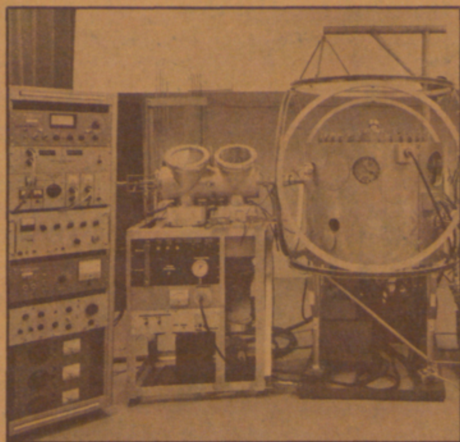
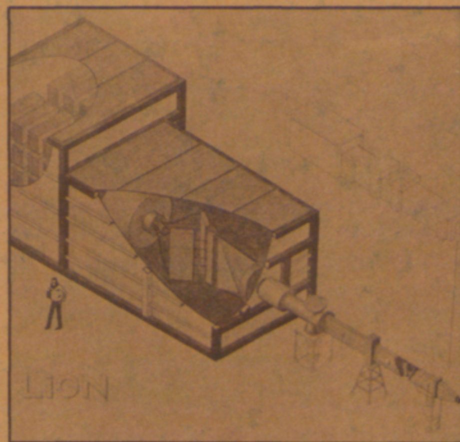
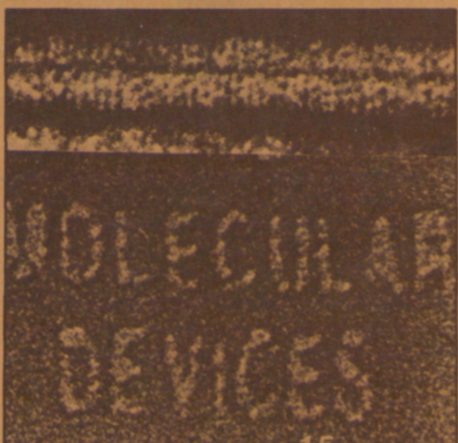
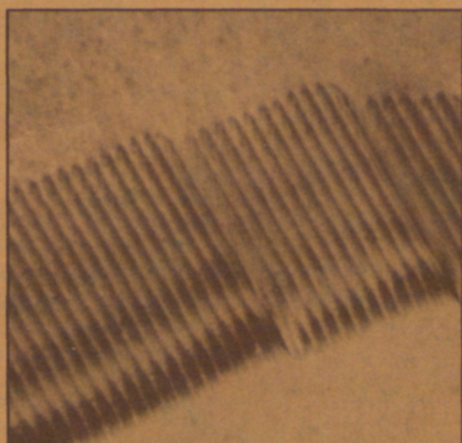
ENGINEERING

CORNELL QUARTERLY









VOLUME 16
NUMBER 2
AUTUMN 1981

MACRO PICTURES
WITH
MICRO DETAIL

IN THIS ISSUE

Outside cover illustrations (clockwise from noon): Equipment for research in the School of Chemical Engineering at Cornell; a newly installed machine for research in controlled nuclear fusion; a micrograph, magnified 120,000 times, of a grain boundary in Al_2O_3, viewed in a transmission electron microscope at the Materials Science Center; a pattern etched by an electron beam in Cornell's submicron facility and magnified more than a half-million times.

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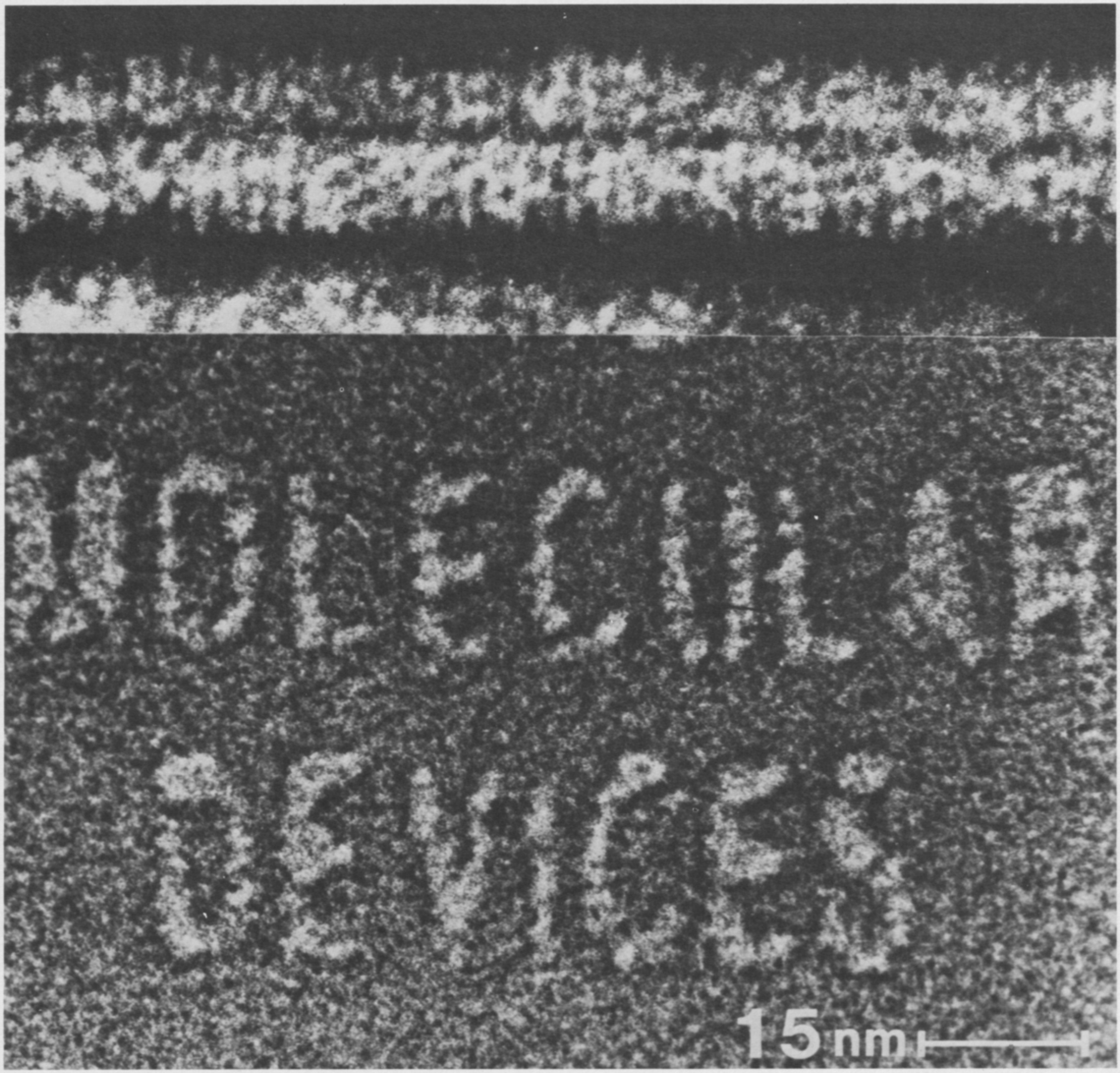


2

AN OVERVIEW

Cornell's $22.5-Million Program in Engineering Research

Painted on the roof of Cornell's newest laboratory is a submicrometer symbol—a landmark for visitors flying in to attend a conference or consult with scientists at the national submicron facility.

The sight is symbolic also of an overview of a multimillion-dollar research program like that in engineering at Cornell. The design on the roof has no real correspondence to an electronic device ten million times smaller. An aerial photograph of the campus shows only the exteriors of buildings, not what goes on inside them. Lists of topics only hint at what actually occurs in research in "semiconductor electronics" or "solid-state physics" or "seismology" or any other area of science and technology.

Opposite: The smallest man-made pattern ever reported is this electron-beam etching produced at Cornell. The pattern, magnified here 1.7 million times, was obtained at the national submicron facility by Professor Michael S. Isaacson. It resulted from the vaporization of NaCl under the action of a beam of electrons of 100,000-volt kinetic energy; the beam was 0.5 nanometer in diameter and had a current density of 0.5 million amperes per square centimeter. If letters the size of those in the pattern were used to print the Encyclopedia Britannica, *the entire contents would fit on a postage stamp.*

An overview is useful, nevertheless, for gaining perspective in a subject as broad and diverse as the research program in engineering at Cornell. Interested people in industry, government, educational institutions, and research centers frequently seek an understanding of what is being done where, and the summary on the following pages is intended to provide general information of that kind.

Because research projects are proposed and supervised by faculty members, the strengths and directions of the program depend on the interests and initiative of the faculty. Partly for this reason, the information summarized in Table I is organized according to academic units—schools or departments. This structure is followed in general in Table II also.

This is not an entirely satisfactory way of grouping research activities because of the network of connections that facilitates and enriches the overall University program. Various interdisciplinary centers and special research laboratories cross the somewhat arbitrary lines of academic units. A few professors have appointments in two departments. Collaborators in some projects come from different departments in and outside the College of Engineering. Agricultural engineering at Cornell is organized as a department within the New York State College of Agriculture and Life Sciences. To

Table I. AREAS OF RESEARCH

Agricultural Engineering
- Energy
- Community and Resource Development
- Environmental Quality
- Water Management
- Food and Biological Engineering
- Production Systems

Applied and Engineering Physics
- Solid-State Physics
- Plasma Physics
- Quantum Optics, Laser Physics, and Nonlinear Optics
- Astrophysics
- Geophysics
- Biophysics
- Atomic and Molecular Physics
- Statistical Physics
- Electron Optics
- Ion Optics

Chemical Engineering
- Biochemical Engineering
- Chemical Reaction Engineering, Kinetics, and Catalysis
- Fluid Dynamics, Rheology, and Biorheology
- Heat and Mass Transfer
- Molecular Thermodynamics and Computer Simulation
- Polymers and Materials Science
- Surface Science

Civil and Environmental Engineering
- Aerial Photographic Studies and Remote Sensing
- Environmental (Sanitary) Engineering
- Environmental Systems Engineering
- Economics of Environmental Engineering
- Environmental Law
- Technology Assessment
- Transportation Engineering and Planning
- Hydraulics and Hydrology
- Water Resource Systems
- Geotechnical Engineering
- Structural Engineering
- Structural Dynamics and Mechanics
- Metal and Concrete Structures
- Nuclear Structures
- Engineering Materials
- Finite Element Analysis
- Computer Graphics

Computer Science
- Theory of Algorithms
- Theory of Computation
- Program Verification and Formal Semantics
- Concurrent Programming
- Programming Methodology
- Program-Development Systems
- Information Organization and Retrieval
- Numerical Analysis

Electrical Engineering
- Bioelectronics and Bioelectric Systems
- Communication, Information, and Decision Theory
- Computer Engineering
- Control Theory
- Digital Signal Processing
- Electromagnetic Theory and Applications
- Electronic Circuits and Instrumentation
- Energy Conversion and Power Systems
- Integrated Circuits and Submicrometer Technology
- Microwave Semiconductors
- Network and System Design
- Plasma Physics and Applications
- Quantum Electronics and Optical Physics
- Radiophysics and Geophysical Plasmas
- Semiconductor Materials for Electron Devices

Geological Sciences
- Sedimentation
- Seismic Stratigraphy
- Mineralogy and Crystallography
- Tectonics
- Geomorphology
- Geophysics
- Paleontology
- Economic Geology
- Seismology
- Marine Geology and Geophysics
- Exploration Geophysics
- Petrology and Geochemistry
- Structural Geology
- Geophysical Fluid Dynamics

Materials Science and Engineering
- Imperfections in Solids
- Surfaces, Interfaces, and Thin Films
- Near-Surface Phenomena
- Mechanical Behavior of Materials
- Polymeric Materials
- Metals and Alloys
- High-Pressure Studies
- Phase Transformations
- Ceramic and Geologic Materials
- Electrical and Magnetic Properties
- Semiconductor Materials
- Electron Microscopy and Microanalysis
- Submicrometer Research

Mechanical and Aerospace Engineering
- Fluid Mechanics, Aerodynamics, and Turbulence
- Geophysical and Atmospheric Flows
- Heat Transfer
- Combustion
- Power and Energy Systems
- Mechanical Systems and Design
- Computer-Aided Design and Manufacture
- Materials and Manufacturing Engineering
- Biomechanical Engineering

Nuclear Science and Engineering
- Nuclear Reactor Engineering
- Fission Reactor Physics
- Low-Energy Nuclear Physics
- Atomic Processes in Controlled Fusion
- Fusion Physics and Technology

Operations Research/Industrial Engineering
- Stochastic Processes and Control
- Reliability Analysis
- Statistical Decision Theory
- Ranking and Selection Procedures
- Simulation
- Production and Inventory Control
- Interactive Optimization and Computer Graphics
- Energy Modeling
- Game Theory
- Combinatorial Optimization
- Nonlinear and Large-Scale Programming
- Network Flows and Graph Theory

Theoretical and Applied Mechanics
- Nondestructive Evaluation of Materials
- Magnetoelasticity
- Combustion
- Nonlinear Dynamics
- Planetary Dynamics
- Geomechanics
- Elasticity and Inelasticity
- Fracture
- Applied Mathematics
- Elastic Wave Propagation
- Mechanics of Unusual Materials

Table II.

SUMMARY OF RESEARCH OPERATIONS IN ENGINEERING AT CORNELL

Unit or Laboratory		Expenditures (1980-81)*	Participating Faculty	M.S. and Ph.D. Students (1981)
Agricultural Engineering		$1,817,500	19	37
Applied and Engineering Physics		2,284,300†	14	59
Chemical Engineering		774,700	15	48
Civil and Environmental Engineering		1,688,500		
Environmental Engineering	$697,700		18	45
Structural Engineering	873,500		12	50
Environmental Sensing‡	117,300		2	3
Computer Science		946,900	15	63
Electrical Engineering		4,409,500†	42	104
Geological Sciences		3,628,700	15	68
Materials Science and Engineering		3,389,200	14	60
Mechanical and Aerospace Engineering		1,274,200	24	64
Nuclear Science and Engineering		102,000†	4	6
Operations Research/Industrial Engineering		453,300	19	46
Plasma Studies (Laboratory of)		1,419,800		
Theoretical and Applied Mechanics		679,300	14	30

**These figures include funds for sponsored research projects administered through the indicated unit; funds administered through other units of the University, including the Materials Science Center; and income from other sources, such as unrestricted gifts to the College, school, or department. The total research expenditure by the Materials Science Center for engineering projects was $1,352,200.*

†Additional amounts were funded through the Laboratory of Plasma Studies and are included in the figure for that laboratory. These amounts were: $370,600 in Applied and Engineering Physics; $783,900 in Electrical Engineering; and $265,300 in Nuclear Science and Engineering.

‡The Program on Environmental Sensing, Evaluation, and Measurement.

Table III.

SPONSORSHIP OF RESEARCH

Source of Funds		Expenditures (1980-81)*
Agency for International Development		$ 17,000
Department of Agriculture		67,000
Department of Defense		3,436,200
Air Force	$1,668,400	
Army	350,900	
Navy	1,416,900	
Department of Education		53,400
Department of Energy		2,269,900
Department of the Interior		409,300
Department of Transportation		94,400
Environmental Protection Agency		9,700
National Aeronautics and Space Administration		1,054,500
National Institutes of Health		443,300
National Science Foundation		10,649,500
Nuclear Regulatory Commission		21,200
N.Y. Sea Grant Institute		30,200
American Iron & Steel Institute		56,400
Electric Power Research Institute		335,400
Corporations		1,483,300
Foundations		78,000
Others		175,300
Total		$20,684,000

**Not included are funds allocated through the Department of Agricultural Engineering, which is part of the N.Y. State College of Agriculture and Life Sciences. Also excluded are funds for certain joint projects administered through University units other than the College of Engineering.*

Figure 1

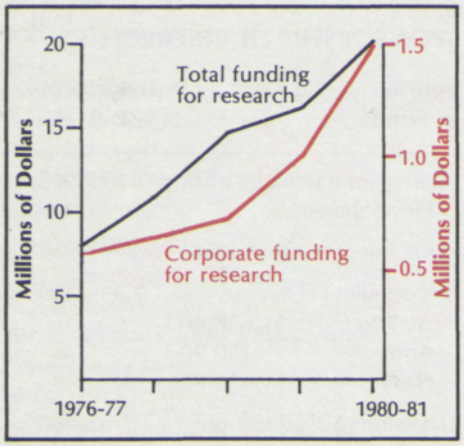


Figure 2

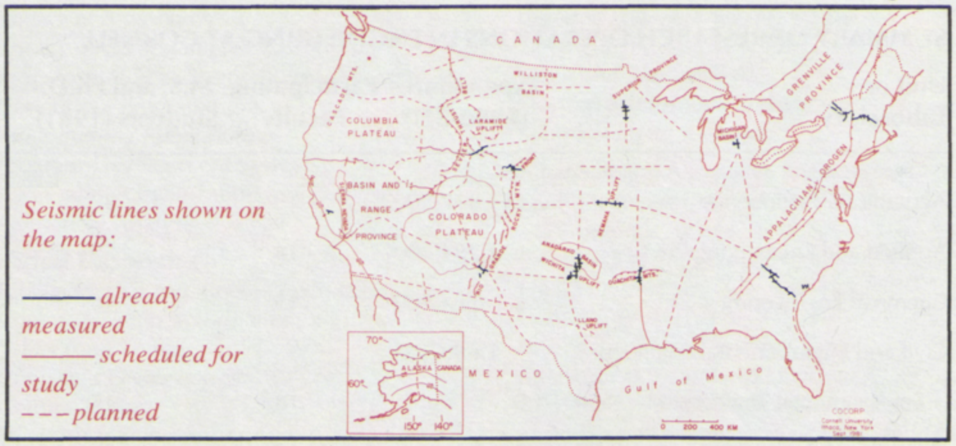
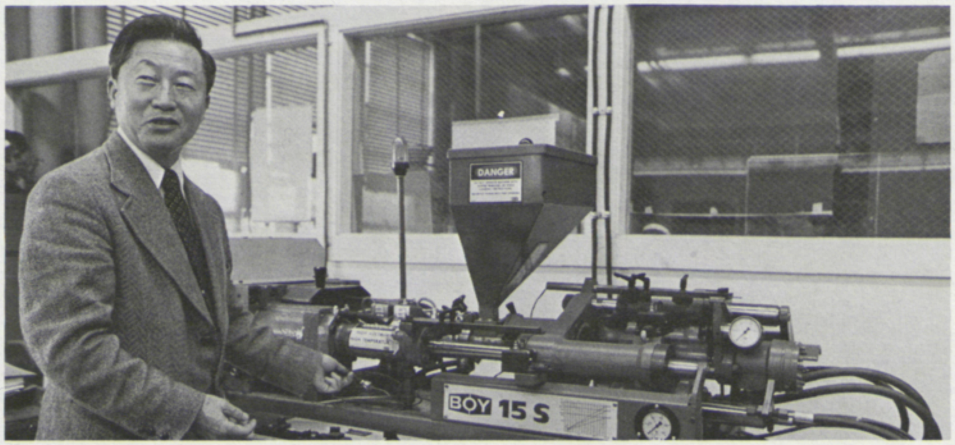


Figure 1. Funding for research projects at the Cornell College of Engineering in recent years. (The figures do not include funds allocated to the Department of Agricultural Engineering, which is administered by the New York State College of Agriculture and Life Sciences.)

Figure 2. Cornell's program in seismic reflection profiling of deep Earth structures. This work is of interest to industrial members of COPSTOC.

Right: Professor K. K. Wang, shown with the College's new injection-molding machine, heads the CIMP program.



further complicate the picture, graduate students—who are important members of university research teams—are enrolled, at Cornell, in Graduate Fields of Instruction that may encompass several academic units through the participation of individual faculty members. (Faculty members frequently are members of more than one graduate field.) In the Table II summary, graduate students are "counted" in the school or department in which their thesis research is being conducted. The number of professors currently supervising research and the 1980-81 expenditures are as reported by the various units.

The major source of funding, as shown in Table III, is the federal government, particularly the National Science Foundation. (Cornell usually ranks among the top three universities in funding from NSF, with engineering contributing in a major way to the project work.) Support from companies, corporate institutes, and foundations is significant, however, and growing (see Figure 1).

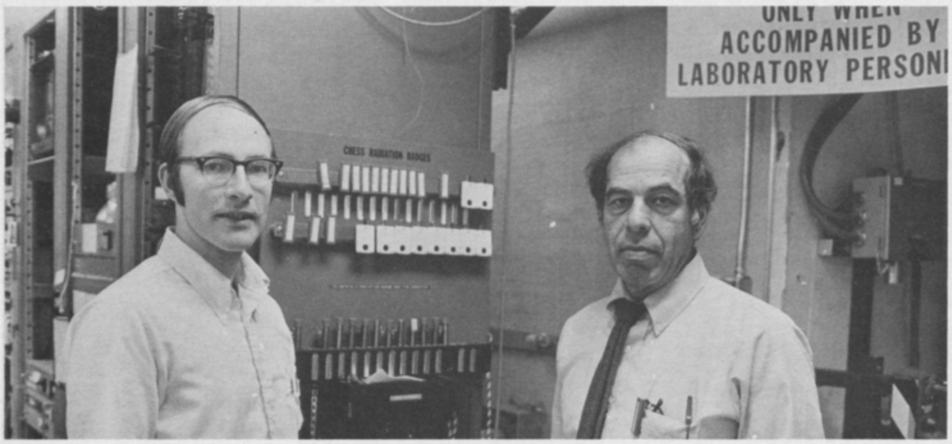
Only part of the corporate support for the College programs shows up in summaries of sponsored research projects. Grants amounting to \$3.5 million to \$4 million a year benefit the research programs through funding for specific construction or equipment or for facilities and educational programs on an unrestricted basis. Support is derived also through several industrial-affiliate programs (see Table IV), which provide a mechanism for corporate participation in information exchange and research efforts.

Table IV. INDUSTRIAL AFFILIATES PROGRAMS

Name	Description	Members
CIAMS Cornell Industrial Affiliates' Program in Materials Science	Affiliated with the Cornell Department of Materials Science and Engineering Purpose: to facilitate contact and information exchange; to promote the Cornell research effort Activities: on-campus annual review meeting; exchange visits; receipt of Cornell research papers	*Now being organized*
CIMP Consortium for the Cornell Injection Molding Program	Affiliated with the Cornell Injection Molding Program (CIMP), an R&D effort aimed at state-of-the-art manufacture of precision plastic parts Purpose: to foster basic and developmental research applicable to injection molding; to exchange information and ideas Activities: on-campus meetings, seminars, and workshops; exchange visits; receipt of papers and newsletters	AMP (Plastics Products Division), Bell Laboratories, DiscoVision Associates, Eastman Kodak, Ford Motor, Graphics Technology, General Electric, Lord Kinematics, NCR, RCA Laboratories, SONY, Xerox
COPSTOC Cornell Program for Study of the Continents	Affiliated with the Cornell Department of Geological Sciences Purpose: to foster Cornell research on the continents, including a project of the Consortium for Continental Reflection Profiling (COCORP) to map the deep structures of the earth (COCORP is operated by the Cornell department) Activities: on-campus meetings; exchanges of scientific literature	Amoco Production, Chevron Oil Field Research, Cities Service, Conoco, ELF Aquitaine, Exxon Production Research, Gulf Science & Technology, Louisiana Land & Exploration, Marathon Oil, Mobil Field Research Laboratory, Phillips Petroleum, Shell Development, Shell International Petroleum, Sohio Petroleum, Texaco, Union Texas Petroleum
PROSUS Cornell Program on Submicrometer Structures	Complements faculty activity in the National Research and Resource Facility for Submicron Structures (NRRFSS), located at Cornell Purpose: to promote industrial participation in the development of Cornell research activities involving submicrometer structures Activities: on-campus meetings; exchange visits; receipt of special mailings	Applicon, Applied Materials, Bell Laboratories, Cambridge Instruments, Digital Equipment, Eastman Kodak, Fairchild Camera & Instrument, General Electric, General Motors, GTE Laboratories, Hewlett-Packard, Honeywell, Hughes Research Laboratories, Intel, IBM, Litton Industries, National Semiconductor, Perkin-Elmer ETEC, Raytheon, Sandia Laboratories, Signetics, Sperry Rand, Texas Instruments, Varian Associates, Xerox

Right: *Instruments available for research through Cornell's interdisciplinary Materials Science Center include this scanning electron microscope.*

Below: *Photographed at Cornell's unique CHESS facility are Donald F. Bilderback (at left), the operations manager, and Professor Boris W. Batterman, the director. CHESS—the Cornell High Energy Synchrotron Source—makes available to researchers in many fields the high-energy x radiation that is generated by the University's electron storage ring at the Wilson Synchrotron. Scientists from all over the United States can make use of this facility.*

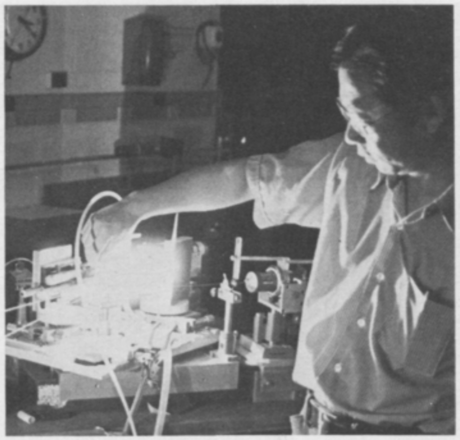


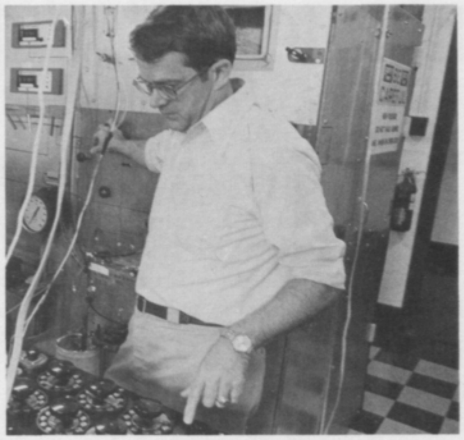
One of the most important reasons for Cornell's strength in research is the presence of interdisciplinary centers, laboratories, and programs, many of which receive major support from NSF through equipment purchase and project funding. The advantages of the interdisciplinary approach are impressive. When there is an interdisciplinary organization, work that cuts across the lines of traditional fields is fostered through better contact among the various researchers. Individual faculty members tend to broaden their knowledge and outlook, becoming more effective as teachers and researchers. In an interdisciplinary laboratory, sophisticated and expensive equipment can be shared by investigators in different parts of the academic system. In some cases, interdisciplinary coordination and cooperation have provided a nucleus of expertise that has led to the selection of Cornell as the host institution or operator of national laboratories or programs.

Laboratories that are especially important in engineering research include two that dedicated new facilities this fall (see *Vantage*): the submicron facility (NRRFSS) and the Laboratory of Plasma Studies. Others are the Materials Science Center, the Cornell High Energy Synchrotron Source (known as CHESS), the Center for Applied Mathematics, the Center for Environmental Research, the Program of Computer Graphics, the Center for Radiophysics and Space Research, the National Astronomy and Ionosphere Center (operated by Cornell for NSF in Arecibo, Puerto Rico), the Center for International Studies, and the Program on Science, Technology and Society.

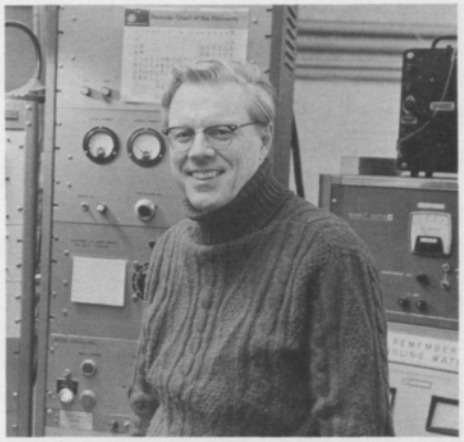
An aspect of the complex research program that may not be immediately evident in a summary review such as this is the close connection between the research and educational functions of the College and the University. A major component of graduate instruction (and an important influence in undergraduate education) is the research activity. A healthy instructional program, involving the attraction and maintenance of high-quality faculty members and students, is the foundation of good research. A vital and adequately funded research program is a necessity for leadership and reputation in engineering education.

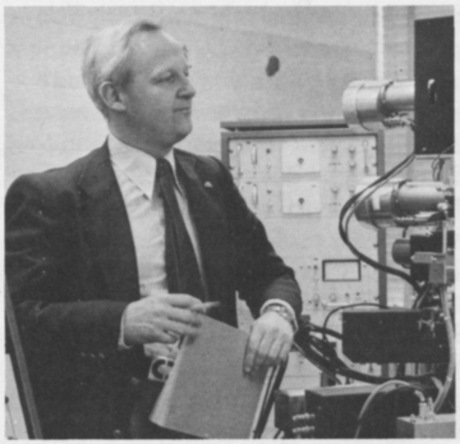
The chief deficiency of a summary report, though, is the impossibility of conveying an idea of the content of specific projects, let alone their significance, or the excitement of discovery, or the frustrations and satisfactions that accompany all original work. Behind the statistics of Cornell's $22.5-million research program is the substance: the work itself and the people who do it. —G. McC.

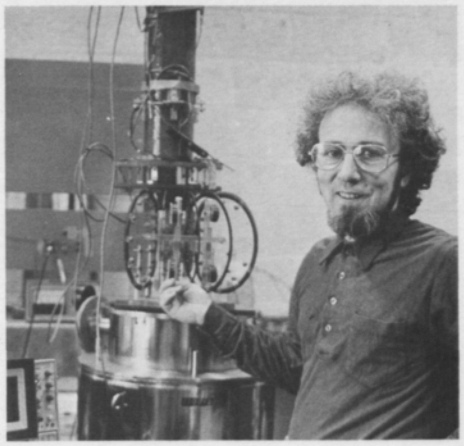




Some two hundred Cornell engineering professors participate in a wide variety of research projects. A sampling of photographs taken for College publications shows a few of them at work in some of their specialty fields. Clockwise, from noon, are: Chung L. Tang (lasers); William B. Streett (molecular liquids); Charles A. Lee (solid-state physics and devices); Francis C. Moon (magnetoelasticity of superconductors); David D. Clark (nuclear structure physics); John Silcox (electron microscopy); Franklin K. Moore (thermal pollution); and Jack E. Oliver (geophysics).







DESIGN SKILLS

The Professional Emphasis in Cornell Engineering

Design, the heart of engineering practice, is also the central feature of Cornell's professional master's degree program.

Project work, often suggested and sometimes partially supervised by practicing engineers, is the counterpart in the Master of Engineering program of the research conducted by graduate students in the Master of Science–Doctor of Philosophy program. M.Eng. projects are frequently related to faculty research activities, but whatever their contribution to the overall research effort, they are a basic component of Cornell education in engineering and applied science.

Prospective students sometimes ask about the difference between the M.Eng. and the M.S. degrees. In general, the M.S.-Ph.D. programs are research-oriented; the M.Eng. curricula, offered in eleven major fields, emphasize specific design skills. A requirement of the one-year program in any of the M.Eng. fields is engineering design experience involving individual effort, and the work must be accompanied by a written report that meets professional standards. In addition, each student takes required courses that are basic to the discipline and electives that usually are related to the design experience. The result is a graduate who is well prepared for sound professional work.

M.ENG. ENROLLMENTS, 1981-82

M.Eng. (Aerospace)	4
M.Eng. (Agricultural)	1
M.Eng. (Chemical)	15
M.Eng. (Civil)	45
M.Eng. (Computer Science)	5
M.Eng. (Electrical)	90
M.Eng. (Engineering Physics)	5
M.Eng. (Materials)	-
M.Eng. (Mechanical)	17
M.Eng. (Nuclear)	6
M.Eng. (OR&IE)	29

Variations of the overall program have developed in the different fields. Sometimes design projects are organized by the school or department and in other cases they arise from research in progress. Projects may be undertaken by individuals or worked on by teams. In general, the modes reflect variations in the disciplines as they are practiced.

■ In the School of Electrical Engineering, the M.Eng. program is well integrated into the overall graduate and research program, and may lead either to professional employment or to doctoral study.

Because the faculty members are involved in both stems of graduate instruction, the M.Eng. design work is frequently related to ongoing research. For example, one recent M.Eng. project was the analysis and design of a power-system stabilizer; it was supervised by a professor whose research is in the area of power-system control. An M.Eng. project on remote monitoring of animal deep-body temperatures by implanted transmitters was supervised by a professor with a research program in bioelectronics and information coding in neural systems. Another M.Eng. project produced a design for a microprocessor-based system for data acquisition and reduction that is useful in a professor's current research in

RECENT M.ENG. (ELECTRICAL) DEGREE PROJECTS

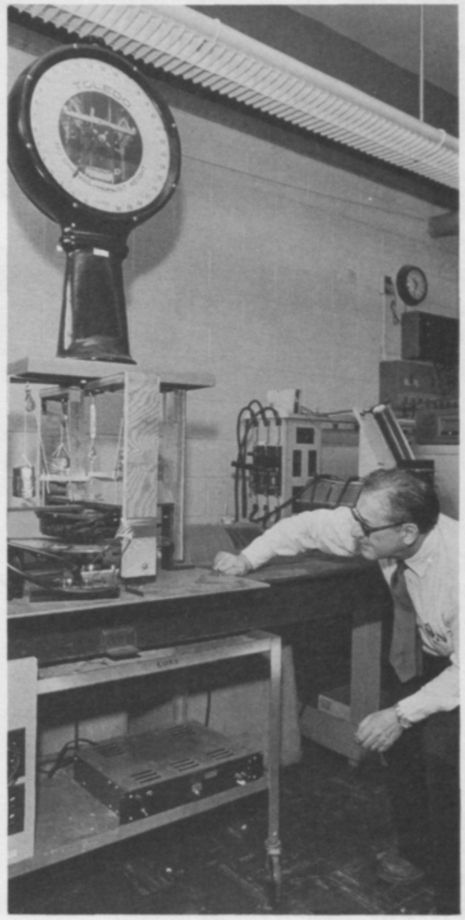
Analysis and Design of the Power-System Stabilizer as a Control Device
Cornell Linear Induction Accelerator
A Design Aid for the Intel MCS-48 Series of Microcomputers
Design and Construction of a Speech Synthesizer Using Linear Predictive Coding Techniques
Determination of the Compositon of D-C Reactively Sputtered Silicon Nitride
A Development of Spread-Spectrum Theory Using Direct-Code Modulation
A Digital Cassette Subsystem
Digital Pipe Organ: Further System Refinement and Design of Digital Tone Generator
Digital Synchronization-Check Relay for Power-System Interconnection
Frequency-Modulated Optical Communication Systems
The Frequency–Phase Constant Relationship for a Concentric Sheath Helix–Circular Waveguide Structure
An Improved 50-MHz Auroral Radar Transmitter Capable of 20 KW Peak R-F Power Output
Integrated Multielectrode Bipotential Recording Array Employing LSI MOSFET Technology
An Investigation of Magnetic Levitation Utilizing a Linear Induction Motor
Mechanical-Pump Failure Detector for Belt-Drive Pumps
A Microprocessor-Based Data Acquisition and Reduction System
A Minimum-Hardware, Switching-Mode Audio Amplifier Using VMOS Power FETs
A Portable Electro-Antennogram
Programs to Solve Sparse Linear Matrix Equations on an Array Processor
Remote Monitoring of Animal Deep-Body Temperatures by Implanted Transmitters
Signal Period Display for Test-Animal Stimuli
Simulation of a Tree Protocol for Packet Data Communications with Feedback
Software for a Microprocessor Controller for Electric Vehicle
A Square Modulator and a Power Leveller Using a GaAs Field-Effect Transistor

rocket and satellite instrumentation and space plasma physics.

The wide variety of options reflects the diversity of electrical engineering today. Recent projects have been in the areas of bioelectronics, communication systems, computer engineering, control systems, digital microwave devices, optoelectronic devices, and power and energy systems.

■ The M.Eng. program in civil engineering is distinctive because of the direct involvement of practicing engineers in many of the projects, which are carried out partly during an intensive three-week period between academic semesters. Often the project assignments are provided by firms that either are doing or have recently completed designs for the same projects, so that they are timely and pertinent to current professional practice. Contacts of faculty members with practicing engineers, including former students and members of firms the professors work with as consultants, help in the identification of projects and the

Below: Magnetic levitation achieved in an apparatus that was developed last year in an M.Eng. (Electrical) project is observed by Professor Simpson Linke, the adviser. An energized, three-phase, axial-air-gap, linear-induction-motor stator winding is levitated when eddy currents induced in an externally driven copper-disk rotor interact with currents in the stator winding. Such a system might find eventual application in rapid-transit vehicles. Future M.Eng. projects will involve improved measurement of forces and elevation, and the development of a suitable control system.



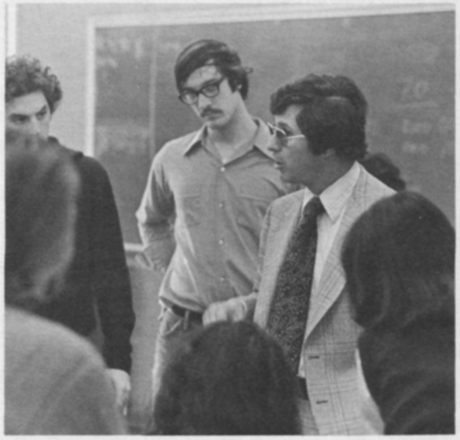
recruitment of participants from industrial or consulting firms.

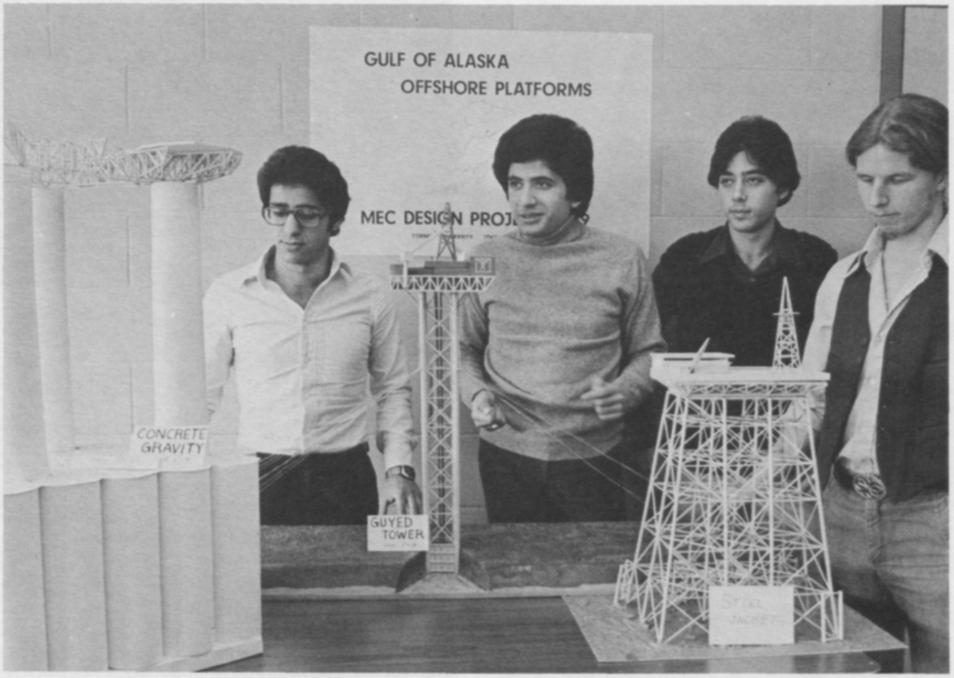
This program has developed into one of the major operations of the School of Civil and Environmental Engineering. Each year there are two large projects—one in some aspect of structural engineering and one in an area of environmental engineering—carried out by groups of up to thirty students (see the chart). Faculty members supervise each project, from its preliminary design in the fall term prior to the intensive design period, to the subsequent writing and presentation of a comprehensive report. Assignments involving one or two students working under faculty supervision can also be arranged; frequently these projects are in the field of remote sensing, on subjects such as airphoto studies of the environmental impact of highway construction; water-quality surveillance; and site location for an industrial plant.

The course work for the degree comprises a major in a specialty field—structural, geotechnical, sanitary, hydraulic, or environmental-systems engineering, transportation

RECENT GROUP PROJECTS OF M.ENG. (CIVIL) STUDENTS

Subject	Consultants	Students
Boeing 747 Hangar and Maintenance Facility for LaGuardia Airport	Lev Zetlin of Lev Zetlin Associates	26
Design of an Addition to the Chicago Board of Trade Building	Richárd Tomasetti of Lev Zetlin Associates	25
Design of a Bridge across Piscataqua River	Richard Christie of Hardesy and Hanover	30
Design of a Radioactive Waste Treatment System for the Offshore Atlantic Generating Station	Robert Cherdack of Burns and Roe	2
Development of an Economical Wastewater Treatment Plant for the Doe Run Effluent, Olin Chemicals Group, Brandenburg, Kentucky	H. H. Hogeman, D. R. Vaughn, and C. T. Avery of Olin Chemicals Group; Paul L. Busch of Malcolm Pirnie	14
Gulf of Alaska Offshore Platforms	Robert Bea of Woodward-Clyde Consultants; Rudy Hall of Petro-Marine	27
High-Rise Building, New York City	Leslie Robertson of Skilling, Helle, Christiansen, and Robertson	20
Liquified Natural Gas Terminal at Cove Point, Chesapeake Bay, Md.	M. Esrig of Woodward-Clyde Consultants	15
Municipal Wastewater Treatment by Automatic and Computer Control	Elmer Ballotti of Greeley and Hansen Engineers	10
Offshore Floating Nuclear Power Station: Structural and Foundation Site Aspects	Eugene Harlow of F. R. Harris; Harcharan Singh of Dames and Moore	23
Olympic Facilities	Elio D'Appolonia of D'Appolonia Consulting Engineers	28
Reservoir Systems Planning for Irrigation in Northern Africa		3
Upgrading the Binghamton-Johnson City, N.Y. Joint Sewage Treatment Plant	Paul L. Busch of Malcolm Pirnie	9
Upgrading the Wastewater Treatment Facilities at Canandaigua, N.Y.	Wayne P. Ackart and Thomas J. Lawson of Lozier Associates	6
Wastewater Treatment Plant for Ithaca, N.Y.	A. Gordon Wheler of Stearns and Wheler	10

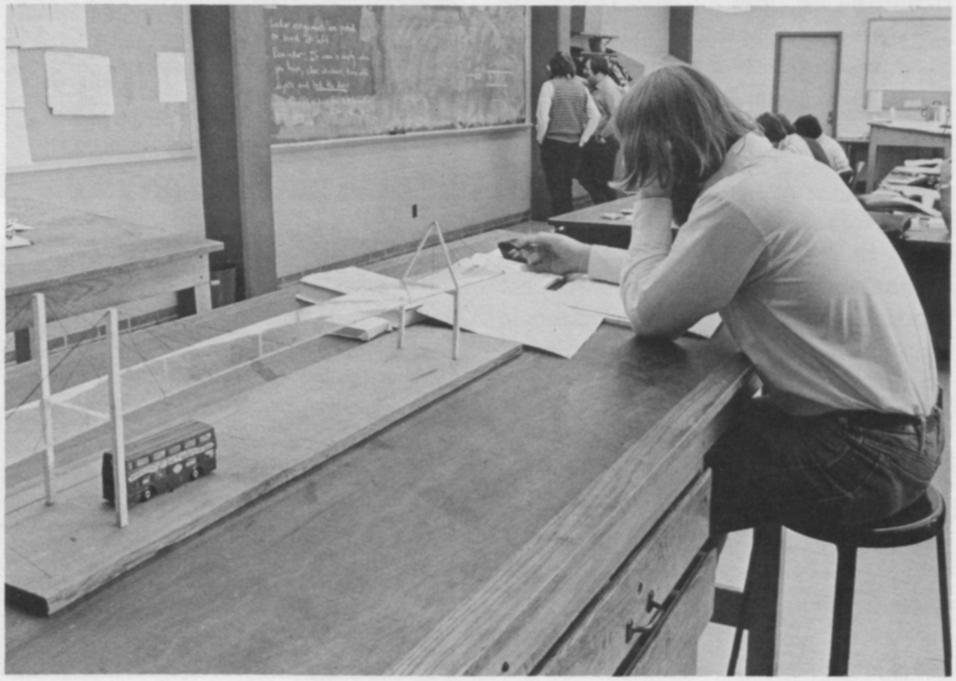




Above: Industrial consultants work closely with the M.Eng. (Civil) students during an intensive three-week intersession period. Here Paul L. Busch of Malcolm Pirnie Associates discusses problems in the design of a wastewater treatment plant.

Right above: A presentation of the designs is given at the end of the term by the student team members, who also prepare a comprehensive written report.

Right below: Individual work is required for the team project. This student participated in the design of a cable-stayed bridge.



planning, or remote sensing—and a related minor subject. All the M.Eng.(Civil) candidates take a special course in professional engineering practice that covers ethics, economics, management, and law.

The M.Eng.(Civil) program at Cornell is valuable not only for students who want to become practitioners in established companies, but for those who wish to join or form smaller consulting firms, a possibility that is particularly significant in civil and environmental engineering.

Right: Inventory procedures at a nearby manufacturing plant were the subject of an M. Eng. (OR & IE) group project.

■ In the School of Operations Research and Industrial Engineering, a large part of the graduate enrollment is in the M.Eng. program. In recent years the faculty has made a special effort to arrange cooperative projects with industrial or government organizations so that M.Eng. students can work closely with practicing engineers and analysts, as well as with their own professors. The students actually apply the mathematical and analytical techniques learned in their course work: they help effect a reduction in manufacturing costs, for example, or the improvement of services, or the speeding up of an operation.

A generalization is that in the M.S.-Ph.D. stem of the school's program the emphasis is on highly analytical approaches to the problem areas and techniques of operations research, whereas in the M.Eng. program the very practical essence of the science is revealed.

RECENT OR&IE PROJECTS

Economic Feasibility of the Hydroelectric Potential of Sites along the Keuka Lake Outlet

Scheduling Multiproduct Process Facilities

Analysis of the Xerox de Mexico Logistics System

Analysis of Space Utilization and an Information System for a Unit Loan Warehouse

Economic and Legal Feasibility of Multiunit Wind Energy System

■ Two M.Eng. degrees, one in each of the two disciplines encompassed in the School of Mechanical and Aerospace Engineering, are offered through the school's faculty. The project work is generally tied to the current activities and interests of the professors who supervise it.

Much of the ongoing research in mechanical engineering includes design aspects, and because the faculty interests range over a particularly broad field of engineering, the students can choose their projects from many

DESIGN WORK FOR THE M.ENG. (MECHANICAL) DEGREE

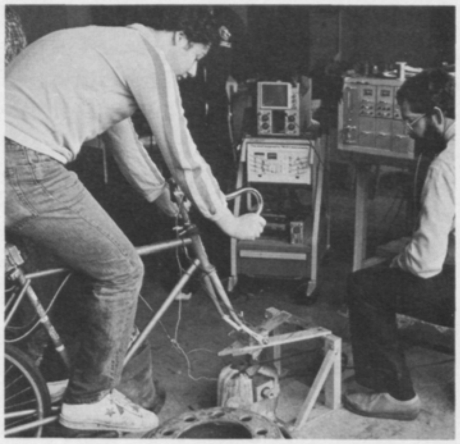
Design and Evaluation of a Two-Stage Combustor for Emission Control
Design of Coolings Lines for Injection Molding of Plastics
Design of Total Hip Replacement for Limb Salvage Procedures
Impact Testing of Motorcycle Forks
Improvement of the Upson Hall Sun Tracking Control System
Inertia–Internal Combustion Engine Hybrid Drive for a Short-Range Car
The Problem of Self-Sufficiency and Electrical Power—Is There a Solution?
Six-Degree-of-Freedom Displacement/Load Transducer
Thermal Design of a Spacecraft Component
Use of Cascade to Reduce Heat-Exchanger Loss
Waste Heat Utilization
Wind Tunnel Equipment for Automotive Applications

possibilities. Projects have ranged from experimental activities to the development of computer-aided design tools. The areas of particular interest at the present time include bioengineering, machine design and control, mechanical system analysis, vehicles and propulsion, energy systems, thermal environment, manufacturing engineering, and materials processing.

In aerospace engineering, subject areas available for projects include pollution control in automobile engines, hydrogen and methanol internal combustion engines, solar-energy collectors, combustion studies, wind-tunnel experimentation, vehicle aerodynamics, controlled fusion, and turbulence.

Below left: A group of M.Eng. (Mechanical) students worked on the determination of comfort criteria for riders of competition bicycles. They considered aspects of analysis and design involved in a reduction of energy loss through vibration. Professor Dean L. Taylor (at right) served as a faculty adviser.

Below: Another M.Eng. (Mechanical) project was the design of streamlined high-speed bicycles with the aid of wind-tunnel testing and computer calculations. Some models tested at speeds near 45 mph.



Right: A heliostat or "sun follower" on the roof of Upson Hall was used by M. Eng. (Mechanical) students in design project work. The flat mirror at left is moved by a controlling mechanism activated by photopotentiometers; the rays it reflects are directed to the parabolic mirror, which concentrates the solar energy. Faculty adviser Richard M. Phelan appears in the picture.

M.ENG. (CHEMICAL) PROJECTS

Alcohol from Corn for Gasohol
Clean Fuels from Solvent-Refined Coal
Direct-Contact Heat Transfer in a Desalination Process
Gasoline from Methanol by the Mobil Process
Production of Hydrogen by Chemical Means
Regeneration of Spent Carbon Adsorbents in a Fluidized Bed
Waste Treatment in a Space Capsule

■ As in all fields, the M.Eng. program in chemical engineering differs from the M.S.-Ph.D. program in being more practice-oriented. Rather than emphasizing mathematical and theoretical research and course work, it is more concerned with applications in such areas as the design and control of process equipment. The economics of chemical engineering industries and the numerical methods used in their operations are important aspects of the academic and project work.

The design projects are related to the specialties of the faculty. The scope of activity is suggested by the sampling of project titles given in the table.

■ The other M.Eng. programs are smaller because they are offered by smaller departments, are relatively new, or have a more restricted function in the department's program. They are nevertheless well defined and active.

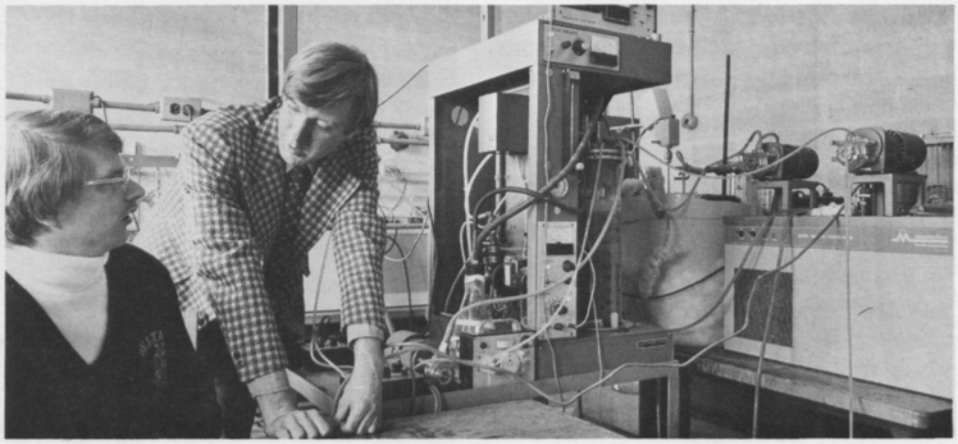
Projects for the M.Eng. (Engineering Physics) and M.Eng. (Materials) degrees are almost always associated with ongoing research. In engineering physics, the project work frequently develops useful instrumentation, resolves problems encountered in making physical measurements, or extends the applicability of equipment. In materials science and engineering, a typical project might be an electron microscopic study of radiation damage or the selection of an alloy for a particular engineering application.

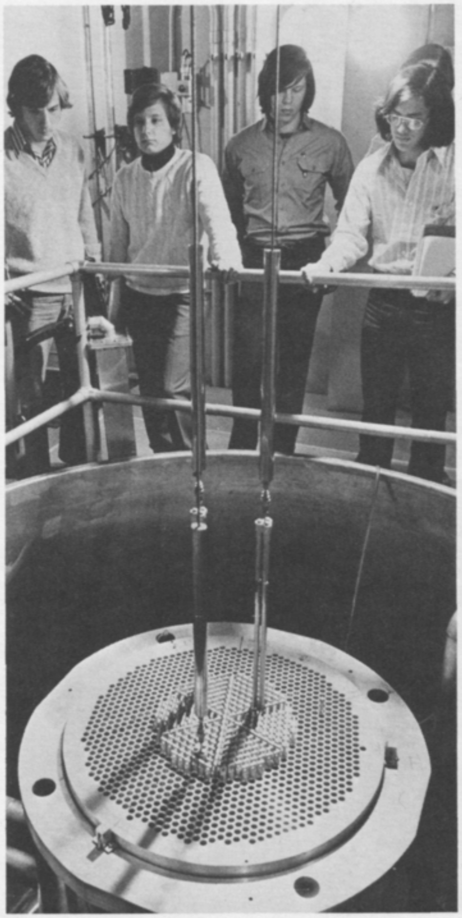
A special emphasis in the M.Eng. (Nuclear) program is reactor safety and radiation protection and control. Recent project work has included the design of metal vapor heat pipes, a feasibility study of neutron burnup of fission products, a study of void detection in pressurized water reactors, and the development of a plan for radioactive waste management.

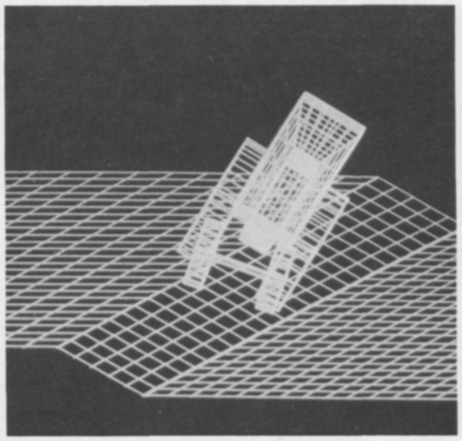
The M.Eng. (Agricultural) program exists alongside a somewhat analogous Master of Professional Studies curriculum, which also includes project work. Recent M.Eng. projects, reflecting the breadth of current faculty interest and activity, have been concerned with such practical matters as tractor motion, the design of a cranberry harvester, reduction of heat loss and maximum use of solar energy in greenhouses, computer programming for problems in irrigation management, the optimization of milking-parlor operations, the treatment and disposal of septic-tank sludge, energy conservation in the milking center of a modern dairy farm, and the selection of a rice-milling process for remote areas of Nepal.

The M.Eng. in computer science was introduced just a few years ago in response to industrial need for specialists capable of designing software for specific applications. Projects can involve programming languages and systems, algorithms and techniques of computation, or the processing of information.

Below: The microbial conversion of poultry manure to chicken feed was the subject of a recent project in the M.Eng. (Chemical) degree program. The adviser was Professor Michael L. Shuler (at right), whose research area is biochemical engineering.



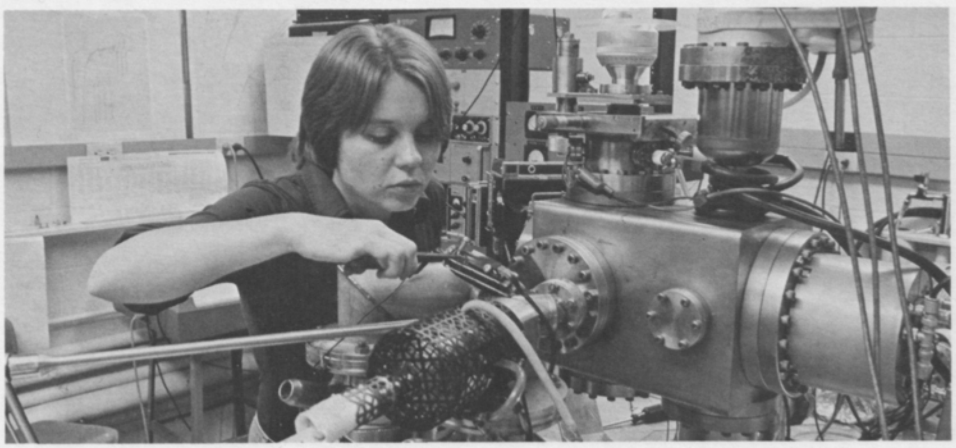




Left: The "zero-power" reactor, a facility unique to Cornell University, is available to students in the M. Eng. (Nuclear) degree program. It is located in the Ward Laboratory of Nuclear Engineering.

Above: This computer-graphics simulation of a tractor overturn was used in an agricultural engineering study of vehicle stability as related to design and operation.

Below: A photon radiation source using microwave excitation of a helium gas plasma was developed in an M.Eng. (Engineering Physics) project.



Though these different M.Eng. programs vary considerably, they have several features in common.

All the projects are related to the interests and activities of the people the students work with—their professors and often professional engineers from outside the University. This connection gives intensity and immediacy to the work.

All the programs provide a means of interaction between the College and the industry and profession it serves. Initiative in suggesting projects can come from outside as well as within a department. Helping with project work gives practicing engineers an opportunity to participate directly in educational programs that shape the profession, and to become acquainted with future engineers. Similarly, faculty members have additional opportunities to keep in touch with what is going on in industry.

Another common characteristic is that the programs are educationally versatile. In addition to preparing students for professional practice, M.Eng. curricula can serve as excellent first-year graduate programs for doctoral candidates who want practical as well as fundamental backgrounds for research.

Above all, the M.Eng. programs share an ability to adapt readily to the changing needs and directions in industry and in the professions. They are bridges between classroom and workplace, but they are not chiseled in rock or cast in concrete. Designed for flexibility as well as strength, they adapt to the environment and hold up well.

Taking in a Lion

An important new facility for research in controlled nuclear fusion—a machine that delivers nearly a trillion watts of power in 40 billionths of a second—was dedicated at Cornell's Laboratory of Plasma Studies (LPS) this fall. The ceremony was held in conjunction with a workshop September 28 and 29 that brought to the campus specialists in fusion research from all over the United States. The events also included public tours of the facility and other LPS laboratories.

The new equipment, called LION (light-ion fusion facility) was supplied by Sandia Laboratories, the national research center in Albuquerque, New Mexico, where an array of thirty-six similar machines constitutes the Particle Beam Fusion Accelerator (PBFA). The purpose of PBFA is to develop a fusion technology based on the firing of high-intensity beams of ions at a target of nuclear fuel.

The fusion process, which occurs in the sun and other stars, could be the basis of an energy-production technology that would be much "cleaner" than fission (the power source of cur-

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1. Visitors at the dedication of the recently installed LION were cautioned to protect their ears as technicians prepared to demonstrate the firing of the machine. (They were rewarded with a loud bang.)

2. During their two days on campus, delegates to the Workshop on Physics of Intense Ion-Beam Diodes visited the new LION facility in Upson Hall and toured other facilities of Cornell's Laboratory of Plasma Studies.

3. A schematic diagram of the LION shows the energy-storage, pulse-forming network and (at the front) the magnetically insulated transmission line.

4. The installation includes the high-voltage machine and a tall cylindrical structure containing deionized water for the pulse-forming section of the machine.

5. Visitors inspect the beam-output section of the facility in the experimental hall.

6. Operation of the machine is controlled from an adjacent booth.

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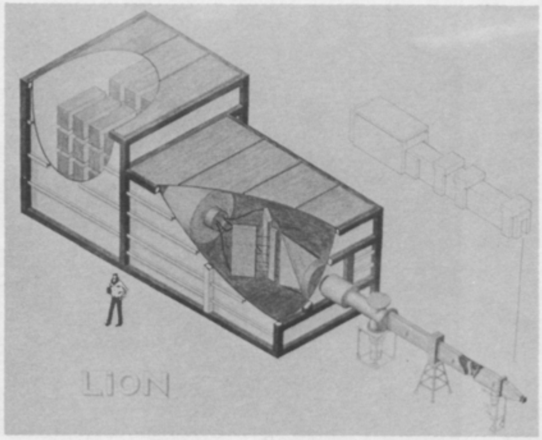

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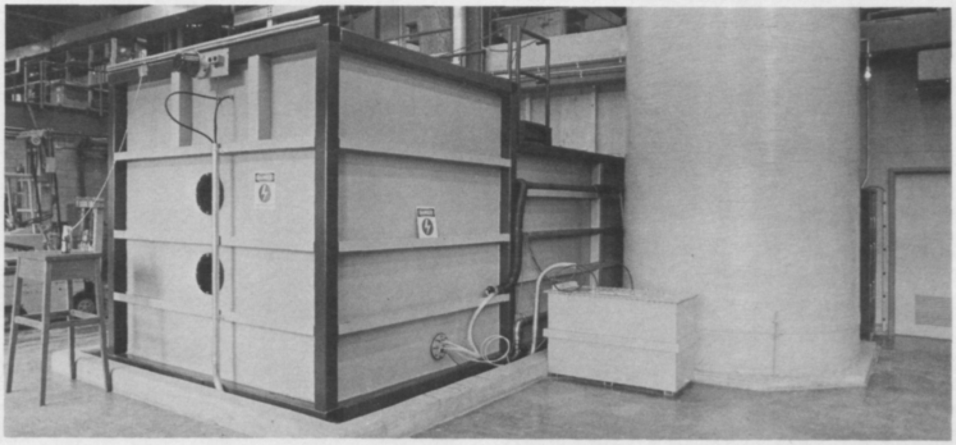

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Participants in the fusion-facility dedication events included official representatives of the University and the government and fusion specialists from Cornell and from laboratories across the country.

1. Ravindra N. Sudan (left foreground), director of Cornell's Laboratory of Plasma Studies, was the chief host. With him in the photograph are (left to right) Ezra Hertowit, Cornell Ph.D. of 1971, who is a staff director of a Congressional subcommittee on energy development; Simpson Linke, Cornell professor of electrical engineering; and Boyce D. McDaniel, director of the University's Laboratory of Nuclear Studies.

2. Representing Sandia Laboratories, which provided the LION, was Gerold Yonas (at right), director of Sandia's pulsed energy programs. Here he talks with Dale R. Corson, president emeritus and chancellor of the University, who is a nuclear physicist.

3. The official visitors included R. L. Schriever (at left), acting director of the federal Office of Inertial Fusion. At center is Terry Godlove from that office. At right is mechanical and aerospace engineering professor Edwin L. Resler, Jr.

4. Everyone toured the laboratory where the new facility had been installed. The people appearing most prominently in the photograph are (left to right) W. Donald Cooke, Cornell vice president for research; Charles E. Seyler, assistant professor of electrical engineering; T. P. Coffey, associate director of the Naval Research Laboratory; and (second from right) Donald T. Farley, professor of electrical engineering. The windows in the beam-generating machine permit a glimpse of the Marx capacitor bank.

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5. Professor Bruce R. Kusse (at right), cochairman of the ion-beam workshop, explained some of the LION controls during a tour of the facility.

6. Professor David A. Hammer (at right) was the other workshop cochairman. Here he explains a diagram of the machine to his colleague David D. Clark, director of the College's Ward Laboratory of Nuclear Engineering.

7. The LION was christened with a bottle of Löwenbrau beer, swung by Rosemary Saltzman, administrative aide at the Laboratory of Plasma Studies.

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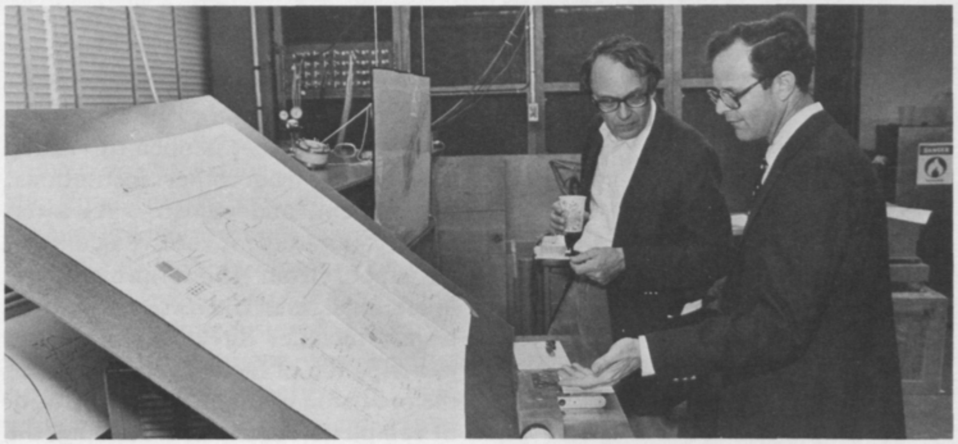

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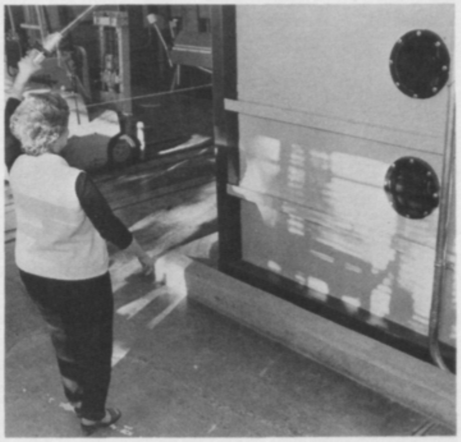

rent nuclear power plants) and would use as its fuel isotopes of hydrogen obtainable in virtually limitless quantity from sea water. Scientists estimate that twenty to thirty years of further research are needed before nuclear fusion could be used commercially.

The new LION at Cornell will be used to study fundamental problems of physics pertaining to the production and focusing of intense ion beams, a technique that originated at Cornell some seven years ago. Problems under study include how to heat the nuclear fuel to the extremely high temperatures—50 to 100 million degrees—that are required to initiate thermonuclear reaction. (With particle bombardment, there is no need to contain hot plasma, as there is in the other major technique—magnetic fusion—that is under study in the world's fusion research laboratories. For example, the Tokomak Fusion Test Reactor now nearing completion at Princeton University uses a magnetic field as a "bottle" to contain plasma long enough for thermonuclear burn.)

At the dedication ceremony for Cornell's LION, the speakers included R. L. Schriever, acting director of the Office of Inertial Fusion, U.S. Department of Energy; Gerold Yonas, director of Pulsed Energy Programs at Sandia Laboratories; and Timothy P. Coffey, associate director of the Naval Research Laboratory. Representing Cornell were W. Donald Cooke, vice president for research; Thomas E. Everhart, dean of the College of Engineering; and Ravindra N. Sudan, director of LPS, who presided.

The New Knight Laboratory for the National Submicron Facility

Representatives from industry, government, and education gathered at Cornell in mid-October for a celebration and a conference.

The celebration was occasioned by the dedication of the University's new Knight Laboratory for the National Research and Resource Facility for Submicron Structures (NRRFSS). The conference was on issues in semiconductor electronics, the rapidly growing technology that the facility advances.

Pervading the events was a feeling of excitement—an awareness that Cornell has taken a place at the forefront of developments in a rapidly moving and nationally important area of research.

NRRFSS, established at Cornell in 1977 with an initial $5-million grant from the National Science Foundation (NSF), sponsors research aimed at developing microfabrication techniques and materials that will make possible a new generation of electronic devices with dimensions smaller than a micrometer (one millionth of a meter). The new laboratory was designed to meet the special needs of this kind of research. Work on electronic components with dimensions as small as 10 or 20 angstroms (of the order of ten atomic diameters) requires stringently clean laboratory areas, vibration-free mountings for instruments, and special regulation and grounding of electrical equipment.

At the dedication ceremony, Lester B. Knight, Jr., acknowledged the naming of the laboratory in his honor.

NRRFSS is the only microstructure-science laboratory in an American university that is open to visiting researchers from other institutions, government, and industry. As a national laboratory, it receives continuing support from NSF for projects and operations. The University's responsibility includes direction, significant participation of faculty members, and the provision of suitable housing. (Until completion of the new building, the facility used space in adjacent Phillips Hall, home of the School of Electrical Engineering.) Financing of the planning and construction of the $3.85-million Knight Laboratory was made possible by gifts from foundations, industries, and individuals; the NRRFSS fund, currently at $10.7 million, also helps provide capital equipment and project support.

The naming of the new building in honor of Lester B. Knight, Jr., a 1929 Cornell graduate in mechanical engineering who was a major donor of funds for the construction, was an-

Left: Cornellians participating in the dedicaton program included (left to right) Thomas E. Everhart, dean of the College of Engineering; Lester B. Knight, Jr.; Jerrier A. Haddad, chairman of the Engineering College Council; and Frank H. T. Rhodes, president of the University.

Below: The dedication, with the accompanying events, was a festive occasion for Cornell personnel and visitors from across the country. A reception and banquet followed the afternoon program.

nounced at the dedication program. Knight was also involved in the architectural design of the laboratory through his firm, Lester B. Knight and Associates. In earlier support of the University, he established a scholarship fund for students enrolled in a special graduate program leading to master's degrees in both engineering and business administration, a combination Knight has fostered: Lester B. Knight and Associates was the first firm to provide expertise in both architectural-engineering planning and management consulting. Knight began his career as a sales manager for an engineering company, rose to become its president, and then, after service with the United States Navy during World War II, established his own firm in 1945. Its operations are now international in scope. In 1977 the University honored Knight by naming him a Presidential Councillor.

The day's events began with the conference, proceeded with the dedication program in the late afternoon, and concluded with a reception and banquet.

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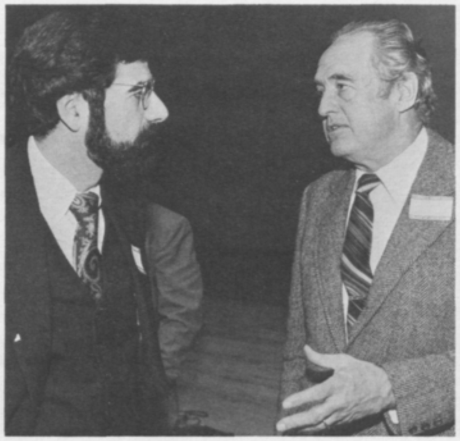

1. Edward D. Wolf, director of NRRFSS, described the functions of the national facility at the dedication program.

2. The economic, political, and educational environment of the semiconductor industry was examined in two symposia. (See the Commentary *on the following pages.) Participants at the session on "Issues Facing the Semiconductor Industry" included Steven J. Falken (at left), industrial trade policy specialist with the federal government, and moderator Walter A. Fallon, chairman of Eastman Kodak and a member of Cornell's Engineering College Council. The others on the panel were William G. Howard of Motorola and Charles E. Sporck of National Semiconductor.*

3. Panelists for the symposium on "Issues Facing Technical Education" were (left to right) Jerrier A. Haddad from IBM; James F. Gibbons from Stanford University; Donald N. Langenberg from NSF; and Matthew F. McHugh, U.S. Congressional representative from New York State, who served as moderator.

4. Representing the College at the symposium and the dedication was Dean Thomas E. Everhart, who is a specialist in microfabrication technology.

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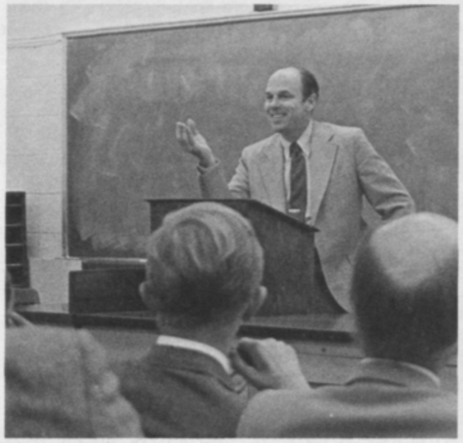

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5. The Knight Laboratory is constructed so as to meet the exacting requirements for research on devices and materials with features of submicrometer dimensions. Air quality in the "clean" rooms is controlled by a highly efficient filtering system; vibration-sensitive instruments are installed on floating inertial slabs; and electrically operated instruments are protected by voltage regulators and isolation transformers. The state-of-the-art capabilities of NRRFSS include very-high-resolution electron-beam lithography, thin-film growth and processing, and Auger microanalysis.

6 and 7. Facilities include a conference room and air-conditioned laboratories, where protective clothing helps preserve the dust-free environment.

8. The ground floor of the laboratory includes 7,500 square feet of "clean" laboratory and processing space (shaded). In addition, the two-story building provides 9,000 square feet of office and service space. (The instruments referred to on the floor plan as SEM, STEM, and SAM are, respectively, the scanning electron microscope, the scanning transmission electron microscope, and the scanning Auger microprobe.)

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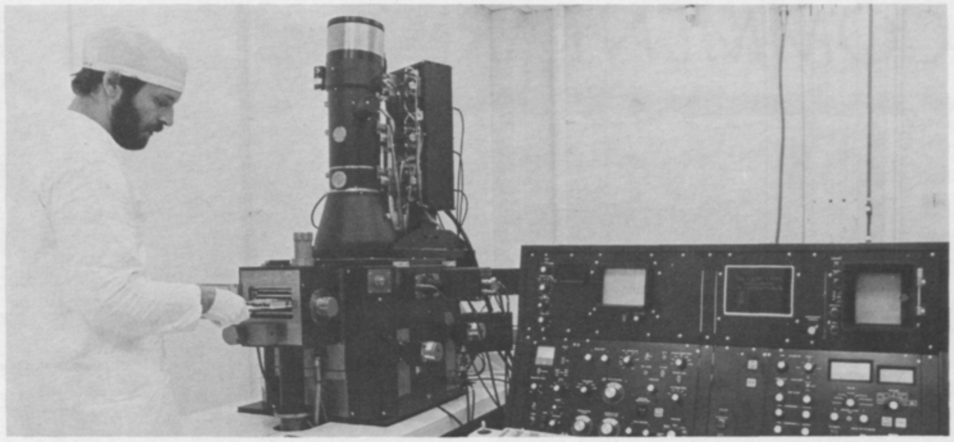

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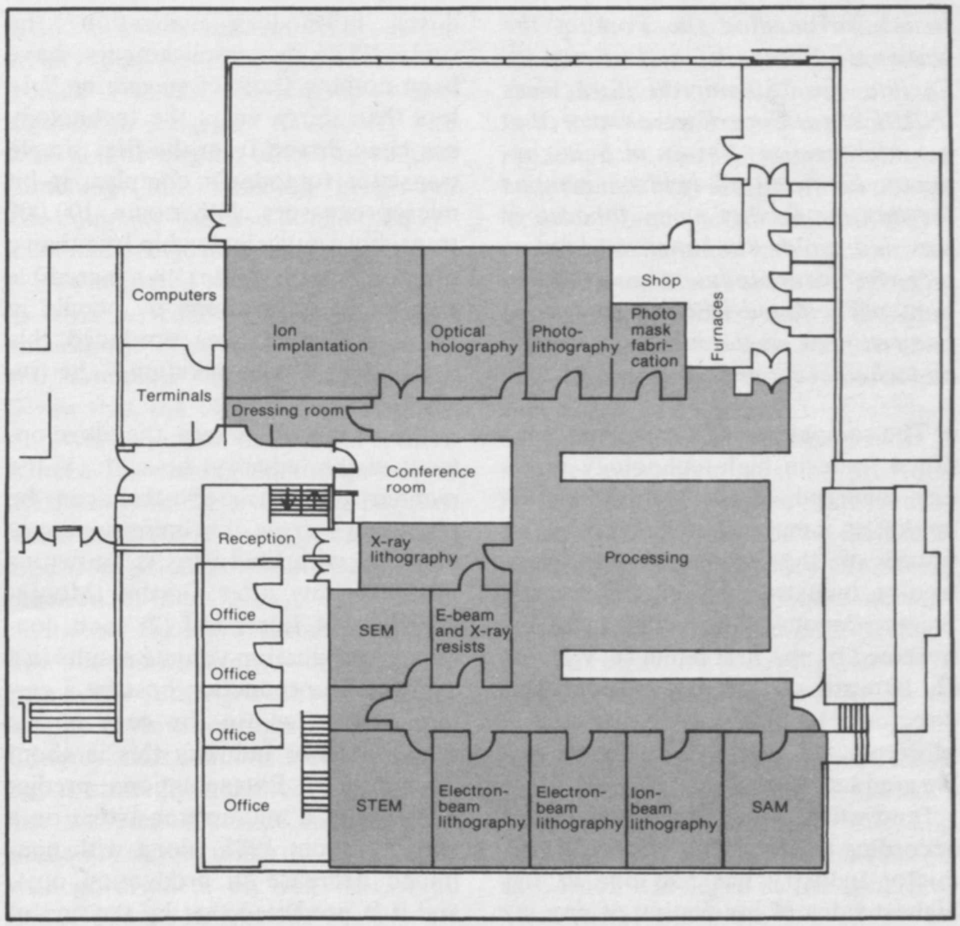

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COMMENTARY

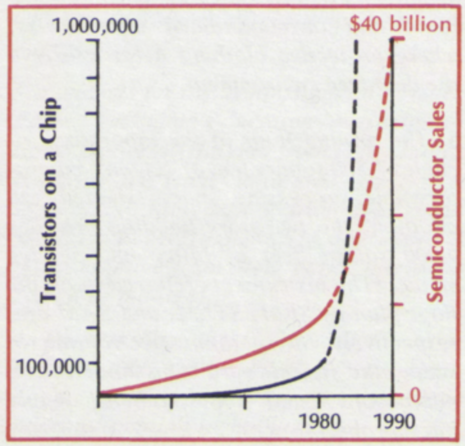
Issues in Semiconductor Electronics

Issues surrounding the work of the National Research and Resource Facility for Submicron Structures (NRRFSS) at Cornell were explored at a conference on "Issues in Semiconductor Electronics" held on campus the day the facility's new laboratory was dedicated. Six panelists, leaders in government, industry, and education, participated in two symposia—one centered on the industry and one on technical education.

■ The competition of Japan in international trade in high-technology products emerged, in the symposium remarks, as a major factor affecting the future of the semiconductor electronics industry and of the United States economy. The subject was introduced by the first panelist, William G. Howard, Jr., vice president and director of technology and planning at Motorola, Inc. (and a Cornell engineering graduate of 1964).

Innovation is the underlying issue, according to Howard. "The semiconductor industry has had one of the highest rates of innovation of any industry in modern civilization," he said. "The accomplishments have been nothing short of staggering." In less than thirty years the technology has been driven from the first simple transistor to today's complex 16-bit microprocessors with some 100,000 transistors on a single chip less than a quarter inch on a side. "An incredible number of innovations by people in many disciplines has produced this technological skyrocketing," he remarked.

Two "laws" govern the development of the industry, he said: (1) the number of transistors that can be placed on a single chip increases exponentially with time (this is known as Moore's Law after Gordon Moore, chairman of Intel) and (2) each doubling in production volume results in a decrease in production cost by a certain percentage (in the case of the semiconductor industry this is about 70 percent). Extrapolations predict densities of a million transistors on a chip by about 1985, along with continued decrease in production cost, and it is predicted that by the end of the decade, the semiconductor industry will have grown from the current level of $10 billion in annual sales to $40 billion. Of course, he pointed out, all of this assumes that innovation will continue at an ever higher rate.



Above: A representation (in black) of the exponential increase in transistors on a chip. This technical advance is accompanied by rising production volume, declining costs, and increases in sales. (The illustrative curves are based on data for 1981 and projections.)

An important factor in the growth of

Howard

"The accomplishments have been nothing short of staggering."

the industry, Howard said, is a continued supply of technical professionals; in accordance with the anticipated growth in sales, the need for a 15 to 20 percent annual increase in technical manpower is projected. "The universities must supply this manpower," he said, "since industry is ill equipped to provide employees with the well-rounded education necessary for basic work." Shortages are expected, however; a deficiency, by the end of the decade, of 179,000 technical people is predicted for the electronics industry.

Industry has exacerbated the personnel problem, he said, by hiring away professors (and potential professors). However, it is now understood that solutions must be found through highly cooperative efforts by industry, government, and academia, and it is in the best interests of industry to play a major role. This can be done by such means as motivating people to seek technical education and helping colleges and universities upgrade their facilities, faculties, and curricula. As an example, he cited Motorola's efforts to work with nearby universities in finding and interviewing prospective faculty members, planning microelectronics courses, developing work-experience programs for faculty and students, setting up laboratories, and launching joint research programs. The company has also donated equipment and provided scholarships.

Howard cited several other factors in what he called "the anatomy of innovation." One is the productivity and retention of technical people. Given that the size of the technical staff will be smaller in the future, there is need for making maximum use of what help will be available, he said. More computerization will help—and indeed, is a necessity—but *people* are required for innovation.

Another need is for a continuing free flow of information, "the seedbed from which future growth will sprout," despite a view recently expressed in Congress that semiconductor technology is strategic and should be treated like weapons. Perhaps industry and academia should undertake a dialogue with government on this unresolved issue, Howard suggested.

The third factor he listed is the management of size. In American corporations size tends to stifle innovation, he said, and "we must prevent bureaucratization." The Japanese seem to have found a way around this problem, he added, and though cultural differences must be taken into account, we in the United States are now beginning to try some remedies, such as breaking large organizations into smaller units and introducing employee-participation plans.

The financing of future growth is another need that must be provided for, Howard said. United States industry tends to be pressured by the financial community to produce short-term results (whereas the Japanese are willing to accept smaller initial profits), and "a continuing focus on short-term results could be a major inhibitor to semiconductor innovation."

Finally, there is need for increased basic research, Howard said. Industry looks to the universities for this, and programs such as that of the NRRFSS at Cornell will serve as the source of continuing innovation.

"International competition dwarfs all other factors."

Sporck

■ The United States' dependence on high technology and the competition from Japan were stressed by the second speaker, Charles E. Sporck, president of the National Semiconductor Corporation (and Cornell engineering graduate of the class of 1951).

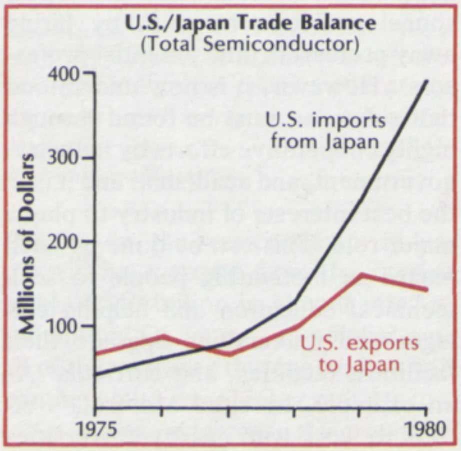
"International competition dwarfs all other factors," Sporck said, for "our position as an industrial power has been eroding at an accelerating rate." The United States is at the bottom of the list in rate of overall production growth; Japan leads. To compound the problem, our unit labor costs are skyrocketing relative to that same competitor, he said. In high-technology industries the United States is better off—the semiconductor industry still has a major share of the world market, although it is possible that productivity in this industry is growing even faster in Japan.

Problems of productivity can be addressed in three ways, he said: through people, through innovation in R&D, and through improvements in capital equipment.

Only recently have we begun to see any formal, committed effort on the part of corporate management to bring all employees into the direction of the companies, he said. "We have tended to use our employees' arms and legs and ignore their minds," creating a debilitating environment. Japanese firms, he remarked, have a broader understanding of motivation and efficiency, and the Japanese people have a better understanding of the importance of effective productivity performance. United States industries must make jobs more rewarding and utilize all capabilities. In addition, he said, management must work to change the current adversary attitude of the media. The universities' role is to see that their graduates have an understanding of economics and the good of industry ("which is responsible for jobs, for our standard of living, and for our defense"), and the opportunity to learn management skills.

In R&D we do better, he said, expanding more rapidly than the Japanese. The chief problem is in duplication of efforts. "I believe the Japanese get a bigger 'bang for the yen' that we do for the buck," he remarked. To improve efficiency, companies could undertake cooperative efforts. They could also help their R&D effort by making more use of the innovative ideas of the financial community, as in the formation of R&D partnerships, which offer tax shelter for investors. Obviously, R&D tax concessions help, but a drawback in the competitive situation is that the United States does not permit the kind of collaboration of government and industry that helps development in Japan. As an example, he mentioned a new $500-million investment by the Japanese government, aimed at development of a new architecture for computers.

Below: Since late 1976 the United States-Japan trade balance in semiconductor products has shifted in favor of Japan. The United States still leads the world in total semiconductor sales, however; in 1980 its market share was 63 percent, as compared with 15 percent for Japan and 22 percent for European countries. (Data source: U.S. Department of Commerce, SIA.)



Sporck agreed that the emphasis of United States banks on short-term profits hinders capital improvements. In Japan, by contrast, backing from the government Bank of Japan ensures that there is no such restriction on the availability of capital for expansion. The largest Japanese semiconductor company, for example, has essentially only broken even in profit performance for the past ten years. It must be recognized, Sporck said, that we do not operate in a free-trade world; the United States only acts that way. Actually, all other economies are directed. It is essential that our country develop an industrial policy, he said; "it is insane for the government to support milk prices but not the critical semiconductor industry."

"Once we address the need for an industrial policy," he said, "I am confident we will find ways to respond to the challenge, if for no other reason than that the alternative is unbelievably bleak for our economy in the future."

Falken

"The test of . . . federal trade policy is how well goods move across borders."

■ "Government is listening," commented Steven J. Falken, whose discussion centered on the development of federal trade policy through negotiation. Falken is director of economic analyses for United States industrial trade policy.

Until relatively recently, he said, there was no federal trade policy in relation to the semiconductor industry, and there still is no policy designed to promote particular industries (with the large exception of the agricultural sector). United States high-technology industries have been hampered by tariff and nontariff barriers.

In the six rounds of tariff negotiations that followed World War II, he explained, the United States did not seek tariff reductions on high-technology products because we did not have competitors at the time. But by the time the seventh round of negotiations opened in 1975, there were sharp disparities in tariffs on high-technology products. For example, the duty on semiconductors and active electronic components was 6 percent in the United States, 12 percent in Japan, and 17 percent in Europe. During this so-called "Tokyo round" of negotiations, the Japanese agreed to equalize semiconductor tariffs at 4.2 percent over an eight-year period. (Recently they agreed to accelerate this reduction to reach the 4.2 percent level by next spring.)

Better progress was made in reducing nontariff barriers. New codes were established for the assessment of customs duties, particularly in intercompany transactions, and for standards in matters such as product testing and certification. A third code opened up government procurement markets in certain sectors. "The test of the effectiveness of these codes, and of all federal trade policy," Falken noted, "is how well goods move across borders."

In regard to the future, he commented that "the new administration in Washington and the Congress are listening to the problems of the industries." There is recognition, he said, that "the semiconductor industry and related microtechnologies are essential to many industries and products, and important to the national security in both the defense sense and the economic and commercial sense."

Future United States negotiating efforts, he said, will encompass issues not only of tariffs, but of nontariff barriers such as those resulting from investment policies, sales of equipment, trade in services, and R&D subsidies. One factor that will receive attention, for instance, is the problem of government interventions that are not addressed by existing international trade law; an example is the Japanese government's subsidy of domestic R&D in high-technology goods.

"Business and industry are recognizing that . . . they must provide substantial help."

Langenberg

■ The national decline in graduate enrollments in engineering and applied sciences and the resulting shortages of technically proficient people in both industry and the universities was the chief subject of Donald N. Langenberg, deputy director of the National Science Foundation.

The dimensions of what has been called the crisis in engineering education are by now familiar, he said. Some signs could be construed as positive: the demand for places in undergraduate engineering schools has more than doubled in the last decade or so and appears to be still increasing, and the job situation for engineers is very good. On the other hand, the engineering schools are having increasing difficulty maintaining the ability to teach that flood of students.

A major difficulty is getting and keeping faculty, he said. This is partly because of salary competition from industry (graduates with baccalaureate degrees are getting salaries equivalent to what a university can pay an assistant professor). Also, because graduate enrollments are dropping, the opportunities to interact with research students are smaller. The availability of equipment for research is a factor in many institutions: estimates are that it would cost between $1 billion and $4 billion for facilities that would get academic research institutions back at the forefront of research activity. Another reason that academic careers are becoming less attractive, he suggested, is that bureaucratic "Mickey Mouse" red tape seems to be eroding the freedom that attracts people to universities. Problems in technical education extend also to fields other than engineering and to the pre-college levels, Langenberg remarked; unlike our international competitors, we in the United States are not providing adequate instruction in science and mathematics in our secondary schools.

Everybody, he said, must help solve these problems. In the area of education, this means that there must be some sort of coordination of the many units, public and private, of our decentralized school system. Business and industry are recognizing that as principal beneficiaries of education, they must provide substantial help. Of course, government at all levels is involved. At the federal level, there may be taking place what some have characterized as the largest fundamental change in direction since the early thirties; the underlying philosophical change includes the feeling that there has been too much federal involvement in all aspects of life, including education.

This attitude may affect the National Science Foundation, he indicated. NSF has been supporting and encouraging science and engineering education through graduate fellowships, programs for the professional development of teachers, and the provision of educational materials. The current administration has proposed to essentially eliminate funding for that part of the foundation's activities; alternative schemes have been proposed by members of Congress. However this issue is resolved, Langenberg said, NSF will continue to do what it can to help solve the problems of technical education.

STARTING SALARIES
of Cornell engineering graduates and faculty members in 1981

Average annual salaries accepted by graduates	
B.S.	$23,172
M.S. and M.Eng.	26,076
Ph.D.	33,156
Range of academic-year salaries for assistant professors	$23,000 to $25,000

Gibbons

"Good teaching and good research are tightly coupled."

■ The importance of high technology, "our great resource," was stressed by James F. Gibbons, professor of electrical engineering at Stanford University. High technology has an extraordinary importance in the economic future of the United States, he said, and many people are concerned that we are experiencing both a decline in productivity and an inability to focus on resources necessary to keep our country in the forefront of technology.

Unlike a resource like oil, he said, high technology is created, not found, and must be carefully nurtured. "The relationship among government, industry, and the universities will be more important in the next decade than it has ever been," he said; "we won't be able to get to first base with serious advances in technical education unless that relationship changes dramatically."

In considering the conditions needed to maintain the highest quality of science at universities, Gibbons quoted Harvard University president Derek Bok. These conditions are summarized as: sufficient opportunity for a satisfying career in science and engineering, especially at universities, to attract the most talented young people; the presence of first-rate scientists and the availability of proper instrumentation and facilities; the provision to scientists of time to concentrate fully on their work, able colleagues with whom to interact, and access to the body of scientific work; wide discretion in the choice of research topics; some process for assessing and maintaining the quality of research and teaching; and high morale. Awareness of these criteria has led a number of universities to conclude that in the area of semiconductor electronics, they must establish major new facilities such as NRRFSS at Cornell. "If the facilities are available only in industry, the faculty will have to work in industry," Gibbons pointed out.

A major problem, he said, is that the money needed for such facilities—in the range of $10 to $20 million—vastly exceeds the amounts universities are accustomed to spending. Furthermore, an equivalent level of annual research funding is needed for effective use of such facilities. Gibbons noted that in the area of semiconductor research, only about ten such university centers, each with an area of concentration, can be anticipated. He recommended that the costs of operating them be borne equally by industry and the federal government.

Ways in which universities could cooperate with industries to promote the further education of working professionals were also suggested by Gibbons. "Courses incorporating advances in research must be made available to people wherever they may be found," he said. For example, course work giving academic credit could be offered at industrial sites via video tape and a tutorial system. In fact, continuing-education programs along these lines have been successfully introduced by some universities.

Issues that face technical education are closely intertwined with the issues that face research, Gibbons commented, for "good teaching and good research are tightly coupled." The mandate for universities is to stress fundamental teaching and research and to encourage gifted students to continue their studies, he indicated, for extremely rapid progress can be made if truly gifted and appropriately educated people are encouraged to work in a particular area. As an example, he pointed out that the scientists and engineers who staffed the wartime university-based projects on radar-control systems were primarily people with strong backgrounds in fundamentals. "Because things are changing faster," he concluded, "university education will have to become increasingly basic."

"The essentials of engineering practice are good design, production, and distribution—not research."

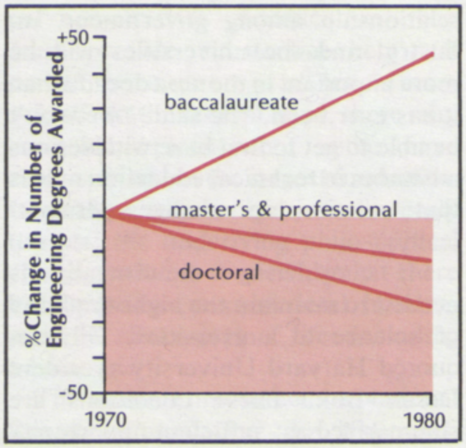
Haddad

■ "Pockets of trouble" exist in technical education, Jerrier A. Haddad told the symposium audience, but "the problems of engineering education will not be solved by the federal government or by industry" and, in fact, universities "don't want either to tell them how to run their institutions." Haddad, a consultant and vice president (retired) of the International Business Machines Corporation, is a Cornell engineering graduate and the current chairman of the Engineering College Council.

He agreed with previous speakers that the "pockets of trouble" include the decline in doctoral candidates—amounting to 24 percent over the past decade—and the accompanying difficulty in filling faculty positions. Two thousand of about twenty thousand available jobs were unfilled in 1980. The shortage is magnified by the fact that more than a third of the present Ph.D. students in technical subjects are non-United States citizens (the actual number has not gone up, only the percentage). In recruiting faculty members, universities must compete not only with other educational institutions, but with government and industry, Haddad pointed out, and because of factors such as salary, the availability of equipment, and teaching load, an academic career is "vastly less attractive than it was a decade ago."

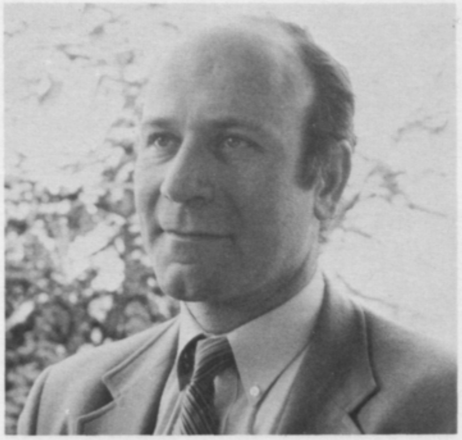
In reference to engineering educational programs, Haddad disagreed with the opinion that good teaching can be simply equated with good research, especially since research institutions are only part of the educational resource. "The essentials of engineering practice are good design, production, and distribution—not research," he said. An illustration of this is that the Japanese have practically taken over the home-electronics market, irrespective of United States achievements in semiconductor research. Engineering, he noted, is probably the only profession in which practitioners are not an intimate part of the educational system.

The basic problem of creating more engineers (and faculty members), he pointed out, will not be helped by R&D subsidies that will only increase competition for technical professionals. He concluded that although there may be a delay, the problem will be solved ultimately by the workings of the free-market economy.



Above: A schematic representation of how the numbers of engineering graduates have changed from 1970 to 1980. A shortage of advanced-degree graduates is already being felt by both industry and the universities.

Birnbaum



Four Leaders Join Council

Three industrial leaders—all Cornell engineering alumni—and a former Cornell president and engineering dean have recently joined the Engineering College Council, the advisory board for the College.

The new counsellors are *Joel S. Birnbaum,* director of the Computer Research Center at the Hewlett-Packard Laboratories in Palo Alto, California; *Martin Goland,* president of the Southwest Research Institute in San Antonio, Texas; *Charles F. Knight,* chairman and chief executive officer of the Emerson Electric Company in St. Louis, Missouri; and *Dale R. Corson,* president emeritus and chancellor of Cornell University.

The twenty-one-member council is chaired by Jerrier A. Haddad, consultant and vice president (retired) of the International Business Machines Corporation, Armonk, New York.

■ Birnbaum studied at Cornell for the B.S. degree in engineering physics, awarded in 1960. He did his graduate work in experimental nuclear physics at Yale University, earning the M.S. in 1961 and the Ph.D. in 1965. After receiving the doctorate, he joined the Thomas J. Watson Research Laboratory of the International Business Machines Corporation, where he worked on various projects involving data-acquisition and control systems, processor design, communication systems, and programming productivity. In the early 1970s he headed a large-scale project to design a digital central telephone exchange that resulted in new technology in the controller, switching, operating-system, and signal-processing areas; and in 1975 he became director of computer science, responsible for a wide range of projects and some 350 people. He has been at Hewlett-Packard since late 1980.

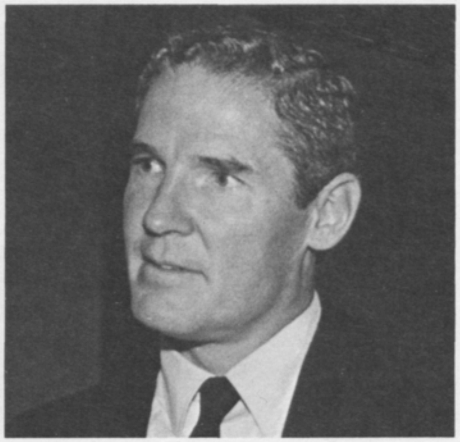
Birnbaum serves on the Computer Science Board of the United States, the steering committee of CSNET (an emerging network of computer science research organizations), and the Socio-Technical Commission of the National Academy of Sciences. He is a member of the Association for Computing Machinery and the Institute of Electrical & Electronics Engineers.

■ Goland earned the degree of Mechanical Engineer at Cornell in 1946, served as an instructor here for two years, and then proceeded to develop an industrial and research career in the fields of aircraft design, applied mechanics, and operations research. He was first employed at the Curtiss-Wright Corporation, joined the Midwest Research Institute in 1946, and has been at Southwest Research Institute since 1955, serving as president since 1959. He is also president of the associated Southwest Foundation for Research and Education, a biomedical institute.

Goland is active as an advisory board member or consultant to numerous industrial, business, educational, and government organizations. He has written more than sixty professional papers and has won a number of awards in both the civil and mechanical branches of his discipline. He is a member of the National Academy of Engineering; a fellow, past president, and director of the American Institute of Aeronautics and Astronautics; a fellow of the American Association for

Goland

Knight



Corson

the Advancement of Science; and a member of several other professional and honorary societies. He holds an honorary doctorate from St. Mary's University.

■ Knight studied both engineering and business at Cornell: he earned the degrees of Bachelor of Mechanical Engineering in 1958 and Master of Business Administration in 1959, and then proceeded to develop a career in engineering-based industrial management. After twelve years with his father's engineering consulting firm, Lester B. Knight and Associates of Chicago, he joined the Emerson Electric Company, which he now heads.

Charles is a director of a number of firms in addition to Emerson Electric. He is also active in community affairs in St. Louis, serving as a director of the Barnes Hospital, the Arts and Education Council of Greater St. Louis, and the United Way, and as a member of the Boy Scouts council. He is a trustee of Washington University.

Honors he has received reflect both his business and community accomplishments. He was a recipient in 1977 of a *Dun's Review* One of Five Best Managed Companies Award and in 1978 he received the Excellence in Management Award given by *Industry Week*. He has also received the St. Louis Award, the St. Louis Argus Award for Outstanding Service, and, on two occasions the Special Humanitarian Award from the Human Development Corporation. He has been awarded an honorary Doctor of Law degree from the University of Missouri in St. Louis.

■ Corson was dean of the College of Engineering from 1959 to 1963, when he became provost of the University; he was president from 1969 to 1977. He first came to Cornell in 1946 as a member of the Department of Physics, which he later served as chairman.

His professional work has included participation in cyclotron design and construction at Berkeley and in synchrotron construction at Cornell. He was a radar specialist at the M.I.T. radiation laboratory, served as a consultant to the Air Force during World War II, and worked at the Los Alamos Scientific Laboratory. He has written extensively on scientific and educational subjects; among his publications is the book *Electromagnetic Fields and Waves*. In recognition of his contributions to engineering, education, and the national welfare, he was elected earlier this year to the National Academy of Engineers.

Corson's recent activities have included participation in a national study of university-government relations. Also, he was chairman of a National Academy of Sciences committee that studied satellite power systems. He serves on the boards of trustees of Deep Springs College in California and of the Museum of Northern Arizona, and he is a member of the Science Advisory Committee of the Whitaker Foundation, sponsor of biomedical research. At Cornell last year he headed the Faculty Committee on Music.

His academic degrees are from the College of Emporia in Kansas, the University of Kansas, and the University of California at Berkeley, which awarded him the doctorate in physics.

New Faces: Dean, Librarian, Trustee

■ *William B. Streett*, professor of chemical engineering, was appointed an associate dean of the College this fall (replacing Daniel P. Loucks, who is on leave). The responsibilities of this office are to coordinate the research programs and to facilitate graduate education.

Streett came to Cornell in 1978 from the U.S. Military Academy at West Point, where he had been a faculty member for more than fifteen years. He founded the Science Research Laboratory at West Point and served as its director until his retirement from the Army. He was graduated from the Academy in 1955 and subsequently earned the M.S. and Ph.D. degrees in mechanical engineering at the University of Michigan.

Streett

His research includes experimental studies of fluids at high pressures and computer simulation studies of molecular liquids; he has published more than sixty papers in these fields. He has held NATO and Guggenheim fellowships for research at Oxford University.

■ *Susan Markowitz* became head of the Engineering Library this fall. She previously served at Cornell's Olin Library as head of the science and technology cataloging team and, most recently, as a member of the reference division at Mann Library. Her major responsibility at Mann was the development of an online search service, and she has trained a number of Cornell librarians in the techniques. Earlier she worked at Cornell as a technical aide in the Office of Computer Services, and she has assisted in educational projects at Syracuse University, taught mathematics in junior high school, and worked as a computer programmer and analyst for a bank.

Markowitz holds the A.B. degree in chemistry from Brown University, the M.S. in mathematics education from Syracuse, and the M.L.S. with a major in information studies from Syracuse.

■ *Steven N. Nesterak, Jr.*, a civil and environmental engineering junior, began a term on the University Board of Trustees this fall. The seat was vacated early this semester with the resignation of a trustee elected by campus-wide student vote last year, and the Student Assembly decided to select a replacement by running the results of the hare-system balloting through the computer with the elimination of the resigned student's name. Nesterak emerged as the winner.

In an interview following his election, Nesterak said he believes students should be well informed so that they understand the rationale behind budget decisions, and should have input to the decision-making process.

New Professors Augment Engineering Faculty

Fifteen professors in six schools and departments joined the Cornell engineering faculty this fall.

■ The largest number is in the School of Electrical Engineering. New associate professors are *C. Richard Johnson, Jr.*, and *J. Peter Krusius*. Assistant professors are *Chris D. Heegard, Paul M. Kintner*, and *Charles E. Seyler*.

Johnson, a specialist in adaptive system theory and control theory, came to Cornell from the Virginia Polytechnic Institute and State University, where he had been an assistant professor since 1977. He received the B.E.E. degree with high honor from the Georgia Institute of Technology in 1973 and did his graduate work at Stanford University. His Ph.D. was in electrical engineering, with minors in engineering-economic systems and in art history. He has directed research projects funded by NASA and NSF, and he was a curriculum consultant for a National Endowment for the Humanities study on the "changing role of humanities in a land-grant university."

Krusius, a native of Finland, was educated at the Helsinki University of Technology, specializing in electron physics. He earned the Diploma Engineer in 1969, the Licentiate of Technology in 1972, and the Doctor of Technology in 1975. Subsequently, he served as a postdoctoral fellow in solid-state physics at Dortmund University in West Germany. He returned to Finland as a lecturer and engineer at the Electron Physics Laboratory of the Helsinki University of Technology and also as a senior research associate at the Semiconductor Laboratory of the Technical Research Center of Finland in Otaniemi. He came to Cornell in 1979 to work at the National Research and Resource Facility for Submicron Structures, first as a Fulbright fellow and later as a research associate and lecturer in electrical engineering. The research in which he participated at NRRFSS included a project, sponsored by the Department of Energy, on very-high-speed integrated circuits (VHSIC).

Heegard received his Ph.D. in electrical engineering this spring from Stanford University, where he conducted research in the areas of information and coding theory. He earned the B.S. and M.S. degrees at the University of Massachusetts at Amherst in electrical and computer engineering, and then worked for two years as a development engineer in satellite communications at Linkabit Corporation before beginning his doctoral studies.

Kintner has been at Cornell since 1976 as a senior research associate, working with Professor Michael C. Kelley on studies of the upper atmosphere, including rocket and balloon experiments, and as a lecturer in electrical engineering. He holds the B.S. degree in physics from the University of Rochester and the Ph.D. in physics from the University of Minnesota, and he served for two years as a research associate in physics and astronomy at the University of Iowa. His research experience has included work in nonlinear plasmas, plasma waves, and physics of the magnetosphere, ionosphere, and upper atmosphere.

Seyler received the Ph.D. in plasma

physics from the University of Iowa in 1975 and subsequently served as a research scientist at New York University's Courant Institute of Mathematical Sciences and as a staff member of the Los Alamos Scientific Laboratory. He has also been a visiting scientist at the Culham Laboratory in Abingdon, England. His research has been in the areas of turbulence theory and the physics of controlled thermonuclear plasmas. His predoctoral degrees in physics are from the University of South Florida.

■ New assistant professors in the Department of Theoretical and Applied Mechanics are *Chung Yuen Hui* and *Andy L. Ruina.*

Hui, a native of Hong Kong, received his Ph.D. in applied mechanics from Harvard University in June, and continued there as a postdoctoral fellow through the summer. He attended the University of Wisconsin for his undergraduate degree in physics and mathematics, granted in 1975. His research has included studies of crack formation in creeping materials.

Ruina, a specialist in rock friction and fracture, was educated at Brown University; he received the Sc.B. degree in mechanical systems in 1976, the Sc.M. in 1978, and the Ph.D. in applied mechanics in 1980. Last year he was a visiting assistant professor at Cornell. His experience also includes work as a geophysicist with the Hazards Reduction Laboratory of the U.S. Geological Survey.

■ *Donald W. Henderson* is an acting assistant professor in the Department of Materials Science and Engineering. He completed his doctoral studies in the same department in January 1981, after teaching for several years as a graduate assistant, instructor, and visiting assistant professor. His present interests include the mechanical and thermal properties of amorphous materials, the viscosity and crystallization kinetics of glass-forming melts, and the techniques of differential calorimetry. He received the B.S. degree in electrical engineering from the University of Pennsylvania.

■ At the School of Mechanical and Aerospace Engineering, a new assistant professor is *Ming-chuan Leu,* who received his Ph.D. in mechanical engineering from the University of California at Berkeley this past summer. A native of Taiwan, he studied at National Taiwan University for the B.S. degree in mechanical engineering, awarded in 1972. After completing ROTC training, he taught at that university for a year before entering graduate school at Pennsylvania State University, which awarded him the M.S. degree in 1977. His doctoral research was on the generation and suppression of vibration and noise in circular saws. A paper of his based on this research won second prize in the 1981 Wood Award competition of the Forest Products Research Society.

■ The Department of Computer Science has four new assistant professors—*Ozalp Babaoglu, Thomas F. Coleman, Paul A. Pritchard,* and *M. Dale Skeen.*

Babaoglu recently completed his doctoral work in computer science at the University of California at Berkeley. He earned the M.S. degree there in 1977, and the B.S. in electrical engineering at George Washington University in 1976. Last year he spent six months as a visiting foreign fellow at the University of Pavia, Italy. His research interests are in the fields of operating systems and performance modeling. He is a native of Turkey.

Coleman came to Cornell from the Argonne National Laboratory, where he had been a computer scientist since 1979. He holds three degrees in mathematics from the University of Waterloo, Canada: the bachelor's (1975), the master's (1976), and the Ph.D. (1979). His research interests are in the fields of numerical optimization, numerical analysis, and graph theory.

Pritchard, who was born in Australia, earned the B.Sc. (with honors) and the M.Sc. degrees at the University of Melbourne, and the Ph.D., granted in 1980, at the Australian National University. Last year he taught computer science at the University of Queensland. His research is in the area of programming methodology.

Skeen, a specialist in distributed

database systems, expects to receive the Ph.D. in computer science from the University of California at Berkeley in late 1981. He was graduated from North Carolina State University in 1976 with a B.S. degree in computer science. He has taught at San Francisco State University and was recently a consultant to the Friden Equipment Company in Oakland.

■ At the School of Civil and Environmental Engineering, new faculty members are Associate Professor *Isao Ishibashi* and Assistant Professor *Leonard W. Lion*.

Ishibashi, a specialist in geotechnical and earthquake engineering, received the Ph.D. in civil engineering from the University of Washington in 1974 and was a member of that department until he came to Cornell this fall. He has also had experience as a geotechnical engineer with Shannon and Wilson, Inc., of Seattle. He studied at Nagoya University in Japan for the B.S. and M.S. degrees in civil engineering, granted in 1968 and 1970, respectively.

Lion did his graduate work at Stanford University, earning the M.S. in environmental engineering in 1971 and the Ph.D. in environmental science in 1980, and last year he was a postdoctoral research associate there. His undergraduate degree, in civil engineering, is from Loyola University. His research interests are in the areas of air-sea interaction and the biochemical fate of pollutant trace metals. His research experience includes two years at the Environmental Protection Agency's Office of Solid Waste Management Programs.

Arthur M. Bueche 1920-1981

Arthur M. Bueche, senior vice president for corporate technology at the General Electric Company and a member of Cornell's Engineering College Council for the past fifteen years, died October 20 at the age of sixty. He had been on campus a few days earlier to attend a meeting of the council, which he had served as chairman from 1975 until the spring of this year. (The accompanying photograph was taken during that visit).

Bueche joined General Electric in 1950 and became senior vice president in 1978, serving as the company's principal technical officer and a member of the corporate executive council. He was recognized as a major innovator in technological development, planning, and management, and was known internationally as a spokesman on technology and energy policy.

He was a member of both the National Academy of Sciences and the National Academy of Engineering and a fellow of the American Physical Society, and he was active in a wide range of professional and civic organizations. He served on advisory committees to the National Science Foundation, the National Research Council, the National Bureau of Standards, the National Governors' Council on Science and Technology, and the United States Air Force, and was a member of advisory groups to many educational institutions in addition to Cornell. Five institutions of higher education had awarded him honorary doctorates.

Bueche studied at the University of Michigan for the B.S. degree in chemistry. His Cornell connections stem from his doctoral and postdoctoral study in physical chemistry; he received the Ph.D. degree in 1947 and remained as a research associate for three years before joining the staff of General Electric's research laboratory. His early specialties were the physics and chemistry of polymers and the effects of high-energy radiation on plastic materials.

Under his leadership at General Electric, research and development resulted in a wide variety of new products, including plastics, lamps, and solid-state devices, and in new technology for medicine, data handling, and the generation, delivery, and utilization of electricity.

His survivors include three daughters and a son.

FACULTY PUBLICATIONS

Current research activities at the Cornell College of Engineering are represented by the following publications and conference papers that appeared or were presented during the six-month period March through August, 1981. (Earlier entries omitted from previous *Quarterly* listings are included here with the year of publication in parentheses.) The names of Cornell personnel are in italics.

■ AGRICULTURAL ENGINEERING

Baker, R. C.; Darfler, J. M.; and *Rehkugler, G. E.* 1981. Electrical energy used and time consumed when cooking foods by various home methods: Chickens. *Poultry Science* 60:2062–70.

Bland, R. R.; Martin, J. H.; and *Loehr, R. C.* 1981. Treatment of milking center wastewaters in facultative ponds. In *Livestock waste: A renewable resource,* pp. 221–24. St. Joseph, Mich.: American Society of Agricultural Engineers.

Haith, D. A., and *Loehr, R. C.* 1981. The role of soil and water conservation practices in water quality control. In *Environmental management of agricultural watersheds,* ed. G. Golubev, pp. 462–85. Oxford: Pergamon.

Hayes, T. D.; Jewell, W. J.; Dell'Orto, S.; Fanfoni, K. J.; Leuschner, A. P.; and *Sherman, D. F.* (1980). Anaerobic digestion of cattle manure. In *Proceedings of 1st international symposium on anaerobic digestion.* ed. D. A. Stafford, B. I. Wheatley, and D. E. Hughes, pp. 255–88. London: Applied Science Publishers.

Jewell, W. J. (1980). Future trends in digester design. In *Proceedings of 1st international symposium on anaerobic digestion,* ed. D. A. Stafford, B. I. Wheatley, and D. E. Hughes, pp. 467–91. London: Applied Science Publishers.

———. 1981. Designing Land Application of Sewage Sludge Systems. Paper read at Design for the Eighties, a Problem-Oriented Workshop, 20 March 1981, at Vanderbilt University, Nashville, Tenn.

Jewell, W. J.; Cummings, R. J.; Dell'Orto, S.; Fanfoni, K. J.; Fast, S. J.; Jackson, D. A.; Kabrick, R. M.; and *Metzger, J.* 1981. *Low cost approach to methane generation, storage and utilization from crop and animal residues.* Solar Energy Research Institute report XB-0-9038-1-5.

Jewell, W. J.; Dell'Orto, S.; Fanfoni, K. J.; Fast, S.; Jackson, D.; and *Kabrick, R. M.* 1981. Dry Anaerobic Methane Fermentation. Paper read at Biogas and Alcohol Fuels Seminar, 13 March 1981, in Chicago, Ill.

Jewell, W. J.; Dell'Orto, S.; Fanfoni, K. J.; and *Kabrick, R. M.* 1981. Economics of plug flow methane reactors. In *Proceedings of the methane technology for agriculture conference,* pp. 181–207. Ithaca, N.Y.: Northeast Regional Agricultural Engineering Service.

Jewell, W. J., and *Kabrick, R. M.* 1981. Combined Biological-Chemical Treatment for the Detoxification of Sludges. Paper read at Design for the Eighties, a Problem-Oriented Workshop, 20 March 1981, at Vanderbilt University, Nashville, Tenn.

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LETTERS

Professionalism and Specialization

Editor: I enjoyed reading the thought-provoking article on engineering education by Stuart Brown and Walter Lynn, and strongly agree with their recommendations for providing "better professionals, capable of practicing engineering as a specialty and as a social and moral enterprise." I am hopeful that M.I.T.'s new Program in Science, Technology and Society will help advance some of the things Brown and Lynn suggest. I am doubtful, though, about the motivation of engineering faculties in learning how to "discuss moral and social issues seriously and cogently." Pressure coming from outside the universities may be required.
Alan F. White
Director of Executive Development Programs
Massachusetts Institute of Technology
Cambridge, Massachusetts

Beauty and the Sundial

Editor: Now that the subject of beauty has been raised [in connection with the new sundial, designed by Dale Corson, on the engineering quadrangle], you might be interested to know that Dean Dexter Kimball cited two other types of beauty [in addition to "beauty of purpose," exemplified by the single-bitted ax handle], the names of which I have been trying to establish since graduation. The examples he gave were: (1) a sheaf of wheat and (2) a carving of a plume on the back of a rocking chair. The lectures in which these three types of beauty were discussed were in Kimball's one-hour freshman course given in Sibley Hall in the fall of 1924. Perhaps the sheaf of wheat could be illustrative of "beauty of Nature", but what is the second? Can any of your readers help?
Joseph H. DeFrees '29, President
Allegheny Valve Company
Warren, Pennsylvania

The New Curriculum

Editor: As a Cornell graduate (Arts '59), high school French teacher, and the mother of four sons, I was very interested in Dean Malcolm S. Burton's article about curricular changes in the College of Engineering at Cornell. Although I was a French major at Cornell, I very much enjoyed the math and science courses I took in public high school . . . and I originally wanted to be an engineer. Because of my personal experience and attitude, I do not understand your reference to the humanists who "venture timidly or not at all into the analytical world of scientists and engineers". (Also, I imagine that any linguist at Cornell would question your implication that his field was not "analytical". A historian or economist or literary critic might take the same exception.) I missed being able to take physics until we studied Pascal in French literature—he was both a humanist and a physicist, and he was comforting.

I was surprised to read on a Cornell information sheet for prospective applicants for admission that the college preparatory suggestions for the College of Engineering [do not include foreign languages] . . . . I am surprised that as American businesses become more and more active on the international level, and more and more American engineers are exposed to foreign engineers, colleges of engineering are not already recommending that potential entrants and graduates develop fluency in a second language. Although a case for a reading knowledge of a foreign language can no longer be made on the grounds that it is necessary for the acquisition of technical knowledge (most articles and texts being easily available, if not originally written, in English), I would think a strong case could be made for the necessity of better person-to-person communication among scientists and technicians. I think we are at a disadvantage when our international associates can speak our language as well as their own, but we can only speak our own.

I wonder if many educators are aware of the improvements that have been made in foreign language instruction in the past twenty years . . . . If a student has two or three good years of study at the high school level in one language, he can attain the goal of fluency by one or two more years of study at the college level . . . .
Celinda Cass Scott
Russell, Kentucky

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