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CO-OP = VITALIZED ENGINEERING EDUCATION
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Therefore, management ought to be interested in the Cornell Engineering Cooperative Program because it gives industry a chance to participate in undergraduate training. If industry does its part well, it stands a fair chance of recruiting many of the Co-op students for permanent jobs later.

**MUTUAL BENEFITS**

The student-industry relationship begins with interviews at Cornell. Often it is difficult for the young interviewee to express what his interests are in terms of industry. But, by discussing his scholastic and extracurricular activities and by carefully studying his background, we, from Emerson Electric, try to guide him to the position most advantageous for him in the Company.

When the Co-op student reports for his first industrial assignment with us, he is not treated as a student on a summer job. He is introduced to the people with whom he will be working and is made a part of the regular working staff. He is given an interesting problem which we want solved and which we think he can handle.

**WORK ASSIGNMENTS**

During these periods of intense professional development, the Co-op student is paid wages commensurate with his responsibilities and with the time he has spent with the Company. At the end of the first term, our students often wonder if they have earned their wages. They have learned a great deal, they say, but the Company has nothing to show for it—no revolutionary new products and perhaps little more than a report of tests which failed. But after three terms, during which the student has likely seen one of his earlier projects carried to completion, he begins to see the evolution of new products and ideas from the tedious failures that characterize most new product development.

He realizes that he played a necessary role in shaping the finished product. It is difficult to evaluate what he did in terms of dollars and to say whether he "paid" for his term in industry. Sometimes he does. In most cases, we can say that the student did as much or more than was expected of him.

**ADJUSTING TO PROFESSIONAL LIFE**

Many engineering graduates spend their first year in industry trying to relate what they learned in college to what they find in industry. The Co-op graduate already has a much better grasp of this relationship. The workings of industry have become such a vital part of his undergraduate education that a major reorientation after graduation isn't necessary. Thus, the Program has given the student approximately a year's head start professionally, and has enabled him to complement his formal education with practical industrial knowledge. There is no doubt that the Co-op students who have permanently joined Emerson have adapted more quickly than other new employees.
STUDIES

Through the Co-op Program, the student can learn, before his education is at a critical stage, whether he is in the right engineering field or not. Sometimes, after a term or two in industry, he finds that his idea of his intended field is inaccurate. This discovery may prompt only a modification of attitude; sometimes it leads to a curriculum change. A high percentage of the Co-op students at Emerson have made such adjustments. One of our mechanical engineering students, for example, who had avoided mathematics as much as possible, decided that his professional work required a strengthening of his analytical ability, so he managed to take two advanced calculus courses in his fifth year. Another student changed from engineering physics to electrical engineering as a result of his industrial experience.

The Co-op student, then, has the learning experiences that all professional engineers have eventually, but, because of his head start, he has them a year or two earlier than most. He has

The author, L. K. Stringham, vice president for research and development at the Emerson Electric Company, has supervised the work of Cooperative Program students at his Company for several years.
"The shortage of enthusiastic, creative engineers—the kind the Co-op Program often produces—is never past."

steeped himself alternately in the academic and industrial worlds and has brought the techniques, knowledge, and personal maturity gained in one to bear on the other. The result—a more mature young engineer who has the confidence of knowing who he is and where he is going.

UNIVERSITY AND INDUSTRY

Because Cornell and Emerson Electric have cooperated to integrate, meaningfully, theoretical and practical training, our Engineering Cooperative Program has been successful. The students are enthusiastic about what they have learned, and their supervisors are enthusiastic about the students’ abilities, drive, high motivation, and willingness to learn.

The shortage of enthusiastic, creative engineers—the kind the Co-op Program often produces—is never past. We at Emerson think that the Cornell Co-op Program represents a wonderful opportunity for both the student and industry. It requires much work by all parties, but it is well worth the effort.

L. K. Stringham, a Cornellian who took his Bachelor of Science degree in electrical engineering in 1933, has been vice president for research and development at the Emerson Electric Company since 1958. Prior to this, he was employed by the Lincoln Electric Company in Cleveland, Ohio, where he advanced from sales student to vice president for engineering.

Mr. Stringham has long been interested in Cornell affairs. He has assisted the University in its fund drives and in its secondary school admissions activity in the greater St. Louis area. Presently he is a member of the University Council.

Active in community affairs, Mr. Stringham is a member of the Sustaining Associates Program of Washington University, a member of the board of the St. Louis Bi-state Chapter of the American Red Cross, an adviser for Junior Achievement, a member of the managerial board of the Central Institute of the Deaf, and a member of the executive committee of the St. Louis Electrical Board of Trade.

Mr. Stringham is a Fellow of the Institute of Electrical and Electronics Engineers and a member of the American Welding Society. He is a licensed professional engineer in Ohio.
WHY COOPERATIVE EDUCATION?

Because it involves problems, objectives, and responsibilities quite unlike those found at a university, industry can play a major role in a student's undergraduate education by giving him the truly functional concept of engineering that he often doesn't have even after four years of college training. This can be done through special cooperative education programs in which students spend alternate periods in college and in industry.

Many of the ingredients of a college education can be enumerated in a syllabus. Industry's educational values are less easy to specify. There, learning results from doing a specific job; it results from contact with the people, policies, products, and organization of a company that is sensitive to the student's needs. It results from his acceptance of steadily increasing responsibilities. Therefore, though the job itself is satisfactory when it challenges the student and when it satisfies his desire for accomplishment, it is only one part of his industrial education.

The custom planning of Co-op job assignments requires that administrative provisions be made that are not a part of the normal operations of modern industry. Despite this, some companies seek the responsibility. They realize the importance of developing our limited national supply of engineering talent effectively. This entails helping each individual to identify his talents and to utilize them to the advantage of the profession and to his personal satisfaction. Attempting to instill in each student a standard concept of what an engineer should be plays no part in cooperative education.

WORK ASSIGNMENTS

Industry is more than a laboratory for experimenting with what is learned on campus. Thus, it is not reasonable or necessary that the student use his most recently acquired academic knowledge on each job assignment. He should, however, be required to use his basic engineering knowledge and not just his technical craftsmanship on each job. Too often he is given only technician's work on the grounds that this is basic to his training. At least after the second college year, when many students begin their Co-op periods, the validity of this premise is questionable. The function of a professional engineer today simply is not built upon his skills with shop tools as it may have been thirty or forty years ago.

Further, the caliber of the job should be at, and, in part, above, the student's academic and personal maturities. The Co-op student is not looking for something easy to do. He responds to and learns from challenge. What he doesn't
want is an observer assignment in which he only watches others at work (punishment of the first order!) or is assigned "made" work which is destined for the trash can.

The work done in three representative areas, test, research, and design, illustrates how industrial job assignments can be educative. These are not the only work areas available, but, because many Co-op students have worked in them, much is known about their educational values.

Between the routine testing of each item off a production line and the more sophisticated testing which is done in experimental laboratories, there are many areas where students can work profitably. Much of the success of a student's testing work depends on how much he interacts with the company's engineers, how much he is exposed to "real engineering," and how much he is allowed to function beyond the technician's scope of "connect," "read," and "record." When the student himself may plan the test, design the instrumentation for it, and be responsible for the results, he will have had a worthwhile learning experience.

Research has attained so much prestige that it entices many whose talents are not best suited to such a career. It is also an area where industry has the least to offer that is different from what a university offers. With wise counseling, those who are truly talented for this work can be sorted out from those who are merely wishful, and little time will be wasted in pursuing wrong objectives.

Design, or creative synthesis, characterizes the engineering profession and distinguishes it from the basically analytical pursuits of science and mathematics. It requires the coordination of materials with factors such as economics, safety, reliability, and salability. This process is still very much an art. A basic qualification for it is creativity with purposeful imagination and ingenuity. During his first two years, the engineering student, who is more skilled in analysis than in synthesis, might not seem ready for a design assignment. But, in fact, he is often capable of doing effective work, and a well-guided assignment in design can have important consequences for his formal studies and later career.

Design activities extend from applied research to the building of production prototypes. Where in this range the student might best be assigned depends on his preparation and interests, and on the company's current areas of product development.

The activities outlined above constitute the essence of the assignments but by no means represent the total job. The student, like any other employee, should have his share of the quite unglamorous responsibilities that have survived automation. Thus, it is hoped that he will acquire self-discipline and will take his place among his fellow workers as one of them, and not as a person more or less favored because he is a student.

WHY ONE COMPANY?

There is some feeling among collegians that they must move from company to company to get breadth of experience. It is not the purpose of Cornell's Engineering Cooperative Program to provide a survey of each company's peculiarities of organization, operation, technology, and policy. The student decides to study at a particular
PARTICIPATING ORGANIZATIONS
IN CORNELL'S ENGINEERING
COOPERATIVE PROGRAM

American Electric Power Service Corporation
Anaconda Wire and Cable Company
Campbell Soup Company
Cornell Aeronautical Laboratory
Eastman Kodak Company
Emerson Electric Company
Farrel Corporation
General Electric Company
General Radio Company
Gleason Works
Hewlett-Packard, Sanborn Division
International Business Machines Corporation
Moore Products Company
Raytheon Company
Sanders Associates, Incorporated
United Airlines
Xerox Corporation
In the Cornell Program, the students begin their industrial periods, which alternate with periods of campus study, after the second term of their sophomore year. Any student who majors in electrical engineering, engineering physics, mechanical engineering, or industrial engineering and operations research, who has a sound scholastic record, and who ranks in the upper half of his class, may apply for admission to the Program.

Each of the sixteen companies in the Co-op Program visits the campus early in the spring term to interview sophomore applicants to the Program. Individual selections are subsequently forwarded by the companies to the Engineering Cooperative Program Office where, in turn, an attempt is made to match a student's preference with the results of the interviews.

Shown on the chart is the Co-op students' work and study schedule. By utilizing the summers that follow completion of the sophomore, junior, and senior years, three work periods, designated "Industry I, II, and III," totaling nearly a calendar year are provided. For all but one summer term, the schedules of the Co-op students parallel those of their classmates who are not enrolled in the Program. Fifth-term studies are taken on campus in a fourteen-week summer session of two seven-week periods that is administered by the Program Office.
university and not to make a study of it. This should be his approach to industry as well. For the student to “bum around” from one company to another would gain no more for him than would his transferring from one college to another during his undergraduate years. Furthermore, due to competition, almost any company must have some reservations about known “floating” personnel who might carry information to its competitors.

If he were to remain with a company for only one work period, the student would do himself a great disservice. One work period of three to four months is too short a time for the student to become really conversant with an industry, and is too short a time for a company to assess his growth potential and to guide meaningfully his development. Neither party can function optimally except in a situation where each feels wanted beyond the present obligation.

INDUSTRY’S MOTIVES AND OBJECTIVES

Many companies embark on cooperative programs without adequately defining their motives and objectives. Yet, the success of any company’s cooperative program depends on such definition. Indeed, the same thoughtful, critical analysis that is applied to its products and services should be applied to this venture with students.

The inquiry “Why do you have a cooperative program?” often elicits such replies as “We want to do our share to help education” or “We like to have young people with fresh viewpoints among us.” Too often, though, the motive is just to “get in the swim” or, at worst, to obtain cheap labor. Many industries fail to recognize that cooperative education is a serious, long-range business, and that it is a poor gamble to conduct it on any other basis. Education, whether in a college or industry, requires the same evaluation, planning, and implementation as any other service.

Clearly, a company must have a serious business incentive to justify active interest in cooperative education. Recruiting will be this incentive if the company recognizes that its future success depends on its finding and helping to train the best possible talent it can attract.

ADMINISTRATION

A company should have decided to enter cooperative education only after it has thoroughly examined its educational potential in terms of manpower and facilities. Areas suitable for student assignment must be determined. The nature, level, and duration of work in each area must be decided and qualified supervisors found. Students must be interviewed to determine whether their qualifications and career potential are of interest to the company. Effective assignment requires that the accepted student be interviewed by more than one of the various work area supervisors. After assignment, the company must be constantly alert to his technical progress, his relations with people, and his attitudes. Systematic, direct contact with both the student and supervisor is necessary for this. The student’s activities should be recorded at the end of the assignment and preferably at midperiod as well. Regular contact, too, should be maintained with his college. This usually involves written reports from the student and the company, plus visits by a coordinator from the University. The student
In early February, prospective Co-op students can meet informally with representatives from all participating companies at two evening smokers; individual interviews with the representatives are then scheduled for the following day. The companies' selection of students and the students' preferences are coordinated by the Engineering Cooperative Program Office which extends the bids.
should be counselled, especially before he returns to campus, about his progress, and about his tentative choice of work for his next assignment. If the company later finds that it would like to offer him permanent employment, it should maintain direct contact with him, especially should he do graduate work or military service.

THE SUPERVISOR

The supervisor, more than anyone in the company, can make or break the value of an assignment. Unless a supervisor can be found who is a wise and capable teacher as well as a competent engineer, a company would be best advised not to seek cooperative contact with students. The hard-boiled, inarticulate, self-centered, over-burdened, or unhappy employee is the worst possible choice. Not that the student should be pampered, but his problems of understanding his new environment and how he can best function in it need understanding and not indifference or obstruction. The supervisor's selection of responsibilities, his interest in the student, and his ability to provide an educative climate, require that he have an adequate background knowledge of the student as well as of the men with whom the student will work.

COMPANY SIZE

There is much well-worn debate among all students about small versus large companies. Largeness or smallness is no criterion for judging the suitability of a company for a particular student. Only through study of both parties can suitability be determined.

The warmth of the environment and the challenge of the work often don't depend on size either. The large company is usually thought to offer a greater range of assignments in varied technical fields. But today, it cannot be assumed that this asset derives from largeness alone. Decentralization often reduces a large organization to independent production or research units where a Co-op student is likely to have the feeling that he is in a small company.

BENEFITS

Cooperative programs offer industry more than the chance to do some well-informed permanent recruiting. They offer a prime opportunity to build a favorable image among both students and faculty at various universities. Many a Cornell student who did not participate in a particular company's cooperative program later has chosen a career with that company because of its good name at the University and because he had direct contact with a Co-op student from that company.

Often better communications are established between a university and industry whereby each can profit from the skills and discoveries of the other.

The work of some students will have early and outstanding value to their companies. Industries who give their students quality work assignments commonly report that the students "pay their way" through all their industrial work periods.

OUTLOOK

Some college cooperative programs greatly emphasize the fact that the student earns wages that enable him to work his way through college. Supporting funds for such programs have even
Robert N. Allen, Associate Professor of Operations Research at Cornell has been appointed Director of the Engineering Cooperative Program at the University. Professor Allen succeeds Professor Emeritus Everett M. Strong, who developed the Program and has directed it since its beginning. The new Director is a 1940 graduate of the administrative engineering course in Cornell's Sibley School of Mechanical Engineering. He has been associated with Cornell since joining the faculty in 1947.

He has had much experience with students not only through teaching, but also through various University committees that are concerned with student affairs. Among them are the Admissions Committee in the Division of Unclassified Students, the Admissions Standards Committee for the School of Industrial Engineering, the Admissions Standards Committee of the Division of Basic Studies, the University Financial Aid Committee, the University Board of Physical Education and Athletics, and a special study committee on undergraduate intercollege transfers.

Professor Allen is a member of the American Society for Engineering Education, the National Association of Accountants, and Pi Tau Sigma. In 1964 he was the recipient of the student-faculty relations award of the Cornell Engineer, the College's student-operated quarterly magazine.
been allocated by the Federal Poverty Program.

It should be clear that Cornell's Engineering Cooperative Program is not an "earn your way" plan. The student's earnings in the fifty weeks of the Cornell Program can't contribute much toward his tuition for one-hundred fifty weeks of campus study.

The purpose of the Cornell Program is to serve the educational needs of students who have demonstrated that they are of high academic caliber and have sufficient technical preparation to profit professionally by an industrial assignment. In this, the Program has been successful. A significant number of Co-op students have graduated being better informed as to choice of employment and being more eligible for it than many of their fellow graduates.

Participating in a program of this scope and responsibility is not to be advocated for all students, universities, and industries. But for those who do undertake it, the rewards in terms of education, greater career satisfaction, and more competent company personnel are great.

Everett M. Strong, Emeritus Professor of Electrical Engineering at Cornell, writes knowingly about cooperative education for engineering students because he developed Cornell's Engineering Cooperative Program twenty years ago and has been its director ever since.

During his tenure, more than four hundred Cornell engineering students have taken part in the Program. Sixteen companies and sixty-six students will participate during the present calendar year.

Professor Strong received his Bachelor of Science degree in electrical engineering from M.I.T. in 1922 and has been a member of the Cornell faculty since 1924.

The Illuminating Engineering Society awarded him its Gold Medal in 1966 in recognition of his leadership in research programs in light vision. His honoraries and listings include Tau Beta Pi, Sigma Xi, Eta Kappa Nu, American Men of Science, Who's Who in the East, Who's Who in America, and World Biography. Professor Strong is a licensed professional engineer in New York State.
This article is based on interviews with students who were preparing for their first work period in industry as participants in Cornell's Engineering Cooperative Program. Views were also given by students who are now in their second and third industrial terms, and by alumni of the Program. Student job assignment reports from the Engineering Cooperative Program Office were also used.

"I like engineering, I like the schoolwork. But now I want to see how it is to do this work from 8:00 to 5:00, to see the different aspects and areas of engineering, and to see how to use this knowledge I've been acquiring." So went the comments of one student. Another remarked, "This is what I plan to be doing for the rest of my life. I'd better see if this is it." These are the thoughts of Co-op students who want to put their knowledge to work and to see whether what is theoretical can also be practical.

Sometimes they found little direct relationship between the theories and skills of the classroom and those required on their job assignments. Most students, though, saw what they had learned in the classroom put to work in industry. "My studies will have more meaning because now I have seen how the material one learns is used in actual practice." And in turn, nearly every Co-op student interviewed said, "I learned a lot that I expect to apply when I return to Cornell." The students, too, felt the impact of the Co-op experience on their educational goals: "It showed me how all of my separate courses of study are important. An engineer today has to have a diverse storehouse of knowledge to draw from." More than one student commented that his work experience gave him greater incentive for studies: "The significance of a college degree has really been driven home to me."

Industrial experience often opened whole new areas of interest to these students. "My Co-op experience introduced me to computers, a field I would never have considered otherwise. As a result, I took quite a few computer courses . . . got a great deal out of them. Eventually I hope to get into work dealing with computer design or some related field." Another student stated, "It helped me decide what I want to do and in what areas I would like to put emphasis." The process worked in reverse, too. One student commented that as a result of a term in industry, he decided against an elective which he had previously planned to take.

PERSONAL REWARDS

"The first impression that I had of my job . . . was that they had given me a great deal of responsibility. . . . I understand now that my membership in the Cooperative Program was evidence enough of my competence for the supervisor to assume that I knew what I was doing." The students develop a sense of pride and professionalism about their work. "The complete responsibility for the design and building of a test instrument . . . [was the] most interesting and gratifying job I performed during my first Co-op term. . . . The design was all mine, and most importantly, it worked. . . ." An electrical engineering student told how at 14
the beginning of his second work period he was questioned about his interests, capabilities, and previous background in electronics and was then allowed to work on an actual circuit design after two or three weeks of familiarization with the procedures of the department. He received help from the company’s engineers whenever he asked for it. As his dependence on them lessened, he was given the opportunity to design a complete circuit. Progress was slow at first while he learned to relate his knowledge and experience to the problem. With the help of others in his department, especially his group leader, he was able to complete the design, test it, and use it in conjunction with its associated circuits.

The students learn what teamwork means. “[The experience proved] very useful in making me aware of my own particular problems in learning how to work with other people in such an environment.” One student remarked, “I saw how relationships between worker and supervisor go—much less formal than I had anticipated.”

Thus, student enthusiasm about the rewards of the Program was high despite the fact that in order to graduate with their classmates they must attend one summer school session, and spend one fall term and two summers working in industry, often far away from home. Though many could have lived at home and earned as much or more money at a job that might not have been related to engineering, they recognized the influence of the Program on their potential earning power and were willing to devote themselves to its year-round study and work curriculum.

THE INDUSTRIAL ENVIRONMENT

Only rarely did the students find their fellow workers and supervisors anything but helpful. “The personnel I worked with were friendly, understanding, and quite eager to help me with my job. My supervisor visited me frequently to inform me of changes . . ., to check my work, and to explain pertinent procedures, policies, and relationships within the plant.” “Someone was always available to talk with me about any problem.” “The people [at the company] always made it a point to answer my questions and even to anticipate my questions and explain things to me.”

There were some exceptions, of course. “The work being done was either . . . above my capabilities, or technician’s work. In addition, all the engineers in the department were too busy trying to meet deadlines to spend much time familiarizing me with their work. . . . [I] arranged for transfer to another department. . . . Immediately things were different, for in this depart-
I can't conceive of a better place . . . to learn the shortcomings of both men and machines.'
The following represent Co-op students' first-period work.


2. Comparing plots in a computer research program at the Cornell Aeronautical Laboratory, Buffalo, N.Y.

3. Also at CAL, a student studying a plasma with a resonant probe and brush cathode discharge tube.

4. Performing a test evaluation of an instrument prototype built by students at the General Radio Company.

5. Reviewing the performance of a new recording instrument designed and produced by the Sanborn Division of Hewlett-Packard, Waltham, Massachusetts.


7. A student employed by CAL uses a QUICKTRAN terminal for obtaining results on his engineering problems.

8. Experimenting with a new bevel-gear cutting method to determine its effect on the machine's torque and stress at the Gleason Works, Rochester, N.Y.

ment I was working along with engineers . . . [who] acquainted me with work to be done . . . [A memo from the supervisor] described the work in great detail with instructions to come to him about things I did not understand.”

In any industry there are many routine though necessary tasks which are often performed by Co-op students. Several students, for example, commented on the amount of paper work that is involved in professional engineering. “The paper work, which is so necessary to company communications, was dull for the most part. [It] was instructive, though, in that I became familiar with configurations of elements and also some of their functions.”

Part of the learning experience came from outside the job assignment itself—seeing the operation, organization, and interaction of departments; working and talking with others in an “action” environment; getting the “inside story”; and taking after-hours courses. “By the time my term was over, I was familiar with the complete plant structure and knew most of the areas of responsibility for personnel in
manufacturing operations through the functional level." One student told of his participation in a summer trainees' program which consisted of lectures, discussions, and trips, and stated that he found this the most interesting part of his industrial term. Another was grateful to an engineer in the plant where he had worked for urging him to get his Master's degree before leaving school which he subsequently did.

EFFECTIVENESS OF THE PROGRAM

The key objective of the Co-op Program is to give the students industrial experience that complements their educational experience. In this it has been successful. As one student expressed it, "If you are seeking experience and knowledge . . . I can't conceive of a better place to acquire information [that is] found in no textbooks and in no classrooms, and equally important, to learn the shortcomings of both men and machines." Another student commented, "Even more important than the actual knowledge attained from my
1. A different form of Co-op experience is furnished by a NASA design contract under which several Cornell Master of Engineering candidates are producing lunar rover sensor systems.

2. The Co-op student's fifth academic term is spent in summer school where he has the advantage of smaller classes and more instructor contact.

3. After completing the Co-op Program, most students continue with their professional education by earning the Master of Engineering degree. Several work on design projects that are closely related to their industrial experiences. Here, a graduate student in aerospace engineering works on a plasma generator.

...faith I have in practical learning. I really can't see that there is any other way with the same satisfying results. Theories are fine. I like them a lot. But even more, I like to see them work. I like to see how they are limited in reality. And the only way to do that is to go out and get your hands a little dirty."

Judith E. Olson is a part-time editorial assistant for ENGINEERING: Cornell Quarterly. Born in Bremerton, Washington, she graduated with honors from Washington State University in 1964, receiving a Bachelor of Arts degree in English. During her college career she directed her course of study towards technical writing and worked on the engineering student publication, the WSU Technometer.

Mrs. Olson's husband, David, is a Cornell graduate student who expects to receive his doctorate in materials science and engineering in 1969.
Meetings, convocations, receptions, registration . . . and bewilderment. This was Freshman Orientation 1967 and it could have been Freshman Orientation in any other year. These event-filled days, organized to familiarize new Cornellians with their University, its faculty, and its procedures, hold a special place in the memory of both returning student and alumnus. They are days that are exciting with plans for the future, clumsy with the uncertainty of youth, gay with the anticipation of college social life, and serious, too, with the realization of what the year ahead can mean.

In early September, six hundred new engineering students arrive at Cornell. Many are accompanied by parents and little brother who want to meet their future engineer's roommate, the dean, and some of the faculty, and want to see that he is properly settled. When they're gone and the student has their final "Good luck! Give it all you've got!" ringing in his ears, he suddenly feels very much alone . . . but not for long. A look at the Freshman Orientation schedule suggests busy days ahead.
First there is a general freshman convocation, then meetings with advisers and dormitory counselors; there are placement examinations to schedule and ID pictures to be taken. Most important of all is registration. Here the impact of the computer on the academic world becomes apparent. Instead of filling out one or two forms, the new student is given a stack of IBM cards on which he must write bits of information by squeezing his letters between the holes. And then, what always happens to some unfortunate student after a long wait in registration lines—he discovers that a card is missing.

After a trip to the campus store, he is staggered by the expense of the books required, but is beguiled as well by their promise. Next to pay the tuition bill—another line.

Monday morning, first day of classes, naturally begins with an eight o'clock. Somehow getting up and getting ready in the morning isn't quite as easy here as it was at home. The climb up "libe slope" is invigorating because a brisk pace is necessary in order to get to class on time.
Should he sit at the front of the lecture hall and take a chance on becoming too conspicuous to the professor, or should he risk sitting in the back where he might not be able to hear everything? Finally he decides on the fifth row. After a morning fraught with making such decisions and with writing down endless homework assignments, lunchtime is a welcome break.

By the end of the first day, it is plain that long hours of study are in order. The student wonders how much of the knowledge housed in the Engineering Library in Carpenter Hall he will be expected to master, and wonders, too, if he can do it. He wonders if others can have the same doubts and hopes as he. Back at the dormitory, a full evening of study lies ahead. Already there's a bridge game in progress in the room across the hall. This time he resists. Trudging back up the hill to the library which is filled with other young hopefuls like himself, he hopes to find some peace and quiet. Satisfied that he is prepared for the next day, it is back to the dorm and to bed. He thinks that if he can survive climbing the hills he can take all the rest of it. A case of "frosh cramps" is beginning to set in.

Soon these first few days will seem far away, and their problems and uncertainties may seem trivial. But they will never be forgotten.

1. "Good grief! Six eight o'clocks!"
2. At Noyes Student Center there are serious matters besides studying.
3. Not too many get to breakfast on the second day.
1. The wild sprint up Libe Slope.
2. Leaving Convocation, the new freshmen are united by the spirit of '71.
3. Engineering students in a small freshman humanities seminar.
Edmund T. Cranch has been named Associate Dean in the College of Engineering. His biography and brief biographies of new and visiting faculty members follow.

Edmund T. Cranch, Chairman of the Department of Theoretical and Applied Mechanics, has been appointed Associate Dean in the Cornell College of Engineering. His primary College responsibilities are in the areas of research and graduate study. In addition, he will continue in his position of department chairman.

The appointment of a dean responsible for research and graduate study is an indication of their increasingly educational role. Dean Cranch will be concerned with the further development of research activities and with the funding necessary to institute new research projects. During the past year, College research was supported by expenditures of more than $5 million. This represents a threefold increase in monetary support in the last six years.

Dean Cranch notes that some changes now are occurring in the way in which university research projects are initiated and in the way in which support money is provided. Previously, the individual professor initiated a research proposal and then sought funds from an interested sponsoring agency. Now the government is focusing more attention on what may be called “mission-oriented” projects in which many professors and their students participate. Thus academic expertise is channeled towards broad problems of national importance. Block amounts of money are given to universities which then internally administer the funds to support the research efforts of professors with different specialties who are working on various facets of a large-scale problem. Frequently, part of this support is in the form of laboratory facilities and technicians. The advantage of this approach is that a more powerful attack can be mounted on a problem when several engineering and scientific disciplines are drawn together to work on it.

In nearly all areas of engineering, one of the major obstacles to progress has been the lack of suitable materials. The Materials Science Center at Cornell was established to enhance the research and educational programs in those fields of engineering and science which are most closely related to the study of materials.

A more recently developed area of research activity is the Plasma Studies Laboratory where the talents of students and professors from four or five divisions of the College of Engineering are brought together. It is the goal of the Laboratory to do research in the area of thermonuclear fusion, which may be the power source of the future, and to train researchers and teachers who will carry on this work.

Though no decision has been made as yet to explore the areas of biophysics and bioengineering in terms of a College-wide research center, several professors are working in these areas, and Dean Cranch feels that these studies have great potential for future interdisciplinary activity.

Another field certain to attract increasing attention is that of engineering in the ocean environment. Through the National Science Foundation, the United States government plans to
support an extensive program for the exploration and utilization of the oceans and large lakes. Such diverse topics as communications systems, materials synthesis, ocean floor soil stability, mineral extraction, and underwater structures are but a few of the areas which would be involved in an ocean engineering program. At Cornell, the Water Resources Center could be expected to play a vital role, and a major contribution could be made by the biological scientists. Thus, the need and possibilities for an interdisciplinary approach are evident.

Part of Dean Cranch's own research involves mechanics problems which arise in the ocean environment. His recent research has been on the dynamics of shell structures, especially when they are subjected to initial loads which strongly influence their dynamic response. Although his first interest was the use of such shells in lightweight space flight applications, he is now concerned with shells made of glass and fiber-reinforced composite materials which are subjected to the intense load of the ocean.
In his consulting practice, he has worked for the M.I.T. Lincoln Laboratory, the Cornell Aeronautical Laboratory, the Ramo-Wooldridge Corporation, the General Electric Company, the Aerojet General Corporation, Bausch & Lomb, Incorporated, and the International Business Machines Corporation.

He is a member of several professional and honorary societies including the American Society of Mechanical Engineers, the Society for Experimental Stress Analysis, the American Society for Testing Materials, the American Society for Engineering Education, Tau Beta Pi, and Sigma Xi. He is listed in Who's Who in Engineering and is a reviewer for the Journal of Applied Mathematics.

After taking the Bachelor of Mechanical Engineering degree at Cornell, Dean Cranch became a member of the technical staff at the Bell Telephone Laboratories. He returned to Cornell for the Doctor of Philosophy degree and joined the faculty in 1952.

During the academic year 1958-59, he was a National Science Foundation Faculty Fellow at Stanford University. In 1962 he was administrative director of the NASA Summer Seminar in Space Mathematics. The academic year of 1964-65 was spent at the Swiss Federal Institute of Technology in Zurich where he was a National Science Foundation Senior Postdoctoral Fellow.

At the undergraduate level, he has helped to develop a unique sophomore mathematics course which is taken by all engineering students after a year of freshman calculus. The purpose of this course, which has been given now for five years, is to provide high quality mathematics instruction which has relevance to engineering. The lectures are given by two faculty members from the Department of Mathematics and two from the College of Engineering. The course is coordinated with the programs of the Departments of Physics and Chemistry, as well as with the instruction given in the basic engineering sciences in order that the students may be prepared for the mathematical demands made in these areas. There are indications that this type of mathematics program will be adopted by many colleges of engineering. The instructional materials were gathered under an NSF grant and now are being revised into a textbook which is authored by Professors Henry D. Block, Mr. Cranch, Peter J. Hilton, and Robert J. Walker.

Kyle T. Alfriend comes to Cornell from Virginia Polytechnic Institute where he completed work for the doctoral degree in 1967. He received the Bachelor of Science degree from this institution in 1962, and took the Master of Science degree from Stanford University in 1964. Now an Assistant Professor in the Department of Theoretical and Applied Mechanics, Mr. Alfriend is specializing in dynamics, space mechanics, and optimal control. He has had professional experience with Lockheed Missiles & Space Division of Lockheed Aircraft Corporation. He is a member of Tau Beta Pi, Sigma Xi, the Institute of Electrical and Electronics Engineers, and the American Institute of Aeronautics and Astronautics.
Hamilton Emmons, Assistant Professor in the Department of Industrial Engineering/Operations Research, took the Bachelor of Arts degree from Harvard University in 1952, the Master of Science degree in applied mathematics from the University of Minnesota in 1958, the Master of Science degree in electrical engineering from New York University in 1962, and expects to receive his Doctor of Philosophy degree from Johns Hopkins University in 1968. Mr. Emmons taught at Johns Hopkins and has worked at the Bell Telephone Laboratories in Holmdel and Murray Hill, New Jersey. At Cornell his specialty is operations research. The organizations to which he belongs include the Institute of Management Sciences and the Operations Research Society of America.

Donald T. Farley was formerly associated with the Jicamarca radar station in Lima, Peru, where he worked for the United States Bureau of Standards since 1961, studying the incoherent scattering of powerful radio waves near the geomagnetic equator. For this work he received the Gold Medal of Merit from the United States Department of Commerce. Mr. Farley took both his Bachelor of Science degree in engineering physics, 1956, and his doctoral degree, 1959, from Cornell. He spent a year at the University of Cambridge as a NATO Fellow studying incoherent scattering of radio waves in a magnetoionic medium. In 1960–61 he gave a lecture series on radio wave scattering at the Teckniska Högskola in Chalmers, Sweden. He is now a Professor of Electrical Engineering.

Hans H. Fleischmann joins Cornell as Associate Professor of Engineering Physics from General Atomic Division of General Dynamics Corporation. Educated at the Technische Hochschule in Munich, Germany, where he took the degrees Diplom Physiker in 1959 and Doktor rerum naturalium in 1962, Mr. Fleischmann has published widely in the field of nuclear and atomic physics. He is a member of the American Physical Society and the Institute of Electrical and Electronics Engineers.

Richard H. Gallagher was associated with the Bell Aerosystems Company Division of Bell Aerospace Corporation at Buffalo, New York, as assistant chief engineer for structural dynamics for more than ten years. Prior to this, he worked with Texaco, Incorporated and with the Civil Aeronautics Administration of the United States Department of Commerce. Mr. Gallagher took the Bachelor of Civil Engineering degree from New York University in 1955 and was awarded the Doctor of Philosophy degree in 1965 from the State University of New York at Buffalo. He has been a guest lecturer at the State University of New York at Buffalo, the University of California at Los Angeles, and Case Institute of Technology, as well as at Cornell. At Cornell he is a Professor of Structural Engineering in the School of Civil Engineering where he is studying aerospace structures and computer methods. He is a member of the American Society of Civil Engineers, the American Institute of Aeronautics and Astronautics, the Society for Experimental Stress Analysis, and Sigma Xi.
John E. Hopcroft, Associate Professor of Computer Science, was graduated from Seattle University in 1961 with the Bachelor of Science degree and went on to take the Master of Science degree in 1962 and the Doctor of Philosophy degree in 1964 from Stanford University. Before coming to Cornell, Mr. Hopcroft had been teaching at Princeton. He specializes in the areas of formal languages and automata theory. The organizations of which he is a member include the Institute of Electrical and Electronics Engineers, the Association for Computing Machinery, Sigma Xi, Tau Beta Pi, and Pi Mu Epsilon.

Edwin F. Johnson took the Bachelor of Arts degree in 1960 from the University of Utah and earned his doctorate in 1967 from Cornell. Now Assistant Professor of Electrical Engineering, he was formerly a research associate at Cornell and had teaching experience as well. His areas of interest are physical electronics and microwave properties of semiconductors. He is a member of Phi Beta Kappa.

Edward J. Kramer is a Cornellian who took the Bachelor of Chemical Engineering degree in 1962 and was awarded the Doctor of Philosophy degree by Carnegie Institute of Technology in 1967. During 1967 he studied at the University of Oxford on a NATO postdoctoral fellowship. Mr. Kramer is now Assistant Professor of Materials Science and Engineering, and his specialties are plastic deformation, superconductivity, and physical acoustics. His memberships include Tau Beta Pi and Phi Kappa Phi.

Alonzo Wm. Lawrence, who specializes in water quality control engineering, particularly removal of organics from wastewater and effects of wastes on receiving waters, is Assistant Professor of Water Resources Engineering in the School of Civil Engineering. He was graduated from the State University at Rutgers in 1959 with the Bachelor of Science degree. In 1960 he took the Master of Science degree from M.I.T., and in 1967 he took the Doctor of Philosophy degree from Stanford University. Mr. Lawrence has taught at Drexel Institute of Technology. He is a member of the American Society of Civil Engineers, Tau Beta Pi, Sigma Xi, and the Water Pollution Control Association of Pennsylvania.

Charles A. Lee, Associate Professor of Electrical Engineering, took the Bachelor of Electrical Engineering degree from Rensselaer Polytechnic Institute in 1944 and the doctorate from Columbia University in 1954. In addition to teaching at Columbia, he has had professional experience with Bell Telephone Laboratories at Murray Hill, New Jersey. Mr. Lee is a member of the American Physical Society, Sigma Xi, Tau Beta Pi, and Eta Kappa Nu. He has published widely in the fields of physical electronics and semiconductors, and microwaves.

Raymond C. Loehr became a Professor of Agriculture and Water Resources Engineering in the Colleges of Agriculture and Engineering following a spring term visiting professorship at Cornell in 1967. He was formerly a Professor of Civil Engineering and Di-
rector of the Environmental Health Research Laboratory of the Nuclear Reactor Center at the University of Kansas. Professor Loehr specializes in wastewater treatment processes and disposal methods, agricultural waste management, and solid wastes disposal. He took both the Bachelor of Science and the Master of Science degrees from Case Institute of Technology and the doctorate from the University of Wisconsin. He is a member of Sigma Xi, the American Water Works Association, the American Society for Microbiology, the American Association of University Professors, and the American Society for Engineering Education.

- Richard H. Rand is an Assistant Professor of Theoretical and Applied Mechanics whose present interest is celestial mechanics. After taking the Bachelor of Engineering degree from Cooper Union College in 1964, he was awarded the Master of Science degree in engineering mechanics in 1965 and the Doctor of Engineering Science degree in 1967 by Columbia University. Mr. Rand was awarded a Guggenheim Fellowship in Flight Structures, a NASA Predoctoral Traineeship, and the Columbia University School of Engineering Citation for Outstanding Achievement for the Master of Science Degree. He is a member of Chi Epsilon and Tau Beta Pi.

- Charles S. ReVelle earned both the Bachelor of Chemical Engineering degree and the doctorate at Cornell where he was a research associate and had teaching experience. He is now Assistant Professor of Environmental Systems Engineering. His special interests are mathematical epidemiology, water pollution control, and medical engineering. Mr. ReVelle is a member of Phi Kappa Phi, Sigma Xi, the Water Pollution Control Association of New York, the Institute of Management Sciences, and the Operations Research Society of America.

- Stephen L. Sass was a Fulbright scholar at the Technische Hogeschool at Delft before coming to Cornell as Assistant Professor of Materials Science and Engineering. He was graduated from the City University of New York in 1961 with the Bachelor of Chemical Engineering degree, and in 1966 he took the Doctor of Philosophy degree from Northwestern University. In addition to teaching at Northwestern, Mr. Sass has had industrial experience with the Reynolds Metals Company Research Laboratory in Richmond, Virginia. His special interest is electron microscopy. He is a member of Tau Beta Pi and Sigma Xi.

- Robert G. Sexsmith, from Regina, Saskatchewan, is an Assistant Professor of Structural Engineering in the School of Civil Engineering. His research concerns probabilistic and stochastic methods as applied to structural engineering. Mr. Sexsmith took the Bachelor of Applied Science degree from the University of British Columbia in 1961 and the Master of Science and doctoral degrees from Stanford University where he also taught. His professional experience includes work for the British Columbia Department of Highways, Phillips Barratt and Partners, and Swan Wooster Engineering, Limited. He is a
member of the Engineering Institute of Canada, the Association of Professional Engineers of British Columbia, the American Society of Civil Engineers, and the American Concrete Institute.

- **Neil J. A. Sloane** was born in Wales, received his undergraduate education in Australia, and his graduate education in the United States. The University of Melbourne awarded him the Bachelor of Electrical Engineering degree in 1959 and the Bachelor of Arts degree in 1960. From Cornell he took the Master of Science degree in 1964 and the Doctor of Philosophy degree in 1967. Mr. Sloane is now an Assistant Professor of Electrical Engineering with special interest in coding theory and combinatorial analysis. He is a member of the Institute of Electrical and Electronics Engineers, the Tensor Society of Great Britain, the American Mathematical Society, and the Mathematical Association of America.

- **Roland A. Sweet** is an Assistant Professor of Computer Science whose specialty is numerical analysis. He has had industrial experience with Sandia Corporation and Honeywell, Incorporated. He was educated at St. Petersburg Junior College where he obtained the Associate of Arts degree in 1962, at Florida State University where he earned the Bachelor of Science degree in 1963, and at Purdue University where he earned the Master of Science and Doctor of Philosophy degrees in 1967 and 1968. Mr. Sweet is a member of the Association for Computing Machinery, Pi Mu Epsilon, and Phi Theta Kappa.

- **Charles B. Wharton**, Professor of Electrical Engineering, comes to Cornell from General Atomic Division of General Dynamics Corporation where he led several investigations in plasma physics. From 1950 to 1962 he was a staff member at the University of California’s Lawrence Radiation Laboratory where he headed the Diagnostic Development Group in the Controlled Fusion Program and invented the microwave diagnostic instrument now widely used in plasma research. During 1959 and 1960, Mr. Wharton was on leave of absence at the Max Planck Institute for Physics in Munich where he assisted in the establishment of their plasma physics laboratory. He also spent three months at the United Kingdom Atomic Energy Authority's Research Establishment at Harwell, England, and lectured at the International Summer course in Plasma Physics at Roskilde, Denmark. He served as technical advisor to the United Nations at the 1958 Geneva Conference on Peaceful Uses of Atomic Energy and was lecturer at the University of California Extension Division from 1961 to 1963. Professor Wharton took both the Bachelor of Science and Master of Science degrees from the University of California at Berkeley. He is a member of the American Physical Society, Eta Kappa Nu, Tau Kappa Pi, and the Institute of Electrical and Electronics Engineers. Mr. Wharton is the author of *Plasma Diagnostics with Microwaves* which was published in 1965.

- **Raphael S. Aronson**, who is owner and president of Aronson Associates, Incorporated, in Harrisburg, Pennsyl-
vania, is Visiting Assistant Professor of Machine Design in the School of Mechanical Engineering.

- **Maurice Robert Coyaud** is Visiting Lecturer of Computer Science under a joint appointment with the College of Engineering and the Department of Linguistics (second term). Mr. Coyaud is a linguist in the Automatic Document Section of the National Center for Scientific Research (CNRS) in Paris. He has written numerous articles and five books.

- **Peter A. Egelstaff** came as Visiting Professor of Electrical Engineering from the United Kingdom Atomic Energy Authority's Research Establishment at Harwell, England.

- **Frank Feiner**, who is with Knolls Atomic Power Laboratory Division of General Electric Company in Schenectady, New York, is Visiting Professor of Applied Physics.

- **Antoine F. Gagne**, head of the design firm of A. F. Gagne Associates in Binghamton, New York, is Visiting Professor of Machine Design. Mr. Gagne is a licensed professional engineer in New York State.

- **Maurice S. Gjesdahl**, Visiting Professor of Machine Design in the School of Mechanical Engineering, taught at The Pennsylvania State University from which he retired in 1962. He is now a consultant to several industrial firms.

- **Bernd Höfling** came from Munich where he is employed by Siemens A. G. At Cornell he is Visiting Assistant Professor of Electrical Engineering.

- **Robert H. Hollier**, Visiting Associate Professor of Industrial Engineering and Operations Research (first term), is a lecturer at the University of Birmingham, England, and has worked with the Dunlop Company, Limited, England.

- **Robin J. Knops** earned his degrees at the University of Nottingham, England, and has taught both there and at the University of Newcastle-on-Tyne, England. He is Visiting Associate Professor of Theoretical and Applied Mechanics (first term).

- **John Laski** is a Senior Research Assistant at the London School of Economics and a part-time lecturer at the Imperial College of Science and Technology. At Cornell he is Visiting Lecturer in Computer Science (second term).

- **Stephen C. Traugott**, Visiting Associate Professor of Mechanical Engineering in the School of Mechanical Engineering, is with the Martin-Marietta Corporation's research division. He has taught part time at Johns Hopkins University and at the University of Maryland.

- **Peter G. Winchell**, on sabbatic leave from Purdue University, is Visiting Professor of Materials Science and Engineering.

- **C. Peter Wroth** teaches at the University of Cambridge and is presently Visiting Associate Professor of Geotechnical Engineering in the School of Civil Engineering.
The following publications and conference papers by members of the Cornell College of Engineering faculty were published during May, June, and July 1967. In cases of coauthorship, the names of Cornell faculty members are in italics.

### AEROSPACE ENGINEERING


### AGRICULTURAL ENGINEERING


### CHEMICAL ENGINEERING


CIVIL ENGINEERING


ENGINEERING PHYSICS


INDUSTRIAL ENGINEERING AND OPERATIONS RESEARCH


MATERIALS SCIENCE AND ENGINEERING


MECHANICAL ENGINEERING


THEORETICAL AND APPLIED MECHANICS


Co-op=Vitalized Engineering Education

For twenty years now, a comparatively small but important fraction of Cornell engineering students have participated in the College's Engineering Cooperative Program. Directed since its inception by Everett M. Strong, newly appointed Emeritus Professor of Electrical Engineering, the Program accounts for 6 to 7 percent of Cornell's engineering graduates—about 400 in total.

Why can "vitalized" education be equated with the Co-op Program? Recall first what has occurred within the engineering educational process itself. We know that the process of formal education of engineers is steadily extending beyond the baccalaureate degree. We know that the content itself has shifted more to the teaching of fundamental knowledge from the teaching of professionally directed applications. And we know that today's faculty is less likely to have had much in the way of professional engineering experience which would enable them to impart the "flavor" of what engineering practice is all about.

At the same time, the practicing engineer may not always be able to select from among the output by faculty that knowledge which might enable him to perform engineering more ably and more professionally. Recognizing that the goals of the engineering practitioner and the educator are really complementary, it is the young man who is in the process of his formal education who stands the most to gain by being exposed to the perspectives of each.

Through alternating periods from campus to industry to campus, thoughtfully and cooperatively planned by practitioner and educator as is done in the Cornell Program, education in engineering today can become vitalized. The promise of accomplishing these aims lies with those students who are anxious to add a professional dimension to their formal classroom education.

The Editor