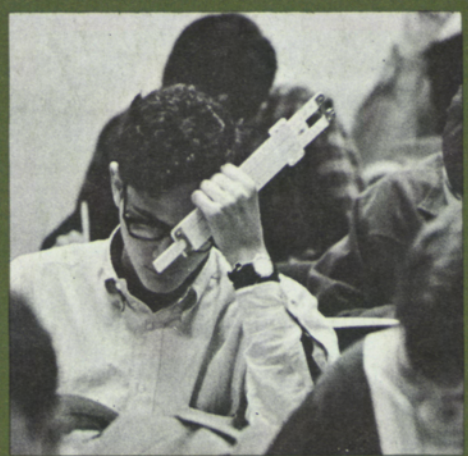
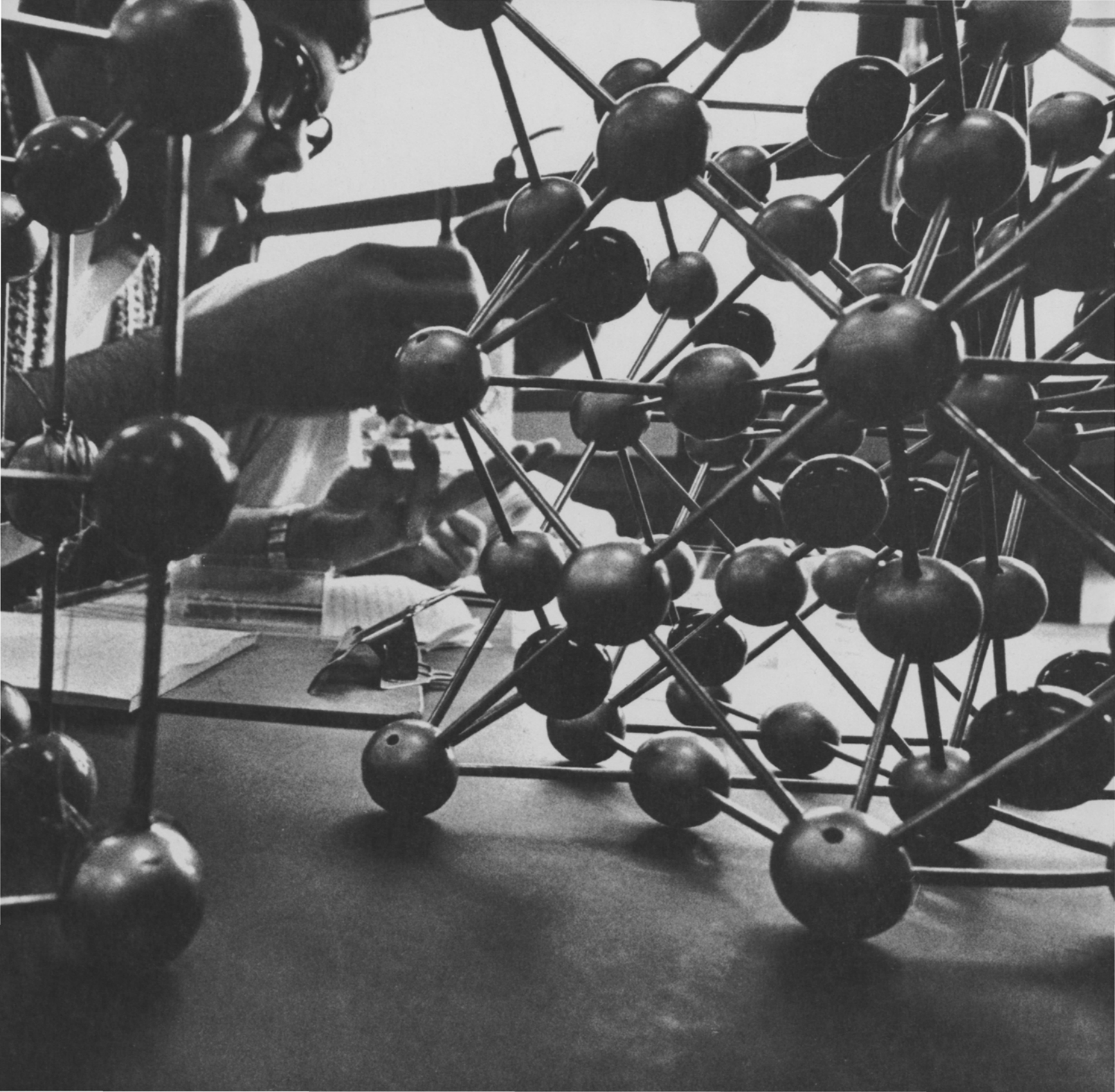
# ENGINEERING

## CORNELL QUARTERLY



VOLUME 1
SPRING 1966

ENGINEERING
EDUCATION
TODAY



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ENGINEERING: Cornell Quarterly, Spring, 1966, Vol. 1, No. 1. Published four times a year in April, July, October, and January, by the College of Engineering, Cornell University, Carpenter Hall, Campus Road, Ithaca, New York 14850. Application to mail at second class postage rates is pending at Ithaca, New York. Subscription rates: $2.50 per year.

# CORNELL AND ENGINEERING EDUCATION: Past...Present...Future

*By Andrew Schultz, Jr.*

Educating engineers has been of major importance at Cornell University since its founding a hundred years ago, and the College of Engineering looks back with satisfaction on its first century. The College and technology grew up together, and Cornellians—alumni and faculty—have played their significant roles during the era. Soon the young people we teach today will have their turn helping to shape the human scene.

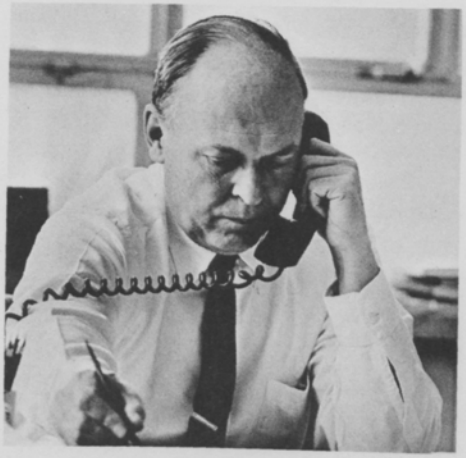
The atmosphere in the College is restless and revitalizing, just as our founder Ezra Cornell intended it to be. Cornell himself practiced the Yankee "mechanic arts" of his time, tackling with intuition and ingenuity a variety of practical problems in agriculture, manufacturing, and communications. His formal education had ended early, but he was a master builder of substantial technical accomplishment: In 1844 Cornell conceived and constructed between Washington and Baltimore the world's first workable telegraph line, for the Morse demonstration of telegraph feasibility. Cornell subsequently worked with others in the formation of the Western Union Telegraph Company, and its success brought him wealth and political and financial contacts. He then used his fortune and influence to found a new kind of college, a people's college, where engineering and the applied sciences, the subjects he wished he had been taught himself, were to play a significant part.

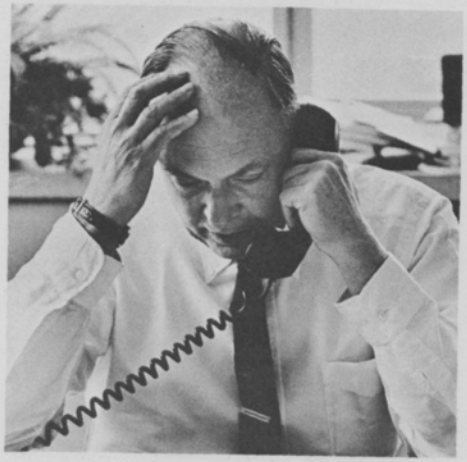
Ezra Cornell believed in engineering education as a University function, and this belief was shared by the classicist, scholar, and statesman who became the University's first president: Andrew Dickson White. In fact, it was White who was extraordinarily successful in attracting a distinguished and vigorous faculty to this raw setting on a remote hill in Central New York. From this faculty came the many educational innovations which characterized the formative years of Cornell Engineering and which influenced the development of engineering education far and wide.

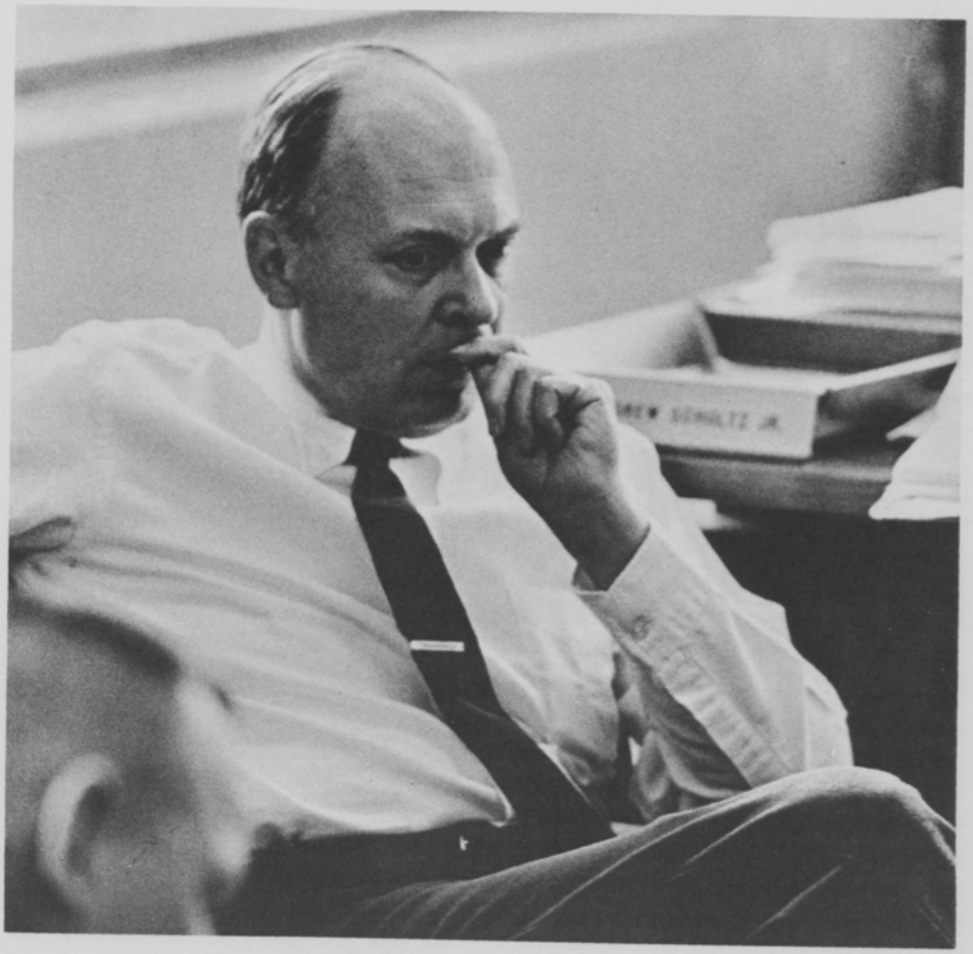
This Cornell philosophy of education has been spread and transplanted by hundreds of Cornell alumni when they migrated to the faculties and administrations of new and established engineering schools across the country. Even larger numbers of alumni have participated in the industrial development of the past century, and many have given distinguished leadership to private enterprise and public service. By now, in fact, Cornell has graduated some 20,000 engineers from the lively environment of this young and precursory University.

Thus the heritage of the College of Engineering is strong, and is a substantial base on which to build. The College has continued to approach its educational responsibilities with the innovative attitude of its early years. Firsts, from the introduction of graduate work to the development of new engineering fields, have been recorded throughout its history. For example, in 1946 with the engineer facing increased demands for greater scientific and technical competence and for greater understanding of the complexities of modern society, the College established the five-year professional engineering program, which remains the basic requirement for a professional engineering degree.

Within recent years, the College has undertaken another exhaustive self-







*"Nationally, engineering education is today at the threshold of defining its direction for the next decade or more."*

examination of its programs and activities, developing a number of possibilities for curricular and structural changes within the College. These new ideas have far-reaching implications for both the immediate and the long-range activities of Cornell Engineering, some of which are discussed in the articles that follow. Others will be reviewed in following issues of ENGINEERING.

The point is that nationally, engineering education is today at the threshold of defining its direction for the next decade or more. This is evidenced by the recent publication by the American Society for Engineering Education of the preliminary report, "Goals of Engineering Education." In its final form, this study is certain to have profound effect on the educational process in engineering as have other such studies in the past.

We have already taken significant steps to insure the vitality and effectiveness of the Cornell program. We have directed our own efforts to establishing an environment which will (1) accommodate the many different objectives that must be served by engineering education today, and (2) adjust to new needs and new directions without the racking violence so often associated with change. The ability to respond to change without losing stability is essential for any institution which is associated with the dynamic process known as technology.

Engineering educators in the United States have long studied the academic process of responding to the high rate of change in our environment. Among major projects were the Mann Report of 1907, the Wickenden Report of 1926–29, the Hammond Reports of 1940–44, and, most recently, the Grinter Report of 1955. Cornell's Dean S. C. Hollister was president of the American Society for Engineering Education when the society published the Grinter Report, a study which offered new guidelines for engineering colleges.

Painful as critical self-appraisals can be, these periodic reviews have helped to insure that our profession's educational processes will anticipate new needs and the changes in education these needs will demand. America's material prosperity and the level of her technical know-how are excellent endorsements of the ability of her engineers, and suggest that engineering colleges have been doing their job well.

## CURRICULUM EVOLUTION

A student who graduated from an engineering curriculum immediately prior to the Second World War found little difference between the courses he took and those taken by engineers of his father's generation. Curricula were highly specialized; time devoted to "skill" courses such as foundry, machine shop, and the like, had been reduced; but extensive technological detail and applied technology were still covered. However, a similar comparison made twenty years later would have shown major differences. The impact of the Grinter Report was substantial, as its recommendations influenced the accreditation of curricula through the remainder of the 1950's.

Because of advances made throughout the war years, the amount of science and engineering science in the curricula has increased considerably at all engi-

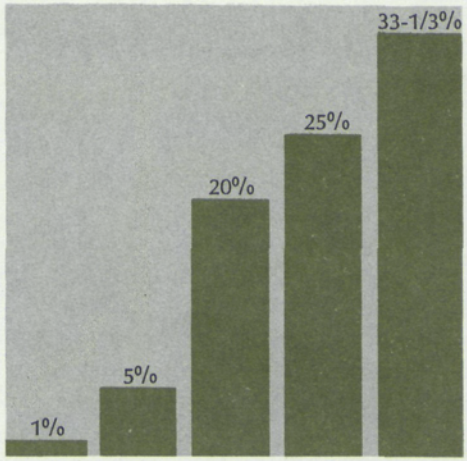



*Figure 1. Percentage of Graduate degrees to total Engineering degrees.*

neering colleges. At the same time, many engineering colleges, including Cornell, have committed themselves to giving undergraduate students more time for liberal arts and humanities courses. Consequently, a relatively small proportion of the undergraduate curriculum remains available today for specialized engineering fields. But to those who are concerned that "engineering is disappearing from engineering education," I would say I don't believe this is true at Cornell. Rather many "state of the art" and shop type courses have necessarily and properly been replaced with more fundamental material of wider application.

Engineering practice has also changed as the boundaries between the traditional undergraduate engineering disciplines have been crumbling. Today there is a core of science and engineering science courses which, when added to the humanities and social sciences courses mentioned above, consumes most of the undergraduate curriculum. The little time remaining has had to be used in a more restrictive or specialized manner. This accounts in part for the recent proliferation of accredited engineering degree designations: from 26 to 53 designations between 1960 and 1965.

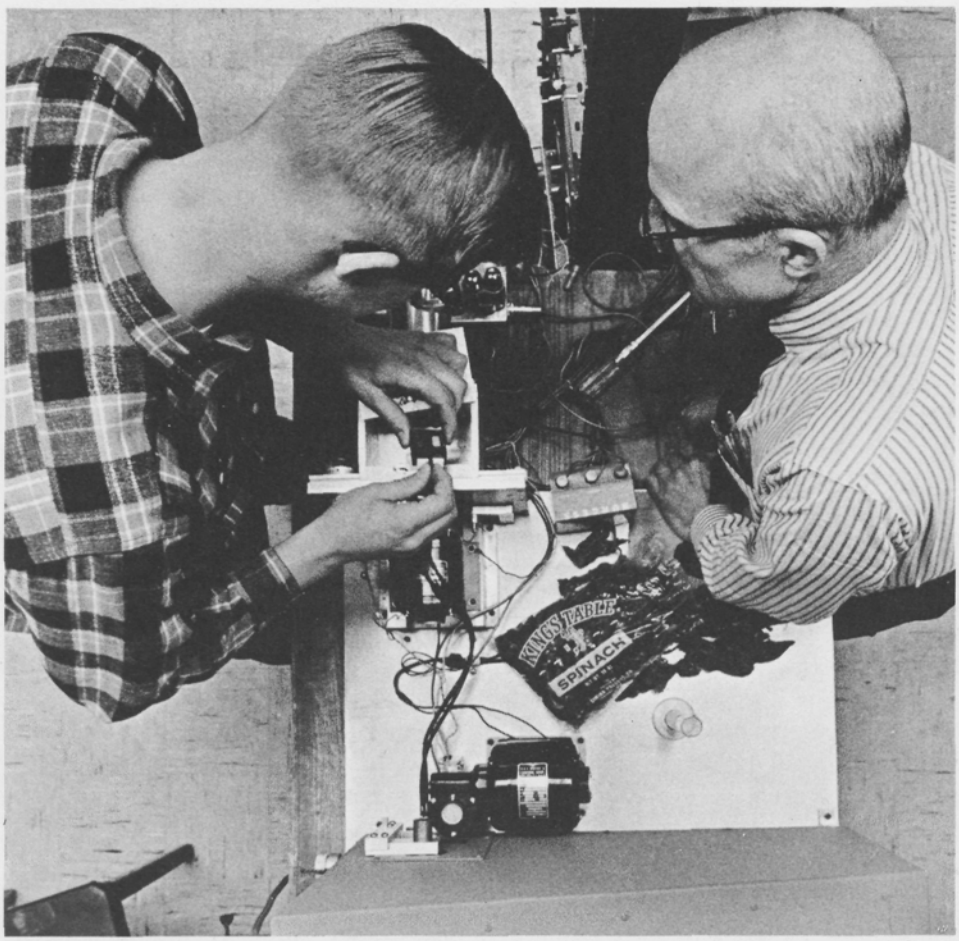
The present increased emphasis on graduate study (as shown in figure 1) has occurred not only because changing curricular patterns require a longer period of study for professional competence, but also because of the growing federal commitment to advanced programs. An increasing proportion of our national budget has been devoted to research and development, encouraging graduate study in engineering and the sciences. In engineering, where emphasis on graduate study is relatively recent, the results have been more marked than in science, where graduate study has traditionally been relied upon to produce the skilled practitioner. However, an increase in graduate study in other fields not similarly supported by national policy has also taken place. Evidently, many undergraduates—perhaps economically motivated—have a strong desire to continue beyond the Bachelor's degree.

The enrichment of secondary school science and mathematics programs around the United States is another important development to engineering education. Superior students, so often neglected in the past, are found to be working more and more in activities that stretch their abilities to the limit. Our engineering colleges need to encourage this type of more unique, more individual, and more creative work throughout engineering education.

## THE INTERFACES

Along with many changes in the types of projects undertaken, changes are occurring in the environment in which the engineer works. Here, environment refers not to physical surroundings, but to persons and occupations contiguous to the engineer. On one side the engineer is associated with the scientist. Their relationship has always been an interesting one. It is not difficult to find many examples in which the engineer of the past was decades away from the scientist in the productive application of scientific knowledge. Conversely, throughout history the engineer has frequently anticipated sci-

*An interface study combining biology and engineering—learning how living organisms generate the energy required to digest food.*




ence by creating his works without the availability of underlying scientific knowledge. Presently, however, the relationship between the two is closer. In fact a scientist often becomes an engineer in order to achieve his scientific objective, while an engineer may behave as a scientist in order to develop a basis for his activity. This is a healthy situation, and it seems to be leading toward even closer relationships.

On another side the engineer is bounded by the manager. And just as the engineer's objectives, methods, and set of values are different from those of the scientist, so they are different from the manager's. Occasionally there is a basis for conflict. The high level professional specialist may look more to his professional colleagues for status and recognition than to his management, and with mobility this introduces problems, for the engineer *can* and *will* leave his management to join colleagues in another firm.

Recent discussions on technological obsolescence, or "limited life," bring out another conflict of values: Engineers inherently want to do a job well,

and they may take a longer-range view than the manager, who may be more concerned with the company's profit for the current period and with his own chances for advancement. Frequently the technical substance of engineering decisions is crucial in resource allocation decisions made by the manager. In such cases, managerial penetration of the engineer's domain can be dangerous unless the manager is also an engineer. Engineers find it far easier to penetrate the managerial domain, and often do so. For example, engineers, up from the technical ranks, hold 53 percent of the 59 top management positions in one of our largest chemical industrial organizations, although they hold less than a third of lower management positions in the same company. This tendency for the engineer and the scientist to move into management, initially, often to secure their own ends, and then to progress into top management, seems to be a trend in our society. However, this must not mask or confuse essential functional relationships, the mutually supporting and frequently compromising managerial-engineering contrast.

In another dimension, the engineer is related to the technician. For some years well-established research laboratories—governmental, industrial, and academic—have efficiently used the technician to support the engineer. More recently, the shortage of scientists and engineers has caused many engineering departments in industry to attempt a similar redefinition of tasks so as to properly support the engineer with suitable and competent technical assistance. We can expect the technician and the computer to take an even more effective and complementary role in improving the quality of engineering practice. Nevertheless, the young engineer must be made aware of possible pitfalls, such as the danger that in order to accelerate the task he will be diverted to activities properly those of the technician and fail to progress or to be challenged professionally.

Since the engineer exists in order to anticipate and meet human needs, another boundary of his activity is provided by the "market place." Human needs can be broadly humanitarian, political, individual, or pragmatic, and to meet them the engineer must adjust to and appreciate underlying social, economic, and political structures. This interaction between the process of engineering and the context in which engineering functions is often referred to as operations analysis, preliminary systems engineering, or market analysis. The role of the engineer in this type of activity is broadly accepted in the defense and aerospace fields, and is emerging in the urban-community planning field. It seems destined in the next decade to create in engineering education and practice a situation no less dynamic than the defense research explosion of the last fifteen years.

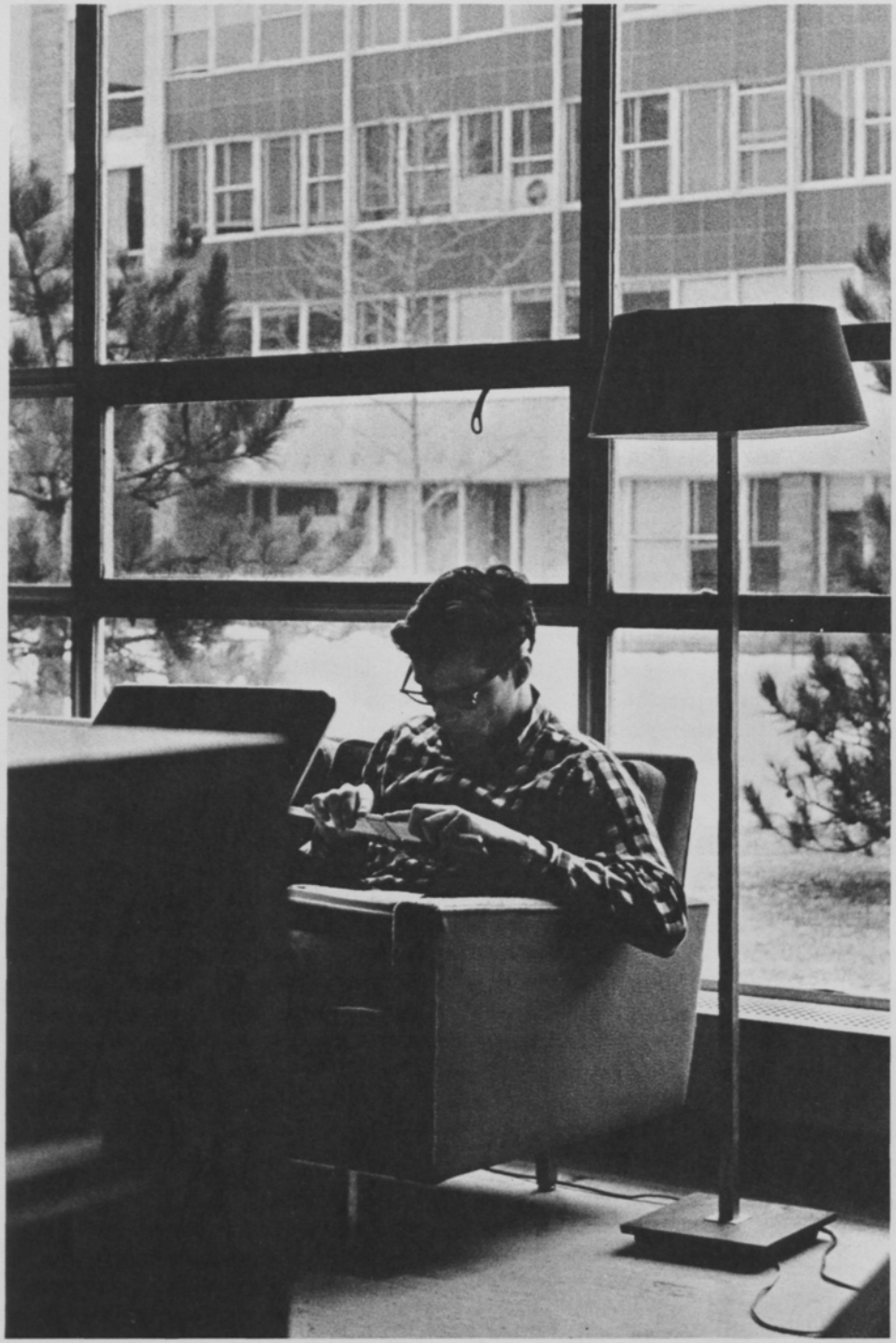
## INDUSTRY–UNIVERSITY INTERACTION

Because both engineering practice and education continually experience strong, dynamic changes, the maintenance of a sound, imaginative, and responsive faculty is all the more important. A faculty member cannot be isolated from the environments in which his present and future students will be expected to function. Industry is rightly concerned about avoiding such a situation, and recognizes its responsibility to the educational process. By providing opportunities in their organizations for faculty members on leave, industries give them insights into modern technology and guidelines for the translation of theoretical concepts into engineering applications. (Cornell follows the policy of awarding the opportunity for a sabbatic leave after six years of service, and in recent years has allowed individual members of the faculty to take leave without pay between sabbatics for such special professional assignments.)

This year at least ten of our professors on sabbatic leave are working in industrial laboratories and plants. An equal number, on leave without pay, are gaining valuable industrial experience or applied experience in government laboratories. Some are supported by the Ford Foundation Residency Program; others are in residence in industrial laboratories, paid by the firm with which they are working. Since many of our young assistant professors have had limited industrial experience, the opportunity to take such a leave to work in industry is a valuable one and benefits the University, the individual, and industry alike. It is as difficult for an engineering faculty to fight obsolescence as it is for practicing engineers and scientists in industry. If the much needed continuing education programs for practicing engineers are to be useful, such contact between industry and engineering colleges is a necessity.

## OUR EDUCATIONAL GOALS

Cornell's new curriculum has the elements which respond to the characteristics an engineer needs today: We give a strong background in the sciences and engineering sciences, and emphasize



the commonality of basic subject matter through a "core curriculum"; the entire curriculum is flexible and allows for developing programs across disciplines and engineering fields; students also have substantial access to liberal and general studies. Our curriculum plan has another element, however, which we believe to be particularly important, and particularly Cornell in character: A straight route is available to strong professional education at the Master's degree level. Thus the first Cornell degree with an *engineering* designation is the Master of Engineering degree, awarded after a five-year integrated study program in traditional fields such as civil, mechanical, chemical, electrical, industrial, metallurgical, or agricultural engineering; and in the younger fields of nuclear and aerospace engineering or engineering physics, and in even newer specialties.

These programs are consistent with the faculty's belief that in this age of expanding science and technology, a minimum of five years is essential to educate an engineer for modern practice.

We also recognize that some of our students want an engineering background as preparation for advanced study in other professional fields, for example, law, business, or medicine. Therefore in a sense, the first four years in college serve students as a base for advanced training leading to professional practice, or to research careers in engineering, or for further study in adjacent fields where an engineering background can be well utilized. These years serve the generalist as well as the specialist, and for this reason we award a Bachelor of Science degree after four years of study, but a *professional* engineering degree only after five.

To accomplish these broadened educational goals, the Cornell programs and the educational pattern for engineers proposed in the ASEE "Goals of Engineering Education" report are quite similar.

In summary, at Cornell we believe that education must respond to developments in modern engineering, including (1) the increasing interaction among various fields, especially those with strong social, political, and economic implications; (2) the decreasing time lapse between the scientist's discovery and the engineer's application, which requires the engineer to be qualified in modern science and imaginative in its application; (3) a coincidentally greater direct involvement of engineers in both basic and applied research, and (4) the increasing need for advanced study and continuing education to insure high competence in engineering practice.

Those are our beliefs, and adhering to them has made the job of preparing engineers more interesting, more dynamic, and more demanding than ever before.



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Andrew Schultz, Jr., Dean of Cornell's College of Engineering and Professor of Industrial Engineering and Operations Research, received his Bachelor's and Ph.D. degrees from Cornell. His specialty is operations analysis. Born in Harrisburg, Pennsylvania, Dean Schultz attended public schools there, and was graduated from Phillips Academy in Andover, Massachusetts. Starting as an instructor when he was a graduate student at Cornell, he rose steadily through the ranks to become a full Professor, then head of the Department of Industrial Engineering, and finally Dean of the College.

During World War II, Dean Schultz attained the rank of Lieutenant Colonel in the U.S. Army and was Chief of Section in the Industrial Service, Ammunition Division, Office of the Chief of Ordnance. His experience in industry includes positions with the New Jersey Bell Telephone Co. and the Western Electric Co., and he is a consultant for several of the nation's largest firms. During 1962–63 Dean Schultz was Vice-President and Director of Research for the Logistics Management Institute in Washington, D.C. Currently he is Chairman of the Accident Prevention Study Section of the National Institutes of Health, holds several directorships, and is a member of the Board of the Commission on Engineering Education.

Despite a heavy administrative schedule, Dean Schultz finds time to teach courses in industrial engineering and operations research, and this past year he even organized and participated in an experimental freshman seminar designed to acquaint young engineers with some of the great issues which will face them in the future. He keeps close contact with students in the Cornell undergraduate chapter of the AIIE and is never too busy to see any student who seeks his advice on either a curricular or a personal problem.

Dean Schultz is also concerned with the problems of the engineer in underdeveloped countries, and along with several others on Cornell's staff, he serves as a consultant to the Universidad del Valle in Cali, Colombia, a university which is being encouraged in its growth and organizational efforts by both the Ford and Rockefeller Foundations.

Dean Schultz is a member of Sigma Xi and Tau Beta Pi and is active in the work of the American Society for Engineering Education, the American Institute of Industrial Engineers, the Institute of Management Science, and the Operations Research Society of America.

# TODAY'S APPLICANT: SOME ADMISSIONS PROBLEMS

*By Donald H. Moyer*

On this subject one is tempted to make a number of "off-the-cuff" observations.

- The average freshman in Cornell's College of Engineering is today more science-oriented and less practice-oriented than he was perhaps twenty years ago.
- He has certainly had a better school preparation than his older brothers and academically is probably a better qualified student.
- He often has a greater interest in the liberal arts.
- He appears to know less about what he is getting into, regarding both the engineering profession and the Engineering College, than he did in 1946 or earlier.

I suspect that these statements are half-truths and are only partly demonstrable, but whatever truth there is in them is certainly more a reflection of changes in the times, in the engineering profession, and in engineering curricula, than of changes in American youth.

Since World War II and particularly in the last decade, we have witnessed the development of a highly sophisticated technology requiring more knowledge of science and mathematics. There has been a corresponding improvement, especially in recent years, in the science and mathematics instruction given in the high schools, and at the same time, the engineering colleges have broadened the common foundation given all students in advanced mathematics, in the physical sciences, and in engineering science. In part, the college curriculum reflects industry's increasing demand for engineers capable of sophisticated research and development work, a function of the profession which today amounts to as much as 40 percent of its activities, compared with 15 to 25 percent twenty-five or thirty years ago.

Not so long ago there was a relatively clear-cut distinction between the scientist-discoverer and the engineer-innovator. Within the last decade this distinction has become less obvious, largely because of a closer association between science and engineering and an increasing interdependence of the two. With the advent of the space age, engineering accomplishment has often been credited to science, and in the public press the engineer has often been mistaken for the scientist. The time lag between scientific discovery and its technological application has been reduced almost to zero since the scientist and the research engineer often work hand-in-glove on the conversion of the most recent scientific discovery into its practical application. Little wonder, therefore, that many of today's high school students sometimes find it hard to determine whether to become engineering students or science majors.

Today's College of Engineering applicants seldom show a strong interest in a purely technological area. More often they are students who have done well in mathematics and science in high school and who have been informed that with this strong interest and ability they should consider engineering. Certainly among them are those who will become successful engineers just as there are those who will not succeed, for some students, despite their capabilities in math and science, would do well to forsake professional fulfillment in engineering. And herein lies the root of one of the basic problems which has confronted engineering colleges for years: attrition.

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*The recent explosion of technical knowledge has changed both the engineering profession and curricula. Engineering education today includes more mathematics, physical science, and engineering science than ever, and this causes problems for many students (1). It is hard to decide whether to be an engineering student or a science major. The author says (2), that as the time lag between discovery and application has shortened, the scientist and the engineer have become interdependent, and the distinction between them, less obvious.*

Only about 50 percent of the students who matriculate in the 170 odd accredited engineering colleges in America stay to take their degrees in engineering. It should be noted that the problem of attrition is not peculiar to engineering: liberal arts colleges have it, too. When a student changes his major from history to economics, that is attrition from history's standpoint.

There are several reasons for these dropouts. Obviously we sometimes make mistakes in taking into the Engineering College boys whose abilities and records of achievement do not fully qualify them to meet the competition. We try to avoid this, but it does happen. Secondly, the very rigor of an engineering curriculum is such that there will be those who, despite having all the requisite abilities and achievements, are unable to apply themselves with sufficient effectiveness; and their work will suffer to the point of failure. The greatest reason for dropouts, however, is a change of interest or a discovery that engineering is not what the student thought it was. To forestall these situations, we in admissions should encourage prospective engineering students to investigate the profession before committing themselves to it in college. We should urge them to talk with practicing engineers, to visit companies in which engineers work, and to read selectively on the question of engineering as a profession. Few of them, it seems, have ever done much in any of these directions.

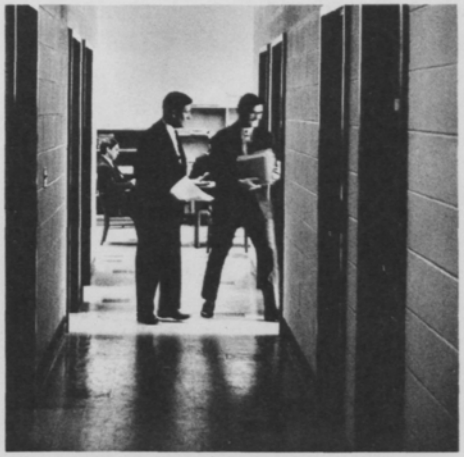
The natural tendency of a boy in high school is to seek a professional fulfillment of those courses he is taking which he enjoys and in which he does well. With all too many boys, the ready assumption is made that interest in mathematics and science, and the ability to handle these subjects, points the finger at engineering—and *only* at engineering. It never occurs to them that if all the high school students who are good at math and science were to go to engineering school and become engineers, there would not be enough people left to do the world's work. They do not realize that mathematics has become a second language for people in many occupations, and that some understanding of and interest in science are almost imperative for everyone in a world that is in-

*"There is no single (admissions) criterion with which we can predict success or which clearly outweighs all other factors."*

creasingly fashioned by science and technology.

Then why engineering? It must be pointed out to these boys that there is no actual engineering in any high school curriculum, any more than there is any real law, or medicine, or business; for that matter there is little actual engineering in the first two years of most engineering college curricula. It is hard for them to understand that to find out what the profession really is, they must somehow get out and look beyond the high school classroom, that they must investigate on their own. They see that their friends in liberal arts colleges are able to defer making this choice of profession for two to three years, but they do not realize that these liberal arts students, too, must sooner or later get out of the classroom and into the market place to meet and talk with people practicing in professions, to observe them at work, and to read about what they are doing. It is a problem created in part by the fact that engineering is a professional curriculum beginning at the undergraduate level, whereas, for most of the other professions, professional education takes over only in graduate work.

Many prospective engineering students come to the campus for interviews, and a large part of the time is taken up trying to reduce the confusion between educational interests and professional objectives. A great majority of students, however, do not come for interviews, and therefore those of us on selection committees must rely on what we read in the application to determine the boy's motivation and those other intangibles which may or may not make him successful in engineering. Here our alumni can render valuable service to the College. They can meet



prospective students, tell them about engineering, show them what engineers are doing, and direct them to provocative reading on the subject. Thus they will whet the appetite of some and make them more likely prospects for success in the College. Others will have their spirits dampened. Some of these will apply directly to liberal arts rather than come in to engineering and face the sticky prospect of transferring to another college after a year or two when they realize engineering is not for them.

A volunteer organization known as JETS (Junior Engineering Technical Society) operates today in many high schools. The JETS are practicing engineers in a community who meet periodically throughout the school year with high school students who have expressed an interest in engineering, discussing with them their jobs, taking them on field trips to see engineers at work, directing their reading, and in some instances giving them simple projects on which to work. These volunteers are in my judgment performing a vital function, one which only they can perform. If high school boys are to get a clearer and sounder comprehension of what engineering is all about, they will get it chiefly through the generous efforts of practicing engineers in the field.

Prospective engineering students also need to be advised of the differences among engineering institutions, not so much between the technological schools and the university colleges of engineering, as between those institutions emphasizing theory and analytical capabilities in the curriculum and those which are more practice-oriented. While not all Cornell engineering graduates go into research and development (the fraction is still less than 50 percent), there is little doubt that our basic curriculum, with its insistence on depth in mathematics, science, and engineering science, tends to attract the more theory-oriented, analytical types, or at least tends to favor them. Basically, Cornell is preparing engineers for more sophisticated technological problems requiring high professional competence and superior analytical ability.

Without a doubt, the majority of our faculty is more interested in the engineer who is going to do high-level research, development, or design than in the other operational types of engineers. On the other hand, all would argue, I think, that unlike some engineering colleges, Cornell has not "gone science" but is still teaching "engineering." Our establishment of a professional Master's degree program in more than ten fields is testimony to this. What I mean here is that Cornell accepts only students who show academic promise, who have the capability for analysis, and who are able to cope with theoretical concepts. While we welcome any boy with a down-to-earth, practical, common-sense approach, who does things well with his hands and who enjoys working with people—all of which are earmarks of a good engineer—he must combine these characteristics with the intellectual attributes the curriculum now requires to succeed at Cornell.

Many prospective engineering students are concerned also with the role of the humanities and social sciences in engineering programs. There can be no generalization as to the importance engineers attach to formal instruction in

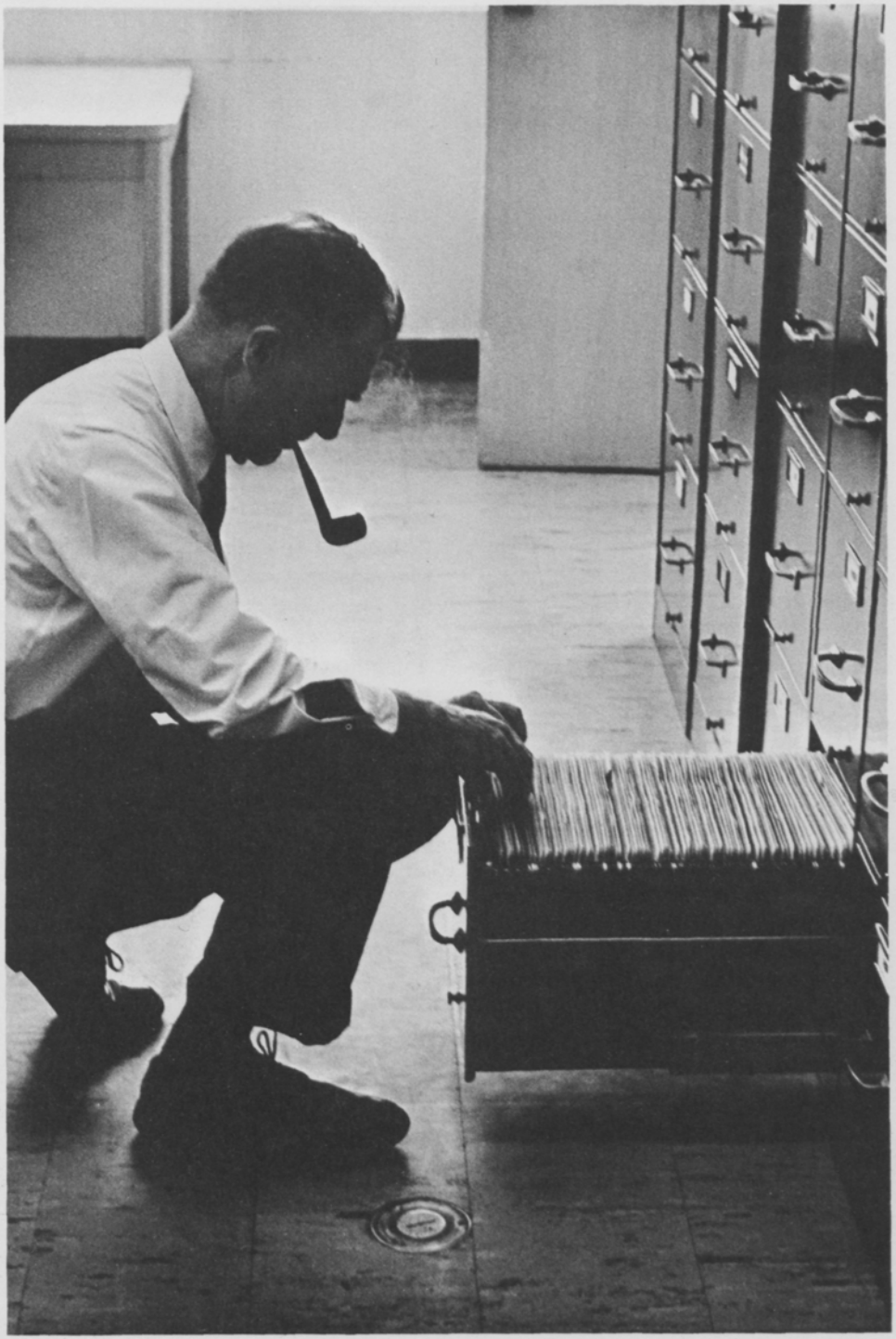
*"Much of the data now used in the selection of college students could be better entrusted to a machine than to the fallibility of humans."*

the humanities and social sciences. The individual student himself decides this question, but time and again a prospective student will ask, "How much will I have in the way of liberal arts in your curriculum?" It must then be explained to him that if he takes the most direct route to a professional engineering degree at Cornell, or at any other reputable engineering college, the maximum amount of work that he will have in the humanities and the social sciences will amount to about 20 percent of his curriculum. If he wishes to take more work in the liberal arts at Cornell, he may do so by extending his Basic Studies program from two years to three and will receive his Bachelor of Science degree at the end of five years instead of four. He is encouraged to understand that just so much can be crowded into a given span of time and that while there is nothing to preclude his taking all the work he wants in the liberal arts, he must be willing to pay for the privilege in time and money.

The selection of undergraduate engineers at Cornell today is made by three members of the Engineering College faculty. Each of the three reviews the credentials of every applicant, considering the boy's over-all school record, the school itself if it has had students here, the boy's rank in class, his College Board Achievement Test scores, and the Scholastic Aptitude Test results. There is no single criterion with which we can predict success or which clearly outweighs all other factors; rather a combination of all these factors offers the best indication of success. And still it is impossible to know how hard a boy will work, how effective his study habits may be, how well motivated he is, and how well emotionally and academically he will be able to cope with the diversity of Cornell. Let any one of these factors be negative, and he can go down the drain in a matter of weeks, even though he may have the earmarks of a genius. On the other hand, if these intangibles are all positive, his academic qualifications may be somewhat more modest and yet ensure his success. If success seems unlikely a student is refused, not certainly to penalize him, but to protect him against the serious problem of trying to relocate himself after a year or two on the basis of a failing record here.

The admissions process is anything but scientific, and, until better instruments are devised to measure the noncognitive factors essential to success in engineering, there will be a substantial margin of error. It cannot be emphasized enough that the success of an engineering student, granted adequate abilities and achievement, depends in large measure upon intrinsic personal qualities. Our alumni can greatly help us assess candidates by giving us personal information about prospective students whom they know at all intimately. They can also render invaluable assistance to the student and the College by taking the time to tell prospective students just what it is that engineers are and do, and what engineering is all about.

As a concluding thought, let me invoke the computer, which in time will revolutionize more aspects of our society than we perhaps dare dream of now. If the computer can select compatible "dates" for college students and diagnose the medical ills of mankind, as is said to be probable within a few years, why not select applicants to college by means of this quick and unflinching appraisal? Some "way out" ideas for the



*Mr. Moyer believes computers will reduce much of the paper work he and other admissions officers presently have to do.*

better selection of college students have been advanced, but the use of the computer is not one of them, for it is no longer "way out"—it is already being discussed in the inner circles of the admissions officers. My only comment is that much of the data now used in the selection of college students could be better entrusted to a machine than to the fallibility of humans. In the not too distant future, the machine may well bake the cake while man adds only the frosting. The frosting had better be good!

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Donald H. Moyer is Director of the Office of Student Personnel in the College of Engineering at Cornell University, the office responsible for undergraduate engineering admissions and scholarships, placement, and maintenance of alumni records. On June 1, Mr. Moyer assumes a new post, assistant to the University Provost, Dale R. Corson. Born in New York City, Mr. Moyer is a *cum laude* graduate of Harvard and holds an M.A. degree in psychology from the University of Michigan. He was assistant director of the Harvard Alumni Placement Service prior to World War II, and then served as commanding officer of the Naval V-12 unit at St. Lawrence University during the war.

He assumed his present position in 1949 after serving as Cornell's Counselor of Students and Director of Veterans Education. His avocations include meteorology, photography, and hiking—all skillfully practiced on vacations with his wife, Helen.

# THE FRESHMAN AND SOPHOMORE YEARS

## *An Interview with Howard G. Smith*

Prior to 1961, freshman and sophomore students in the College of Engineering at Cornell University were the responsibility of the separate Schools (e.g., Mechanical, Civil, Electrical, and Chemical) in which they had enrolled. While the various Schools had many elements of their curricula in common, each one had its own unique requirements. The Division of Basic Studies was established to permit entering students to come here uncommitted to a particular engineering field and to enable them to choose an upperclass major after careful consideration of the various possibilities open to them. The Division's responsibilities include design of the underclass curriculum, coordination of the faculty adviser program, and administration of student financial aid. Through D.B.S. all freshmen and sophomores take a common studies core of subjects. Each term of the first year the core includes mathematics, physics, chemistry, English, and an introductory engineering course. During the sophomore year students further their work in mathematics and physics, and they take a liberal arts course and two engineering science courses each term.

*What are the most important achievements of D.B.S. during these past five years?*

I think we've developed more of an over-all College viewpoint with regard to the preparation of engineers and have given students greater flexibility. They have more time now in which to choose their upperclass curriculum. In Basic Studies we are able to adjust the program to fit the capabilities of honors students and average students alike.

*What about the advising program during the freshman and sophomore years? Without a Basic Studies faculty isn't it difficult to get men interested in freshman and sophomore advising?*

Actually, I don't find it so difficult getting men who are interested in advising as I do finding men who aren't already loaded down with other time-consuming matters. I know people who would be more than willing to serve as advisers to freshmen and sophomores, but their research programs and their upperclass and graduate student advising simply take priority in the judgment of the various School directors within the College.

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1. *At the weekly discussion meeting of the staff of the freshman engineering course.*

2. *The author makes a point in the bi-weekly freshman adviser meeting.*

3. *"They get tired."*

4. *"The curriculum imposes heavy demands."*

*Is anything done to coordinate the experiences and the activities of the advisers?*

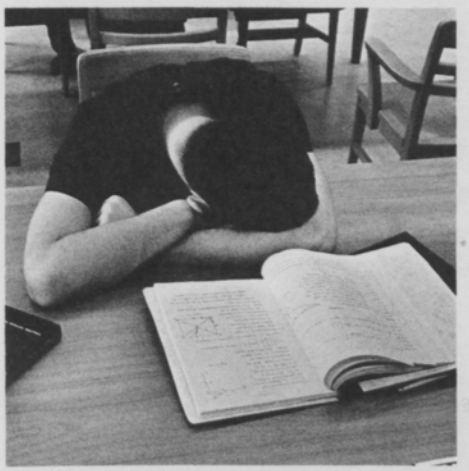
Yes. We meet every two weeks for discussion, for example. I try to bring them up to date on what's happening academically on campus. Their questions are aired, so we are constantly pooling ideas and experiences. Furthermore, these meetings provide an opportunity for us to learn whether something is really going wrong anywhere, and to make efforts to correct any problems.

*One of the problems associated with engineering education is that of retention of students: Has there been any perceptible change in this regard during the existence of D.B.S.?*

If we compare these last five years with the previous five, there's been a definite change. Retention to the junior year prior to the establishment of D.B.S. averaged about 59 percent. For the five years of D.B.S. it's been running pretty close to 66 percent. This means we have reduced attrition about 20 percent.

*How much of this improvement in retention do you attribute to D.B.S.?*

I think there were many factors involved, and it's hard to put a finger on



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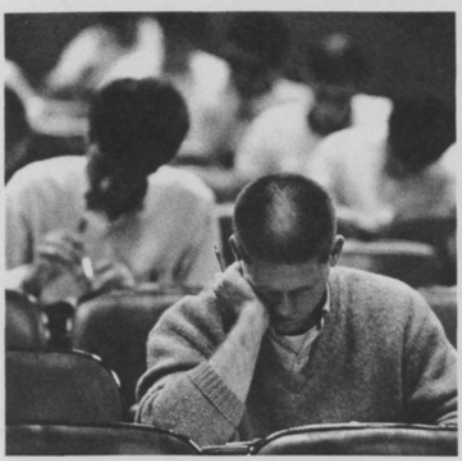

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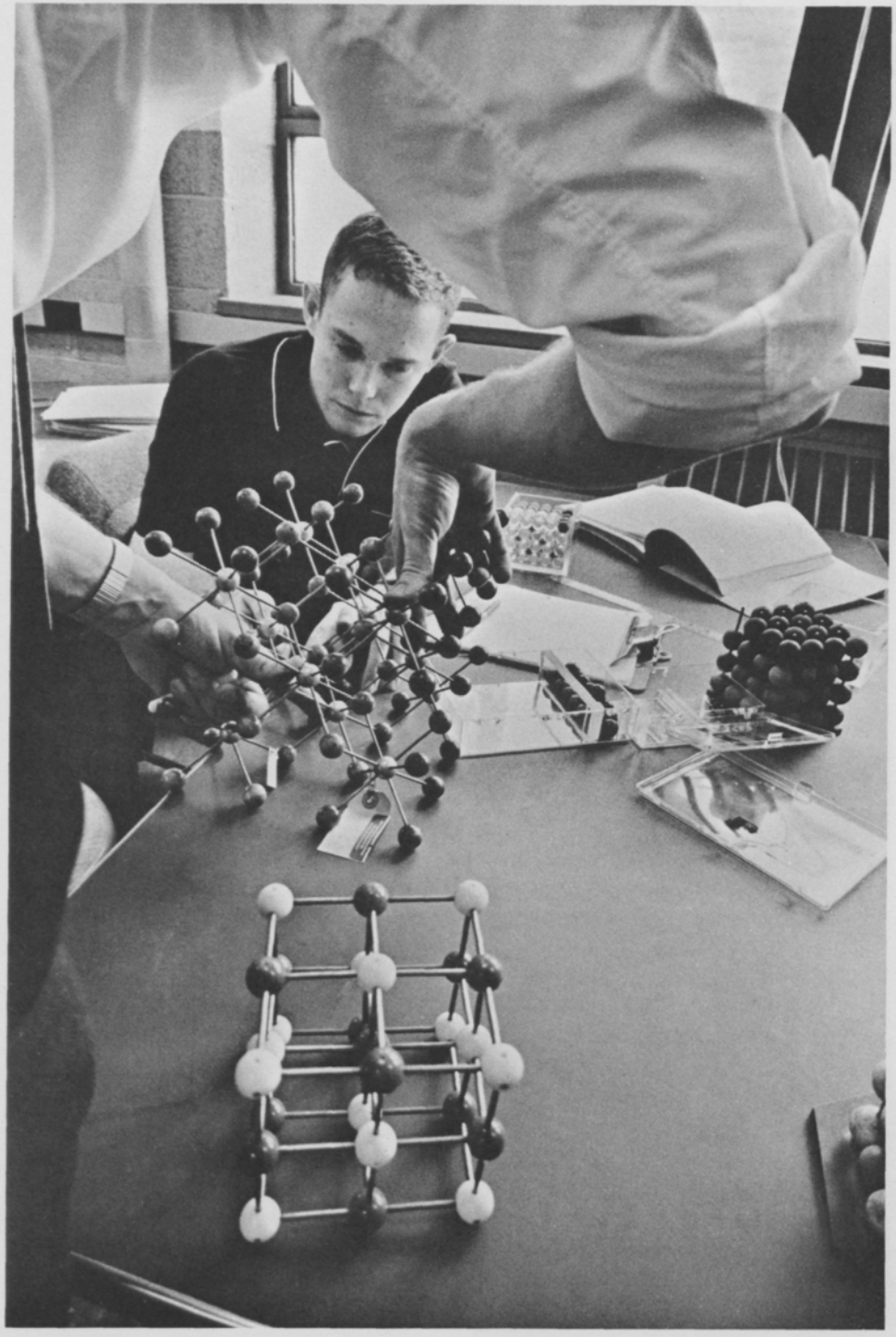
one. Our ability to adjust the programs to the students' abilities and to work carefully in advanced placement proved helpful. We worked fairly closely with the various departments of the College to encourage more realistic grading practices, so as to eliminate erratic grade shifts when new staff members took over courses.

*At Cornell, as elsewhere, most of the student attrition in engineering occurs in the freshman and sophomore years. Can you account for these withdrawals?*

They get tired! It's a demanding program which places top students in competition with each other. When students are mixed in the dormitories, unless the student has a really strong desire he's likely to decide he just doesn't want to work this hard and will look for "greener pastures" elsewhere. This is particularly true when the student is doing his best to fulfill his parents' idea of what he ought to be, rather than his own idea of what he *can* and really *wants* to be. Some students have the feeling that some of the Arts College courses would be somewhat simpler. If they run into a good stiff history course with lots of reading, of course,



they discover this is not the case!

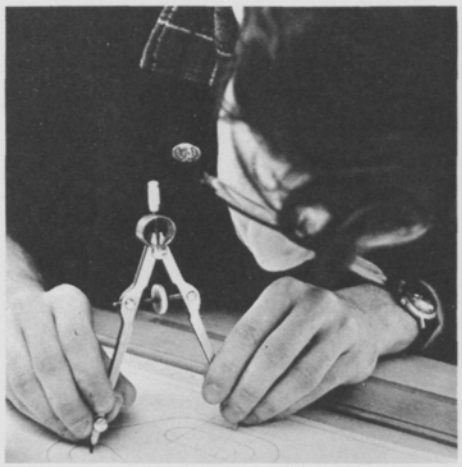
If we can increase their laboratory experience as we have done in physics, we may alleviate more attrition. Frequently boys want to become engineers because they have enjoyed working with "things" in high school and science fairs, or have had a similar experience. They don't find very much "working with things" as college freshmen. Consequently, I would like to see more laboratory work in electrical science and in the physical chemistry-materials science sequence. Mechanics has made progress during the last three years by introducing more experiments to meet this very need.

*What is the College doing in the selection of engineering candidates to increase the likelihood that more students will complete their degree programs?*

Throughout these last five years, the criteria in the admissions procedure have been constantly re-evaluated to see which actually have any correlation to freshman performance. We have discovered, for example, that the actual correlation of the verbal scores with performance in the College, as long as they are above a certain minimum, doesn't seem very high, and consequently, we have de-emphasized them.

*Could a program be offered at Cornell that would permit a student to start in engineering or to start in science, and make a switch at the end of the sophomore year depending on whether his interests prove to be more applied or more fundamental?*

I think that the student *could* move from a program very much akin to our first-year program, for example, toward science or mathematics. I would rather doubt the practicality of a common admissions process, however. The admis-



sions committee in engineering tries to evaluate motivation. While we are not always as successful as we would like to be, it is necessary to have some knowledgeable engineering reviewers trying to see beyond the obvious information in the applicant's folder; otherwise, we would have a group of first-year students who would be less committed to engineering than those we have now.

*Frequently, we find engineering students are anxious to take greater advantage of the University's offerings in the humanities and social sciences. With approximately 20 percent of the engineering curriculum now devoted to those areas, what provisions are made to accommodate students who want even more?*

If a student wishes, he can increase the liberal arts content of his underclass work from 20 to 40 percent while retaining the technical strength of the Engineering curriculum. He obviously cannot do this by lengthening the day to 28 hours, but the two-year Basic Studies program can be extended to three years to accommodate him. There are some students who take advantage of this, but they constitute a very small number. At the present time, many more students seem more anxious to finish their degree on time than to bear the added expense of an additional year to take a broader program. But the opportunity is still open.

*Wouldn't this plan be very much like the so-called 3-2 programs that exist in other liberal arts colleges?*

I feel quite certain that if you look at the program a student can take under this plan, you will find that he probably meets within a straw the liberal course requirements of the A.B. degree at the same time he is earning his engineering degree.

*What about the financial aid? If a student has a scholarship, would he be able to retain it for that extra year in D.B.S.?*

In all probability he would, but the student must reapply for financial aid at the end of four years, the period of time normally covered by engineering scholarships. However, if the student is in good standing, he is generally assured of continued financial support for that extra year.

*Some engineering educators say that mere exposure to liberal arts courses does not necessarily lead to more broadly educated engineers. Should liberal arts courses be offered at Cornell that have greater relevance to engineering?*

This isn't a new idea. At the close of World War II, "required" liberal arts courses such as history of science, chemical engineering economics, and other courses of that kind were introduced. Most faculty would now agree that mixing engineering students with liberal arts students is really a better exposure to liberal arts studies than creating special courses for this or that kind of engineer.

*What have been the most popular electives among our engineers in the last few years?*

Economics is far and away the most popular. The next ones in descending order are psychology, government, philosophy, and sociology. For this reason we try to make special schedule arrangements with the Arts College so as to make it possible for the engineer to work courses in these popular subjects into his schedule.

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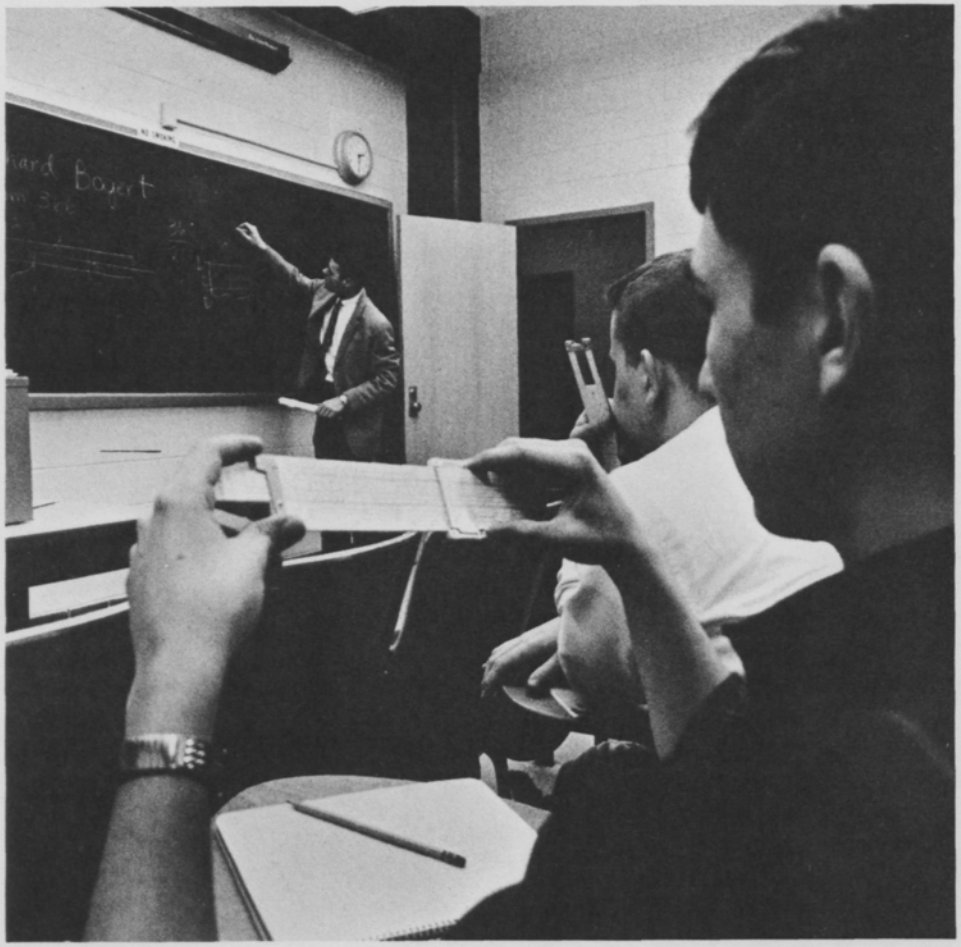

*What is done to help D.B.S. students who are having difficulty in a course?*

Ever since Basic Studies has been in existence, we have had tutoring in mathematics supported by the College. The attendance, of course, built up as the term went on, starting with about a half a dozen students and growing to 50 or so as shown by the records of the last four years. However, there were also other organizations with help sessions. One of them was the Interfraternity Council, which offered help in mathematics, physics, and chemistry. For four years, the Engineering Student Council also ran a "big brother" type counseling program for students found to be in early-fall-term difficulties.

*In other words, help is here if the student will seek it.*

Yes, his channels may vary, and the D.B.S. office doesn't attempt to prepare a list of available departmental tutors. The individual departments frequently do have lists of graduate students who are willing to tutor in their field.

*Many observers believe there is too much science, especially mathematics, and not enough engineering during the*

*student engineers' first two years of college. What do you think?*

There's no question in my mind that today's curricula are more science-oriented than those of ten years ago. Of course, we always have to be on guard against overemphasis in this direction, but I think we have attempted to keep a balance. For example, we urge that the two required engineering courses of the sophomore year include all relevant engineering applications. Engineering-minded boys tend to get a little bit dry on the abstract and highly mathematical orientation of courses at that point in their studies. I have a strong feeling that this is a part of a morale problem at the sophomore level—students are not getting enough chance to work in the laboratory. Consequently, D.B.S. took an active role last year in emphasizing laboratory experiences at all levels, and time spent in the sophomore physics laboratory was essentially doubled this year. We have not yet had time for meaningful feedback on this, but I am convinced that it was a very good move. Students need mathematics and their math requirement has been raised from 12 to 15 hours, but we aren't out to educate mathematicians in the Engineering College.

*What is done to introduce "engineering activity" to our freshmen? We don't find much engineering in math, physics, and chemistry—or English, for that matter. Just where does the engineering come in?*

The College faculty originally directed D.B.S. to try introducing some engineering courses in the freshman year. This was fighting one's way in a no man's

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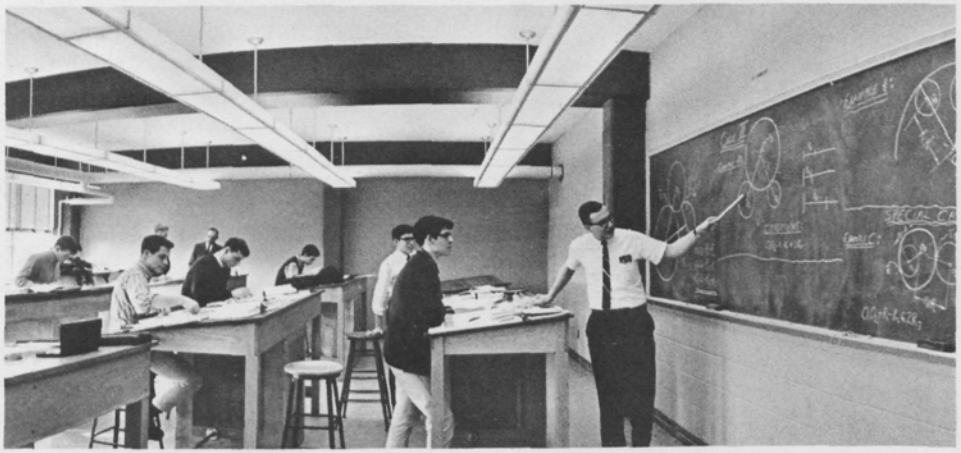

1. *Fifth-year engineering students serve as tutorial assistants to freshman engineers.*

2. *Freshmen are exposed to elements of engineering design in the first year program.*

land, but four years ago we began trying to orient first-year students in the activities of the profession, both by functions and by fields. The first three years this program was a two-term offering, with graphics also taught throughout the year. This past year we found it worked out better to concentrate on graphics in one one-term course and on professional orientation, introduction to digital computing, and engineering economics in the other.

We have made several attempts to set up voluntary seminars, Sunday afternoon meetings, and Saturday morning lectures for freshmen, so that they can meet School directors and faculty and learn more about the profession. Student interest in these efforts has been poor, but we are still trying to get the information across in the professional orientation course.

*Is it true that only a small number of entering freshmen are certain of what engineering field they intend to pursue?* The College investigated this once—in 1961 just before D.B.S. began operations. Prospective students were asked what kind of an engineer they wanted to be on the College application form. Two years later we checked to see how many had changed their mind. We found that one out of every three had. I think that is prima facie evidence that the college curriculum is flexible and enables a substantial number of students to reorient their goals as they learn more about themselves and engineering. This flexibility is, I believe, not unrelated to the reduction in attrition.

*If the student comes to Cornell completely undecided as to his career goals, how, in addition to the orientation program you've described, does he find out about the engineering profession?*

There are many channels, some good and some bad. Somehow the freshman doesn't seem to go to his adviser for help; he tends to wait until his sophomore year. Instead, he usually relies on informal means, such as association with upperclassmen in his fraternity and in his living quarters, for information about what upperclassmen are doing, where they're headed, and what their summer or co-op experiences have been.

*From your long experience as a professor of electrical engineering, does the fellow with summer job experience tend to make a better engineering student than those who don't have any?*

When I was teaching junior electrical engineers, I was certain that the students in our Cooperative Program could be identified by their demonstrated motivation. I'm not so sure, however, that the kind of experience that could be had following a freshman year is likely to be so useful. It would be a very good idea, however, if we could promote a plan with industry for most students to take summer career-related work at the end of their sophomore year. As an undergraduate, I was convinced of the merit of this and found such a summer job on my own. But companies today are still a little reluctant to take sophomores, much less freshmen. I think the College will have to stress the value of hiring underclassmen for summer industry work before industry will really support such an activity.

*What are prospects that the College of Engineering will offer a course really emphasizing the impact of technology on society, one fashioned to bring about a better understanding of the interaction of C.P. Snow's "two cultures"?*

In a way we've had some of this in an experimental seminar this year. It's for a small selected group of superior students and is given by four of our faculty including Dean Schultz.

*What about extracurricular activities? Isn't Cornell a place where a young man can get himself into trouble by getting too involved in extracurricular programs? Has this been a problem for the students you have had in Basic Studies?*

Yes. We've had some students for whom that was really a problem. Engineers who are willing to organize their time, however, and undertake one activity and not spread themselves too thin are able to carry out such things very well. The classic example, of course, is the crew that beat the Russians at Henley where seven out of eight oars were manned by engineers.

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Howard G. Smith is Director of the Division of Basic Studies in the College of Engineering at Cornell, which was established in February 1961 to coordinate and administer the freshman and sophomore programs of the College. Born in Brooklyn, Dr. Smith's association with Cornell has been a long one. He received his Bachelor's and Master's degrees in electrical engineering and his Ph.D. from Cornell. Honors include a McMullen fellowship, Tau Beta Pi, Sigma Xi, and Eta Kappa Nu. Having advanced through all academic ranks in the School of Electrical Engineering, Dr. Smith continues as a Professor of Electrical Engineering. His wife, the former Jane Blakeslee, is also a Cornellian. They have two sons and a daughter. John, Cornell A.B. with distinction '58, is an Assistant Professor of Mathematics at the University of Michigan. Donald is a teacher at Cortland (New York) High School, and Barbara is a Cornell freshman.

# CORNELL'S NEW COLLEGE PROGRAM

*By William H. Erickson*

——An automatic scanner which can read a foreign language and print out the English translation. . . .

——An artificial heart, kidney, or lung to replace a diseased one. . . .

——An underwater harvester to recover new sources of food from the ocean. . . .

——A successful method for the direct conversion of solar to electrical energy. . . .

——An information retrieval system to search out and present intelligence from research libraries all over the world. . . .

For those who are under the impression that most problems requiring substantial technological know-how have been solved, these examples should stimulate a new point of view. What they perhaps illustrate is the fact that many fertile areas that engineers are cultivating require new technical knowledge and skills and a greater comprehension of man's changing environment. The rewards of modifying educational patterns in engineering to prepare our men for new, exciting, and productive careers are obvious.

In December 1964, the Cornell College of Engineering modified the basic educational pattern it had been following for twenty years. The engineering faculty acted to provide a new basic curriculum in which seventy percent of the undergraduate program (the "Core Curriculum") is the same for every student. The remaining thirty percent is flexible, and allows:

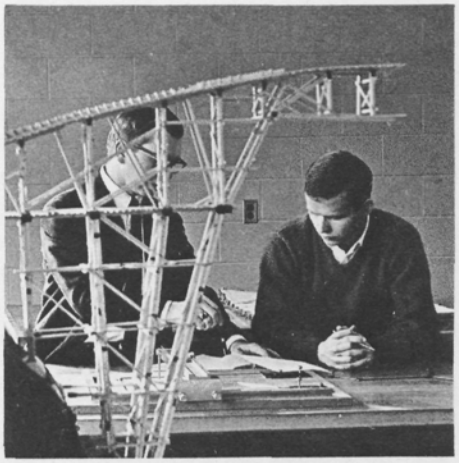
1. A convenient exit from the College with a B.S. degree at the end of four years for the student who decides to continue his education in a non-engineering profession, such as business or law.

2. A choice, without penalty for most students, among several engineering fields as late as the end of the sophomore year. All sophomores, except those headed for chemical engineering, can keep at least four alternatives (mechanical or civil engineering and so on) available without losing time.

3. Considerable freedom in student's choices of electives.

4. The establishment of new engineering-based programs that could not be achieved within the existing traditional fields in the College.

The so-called "traditional fields" do not, of course, remain stagnant, but change with the times. However, because each engineering field has well-defined objectives, the faculty established the *College Program* for those students whose broader educational objectives require greater program flexibility. Therefore, after completing our Basic Studies program, a junior-year engineering student in the College Program may combine course sequences from two or more engineering fields, or combine an engineering course sequence with that of a non-engineering subject. Examples already proposed by students and approved by the College Program

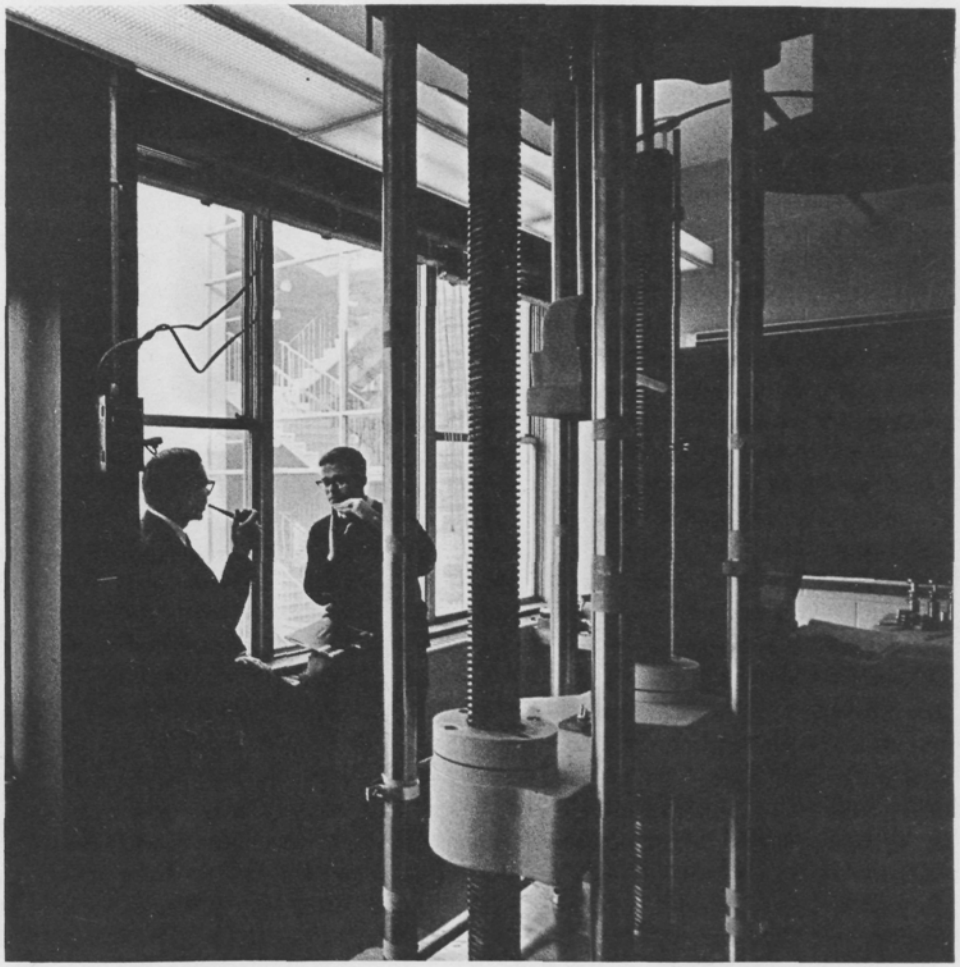


Committee are combinations of electrical systems and laboratory courses with biological science courses (object: medical school and medical research), and air-photo interpretation courses with geology courses (object: better evaluation of land resources).

The College Program requires that of the forty to forty-six credit hours required for graduation in addition to Core Curriculum subjects, the student must take an engineering major of at least twelve credit hours, an engineering minor of eight credit hours, and eight credits in technical electives. The remaining credits are taken in courses appropriate to a student's objective. In some instances the engineering minor may be waived if the student's proposed program is best accomplished by a combination of an engineering major and a non-engineering minor. Aware of the restrictions imposed by the legislation, the College Program Committee does not attempt to pigeonhole courses into major, minor, or technical electives, rather it examines an entire College Program proposal in light of the stated student objective.

As is common to many new ideas,

*Combining structural engineering with geology in a unique College Program.*



1. *Another illustration of the College Program: developing a specialty in air photo interpretation courses combined with studies in geology to help train experts in resource planning.*

2. *Cornell offers many engineering students the opportunity to study in fields of interest not ordinarily associated with engineering.*

some students initially misunderstand the purpose of the College Program, seeing it as an "easier" program, "half liberal arts and half engineering." To correct this type of thinking, we need only describe the College Program and outline its real purpose. The dedicated young men who have adopted the program's idea are pioneering in educational patterns that may one day be commonplace.

Although challenges such as those mentioned at the beginning of this article could be met by graduates of the traditional field programs, Cornell concluded, in adopting the College Program, that such a flexibly designed program would better satisfy the motivated student having more specialized goals. It also enhances the possibility of developing useful new curricula without having to establish new departments or schools. Should particular types of programs prove popular, new departments may well be formed.

The College Program is also expected to bring about closer cooperation between other divisions of the University and the College of Engineering. Students often apply to the College because it is part of a University with vast educational resources. With the College Program, these resources can be more imaginatively explored by some students. The Engineering College should also be in a better position to accommodate transfers from two-year junior and community colleges who might not satisfy all the prerequisites now incorporated in the Basic Studies Division. There are advantages in accepting successful junior college students since they do not face the serious adjustment problems that many of our freshmen do. Frequently a freshman has trouble adjusting to college because he is uncertain of the field he wants to study, or even uncertain whether he should be in engineering at all. In this regard, industry and practicing engineers can be of great assistance.

Industry can increase motivation in a student for an engineering career (or convince him that engineering is not for him) by providing substantive summer jobs, particularly between the freshman and sophomore years at college. A few companies are doing this, but more are needed. If more of this "industrial orientation" can be accomplished, the

engineering profession and industry itself will reap long-range benefits. Practicing engineers can assist by helping guidance counselors explain engineering opportunities to interested high school students. Too often the student's basis for selecting engineering is, "I'm good in math and science and don't like humanities or social studies."

Engineering educators need the cooperation of industry and practicing engineers if they are to continue to attract and retain some of the nation's best young minds. With the College Program, Cornell is doing what it can to spark student enthusiasm and to prepare our engineering students for future engineering needs. The job, though, is not ours alone.

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William H. Erickson is Associate Dean of the College of Engineering and Professor of Electrical Engineering at Cornell. A native of McKeesport, Pennsylvania, Dean Erickson received his B.S. degree in Electrical Engineering at the University of Pittsburgh, and his M.S. degree at the Carnegie Institute of Technology. He is also a registered Professional Engineer in New York State.

He is a Fellow of the Institute of Electrical and Electronics Engineers and a member of Eta Kappa Nu, Tau Beta Pi, and Sigma Tau. He joined the Cornell faculty in 1942 after four years of experience as a power engineer with the Duquesne Light Company of Pittsburgh. Before his appointment as Associate Dean, he was for six years Assistant Director of the School of Electrical Engineering. In his current post, Dean Erickson is responsible for over-all undergraduate affairs in the College. With Nelson H. Bryant he is co-author of the textbook *Electrical Engineering: Theory and Practice*.

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# REGISTER

*This month's* Register *introduces new engineering faculty at Cornell. An interview with a just-arrived department director is followed by biographies of other new and visiting faculty.*

## ■ WALTER S. OWEN

The emergence of materials science as a subject has long been of great concern to Dr. Walter S. Owen, the new Director of the Department of Materials Science and Engineering. He brings to Cornell a broad background of experience in the British Isles, where he was Dean of the Faculty of Engineering Sciences, and the Henry Bell Wortley Professor of Metallurgy at the University of Liverpool.

Dr. Owen says that he has "done a lot of talking" about the importance of materials science, and he points out that its birth as a subject has been painful everywhere: "Really a messy business!"

Through activity in its Materials Science Center, Cornell is at the heart of this field and is attracting worldwide attention. Progress here is being watched with "envy, interest, and even suspicion" by engineering schools everywhere, according to Dr. Owen.

While a Commonwealth Fund Fellow at M.I.T. in 1951, one of two metallurgists so honored by a British awards committee, Dr. Owen married a New Hampshire girl, then a student at Boston University. Loyalty to his alma mater took him back to Liverpool in 1957, but he has kept in touch with professional activities in the United States. He crossed the Atlantic three or four times a year to cooperate with several research efforts in this country, particularly at Wright-Patterson Air Force Base, a test center and home of the U.S. Air Force Institute of Technology.

Comparing the teaching experience at Cornell with that at Liverpool, Dr. Owen points out that university education is more homogeneous in Britain, with all admissions processed through a central office in London. This, along with an inflexible high school curriculum, tends to produce a "pretty standard" product, less "inquiring" than the average American student. Dr. Owen says the engineering student, entering the more uniform English universities with their standard examining system, has done math at a higher level than the entering freshman here, but may be somewhat "stodgy" about it.

On the present "live" problem of teaching design, Dr. Owen feels strongly that the materials engineer should be at the center of the project, should be in "at the beginning as a part of the team" rather than called in at the end where he "tends to stick out like a sore thumb." For this reason, he emphasizes the importance of teaching the student in materials at Cornell the importance of his role in design. Thorough mastery of the basic tools of design is a necessity when the student assumes his proper role in the creative process.

The new director also holds the Thomas R. Briggs professorship, endowed by the Ohio petroleum industrialist Floyd R. Newman, '12, with a matching grant from the Ford Foundation. The late Professor Briggs was a chemistry teacher of Newman's.

Walter Owen earned his Bachelor of Engineering, Master of Engineering, and Ph.D. degrees at the University of Liverpool, all in metallurgy. His British affiliations include memberships in the Council for Scientific and Industrial Research Grants Committee; the Metallurgical Research Council, and the

Physical Metallurgy Group of the British Iron and Steel Research Association, of which he is chairman. Among the agencies and companies in England which he has served as consultant are the United Kingdom Atomic Energy Authority at Aldermaston; the International Nickel Company, Ltd., Birmingham; the English Electric Company, Ltd., Leicester; and Richard, Thomas and Baldwins, Ltd., Whitechurch, Bucks.

He is the editor, for Pergamon Press, of the physical metallurgy series in the Commonwealth Library of Technology; he is also author and co-author of nearly fifty publications.

At Cornell Professor Owen teaches in the areas of mechanical properties and physical metallurgy of steel. His research interests, which include alloying, heat treatment, and properties of iron and steel, have recently included investigations directed to the refractory metals, particularly tantulum.

American professional societies of which he is a member are Sigma Xi, the American Institute of Mining and Metallurgical Engineers, and the American Society of Metals.

■ *Boris W. Batterman,* Associate Professor of Materials Science and Engineering, was educated at M.I.T., receiving his B.S. degree in 1952 and the Ph.D. in 1956. His work is in the area of X-ray diffraction. In addition to teaching at M.I.T., he has had industrial experience with the National Bureau of Standards and Bell Laboratories. He was a Fulbright scholar and is a member of the Physics Society and the Crystallographic Society.

■ *Terrill A. Cool,* Assistant Professor of Mechanical Engineering, comes to Cornell from California. He received the B.S. from the University of California at Los Angeles in 1961; the M.S. in 1962 and the Ph.D. in 1965, both from the California Institute of Technology, where he also taught. During his college years he worked during the summers as a member of the technical staff of the General Electric Company, Schenectady; as an engineering aide with the Los Angeles County Flood Control District, and as a technician for the Wiancko Engineering Company, Pasadena. He specializes in plasma physics and thermodynamics. His memberships in professional societies include the American Society of Mechanical Engineers, American Association for the Advancement of Science, Sigma Xi, and Tau Beta Pi.

■ *Patrick C. Fischer,* Associate Professor of Computer Science, received the B.S. degree in 1957 and the M.B.A. degree in 1958 from The University of Michigan. In 1962 he was awarded the Ph.D. at M.I.T., where he had been a National Science Foundation fellow. From 1962 until coming to Cornell, he was Assistant Professor of Applied Mathematics at Harvard. He specializes in the theories of automatic and recursive function. Dr. Fischer is a member of Phi Beta Kappa, Phi Kappa Phi, Beta Gamma Sigma, Sigma Xi, the American Mathematical Society, the Association for Computing Machinery, the Society of Actuaries, the Association for Symbolic Logic, and the Mathematical Association of America.

■ *Newell Thomas Gaarder,* Assistant Professor of Electrical Engineering, received his B.S. degree from the University of Wisconsin in 1961, his M.S. degree from Stanford in 1962, and his Ph.D. degree, also from Stanford, in 1965. His specialty is in systems with particular emphasis on statistical communication theory. He has had experience at Hewlett Packard; Cornell Aeronautical Laboratory; Lincoln Laboratory, Lexington, Mass., and Stanford Research Institute. Dr. Gaarder is a member of Tau Beta Pi, Eta Kappa Nu, Phi Eta Sigma, and Phi Kappa Phi.

■ *Albert R. George,* Assistant Professor of Aerospace Engineering, comes to Cornell from the University of Washington where he held similar rank during 1964–65. He was awarded the B.S.E., M.A., and Ph.D. degrees at Princeton, where he was research assistant and assistant in instruction from 1961 to 1964. Shortly before receiving his doctorate in 1964 he visited Cornell and lectured during a colloquium in the regular aerospace lecture series. He is a specialist in fluid mechanics and hypersonic flow, and his industrial experience includes summers with Swiflite Aircraft Corporation and Grumman Aircraft.

■ *Juris Hartmanis,* Professor and Chairman, Computer Science, was born in Riga, Latvia. He received a Cond. Phil. at the University of Marburg in 1949; an M.A. from the University of Kansas City in 1951, and a Ph.D. from

the California Institute of Technology in 1955. Before coming to Cornell he was a research mathematician for the General Electric Company, and Assistant Professor of Mathematics at Ohio State University. He teaches in the fields of the theory of automatic and sequential machines. Dr. Hartmanis is a United States citizen and a member of Sigma Xi, the American Mathematical Society, and the American Mathematical Association.

■ *David J. Henkel,* Professor of Civil Engineering, was born in Southern Rhodesia and educated at the University of Natal in Durban (B.S. '41), Imperial College (Dipl. '58), and the University of London (Ph.D. '58). He comes to Cornell from the Indian Institute of Technology at Delhi where he was Professor of Soil Mechanics. Prior to this he was head of the Soil Mechanics Division at the Research Institute in Pretoria, a lecturer at the Imperial College of Science and Technology, London; and Visiting Lecturer at the University of Illinois. He has published widely in areas of shear strength and engineering properties of clays, and in slope stability studies.

■ *Franklin K. Moore,* Joseph C. Ford Professor of Mechanical Engineering, is a Cornellian, having received the B.S. in Mechanical Engineering in 1944, and the Ph.D. in 1949. He was formerly an instructor in the Cornell Engineering Mechanics Department. From 1949 to 1956 he was with the NASA Lewis Flight Propulsion Laboratory. In 1959 he became Department Head, Aerodynamic Research, Cornell Aeronautical Laboratory (CAL) and in 1959 Director of the Aerodynamics Division at CAL, where he was also Visiting Professor, 1962–63. Dr. Moore's specialties are boundary-layer effects of heat transfer and skin friction; propulsion and power problems, and heat transfer. He has published widely in these fields.

■ *John P. Moran,* Assistant Professor of Theoretical and Applied Mechanics, was awarded undergraduate and graduate degrees at Cornell, the B.M.E. in 1959, M. Aero.Eng. in 1960, and the Ph.D. in 1965. His industrial experience includes working with Therm Advanced Research, the G.E. Advanced Electronics Center, and Grumman Aircraft. Dr. Moran's work is in the area of fluid mechanics. He is a member of Tau Beta Pi, Pi Tau Sigma, Sigma Xi, and the A.I.A.A.

■ *Narahari Umanath Prabhu,* Associate Professor of Industrial Engineering and Operations Research, received a B.A. from Loyola College (Madras University), India, in 1946; the M.A. from Bombay University, India, 1950, and the M.Sc. from Manchester University, England. His specialty is stochastic processes. In 1964–65 he was Associate Professor at Michigan State University; prior to this he lectured at a number of universities in India and Western Australia. He has published extensively. Professor Prabhu is a member of the American Mathematical Society, Institute of Mathematical Statistics, Royal Statistical Society, Calcutta Statistical Association, Australian Mathematical Society, and the Statistical Society of Australia.

■ *Gerard Salton,* Associate Professor of Computer Science, was graduated from Brooklyn College in 1950 with the A.B. degree, *magna cum laude*. In 1952 he received the M.A. from Brooklyn, and in 1958 the Ph.D. from Harvard. Since that time he has taught at Har-

vard, has been a Guggenheim Fellow, and in 1964–65 was a National Lecturer for the Association for Computing Machinery. He has also held industrial positions with Sylvania; Systems Development Corporation; IBM in Zurich, Switzerland; the Arthur D. Little Company, Inc., and the Burroughs Corporation. Dr. Salton is a member of Phi Beta Kappa, Sigma Xi, the Institute for Computing Machinery, the Society for Industrial and Applied Mathematics, the American Documentation Institute, and the Association for Machine Translation and Computational Linguistics.

■ *Howard M. Taylor,* Assistant Professor of Industrial Engineering and Operations Research, is a Cornellian, having received the B.M.E. here in 1959, and the M.I.E. in 1960. In 1964 he was awarded the Ph.D. at Stanford. A specialist in statistical control, his past employment has been with IBM in Albany and San José, California. His memberships in honorary and professional societies include the Institute of Mathematical Statistics, American Statistical Association, and Sigma Xi.

■ *Lemuel Bell Wingard,* Assistant Professor of Chemical Engineering, received both his B.Ch.E. in 1953, and his Ph.D. in 1965, from Cornell. As an undergraduate he was crew coxswain and president and treasurer of the student chapter of A.I.Ch.E. His professional experience has been with Carbide and Carbon Chemicals, the U.S. Army Ordnance Corps, and Du Pont. Dr. Wingard teaches in the areas of biochemical engineering, biophysics, and bionics. Honors include Phi Kappa Phi.

In addition to the appointments listed above, the staff of the College of Engineering has included the following visiting professors during the current year:

■ *J. M. Burgers,* Avco Victor Emanuel Distinguished Visiting Professor of Aerospace Engineering (September–December). Dr. Burgers is Research Professor at the Institute for Fluid Dynamics and Applied Mathematics at the University of Maryland.

■ *Isao Imai,* Visiting Professor of Aerospace Engineering. Dr. Imai is Professor of Physics at the University of Tokyo.

■ *J. W. Linnett,* Avco Victor Emanuel Distinguished Visiting Professor of Aerospace Engineering (second term). Dr. Linnett comes to Cornell from Oxford, England, where he was a Fellow at Queens College.

■ *Walter A. Flood,* Visiting Associate Professor of Electrical Engineering. Dr. Flood is from Cornell Aeronautical Laboratory.

■ *Robert L. Gunshor,* Visiting Assistant Professor of Electrical Engineering. Dr. Gunshor comes to Cornell from Rensselaer Polytechnic Institute where he received his doctorate last year.

■ *Brian P. Leonard,* Visiting Assistant Professor of Electrical Engineering. Dr. Leonard, a native of Melbourne, Australia, received his doctorate at Cornell last year.

■ *John A. Nation,* Visiting Assistant Professor of Electrical Engineering. Dr. Nation comes to Cornell from London, England, where he is Physicist at Central Research Laboratories.

■ *Alexander W. Luce,* Visiting Professor of Mechanical Engineering, is a Professor at the Georgia Institute of Technology.

# FACULTY PUBLICATIONS

*The following publications and conference papers by members of the Cornell College of Engineering faculty were published during the last quarter of 1965 and January 1966. In cases of co-authorship, the names of Cornell faculty members are in italics.*

## ■ AEROSPACE ENGINEERING

*Shen, S. F.* and Crimi, P., "The Theory for an Oscillating Thin Airfoil as Derived from the Oseen Equation," *Journal of Fluid Mechanics,* Vol. 23, part 3, pp. 585–609 (1965).

*Resler, E. L., Jr.,* and Harris, F. T., "Plasma Waves," *American Institute of Aeronautics and Astronautics Journal,* Vol. 3, No. 11, pp. 2033–2042 (1965)

*Seebass, A. R.,* Tamada, K., and Miyagi, T., "Oseen Flow Past a Finite Flat Plate," presented at the 1965 fall meeting of the American Physical Society, Cleveland, Ohio, November 1965.

## ■ AGRICULTURAL ENGINEERING

*Furry, R. B.* and Hazen, T. W., "Methodology for Investigation of the Ventilation-Dilution Phenomenon," presented at 1965 winter meeting of the American Society of Agricultural Engineers, Chicago, Ill., December 1965 (#65–941).

*Scott, N. R.* and Boys, L. L., "An Experimental and Theoretical Study of Heat Transfer through Masonry Walls," presented at 1965 winter meeting of the American Society of Agricultural Engineers, Chicago, Ill., December 1965 (#65–902).

*Scott, N. R.,* Parsons, R. A., and Koehler, T. A., "Analysis and Performance of an Earth-Air Heat Exchange," presented at 1965 winter meeting of the American Society of Agricultural Engineers, Chicago, Ill., December 1965 (#65–840).

*Price, D. R.* and *Gunkel, W. W.,* "Measuring Distribution Patterns of Granular Applicators," *Transactions of the American Society of Agricultural Engineers,* Vol. 8, No. 3, pp. 423–425, 1965.

## ■ CHEMICAL ENGINEERING

Wald, S. A. and *Winding, C. C.,* "Differential Thermal Analysis Using High Frequency Electrical Fields," *Analytical Chemistry,* Vol. 37, p. 1622, November 1965.

Blackford, D. S., and *York, R.,* "Vapor-Liquid Equilibria of the System: Acrylonitrile-Acetonitrile-Water," *Journal of Chemical and Engineering Data,* Vol. 10, p. 313, October 1965.

## ■ CIVIL ENGINEERING

Broms, B. B., and *Lutz, L. A.,* "Effects of Arrangement of Reinforcement on Crack Width and Spacing of Reinforced Concrete Members," *Journal of the American Concrete Institute* (Title No. 62–77), pp. 1395–1410, November 1965.

*Liggett, J. A.,* Chin, C. L., and Miao, L. S., "Secondary Currents in Corner," *Journal of the Hydraulics Division, American Society of Civil Engineers,* November 1965.

Einstein, H. A., and *Graf, W. H.,* "Loop System for Measuring Sand-Water Mixtures," *Journal of the Hydraulics Division, American Society of Civil Engineers,* November 1965.

*Brutsaert, W. H.,* "Methods for Calculating Unsaturated Permeability," presented at 1965 winter meeting of the American Society of Agricultural Engineers, Chicago, December 1965.

*Esrig, M. I.,* "Feasibility Study of Electrokinetic Processes for Stabilization of Soils for Military Mobility Purposes," Report No. 3, U.S. Army Corps of Engineers, December 1965.

*Winter, G.,* "Report on Cornell Colloquium on the Nature of Inelasticity of Concrete and Its Structural Effects," presented at the Structural Engineering

Conference of the American Society of Civil Engineers, Miami Beach, January 1966.

*Johnson, A. L.,* and *Winter, G.,* "Behavior of Stainless-Steel Columns and Beams," presented at the Structural Engineering Conference of the American Society of Civil Engineers, Miami Beach, January 1966.

Karren, K. W., and *Winter, G.,* "Effects of Cold-Forming on Light-Gage Steel Members," presented at the Structural Engineering Conference of the American Society of Civil Engineers, Miami Beach, January 1966.

*Errera, S. J.,* Pincus, G., and *Fisher, G. P.,* "Buckling of Columns and Beams Stiffened by Shear-Rigid Diaphragms," presented at the Structural Engineering Conference of the American Society of Civil Engineers, Miami Beach, January 1966.

Sturman, G., Shah, S., and *Winter, G.,* "Microcracking and Inelastic Behavior of Concrete," *Proceedings of the International Symposium on Flexural Mechanics of Reinforced Concrete, American Society of Civil Engineers-American Concrete Institute,* 1965.

*Winter, G.,* "Whither Inelastic Concrete Design?" *Proceedings of the International Symposium on Flexural Mechanics of Reinforced Concrete, American Society of Civil Engineers-American Concrete Institute,* 1965.

*Dworsky, L. B.,* "Metropolitan Water Problems," presented at the National Seminar on Metropolitan Problems, Riverside, California.

*Dworsky, L. B.,* "On the Status of Cooperation among U.S. Universities for Water Resources Research." Report presented as chairman of panel of eight directors of University Water Resources at the First National Conference of the Directors of Water Resources, Washington, D.C., January 1966.

*Dworsky, L. B.,* "Northeastern Water Problems and Cornell University's Contribution in Seeking Solutions to Them," presented at the Interregional Conference on Water Resources, Southern California Water Conference, Los Angeles.

## ■ ELECTRICAL ENGINEERING

*DeClaris, N.,* and Titlebaum, E. L., "Linear Transformations of the Ambiguity Function," presented at International Symposium on Information Theory, Los Angeles, Jan. 31–Feb. 2, 1966.

*Eastman, L. F.,* "A Current-Controlled Negative-Resistance Effect in Indium Antimonide," *Transactions of the Institute of Electrical and Electronics Engineers,* special issue on "Semiconductor Bulk Effect and Transit-Time Devices," January 1966.

*Nation, J. A.,* "Shock Propagation in Transverse Magnetic Fields," *British Journal of Applied Physics,* Vol. 16, p. 1693, November 1965.

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*Kim, M.,* "On Optimum Control of Discrete Systems: I," *Instrument Society of America Transactions,* Vol. 5, p. 93–98, January 1966.

*Thorp, J. S.,* and Rashba, S., "The Design and Construction of a 200 Mc Band-Passed Matched Filter," *Proceedings of the Institute of Electrical and Electronics Engineers,* Vol. 53, pp. 1762–63, November 1965.

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*Linke, S.,* "Blackout in the Northeast," *Cornell Engineer,* Vol. 31, No. 2, p. 27, November 1965.

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*Liboff, R. L.,* "Brownian Motion of Charged Particles in Crossed Electric and Magnetic Fields," *Physical Review,* 141, 222 (1966).

*Liboff, R. L.,* "A Biomagnetic Hypothesis," *Biophysical Journal,* 5, 845 (1965).

*Liboff, R. L.,* "Equation of State of an Ideal Magnetoactive Plasma," presented at American Physical Society meeting in New York City.

*Wolga, G. J.,* and Teich, M. C., "Multiple Quantum Processes and Higher Order Correlation Functions," *Physics Review Letters.*

*Wolga, G. J.,* "Double Resonance Laser Spectroscopy," presented at ARPA-IDL Conference at Brown University, December 1965.

## ■ ENGINEERING PHYSICS

*Wade, R. H.,* "An Investigation of the Geometrical-optical Theory of Magnetic Structure Imaging in the Electron Microscope," *Journal of Applied Physics,* January 1966.

*Kitamura, N.,* "The Temperature Dependence of the Diffuse Streaks in Single Crystal Electron Diffraction Patterns," *Journal of Applied Physics,* January 1966.

*Wade, R. H.,* and *Silcox, J.,* "Columnar Structure in Thin Vacuum Condensed Films," *Applied Physics Letters,* December 1965.

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*Nelkin, M. S.,* "Summary of the Symposium on Pulsed Neutron Research," *Pulsed Neutron Research,* Vol. II, International Atomic Energy Commission, Vienna, 1965.

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## ■ MATERIALS SCIENCE AND ENGINEERING

*Behun, M. F., Burton, M. S.,* and *Smith G. V.,* "A Low Temperature Testing Cell with Controlled Temperatures Between 50° and 150°," *Materials Research and Standards* (ASTM) 5, December 1965, p. 624.

*Blakely, J. M.* and *Li, C. Y.,* "Formation Energy of Vacancies at (100) Sodium Chloride Surface," *Journal of Physical Chemistry of Solids,* 26, 1863, 1965.

Christ, B. W., *Smith, G. V.,* and *Burton, M. S.,* "The Influence of Grain Boundaries and Veining Subgrain Boundaries on the Yield Phenomenon in Zone Refined Form," *Transactions of American Institute of Materials Engineers,* January 1966, *236,* pp. 9–13.

Formsby, C. L., and *Owen, W. S.,* "The Strain-Ageing and Quench-Ageing of Tantalum," *Journal of Less Common Metals,* 1965.

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*Seidman, D. N.,* and *Balluffi, R. W.,* "Dislocations as Sources and Sinks for Point Defects in Metals," *Interactions Between Lattice Defects,* Hasiguti (ed.), New York: Gordon and Breach, Inc. (1966).

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*Dropkin, D.* and Gelb, G. H., "Measurements in the Thermal Field of Mercury undergoing Natural Convection with and without Rotation," *International Journal of Heat and Mass Transfer,* Vol. 8, pp. 1341–1352.

*Pierce, F. J.,* "The Law of the Wake and Plane of Symmetry Flows in Three-Dimensional Turbulent Boundary Layers," presented at the 1965 Annual Meeting of the American Society of Mechanical Engineers.

## ■ NUCLEAR ENGINEERING

*Cady, K. B.,* Masters, C. F. and Zolotar, B. A., "Asymptotic Reactor-Theory Analysis of the Garelis-Russell Experiment," *Transactions of the American Nuclear Society* 8, 432, November 1965.

## ■ THEORETICAL AND APPLIED MECHANICS

*Conway, H. D.,* "Vibration Frequencies of Truncated Cone and Wedge Beams," *Journal of Applied Mechanics,* December 1965.

*Conway, H. D.,* "The Free Flexural Vibrations of Triangular, Rhombic and Parallelogram Plates and Some Analogies," *International Journal of Mechanical Science,* December 1965.

*Mitchell, T. P.,* "The Evolution of the Solar Magnetic Field," *ICARUS,* January 1966.

*Pao, Y.,* and *Kowal, C. R.,* "A Laboratory for Teaching Mechanical Vibration," *Journal of Engineering Education,* November 1965.

# Engineering Education Today

*The Faculty Advisory Board—(from the left) Howard N. McManus, Jr., Ferdinand Rodriguez, Donald F. Berth, Nelson H. Bryant, and Gordon P. Fisher. Absent when the picture was taken were William H. Erickson and John P. Howe.*

ENGINEERING: Cornell Quarterly

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Dynamic! That seems to us the best way to describe a profession whose educational process is responsive to man's changing conditions. Engineering education indeed has always been dynamic. But if the term "dynamic" could be measured, the measuring instrument's deflection nowadays would show a huge positive spread from the mean. Not only has scientific knowledge increased, adding to the backlog of potential engineering applicability, but the very needs and desires of man himself have broadened, far beyond his basic material wants.

The theme for this inaugural issue, "Engineering Education Today," is timely. At its 1966 Annual Meeting this June, the American Society for Engineering Education will discuss a preliminary report, "Goals for Engineering Education," commissioned by the Society a few years back. The major recommendation proposed for adoption is that "The *first professional degree* in engineering should be the master's degree, awarded upon completion of an integrated program of at least five years' duration."

Partly in recognition of new needs but also with an eye to increased leadership and responsibility engineers will have to shoulder in tomorrow's society, the report stresses that *imagination* is essential, not only to strengthen and improve liberal education but to offer greater diversity and flexibility in engineering curricula.

To have a healthy profession, industry, government, and engineering colleges must become *more effective partners*. Statements such as "continuing education for experienced engineers," on the one hand, and a demand for "practical experience for engineering educators," on the other, suggest that the Goals Committee envisages no merely one-sided partnership.

Several of the ASEE Goals Study recommendations have quickly touched off heated debate within the engineering profession. Whatever final form these recommendations will take, their influence is bound to affect the education of engineers for at least the next decade.

And now a note about ENGINEERING itself. It is intended that this publication serve a broad readership, interested, one way or another, in engineering today. Every issue will carry three or four articles related to a particular theme or subject: an approach that should demonstrate the wide diversity of contribution within Cornell's College of Engineering.

We hope, as issue succeeds issue, that our efforts will contribute to a better understanding of some of the more interesting and important undertakings in engineering in general and at Cornell in particular. We look forward to any comments and suggestions that will help us in this endeavor.

THE EDITOR