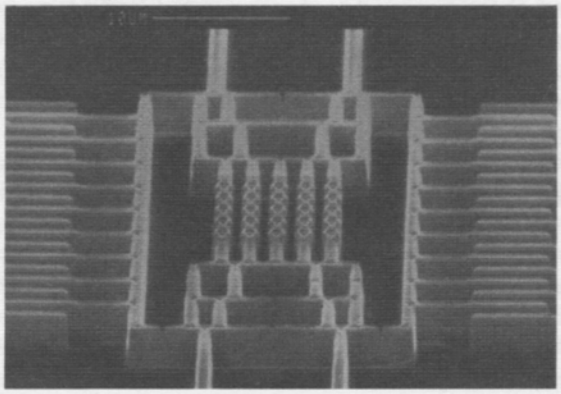
CONNECTIONS

A Report from the SCHOOL OF ELECTRICAL ENGINEERING • Cornell University

MICROELECTROMECHANICAL SYSTEMS,

a new area of research in the School of Electrical Engineering



DIAMETER OF A HUMAN HAIR

This photograph, obtained by a scanning electron microscope (SEM), illustrates microelectromechanical systems (MEMS), a new area of research in the EE School. Movable mechanical devices, smaller than the cross section of a human hair, are fabricated in the Knight Laboratory from single-crystal silicon. In the depicted three-dimensional mechanism, the coupled linear-spring-capacitor-plate structures vibrate at a mechanical-resonant frequency of one megahertz when a high-frequency source is applied. "Tips" with diameters of 10–20 nanometers, attached to a vibrating rack in the center of the structure, are used to move objects of atomic dimensions and to produce electron beams or other scanned-probe systems. This microstructure was fabricated by EE graduate student Lisa Zhang as part of her Ph.D. thesis research. Professor Noel MacDonald, who directs this research in the school, describes his program on page 3.

This third edition of *Connections* features the new undergraduate teaching laboratory facility, describes exciting research in the new field of micro-electromechanics, and reports on the current status of our computer facilities and the Electric-Vehicle Project. The "Positive Feedback" section contains recollections gleaned from participants in the College of Engineering's World War II Reunion on April 22, 1993. Other items of interest to alumni are listed in the table of contents on this cover page. 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.

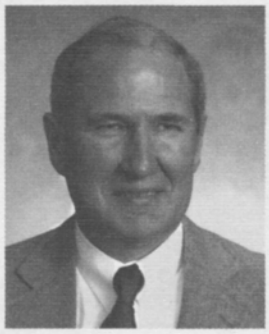
Simpson (Sam) Linke, editor

SPRING 1994

In this Issue

Report from the Director

Noel C. MacDonald



Well, five years have elapsed and I'm ready to begin a one-year sabbatical leave and return to teaching and research! It has been a challenging and rewarding five years. I entered the position of director with three goals: improve our undergraduate laboratory facilities and improve the quality of our space; equalize the teaching and research loading for all EE faculty; and encourage the necessary cultural changes in the school to be able to compete effectively in the twenty-first century.

With the assistance of Dean **Bill Streett,** the EE School's space was expanded to include the third floor of the Engineering and Theory Center building (E&TC): we moved our space plasma group from Upson Hall and the systems and computer engineering group from Phillips Hall into air-conditioned offices and laboratories in the new E&TC, thereby allowing us to reorganize the space in Phillips Hall for undergraduate teaching laboratories and research laboratories. In particular, a new undergraduate computer/workstation laboratory was completed in 1992 using university and school funds, a very large grant of workstations and computers from Hewlett-Packard, and a matching grant of seventeen Macintosh II fx computers from Apple Computers, Inc. The availability of the new undergraduate computer/workstation facility encouraged many faculty members to include computer-related experiments and homework assignments in over twenty-nine undergraduate and first-year graduate courses. The computer laboratory is available for over 100 hours each week with student monitors. For the remaining hours, special-access privileges are available to graduate students, and network access is available to the Hewlett-Packard workstations. This facility continues to be a major resource for the students and faculty of our school.

To improve the quality and access to our undergraduate laboratories, we renovated over 5,000 square feet of the second floor of Phillips Hall. This new undergraduate laboratory has been partially funded by a generous cash grant from Motorola Corporation and the Motorola Foundation, equipment grants from Hewlett-Packard Company, Intel Corporation, Keithley Instruments, Inc., and from school funds generated by our Master of Engineering program. Our undergraduates now have access to state-of-the-art equipment *and* an air-conditioned laboratory environment that can be used for summer and fall sessions.

In addition to major improvements in the undergraduate facilities, we continue to make stop-gap improvements in some of the Phillips Hall research space, such as the newly renovated optical electronics and microwave laboratory. New modern research laboratories are required, however, to meet the needs of our faculty and students in the twenty-first century. Fortunately, Dean **John Hopcroft** realizes the need for such new facilities, and has already begun to plan for these space needs.

This year we started to implement a plan to highlight information systems as a strategic area for teaching and research. The study of information systems, including multimedia, virtual reality, speech and handwriting recognition, portable communication, and the information superhighway is the stuff of the twenty-first century and the stuff of electrical engineering. Our students must have access to modern concepts, theory, and practice for this developing technical area. In spring 1994 we began to fill five open faculty positions in this exciting and commercially important field. We plan to use our graduate teaching and research programs to accelerate the transfer of information-systems concepts to our undergraduate lectures and laboratory courses.

In my five-year term as director, it was only with the assistance of many faculty and staff members that these exciting projects were accomplished. In particular, I would like to thank those individuals who have shared the administrative responsibilities with me: Professors **Rick Johnson** (7/1/88–6/30/91) and **Jim Thorp** (7/1/91–6/30/94) as associate directors; Professors **H.C. Torng** (7/1/89–6/30/92) and **Paul McIsaac** (7/1/92–present) as graduate faculty representatives; Professor **Terry Fine,** as school computer coordinator; and **John Belina,** who coordinates our Master of Engineering Program and advises our undergraduate students. Also, I have been blessed with substantial and critical assistance of emeriti faculty: Professor **Sam Linke,** editor of this newsletter and ABET review coordinator; Professor **Norm Vrana,** computer coordinator; and Professor **Nels Bryant,** who has taught undergraduate courses. These dedicated "retired" faculty continue to serve the school with distinction.

Jean Coonradt, who retired early this year, was the department administrative secretary for me and the past four directors. Jean has been a major contributor to the school's administrative structure and culture. She was a life saver for me! Jean, Phillips Hall misses your presence, your help, and your dedication. Fortunately, Jean has left me with an excellent administrative secretary, **Mary Root,** who has made the transition period seamless. Thank you all for your help!

It is great to exit this position knowing that a first-class administration is to follow. Professor **Jim Thorp** (Cornell B.E.E. '59, M.S. '61, Ph.D. '62), the present associate director of the school, has been selected by the faculty and Dean Hopcroft to be the new director. Professor **Clif Pollock** has accepted the challenging position of associate director. This is a strong team—excellent teachers and administrators. The best to Jim and Clif; they have my full support and admiration.

Generous donations from industry and the many alumni and friends of the school have made it possible to upgrade our undergraduate laboratories to their present world-class status. Thank you for your contributions and continued support.

Now it is time to prepare for my sabbatical. I am looking forward to closer, more frequent interactions with graduate students, industry, and colleagues, and to develop a senior-level course related to my research.

Regards,

Noel C. MacDonald

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ENROLLMENT AND GRADUATION STATISTICS

UNDERGRADUATE PROGRAM

Year	*Juniors*	*Seniors*	*Degrees*
91–92	132	140	142
92–93	114	117	127
93–94	103	111	*

M.ENG.(ELECTRICAL) DEGREES

August	*January*	*May*	*Total*
42	7	67	116
40	5	37	82
32	11	*	*

M.S./PH.D. PROGRAM

Year	*Applicants*	*Admissions*	*Total Enrollment*	*Degrees*
91–92	648	21	148	30 Ph.D.s, 11 M.S.s
92–93	617	10	134	18 Ph.D.s, 10 M.S.s
93–94	508	17	126	18 Ph.D.s, 8 M.S.s

These figures indicate that both undergraduate and graduate programs have been relatively stable over the past three years.

*Not available at press time. The number of degrees to be awarded in 1994 is expected to be somewhat higher than that of the two previous years.

Microelectromechanical Systems

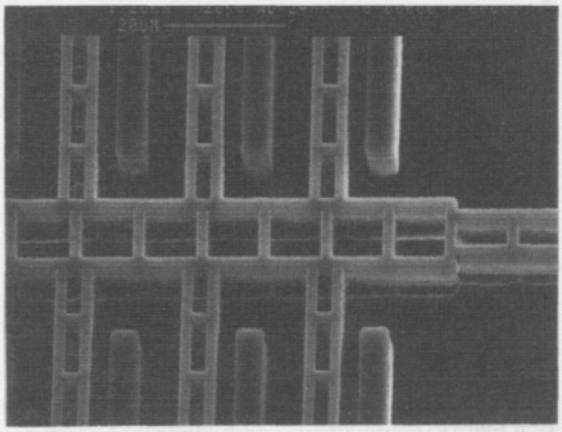
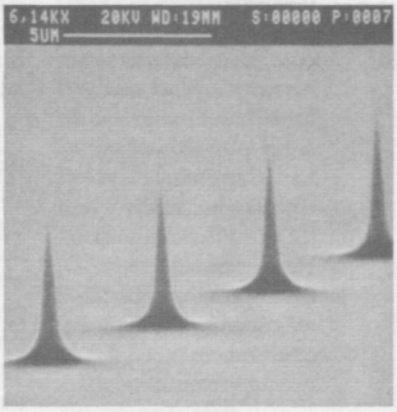


Figure A *(above)*: SEM image of a potential microaccelerator.

Figure B *(below)*: SEM image of microscopic "tips."



The ability to sense our environment is necessary for the maintenance of life. Our brain makes decisions based on input from our bodily sensing systems, and then "actuates" a response, for example, to jump, or touch, or eat. Artificial electronic "brainpower" is now available to us through the science of microelectronics, but electromechanical sensing and actuation systems of comparable small size and at silicon-chip integration levels have been introduced only recently. The generic name for the technology required to make moving electromechanical microstructures is microelectromechanical systems (MEMS). The IEEE publishes a quarterly *Journal of Microelectromechanical Systems*, and the Institute of Physics publishes the *Journal of Micromechanics and Microengineering*.

My research group is developing sensors and electromechanical actuators that can be integrated on a silicon chip with microelectronics. Thus, moving mechanical and optical sensors—for example, micro devices to emulate the eye—can be combined with a microcomputer. These sensors and actuators are now being used to control the deployment of the airbag in your automobile, and in the future, new microsystems will be used to emulate human-like sensors for atomic-level robotics, to explore the veins in your body, and to touch and move atoms and molecules. Our research emphasis is concerned with making atomic manipulators to move atoms and to make microinstruments that emulate their macroscopic cousins that are 1,000 times larger—a grain of rice compared with a computer disk.

Accelerometers are used to measure the rate of change of velocity of moving objects such as an automobile or your body. Newton's Law: force = mass × acceleration is used as the basis of a microelectromechanical accelerometer. The force is related to acceleration of the mass of the microstructure, and this force can be canceled by an electrically generated opposing force applied to the microstructure. Figure A is a scanning electron microscope (SEM) image of an interdigitated microstructure made by two of my graduate students, **Kevin Shaw** and **Scott Adams.** The white fingers (with indentations) are suspended silicon beams, while the solid black silicon fingers are fixed. If such a structure is placed in your moving automobile and you slam on the brakes, your body would move forward and the white fingers would also move forward toward the fixed black fingers. This movement creates an electrical control signal that causes a voltage to be applied to the structure by placement of a positive charge on the black fingers, and a negative charge on the white fingers. The force between the fingers produced by the charges is used to cancel the deceleration force. The amount of charge (voltage) required to cancel the deceleration force is directly related to the deceleration of the automobile. The voltage signal generated by the microaccelerometer is sent to a microprocessor that determines if your airbag should be deployed. Future applications for similar microaccelerometers include anti-skid braking systems and automobile-suspension systems.

Micro instruments to image and move atoms require further scaling of the parts of the microstructures to the nanometer (nm) scale. Hence my research actively uses the Cornell National Nanofabrication Facility (NNF) to make moving nm-scale tips mounted on a silicon micro structure that moves in three dimensions. We move the tips by using electromechanical actuators or motors similar to the actuator used in the microaccelerometer described in the previous paragraph. The picture on the front cover of this newsletter shows a moving mechanical structure with tips that emit electron beams. Such electron beams are used to generate the image on your TV screen and to image microscopic structures in the SEM. This structure on the cover is the heart of a new micro SEM. The tips at the center of the suspended structure move back and forth and up and down when voltages are applied to the appropriate motor, the finger-like structures in the picture. Recently a similar actuator structure has been made and tested by graduate students, **Yang Xu** and **Scott Miller.** The new structure has a tall shaft (0.0002 inches high) with a 20 nm diameter (20 atoms across) tip at the top. The tips are similar to those shown in Figure B. This new micro instrument is a micro scanning tunneling microscope (micro STM), an instrument that can image and move individual atoms. Again our micro STM is more than 1,000 times smaller than the commercial version of the STM, and 50 to 100 of these micro STMs can be placed on a silicon chip the size of nickel. Together with Professor **Yu-Hwa Lo,** we continue an aggressive research program to demonstrate information storage at the nm-scale using micro STM technology and optoelectronics technology for optical readout of the stored information.

Microelectronic systems and microelectromechanical systems are merging; microsensors, microcomputers, and microactuators are now available to build potential integrated microsystems that emulate and mimic biological systems. Future research should bring forth new micro instruments to store information; to guide and switch light for optical communication; to image and move atoms and molecules; to move and position small objects, for example, transport of a blood cell; and to sense our environment and actuate the appropriate response.

—Noel C. MacDonald
professor
electrical engineering

Associate professor **Venkatachalam Anantharam** (information theory) has developed a theory that leads to real-time control algorithms for network layer control of broadband integrated-services digital network/asynchronous-transfer-mode (B-ISDN/ATM) networks. He has found schemes for improving communications in highly noisy environments using timing information.

• 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 invented a new method for making monolithic waveguide diode ring lasers (WDRL) oscillate in a unidirectional traveling-wave mode. Under testing, these WDRLs set a world record for low-threshold currents and spectral purity.

• Professor **Toby Berger** (information theory and communications) has spearheaded the growth of the Digital Signal Compression and Video Encoding Research (DISCOVER) laboratory, a teaching and research facility devoted to the development and implementation of algorithms for low-bit-rate video compression. Five EE undergraduate and a dozen EE Master of Engineering students have participated in design projects that further the goals of this laboratory.

• Assistant professor **Adam W. Bojanczyk** (computer engineering, parallel architecture, and algorithms for signal and image processing) has developed block modification algorithms for the Intel parallel supercomputer IPSC/860.

• **Geoffrey M. Brown** (concurrent systems, communications protocols, and hardware synthesis) was promoted to associate professor on November 1, 1993. During the past year he designed, implemented, and put into use a new hardware laboratory for course EE 230, Introduction to Digital Systems. For the past six to eight years, this course featured a simulation-only laboratory. The new hardware now allows students to build and test the circuits they design.

• Associate professor **Hsiao-Dong Chiang** (analysis and control of nonlinear systems with applications to electric-power networks) developed a computer package, called CPFLOW, to be used in the electric-power industry for the analysis of voltage stability. The package features a practical performance index for the prediction of voltage collapse.

• Assistant professor **Richard C. Compton** (millimeter and microwave integrated circuits) offered a new freshman course in the College of Engineering, ENGR 114, An Introduction to Engineering Design, in spring 1993. His research group developed a new process sequence that allows fabrication of metal-oxide field-effect transistors with 0.25 micron gates on patterned substrates.

• Professor **Harold G. Craighead,** Ph.D. '80 (microprocessing and microfabrication of materials with applications to optoelectronics), director of the National Nanofabrication Facility (NNF) since 1989, was named the first Lester B. Knight Director of the Knight Laboratory at the dedication of the directorship on September 29, 1993. Harold was reappointed as director of NNF for another five-year term on March 8, 1994.

• Professor emeritus **G. Conrad Dalman** (microwave theory and techniques, semiconductor microwave devices) and professor emeritus **Charles A. Lee** (quantum and solid-state electronics, semiconductor physics, solid-state microwave systems) are coauthors of a new textbook, *Microwave Devices, Circuits and Their Interactions*, published in 1994 by John Wiley and Sons, New York, as the latest addition to the Wiley Series in Microwave and Optical Engineering.

• Associate professor **David F. Delchamps** (control and system theory) and his research group are continuing their quest for exact mathematical characterizations of the statistical and spectral properties of quantization error sequences that arise in certain commonly used oversampling analog-to-digital converters, including delta and delta-sigma modulators. David was selected by Merrill Presidential Scholar **Ricardo A. Rivera-Cardona** '93 as the professor who made the most significant contribution to his university education.

• Professor **Lester F. Eastman** (compound semiconductor materials, devices, and circuits), the John LaPorte Given Professor of Engineering, and his group have achieved a substantially improved pseudomorphic quantum-well channel for a modulation-doped field-effect indium-gallium-arsinide transistor. Lester has also initiated research on the use of artificial-diamond heat sinks for semiconductor lasers that are capable of being modulated at very high frequencies (> 30 GHz). Professor Eastman was selected by Merrill Presidential Scholar **Eric Gon-Chee Poon** '93 as the professor who made the most significant contribution to his university education.

• Professor **Donald T. Farley** (radiowave and upper-atmospheric physics) was elected a fellow of the Institute of Electrical and Electronics Engineers (IEEE) "for contributions to ionospheric physics and scatter radar probing of the ionosphere," effective January 1, 1993. Don, together with his former graduate student (now a postdoc) **David Hysell,** have developed and used a highly refined version of radar interferometry at the Jicamarca Radio Observatory in Peru.

• Professor **Terrence L. Fine** (information theory, inference and decision making in the presence of uncertainty) has developed a very promising neural network–based blind equalizer for use in digital communications. Most prior designs were linear systems that could not implement optimal data recovery. During the past year, Terry has continued his duties as computer coordinator for the EE School.

• Associate professor **Chris Heegard** (communication, information, and coding theory) has been elected president of the IEEE Information Theory Society, effective January 1, 1994. In his inaugural letter to the society, Chris reviews the profound impact that information theory-based technology has had on the current digital revolution in a multitude of communications and information applications.

• Professor **C. Richard Johnson, Jr.** (adaptive control and signal processing), has been invited to be the Plenary/Survey speaker at the 10th International Federation for Automatic Control (IFAC) Symposium on Identification and System Parameter Estimation, Copenhagen, Denmark, in July 1994.

• Professor **Michael C. Kelley** (upper-atmospheric and ionospheric physics) received, in 1993, a shared award from the dean "for contributions to improving the teaching of Math 191." In 1994, he received the Dean's Prize for Excellence and Innovation in Teaching. With the help of the EE School and NSF, Mike has been able to re-establish a role for the College of Engineering in the National Astronomy and Ionosphere Center, thereby reversing a nearly twenty-year trend of minimal participation.

• Professor **Paul M. Kintner** (atmospheric plasma physics) was the principal investigator for an experiment involving a plasma-wave instrument carried aboard a recently launched Swedish spacecraft. Preliminary results obtained from the instrument were recognized by European scientists as being "most interesting new data."

• **Ronald R. Kline** (history of technology and electrical engineering) was promoted to associate professor on November 1, 1993. Ron has started a new research project on how scientists and engineers developed the applied-science model of technology, from 1880 to 1945, a model that has been very influential in setting national-science policy in the United States.

• Professor **J. Peter Krusius** (solid-state electronics, semiconductor devices and systems, and electronic packaging), director of the Cornell Joint Services Electronics Program (JSEP), has introduced a new program theme, "Ultra-High-Speed Compound Semiconductor Photonics," for the contract period from May 1, 1993, to April 30, 1996.

• Assistant professor **Soo-Young Lee** (parallel architectures and algorithms) has developed efficient methods to share data among processing elements for large-scale data-parallel algorithms. He has demonstrated that the proximity effect correction scheme (PYRAMID) can handle thick resists using real circuits.

• Assistant professor **Miriam E. Leeser** (VLSI design and computer engineering) and her students have developed a framework for describing the control circuitry for pipelined circuits. This framework handles data-dependent and data-independent control structures for pipelines with out-of-order execution, and supports data-stationary and time-stationary control, as well as a mixture of the two.

• Professor **Richard L. Liboff** (physics of microsemiconductor devices and solid-state plasmas) has derived a new technique for the calculation of the density of states for a disordered one-dimensional array of quantum wells in the weak-coupling limit. A Korean translation of Richard's textbook, *Introductory Quantum Mechanics*, was issued in June, 1993. The book, published by Addison Wesley, is now in the fourth printing of the second edition.

• Assistant professor **Yu-Hwa Lo** (optoelectronic materials and devices, and integrated optoelectronic circuits) has used a new-technology bonding technique, based on atomic rearrangement, to demonstrate the first high-performance quantum-well lasers on a silicon substrate.

• Professor **Noel C. MacDonald** (micro-electromechanical and nanoelectromechanical systems), director of the School of Electrical Engineering, has been named a fellow of the IEEE "for contributions to the development and commercialization of the scanning auger microprobe."

In the past year Noel had three patents issued by the U.S. Patent Office, and was invited to present over ten papers at various conferences, including the 1994 Minerals, Metals, and Materials Symposium, the 1994 Microbeam Analysis Society Conference, and the 1994 High-Throughput Charged-Particle Lithography Workshop and Plenary Session at the Midwest Electrotechnical Conference. In July 1994, he will present a paper at a Gordon Research Conference on Nanotechnology at Wolfboro, New Hampshire. With his graduate student Dr. **Lisa Zhang,** he fabricated a three-dimensional microstructure with integrated field-emission tips. He has received a $1.8 million three-year contract (with assistant professor **Yu-Hwa Lo**) for research on the use of microelectromechanical systems (MEMS) three-dimensional actuators for terabit information storage.

• Professor **Paul R. McIsaac** (microwave theory and techniques), coordinator of graduate studies in the School of Electrical Engineering, extended conventional cavity-mode theory to include cavities containing inhomogeneous media that may be anisotropic. The case of cavities loaded with reciprocal media was completed, while, for the case of cavities loaded with nonreciprocal media, two approaches were suggested and explored.

• Professor **John A. Nation** (electromagnetic fields and waves) successfully developed a technique for the suppression of side-bands in ultra-high-power traveling-wave -tube amplifiers. John has been on sabbatic leave during the 1993–94 academic year with the European Organization for Nuclear Research Laboratory (CERN) in Geneva, Switzerland, where he is working on multiple bunch beam generation at high frequencies. He also plans to visit laboratories in Russia, Germany, California, and Japan where related work is in progress.

• Professor emeritus **Benjamin Nichols** (advancement of engineering education), after two successful terms as mayor of Ithaca, was reelected for a third term in November, 1993.

• Professor **Thomas W. Parks** (signal theory and digital signal processing) received a research grant from the National Science Foundation to develop a new approach to the design of multirate digital filters.

• Associate professor **Alfred Phillips, Jr.** (quantum mechanical devices, optical switches, and process modeling), taught two upperclass courses in silicon-semiconductor and compound-semiconductor electronics. Al presented two papers at off-campus

conferences, and two talks at the EE School colloquium series. He has been active in the support of minority students, conducts weekly tutorials on sophomore physics, and has served as chairman of the Engineering Minority Recruiting search committee.

• **Clifford R. Pollock** (lasers and optoelectronics) was promoted to full professor on November 1, 1993 (see feature article, page 7). He received the 1993 IEEE Student Chapter Award for Excellence in Teaching. He has introduced modern material into course EE 210, Introduction to Electrical Systems, and completed a textbook for course EE 530, Fiber and Integrated Optics.

• Professor **Christopher Pottle** (computer engineering, parallel processors, VLSI technology) has been working with graduate student **Robert C. Durie** on parallel real-time simulation of power systems using transputers (interconnected computer processors). With a donation of equipment from Intel Corporation, Chris has developed stand-alone microcontroller applications for a number of Master of Engineering and senior projects.

• Associate professor **Anthony P. Reeves** (parallel computer systems, computer-vision algorithms) has made significant progress in his research on the mechanisms of biological cell mitosis (nuclear division of cells) by means of a multispectral imaging microscope that produces video images of a living cell.

• **Charles E. Seyler, Jr.** (space-plasma physics, physics of relativistic electron beams), was promoted to full professor on November 1, 1993. In the same year, he received a shared award from the dean "for contributions to improving the teaching of Math 191." Charles is on sabbatic leave for the 1994 spring term with plans to initiate research based upon new developments in the theory of chaotic dynamical systems. He will also collaborate with colleagues at Los Alamos National Laboratory on problems related to controlled fusion.

• Assistant professor **Yosef Y. Schacham** (VLSI technology, nanoelectronics, and process integration) has been doing theoretical modeling of a high-speed quantum-well p-type metal-oxide semiconductor (MOS) transistor that shows the possibility of using Si/SiGe structures for microwave applications. Yosi has also developed an ultra-large-scale process for the fabrication of copper interconnects.

• Associate professor **J. Richard Shealy** (development of compound semiconductors) received the 1992–93 Ruth and Joel Spira Excellence in Teaching Award. Dick is on sabbatic leave for the 1994 spring term. He plans to interact with faculty members of the Optoelectronics Technology Center (OTC) at the University of California at Santa Barbara, and will also spend some time at the Rockwell Science Center in Thousand Oaks, California.

• Assistant professor **Allen O. Steinhardt** (digital signal processing and adaptive protection) introduced a new dynamical systems simulator, SIMULINK, into computing sessions in course EE 528, Multisensor Signal Processing.

• Professor **Ravindra N. Sudan** (plasma physics), the IBM Professor of Engineering, was invited by the 1993 Institute of Plasma and Fusion to be an Annual Institute Lecturer. In the past year, Ravi and his colleagues have developed four new theories in the fields of lasers, plasmas, and inertial confinement fusion, and have filed two inventions in related fields with the U.S. Patent Office.

• Professor **Chung L. Tang** (lasers, optoelectric devices, nonlinear and coherent optical processes), the Spencer T. Olin Professor of Engineering, has made the first successful demonstration of the femtosecond optical parametric oscillator to cover the visible spectrum. Successful transfer of this technology to industry has led to the production of the first commercial broadly tunable parametric oscillator.

• Professor **Robert J. Thomas** (control techniques for large-scale power networks, analysis of microelectro–mechanical systems) has been named a fellow of the IEEE "For leadership in power systems engineering education and research and contributions to the analysis and control of power systems." Bob has cotaught ENGRI 181, Engineering in Context, a new course that uses a multimedia format to teach engineering and arts freshmen about design and engineering as a profession.

• Professor **James S. Thorp** (estimation and control of discrete linear systems as applied to control of electric-power networks) and his students developed a technique for training a decision tree to differentiate between stable or unstable swings of a power system using real-time phasor measurements as inputs. The decision trees are trained on exhaustive sets of simulated events produced by the Cornell National Supercomputer Facility. The actual training is quite fast (faster than training neural nets, for example) and in some cases comes complete with a confidence measure that can be used to make sure that action is taken only when a guaranteed improvement will be made.

• Professor **H.C. Torng** (computer architecture applied to design of intelligent communications networks), in collaboration with associate professor **Geoffrey Brown,** has completely revised EE 230, Introduction to Digital Systems, so that freshmen and sophomores now obtain hands-on experience with "real" chips and a unified presentation on computers and telecommunications. H.C. is on sabattic leave for the 1994 spring term. He is working on a text, *Introduction to Digital Systems,* intended for a course such as our EE 230.

• Professor **George J. Wolga** (quantum and solid-state electronics) and his group have designed and built a novel, computer-controlled, color-center laser to monitor combustion products. This research has been conducted under a five-year grant from the U.S. Army's University Research Initiative (URI).

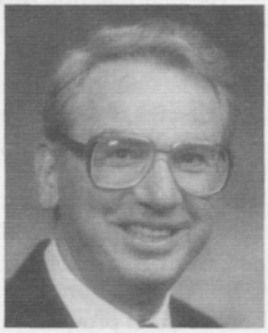
Two Distinguished Alumni

• **David A. Hodges** received the B.E.E. degree from Cornell University in 1960, and the M.S. and Ph.D. degrees from the University of California at Berkeley in 1961 and 1966, respectively. After four years at AT&T Bell Laboratories, he joined the faculty at U.C. Berkeley in 1970, where he is now professor of electrical engineering and computer sciences. Following service as chairman of the EECS department, he was appointed in 1990 to his present position of dean of the College of Engineering.

Since 1984, Dave's research has centered on semiconductor manufacturing. He is co-principal investigator for Berkeley's Competitive Semiconductor Manufacturing Program, and was the founding editor of the IEEE Transactions on Semiconductor Manufacturing. He is a fellow of the IEEE and of the American Association for the Advancement of Science, and a member of the U.S. National Academy of Engineering.

Dave writes us that "Electrical engineering has given me a fascinating career during an era of rapid innovation and growth in electronics and computer technology." On his Cornell days, he comments, "I've always believed that Cornell's five-year B.E.E. curriculum was an outstanding program. I had the opportunity for broad nontechnical studies that have been a great asset to me in personal as well as professional life."

We congratulate Dave on his distinguished career and expect to hear reports of many equally impressive achievements in the future.



• **Irwin Mark Jacobs** received the B.E.E. degree in 1956 from Cornell University and the M.S. and Sc.D degrees in electrical engineering from M.I.T. in 1957 and 1959, respectively.

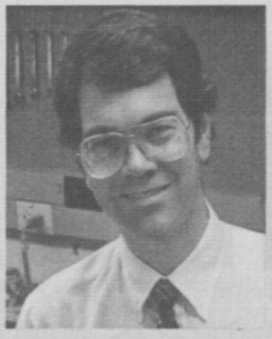
From 1959 to 1966, Irwin was an assistant/associate professor of electrical engineering at M.I.T., and from 1966 to 1972 he was a professor of information and computer science at the University of California, San Diego (USCD). He is coauthor of *Principles of Communication Engineering*, published in 1965 as the first comprehensive textbook on digital communications. In 1968 he cofounded the LINKABIT Corporation, and in 1972 he resigned his professorship in order to devote full time to the business. As president, CEO, and chairman, he guided the growth of LINKABIT from a few part-time employees in 1969 to over 1,400 employees in 1985, located in San Diego, Boston, and Washington, D.C. After the merger of LINKABIT with M/A-COM in 1980, Irwin became a member of the Board of Directors, and in 1983 he assumed the position of executive vice president. On July 1, 1985, Irwin became a founder and the chairman and CEO of QUALCOMM Incorporated. He has led QUALCOMM into international activities in mobile satellite communications and digital wireless telephony. Irwin and QUALCOMM were featured in the Sunday business section of the *New York Times* on August 1, 1993, in an article about maximization of the capacity of cellular communications channels, an important technical concern of his company.

Dr. Jacobs is a member of the National Academy of Engineering and a fellow of the IEEE. In 1980, he was joint recipient, with Dr. Andrew J. Viterbi, of the American Institute of Aeronautics and Astronautics (AIAA) biannual award for "outstanding contributions to aerospace communications." In May 1993, he received the American Electronics Association (AEA) "Inventing America's Future" award for his contributions to the electronics and information technology industry.

Irwin also collects "Entrepreneur of the Year" awards: his first was received in June 1992 for achievement in the University of California at San Diego's high-technology industry category. More recently, in April 1994, he was honored as Entrepreneur of the Year at the annual Celebration of the Cornell Entrepreneurship and Personal Enterprise program.

We congratulate Irwin on his distinguished career and are certain he will continue to make outstanding contributions to communications technology.

Clif Pollock Named Lee Professor



Clifford R. Pollock, B.S. '76, M.S. '79, Ph.D. '81, all in electrical engineering from Rice University, has been named the first holder of the newly endowed Ilda and Charles Lee Professorship of Engineering. The chair was established on November 6, 1993, by Charles R. Lee '61 (Met.E.), chairman and CEO of GTE Corporation, and his wife, Ilda Gerhardt Lee.

After completing his doctorate, Clif received a postdoctoral fellowship from the National Research Council that permitted him to work at the National Bureau of Standards for two years. He joined the faculty of the EE School as an assistant professor in 1983, was promoted to associate professor in 1987, and became a full professor on November 1, 1993. His major research is concerned with tunable solid-state laser development, ultrafast pulse generation using nonlinear effects in optical fibers, and ultrafast measurements of carrier dynamics in semiconductors. He holds five patents in these and related fields. Clif has been active in developing new material for sophomore and junior-level EE courses, and also teaches an advanced course on integrated and fiber optics. Since coming to Cornell, Clif has won five Excellence in Teaching awards as follows:

1988	Cornell Society of Engineers/Tau Beta Pi Award
1988	C. Holmes MacDonald Award
1989	Dean's Prize for Excellence and Innovation in Teaching
1990	Ruth and Joel Spira Award
1993	IEEE Student Chapter Award

In 1984, he was also one of the first recipients of the National Science Foundation's Presidential Young Investigator (PYI) Award in the school. His textbook, *Fundamentals of Optoelectronics*, will be published in October 1994 by Irwin, Inc., in Boston, Massachusetts. He is a member of the Optical Society of America, the Institute of Electrical and Electronics Engineers, the Cornell Materials Science Center, and the Optoelectronics Consortium.

Clif says that people identify him as the fellow who "makes lasers out of table salt," and admits to the truth of the statement. Much of his work is on "color-center" lasers made from alkali-halide crystals such as NaCl and KCl that have defects in their crystalline lattices; the nature of the defect determines the color of the laser. Color-center lasers have proven to be one of the few broadly tunable types that operate with reasonable power in the near-infrared region of the spectrum. They have opened the door to many new laser applications.

Clif lives in Ithaca with his wife and three children in an eighty-year-old house that he and his family are renovating. Woodworking and furniture making are hobbies he enjoys when time allows.

Phillips Hall: The Early Years

Typical electronics laboratory-bench arrangement in Franklin Hall about 1950. Note the "standard" Dumont oscilloscopes.

Housing for electrical engineering at Cornell was a mixed bag from the very beginning of the discipline. When Franklin Hall was opened in 1883, the principal occupant was the Department of Physics. Two years later, electrical engineering was established as a department in the Sibley College of Mechanical Engineering, the first courses in the new program were offered in Franklin Hall, and machinery laboratory instruction was conducted in Sibley Hall. In 1904, physics moved into brand-new Rockefeller Hall, Franklin Hall became the permanent home of electrical engineering, and a new electrical machinery laboratory in Rockefeller was used by both physics and electrical engineering until 1916 when EE opened its own machinery laboratory in the second floor of Rand Hall.

The School of Electrical Engineering became a separate entity in 1921, but the 1916-level classroom and laboratory space remained essentially unchanged until World War II days. At that time an additional machinery laboratory for the Navy V-12 program was installed in the Old Heating Plant, a long barn-like structure located in the area now occupied by Bard Hall. By 1946, when the first wave of veterans came to Cornell under the G.I. Bill, five professors and a dozen graduate instructors had been added to the teaching staff, many of whom were given office space in the old Franklin Annex behind Franklin Hall. The service-courses staff (for non-electrical engineering students) was housed in the Old Armory next to the Old Heating Plant, a high-voltage laboratory was in operation on Mitchell Street Extension, and the EE School machine shop was located in the basement of Morris Hall adjacent to Franklin Hall on the present site of the Johnson Museum.

Dean **S. C. Hollister,** who had been planning the development of a new engineering quadrangle for a number of years, was fully aware of the fragmented state of housing for electrical engineering. When the new EE director, **Charles E. Burrows,** arrived on campus in mid-1945, the dean told him that the EE School had first priority for construction of the next addition to the quad. Dr. Burrows appointed a Building Committee to study projected enrollment and space requirements and to prepare a plan for a new building. On January 10, 1947, the committee, under the chairmanship of professor **L. A. Burckmyer, Jr.,** presented a preliminary report to the EE faculty based on estimated future totals of 400 undergraduates and forty graduate students. The faculty was invited to examine the report and to submit criticisms, suggestions, and recommendations. The faculty's responses were incorporated into the study, and a highly detailed and completely documented final report was submitted on July 8, 1947. The members of Professor Burckmyer's subcommittee were professors **A. Berry Credle** '30, **H. G. Smith** '30, **E. M. Strong,** and **J. G. Tarboux** '23.

While the dean struggled with the problem of finding a donor, Professor Burckmyer and his committee labored for several years on a series of alternate building designs that would meet the criteria set forth in its 1947 Report, fit within the selected site, and satisfy assumed budgetary constraints. After six separate plans had been considered and discarded, a seventh design was finally adopted in early 1952, and the architectural firm of Perkins and Will was commissioned to draw up preliminary designs. In September of that year, the architects sent Dean Hollister a large oil painting of an external view of their projected design for the new building. Shortly thereafter, the dean announced a visit by a potential donor, Mr. Ellis L. Phillips, president of the Phillips Foundation, who wished to speak to members of the EE faculty about their plans for use of a new building. The interviews took place in the dean's office where the painting was prominently displayed on an appropriate easel. In the spring of 1953, Cornell received a grant of one million dollars from the Phillips Foundation for a new electrical engineering building, and an additional grant of $100,000 for furniture and equipment. Construction of Phillips Hall began later that summer.

The new building was to be a modern edifice, complete with state-of-the-art laboratories and facilities, that would offer relief from the existing cramped quarters, encourage pedagogical benefits from the presence of most of the school divisions under one roof, and provide adequate space for future expansion. The design included a number of special features that reflected the educational views and interests of the EE faculty at the time. In addition to the standard power and machinery components of the curriculum, the areas of power-network analysis, servomechanisms and control systems, power electronics, illumination, analog computers, advanced radar and radio communication, audio and acoustic systems, and vacuum-tube electronics were all represented.

Members of the EE faculty worked diligently to prepare for the transfer of the school to the new building. Professor Burckmyer designed a unique and flexible electrical power supply and audio communications system that would allow interconnections between discrete points in the building. It would thus be possible, for example, to have an experiment in progress in a laboratory, and, in a classroom in another part of the building, to receive a description of the activity and measure resulting data. Professor **Sam Linke,** who had joined the Building Committee when Professor Tarboux left Cornell to go to the University of Michigan, and lecturer **Lawrence B. Spencer** '34 planned the installation of a Power Network Calculator for the second-floor south wing. Professors Strong and **C. L. Cottrell** designed a special illumination laboratory for the third-floor north wing. Professors **B. K. Northrop** and **Walter Cotner** prepared for the development of a power-electronics laboratory for the third-floor south wing. Professor **Wilbur E. Meserve** designed a servomechanisms and control-systems laboratory for the third-floor east wing. Professors Credle and **True McLean** planned an extensive radar and radio communications laboratory for the fourth-floor east

wing. The vacuum-tube manufacturing and analysis facility in Franklin Hall was designated for transfer to the fourth-floor north wing of Phillips Hall. A building tower specified by the architects was designed to accommodate a future anechoic chamber for acoustical research.

Occupancy of Phillips Hall occurred between terms (under the old academic calendar) during the first week of February 1955. Professor Credle, assistant director of the EE School, was in charge of the well-planned operation. Previously (during exam week), the large electric machines had been brought into Phillips Hall and permanently wired. Since most of these heavy items could not be accommodated by the building elevator, it was necessary to use cranes to insert them through windows that had been temporarily removed. New office furniture and laboratory benches had been back-ordered and were in place, and the new laboratory power supply was energized and ready for use. By the end of the week the move had been completed. Spring-term classes began in the new building on the following Monday with relatively few problems. The building was formally dedicated on June 11, 1955.

The new building had an instant and positive impact on the EE School. The faculty was pleased with the new classrooms, laboratories, and facilities. The 94,000 square feet of space, identical with the target set by the 1947 Building Committee Study, offered opportunities for development of innovative educational techniques, and encouraged expansion of faculty research activities. These changes could not occur immediately, of course, so for several years members of the Arts and Sciences faculty often gave instruction in mathematics, history, and English literature in some of the classrooms, and, on occasion, other schools in the engineering college would use the Phillips Hall lecture rooms. Eventually the EE School caught up with the building as the curriculum underwent major revisions, and graduate study and faculty research expanded far beyond the original projections of the Building Committee.

During the first two decades of its presence on the engineering quad, there was little physical change in Phillips Hall. Certain laboratory modifications were introduced, however, to match the new content of the EE curriculum. The Power Network Calculator was abandoned in favor of the digital computer, and its former location in the building eventually became a laser and optics laboratory. Power and machinery courses were removed from the required curriculum with a concurrent reduction in the laboratory space allocated for those disciplines. The control-systems laboratory was updated with modern equipment and associated computer facilities. Solid-state electronics completely superseded vacuum-tube laboratory activities. The space allotted to the former illuminations laboratory was assigned to a new research program in bioelectronics conducted by professor **Myunghwan Kim.** The projected anechoic chamber for the tower was never installed, but professor **Clyde Ingalls** conducted acoustic research in the space for a number of years.

Significant changes to the building began in the mid-70s with the advent of the controlled-atmosphere microelectronics laboratory, the so-called "clean rooms" in the fourth-floor north wing, which led to the establishment of the National Research and Resource Facility for Submicron Structures and the construction in 1982–83 of the major addition now known as the Knight Laboratory, the home of the National Nanofabrication Facility. After thirty years, the EE School once again found itself in cramped quarters and discussions of plans for a new building were initiated. Some of the pressure for additional space was relieved by transfer of faculty office space to the Upson Hall extension, and again in 1991 when the third floor of the new Engineering and Theory Center Building was made available to the EE School. The latter move opened up substantial areas in Phillips Hall for the development of the new computer facility, the laser laboratory, the Master of Engineering Program, and the Electric-Vehicle Project that have all been described in previous issues of *Connections*.

When we moved into Phillips Hall back in 1955, many EE faculty members were of the opinion that the building would be obsolete in about thirty years. The structure is approaching its fortieth anniversary and is still going strong. Certain imperfections have been corrected, internal architectural improvements have reduced the former barren institutional appearance, and partial air conditioning has made the building more comfortable. The ongoing modernization and upgrading of the laboratories bodes well for many more years of useful service to the EE School.

—Sam Linke
professor emeritus
electrical engineering

Electric-Vehicle Update

In the past year, significant changes have occurred in the Electric-Vehicle Program at Cornell. The project has been divided into two separate groups in order to improve the efficiency of technological development and practical vehicle design, and to provide enhanced design experience at appropriate levels for both undergraduate and Master of Engineering (Electrical) students.

One of the new groups, the Hybrid-Electric-Vehicle Team, was formed last year in response to a Department of Energy and Ford Motor Company challenge to U.S. and Canadian universities. Under the direction of professor **Robert J. Thomas** of the EE School, and assistant professor **Richard Warkentin** of the School of Mechanical and Aerospace Engineering, the students won the competition by a wide margin over their nearest competitor. The hybrid group is continuing its efforts this year in hopes of winning the competition again in their second attempt.

Innovative use of technology to meet the particular demands of an electric vehicle is a key element in the hybrid-vehicle competition. Our second group, the AC Motor-Vector-Control Team, directed by Bob Thomas and lecturer **John C. Belina,** is addressing these problems by developing a procedure that promises better efficiency and response than control techniques now available as commercial products. Although this control approach is a calculation-intensive effort that requires one microcontroller and several fast digital-signal processors (DSP), a successful solution would aid the hybrid team's future ventures. The research and development undertaken by this group also provides a number of rich design opportunities for students interested in microcontroller design, DSP systems, electronic power switching, and control theory.

The control-team effort is moving ahead quickly even though the students had to learn about motors and power electronics before they could understand the scope and context of their design problems. With these tasks behind us, we intend to test a prototype before the end of summer 1994.

—John C. Belina

New Undergraduate Teaching Laboratory Established

The following introduction to *Laboratory Notes*, published by professor **Vladimir Karapetoff** in 1906, provides a clear picture of Cornell EE laboratory practice of the time:

"In coming to the laboratory, bring with you a slide rule, an inch rule or tape, a speed counter, a screw driver and a pair of plyers [sic]. This will save you time and trouble of looking for them or borrowing them. Do not forget to have a pocket knife for skinning off wire; a bicycle wrench is also sometimes handy to have. Have enough clean paper for your sketches, diagrams, and remarks."

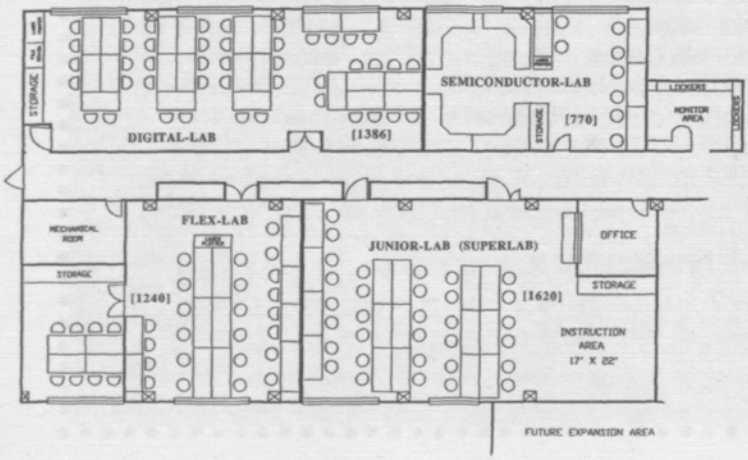
How times have changed!

When the School of Electrical Engineering moved into brand-new Phillips Hall in 1955, the undergraduate laboratory, housed in Rand Hall since 1916, was established in Room 126 of the new building. In the early '70s, one-half of that first-floor east-wing laboratory space was transferred to the Knight Laboratory Submicron Facility. Since then, the remaining portion has been used for undergraduate laboratory instruction, with the furnishings and surroundings essentially unchanged. For example, the old-style Rand Lab–type benches are still to be found at every station in the laboratory. By 1975, most of the machinery and electric-power-related components of the curriculum had been superseded by more up-to-date topics, but the traditionally rigorous performance standards of the EE undergraduate laboratory remained in effect. One student at that time, whether from admiration for the two required junior lab courses or from frustration, dubbed them "Superlab." The name caught on and remains to this day.

As outlined in the spring 1992 issue of *Connections*, Superlab (now the required course EE 315) makes use of leading-edge technology and instrumentation, incorporates state-of-the-art practices found in leading electrical and electronics industries, and provides the necessary background for advanced upperclass studies and possible future research. Superlab stations are also being used for several elective laboratory courses at both junior and senior levels, as well as for a required sophomore course (EE 230, Introduction to Digital Systems) that has a laboratory component to augment computer instruction. These expanded teaching requirements, plus space for Master of Engineering and senior projects, have caused the lab units of Room 126 to be used at their maximum capability. Several laboratory courses are also taught with old-style lab stations under similarly crowded conditions in other rooms in Phillips Hall.

In recent months, primary attention has been given to the planning and development of a spacious and comfortable laboratory, complete with modern accommodations and additional new equipment, that would replace the currently overcrowded workstations. Now we are pleased to report the establishment of a new undergraduate laboratory instruction center that will be completed and in use by the end of the spring 1994 term. In the same manner as in our recently updated and well-received computing center, all of our undergraduate laboratories will be located in one air-conditioned monitor-controlled space.

The entire laboratory has been designed to serve as an effective teaching center with emphasis on encouragement of student-faculty interactions. Since all laboratory instruction will be conducted within the same general area, it will be possible to organize the facility to ensure maximum availability of equipment for all classes, provide efficient scheduling of space, and even allow overlapping use of



Layout of the Undergraduate Laboratory Facility. Numbers in brackets are individual lab areas in square feet.

JUNIOR LABORATORY (SUPERLA

Subject matter: Introduction to electro
Course objectives: To introduce students
Technical content: Study of single-transis systems.
Equipment: 16 workstations with
Course schedule: EE 315 Electrical Labo
EE 316 Electrophysics
EE 318 Electric and El
EE 320 The Audio Eng

DIGITAL-CIRCUITS LABORATORY

Subject matter: Introduction to logic c systems design.
Course objectives: To allow students to c of computer architect
Technical content: Use of large-scale pro of computer circuits in
Equipment: 20 workstations with
Course schedule: EE 230 Introduction t
EE 475 Computer Stru
EE 476 Digital-System
EE 554 Advanced VLS

SOLID-STATE ELECTRONICS LABO

Subject matter: Integrated circuits; VL
Course objectives: Design, analysis, and
Technical content: Use of advanced com the characterization o
Equipment: 4 workstations with H probe stations with H
Course schedule: EE 453 Integrated-Cir
EE 457 Silicon Semico
EE 536 VLSI Technolog
EE 539 VLSI Digital-Sy
EE 554 Advanced VLS
EE 558 Compound Se

FLEXIBLE LABORATORY

Subject matter: Introduction to engine
Course objectives: EE instruction for fresh
Technical content: Familiarization with f
Equipment: 12 Macintosh worksta
Course schedule: ENGRI 114 Introducti
Lab stations to accom

RLAB)

ectronics; audio engineering; project design.
ents to basic electronic circuits and engineering principles.
ansistor amplifiers, operational-amplifier circuits, and simple fiber-optic

vith Hewlett-Packard PCs, digital oscilloscopes, and function generators.
Laboratory (Superlab) [Fall]
ysics and Communications [Spring]
d Electromechanical Circuits and Systems [Spring]
Engineering Laboratory [Spring]

DRY

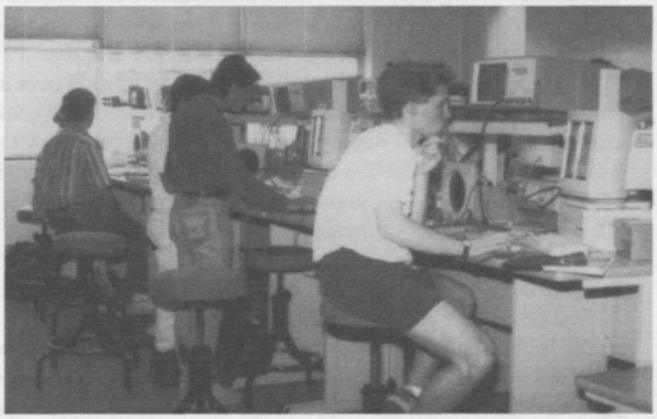
gic circuits; introduction to advanced computer architecture; digital-

to concentrate their attention on design and evaluation of several levels
itecture.
programmable logic arrays and microcontrollers to translate simulation
its into actual physical devices.
vith Intel 486 (66 MHz) PCs and associated Altera software.
on to Digital Systems [Fall & Spring]
Structures [Fall]
stems Design Using Microcontrollers [Fall & Spring]
VLSI Circuit Design [Spring]

ABORATORY

; VLSI technology; compound semiconductors.
and application of semiconductor devices and integrated circuits.
computer-aided-design, processing and instrumentation techniques for
on of integrated-circuit devices.
th Hewlett-Packard simulation and data-logging apparatus, and four
h Hewlett-Packard instruments.
l-Circuit Design [Fall]
niconductor Electronics [Fall]
ology [Spring]
al-System Design [Fall & Spring]
VLSI Circuit Design [Spring]
Semiconductor Electronics [Spring]

gineering design; basic electronic devices and instruments.
freshmen, and overlap with upperclass courses as necessary.
th fundamental electrical engineering principles.
kstations to accommodate a variety of experiments.
uction to Engineering Design [Spring]
commodate overflow from other courses [Fall & Spring]



Before *(top)*: The Audio Engineering Laboratory in progress in the Superlab room in Phillips 126.

After *(bottom)*: The same laboratory conducted in the new undergraduate laboratory facility.

instruments between separate experiments, as needed. The proximity of laboratories at different levels of instruction will offer students the opportunity to observe activities in other courses. As in the past, students will be expected to make maximum use of regularly scheduled laboratory periods, but individuals will have opportunities to arrange for appropriate after-hours use upon consultation with an instructor.

The new laboratory is housed in the completely renovated second-floor south wing of Phillips Hall, the former location of the laser and optoelectronics laboratories that were moved to the third-floor south wing last year. Originally this wing contained the first high-speed digital computer on campus (the IBM-650 machine with magnetic-drum memory), the AC Power Network Calculator, and associated research areas. Lecturer **Francis D. McLeod, Jr.** '63, assisted in the design and planning of the new center and coordinated all of the faculty input to the project. He will be responsible for the management of the laboratory.

Complete renovation of the space, including acquisition of new laboratory benches and desks of efficient design, was funded by generous grants from the Motorola Corporation and the Motorola Foundation, with matching funds from the university. The state-of-the-art equipment that the school has acquired in recent years through the generosity of Hewlett-Packard, Intel, Apple, Altera, and Mentor Graphics corporations, and Keithley Instruments, Inc., is being used extensively in our current laboratory locations. When the move to the new center is completed in spring 1994, these resources will be combined to form an undergraduate laboratory teaching facility that will be unsurpassed in the nation.

The 5,000 square feet of available space for the undergraduate teaching laboratory has been divided into four major areas of instruction, listed at left with courses and major equipment components contained in each area. Each laboratory will have remote access to the computer center through the Phillips Hall network, and will be equipped with a file server and a laser printer. Top-of-the-line Vibraplane air-suspended precision instrumentation has been acquired by the EE School for the "prober" area in the Solid-State Electronics Laboratory. Other special features include an instructional area for the Junior Laboratory, a conference room for the Flexible Lab, long-needed storage lockers for students' belongings, and a monitor area that includes magnetic-card log-in and screening facilities. The entire facility is designed to accommodate up to 600 students per week.

EE Computer Status Reviewed

In the past decade, the acquisition of high-quality computer facilities has created major changes in electrical engineering education in the EE School. Faculty members, graduate students, and undergraduates benefit from the availability of these powerful tools and creative techniques that now facilitate the study of engineering principles, and the students gain exposure to state-of-the-art hardware, software, and workstations used in industry.

Our present computer status gradually developed over a thirty-year period. In the early days of Phillips Hall, the first high-speed digital computer on campus (the IBM 650) was operating in the building. As a series of mainframe machines were installed in the University Computing Center, only to become obsolete almost as soon as they came on-line, computer-oriented members of the EE faculty used the mainframe in their teaching and research while they awaited the day when an individual computer for exclusive use in the school would become available. In 1973, we obtained a Digital Equipment Corporation PDP11/40 minicomputer, an event that marked the beginning of the computer revolution in the school. In the next ten years, a succession of ever more powerful and versatile machines were installed in Phillips Hall, with access available through remote "dumb terminals." Use of the few so-called "smart terminals," the personal computers (PCs) in the school, was limited to ongoing research programs, with little or no access by undergraduate students. The full-time staff member, who was engaged at that time to maintain the equipment and to provide necessary assistance in its use, was under considerable pressure to meet the heavy demands on his time. Consequently, it was necessary for faculty members to "find their own way."

It seems commonplace nowadays for computer-system staffs everywhere to find there are times when changing demands and new versions of software and hardware arrive too rapidly for immediate installation.

A significant increase in computer activity at the undergraduate level occurred in 1984 when twelve Macintosh PCs were acquired for course EE 230, Introduction to Digital Systems. Since that time, computer growth in the school has been remarkable. The generous grants of hardware from Hewlett-Packard, Intel, Apple, and Altera Corporations, and software from Mentor Graphics, as arranged by professor emeritus **Norman Vrana** and associate professor **Geoffrey Brown,** have brought state-of-the-art technology to our computing center (described in the 1992 issue of *Connections*) and the new undergraduate teaching laboratory (described in the centerfold of this newsletter). When equipment from Digital Equipment Corporation and Sun Corporation is included, we now have about 100 workstations available for undergraduate and graduate student use. Geoffrey has recently received six new 486 processor-based PCs from Intel, plus components that allowed fifteen PCs previously donated by Intel to be upgraded from the 386-based processor to the 486 chip. Altera Corporation has supplied Geoffrey with twenty copies of their new software for use with these new Intel machines. Professor **H.C. Torng** has also received four new 486 PCs from Intel. A recent proposal to Intel by Norman and Geoffrey has resulted in a donation of twenty-seven additional 486-based PCs for the Phillips Hall computing center.

Schools of electrical engineering have always benefited from industrial gifts of equipment for their laboratories. In earlier years, these grants were in the form of electric machinery or electronic components that could be wired in with relative ease, be ready for immediate use, and would need only routine maintenance. On the other hand, today's computing machines with their networked environments require constant system surveillance by experienced and specialized staff personnel. Computers and an associated network can provide e-mail and file-transfer communication, database access throughout the world, and software tools for teaching and research. In the past few years, the EE School networked computer system has grown from an important resource to an essential ingredient in the fabric of our teaching, research, and communication activities.

In terms of service to teaching, research innovation, and creativity, the overall productivity of the Phillips Hall computer system depends on how well the installed operating system and user software is kept up-to-date with the latest versions released by the computer industry. In addition, the system must be completely debugged, always operational, and constantly in tune with the changing demands placed on it. Our capable computer staff consists of **Robert G. Byrnes** '92, **Ruth S. Lord,** and **Alison Schary.** They are fully engaged with these details of the management of the Phillips Hall network, all related computer facilities in the school, and the file servers and network interconnections with the Engineering and Theory Center computers. The staff also establishes priorities to take care of the many projects needed to sustain the system, monitors system security, and writes the procedures needed for various accounting objectives.

It seems commonplace nowadays for computer-system staffs everywhere to find there are times when changing demands and new versions of software and hardware arrive too rapidly for immediate installation. In the EE School it is not unusual for some faculty members to find it necessary to personally install the functions needed to meet their teaching and research demands. For example, associate professor **Geoffrey Brown** has designed and implemented the computer-aided-design tools for the new hardware laboratory component of course EE 230, Introduction to Digital Systems, and assistant professor **Miriam E. Leeser** '80 has been installing appropriate software on the HP700 machines in the central computer facility for use in her course EE 596, Design Tools for VLSI. In order to provide the faculty with adequate staff support and to ensure that future hardware and software acquisitions will receive the necessary proper attention, the EE School will continue to monitor computer facility operating expenditures and the workload of the computer staff.

The clearly demonstrated serious use of our advanced hardware and software in the EE School, by student and faculty alike, has been the key to the successful establishment of our computing center and the new undergraduate teaching laboratory. These two instructional units were created to bring our PCs and workstations into organized central locations in order to maximize their use and allow them to be available to students during off hours. The presence of these two world-class facilities bodes well for our ability to keep abreast of new developments in the computer field.

—Norman Vrana
professor emeritus
electrical engineering

Power-System Instruction Updated

Many alumni will recall that electric-power circuits and electric machinery constituted a major portion of the early required curriculum in the EE School. In keeping with trends in electrical engineering education in this country and abroad, these topics have not been taught at Cornell in their original form for at least twenty years, and for the past decade they have only been offered occasionally in modified form. It would not be correct to say, however, that power has disappeared from the curriculum; it is only that the nature and emphasis of the field has changed.

Present-day utility systems have become very complex indeed, from both technical and economic standpoints. Modern control methods coupled with advanced computer techniques are being applied to the generation, transmission, and distribution of electric power in ways that were "such stuff as dreams are made on" to old-line power engineers.

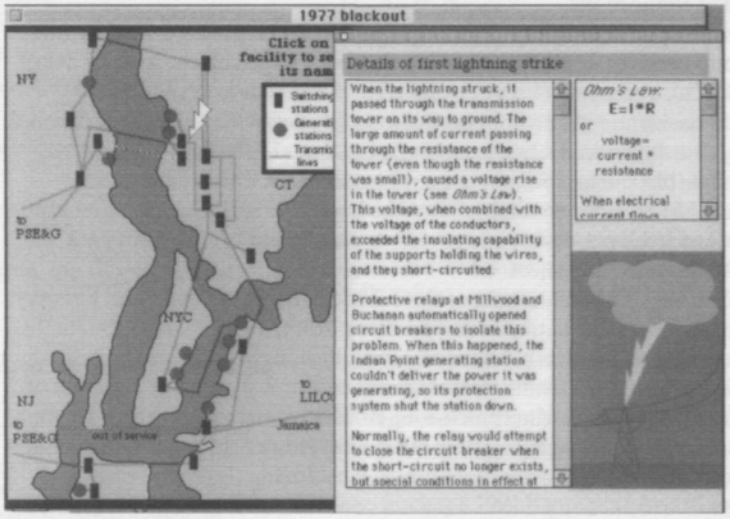
One example is the emergence of the Flexible AC Transmission Systems (FACTS) concept, in which high-speed communication channels and computer-processing techniques are used to control high-powered solid-state switches in the power-system network. It thereby becomes possible to have instant response to emergency conditions or rapid changes in demand through real-time monitoring and management of power flow on specific lines. In advanced courses and research conducted by professors **James S. Thorp** '50, **Robert J. Thomas,** and associate professor **H. D. Chiang,** Cornell EE seniors and graduate students are being introduced to the challenging problems posed by these new systems.

In other engineering disciplines, as in the power field in electrical engineering, many traditional courses are no longer offered in standard undergraduate curricula. Consequently, the College of Engineering has in recent years established "introductory" and "common" courses at the freshman and sophomore levels to help students choose their areas of specialization. An elective distribution course, ENGRI 114, An Introduction to Engineering Design, for students who may wish to major in electrical engineering, is described on page 14 of this newsletter.

Another elective engineering common course, ENGRI 181, Engineering in Context, is designed to introduce students majoring in engineering and other disciplines to the traditions and practices of the engineering profession. This course features a case study of the 1977 Power Blackout in New York City that may interest potential EEs in modern power-system problems. The blackout study is presented by means of a multimedia teaching module that was developed in the School of Electrical Engineering by professor **Robert J. Thomas,** director of the Cornell component of the National Science Foundation (NSF) program called Synthesis: A National Engineering Education Coalition. The module is contained in a computer disk whose contents may be projected on a screen in the classroom as a visual aid to a lecture, or as a demonstration tool in a laboratory, or as an adjunct to a textbook for self-study at home. Text, animation, photographs, graphics, and sound are incorporated in the disk and arranged so that the student can interact with the information as desired. In addition to the New York City blackout study, several power-system multimedia teaching modules have been developed, including a teaching module for a short course in nonlinear dynamics that has been taught at the University of Illinois to personnel of the Union Electric Power Company.

These teaching modules are being created in the Engineering Multimedia Research Laboratory (EMRL), a prototype courseware development studio, directed by Professor Thomas with the able assistance of staff members **Christopher DeBruin** '93, **Scott E. McCormack** '89, and **Michael Tolomeo.** The EMRL mission is to develop multimedia tools and courseware for enhancing engineering education by means of visualization techniques. Although the current effort has been devoted to development of modules that relate to the power field, the technology can be used to convey all manner of complex information in many other fields. Examples of modules that have been constructed for course ENGRI 181 include presentations of novel situations in mechanical engineering and theoretical and applied mechanics, visualization of concepts in electrical engineering topics such as circuit design, applications of Boolean algebra, and use of extracts of documentary films and images of classic experiments to illustrate the history of the development of engineering theories and knowledge. In order to encourage use of this technology, EMRL, under an NSF faculty enhancement grant, will sponsor a course at Cornell this summer on courseware module creation.

EMRL plans to continue development of educational modules that will feature creative approaches to the understanding and design of power systems. The use of virtual-reality tools would be an interesting extension to current techniques for the display of pertinent information in various applications. It may be possible, for example, to create a virtual world wherein the spatial aspects of power-transmission problems can be readily visualized to study phenomena such as the impact of weather fronts on power-system operations. Similarly, power-control-center dispatchers would benefit from the development of a virtual three-dimensional operator's console to replace the standard two-dimensional devices in use today.



Excerpt from the EMRL Blackout Case Study educational module.

Freshmen Challenged by New Design Course

> **Students in these courses become directly involved with real engineering situations in a chosen discipline, and are required to produce a working solution to a given problem.**

Years ago, Cornell engineering freshmen struggled with Elementary Surveying, Foundry (known as "Sand-Pounding 101"), and Machine Shop (called "Tools for Fools"). Those venerable courses may have been relatively unpopular, but they provided some early contact with the technology of the day and helped students to select a major in a particular branch of engineering. When these traditional elements of the curriculum were superseded by increased amounts of mathematics, physics, and engineering science, exposure to engineering practice was generally left for upperclass study. Recent action by the College of Engineering faculty, however, has encouraged the development of freshman distribution courses of an introductory nature.

Students in these courses become directly involved with real engineering situations in a chosen discipline, and are required to produce a working solution to a given problem. One of the courses of interest to potential electrical and mechanical engineering students is ENGRI 114, An Introduction to Engineering Design. The course was developed by assistant professor of electrical engineering **Richard C. Compton** and mechanical engineering graduate student **Raj Sundra.** Additional input was provided by assistant professor **Samuel Landsberger** and visiting assistant professor **Subhas Desa,** both of Mechanical and Aerospace Engineering. Through a series of linked projects, students are introduced to the areas of computer-aided design, electromechanics, multimedia, robotics, electronics, and mechanical design.

The class is formed into groups of three individuals and given a two-phase project concerned with the design and construction of a small electromechanical vehicle that must successfully negotiate a 20-foot-long, 15-inch-wide S-shaped track under the following constraints:

- Operation must be completely autonomous. Human intervention is limited to turning on the vehicle at the starting line and turning it off at the finish line.
- Propulsion and steering are to be accomplished by means of two dc Lego motors (supplied).
- Power is to be obtained from a 6V Yuasa battery (supplied).
- Maximum voltage to each Lego motor is to be 4.5V.
- Vehicle must support the center of mass of the battery at 10 inches above the vehicle's wheel/ground contact plane during the track run.
- Vehicle must be self-contained without remote controls or external connections.
- Materials specifications must be satisfied.

Each group receives a kit of materials including a Lego set (the Erector Set of the '70s and '80s), a compact (4 ampere-hour) rechargeable lead-acid battery (Yuasa, trademark), and electronic components. Students may supply additional materials such as balsa wood, paper, string, glue, metal/plastic hangers, pins, and paper clips, but the total cost must not exceed $6.00. Cardboard and polystyrene foam are not permitted. Since the Lego configurations are already familiar to most students, their use provides a convenient bridge from past experience to the present project.

Phase I consists of initial designs of the vehicle, steering system, and battery-support chassis, assembly of a working prototype that attempts to negotiate the entire track, and introduction of necessary design changes, followed by testing of the modified prototype, evaluation of the second prototype, and insertion of final modifications to ready the vehicle for a final demonstration before an open-house audience. In this first phase, both sides of the entire track have 4-inch-high guide fences that serve to prevent wild excursions during the early test stages and help to keep the vehicle on course. A 4-foot-long ramp is included in the track beyond the finish line to serve as a "bonus" for exceptional vehicle performance. This portion of the course is conducted during the first seven weeks of the term, with two lectures and a laboratory period each week. During Phase I, the technical emphasis is on mechanical engineering concepts of the project. Each student is required to maintain a careful notebook throughout the course and hold frequent consultations with the instructors for inspection of the notes and discussion of trouble points.

In Phase II, electronic circuitry is to be added to the Phase I vehicle so it will be able to detect the presence of a reflecting strip in the center of the pathway and thereby negotiate the track with the guide fences removed. The lecture-laboratory format of Phase I is continued in Phase II except that technical content is related to electrical engineering concepts in order to provide the necessary background for design and construction of the required electronic detection and steering systems. Topics such as basic electronic circuits, infrared detectors, and transient behavior of mechanical and electrical systems are covered in lectures at suitable introductory levels. In both Phase I and Phase II, students are urged to suggest subjects for presentation in these lectures. During an evening session in the last week of the term, each group gives a demonstration of its final version of the vehicle to the entire class. In the final examination, students are allowed to use their notebooks and thus reap a reward for keeping complete and legible notes.

Some forty freshmen took ENGRI 114 when it was offered for the first time in spring 1993, and about 100 students are currently enrolled in the spring 1994 term. Strong interest in the project is evident: it is not unusual to find many class members hard at work in the laboratory during evening hours. Next year's scheduled move to the new undergraduate laboratory instruction center will doubtless enhance the course's popularity and offer a glimpse of advanced EE work in progress in the adjacent laboratories.

The following comment by a freshman who took the course last year is pertinent: "This course gives me the motivation to get through the grind of engineering courses I know I will have to take over the next three years. Before this course, I didn't know if engineering was worth it—or if it was right for me. Now I know that engineering allows the creativity and theoretical application that I have been looking for."

Positive Feedback

In this issue we are continuing the "Positive Feedback" feature of previous years. The first two 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 blue dots (•) attached to some of the names in the following listing refer to respondents who contributed interesting stories that are contained in "More Tales from the Past," page 19.

A special reunion for World War II alumni (1941–1952) was held in the College of Engineering on April 22, 1993. The EE School had an Alumni Breakfast in the Phillips Hall Lounge on that day. There was a good turnout of EE alumni and faculty in spite of a freak snowstorm on the previous evening. The asterisks (*) attached to some of the following names refer to alumni who attended the breakfast.

NOTE: Our alumni file is somewhat incomplete. If you know of fellow 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.

Nelson H. Bryant '39, M.E.E. '49 (professor emeritus, electrical engineering, Cornell) lives in Ithaca, New York.

Solon B. Kemon '43; Ph.D., George Washington University (attorney-at-law with Shlesinger, Arkwright & Garvey) remembers eminent professors **L. A. Burckmyer, W. Meserve, H. G. Smith,** and **Everett Strong.** He lives in Chevy Chase, Maryland.

Douglas B. Whitney '43 (retired from MIT Lincoln Laboratory) also remembers eminent professors **H. G. Smith** and **Everett Strong.** He lives in Lexington, Massachusetts.

Robert H. Garmezy* '44 (retired) lives in Jamestown, New York.

Prentice Cushing, Jr.,* '45 (manager with Heller Corporation in Floral Park, New York) lives in Douglastown, New York.

Joseph N. McDonald* '45 (president, Joseph McDonald Associates, Inc.) lives in Lexington, Massachusetts.

Paul R. McIsaac* '47, M.A./M.S. '49; Ph.D. '54, University of Michigan at Ann Arbor (professor of electrical engineering, Cornell) is serving his fourth term as coordinator of graduate studies in electrical engineering.

• **Kenneth O. Jensen*** '48 (engineer with Sperry Corporation in Great Neck, New York) lives in Hicksville, New York.

• **Robert E. McGayhey** '48 (retired) lives in Poughkeepsie, New York.

• **Robert W. Persons, Jr.,** '48 (consulting forensic engineer with R. W. Persons & Associates, Inc.) lives in Port Washington, New York.

Robert H. Snider* '48 (retired) lives in Fairport, New York.

Robert S. Breitbarth* '49 (retired) lives in Westport, Connecticut.

Simpson (Sam) Linke,* M.E.E. '49 (professor emeritus, electrical engineering, Cornell), lives in Ithaca, New York.

Henry S. McGaughan,* M.E.E. '49 (professor emeritus, electrical engineering, Cornell), lives in Ithaca, New York.

• **Ramon H. Aires** '50 (retired from Datatape, a Kodak Company, in Pasadena, California) lives in Granada Hills, California.

• **Douglas W. Anderson*** '50 (sales department of Carl Citron, Inc., Rochester, New York) lives in Rochester, New York.

William Gombash, Jr.,* '50 lives in Newfield, New York.

• **Richard L. Gordon** '50 (retired from Eaton Corporation in Farmingdale, New York) lives in Huntington, New York.

Norman M. Vrana,* M.E.E. '51 (professor emeritus, electrical engineering, Cornell), lives in Ithaca, New York.

William J. Balet, Jr., '58 (executive director, New York Power Pool in Schenectady, New York) was the speaker at the Cornell Energy Engineering Seminar Series on November 4, 1993, and took a tour of new facilities in Phillips Hall and in the Engineering and Theory Center building.

• **R. Sridhara Rao,** M.E.E. '59 (retired as professor of electrical engineering from Indian Institute of Science, Bangalore, India), is writing a textbook on introductory control system theory.

Raymond E. Siatkowski '64; D.M.D. '71, Harvard; Orthodontics '74, University of Connecticut (assistant professor at Vanderbilt University Medical Center in Nashville, Tennessee), was recently named a peer-review referee for the *American Journal of Orthodontics*.

Kenneth S. Schneider '65, M.E.E. '66, Ph.D. '70 (V.P. sales, Telebyte Technology, Inc., Greenlawn, New York) remembers professor emeritus **Joe Rosson.**

• **William M. Wichman** '60 (senior principal systems engineer with Lockheed Sanders in Nashua, New Hampshire) writes of his continuing enthusiasm for the Engineering Cooperative Program.

• **Michael P. Tien** '72 (chairman of Generation 2000 Ltd. in Hong Kong) has established an endowment fund in the College of Engineering to recognize excellence in undergraduate teaching (see page 16).

Michael G. Spencer '74, M.Eng.(Electrical) '75, Ph.D. '80 (professor of electrical engineering, Howard University, Washington, D.C.) was selected in 1987 as director of the first Minority Research Center of Excellence funded by the National Science Foundation. Michael was the EE Colloquium speaker on September 7, 1993.

Armen D. Meguerditchian '83 (manager/controller, Cameras, Inc., Arlington, Massachusetts) remembers professor emeritus **Joe Rosson.**

Loi D. Nguyen '84, Ph.D. '89 (with Hughes Research Laboratory in Malibu, California) was selected (with three coauthors) for the Electron Devices Society's 1992 Rappaport Award for the best paper in an EDS publication during 1992.

ALUMNI BREAKFAST

Mark Saturday, June 11, 1994, 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.

Teaching and Research Grants

Details of corporate gifts to the EE School for computing facilities and laboratory equipment are described on pages 10, 11, and 12. In addition, approximately $350,000 has been received by the school in the past academic year in support of faculty research and special projects. Major cash gifts have been received from ARINC, Inc., AT&T, Bellcore, Fuji Electric Company, GTE Corporation, Intel Foundation, Kodak Corporation, Lutron Foundation, McDonnell Douglas Corporation, Motorola Foundation, Raytheon Corporation, Rockwell International, Schlumberger, Taiwan Power Company, Welch Allyn Corporation, and Xerox Corporation. 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 establish and maintain a leading edge in the discipline.

Papa Joe Fund

The Papa Joe Fund, established in honor of Professor **Joe Rosson,** continues to grow. Income from this fund is used to support the work-study program for EE undergraduates. Alumni who would like to add to the Papa Joe Fund should contact Professor **Noel MacDonald** in care of the EE School, Room 224 Phillips Hall.

In October 1992, Joe moved to his hometown of Memphis, Tennessee. He is still confined to his home because of his illness. Joe would appreciate receiving occasional cards or letters from his former students and friends. His address is 6539 Knight-Arnold Blvd. # 36, Memphis, TN 38115.

Philip N. Summers '76 Memorial Endowment

For the past twelve years, a unique tutorial program for electrical engineering undergraduates has been administered and conducted by members of Eta Kappa Nu, the electrical engineering honor society. The program is funded by an endowment established in 1981 in memory of Philip N. Summers '76 (EE), by his parents, Willard and Charlotte Summers. Some twelve to fifteen EE courses are now being provided with tutorial services in a dedicated effort that assists hundreds of students each year. The tutoring sessions are held on Sunday afternoons in Phillips Hall. Students are urged to prepare for the sessions beforehand since the tutors are there to answer specific questions rather than to teach or to summarize professors' lectures. In addition to the weekly sessions, Eta Kappa Nu offers individual tutoring by appointment. The endowment, which receives matching funds from IBM, pays the salaries of the tutors and has funded the renovation of an office to provide administrative space and a room for individual sessions.

Philip obtained the B.S. degree in electrical engineering in 1976, and the M.B.A. degree from Boston University in 1978. He died in an automobile accident in November 1979, while traveling to Cornell to attend a Homecoming weekend. During his undergraduate career at Cornell, Philip elected a number of nontechnical courses in communication arts and public policy. In his application to business school he indicated related interests by statements that clearly established his desire to strengthen his already considerable skills in communication. It is altogether fitting that his memorial is identified with an activity that requires personal interactions similar to those in which he had hoped to excel.

Michael Tien '72 Teaching Prize

Michael P. Tien '72 (EE with distinction) has established an endowment fund to encourage improvement of teaching skills in the College of Engineering. The award will be made annually to the engineering faculty member who has achieved excellence in the quality of undergraduate teaching, with special emphasis on demonstrated improvement. The recipient of the $4,000 prize will be chosen through a combination of student evaluations and departmental nominations.

Michael, now a successful businessman in Hong Kong, visited the campus last June, spent some time with several of his professors in the EE School, and expressed his appreciation for the excellent instruction that he had received when he was a student. On the occasion of the announcement of the fund, Michael commented, "I asked that the criteria for awarding the prize emphasize improvement, so that there will be more opportunity for new faculty members to achieve this recognition of their efforts."

The winner of the first Michael Tien '72 Teaching Prize will be announced at the annual awards banquet on April 23, 1994, as part of the Cornell Society of Engineers Engineering Weekend.

We take this opportunity to express our appreciation to Michael for this generous and most thoughtful gift to the College of Engineering.

Retirement announcements this year are somewhat unusual. The three individuals whose careers are reviewed here have all been associated with the EE School in special positions in addition to their regular academic and professional duties. Their biographies follow.

• **Richard E. Blahut,** Courtesy Professor of Electrical Engineering since 1980, has resigned from that position to join the faculty of the Department of Electrical and Computer Engineering at the University of Illinois.

Dick received the B.S. degree in EE from MIT in 1960, the M.S. degree in physics from Stevens Institute of Technology in 1964, and the Ph.D. degree in EE from Cornell in 1972. Starting in 1964, he was with the IBM Federal Systems Division in Owego, New York, where he had general responsibility for the analysis and design of coherent signal-processing, digital-communications, and statistical information-processing systems. In 1990 he became national head of engineering for IBM, his current position until his transfer to the University of Illinois. Dr. Blahut was named a fellow of the IBM Corporation in 1980, and became a fellow of the IEEE in 1981. From 1983 to 1991 he published five textbooks in the fields of information theory, communications theory, and signal processing. He was a member of the IEEE Activities Board of Governors from 1978 to 1984, was the recipient of the IEEE Information Theory Group Outstanding Paper Award in 1974, and later, in 1982, served as president of that group.

As a Courtesy Professor in the EE School, Dick taught advanced courses in his fields of expertise at periodic intervals. On a famous occasion on April 10, 1985, when Dick presented a lecture at the EE Centennial Symposium on Communications in Newton, Massachusetts, he related that someone asked him what a Courtesy Professor does, and his response was: "I teach students to say 'thank you.'" In more serious vein, his latest Cornell course, offered in fall 1993, was EE 669, Theory of Remote Surveillance.

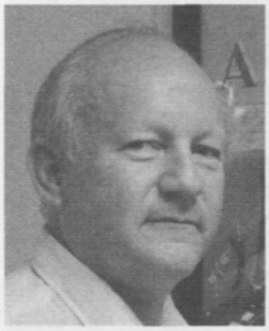
Dick played basketball in high school and college and likes to point out that he still has four years of college eligibility in the NCAA. He and his family (including five grandchildren) enjoy skiing at their ski house in Vermont, and ocean sailing when they visit their beach house on the Atlantic shore.

• **Robert R. Capranica,** a joint member of the EE faculty and of the Neurobiology and Behavior faculty for twenty-three years, became professor emeritus on July 1, 1993.

Bob received the B.S. degree at the University of California at Berkeley in 1958, the M.S. degree at New York University in 1960, and the Sc.D. degree at MIT in 1964, all in electrical engineering. After graduating with highest honors, he joined the technical staff of Bell Laboratories. Following graduate study at NYU he was awarded a Bell Labs Communications Development fellow ship for doctoral studies at MIT. He joined the faculty at Cornell in 1968. Bob's interest in biophysics began during his graduate school years. His doctoral thesis was concerned with a study of sound perception in animals with emphasis on the auditory system of the frog, a subject that engaged his interest throughout his subsequent career.

Dr. Capranica was a NATO senior fellow in science (1976–77), a visiting professor at Bonn University (1976–77), a fellow of the Council for Scientific and Industrial Research (government of South Africa, 1982–83), and a visiting lecturer at the University of the Witwatersrand, in Johannesburg, South Africa. He was editor of the *Journal of Comparative Physiology* from 1971 to 1981, served as a member of the editorial board of several scientific journals, and was president of the International Society of Neuroethology from 1984 to 1985. Bob is a fellow of the Acoustical Society of America, the Explorers Club, and the American Association for the Advancement of Science. From 1977 to 1993 he was the recipient of a prestigious Jacob Javits Congressional NIH Award for studies of information processing in the auditory nervous system.

During the years of his joint tenure in the EE School and the Division of Biological Sciences, Bob taught undergraduate EE courses in bioelectric engineering, directed both graduate and undergraduate students in experimental projects in sensory electrophysiology, and for several years collaborated with members of the EE faculty who were working in related fields. In a retirement letter to **Noel McDonald,** director of the EE School, Bob wrote: "It has been a pleasure to have been associated with the School of Electrical Engineering for the past twenty-three years. I feel very fortunate to have had the opportunity to help bright young graduate students and postdocs cross the barrier between the disparate disciplines of electrical engineering and neurobiology. That has been an exciting challenge that few professors ever get to experience—thank you for having allowed me that opportunity."



• **Tor Hagfors,** a joint member of the faculties of Astronomy and Electrical Engineering for eleven years, became professor emeritus on July 1, 1993.

Tor received the Master of Engineering degree from the University of Trondheim, Norway, in 1955, and the Ph.D. degree from the University of Oslo, Norway, in 1959. From 1955 to 1966, he held research positions at the Norwegian Defense Research Establishment, at Stanford University in California, and at MIT Lincoln Laboratory. He was director of the Jicamarca Observatory in Lima, Peru, from 1966 to 1969, and after another three-year period at Lincoln Laboratory, became director of operations at the Arecibo Observatory in Puerto Rico in 1971. In 1973 he joined the faculty at the University of Trondheim as a professor of electrical engineering, and also served as director of the European Incoherent Scatter Radar Observatory from 1975 until 1982. In 1982 he was appointed director of the National Astronomy and Ionosphere Center (NAIC) and professor of electrical Engineering and astronomy at Cornell University.

Dr. Hagfors is a member of the American Astronomical Union, the American Geophysical Union, and the Institute of Electrical and Electronics Engineers. He is a fellow of the International Union for Radio Science, from which he received the 1987 van der Pol gold medal.

At Cornell, Tor was directly involved in the ionospheric heating program, in planning cometary tail occulation experiments, and in devising new methods for the measurement of scattering from plasma oscillations in the atmosphere. During most of his tenure at NAIC, he directed the planning and execution of a multimillion-dollar upgrade of the Arecibo Observatory. Following his retirement from Cornell, Tor has moved to Lindau-Harz, Germany, where he is a scientific member and member of the colleagues of the Max-Planck Institute for Aeronomy, and director of the institute.

EE SCHOOL RESEARCH FUNDING SUMMARY

Total research funds expended in 1990–91
$12,296,131

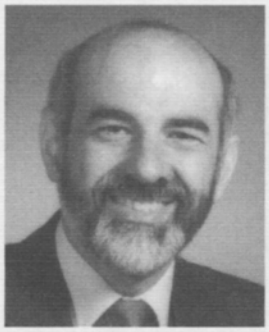
Total research funds expended in 1991–92
$14,087,788

Percent increase
14.57%

Total research funds for 1992–93 (estimated)
$12,000,000

Staff News

Sharon A. Calhoun, administrative aide in the director's office for several years, has transferred to the School of Mechanical and Aerospace Engineering, where she is secretary to the graduate field representative. **Jean Coonradt,** executive staff assistant to the director, retired on January 12, 1994, after twenty-seven years of service in the EE School. She now lives in Sarasota, Florida, with her daughter and grandchildren. We wish her many happy retirement years. **Bruce Fingerhood,** research equipment technician, has used his photographic skills recently to assist in the production of a hologram of the Samuel F. B. Morse original telegraph receiver. Bruce also produced several of the laboratory photographs in this issue of *Connections*. **Raymond C. Ink,** supervisor of technical services, has been responsible for coordination of the installation of services and furniture in the new undergraduate teaching laboratory facility. **Kate McCann,** administrative assistant in the director's office, was formerly with the university facilities construction office. **Francis D. McLeod, Jr.,** '63, B.S. (EE) '65, has been appointed manager of the new undergraduate teaching laboratory facility. **Mary L. Root,** administrate aide in the EE School for the past seven years, has been appointed executive staff assistant to the director. **Paula G. Solat** has been appointed administrative aide to EE faculty members who have offices in the Engineering and Theory Center building. Paula comes to the EE School after fifteen years of service in a similar position with the Department of Agricultural and Biological Engineering. **Linda L. Struzinsky,** administrative aide, retired after twelve years of service in the EE School. She now lives in Memphis, Tennessee. We wish her many happy retirement years. **Deborah A. Vrooman** has been appointed administrative assistant to EE faculty members who have offices in the third and fourth floors of Phillips Hall. Debbie comes to the EE School from the Department of Geological Sciences, where she was administrative assistant to the department chairman.



• **Roger K. Berman** '70 (EE with distinction), M.Eng. (Electrical) '71, died at age 45 on December 2, 1993, in Freehold, New Jersey, after an extended illness. He was a dedicated alumnus of the EE School and of the College of Engineering who gave many years of devoted attention to the activities of the Cornell Society of Engineers (CSE) and the Cornell Alumni Federation Board. Roger was a member of the CSE Board of Directors for fifteen years, served as president of the board in 1989–90, and became a member of the Cornell University Council in 1990. He served as the CSE's member-at-large on the Alumni Federation Board of Directors as head of the Ways and Means Committee, and was elected vice president of the board in 1993. Over the years, he had been active in many related alumni activities in the State of New Jersey. He was a founding member of the advisory council for the College of Engineering Communications Program, which offers instruction in communications skills necessary for success in the business world.

Roger was in the Engineering Cooperative Program with Xerox Corporation in Rochester, New York, in 1968–69. As a candidate for the M.Eng. (Electrical) degree, he was one of the first "One Year on Campus" (OYOC) students in that Bell Laboratories program. He joined the technical staff at Bell Labs in 1971, and returned to the campus often to recruit students for the OYOC program. In 1984 he transferred to Bellcore as a district manager in the technology systems area, and continued his recruiting efforts for that organization.

Roger's extracurricular interests as an undergraduate were concerned with journalism. He was a member of the News Board of the *Cornell Daily Sun* in 1967–68, and managing editor of the *Cornell Engineer* in 1969–70. He was a McMullen Regional Scholar, held a New York State Incentive Scholarship, and made the Dean's List in all four terms of his junior and senior years. He was a member of the honorary societies of Tau Beta Pi, Eta Kappa Nu, and Pi Delta Epsilon (journalism). He performed additional postgraduate study at New York University, where he earned the M.B.A. degree in October 1979.

In a tribute sent to Roger's wife, Alice, dean **Bill Streett** wrote, "Roger was a great friend of Cornell. He knew and kept in touch with many members of the faculty and staff, and he appeared to enjoy most his interactions with students during his visits to Ithaca. He was one of our most generous alumni, whose contributions to the university included not only material gifts, but also intellectual and professional contributions based in part on the education he received here."

A memorial fund has been established to award an annual prize to a student in the Engineering Communications Program. Contributions to the fund should be made payable to Cornell University with a memo that refers to the Roger K. Berman Memorial Fund, and should be sent to Janice Conrad, 248 Carpenter Hall.

• We regret to report the passing of **Joseph Andrew (Andy) Breslin,** a candidate for the M.Eng. (Electrical) degree, on November 25, 1993. Andy, and his friend Paul Thibault, died in an automobile accident on Thanksgiving morning in their home town of Lancaster, Pennsylvania.

Andy, a National Merit Scholar at Lancaster Catholic High School, obtained the B.S.E.E. degree from the University of Pennsylvania in May 1993, and became a candidate for the M.Eng. (Electrical) degree at Cornell in fall 1993. He expressed an early interest in the Cornell Electric-Vehicle Program, and joined the design-project team soon after the beginning of the term.

We express our condolences to Dr. and Mrs. Breslin and their family and friends on their profound loss, and on this tragic ending to the career of a most promising young man.

More Tales from the Past

Several EE alumni who attended the World War II–era engineering reunion and accompanying EE Alumni Breakfast (reviewed in "Positive Feedback" on page 15) waxed nostalgic about the EE Delta Club and wondered if that venerable organization was still active. Current age limitations on "institutionally authorized" consumption of beer have unhappily caused our old-time faculty-student social club to disappear. For several years, in the not-too-distant past, the Phillips Hall Lounge was the site of regular T.G.I.F meetings well-supplied with liquid refreshments unearthed from a secret and guarded storage space, probably in the basement, but those days may be gone forever.

For the benefit of younger alumni who may not have experienced the joys of membership in that august body, a bit of background is in order. Unfortunately, my memories only go back to 1946, when I came to Cornell. Alumni who have earlier recollections are invited to contribute them to this space. The nature of the formal organization, if any, is unknown. Undoubtedly, there was a president, a secretary, and most certainly a treasurer whose principal duty was to manage the funds for the purchase of "refreshments." Initiation to the club and election of new officers appears to have occurred at a banquet in December. The annual picnic took place in May. Each member was the proud owner of a handsome white porcelain beer mug emblazoned with the club's coat of arms, to wit: a large red greek-letter, delta, supporting a white shield divided into two chambers by a diagonal stripe containing three musical quarter notes; the lower chamber displaying a small replica of the mug itself, the upper chamber featuring two hands in a clasp of friendship rampant on a flash of red sparks; the words DELTA CLUB across the top of the shield, and a classically curled ribbon at the base with the Latin motto *pro una causa*. The member's nickname was printed in block capitals on the side opposite the coat of arms, and "Cornell University" appeared overall along the rim of the mug. There is little doubt that the letter, delta, was chosen by the progenitors of the club as a synonym for the letter D, which, of course, signifies the consumption of quantities of "suds."

Harking back to the late '40s, a Saturday-evening Delta Club initiation banquet at the "Old Landmark" on Aurora Street was an occasion that startled many a casual visitor to the main floor of the tavern. From the lower deck, the sound of the combined voices of 120 slightly inebriated EEs belting out some raucous ditty of the day would literally shake the rafters. The substance of one of those evenings is best described by the following verbatim copy of an initiation bid exhibited by **Ken Jensen** '48 during the World War II–era reunion EE Breakfast in June of this year:

> Franklin Hall
> November 21, 1947
>
> _____, Neophyte:
>
> After intensive research and careful survey of the local alcoholic dispensaries, our talent scouts have reported that you fulfill the primary requirement for membership in the Delta Club.
>
> On this basis you have been chosen as a candidate for initiation.
>
> There exist, in addition, certain requirements which must be fulfilled before admission to the organization.
>
> These are:
>
> 1. Chugalug a given amount of beer.
> 2. Be prepared to read a humorous obituary, of your own composition, on one of the faculty members of the Delta Club.
> 3. Initiation fee is $10.00, payable upon admission, or shortly thereafter. (This covers cost of beer mugs, banquet, and parties for the current term.)
>
> Initiates will be at the lower deck of the "Old Landmark" at 2:00 P.M. on Saturday, December 6th, in preparation for a quantitative entrance examination.
>
> Yours in thirst,
>
> Ralph E. Schmidt
> Secretary

Over the years the Delta Club has flourished, only to fade from view and then make a triumphant comeback. Perhaps it will rise again in some new and acceptable form.

• • • •

THE WORLD WAR II–era reunion brought a number of greetings and recollections of "old times" in the EE School. As expected, many of the messages came from alumni who participated in the Navy V-12 program.

Bob McGayhey '48 writes, "After I took an Ag course in the winter of '39–'40, I returned to Cornell in July 1944 as a Navy V-12 student. We were grouped at the railroad station and marched all the way up to the campus. Professor **Grantham**'s physics lectures in Rockefeller Hall were a blast. It was quite a diverse group of students. Some of us were amazed at what we learned, and a few would sleep through it all." Perhaps this comment explains why **Bob Persons** '48 recalls that the V-12 Program was known as "the Battle of Guadalcornell."

(Continued on next page)

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_____

_____
street

_____
city state zip

My current activities are:

_____

_____

Optional:

I would like to explore possibilities in the following areas:

- ❑ Contributions to the Eminent Professors' Fund
- ❑ Contributions to the Papa Joe Fund
- ❑ Establishment of one-year fellowships for professional masters students
- ❑ Engineering Cooperative Program
- ❑ Job placement of EE School seniors or graduate students

And from **Richard Gordon** '50: "My first year at Cornell was when the war ended in the summer of 1945 during the last war-time trimester. During the first term we had participants in military programs such as V-5 and others along with the rest of us. Later, of course, returning veterans flooded in, and brought with them a serious attitude to studies that affected us all—I think for the better." For the same period, **Ray Aires** '50 recalls that he arrived at Cornell in the summer of 1946 on the morning after the temporary dorms burned down. (The university did not open until October 12th of that year.) Ray helped to rebuild WVBR and introduced the first wire recorder for remote broadcasts.

• • • •

Fond recollections of favorite professors are always welcome. **R. Sridhara Rao,** M.E.E. '59, a member of a group of students who came to Cornell from India in 1958, writes that he was impressed by Professor **Malti**'s meticulous way of teaching and his remarkable memory. Sridhara considers professor **Wilbur Meserve** to have been his mentor, particularly in courses in control systems, which were most crucial in his future academic career. He also recalls professors **Ankrum, Erickson,** and **Osborn** as being "strict to the core," and professors **Ingalls** and **McLean** as being "very mellow."

Doug Anderson '50 remembers Dr. **A. Berry Credle** '30 as a "marvelous person and professor whose prelims ranked on a par with the I.R.S. instructions."

Bill Wichman '60 comments on the changes in the EE curriculum since his time on campus: "The curriculum (which, I understand, sustained a thorough scrubbing just after I left) favored the most traditional and entrenched of EE disciplines—at least at the undergraduate level—horsepower, yea; electronics, nay. If it hadn't been for the Co-op Program, I could have graduated with no more concept of practical circuits or of computers than if I had majored in, say, physics. For that reason I've always felt closer to professor **Everett Strong** than to any of the other faculty."

Everett's famous reputation as a punster led **Ken Jensen** '48 to write a recollection for the World War II–era EE alumni reunion: "I, too, remember Professor Strong's sense of humor. On one occasion, he was using the blackboard to answer a student's question when the bell rang to signal the end of the session. He finished his explanation at just that moment, turned to the class and said, 'I hope that rings the bell.' On another occasion I was with a group of students awaiting him in his office when one of us placed an apple on his desk. As he entered the office he saw the apple and said, 'This touches me to the core.'"

Michael Tien '72 visited the school in June, talked with professors **Jim Thorp** and **Sam Linke,** and was disappointed that professor **Joe Rosson** was no longer in Ithaca. He remembers Joe with great affection and said that Joe had more influence on him than any other professor at Cornell. Michael says he often hears Joe's distinctive voice pronouncing "resisTOR" and "inducTOR."

—*Sam Linke*

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.

EMINENT PROFESSORS' FUND

Two 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, L. A. Burckmyer, Clyde E. Ingalls, M. Kim, Wilbur Meserve, Robert Osborn, 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.

Alumni who would like to contribute to the Eminent Professors' Fund should contact professor Noel MacDonald in care of the School of Electrical Engineering, Room 224, Phillips Hall.

CORNELL UNIVERSITY

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