Ingenuity in the Classroom /2

As the engineer finds himself faced with shifting priorities and the need for broader insights into his daily responsibilities, so too do the educators. At Cornell ingenuity in meeting these challenges takes various forms—new teaching "hardware," new strategies and course formats, revitalization of traditional courses, greater curriculum flexibility, and, most notably, new attitudes about the functions of education. Here we report on some interesting departures from classroom norms.

1 MINI COURSES
   Professors Doing Their Own Thing /5

2 SOCIAL AWARENESS
   A New Priority for Engineers /10

3 TEACHING ATTITUDES
   Thermodynamics with Meaning /15

4 NEW TEACHING TOOLS
   Technology Enters the Classroom /20

5 BROADENING THE PERSPECTIVES
   Law and Environmental Control /25

Register /28

Jack E. Oliver, newly appointed Irving Porter Church Professor of Engineering and chairman of a new intercollege Department of Geological Sciences, is featured in the Register. Other sketches are of faculty members who have been appointed to new positions within the College of Engineering.

Faculty Publications /33

Engineering: Cornell Quarterly, Vol. 6, No. 1, Spring 1971. Published four times a year, in spring, summer, autumn, and winter, by the College of Engineering, Carpenter Hall, Campus Road, Cornell University, Ithaca, New York 14850. Second-class postage paid at Ithaca, New York. Subscription rate: $2.50 per year.

Opposite: Slides and a taped lesson are used by a student in the Materials Learning Center at the College of Engineering (see p. 20). Behind the individual carrel is a "forest" of molecular models used for experimental work in the course.
INGENUITY IN THE CLASSROOM

by Donald F. Berth and Gladys J. McConkey

Ideas that affect engineering education and the profession itself germinate not only in departmental offices, committee rooms, and research laboratories, but within individuals. At the College of Engineering, ideas developed by individual members of the faculty are being tested in the classroom. Some of these experimental ventures are attempts to increase the efficiency and effectiveness of teaching or to help students get a feel for the complexity of modern engineering. Some of the most important, we feel, constitute a response to the increasing need for technical specialists who have an understanding of the broad context of their work.

And so we have taken a departure in format for this issue. Instead of featuring expository articles by faculty members, we are taking a look at what some of these professors are doing in their classrooms. The five courses we chose to write about are not typical ones; rather, they are innovative courses which may offer some alternatives to traditional curriculum patterns and teaching approaches in engineering education.

A WINDOW ON THE WORLD OF ENGINEERING

First, we take a look at the “mini course” program of the freshman year. In this venture more than twenty-five faculty members collaborate to provide an overall view of engineering and an insight into particular aspects of it. Each professor works in his own special area with a small group of a dozen or so students, using projects, field trips, and seminar-type discussions to help form an introduction to his area of interest. This program of Freshman Mini Courses is an attempt to meet the challenge of how to effectively introduce “engineering” to freshmen—an important and continuing concern of every engineering school. Students begin their education with high expectations, and they need to feel a sense of excitement and to form (or, more often these days, reinforce) their concepts of the engineering profession. Some want it to be bigger than it really is or can be, and some want it too specific for their own good. This is, we think, the area where vitality, good strategy, and enthusiasm for teaching are most needed, but often lacking.

ENGINEERS IN THE SOCIAL-TECHNOLOGICAL SQUEEZE

A few years ago the press and the public began to become more conscious of and vocal about the secondary—and frequently negative—effects of technological advances. Perhaps partly because of political naivete, or the notion that technology breeds more technology, or just because they are the most visible promulgators of technology, engineers rapidly became the “bad guys.” Many engineering educators were concerned about public issues such as environmental deterioration, the magnitude of spending for space exploration, and national defense policies, and they felt a need to examine and explore the whole area of interaction between technology and the public good. It was in this context that the College of Engineering introduced the undergraduate course, Social Implications of Technology. The course dealt in generalizations at first, partly to sensitize young engineers to “seeing
beyond their noses,” but it is gradually moving in the direction of detailed study of specific issues, viewed from social-political and humane as well as technological points of view. As in the “mini courses,” a number of faculty members participate as volunteer group leaders in this course.

NEW DIMENSIONS OF AN ESTABLISHED COURSE

Some educators—often too few in the present era of specialist expertise—have the spark and versatility of a modern Renaissance man. Bart Conta, professor of thermal engineering, is one of these. Long popular as a teacher and appreciated as an individual, he has been able to breathe life into a subject many of us remember as rather dry stuff: thermodynamics. This year he decided to experiment with a new way of looking at thermo—from a historical and intellectual perspective. We chose to write about Conta’s course, The Nature of Thermodynamics, for two reasons: to show how innovation can be brought to bear even on a “shopworn” but “necessary” subject,
and to suggest through an exploration of this professor's interests, experiences, and personal attributes how the quality and outlook of the teacher can contribute to course rejuvenation.

TECHNOLOGY ENTERS THE CLASSROOM

Modern engineered hardware designed to enhance or supplement the more traditional "chalk and talk" classroom methods might appear to be a natural for an engineering teacher, but until Arthur Ruoff decided to experiment with new teaching techniques, very little along these lines had been tried in the Cornell College of Engineering. Supported by a grant from the Ford Foundation, Ruoff introduced this spring a new course, Elements of Materials Science, in which "hardware" and "software" replace the traditional lecture-recitation format, and in which students can set their own learning pace. Ruoff is attempting to find ways of providing quality education in the face of escalating costs, as well as of avoiding the traditional "lock-step" methods of instruction. The course was offered, along with a large number of social and natural sciences, as a freshman elective subject, and it was chosen by more than one hundred students. Only second-term chemistry, long an established part of the engineering curriculum and dropped only this year as a requirement, drew more interest.

NEW "TOOLS" FOR ENGINEERING IN THE PUBLIC SECTOR

The complexities and extent of contemporary public problems with a technological component have required that the modern engineer be knowledgeable in areas beyond the limits of his expertise. In many cases, the engineer who is able to cope with social, economic, or political factors can function most effectively, both technically and humanely. One way in which an expanded outlook can be cultivated in prospective engineers is through course work which promotes an understanding of the legal ramifications of technology; accordingly, The Law and Environmental Engineering, of particular value to civil engineers, was introduced into the College's offerings this year. The crucial requirement for an interdisciplinary course of this sort is a teacher who is proficient in both areas and who has a highly developed sense of their interaction and impact on society. Such a man is Philip Bermano—lawyer, engineer, and city planner by education and inclination.

Departures from the norm, academic or otherwise, always require proponents with imagination, drive, and the willingness to take a chance. Required too is a degree of restlessness that comes from an awareness of what needs to be done and a feeling of responsibility for doing something about it. Competence and personal magnetism are also assets for an innovator. But in the end the real determinant of success or failure is whether the effort has made a difference. We believe that the educators we have written about are among those who are making a difference in the competence and outlook of tomorrow's Cornell engineers.

Articles 1 and 5 are by Mr. Berth and 2, 3, and 4 are by Mrs. McConkey.
It was one of those dreary spring days in Ithaca—raining and cold outside. Inside Hollister Hall, room 201, a group of freshmen were gathering for an afternoon engineering course called Waiting and What Can Be Done About It. Nearly all of the early arrivals, some dozen in all, were poring over computer printouts of a problem assigned by Professor Shaler Stidham, Jr., a week before. It seemed to have something to do with efficiency of service in a cafeteria. "A straight cafeteria would be easier." "Straight cafeteria?" "Right." Engineering, I wondered? Most students were trying to figure out why their programs for the solution of the problem had been rejected by the computer. A couple of them were heard to comment that they had run out of money in their computing accounts. One student, either self-sufficient or indifferent to the banterings before Stidham arrived, was busy reading poetry. Another was gulping down the remains of his lunch, sipping at a can of orange soda. Two girls were in the group; one was intensely involved in the "debugging" discussions and the other seemed entranced in "spring fever."

Stidham appeared a minute or two before 2:30 p.m., when the class was to begin. All were present and accounted for, and all seemed interested in getting on with the business of the day, which turned out to be a one and one-half-hour discussion of deterministic versus probabilistic models of queuing (waiting line) systems. "Remember, probability can be thought of as 'area,' if you like," commented Stidham, "and if the arrival rate (of traffic) is less than the service rate, a state of stability in probability is hit." The explanation proceeded with derivations of proofs of some theorems in probability that would enable these freshmen to extend their acuity to "waiting line" problems of greater complexity than that of the simulated cafeteria. What was really being given was a rudimentary introduction to techniques in operations research. Shaler Stidham, a young assistant professor, holds a joint appointment in operations research and environmental engineering.

What was remarkable was that the class, with one or two exceptions, was
1970-71 CORNELL FRESHMAN MINI-COURSE OFFERINGS

AN ENGINEER AND AN ENGINEERING PROJECT
Yih-Hsing Pao, Theoretical and Applied Mechanics

MICRO-STRUCTURE OF CONSTRUCTION MATERIALS
Floyd O. Slate, Civil and Environmental Engineering

TECHNOLOGY ASSESSMENT: A MAJOR PROBLEM OF MODERN SOCIETY
Byron W. Saunders, Industrial Engineering and Operations Research

FRESH WATER FOR THE FUTURE
Robert L. Von Berg, Chemical Engineering

MATERIALS AND STRUCTURES FOR SPACE PROPULSION SYSTEMS
E. N. Scala, Materials Science and Engineering

EXPERIMENTAL COMPARISON OF EFFICIENCY OF PROGRAMMING LANGUAGES
Richard W. Conway, Computer Science

MEN, MACHINES, AND CHEMICAL SYSTEMS
Raymond G. Thorpe, Chemical Engineering

PLANNING FOR THE ENVIRONMENT
Donald J. Belcher, Civil and Environmental Engineering

ENGINEERING IN THE URBAN ENVIRONMENT
James Porter, Visiting Lecturer, Abcor, Inc., Cambridge, Massachusetts

ENGINEERING IN SOCIETY
Ralph Bolgiano, Jr., Electrical Engineering

CULTIVATION OF CELLS IN THE SERVICE OF MAN
Robert K. Finn, Chemical Engineering

MAN-MACHINE SYSTEMS FOR PRODUCING MATERIAL GOODS
Roger L. Geer, Mechanical Engineering

RECYCLE OF AUTO HULKS
Charles S. ReVelle, Environmental Systems Engineering

POLLUTION ABATEMENT AT A COMPLEX RESEARCH LABORATORY
Vaughn C. Behn, Water Resources Engineering

ENERGY AND THE ENVIRONMENT
Simpson Linke, Electrical Engineering

ENGINEERING CONCEPTS: THE BASIS OF ENGINEERING
Solomon C. Hollister, Professor Emeritus, Civil and Environmental Engineering

STRUCTURES: PRESENT AND FUTURE
William McGuire, Structural Engineering

CRITICAL ANALYSIS OF DEMAND FOR ELECTRICITY
David D. Clark and K. Bingham Cady, Applied Physics

COMPUTER APPRECIATION
Daniel J. Aneshansley, Electrical Engineering

WAITING AND WHAT CAN BE DONE ABOUT IT
Shaler Stidham, Jr., Industrial Engineering and Operations Research, and Environmental Systems Engineering

THE ENGINEERING OF POWER AND MOTION
Arthur H. Burr, Mechanical Engineering

DYNAMICS OF FIRES AND URBAN HEAT ISLANDS
Kenneth E. Torrance, Thermal Engineering

PHYSICAL PLASMAS: TODAY AND TOMORROW
Hans H. Fleischmann and Arthur F. Kuckes, Applied Physics

REDESIGNING THE FEDERAL WATER POLLUTION CONTROL PROGRAM
Leonard B. Dworsky, Water Resources Engineering
exceedingly alert throughout the period. Even more remarkable, given the weather and the hour, was that it was a Friday! My generation (over 35) would hardly have been the same a couple of decades ago—and, thank our lucky stars, neither would the sophistication of the content under discussion! Because Stidham would be unable to meet the class the following week due to out-of-town commitments, and a quick check found no compatible free daytime hour, he rescheduled the missed time to a Tuesday evening at 7:30. To my surprise, nary a groan! They are different these days!

THE FRESHMAN MINI-COURSE PROGRAM

Such a setting was undoubtedly duplicated in most of the other mini courses being taken by freshmen this spring. However, not all were classroom discussion courses such as Waiting and What Can Be Done About It. Some mini courses evolved into case studies of technological impact in various contexts, and others concentrated on fostering student ingenuity in the design of simple systems. A few were "laboratory-oriented," while others required field trips to investigate real problems later worked on by student groups. A few dealt with legislation and public problems related to energy production and to water pollution control.

The term "mini courses" was coined because each student enrolls in two of these seven-week courses each term—one for the first half and the other for the second half. Each mini course meets for a total of two and one-half hours a week in two sessions of one hour and one and one-half hours. Leaflets giving descriptions of the mini courses were distributed to the freshmen to help them select the two they wished to take from the total offering of twenty courses in the fall term, when the program was introduced, and seventeen in the spring. Half of the freshman class is enrolled in this program—Engineering 106, Engineering Perspectives—each term, with about 650 freshmen ultimately cycled through. Making assignments is itself an operation in computer programming: students declare their preferences and then a computerized match of students with courses is made so as to maximize preferred choices while holding each class to a maximum of eighteen students. Nearly all got their first choice in either the first or second half of the term.

Tying the whole program together is a weekly lecture given by a professional engineer or a member of the faculty. The mix of topics is eclectic, often with the speaker chosen as much for his "presentation vitality" as for his specialty. Yet the topics have been often timely, occasionally controversial, and usually stimulating. Among the lectures were: "Space Exploration," "Problems in Satisfying Future Energy Needs," "Cities of the Future," "The Cornell Synchrotron," "Use of Foam in Racing Cars for Prevention of Disastrous Fires," "The Recycle of Auto Hulks," "Early History of Engineering," "Controlled Thermonuclear Reactions," and "Oil From the Athabasca Tar Sands."

The program of lectures and student-chosen mini courses evolved from recent freshman course history at Cornell and from the suggestions of a summer study committee, appointed by Andrew
Schultz, Jr., dean of the College, to consider new approaches to the effective and imaginative introduction of freshmen to engineering (and to their College). About ten years ago Cornell consolidated all its freshman engineers into one big unit with an average enrollment of 625. Previously, the freshmen had been admitted and enrolled by five different departments or fields (civil, chemical, electrical, and mechanical engineering, and engineering physics). Nearly everyone agreed that after the "integration" the freshmen needed some source of insight into what engineering was all about, how engineers "designed," and how they as students could approach problems logically. Computer programming came along shortly after. At first a few faculty members were charged with this tall order, but little by little the notion emerged that broader faculty participation was essential to sustain vitality and to satisfy the latent interests of a rather broad spectrum of engineering students—ranging from those already committed to a specific career to those who were thinking about transferring to another Cornell division even before they arrived on campus. We found that a monolithic program, no matter how well designed and presented, could not accommodate the changing aspects of the profession and just didn't do the job of getting the majority of new freshmen involved in engineering.

THE ULTIMATE TEACHING CHALLENGE

Nearly every thoughtful dean of engineering in this country whose college or department enrolls freshmen will admit that one of the most difficult curriculum problems he is likely to have is how to best introduce seventeen- and eighteen-year-olds to the study of engineering: who on the faculty should do it (a good many deans have tried unsuccessfully themselves), how valid content, currency, enthusiasm, and applicability to future courses of study could all be infused, how the diversity of career goals within any engineering student body could be accommodated—the list could go on and on. To top this off there is the problem of finding enough faculty members to share the responsibility so that a few especially effective "men for all seasons" will not end up like wristwatches that gradually run down without winding and no longer keep accurate time. Few engineering practitioners and even fewer engineering professors really comprehend (let alone appreciate) the broad, diverse spectrum of their profession. And few faculty members have truly appreciated their graduates who "leave engineering" to enter other fields such as law, medicine, or social service. But we're all changing.

When the mini-course program was introduced, there were a few defined or implicit reasons. Among them were:

(1) There was much going on in the way of research, occasionally exciting and significant, in the College—over $6,000,000 worth last year—and it seemed desirable to provide an opportunity for some of the freshmen to move closer to this epicenter. The question was how this could be done with students just entering college and still limited in their educational experiences. Also, how could we involve faculty members active in research—how could
we play to their strengths? Often these men are among the younger members of the faculty, isolated from freshmen “for their own good.”

(2) There was, and is, a great need to give freshmen a real sense of belonging. This is usually, although not always, fostered by classes in which small groups work and talk together. Such activity is inefficient when budget deficits grow, we know, but our graduate students get this sort of attention and our freshmen deserve some of it, too.

(3) Some students arrive with fixed educational and career aims, and many of these resent educational diversions which do not seem to meet their expectations of “getting down to business.” Others—let’s call them the philosophers or perhaps even dreamers—really like the give-and-take of “bull” sessions or seminars which we can remember from our own college days. For these students, getting down to business requires a different content approach and, indeed, usually a different sort of faculty member. Very few students these days respond to the “salesmanship” approach which was and still is popular with some colleges and professional engineering societies.

(4) In engineering colleges across the country, general introductory courses for freshmen which have been successful (and few have) usually relied on special circumstances. Perhaps the course was taught by a team of dynamic faculty members who were struck with a zeal for evangelism or who truly enjoyed the challenge of teaching. Perhaps the number of students was relatively small—say, two hundred or less. In this kind of situation, of course, the tendency is to call on fewer faculty members to work with the freshmen; students do not benefit from the enriching experience of exposure to a variety of faculty types, and professors are isolated from contact with budding engineers.

(5) The staffing of a common or core course for a large number of students requires a few faculty “chiefs” and a number of faculty or graduate teaching-assistant “Indians.” Few enjoy being the “Indians.” They rarely feel interested or intellectually involved if another teacher puts a course together (it should be their responsibility!) and often they show it. They, as most of us, like to do their own thing!

A GOOD START

As can be seen from the mini-course topics (see the table on p. 6), the diet has been a rich and extensive one. Twenty-six members of our faculty have offered a mini course this current academic year, and because of this experience twenty-six of our faculty members understand a little bit better what freshmen are like. With twenty professors who served as freshman advisers added to this number, a total of about twenty-five percent of our faculty has been intimately involved this year with freshmen. These professors know a good many freshmen on a first-name basis—not an easy task in a university college with 650 freshmen. The students, too, know their faculty a great deal better than they would if only one or two professors had borne the “burden” of carrying all the freshmen through a full-year introductory course.

What is especially important to note is that impedance to learning is reduced when the student can choose his own “battleground” or “climate” and when the instructor has a group to work with that is interested in what he has to offer. It would be naive to presume that this year’s mini-course program at Cornell is the answer to the “impossible dream” of getting every freshman interested, involved, and genuinely committed to engineering, or that it has met every student’s and every professor’s expectation.

At the very least, though, it is a fresh departure. And if the atmosphere in that rainy Friday afternoon class is any indication, it has been an auspicious one.
SOCIAL AWARENESS

A New Priority for Engineers

It was in 1969, a year when passions ran high on university campuses and phrases like "environmental quality" and "social effects" were echoing around the Cornell campus as around the nation, that the College of Engineering introduced a new course on Social Implications of Technology.

The mood this year was more restrained. The undergraduates enrolled in the course—mostly but not all engineers—were more sophisticated in their approaches, more knowledgeable, perhaps more analytical. But concern about the big issues was undiminished, and the expectation is that this course or comparable efforts will become an integral part of technical education.

"We have had two successful years with a new educational venture," 1970-71 course director Mark Nelkin remarked in his report on the fall term offering. "We now face the more difficult problem of building this success into a viable part of the basic education of undergraduate engineers."

Engineering 205, Social Implications of Technology, is offered by the College of Engineering in cooperation with the University's Program on Science, Technology, and Society, which is also in its second year of operation. The course is funded in part by a curriculum innovation grant from the National Science Foundation. It is a large course—135 students were enrolled this past fall—open to all University students beyond the freshman year, and it is set up in a format that is becoming increasingly familiar: a series of lectures by local and visiting experts in fields related to an interdisciplinary topic, augmented by small discussion groups or seminars. Leaders for the discussion groups (there were twelve last term) are volunteers, mostly from the engineering faculty, who undertake this new kind of responsibility in addition to their normal teaching and research activities.

In addition to attending the weekly Monday evening lectures, students are required to do extensive reading, prepare short papers demonstrating familiarity with the lecture materials, and write a term paper. The reading material consists largely of a coherent collection of articles on the subjects under consideration. In the discussion sections, certain subjects may be developed in greater depth, according to the interests of the group of a dozen or so students and their leader.

Topics considered in the course vary from year to year, but all are concerned with current problems that have an important technological component. According to the course description, "emphasis is on the social, political, and economic aspects of the various issues as they pertain to the development, implementation, and assessment of technology. The technical background is developed to the extent necessary for an intelligent consideration of policy alternatives."

AN EFFORT THAT "HAS TO BE MADE"

The kind of educational effort being made in Social Implications of Technology is a necessity today, Professor Nelkin believes. Like many other responsible educators, Nelkin is concerned about the control and direction of technology; and although he is aware of the difficulties of translating
"Science can no longer be content to present itself as an activity independent of the rest of society, governed by its own rules and directed by the inner dynamics of its own processes." —Robert Morison

Nelkin, who has been a member of the College’s applied physics faculty since 1962, has been active in theoretical and applied research for the past eighteen years, and is continuing an active scientific research and teaching program. Even in strictly scientific projects, he prefers to work in areas where interdisciplinary lines are blurred. His recent work—primarily in statistical physics with emphasis on the dynamics of fluids at the molecular level—entails interaction with scientists in several fields. His earlier work was in elementary particle physics, neutron transport theory, neutron scattering and thermalization, and nuclear reactor physics. In 1966 he was co-winner of the American Nuclear Society Special Award for “outstanding contributions to reactor physics.”

CURRENT ISSUES: ENERGY NEEDS AND ENVIRONMENTAL QUALITY, MILITARY R & D

The 1970–71 course began with introductory discussions designed to provide a background in the history of technology, criteria for the assess-
“The people must choose the society they want and recognize the costs . . . I doubt that such a choice will concern pollution or any other big problem alone; it will be a choice about a just and saner society in which we understand our dependence on and responsibility for one another.” — Lisle Carter

“We are finally beginning to realize that man cannot separate himself and his activities from nature, and that the principles of ecology which govern pond and field also govern the entire world in which we dwell.” — Alonzo Lawrence

“There must be much more citizen knowledge of and participation in solving problems of national security viewed broadly . . . To contain and decrease the spread of military technology and the growth of military spending calls for positive action at both the national and international levels. If we stand passively by, the many strong pressures toward more and more expensive technology will surely prevail.” — Franklin Long
ment of technology, issues of environmental control, and general information in such areas as ecology and economic factors. Then two topics were explored in greater detail: Energy Needs and Environmental Quality, and Military Research and Development.

Although the course’s lecture format was considered a good one by a majority of the students (as indicated by a questionnaire distributed at the end of the term), the greatest number felt that the most valuable parts of the course were the individual research effort for the required term paper and the discussion group. Nelkin believes that this response to the course “emphasizes the importance of broad faculty participation for vitality of an educational innovation of this kind.” The loosely structured introductory part of the course was less well received than the two specific topics treated in more detail later in the semester; the participating faculty members feel that this is partly because everyone is more “sensitized” to the social effects of the impact of technology than they were even a year ago.

THE INTERDISCIPLINARY APPROACH

This year’s unit on Energy Needs and Environmental Quality demonstrates how outside speakers and specialists on the Cornell faculties can be utilized for a varied approach to a specific issue. The series opened with a talk by Theodore Taylor, president of the International Research and Technology Corporation, on the control of environmental effects of energy production. An ensuing discussion by Cornell professors Simpson Linke (electrical engineering) and Nelkin centered on problems of the production and transmission of electrical energy. The unit was concluded with a panel discussion of the current energy crisis by Cornell experts in several fields: Philip Bereano, who is a lawyer as well as an engineer on the environmental systems engineering faculty, K. Bingham Cady, a nuclear engineer on the applied physics faculty, and Jerome Hass of the Graduate School of Business and Public Administration.

The unit on Military Research and Development also consisted of lectures and a panel discussion. Speakers were Franklin Long, director of the University Program on Science, Technology, and Society, and Eugene Fubini, a Washington consultant in the area of defense systems. Members of the panel were Cornell professors Peter Auer, aerospace engineering; Jay Orear, physics; and George Quester, government.

Introductory lectures on historical development and the issue of the assessment of technology and possible controls were given by Robert Morrison, professor of biological sciences, and Raymond Bowers, professor of physics, who are both associated with the University Program on Science, Technology, and Society. Other Cornell lecturers from outside the College of Engineering were biological sciences professor Gene Likens; Alfred Kahn, dean of the College of Arts and Sciences and a professor of economics; and Paul Wozniak of Cornell’s International Population Program. Engineering professor Alonzo Lawrence discussed the technology of pollution control. Lisle Carter, Cornell vice pres-
Lecturers in the initial offering of Social Implications of Technology included environmental engineering professors Alonzo Lawrence (left) and Walter Lynn. Professor Lynn also served as first director for the course.

ident for social and environmental studies, spoke on the subject, “Is the Environment Issue a Cop-Out?” (He suggested that it may be serving, in some instances, as a way of avoiding more fundamental social problems.)

WHAT IS NEEDED NOW?

Dealing as it does with timely issues, Social Implications of Technology is the kind of course that must adapt in content and format to the needs and temper of the times. Next year more time will likely be spent on specific topics of current interest and importance, perhaps in three or four three-week units. Possible topics are the “computerized” society, environmental policy and its relation to poverty, and research and development policy and its connection with the educational enterprise.

The presentation of general introductory material is another aspect of the course that is being reviewed. The challenge, Professor Nelkin feels, is to develop material that is both valid and nontrivial, and that has coherence and an intellectual level appropriate to undergraduate students. One suggestion is that a more coherent historical introduction, with emphasis on past social responses to technological change, would be appropriate.

A “built-in” problem in a course such as Social Implications of Technology is how controversial issues should be handled. Too much caution on the part of lecturers in expressing their own opinions may mean the sacrifice of vitality and relevance. “My own opinion,” says Professor Nelkin, “is that we have a duty to expose the fundamental conflicts on truly controversial issues. Surrounding a problem with an aura of value-neutral technical expertise, when no consensus in fact exists, is not responsible. On the other hand, there is much room for rational consideration of the trade-offs in any given situation, and our basic educational function is to allow difficult social and political problems to be considered on the basis of as much knowledge as we have. We must be careful to avoid the impression, however, that real decisions are taken on the basis of careful weighing of complete information. The realities of an uncertain knowledge base, and of conflicts between interest groups, must be explicitly faced if we are to honestly prepare engineering students for the world in which they will work.”

It is, finally, the matter of values that is central to the purpose of the course. The infusion of an awareness of values—human and social—into technological thought and effort is a difficult and ambitious goal, but that is what Social Implications of Technology is all about.
Thermodynamics is a subject long familiar to engineers, but as taught by Bart Conta in The Nature of Thermodynamics, a course offered at Cornell for the first time this year, it has a new perspective and emphasis. "A study of the history, philosophy, and mathematics of thermodynamics with emphasis on its scope and limitations," the catalog description reads; "... a comparison of the intuitive, the axiomatic, and the statistical approaches. The course will be principle- rather than problem-oriented." And so thermodynamics becomes an engineering subject taught in terms of history and philosophy as well as science and mathematics, as a subject with intellectual rather than strictly professional appeal.

Bart Conta's manner is relaxed and kindly. His way of thinking in matters professional and extracurricular is at once comprehensive and simple, original and traditional, straightforward and suggestive, pragmatic and humanistic. So is his course.

Comments offered by the twenty class members (all of whom had completed introductory thermodynamics) suggest the importance of approach and teaching style in the effectiveness of the course. "I found that the manner in which this course was taught made it easier for me to develop an understanding (which I consider most valuable)," one student commented. "The success of (such a) course depends a great deal on the instructor," said another.

But what Bart Conta is doing in this course is more than giving a new twist to an old subject. He is implementing what he feels should be the goal of education, particularly of engineering education, today: the transmission of professional knowledge and skills within a context of broader intellectual and humanistic values and concerns. He feels that this is also a way of achieving his specific objective—improving the teaching of thermodynamics—because students today are increasingly becoming more responsive to an intellectually stimulating approach than to a "problem-solving" one. As a subject, thermodynamics is easy mathematically and difficult conceptually, but it is the concepts that
are important and interesting. Besides, students who feel they won't ever “need” thermodynamics in their professional capacities do not tend to be enthusiastic about taking a problem-oriented course in the subject.

DEPARTURES FROM TRADITION

In The Nature of Thermodynamics the emphasis was on the great laws as they evolved and as they pertain to the entire physical world, from the cosmological scale down to the workings of a wristwatch or the bursting of a soap bubble. Class discussions centered around ideas and their development more than on the application of equations. Instead of a single prescribed text there was a suggested reading list of fourteen books, including paperbacks. Instead of being given regularly assigned “practical” problems, the students were asked to complete a dozen “concept-oriented” problems some time during the course of the term. And in place of a final examination consisting of more problems, there was a required term paper. Suggested topics for these papers included historical, conceptual, and mathematical subjects; they ranged from the scope, interpretation, and development of thermodynamic ideas to the derivation of specific equations.

The course was planned as a follow-up to the conventional introductory course in thermodynamics, on the theory that a broader perspective would increase understanding of a subject already studied in some detail. This year’s class was about evenly divided between graduate and undergraduate students, most of them majoring in mechanical engineering. Next year, though, the prerequisite will be dropped, and the course will be available to any student who is willing to put forth sufficient effort to get a grasp of the concepts that may already be familiar to some in the class. It will afford an option in the kind of study the student feels is most appropriate for him.

Comments offered by class members suggest that the objectives of the course were met. “Not only did it enhance my understanding of basic thermodynamics, it offered me the opportunity to read works of pioneers. . . .” “The course has . . . given insight into where the core of thermodynamics comes from, and it really makes a difference in the physical understanding of the subject.” “Since the stress was on theory and not on problems, the student had a chance to understand . . . without getting stuck in . . . problems or the memorization of formulae.” “It’s a refreshing change from the usual cookbook type course. . . . I think (it) has helped me to straighten out my thinking process in solving problems.”

Conta feels that the flexibility of the course was an asset in that the students probably worked harder than they would have with a defined set of regular assignments. Some felt a bit uneasy perhaps, even guilty about not “turning something in” at each class session, but in most cases the result was a conscientious effort.

THE EDUCATION OF A TEACHER

Professor Conta has maintained an interest in the humanistic component of technical education throughout his twenty-five years as a college teacher. A special impetus, though, was provided by his experience as a committee member for the Humanistic-Social Research Project of the American Society for Engineering Education, which published its findings and recommendations, commonly referred to as the “Olmsted Report,” in 1968. There existed at that time a general acknowledgement that the status of the “humanistic-social” part of engineering education was unsatisfactory. At most engineering schools about 20 percent of the curriculum was in the humanistic-social areas, but often this was offered reluctantly, without much interest, or as something entirely removed from the real functions of the school, and students tended to reflect this attitude. The Project, staffed largely by university specialists in both engineering and the liberal arts, visited and surveyed engineering schools all over the country, assessed the situation, and drew up guidelines for improvement.

Later Professor Conta was awarded an NSF Science Faculty Fellowship, and he decided to spend the year at
The intellectual appeal of thermodynamic concepts may be obscured in problem solving of the traditional sort, Professor Conta feels. Examples of problems presented to students illustrate what he means. (For answers, please write to Professor Conta, not to the editors!)

A CONVENTIONAL PROFESSIONAL PROBLEM INVOLVING THE CONCEPT OF WORK:

Calculate the useful work which air can deliver as it expands reversibly and adiabatically in a piston and cylinder from a pressure of 100 pounds per square inch absolute and a temperature of 70°F to a pressure of 30 psia. Air may be considered to be a perfect gas.

A MORE INTELLECTUALLY CHALLENGING PROBLEM ON THE SAME SUBJECT:

Calculate the work required to blow a soap bubble of radius r in the atmosphere. Assume that the process is isothermal and that, as a consequence, the film's surface tension has the constant value of γ.

A CONVENTIONAL PROFESSIONAL PROBLEM INVOLVING ENTROPY:

Saturated steam in adiabatic steady-flow at a pressure of 100 psia is throttled through a partly closed valve to a pressure of 50 psia. Find its change in temperature, change in entropy, and the energy made unavailable by this irreversible process relative to a surrounding atmosphere at 70°F.

A MORE INTELLECTUALLY CHALLENGING PROBLEM ON ENTROPY:

A system consists of a watch which requires a work input of W joules to fully wind it. Calculate each of the following for a process in which the watch runs down from a fully wound condition until it stops. The running down may be assumed to occur isothermally in an atmosphere at 70°F.

(a) Heat, work, and the change in internal energy

(b) Entropy change, entropy flow, and entropy production
Berkeley taking courses he felt would have a bearing on his effectiveness as a teacher. He enrolled in Philosophy of Science and subsequently included three other philosophy courses ("there is a lot of philosophy inherent in thermodynamics") in his year's program.

These experiences sharpened his interest in the "interface" areas of technology. His opinions on the overall directions in which engineering education should move are in general agreement with the findings and recommendations set forth in the Olmsted Report: Programs should be designed in such a way that the student acquires a sense of the overall context of professional and personal life in the contemporary world. He should gain an historical perspective, an ability to work with people in other areas and understand their contributions, and a sensitivity to ethical, aesthetic, and human values.

This sounds like a tall order, and some regard it as irrelevant to engineering education or at best the responsibility of some other part of a university. Conta feels, however, that technical studies should be placed within this overall kind of context as they are presented, for it is precisely the separation of technical from other aspects of modern life that has become untenable in the world today. Not all scientific courses lend themselves to philosophical points of view, of course. But even a practical course such as one in engineering technology could be given some historical, social, or economic perspective.

Another innovative course is being planned by Conta for the Cornell Summer Session this year, when he will offer The Age of Power—a History of Technology. Emphasis will not be on the details of power technology, but rather on its relationship to other technologies and to the economic, social, and political developments of the nineteenth and twentieth centuries.

**BENEFITS OF THE “LIBERAL” APPROACH**

It is no surprise to find that Bart Conta was one of the engineering faculty members who served as group discussion leaders for Engineering 205, Social Implications of Technology, when it was offered for the first time in 1969. (See a discussion of this course on pp. 10-14 in this issue.) This semester he is serving in a similar capacity in the large lecture course on Biology and Society, which is sponsored by the University's Program on Science, Technology, and Society. This course is offered for credit (more than six hundred students are enrolled) and is also available to the public through open lectures and radio broadcasts. He feels that courses of this kind, which confront specific issues involving technology and other aspects of contemporary life, are valuable at this time, though they may not prove to have the "steady state" existence in university curricula that he hopes courses like The Nature of Thermodynamics will have. Both types of courses help span the barrier between the scientific-technological and the humanistic-social areas, and both serve to counterbalance the tendency, prevalent among engineers, to want to classify everything, including courses and curricula.

A "liberal" approach to engineering education is in keeping with the needs and temper of the times, he feels, and is not only a good thing in itself but a wise policy on the part of educational institutions. He suggests that the decline in interest in engineering schools on the part of incoming students, which is by now well recognized, has occurred not because of subject matter ("no one denies that knowledge of technology is important today") but because students are skeptical about careers as engineers in the traditional sense. In fact, many students now in engineering schools do not intend to become engineers; they are preparing for careers they consider less restricted and industrially oriented. They regard an engineering education as a good background for other careers and in general for the technological age in which we live. Conta believes that schools should be "glad to educate students for whatever reasons they may have." Many students today are looking for intellectual challenge more than for instruction in defined areas, he suggests, and forward-looking institutions should be meeting this need.

In many ways, he feels, engineering education is still geared to the idea of providing industry with the skills it thinks it needs rather than educating young people in the ways they feel are important. At one time the idea of benefiting mankind through technological advances worked rather well, but this is no longer sufficient, and many young people are particularly aware of the need for new priorities. As a successful educator, Conta knows that ideas are not the province of teachers alone, and that education is a two-way process. "Teachers should sometimes listen to their students," he says.
Pushbuttons and tape recordings are becoming as familiar as blackboards and classroom lectures to students in Arthur Ruoff's introductory course in materials science. The kind of innovation being introduced in this experimental class may be variously viewed as the bright beginnings of an important educational mode, as one approach to increased efficiency and effectiveness in the teaching and learning processes, or as yet another encroachment of technology. But one suspects that whatever else the experiment may be, to students in Engineering 6101, Elements of Materials Science, it's effective and it's fun.

The student's first exposure to the course is in the big Student Response Room in Kimball Hall, where he takes one of 150 seats equipped not only with the traditional writing surface, but with a panel of five pushbuttons. He discovers a new way of responding—not by raising his hand and giving an oral answer if called upon, or by writing out answers to exam questions and then turning in his paper, but by pushing one of those buttons. Immediate analysis of the students' answers can be flashed on a screen at the front of the room.

The heart of the course, though, is the Materials Learning Center, where the student can come any weekday afternoon or evening, without prior scheduling, to learn on an individual basis with the help of tapes, slide projections, films, and other visual displays; to perform experiments; and to work out problems and exercises assigned as part of the taped lesson. No less important is the "non-packaged" part of the learning program: the knowledgeable tutor who is always present during open hours at the Center to explain, discuss, and go over problems.

This is the essence of the "audiotutorial" approach to education, according to Ruoff: on the one hand, carefully prepared instructional material available at the initiative of the student, paced to his individual learning rate and enriched by a variety of audiovisual materials; and, concurrently, the readily available individual help of a competent tutor.

Elements of Materials Science is a freshman course, a natural science elective, and was selected by 110 students this term even though it was too new to be listed in the 1970-71 catalog. The course is organized as a series of twelve distinct units covering different aspects of materials science (see the table on p. 21). Printed material,
prepared by Professor Ruoff, is handed out for each unit and constitutes a full text by the end of the course. For each unit the student must show up at the Learning Center, listen to the taped lesson by Professor Ruoff, and accomplish the assigned work. Sometimes there is a lecture by a guest professor who is a specialist in some aspect of materials science; there are four lecturers scheduled during the spring term this year. Each unit is concluded by a class meeting in the Student Response Room, where the students take an examination over the material just covered, answering questions by means of the buttons.

Development of the course was made possible in part by a grant from the Ford Foundation, which financed the building of ten carrels in the Materials Learning Center. These were designed by Ruoff and his research associate, Richard Lincoln, and equipment was built in the Upson Hall machine shop. Facilities in each carrel include the tape recorder with earphones, a slide projector with a rear-view projection screen and pushbutton controls, and electric outlets so that equipment for special displays or simple experiments can be plugged in. The electronic equipment in the Student Response Room is now being rented with an option to buy.

TAPES, SLIDES, EXPERIMENTS, FILMS

The Materials Learning Center is a large room containing, in addition to the carrels, an area for film projection, facilities for laboratory experiments, and tables, chairs, and blackboards for student-tutor or student-student consultation. For each study unit the tape recorder in each carrel is set up for playback of the appropriate lesson, which is delivered by Professor Ruoff in an informal way and interspersed with questions (answers must be turned in to the tutor before the student leaves the room) or directions ("Switch on Slide No. 1"). The student can stop the tape to reflect for a while, or repeat a section, or hear the whole thing all over again as often as he wishes. If he gets stuck on a problem, he can refer to additional messages.

TOPICS IN ELEMENTS OF MATERIALS SCIENCE

Mechanical Properties
Electrical and Magnetic Properties
Chemical and Thermal Properties
Atomic Structure
Crystal Structure
Polymers
Micro- and Macrostructure
Equilibrium and Kinetics
Phase Diagrams
Corrosion
Strengthening Mechanisms
Electronic Properties
at the end of the tape for some extra hints given in Ruoff's voice.

Out in the open part of the room there may be a film for the current week, and the student can begin a projection or join whatever audience may have collected for a showing in progress or about to begin. Earphones are provided so that as many as ten students can listen without disturbing other activities in the room. The student can work for a while on an experiment (one or two are assigned for each unit in the course). He can solve a set of problems with help as needed from the tutor. Or he can talk with other students—perhaps about materials science! Plans are being discussed to add a coffee maker and a coke machine to the room's equipment to enhance its appeal as a gathering place. Perhaps our student was sick the week before and couldn't come to the Center: no problem; complete sets of previous learning units are available at all times.

The full-time staff member at the Center is Dr. Prakash Rao, and several senior students serve as assistants. Most students, according to Dr. Rao, spend four to six hours each week at the Center, usually during two or three sessions.

EXAMS: NO ERASERS!

The unit examination is an occasion for all the students to assemble as a class in the Student Response Room. The multiple-choice questions are designed to test the student's ability to grasp concepts and his ability to apply this knowledge to specific problems. Immediate automatic grading, with computation of results for the entire class, permits the professor to go over troublesome points during the second half of the period. The students have the added learning impetus of reviewing test material at once, while it is fresh in their minds and of immediate interest. A record of each student's performance is printed out on a machine set up in an adjoining office. Needed conferences can be arranged at once, and the professor's chore of grading and recording is completed before he leaves the classroom.

Although the Student Response System is now used in this course only for the administration of examinations, its possible applications are much more extensive. It can be used as a means of continuous communication between teacher and students, especially in large classes. The teacher can pause at any time to pose a pertinent multiple-choice question, either orally or by projection on a screen, and can assess with a glance at the display unit how the students responded and therefore how well they comprehended the material. He can then modify his lecture according to the response.

When these new techniques are used, does the student suffer from lack of more personal contact with the teacher? Under an audiotutorial system, does he miss out on the stimulus that can be provided by a lecture delivered in person? To many educators and students, these are important questions, especially when the teacher has the reputation for classroom effectiveness that Professor Ruoff has. He feels, however, that the audiotutorial method gives the student at least as great a sense of personal involvement as does the more traditional lecture system.
The Materials Science Center replaces the traditional lecture room for an experimental audiotutorial course in Elements of Materials Science. Left, part of the assignment for a course unit may be a film which can be viewed at the Center at the student's convenience. Right, ten carrels, equipped for individual use of lesson tapes and slides and sometimes displays or simple experiments, are located in the Learning Center. The Center is open every weekday afternoon and evening, and students can come whenever they wish for the week's lesson.

though in different ways. Although much of a student's contact with him is by way of tape recordings, Professor Ruoff feels that these lectures are personalized. And actually, he suggested, there is more opportunity for direct student-teacher contact under a tutorial system than there is likely to be in a large lecture course. In some large university classes, most of the instruction is carried out in "sections" by graduate student instructors who, as Professor Ruoff pointed out, may or may not be good teachers and may or may not care very much about teaching effectively. "If it comes to a choice," he said, "I believe it is better to receive instruction from well prepared tapes and a good tutor than to sit among hundreds of other students in a huge lecture room, listening to the amplified voice of a professor hundreds of feet away."

A CHANCE FOR QUESTIONS, TIME FOR THOUGHT

But there are more positive assets in the audiotutorial method. One big advantage is that the student feels much freer to ask questions about points that elude him than he would as a member of a large class in a lecture hall. "In a big lecture course, most students simply don't ask questions," Professor Ruoff said. He pointed out that in his materials science course it is possible not only to provide direct help, but to make sure that each student masters the material as he goes along in the course. He gets expert help if he needs it, but he answers the questions himself, right at the Center, without the temptation to get his roommate to answer them for him or to put the whole problem off until the night before the big exam.

Even more important is the crucial problem of tempo. "A lecture is usually either too fast for the student to absorb or too slow to keep him interested," Ruoff commented. A taped lecture, on the other hand, can be interrupted at the student's discretion, and even repeated; the traditional "lock-step" system of lecture presentation is eliminated. In this way the method is analogous to learning from books, and has some of the same advantages and limitations. Professor Ruoff's course, by making use of both printed material and tapes, relies entirely on teaching methods that permit this adjustment of pace.

The overall length of time needed for absorption of course material also varies with individuals, and an audiotutorial system permits adjustment of the duration of a course. It would be possible for some students to complete assignments in a much shorter period of time than the usual academic term. In special cases, for example with graduate students who wish to make up a felt deficiency in some specific area, a "package" course might be completed in a few weeks. As a matter of fact, Elements of Materials Science could be offered in an open-ended way, now that the material has been developed. The only restriction at the present time is the examination procedure, which is still a "lock-step" method. Ways of overcoming this restriction have been devised, Professor Ruoff says, but would require "a lot of work and some money" to implement.
The effectiveness of pre-prepared audiovisual materials, as of books, is obviously dependent on their overall quality and educational value. Ruoff believes that much of the faculty resistance to the new learning methods has been brought about by the poor quality of some of the early recorded materials, which were prepared and promoted "not by educators, but by supply houses." Not only tapes but books and, for that matter, professors' lectures, can vary widely in their quality and suitability. An advantage that taped lectures may have over "live" ones, Ruoff feels, is that they can make the very best, even unique, lecturers accessible anywhere at any time.

"PACKAGE" COURSES FOR SMALL COLLEGES

A small community or junior college, for example, could use a "package" course from a university, complete with taped lectures, printed text, slides, films, and perhaps even prepared material for laboratory experiments. The students would benefit from a first-rate course, well taught and well organized. All that would be required locally would be that "knowledgeable tutor" so essential to the success of such a program. One school already implementing this idea is Corning Community College in Corning, New York, which is currently using a "package" biology course from Purdue.

A NEW KIND OF UNIVERSITY?

Professor Ruoff believes that this kind of approach offers a solution to the increasing problems of providing good education to greater numbers of students. He cites the rising costs of a college education, prohibitive to many families, and feels that it would be possible to design a whole new kind of university where excellent instruction could be provided for perhaps a third of the present real cost. The school would offer no small classes, just audio-tutorial and other new kinds of courses in all subjects; the curriculum would be less flexible, he concedes, but could provide a sound education. Although his consideration has been confined largely to the technical subjects with which he is familiar, he feels that the method could be applied to the humanities as well.

This fall term, the Student Response System will be introduced into the required sophomore course in engineering mathematics, which is taught jointly by faculty members of the Colleges of Engineering and of Arts and Sciences. Another Cornell group experimenting with similar new learning techniques is the Department of Physics, which is currently using a locally designed and constructed Student Response System for a course in quantum mechanics.

Learning Centers and Student Response Systems may well become familiar aspects of colleges and universities. It is appropriate that as innovative techniques that rely on technology and are perhaps best suited to scientific and technical education, they are being developed by an educator who is also a scientist.
A sign of the times was an unusual appointment last fall when the School of Civil and Environmental Engineering took on a young assistant professor in environmental engineering. What was unusual is that this new faculty member is a lawyer and a regional planner, and it was primarily for this background—and, one suspects, for his expansive outlook and comprehension of environmental issues—that he was offered a faculty position in engineering. It is just so much the better that he happens to be a chemical engineer as well.

Philip Bereano had spent a few years as a law clerk and associate attorney with a private New York City firm after his graduation from the Columbia University law school, and then a few years as a legislative assistant with the air pollution control program of the United States Public Health Service, before he decided to return to Cornell to take a degree in regional planning. It was here at Cornell that he earned his undergraduate degree in chemical engineering.

THE EARLY CONCERNS OF LAW FOR ENGINEERS

From time to time, engineering schools have employed, on a part-time basis, patent attorneys to teach chemical engineers, and perhaps electrical and mechanical engineers, the rudimentary elements of patent law. And over the years, a small number of baccalaureate engineers have gone this route. The reasoning, of course, was that potentially talented and ingenious engineers should be alerted to the need for legal protection for any new, marketable products that might result from the application of their skills. Perhaps others were helped to comprehend how the limits of protection could be stretched. At any rate, such "patent law" courses served to provide a grasp of the business end of technology, to make one more effective—more clever and astute, perhaps—as a businessman-engineer.

THE BROAD OUTLOOK

The School of Civil and Environmental Engineering had broader aims in mind when it invited Philip Bereano
to join its faculty last September. For years the School has prepared many of its graduates for service in the public sector—as contractors, sanitary engineers, water-supply systems designers, public health engineers, land developers, and conservationists. Yet, clearly, the scale of the problems of utilizing the particular technology of civil engineering to resolve issues in the public sector has grown exponentially. Also, the public acuity has been marshaled in recent years. What is required now are “big” men who can apply with maximum effectiveness and understanding whatever technology is required to meet such public needs as safe drinking water, less polluted rivers and streams—the whole list. Doing this successfully requires both technical expertise and a generalist’s capacity to assess the whole of a particular public problem, qualities rarely found in one individual. We need, in short, to cultivate in today’s environmental engineers both depth of knowledge and skill, and breadth of vision. The Law and Environmental Control, 2605, is offered in part to help meet this need.

AN INTERDISCIPLINARY STUDY

This course, a senior and graduate level offering, has about twenty-five students enrolled this term. Since it is interdisciplinary in nature, the class includes a number of students from outside the College of Engineering. The class is conducted mainly as a discussion group, although Bereano does lec-
ture on material, primarily legal, which he feels is novel to most of the students. The course reading list is extensive, both in content and in its sources; it includes items which are assigned to individuals who subsequently lead discussions on related topics or themes. Hollister Hall, the home of the School of Civil and Environmental Engineering, is only a stone's throw from Cornell's Law Library in Myron Taylor Hall, the "laboratory" for this particular engineering course.

Five major units constitute the course. The first, according to Professor Bereano, is a review of generalized environmental problems which arise from the exploitation of technology. Included are such topics as externalities (second-order consequences of actions taken), "public" and "private" interests, value considerations, and governmental planning—in essence, a sensitization to environmental issues of the day as placed in a broad context.

From this, the course moves to a discussion of the judicial function: trials and procedural aspects of law, judge-made law, and the interpretation of statutes. The laws that sustain the daily workings of a modern municipality are, we are told, no less complex, confusing, and archaic than the underground engineering services of water, electricity, or waste removal. Next comes a review of the functions of administrative agencies. Catching our eye in the reading list for this unit are reports by Nader's Raiders; Reich's article on "The Law of the Planned Society" (Reich is perhaps better known for his current best-seller, The Greening of America); and two provocative essays that appeared a few years ago in Science, Hardin's "Tragedy of the Commons" and Crowe's subsequent "The Tragedy of the Commons Revisited." The class also reads several legal cases in which the issue of the need to gather information versus rights of privacy (as set forth in the Fourth Amendment to the Constitution of the United States) has been raised in cases involving investigations by governmental agencies.

THE ENGINEER AS A SHAPER OF SOCIAL CHANGE

It is in the last two units—Regulation of Polluting Activities and Environmental Litigation—that the course deals with issues of more direct and growing importance to engineers. Here, in the discussion of the regulation of polluting activities, one begins to sense the crucial interface of technology and law. Readings include the National Environmental Policy Act of 1969 and the Environmental Quality Improvement Act of 1970, as well as the Federal Water Pollution Control Act and the Air Quality Act. The class explores the interstate compact concept as a possible mechanism for attempting to make coherent laws in spite of politically defined borders of municipalities, counties, or states. These laws deal with the critically important problems of water and air pollution, the disposition of solid wastes, and the control of noise, land use, and radiation and energy production. The realization grows that unless today's engineer becomes more acutely sensitized to such issues, so that he can participate more effectively as an engineer in the political-legal arena, he will increasingly find the direction of technology determined by "outsiders" who may not appreciate these interactions. He will forfeit his opportunity and responsibility to participate actively in the process by which change is brought about.

AN ENGINEERING MAJOR IN PUBLIC SYSTEMS AND POLICY

Recently the faculty group of which Professor Bereano is a member, the Department of Environmental Engineering, introduced a new major in public systems and public policy, which fuses four areas—systems analysis, economics, probability and statistics, and "applications" courses—into a core to which a student can add complementary work in his own major area of interest, such as transportation or urban planning. Among the "applications" courses are Bereano's course, as well as ones dealing with environmental quality and city and regional planning. This major appears likely to meet the interests of several students. Civil Engineering has been experiencing a great renaissance in student interest at Cornell. After a decade in which the number of juniors (the junior year is the first time a student can be identified with a particular engineering field) held at about forty-five per year, this current junior class numbers about sixty-five and next fall's class will have more than eighty members.

Students, we are reminded, vote with their feet. That there is a growing, rejuvenated interest in the areas long identified with the civil engineering profession suggests that young men with the education, experience, and outlook of Philip Bereano have a real place in a modern engineering faculty—one which can equip tomorrow's practitioners of the craft to be at the center of action, not reaction.
Jack E. Oliver, who was recently appointed to a new engineering professorship, will serve as chairman of a new intercollege geological sciences department. The Register presents biographical sketches of him and of faculty members who were appointed within this academic year to new positions in the College of Engineering.

Joining the Cornell faculty this fall as the first Irving Porter Church Professor of Engineering and as chairman of an intercollege Department of Geological Sciences is Jack E. Oliver, currently chairman of the Department of Geology at Columbia University.

A well known geophysicist specializing in seismology, Oliver has had extensive field work experience in South Africa, the Arctic, New Zealand, Alaska, Iceland, Tonga, Fiji, and Nova Scotia, as well as in several areas of the continental United States. His recent research has included studies of global tectonics, the Arctic ice pack, the moon seismograph program, propagation of elastic waves from nuclear explosions, deep earthquakes and microearthquakes, and postglacial faults in northeastern United States and Canada. He has written nearly seventy monographs and articles on research in his fields of interest.

Oliver, a native of Massillon, Ohio, received his undergraduate and graduate education at Columbia, earning the B.A. degree in 1947, the M.A. in physics in 1950, and the Ph.D. in geophysics in 1953. After completion of his graduate education, he continued his association with Columbia, serving first as instructor and finally as chairman of the geology department. He has been a staff member of the Lamont-Doherty Geological Observatory of Columbia University since 1953, and chairman of its section on seismology since 1955.

In commenting on his appointment to the Cornell faculty, Oliver said, "Probably at no other time in history have the earth sciences seemed more exciting or more promising. The great new theory of plate tectonics that describes the development of the major geological features of the earth is in its infancy; the wave of concern over the environment has properly focused attention on the need for an improved understanding of the earth and man's use of it; the exploration of the moon and the planets has brought a new dimension to geology. The decades ahead should be stimulating for earth scientists and highly productive of geological knowledge that will benefit society as a whole. I hope that Cornell will play a leading role in these developments."

Oliver's activities have included service on several national and international committees and panels. Among them are the National Academy of Sciences' committees on polar research and on seismology (he was chairman of this committee from 1966 to 1970) and its panel on solid earth problems. He has also been a member of the

Jack E. Oliver, newly appointed Irving Porter Church Professor of Engineering at Cornell, studies seismological data at Columbia University's Lamont-Doherty Geological Observatory, with which he has been associated for the past eighteen years.
geophysics research board of the Academy. He is a member of the UNESCO Joint Committee on Seismology and Earthquake Engineering and of the executive committee of the International Association for Seismology and Physics of the Earth's Interior. He is currently a consultant to the U.S. Atomic Energy Commission and the U.S. Arms Control and Disarmament Agency.

A fellow of the American Geophysical Union and of the Geological Society of America, he was president of the former from 1964 to 1968, and is currently a member of the council and chairman of the publications committee of the latter society. In addition, he served as president of the Seismological Society of America in 1964–65. Other organizations of which he is a member are the Society of Exploration Geophysicists, the American Association for the Advancement of Science, and Sigma Xi.

The Irving Porter Church Professorship of Engineering at Cornell was provided by grants from Nicholas H. Noyes '06 and the Ford Foundation. This distinguished professorship was named in honor of Professor Church, one of the University's first faculty members in civil engineering, who taught mechanics and hydraulics at Cornell from 1876 until his retirement in 1916.

The new intercollege department, which Oliver will head, will have an initial faculty of ten members. It will be housed primarily in Kimball Hall on the engineering campus, but some facilities will be maintained in Clark Hall. The University's present Department of Geological Sciences will form the nucleus of the new department, and several areas in the College of Engineering will be associated with the expanded effort. According to Robert A. Plane, University provost, this new organization, which combines the resources of the College of Engineering and the College of Arts and Sciences, will enable the University to strengthen its efforts in various aspects of earth science, including seismology, tectonics, tectonophysics, geomagnetics, marine geology, petrology, geomorphology and glaciology, paleontology, and engineering geology.
Malcolm S. Burton, professor of materials science and engineering, was appointed associate dean of the College of Engineering this past September. In his new role, he is responsible for the overall supervision and coordination of underclass activities, including advising and counseling, freshman engineering courses, and the Division of Basic Studies, the College's administrative office for freshman and sophomore affairs.

Burton has been a member of the engineering faculty at Cornell since 1946. He served as chairman of the College's Policy Committee during the academic year 1968–69, and was assistant director of the Department of Materials Science and Engineering before assuming his new position. Before joining the Cornell faculty he taught at the Massachusetts Institute of Technology in its Department of Metallurgy. During sabbatical leaves, Burton has served as a research metallurgist for the Cornell Aeronautical Laboratory in Buffalo, and for E. I. duPont de Nemours and Company, Inc., in Aiken, South Carolina.

Burton is the author of the text, Applied Metallurgy for Engineers, and numerous technical papers on materials engineering. His interests have centered on the application of new developments in materials science to engineering.

He received his bachelor's degree in mechanical engineering from Worcester Polytechnic Institute in 1940, and his master's degree in metallurgy from the Massachusetts Institute of Technology in 1943. He is a member of the American Society for Metals, the American Society for Engineering Education, the American Institute of Mining, Metallurgical and Petroleum Engineers, and Sigma Xi.

Walter R. Lynn was appointed director of the School of Civil and Environmental Engineering at Cornell in October 1970. Formerly the School of Civil Engineering, the name of the school was changed to emphasize the broadened scope of the educational programs and research activity now under way and contemplated there.

Lynn received his Bachelor of Science degree in civil engineering from the University of Miami in 1950, his Master of Science degree in sanitary engineering from the University of North Carolina at Chapel Hill in 1954, and his Doctor of Philosophy degree in systems engineering from Northwestern University in 1963.

He is author or coauthor of more than thirty papers dealing with applications of systems techniques to environmental and public health problems.
He is a member of the American Society of Civil Engineers, the Water Pollution Control Federation, the American Association for the Advancement of Science, the Institute of Management Science, the American Water Works Association, Phi Kappa Phi, and Sigma Xi.

John Silcox, who has been a member of the College of Engineering faculty since 1961, has been appointed director of the School of Applied and Engineering Physics, effective July 1. He has been serving as acting chairman of the Department of Applied Physics during the current academic year, and was promoted to full professor in November.

The School is being organized to combine the present Departments of Applied Physics, which offers graduate study programs, and of Engineering Physics, which offers undergraduate and professional Master's degree programs.

Silcox came to Cornell upon receipt of his Doctor of Philosophy degree in physics from Cambridge University, England. He earned his Bachelor of Science degree, also in physics, at Bristol University, England, in 1957.

The author of more than forty technical papers in the areas of superconductivity, ferromagnetism, and electron microscopy, Silcox is active in research as well as teaching. He was awarded a John Simon Guggenheim Fellowship for the 1967-68 academic year, and spent this time in research and advanced study first with the Faculté des Sciences d'Orsay, France, and then at Cambridge.

He is a member of the Physical Society, the Electron Microscopy Society of America, the Metallurgical Society of the American Institute of Mining, Metallurgical and Petroleum Engineers, and the Institute of Physics and the Physical Society in Great Britain. He is a member also of the honorary society Sigma Xi.

Serving his first year as director of the Department of Materials Science and Engineering is Herbert H. Johnson, a member of the department since 1960. He succeeded Walter S. Owen, who became dean of the Technological Institute at Northwestern University.

The department consists of thirteen faculty members and about seventy undergraduate and graduate students. It carries on an extensive research program with an annual budget of around one million dollars.

Before coming to Cornell, Johnson taught at Lehigh University for three years, as a member of the metallurgy faculty. During the academic year 1967-68, he served as a visiting professor in the Department of Metallurgy at the Massachusetts Institute of Technology. He holds a bachelor's degree in physics, and Master of Science and Doctor of Philosophy degrees in metallurgy, all from Case Institute of Technology, now Case Western Reserve University. His research interests include dislocation mechanics, gases in metals, cyclic deformation, and environment and fracture.

He is a member of the American Society for Metals, the American Institute of Mining, Metallurgical and Petroleum Engineers, and the American Physical Society.
Richard H. Gallagher, professor of structural engineering at Cornell since 1967, was named chairman of the Department of Structural Engineering in February 1971. He succeeded George Winter, the Class of 1912 Professor of Engineering, who had served as chairman of the department since 1948, and who has returned to full-time teaching and research.

The department, consisting of nine faculty members, carries on a research program with annual expenditures exceeding $200,000. It has for several years been active in establishing codes for lightweight steel structures.

Before joining the Cornell faculty, Gallagher was employed for seventeen years by the Civil Aeronautics Administration, by Texaco, Inc., and by Bell Aerosystems Company. He holds the degrees of Bachelor and Master of Civil Engineering from New York University, and a doctorate in structural engineering from the State University of New York at Buffalo.

Gallagher is an expert on the subject of finite element analysis, a technique that can be used to analyze the behavior of a broad range of physical systems. He is the author of the text, Correlation Study of Methods of Matrix Structural Analysis, and editor of the International Journal of Numerical Methods in Engineering. In the summer of 1969 he organized and was the United States chairman of a U.S.-Japan seminar on matrix methods of structural analysis and design, sponsored by the National Science Foundation and held in Tokyo.

Gallagher is a member of the American Society of Civil Engineers, the American Institute of Aeronautics and Astronautics, the Society for Experimental Stress Analysis, the International Association for Bridge and Structural Engineering, and Sigma Xi.

Named to the Francis Norwood Bard Professorship at the College of Engineering this year was Robert W. Balluffi, professor of materials science and engineering. An authority on crystal defects and radiation damage and diffusion in materials, Balluffi is author or coauthor of nearly one hundred technical papers on these subjects.

He earned the degrees of Bachelor of Science and Doctor of Science, both in metallurgy, at the Massachusetts Institute of Technology in 1947 and 1950, respectively. From 1950 to 1954 he was employed in the Fundamental Metallurgy Group of the Sylvania Electric Company. He then served as research associate at the Columbia University School of Mines for a year before joining the Mining, Metallurgy and Petroleum Engineering Department of the University of Illinois at Urbana, where he served until joining the Cornell faculty in 1964.

Balluffi is a member of the American Physical Society, the American Institute of Mining, Metallurgical and Petroleum Engineers, and the American Society for Metals.

The Francis Norwood Bard Professorship was endowed in 1947 by the late Mr. Bard, a leader in the metallurgical processing industries, who received the degree of Mechanical Engineer from Cornell in 1904. Bard Hall, which houses the College's Department of Materials Science and Engineering, was also a gift to Cornell from Bard.
The following publications and conference papers by faculty members and graduate students of the Cornell College of Engineering were published or presented during August, September, and October 1970. If an earlier publication or conference paper was inadvertently omitted from a previous listing, it is included here with the date of publication in parentheses. The names of Cornell personnel are in italics.

**AEROSPACE ENGINEERING**


**AGRICULTURAL ENGINEERING**


**APPLIED AND ENGINEERING PHYSICS**


**Silcox, J.** 1970. Electron microscope obser-


CHEMICAL ENGINEERING


CIVIL AND ENVIRONMENTAL ENGINEERING


COMPUTER SCIENCE


**MECHANICAL ENGINEERING**


**INDUSTRIAL ENGINEERING AND OPERATIONS RESEARCH**


**THEORETICAL AND APPLIED MECHANICS**


