WHERE DO WE GO FROM HERE?*

An Industry View

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A DECADE HAS GONE by since we last hosted one of your meetings, and we are delighted to do so again. It's a little late in the day for formalities, but let me add my welcome on behalf of the Du Pont Company.

A lot has happened in 10 years. Industry and education have shared some progress, and in the past year or two we have had our share of bruises. The chemical industry has been going through a period of consolidation and retrenchment, and while I don't want to dwell on the recruiting situation, it might help to take a minute to explain our present policy and the reasons for it.

As you know Du Pont is doing very little recuiting this year. We hired significant numbers of technical graduates in 1969-1970, and many people ask why we don't continue to do so this year. The answer is simply that in almost every area of our business we are now at a point where new employment would force us to cut people on a one-for-one basis. We have let some people go, and the easiest thing would be to cut much more deeply into the organization, dropping out a lot of people who are just average or a little above average in ability. Then we could hire a large number of very able students coming out of school this year. That, in our judgment, would not be fair. We feel a primary responsibility to the people on our payroll, and our policy is to force internal transfers, retrain and make whatever other changes are necessary to keep them with us.

We trust that retrenchment is a passing problem, and that the future holds considerably more promise for new graduates. You see most of the data we see, and you know that the economy has begun to pick up. For the seventies we are expecting a solid growth rate, and this of course ought to mean more opportunities.

This doesn't mean that we will return to the conditions that prevailed five or 10 years ago. To the contrary, some basic changes have occured, and this is what I'd like to talk about in terms of our mutual interests. All of us find the present climate of uncertainty difficult to live with, but from our vantage point in industry the only thing we're certain of is that there will be more uncertainty.

On the economic side, industries employing large numbers of engineers are becoming more competitive on an international basis.

To see the potential impact of international competition, we only need look at what has happened already to the small radio and TV market, in textiles and shoe manufacturing, and in shipbuilding. Against that, set the fact that in our own country labor costs have been rising faster than productivity in the past few years, and industrial profits are down.

Despite the boom of the mid-1960's, profits for manufacturers for the decade were substantially lower than in the decade of the 1950s — a full point lower on a base of less than 10. I don't think we have to make the case to you on the importance of profits, as you know this is a basic source of funds for new investment and for modernization of older plants. If profits fall over a period of time, our plant and technology will become noncompetitive just as surely as if we stopped research and process engineering.

What this says to us is that the engineering profession not only has a stake in profitability, but also carries a lot of the responsibility for

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. . . the nation is reshuffling its priorities . . . Some people still want maximum material progress. They want the products, and those in lower income brackets . . . (need) . . . a steady flow of new jobs. Other people tell us to cut back and slow down . . . They want expansion on a selective basis, if at all, . . .

keeping the United States in a viable, competitive position. We have a tough technical job on our hands, and it should provide stimulating work for many thousands of engineers. We have to maximize process yields, and find quicker and less expensive ways to develop new products. We have to improve the efficiency of engineering itself, to make it more reliable, more foresighted, and less prone to those "surprises" that come along late in the game and scuttle the cost estimates and construction schedules.

Even if we stay competitive as a nation, there will still be internal shifts that force companies to change tactics, and place unexpected demands on technical people. Let me give you an example. Our Photo Products Department used to have a fairly large technical group working on films and printing papers for use in professional photographic studios. Today, with the shift in our economy toward services such as medical care, the bulk of these people are now working on x-ray films, and instruments for use in hospitals and medical laboratories. Needless to say, when some of our engineers were interviewed by the Photo Products Department, they had no idea they would be working on devices like an Automatic Clinical Analyzer, and neither did we.

Unfortunately, most shifts like this are easy to see only with hindsight. In trying to plan ahead, we collect lots of data, but much of it proves to be contradictory. All it really tells us is that the nation is reshuffling its priorities, and as yet has arrived at no fixed censensus. This is a relatively new problem for us, at least in terms of scale. Until quite recently, industry had strong signals on what people really wanted us to do, so did the engineering profession. All the vectors pointed the same way. The public wanted to keep Tom Swift in the laboratory inventing everything he could think of, and then industry was supposed to scale up for high-volume low-cost production. If America had any single economic goal, it was to optimize for affluence.

NOW THE GOAL isn't so clear. The signals are mixed. Some people still want maximum material progress. They want the products, and those in lower income brackets know they don't have much chance to climb up the economic ladder unless there is a steady flow of new jobs created by industry. Other people are telling us to cut back and slow down. They think we are overcommitted to GNP. They want expansion on a selective basis, if at all, and they are pushing for more attention to the environment, medical care, and urban renewal.

You've heard all this a hundred times before. My only point is that we cannot optimize for all of society's goals at the same time, and there is no one to tell us exactly where society is going to make its tradeoffs.

Perhaps we'll put more emphasis on the "quality of life," but that does not solve the problem of creating jobs for the 1.5 million people entering the labor force each year, nor does it tell us what to do about the five million people now unemployed, or the growing number of underemployed. We certainly do not want to kick the ladder down in the face of the people who are trying to work their way up to the middle class. At the same time, it's unlikely that we are going back to a policy of growth-at-any price. That kind of policy has gotten us into a fair amount of trouble in the past.

The balance must fall somewhere in between, and it would take a very wise man to know exactly where it will lie in 1985, or even in 1975.

This uncertainty makes it difficult to do any definitive long-range manpower planning and we appreciate the problems this creates for you and your students. We continue to struggle with this problem and have some progress, but as our professors explained years ago, when we were trying to learn the rudiments of engineering, you can't take good sights unless the transit is standing on solid ground. And in our society today, terra firma is hard to find.

THAT APPLIES NOT just to forecasting, but to almost everything that involves the industrial engineer. George Hammond at Caltech said recently that the one talent his graduates need most is a high tolerance for ambiguity. That is certainly true if they have an industrial career in mind.

The younger engineers coming into industry find this is a difficult area of adjustment for *them. They're eager to tackle tough problems, but they sometimes find that the greater task is to identify the problems that need to be solved, and rank them in order of importance. This is still as much of an art as a science. The engineer wants to model a new process so he can optimize key variables, but it often turns out that there isn't enough data to build a complete model. By the time he gets the data, he is asked to design a Mark II process, and frustration sets in all over again. He finds that nothing stays nailed down very long, and that very few important problems are subject to final solutions.*

Along with a tolerance for ambiguity, the engineer needs flexibility. We cannot promise a man that he will always work in his first field of specialization. If he has real talent he is likely to be offered a variety of assignments. Some of my colleagues took a look at the records of five engineers who have been with us an average of seven years. They have had from three to six assignments each, ranging from design to vibration analysis, instrumentation, and reaction kinetics.

A THIRD QUALITY VERY much in demand is the ability to put it all together. Let me clarify that. I'm not trying to revive the old argument about the specialist versus the generalist. I'm not suggesting that every engineer ought to have a little bit of training in everything, because that could easily produce engineers no good at anything.

We still need highly trained specialists and theoreticians, people who dig a mile deep but only an inch wide. But above all there is a need for engineers who know how to collaborate across the disciplinary lines, people who can meld the soft inputs and the hard ones, make allowances for the economic and human factors as well is the technical ones, and come out with a consolidated approach. We know this kind of talent often develops in younger and smaller high technology companies. One of our main goals is to develop more of it in our organization, because it's just as badly needed, and when it is operating for us it has enormous leverage.

We are not sure where these three qualities fit into the educational picture — the tolerance for ambiguity, the personal flexibility, the ability to put it all together. Are they teachable talents and if so, are they related in some way to academic performance, or to the type of engineering curriculum a man goes through?

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We don't see the correlations very clearly, but in any case we defer to you. If these qualities can be incorporated more into the educational process, we know you're likely to find the way to do it.

I'd like to close with some comments about industry's role in adapting to uncertainty. Primarily, it comes down to the way we work with our people.

We acknowledge the incentive problem, and as everybody knows, from a strictly financial point of view, the lines aren't as distinct as they used to be. The median salary for a B.S. engineer with 15 years of service in manufacturing is $17,000 a year. That is about what a man can earn as an able-bodied seaman in the merchant service, as a locomative engineer, or as a tractor-trailer driver on cross-country hauling. Obviously there are psychological fringe benefits that make an engineering career worthwhile, but we don't take them for granted. We make a serious effort to put technical people on projects

(Continued on page 167)

BOOK REVIEW **(Continued from page 152)**

into the problems of the environment that is more profound than he is likely to experience firsthand or from perusing a newspaper or periodical.

Despite the indomitable optimists like the editor of Look magazine who decries the forebodings of the ecological Chicken Littles and fills us with football pep-rally confidence in our ability to overcome all obstacles, the problems of the environment described in this book deserve serious study. The engineer might have preferred more attention to internal and external combustion engines, to methods for converting garbage and recycling paper, and to greater utilization of renewable, non-polluting sources of energy. The author (a geographer at the University of Michigan) advises that the course which uses this book was taught jointly with an associate who is an engineer. So, we discover, that the environment belongs to all of us, even engineers, and we share, alas, in its responsibilities as well.

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comes in and he sees how much his own time and the time of subordinates and cooperating individuals cost, and that his account has to carry part of the support of the library and other so-called "overheads", he is amazed at how fast his $100,000 runs through the funnel.

Finally, on the relationships aspect: The graduate student gets some help from his advisor, and if he's lucky he may have a bright undergraduate to assist in his experiments. The department may even have a shop and a machinist or a technician. Working smoothly and effectively with these individuals influences his success in his graduate program. When he gets on the job, however, the importance of relationships changes by orders of magnitude. His accomplishments depend largely on the cooperation of dozens of others, and dozens of others depend on him. The functions of engineer, technician, designer, accountant, consultant, supervisor, and liaison, are all complexly interrelated. He is called on to exercise skills in relationships, in order to employ all these talents effectively, that he recognized as existing only intuitively, if at all.

What do I suggest to better equip the young engineer to make and meet time and cost commitments and to help him learn a little sooner how to work with and through others? The idea of group graduate research that some schools are practicing has great appeal. Rather than one graduate student working alone toward limited goals, several working cooperatively toward more-ambitious goals; leadership, rather than from the faculty, from within the student group . . . passing from one student to another as some graduate and others matriculate; the work undertaken only after a thoroughly thought-out proposal is developed, written up, and "sold" to the faculty and to the sponsoring agency; definite schedules to be met, definite budgets to be lived within; above all a specific task to be accomplished and by a specified time. A working environment such as this offers the ideal situation in which to teach and practice some of the principles of cooperative work . . . principles of management. Perhaps the Business School could participate and achieve objectives of their own while aiding Engineering.

In conclusion, I feel that graduate research in chemical engineering bears high relevance to interests of industry . . . interests in research, development, consultation, plant design . . . in fact to all aspects of industrial work. Areas that appear to offer intriguing opportunities for improvement are time and cost control and coordination of effort. The group research approach as contrasted to the individual approach, appears to offer excellent possibilities for achievement in these areas.

GEE **(Continued from page 161)**

really worthy of their talents, and to identify the organization with projects that are socially as well as technically worthwhile.

When an engineer joins us, we try to put him or her on a job that involves decisions. Inexperience is no sign that someone lacks professionalism or potential, and we have found that the youthful view often pairs well with the seasoned judgment of an experienced engineer. We bring about those pairings as often as we can, beginning with the first job.

We have two selfish reasons for this procedure. The process of baptism by total immersion produces a better engineer quicker, and we don't want to waste time any more than our engineers do. Second, we have to do a better job of anticipating the impact of technological change. I believe the assessment process has to start with the man in the laboratory or at the plant. He gets the early feedback — long before we could get it from a "think tank"; so the faster we can broaden a man's judgment and sensitivity to the implications of his work, the less our chances of stumbling into trouble with the side effects of technology.

Finally, you can't adjust to a climate of uncertainty unless you have opportunities to keep on learning throughout your career. There is no doubt that most engineers understand this. They are telling us loud and clear that they want to keep on growing on the job, and that they will take advantage of opportunities for continuing education. Our Engineering Department has a completely voluntary series of in-house courses. In just two years of operations, three out of every five technical employees in that department have participated.

Our job in industry is to keep this kind of professional enthusiasm alive, and with your help we will.