*Are engineers selling their birthright for a place in the ivory tower?**

RALPH H. WING

909 *Caldwell Street*
Piqua, Ohio

When I graduated from college, now nearly forty years ago, engineering was defined rather simply as "the art of utilizing the knowledge of the sciences in the production of machines and materials for the benefit of mankind". There was also included some reference to the fact that engineering was to be accomplished for a profit. Science was defined as "an organized body of knowledge." I don't recall any definition of the word "art," but I would suggest that the word art refers to the "doing" and science refers to the "knowledge" used in the "doing." Perhaps skill would be a better word.

In any field of endeavor, both skill and knowledge are required. Even the scientist, engaged in pure research, must have some basic skills. At the very minimum, he must be able to present the results of his work to others in a satisfactory manner. On the other hand, the artist, engaged in abstract art, must have some basic knowledge of the materials and techniques necessary for accomplishment of his work.

In recent years, there has been a tremendous growth in the accumulation of knowledge. As a result, there has been a steady upgrading of the term "science." This is called the "Scientific Age" and the "Scientist," once considered a peculiar individual working in the mysterious confines of something called a laboratory, has now become a well-known and highly respected individual. No one can regret this development. Public recognition of the valuable work of the scientist has been long overdue. However, there are some side effects of this trend that are not so desirable. While respect for knowledge has been increasing, respect for the skills necessary to put this knowledge to use has been steadily declining. For example, when a space ship has been put into orbit successfully, it is hailed as a great "scientific" achievement. When there is a failure, it is referred to as an "engineering" failure, or perhaps less painfully, as a "technical" failure. The terms "engineering" and the title, "engineer," are being definitely and rapidly downgraded.

It is disappointing to note that even among the members of our own profession, there is a reluctance to use the title "engineer." *In reviewing the biographical sketches of recent candidates for offices of one professional society, it was noted that not a single candidate referred to himself as an engineer.* The most commonly used titles were Executive, Administrator, and Educator. (No one, however, referred to himself as a "teacher".)

Engineering, as a profession, and engineers, as individuals, have been known and respected, primarily for their accomplishments; i.e., the actual production of materials and machines. Today there seems to be a growing tendency to believe that engineers should be respected for their knowledge and not for their accomplishments.

A number of years ago, a young engineer of my acquaintance, was proud of the experience he was getting in heat exchanger design. He pointed out that he had "designed" nine heat exchangers that week. "How many of your heat exchangers have been built?" I asked. "Oh, none of them have been built, but what has that got to do with it? I still have the design experience." Actually, of course, he had experience in applied mathematics—not heat exchanger design.

At a more recent technical meeting, I heard

*Presented at the Annual Meeting of ASEE, June 19-22, 1967.

If engineering as a profession, and engineers as individuals, are to retain a prestige based on accomplishment, then there must be a reversal of the present trend to confine engineering to design and management offices.

a discussion on heat exchanger design that went something like this: "There are about 128 variables that affect heat exchanger design. Of these, all but about 32 can be considered to be of negligible importance. With the 32 variables, we could design the ideal heat exchanger. It would require about $15,000 worth of computer time for each exchanger and my company objects to this. I know that these exchangers sell for about $3000 and there would be a net loss of $12,000 on each exchanger, but think of the valuable information we would get." Unhappily, for the "engineer", the company he works for sells heat exchangers for a profit, not "valuable information."

In a conference on a recent plant design, I asked the design engineer if he felt that the resulting plant would be "operable." "What do you mean?" he asked, with a perplexed expression. "Well, can the operating engineers operate this plant satisfactorily?" He was astonished. "I couldn't care less!" was his reply. "This design is based on methods established in the technical literature. I have checked my mathematical computations and there are no errors. If it does not operate satisfactorily, this is of no concern to me."

I submit that the attitudes reflected above do no good to the engineering profession and are not the proper attitudes for an engineer.

The rapid expansion of the sciences in recent years does create difficult problems in the education and training of chemical engineers. It has seemed to me that the chemical engineer has always been somewhat more fortunate than his colleagues in mechanical and electrical engineering, since he has had the additional training in chemistry as well as the basic mathematics and physics. Now, the expansion in physics and mathematics places an additional burden on the chemical engineering student. In addition to this, the present recommendations that 20% of the students' time be devoted to the humanities, adds still another burden.

I would suggest that the whole humanities requirement be eliminated. In reviewing the catalogue of one midwestern university, I noted their requirement for credit for a course in the humanities. "The course must be one that adds to the student's knowledge in a given field, but not to his skill." For example, he may take a course about the theater, but he may not take a course that is designed to develop his skill as an actor. He may take a course about music, but not a course that is designed to teach him to play a musical instrument.

It is inevitable that time spent in the laboratory courses has been, and will be, reduced. In my college years, we were required to take courses in forging and heat treating of metals and also a course in pattern making—laboratory courses taken during the summer months. I still have a set of wrenches that I laboriously forged during that summer. Unfortunately, I have never found a bolt head or nut that they would fit. The case hardening was excellent and I cannot grind them down to fit anything, but they are nice wrenches.

We also had some sixteen clock hours per week of quantitative analysis each semester during the second year. I do not recommend that we return to this; however I do believe that we have reduced that part of the curriculum that can be defined as "training," as opposed to "education," to beyond tolerable limits. Recently, the dean of one engineering school asked me, quite seriously, if the courses in chemistry could not be eliminated from the curriculum in chemical engineering. "I know it sounds silly," he said, "but with the addition we have to make to the curriculum, we simply do not have time to provide the laboratory hours required."

One area in which I believe that laboratory work has been reduced beyond tolerable limits, is in engineering drawing. Many young engineers not only cannot produce a satisfactory drawing, often they cannot read one.

Some colleges have attempted to meet this problem by adding a fifth year to the course of study required for the B.Ch.E. degree. This has resulted in a drop in enrollment and to offset this, they have worked out a combined curriculum that would award the student an additional degree in Business Administration. I do not believe that a student can be given adequate training in both

disciplines to justify this program. He is either a Chemical Engineer with a minor in Business Administration, or he is a graduate in Business Administration with a minor in Chemical Engineering.

I am aware of the fact that a number of the larger chemical companies subscribe to the theory that chemical engineering curriculum should be heavily weighted with courses in the sciences. They say, "You give them all the mathematics, chemistry, physics, etc., that you can. We will teach them the necessary engineering after they come to work for us." Such a procedure does an injustice to the student who expects to be trained in principles of engineering. It also puts the student who elects to work for the smaller companies, at a disadvantage.

When I returned to teaching after some years in industrial work, I introduced a new course in plant design. The course was not intended to develop proficiency in process calculation, it was designed to acquaint the student with the myriad problems which arise from the very beginning of a project. It included site selection, literature survey for necessary data and estimating methods for both equipment size and cost. The course was given in the last half of the senior year. About midway through the course, one student came to me with this comment: "I came here to become an engineer, although I had not decided on which field of engineering. I selected chemical engineering because I met another freshman that I liked and he was going to take chemical engineering. For three and a half years, I have been taking courses in Chemistry, Mathematics, Physics, English, etc., but I never knew just what chemical engineers did until I started this course."

This course was very popular with the students. Actually, it could be given in the last half of the second year or first half of the third year. If the student had some idea of the problems of chemical engineering, at an early point in his training, he would have a better understanding of the requirements for process design and unit operation courses which would follow.

There is a growing concern among some engineering companies for the increasing difficulty they are experiencing in getting new plants "on stream." As a vice president of one engineering company put it, "We design and build a new facility and then send out a 35-year-old "hot shot" to operate it. Then we find out that he simply cannot do it."

If the present trend toward higher academic achievement for the professional engineer continues, there will be an unavoidable gap between the engineer and the supervision of engineering at the working level.

Having had some experience in operations, it is my opinion that almost all difficulties in operating a plant stem from lack of basic engineering knowledge. Actually, I might say, from lack of mechanical and electrical "know-how." For example, while inspecting a pilot plant installation, I pointed out to the project engineer that his pumps had not been properly grouted in. He was highly indignant. "We consider grouting to be window dressing and we do not waste money on this kind of thing." He was wasting money, however, on constant piping repair and packing problems, although the size of the operation was such that it was not too important. The point is, that this was the hallmark of a careless workman and he had a Ph.D. in chemical engineering from one of the leading colleges.

When I was a student, we had an "Engineer's Day" each year, when we dressed up the laboratories for a public inspection. I think that the good Dr. James R. Withrow, in one of his humorous moods, was responsible for one exhibit. Along one wall of the laboratory was a display of such equipment as specific gravity spindles, viscosimeters, analytical balances, etc. The title card read, "Proficiency in the use of this equipment required of all candidates for the B.Ch.E. degree." The next exhibit was a table containing pipe wrenches, chisels, hammers, etc., along with a card stating, "Proficiency in the use of this equipment required of all candidates for the M.Sc. degree. The last exhibit consisted simply of a wheelbarrow and shovel, along with the sign, "Proficiency in the use of this equipment required of all candidates for the Ph.D. in Chemical Engineering". At the time, I thought this simply a macabre jest, but as the years have gone by, I have learned to appreciate the wisdom displayed in this exhibit.

If engineering as a profession, and engineers as individuals, are to retain a prestige based on accomplishment, then there must be a reversal of the present trend to confine engineering to design and management offices. Engineers must be willing and encouraged to go "where the action is." There is a prevalent tendency, even within the profession, to downgrade the work of the engineer in the field. The "hard hat and leather booted" engineer is often referred to with some trace of contempt by his colleagues at the design level. Nevertheless, it is the field engineer who is called upon to correct design errors during the construction, and when a plant goes on stream easily, it is largely due to the efforts of the "hard hat and leather boot" engineers. It is, in fact, a common practice to revise drawings after construction to get an "as built" design.

If we wish to continue to promote engineering as the profession which practices "the art of utilizing the sciences in the production of machines and materials for the benefit of mankind," then I would like to make the following suggestions:

1. Re-evaluate our engineering curriculum with the goal of restoring to it the basic engineering courses. Much of the new material added to the curriculum as new courses, could be incorporated into existing courses.

2. Take a second look at the requirement that 20% of the engineering curriculum be devoted to the humanities.

If we do not wish to continue with the image of the engineer as the man known for his accomplishments, then we should accept the fact that the present trend is leading the engineering profession into a field of activity, not directly connected with what has been traditionally the domain of the engineer. *In the normal course of this development, engineering will become a branch of science.* There is already an increasing use of the term "engineering science." I asume that the term refers to what was once called applied science. It will also lead into what may be called applied mathematics.

Some well-trained technicians are already pushing the engineer out of contact with actual construction and production. Their argument is that because of the professional engineer's broader knowledge of the field, he should confine his talents to those of overall management. What they are implying is that because of the time spent in broadening his knowledge, he is no longer sufficiently well acquainted with the details of the work to provide adequate supervision at the working level. There is considerable merit to this point of view.

Assuming that the present trend toward higher academic achievement for the professional engineer will continue, then there will be an unavoidable gap between the engineer and the supervision of engineering at the working level. Schools offering technical training are rapidly upgrading their courses and it is possible that such schools will, in the future, be called on to provide engineering technicians adequately trained to supervise the work previously supervised by engineers.

My personal preference, for a number of reasons, would be to return to the professional institutions the concept of practical application of the knowledge of the sciences to the field of engineering.

Professor Ralph H. Wing is a graduate of Ohio State University. His early teaching experience was at Pratt Institute, Brooklyn, N.Y. Recent teaching experience was at the West Virginia Institute of Technology where he was head of the department of Chemical Engineering. His engineering experience includes work with M.W. Kellogg Co. and Ford, Bacon and Davis, of New York and the Research and Engineering Division of the U.S. Army Chemical Corps. His operating experience includes work with Heyden Chemical Corps. at Danville, Pa. and Fords, N.J. and Dodge and Olcott at Bayonne, N.J. He is the author of a number of papers dealing principally with plant operating problems.