Keynote Address

Changing Requirements of Engineering Education

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I WANT TO SAY a few words today about the place of the engineer in modern life and about what might be done, through engineering education and the professional societies, to make that place more effective.

The term *engineer* is often used rather loosely. It means different things to different people. If you ask a physicist or a research scientist what an engineer is, he will tell you that we engineers are the plumbers, the hardware men, the guys who worry about the nuts and bolts that hold together the devices he designs. Maybe he won't say so, but what he really believes is that engineers are useful to have around but not really in the same class as other professionals.

At the other extreme, there are some people to whom the engineering profession appears really glamorous. These people have such a high opinion of the engineer that they want to associate themselves with the profession—in name at least. These are the janitors who call themselves service engineers, or maintenance engineers, or the people who list themselves as exterminating engineers. To them an engineer has a pretty enviable image.

The result is that most of us find ourselves —as usual—in the middle. We aren't sure just where we stand. We're likely to feel a little bit like the young girl who was so proud of the fact that her father was a judge that when people asked her who she was, she usually replied, "Oh, I'm Judge Brown's daughter!" Her mother, thinking that this sounded a little snobbish, told her to simply say that she was Dorothy Brown. Later, someone asked her if she wasn't Judge Brown's daughter. "Well, I thought I was," she replied, "but Mother says not."

THE FACT of the matter is that engineers have been trying for a long time to improve their status generally, and engineering educators have been trying not only to improve the engineer's technical education, but to provide him with a professional outlook and with the general attributes of professionalism.

In fact, as long ago as the nineteen twenties, when the Society for the Promotion of Engineering Education undertook its first comprehensive study of engineering educational programs throughout the country, the idea was very seriously considered of going the whole way toward professionalism by making engineering education a form of graduate study, like medicine or law, to be entered into only after completion of a four year bachelor's program. W. E. Wickenden, the director of that study, was convinced that professional training in general involved a great deal more than could be provided at the undergraduate level. And while he was unwilling to propose that engineering schools follow the practice of the other professions to

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this extent, he was keenly aware of the fact that if the engineer was to be really a professional man, he needed to supplement his formal education with something like the physician's internship.

What Wickenden suggested was a program of post-scholastic training, to be made widely available, and to be handled jointly by educators, industry, and the professional societies—a program involving formal education with practice, and recognizing professional development and achievement in a formal way. Levels of accomplishment would be clearly defined and would be related to professional grades of membership in engineering societies. Thus the engineer, through formal training and through practice under the aegis of established professionals, could have his accomplishments formally recognized by being designated a Fellow of his professional society, and his place as a professional engineer would be understood and assured.

IN THIS RESPECT the engineering profession itself was not yet ready to follow the lead of the older professions. And in a sense, this was understandable. The medical profession, and indeed the public itself, was apprehensive of what an improperly educated doctor could do. There was clearly a need for physicians and surgeons to be trained at the hands of established professionals. The legal profession was equally insistent upon a clearly structured program of graduate study before it was willing to admit a neophyte to practice. But the engineering profession felt no such compunctions. Traditionally many of the top-ranking engineers—the men who had been responsible for the machinery and devices and equipment that were changing the world—had been largely self-taught. There was very little public fear of what an uneducated engineer might do. And indeed, it is still possible, even in the complex world of today, for an engineer to educate himself in the necessary science, mathematics, and even design, and to enter the profession by the back door, so to speak.

In any event, the Wickenden committee failed to recommend for engineering the kind of professional graduate education that was generally accepted at the time for the other professions. Probably one of the reasons is that there was then—and indeed there is even today—no clear-cut and generally accepted definition of what an engineer really does. The man who invents or designs engineering apparatus is called an engineer, but so, in many cases, is the man who uses the machinery. It is not necessary to know how to design a computer in order to use one for engineering purposes, nor is it necessary to know anything about the design of a computer in order to design a bridge.

In fact the profession which we call engineering has gradually come to include a wider and wider range of specialized skills and interests and to encompass operations that require a great variety of kinds and levels of training. There was a time when a man could design a battleship by laying out the main specifications for the shape, the propeller, and the engines. Today the design of a ship, or even of a bridge or a highway for that matter, involves an almost infinite number of complex plans and problems. The blueprints for a modern battleship weigh almost as much as the battleship itself. Everything is laid out on paper, parts must be designed to be interchangeable, and all the complex operations and detailed requirements must be provided for.

And all this means not only a great many more engineers, and engineers with different kinds of knowledge and experience, but also engineers working at different levels of the concept all the way from the man who decides on the number of rivets to hold two plates together to the man who determines the weight-to-horsepower ratio for the completed design. And this means a demand for all levels of engineering skill.

UNFORTUNATELY WHAT we have been doing for many years in engineering education is to try to meet these varied demands with a single engineering curriculum in each of a few disciplines. To a very large extent we have been producing engineers in a kind of stereotyped mold, giving them generally the same kind of training right down the line, with the only real differences to be found in the individual's own initiative, understanding, and special interests. And what this means is that when they have gotten out on the job, there have been some who are operating beyond their skills, and many who are not operating up to the limits of their abilities. Both have been unhappy and neither has been as productive as he should be.

Gradually we have tried to take care of the situation by building into our educational system a kind of differentiation, so that on the one hand individual needs and capabilities and interests can be provided for, and on the other so that we can produce the variety and level of engineering personnel to meet the needs of modern life. And this is precisely

what we should be doing. In any big engineering project today, there are going to have to be generals and captains and privates. We need the project engineers, the section leaders, and the detailed designers.

The trouble is that neither the educators nor the profession itself have gone far enough in recognizing the situation, and all too often we find opposition to the concept. In spite of our general awareness of the variety and complexity of modern engineering activity, we are slow in making provisions for our engineering schools to take account of student differences and professional requirements and to provide a proper mix of graduates.

One reason for this, of course, is the natural desire of all engineering colleges to strive for excellence. But unfortunately in our thinking the concept of excellence is too often interpreted as meaning that we must all produce the rarest birds in the cage: the highly skilled, highly educated, highly motivated—and very expensive—project leaders. Few, if any, schools want to provide the captains, much less the privates, that we need as members of the team. We fail to realize that excellence in artisanship is just as important as excellence in leadership, and that if everyone is trying to produce the leaders, there will be no followers and no one to do the work.

Most engineering schools want to be a Cal Tech and confine their efforts to the upper two per cent of the high school graduating class. There are too few schools who are willing to say: here is the particular slot in the engineering team that we're going to fill, this is the kind and level of engineering need that we're going to concentrate on—and then select their students on the basis of this decision, design a curriculum to do the job, and really work toward achieving excellence in this limited area. The fact of the matter is that there are plenty of students who want this kind of training, and who have the interest and capability to succeed in the kind of job it leads to. And there is no question of the demand for them. Someone has got to produce such people. But the job won't be done until educators recognize the need and the profession itself accepts the concept.

The range of engineering activity in the modern world has broadened a whole lot faster than the range of engineering education. And the most important task of engineering education today is to catch up to recognize the need for diversity and to provide systematic ways of filling it. There are very few engineering schools that can, or should, provide for the whole gamut of engineering skills. Yet there are many who could do a first rate job of carving out a niche for themselves and preparing top-notch people to fill this limited area.

Perhaps most of us have been slow in realizing the extent to which engineering knowledge and skill have become essential requisites of almost every activity in modern life. Educators and professional engineers alike are all to prone to think of engineering activity in terms of the traditional needs of industry. We think of the engineer as the man who, at least at the upper level of professional skill, is content with devising a piece of equipment, seeing it through the process of production, and then saying to the prospective customer: here it is; this is the best I can do; take it or leave it. For the most part the engineer has been unconcerned with the things for which there is no immediate market. He has concentrated his efforts on the devices and gadgets that his company can produce and sell at a profit.

Yet today we need, more than at any other time in our national development, engineers who are concerned with, and who have a real understanding of, the large social-technological problems that beset us—the pressing need for clean air, clean land, clean water, good transportation, effective information systems, and so on.

What we need to attack these problems is a new kind of engineer, one who has a broad grasp of government, politics, the business world, and of modern society in general. We need engineers who are not just technically competent, but who also have a broad base of general knowledge so that they can understand the interrelationships of their special skills to the other forces at work in modern society.

Here, too, engineering education has tended to be slow in adapting its programs to the needs of the profession. It is true, of course, that educators have recognized for many years the general need for a broadly based education. Most engineering schools have insisted that about one-fifth of an engineer's undergraduate education be devoted to what we call the social-humanistic stem. Engineering curricula generally have included a number of isolated courses in the humanities and the social sciences. But in actual practice the real purpose behind this requirement has never been very effectively achieved. All too often we have done little more than pay lip

service to the concept, and there has been very little concern with really integrating the content of these courses into the engineer's education or giving him a real grasp of the social and humanistic forces which shape technological needs. Most engineering students have had little incentive to regard these courses as anything more than a necessary bother, or to consider the knowledge gained in them as anything more than incidental and largely useless in their professional careers.

Here again, too many educators, by conceiving of engineers in general as men primarily concerned with performing isolated technical services, or as designers of products to be sold at a profit, have failed to understand the broad range of engineering needs in modern life. But, fortunately or unfortunately, a great many engineers today are being called upon to take stands in public affairs, to express themselves through school boards, borough councils, State and Federal government, industrial organizations, and so on. And in these areas technical competence is not enough.

STRANGELY ENOUGH, the further an engineer goes in his formal education to prepare himself for leadership in engineering, the less knowledge he gets of the humanities and the social sciences. Although we may require him to spend some time on these subjects in his undergraduate education, there is almost no requirement for this sort of knowledge at the graduate level. So on an inadequate social-humanistic stem in undergraduate years, we place no further requirements in the graduate years. At the graduate level, the engineer shores himself up very well on the technical aspects of his education, but all too often, he gets further and further away from any real coupling of these technical aspects to the world in which he lives. The very engineers who have the greatest opportunity to speak out on public matters have the least preparation to do so.

All told, it seems to me that the greatest need in engineering education today is for diversity, differentiation, and flexibility throughout the system. On the one hand we need not only to recognize the very broad and growing range of specialized technical knowledge, but more importantly, we must prepare our students specifically for the varied and various levels of engineering skill needed to satisfy the complex requirements of modern life. On the other hand, we must provide, at all levels of engineering education, including the graduate, a better understanding of the interrelationship of the engineer's special competence to the social and political forces which influence and are influenced by his work. And we must recognize the fact that, except in rare instances, individual engineering schools cannot hope to offer the whole gamut of engineering education to their students, but can perform a better service by providing quality education in a few limited areas. And even within these chosen areas, there must be enough flexibility in course offerings and requirements so that the individual student can find the niche best suited to his capabilities and interests, and prepare himself effectively for the career of his choice.

HERE, IT SEEMS TO ME, the professional societies have a real obligation. If engineering is indeed a profession, and not merely a calling or an occupation, then one of its essential features must be the part that is played by its established practitioners in the education of the younger members of the group.

Perhaps the suggestion that Wickenden made so long ago should be given serious consideration today. What he called a formal post-scholastic training, organized and handled jointly by educators and professional societies, might well be the answer to the problem we face, not only of fitting engineers for more effective leadership in modern society, but of recognizing and formally acknowledging their professional status.

THE EFFORTS WE HAVE MADE in the past to achieve professional unity and to provide for some way of enhancing our professional status have generally failed to accomplish the purpose. The American Association of Engineers tried to pull the various types of engineers together as long ago as 1914, but has failed to gain the recognition it sought. The National Society of Professional Engineers has attempted to establish recognized standards and to screen engineers by a program of licensing, but here, too, there has not been enough general support to accomplish the purpose effectively. The Engineers' Joint Council has attempted to provide an umbrella society that could give unity and coherence to the profession. The Engineers' Council for Professional Development has attempted to enhance the image of the engineer and provide a vehicle for unified action. And the new National Academy of Engineering was established to increase unified engineering activity by providing a focus for the contributions the profession can make in our national development. Yet in spite of all these efforts, engi-

neering seems to remain the stepchild of the professions.

It seems to me that what we must have is a willingness on the part of practicing engineers and engineering educators to join together more closely in establishing the real requisites of professional competence and in recognizing them through appropriate programs, which involve formal education and practice, and can lead to meaningful awards of distinction. In spite of the diverse and varied demands of our separate occupational interests—indeed, because of the very diversity and extensiveness of our potential contributions to modern society, we need professional unity today more than ever before.

In any case, it seems to me that the professional societies should play a more direct and active part in concerning themselves with engineering education and preparation for engineering practice. Only with their constant support will the image of the engineer in the public's view reflect the true importance of the engineer's place in the modern world.

Announcing the Otto von Gruber Award

The von Gruber Gold Medal plus a sum of 500 Dutch guilders (($185.00) will be presented by the International Society of Photogrammetry at its XI Congress in Lausanne, Switzerland, 9–19 July 1968 to the author of an article of outstanding merit on photogrammetry or photo-interpretation.

Author-candidates who meet the qualifications of the deed of award given below are requested to inform Dr. H. Harry, President of ISP, Manuelstrasse 83, 3000 Berne, Switzerland, of their intentions to compete for the Award. Copies of their work in quintuplicate should accompany their letter of intent and be mailed in time to reach Dr. Harry not latter than December 31, 1967.

The qualifications for obtaining the von Gruber Award are the following:

1. The recipient shall have written, within four years immediately preceding the Congress at which the Award is declared, an article of outstanding merit on photogrammetry or photo interpretation, which article shall have been adjudged by the jury to be the best submitted to them; and
2. The recipient shall, within the preceding 12 years, either
   a. Have graduated from a recognized university in photogrammetry or photo interpretation as a major subject; or
   b. After having graduated in other subjects from a university or similar educational institution, have satisfactorily completed a post-graduate course in photogrammetry or photo interpretation at a recognized university, technical college or school; or
   c. Have graduated from the International Training Center for Aerial Survey at Delft.

Travel Arrangements for the 1968 Congress

The American Society of Photogrammetry is pleased to announce that a selective program of special European group travel arrangements is being prepared for its members, their families, and friends. Besides affording economic advantages, the arrangements will assure one of accommodations in spite of the fact that the Congress will convene at the height of the tourist season.

The announcement pertains to the XI Congress of the International Society on Photogrammetry (of which ASP is a member) which is scheduled for Lausanne, Switzerland, July 8 to 20, 1968.

The arrangements, including post-Congress European tours (the only ones sponsored by ASP through this announcement) are being expertly prepared by the Washington, D. C., office of the American Express in liaison with their offices abroad. Complete details will be announced in the very near future.

Based on experience with previous Congresses, this is not too early to plan to take part in the Lausanne Congress with its interesting and informative meetings, technical side trips, social events, and sightseeing tours. Make this the occasion for that long-planned tour of Europe—experience delightful relaxed travel—enjoy the stimulating companionship of fellow photogrammetrists.

Interesting and fun-filled days while their husbands meet are being programmed for the Ladies by the Congress director.