the utility industry.

During his career, Bill has been largely concerned with the reliability of power supply. He writes us, "My education in electrical engineering has been central to this endeavor. Not only power-system engineering but also computers and communication technologies are necessary to keep the lights on. My Cornell education has been a tremendous asset to me throughout the years."

We congratulate Bill on his distinguished career and wish him continued success in his management of the formidable problems in this vital field.

EE Banner in Space

On January 11, 1996, the Space Shuttle *Endeavour* was launched from Kennedy Space Center in Florida with a five-man crew that included an EE School alumnus, Dr. **Daniel T. Barry,** B.S. '75 (electrical engineering), and a special EE School banner. Dan has a doctorate in electrical engineering/computer science and a doctorate in medicine. He was an assistant professor in the Department of Physical Medicine and Rehabilitation and in the Bioengineering Program at the University of Michigan until 1992, when he joined NASA. The banner, shown here, was designed by **Michael Garon** and **Red Star Cleveland,** the two EE students who tied for first place in the Shuttle Banner Contest that was held in the 1995 fall term. When the shuttle mission was completed, Dan returned the now very special banner to the EE School. **Mary Root,** executive staff assistant to director **Jim Thorp,** and her husband, Kevin, were on a vacation trip in Florida and witnessed the 5:00 a.m. frosty morning launch. The photograph of that exciting event, shown here, was taken by Kevin Root.



Above: The EE School Space Banner. (Photograph by William Mutch.)

Left: Launch of Space Shuttle Mission STS-72. (Photograph by Kevin Root.)

John Crissey, accounts representative for the past six years, has been at Cornell for eight years. He came to the EE School from a prior secretarial position in the College of Veterinary Medicine. In his spare time, John plays guitar, sings, and composes songs in a country band, a pastime he has enjoyed for the past eleven years.

Susan Grover has been an accounts representative for the past eight years. Before coming to the EE School she spent eight years in the accounting office of the University Dining Services. Susan obtained a physical education degree from Ithaca College and studied hotel administration at Tompkins Cortland Community College. She is a snowmobile enthusiast and also enjoys cooking, baking, and cake decorating.

Pauline Helfenstein has been computer-operations supervisor in the EE School since 1993, after serving for a period as head of the computer department in the Gannett Health Center. Pauline has a degree in music from Rhode Island College, taught music in an elementary school in Rhode Island, and still plays the violin. She and her husband raise Weimaraner hunting dogs, enter them in occasional field trials, and when time allows, enjoy renovating their house.

While **Linda Marie Heegard** is on leave of absence, **Catherine Johnson** has been engaged as temporary undergraduate coordinator in the EE School. Catherine graduated from Brigham Young University in Salt Lake City, Utah, in December 1991, with a degree in history.

Tami Lobdell has been an accounts representative in the EE School for eighteen months. Following computer data processing courses at BOCES, she gained a year of experience in the University Controller's office. Tami's three children claim most of her spare time but she manages to go for training as an emergency medical technician at the Etna Fire Department.

William Mutch joined the EE School in November 1995 as an equipment technician. In addition to other skills, Bill is a professional photographer and produced the Kettering Lab and space-banner photographs for this issue.

Linda Struzinsky has returned to full-time duty as administrative aide to **John Belina** in the coordination of the M.Eng.(Elec.) Program.

Mary Weber, financial manager in the EE School for the past six years, has been at Cornell for sixteen years. She came to the EE School from prior positions in commercial marketing and ten years in the University Purchasing office in both state and endowed divisions. Mary enjoys crafts, reading, and jogging but finds most of her free time, together with that of her husband, Paul, is given to caring for their family (two grown, three adopted, and two foster children).

Paul Weber, computer-operations manager, came to the EE School in May 1995 after holding similar positions in the College of Veterinary Medicine and in Mann Library. Paul enjoys hunting and fishing, and agrees with Mary that family matters are their first priority at home.

Shelley Weight, administrative assistant in the EE School, came to Cornell in the fall 1995 term. She graduated from the University of Utah in June 1995 as an English major specializing in eighteenth-century literature. Shelley enjoys reading and also engages in an old-fashioned hobby: patchwork quilting.

▼ *Laboratory Data-Acquisition System*

Francis D. McLeod, Jr., '65 (EE), manager of the undergraduate teaching laboratories, reports the availability of LabVIEW™, a control and data-acquisition system for the teaching labs. This graphical programming package for instrumentation and equipment integration was developed and installed by graduate students **Peter Hartwell** and **Mike Wolfson** under the direction of professors **Peter Krusius** and **Geoffrey Brown.** At each workstation, experimental data are obtained with the aid of oscilloscopes, digital multimeters, and analog instruments. LabVIEW software allows the oscilloscopes and output data to be interconnected with MATLAB™ (a numerical manipulation package), PSPICE™ (a circuit simulation and device-modeling program), a voltage-current curve tracer, and a laser printer. The system provides a set of application programs or "virtual instruments" that are available for many experiments in the teaching labs. Input functions include voltage and current measurements with data-plotting capabilities or transport to MATLAB for analysis, on-line spectral analysis of input, and inputs to a digital oscilloscope. Output functions may be useable as dc or ac sources or arbitrary functions. Laboratory data may be transported to MATLAB and/or the laser printer, and results from PSPICE may be transferred to MATLAB and/or the laser printer.

LabVIEW capabilities are not intended to substitute for active student participation in an experiment, but rather to enhance interest and understanding of the topic by reduction of tedium and expenditure of time required for data logging and curve plotting. Laboratory instruction will continue to mandate *observation* of the phenomena under study, combined with careful identification of measurements and proper choice of scale factors. When such correctly prepared experimental data are introduced into LabVIEW for *simulation* and *analysis,* the results will be consistent with the phenomena observed in the laboratory.

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 else you think made the EE School a special place. We'll print 'em as space allows.

The 1995 *Connections* account of early EE School research in solar astronomy brought forth several nostalgic comments from alumni who recalled the project. A particularly interesting and informative account came from Edward Schiffmacher, M.E.E. '52, who pointed out that no mention was made of a Cornell-related solar astronomy observatory at Sacramento Peak near Alamagordo, New Mexico. *In order to complete the record, Ed writes:*

I read the articles about Radio Astronomy with great interest and then dug out my copies of the reports on ESTABLISHMENT AND INSTRUMENTATION OF A RADIO FREQUENCY SOLAR OBSERVATORY IN THE ALAMAGORDO, NEW MEXICO AREA (September 1948–December 1951). Nostalgia! I'll say! After I received my M.E.E. in 1952 I went to the Sacramento Peak Observatory as a research associate and assistant engineer to Don Olmstead who was engineer-in-charge of the Observatory. I replaced **Bob Cohen** who had returned to the campus. When Don left the project, I became engineer-in-charge until the project ended in the summer of 1955. I returned to Ithaca along with the dismantled gear.

The Sac Peak Project was an Air Force installation with Cornell being responsible for radio observations on 55, 200, and 1420 Mhz. Harvard College Observatory collected optical data. Observations were made daily from sunrise to sunset, and records (on Esterline-Angus strip charts) were sent back to Cornell by mail until August 1954 when the radio link was established and operated for the duration of the project. Daily transmissions of solar activity were made on 16.140 or 6.910 Mhz, depending on propagation conditions. As far as I know, the radio project conducted by **Mike Colbert** at the airport did pretty much the same thing. The project was visited on several occasions by EE School director **Charles Burrows,** and by professor **Bill Gordon.** I drove back to Ithaca about once a year and also went to some Astronomical Society meetings while I was at the Peak. Cornell visiting scientist **Takeo Hatanaka** was at the Observatory for several months. If there was a final report on the project, I didn't have anything to do with writing it. Seems to me that Bill Gordon was the project leader at the time. Hope these comments will help to straighten out the record as reported in *Connections.* [*Ed: Indeed they have and thanks very much for filling in the gaps.—Ed.*]

***Robert Rustay** '50 has memories of Cornell days right after WWII:* I read the spring 1995 issue of *Connections* with great interest. I remember the initial pioneering efforts of director **Charles Burrows** and professor **Henry Booker** in radio astronomy that began and continued while I was an undergraduate in the EE School. Since I was a veteran with three years of service in the USN during WWII, I was a member of the last class that was able to pursue the four-year EE program. You will recall that professor **Stan Zimmerman**'s high-voltage lab was destroyed by fire in 1947. Subsequently, various high-voltage equipment (and other surplus equipment) was stored in a large Quonset hut at the far physical end of the "Vetsburg" housing area (the one near the high-volt lab on Mitchell Street extension). I worked one summer vacation at that building. As a married vet, my wife, son, and I lived almost five years in that Vetsburg. We kept a vegetable garden on the hilltop above Vetsburg. I also remember the long cross-country hike from behind the stadium to the fluid-mechanics building near Beebe Lake, often wading through high drifts of snow to make an eight o'clock class there. I also recall the long hike (sometimes two trips in a single day) from Vetsburg to classes in Franklin Hall. (I did not have an automobile during my student days).

I was a candidate for the M.E.E. degree (under professor **Wilbur Meserve**) when I had my first out-of-class EE assignment. As a graduate assistant at the Graduate School of Aeronautical Engineering, I was given the task of correcting a problem with their new wind-tunnel motor drive. A fairly large synchronous motor, connected to the 4,150 volt distribution mains, drove a dc generator that fed a dc motor mechanically coupled to the wind-tunnel propeller, thereby forming a Ward-Leonard drive for speed control. Soon after I arrived on the scene the installation was completed, but when we attempted to power up the system a runaway-current instability in the generator armature caused the protective circuit breakers to open. My job was to diagnose the problem and seek a cure.

I contacted the manufacturer of the generator and found that the machine had been designed for street-car power with a series armature winding, in addition to the normal shunt winding, to compensate for the line drop in the trolley circuit. They told me that the series winding consisted of one turn for each of the field poles. In order to insert a counter series winding to remove the instability, I ordered a quantity of single conductor wire that was about one-half to three-quarters of an inch in diameter. Armed with a simple compass and a dry cell, I determined the polarity of each pole and then laboriously, with lots of lab manpower, installed the cable in continuous-circuit fashion to neutralize the original series winding MMF. When we fired the system up it worked perfectly. (Of course it was somewhat scary to bring the big synchronous motor up to speed!) [*Bob: you will undoubtedly be interested in the next item.—Ed*]

Sam Linke reporting: Photo A on page 4 reminds me of a host of laboratory hours spent with that panel board and associated machinery after it was moved into Phillips Hall. Many alumni, both from Rand Hall and from Phillips, will recall it as the famous Experiment 17, as well as the unique experience of synchronizing the machines to the main distribution line. (After a group of students had accomplished this feat successfully, professor **Bob Osborn** used to say, "Now you are delivering power to the entire Northeast.") A close examination of Photo A should remind former participants in the experiment that the synchronizing switch should NOT be closed when all of the synchronizing lamps are bright! If such a mistake occurred, a dc circuit breaker would open up with a loud bang and a blue flash of light. It seemed to me that this unnerving experience deserved some kind of recognition, so I devised an appropriate certificate that was awarded at the end of the lab session. Just in case some of you did not receive one, it is reproduced here (perhaps in somewhat more elegant form than the original). Congratulations to all from an old powerman!

—*Sam Linke*

SPASM

Society for the Preservation & Appreciation
of
Synchronous Machines

Know All Ye By These Presents: that

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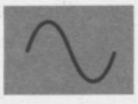
Having Successfully Endured the RIGORS & TREMORS of
SYNCHRONIZING to the LINE
is
Hereby Declared to be a FULL MEMBER of the Society
and
Is entitled to all BENEFITS & AMENITIES,
including the right to display the OFFICIAL EMBLEM:
a PURPLE CYCLE *rampant* on a Field of Green



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Chief Cyclist

ALUMNI BREAKFAST

Mark Saturday, June 8, 1996, on your calendar for the annual EE alumni breakfast. The time is 7:45 to 9:30 a.m., and the place is the Phillips Hall Lounge. We hope you and your spouse will join other alumni and members of the faculty and staff for an event that is always a festive and memorable occasion.

Positive Feedback

The "Positive Feedback" feature of the first four 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 teal dots (•) attached to some of the names in the following listing refer to respondents who are mentioned on page 24.

Notice for Internet surfers: on the World Wide Web, the EE home page may be found on our uniform resource locator (URL), *http://www.ee.cornell.edu*. The College of Engineering URL is *http://www.engr.cornell.edu*. E-mail address for *Connections* is *sl78@cornell.edu*.

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

A. Berry Credle '30, Ph.D. '39, professor of EE from 1941 to 1957, now retired from IBM and living in Chapel Hill, North Carolina, writes that the report on radio astronomy in the 1995 issue of *Connections* brought back memories of the group that worked in the old Franklin Annex. He also recalls the significant contributions to the EE School of the late professors **Nelson Bryant, Joe Rosson,** and **True McLean.**

Thomas J. Higgins '32, professor emeritus of EE at the University of Wisconsin at Madison, retired in 1982 after a distinguished career but continues his writing and editing in the history of electrophysics and electrical engineering. In a letter to *Connections* he remembers professors **Ballard, Burckmyer, Karapetoff, McLean,** and others, and recalls his satisfaction with the high quality of the lecture and laboratory courses of his undergraduate days at Cornell.

Douglas M. Clarkson '50 reports that he is now living in Atlanta, Georgia.

Wilson Greatbatch '50, inventor of the implantable cardiac pacemaker and holder of 140 other patents, was profiled in the March 1995 issue of *IEEE Spectrum*. This interesting article by John A. Adam describes the inventor's distinguished career and includes the following quote of Wilson's personal philosophy: "Don't fear failure, don't crave success. Just immerse yourself in the problem and work hard. The true reward is not in the results but in the doing."

• **Robert C. Rustay** '50, retired and living in Schenectady, New York, well remembers many of his EE professors. As president of Tau Beta Pi he recalls inducting professor **Stan Zimmerman** as an honorary member. He also has special fond memories of **Joe Rosson**: "Just as General Bradley was the soldier's general," he writes, "Joe was the student's instructor/professor."

• **Edward R. Schiffmacher,** M.E.E. '52, retired from the National Geophysical Data Center in Boulder, Colorado, where he was responsible for the network of ionosondes on loan from NOAA to various institutions around the world. His comments on the early solar observatory at Alamagordo, New Mexico, are contained in "More Tales from the Past" on page 24.

Eliot J. McCormack, Jr., B.E.E. '54 (professional engineering consultant), who served as president of the Cornell Society of Engineers from 1969 to 1971, is a member of the Board of Directors of the society for 1996–97.

Raoul E. Drapeau '60, writing from Vienna, Virginia, recalls his experiences with Professor **Burckmyer,** and in particular the professor's admonition not to remove the power from the series-wound rotor, "otherwise we would be picking pieces of metal from the ceiling after the motor self-destructed in runaway." Raoul also reports the sad news of the passing of **George E. Beine** '60.

David P. Snyder, B.E.E. '60 (with Manufacturers Hanover Trust Company in New York City), writes of his sadness at the passing of professor **Nelson Bryant,** and recalls the importance to him as a young student of Nelson's "good humored generosity of time and effort."

Ramachandra G. Ramakumar, Ph.D. '62 (PSO/Albrecht Naeter Professor and Director, Engineering Energy Laboratory at Oklahoma State University, Stillwater, Oklahoma), writes of his sadness at the passing of professor **Nelson Bryant,** "who was one of the best teachers I had the privilege of learning from during my Cornell years."

David A. Duffield, B.E.E. '63 (president of Peoplesoft, Inc., in Walnut Creek, California), was named the 1996 Cornell Entrepreneur of the Year. The award was conferred in April 1996 at the annual Celebration of the Cornell Entrepreneurship and Personal Enterprise Program.

Karl F. Miller, B.E.E. '65 (vice president of finance at Veitsch Radex North America in Pittsburgh, Pennsylvania), is a member of the Board of Directors of the Cornell Society of Engineers for 1995–96.

Stuart J. Sinder, B.E.E. '65 (a partner in the law firm of Kenyon & Kenyon in New York City), is a member of the Board of Directors of the Cornell Society of Engineers for 1995–96.

Jamil Sopher '65 (principal financial analyst, East Asia and Pacific Regions, World Bank, Washington, D.C.) is concerned with financial problems facing the international electric power industry. On June 28, 1995, Jamil addressed the Asia Power 1995 Conference in London on the topic "Improving the Enabling Environment for Independent Power Production Deals."

David B. Rutherford, Jr. '68 (president, Rail Safety Engineering in Rochester, New York), works with fail-safe embedded-processor real-time control systems. He indicates interest in the Engineering College Cooperative Program and in job placement of EE seniors or graduate students.

Donald E. Joslyn '71 (manager, station engineering design with American Electric Power Service Corporation in Cleveland, Ohio) is involved with transmission-station engineering, operation, and maintenance for the AEP system.

• **Daniel T. Barry** '75 (NASA astronaut and mission specialist on the STS-72 orbiter *Endeavour* space-shuttle launch of January 11, 1995) was involved with an EE-related activity on the flight of *Endeavour,* as described on page 22.

Russell W. Elliot '77 (chief engineer and engineering manager, Loral ASIC, Portsmouth, England) directs a multidisciplinary staff of forty engineers on the Royal Navy Merlin Helicopter program. He plans to return to the United States in 1997 after five years in the United Kingdom.

Hiroshi Kondoh, Ph.D. '82 (computer engineer with Hitachi Corporation), reports that he is now working and living in Tokyo, Japan.

Jeffrey A. Metzger '85 (computer engineer with Digital Equipment Corporation) attended the annual EE School Alumni breakfast during his tenth reunion visit to the campus.

Talal G Shamoon '85 (with NEC Research Institute in Princeton, New Jersey) expresses his sadness at the loss of professors **Bryant** and **Rosson,** and writes, "They live on strongly in the memories and through the actions of all of the students whose lives they touched and changed over the course of their long and honorable careers."

Mary Y. Chen, Ph.D. '88 (member of the research staff of Microwave Devices and Circuits Laboratory of the Hughes Research Laboratories), was presented on March 8, 1996, with the Mary Lyon Award by the Mount Holyoke College Alumnae Association.

Denise C. Kresco (Buettgens) '88 (member of technical staff with Hughes Space Company in Los Angeles) is working on commercial antenna design.

Kang Hwa (Ken) Lee '89 (Asia vendor manager with Sun Microsystems, Inc.) manages Solaris localization vendors in Korea, Taiwan, and the People's Republic of China for SunSoft, Inc.

Nicole D. Teitler '93 is a system designer with Motorola Corporation in Austin, Texas.

Alumni: *Please fill out this coupon* ***for the "Positive Feedback" feature and return it to Sam Linke, Cornell University, School of Electrical Engineering, 204 Phillips Hall, Ithaca, NY 14853-5401.***

Name_____

Position title_____

I am employed by_____

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street

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city state zip

My current activities are:

_____

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Optional:

I would like to explore possibilities in the following areas:

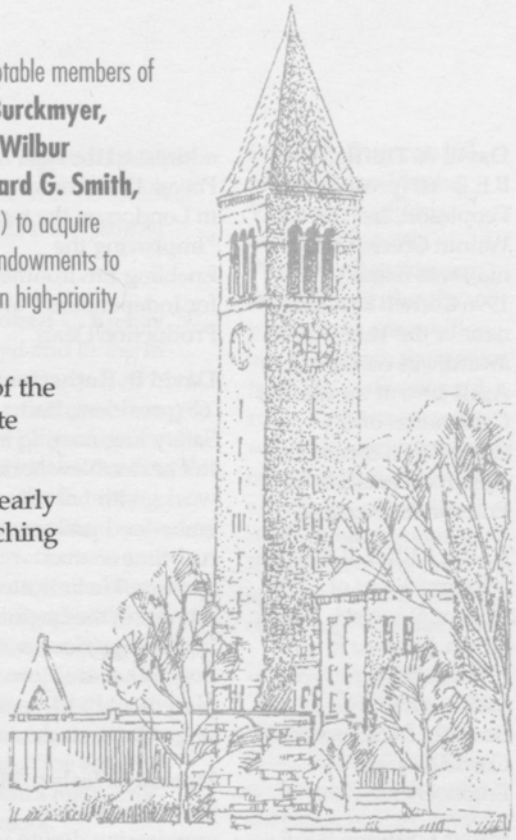
- ❑ Contributions to the Eminent Professors' Fund
- ❑ Contributions to the Joseph L. Rosson (Papa Joe) Memorial Fund
- ❑ Establishment of one-year fellowships for professional masters students
- ❑ Engineering Cooperative Program
- ❑ Job placement of EE School seniors or graduate students
- ❑ Other_____

EMINENT PROFESSORS' FUND

Four years ago the EE School established the Eminent Professors' Fund to honor the memory of notable members of the EE Faculty of recent years such as professors **Henry Booker, Nelson H. Bryant, L. A. Burckmyer, Walter W. Cotner, Casper L. Cottrell, Clyde E. Ingalls, M. Kim, Michel G. Malti, Wilbur Meserve, True McLean, B. K. Northrop, Robert Osborn, Joseph L. Rosson, Howard G. Smith, Everett Strong,** 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 activities:

- Establish an endowment fund to supplement the operating costs of the new undergraduate computing center and the new 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 professional-masters 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.



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