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THE CHEMICAL ENGINEERING CURRICULUM

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If it is to be completely meaningful, an analysis of chemical engineering curricula should properly start with a consideration of the objective sought, and only then examine the means by which the objective is achieved. A suitable objective for chemical engineering education is suggested by the AIChE's official definition of chemical engineering as the profession which is concerned with processes and equipment in which material is treated to effect a change in state, energy content, or composition.

It follows that the chemical engineering student must learn the pertinent characteristics of "change" if he is to be successful in terms of this definition. These characteristics might be broken down as follows:

1) What changes. Here we are concerned with the states and properties of systems, thermodynamically speaking. This area of subject matter is generally covered in physical chemistry or in a first course in chemical engineering.

2) How much changes. The first law of thermodynamics is pertinent at this point, but most schools teach this aspect of change in a course devoted to materials and energy balances or stoichiometry. Three credit hours are devoted to this topic in the average curriculum.

3) Which way and (4) how far will the change go. These two considerations are associated with second law thermodynamics and the concept of equilibrium. On the average, approximately 5 credit hours are allocated to the subject of thermodynamics, but it should be noted that some of this time is used to review first law principles.

5) How fast the change occurs. The rate concept is commonly treated within the unit operations area or, in the case of chemical processes, in a separate course in kinetics. Since the average curriculum devotes only one credit to reaction kinetics, it must be presumed that most of the instruction pertaining to the rate concept comes as part of the unit operations sequence.

The foregoing might be referred to as the theoretical aspects of change. It remains to make practical application of these aspects in seeking answers to the following:

6) How the change can be effected. The study of the unit operations provides needed background in this area, and the survey showed an average of eight credit hours to be devoted to unit operations theory and an additional four hours to be devoted to laboratory work. It should perhaps be noted that no attempt was made to determine the extent to which the transport phenomena approach is being used.

7) How to measure and control the rate and extent of change. Only one credit hour is allocated to process instrumentation in the average curriculum, but it is certain that this topic is also treated as part of the unit operations sequence at many schools.

8) Finally, how much does it cost. This brings us to the economic question as it applies to design. Engineering economics is presumably taught as an integral part of the design sequence at most schools, since only 23 per cent report a separate course in this area. On the average, four credit hours are devoted to chemical engineering design.

In passing, it can be noted that the average curriculum contains seven credit hours of instruction which do not clearly fall into any of the above categories. For the most part these credits pertain to courses in technology or unit processes, and to research projects or electives.

The unit operations, being concerned with the application of knowledge, skill and judgment to the design of equipment which will be practical, safe, and economical, have long been considered to be the strong point of chemical engineering. Generally speaking, either of two approaches may be used: One may write the pertinent differential rate equation and integrate it to relate equipment size or processing time to the change to be accomplished; or, one may use the equilibrium stage approach.

Neither of these design methods is particularly difficult to comprehend, and it is somewhat surprising that they do not receive at least introductory attention earlier in the curriculum. The basic aspects of equilibrium stage calculations, for example, are rather straightforward extensions of mass and energy balance applications. Why should such calculations not be introduced when the latter topics are treated at the sophomore level?

An even stronger case might be made for introducing the generalized rate concept early in the curriculum. Certainly it is at least as important as the balance concept, and a preliminary exposure to the idea of driving forces should be an ideal preparation for the subsequent consideration of equilibrium in thermodynamics. Furthermore, the general relationship among rate, driving force, and resistance can be readily grasped at the sophomore level.

With such an introduction, instruction in the unit operations could be largely devoted to a consideration of the various rate coefficients and the environmental factors which affect them. The importance of economic factors and sound engineering judgment would also receive emphasis.

The foregoing comments are not presented so much as a recommendation -- although the author's personal experience has shown such an approach to be highly effective -- as they are to stimulate thought with respect to curriculum planning and the optimum arrangement of subject matter within the curriculum. Note that the sessions planned for the present meeting will be concerned with only approximately one-third of the total curriculum -- and only one seventh if we disregard the half-day session on chemistry.

This is as it should be for a meeting which is subject-matter oriented rather than concerned with teaching methods and curriculum planning. Yet <u>someone</u> must plan curricula, and new ideas and fresh approaches in this area are <u>no less</u> important than are new areas of subject matter within the curriculum.

The results of the survey here presented would appear to suggest that there has been little change in the chemical engineering curriculum in the past five years. We all know that this is not the case, for there have been significant changes <u>within</u> a relatively stable curricular framework. The lamentable fact is that such changes are all too frequently not reported to groups such as this so that they can be tried elsewhere, perhaps adopted, and, most important, perhaps built upon to achieve even more satisfactory results.

Such is the responsibility with which I wish to charge you in conclusion; Let us continually <u>analyze</u> our curricula, course content, arrangement of subject matter, etc., <u>in terms</u> of what we are trying to accomplish, how we are going about it, and how effective our efforts are. Let us <u>experiment</u> to identify new and more effective ways of achieving our objective. And, finally, let us <u>report</u> the results of both our analyses and our experiments.

A SURVEY OF CHEMICAL ENGINEERING CURRICULA
IN 1961-1962

Report of the AIChE's Committee on Undergraduate Curricula, a sub-committee of both the Education Projects Committee and the Program Committee, presented before the ASEE Chemical Engineering Summer School in Boulder, Colorado, August, 1962.

Introduction

This report presents the results of a survey of the general content of 92 accredited undergraduate chemical engineering curricula for the academic year 1961-62. Included in the report for purposes of comparison are the results of a similar survey of 81 curricula of 1956-57, prepared by Dr. A. X. Schmidt of the City University of New York and presented at the AIChE's Golden Jubilee Symposium on Chemical Engineering Education in Philadelphia in June, 1958. [1]

Source and Interpretation of Data

Each member of the Committee on Undergraduate Curricula gathered data from approximately six schools and submitted a tabulation for final compilation. For the most part the pertinent information was taken directly from school bulletins and catalogs. To facilitate comparison with the earlier survey made by Dr. Schmidt, each curriculum was broken down into the same subject matter categories as were used in that survey. In some cases this made it necessary to apportion a given course among two or more categories, with the course description serving as a guide for such apportionment. Doubtful cases were resolved by consulting the department concerned.

The extent of the instruction given in each category was expressed as a number of semester credit hours, one semester credit hour being equivalent to approximately three hours of a student's time each week for fifteen weeks, this time to include outside preparation as well as time in class or laboratory. The quarter credit hours reported by some schools were converted to an equivalent number of semester credit hours as here defined.

The reported results pertain only to accredited four-year curricula. Curricula which required one or more summer sessions in addition to four academic years have been included in the summary, but those involving five full years of study have not. Those curricula which require a cooperative work program have been included to the extent that the academic requirements of such curricula are generally equivalent to a four-year program.

Results

The results of the survey are presented in the appended Table 1 together with the comparable figures for 1956-57. Column and category headings should be largely self-explanatory with the following exceptions:

a) The numbers appearing at the left margin coincide with those used in the 1956-57 survey and are included to facilitate a detailed comparison should anyone wish to refer directly to Dr. Schmidt's report.

b) Gross credits (line 6) refers to the total requirement for graduation. However, many schools offer physical education, military studies, review mathematics, orientation, etc., on a non-credit basis. Credits assigned to such courses (lines 20 and 23) and to religious training courses at sectarian schools (part of line 14) have therefore been deducted from the gross credits to arrive at the net credits reported on line 7.

c) Materials instruction (lines 54-58) has been broken down into two categories. Category A includes courses which are oriented toward solid state physics, whereas Category B courses are more concerned with engineering applications.

Observations

Although the figures presented in Table 1 tell their own story, there are several aspects of the comparison which deserve specific comment. A somewhat clearer picture is afforded by the rounded figures and percentages given in Table 2, which compares the "average" curriculum in 1961-62 with that in 1965-57.

It can be seen from Table 2 that
1) over the five-year period there has been a slight decrease in the emphasis given communications skills, despite industry's continued appeal for engineering graduates with more proficiency in writing and speaking.

2) the emphasis given the humanistic-social studies area has increased significantly; but the average, including communications skills, is still below the 20 per cent figure suggested in 1955 by the Committee on Evaluation of Engineering Education of the ASEE. [2] It is perhaps worth noting that approximately one-third of the curricula do provide 27 or more credits in the non-technical area, however.

3) the mathematics requirement has been increased by two credits. Courses in differential equations and higher mathematics account for almost all of this increase. (Note that Table 1 shows fewer schools now giving credit for introductory and review mathematics.)

4) the chemistry content of the average curriculum is down two credits. It is interesting to note from Table 1 that this is the result of an across-the-board cutback rather than of cuts in a particular area such as analytical chemistry.

5) the physics content of the curriculum is apparently unchanged. However, Table 1 shows a significant change within this general category, with 38 per cent of the schools now offering instruction in modern physics as opposed to only 9 per cent in 1956-57.

6) there has been a slight decrease in the credits allocated to graphics and mechanics. Attention is also called to the fact that only 55 per cent of the curricula now contain a course in materials (see Table 1).

7) the chemical engineering portion of the average curriculum is essentially unchanged. However, Table 1 shows some internal shifts in emphasis, particularly insofar as the number of schools offering instruction in kinetics is concerned.

8) approximately 57 per cent of the average curriculum of 1961-62 is devoted to basic science and non-technical subjects, whereas only 24 per cent of the curriculum is devoted to specialization within the field of chemical engineering. These figures lend considerable support to the popular claim that the average undergraduate chemical engineer receives a broad education.

Summary

The comparison of undergraduate chemical engineering curricula in 1961-62 with those in 1956-57 shows some changes which may be indicative of trends: Non-technical subjects, higher mathematics, modern physics, and chemical kinetics are receiving slightly greater emphasis, while the attention given chemistry and graphics, for example, has been slightly reduced. For the most part, however the figures do not show any great change over the five-year period.

This is not to suggest that significant changes have not in fact taken place. The objective and nature of the survey was such that changes within various curricula were not identified. Thus such developments as the transport properties approach to the unit operations, instruction in digital and analog computation, and calculus at the freshman level were ignored in this survey. The implication that a further study which would be concerned with changes within curricula might be informative.

It may also be that the breakdown developed by Dr. Schmidt in his earlier survey has out-lived its usefulness. New categories -- such as digital and analog computation, for example -- should almost certainly be added if another survey is made some years hence. The fact that some recent curricular changes provide for elective options and degree requirements which are somewhat "elastic" is another problem which is likely to be faced.

In conclusion, it is sincerely hoped that neither the average curriculum nor the ranges of credit hours reported herein will be looked upon as a performance standard. Carefully planned change and experimentation with the curriculum is essential if stagnation is to be avoided. If this survey provides a basis for a critical evaluation of one's own curriculum it has served its purpose.

LITERATURE CITED

1. A. X. Schmidt, "What Is the Current B.Ch.E. Curriculum," Jnl. of Eng. Educ., 50. NO. 1, October, 1959.

2. "Report on Evaluation of Engineering Education," Amer. Soc. for Engrg. Educ., June 15, 1955.

TABLE 2

Comparison of "Average" Curricula

Category	1956-57 Credits		1956-57 Per Cent*		1961-62 Credits		1961-62 Per Cent*	
Communication Skills	8		6		7		5	
Humanistic-Social	13		9		17		12	
Total non-technical		21		15		24		17
Mathematics	13		9		15		11	
Chemistry	31		23		29		21	
Physics	11		8		11		8	
Total Basic science		55		40		55		40
Mech, Mech of Matls	7		5		6		4	
Electrical Engrg	5		4		5		4	
Materials	2		1		2		1	
Total engrg science		14		10		13		9
Process Principles	9		7		9		6	
Unit Operations	12		9		12		9	
Other Chem Engrg	12		9		12		9	
Total Chem Engrg		33		25		33		24
Graphics	5		4		4		3	
Economics, Bus Ad	3		2		3		2	
Technical Electives	4		3		5		4	
Other	2		1		1		1	
Sub-total		14		10		13		10
		137		100		138		100

*Percentage of total credits required

TABLE 1

Average American B.Ch.E. Curriculum of 1960-61
Compared with 1956-57

		Range of ECPD Credits		Avg. Number of credits		Percentage of Schools Offering		Avg. Number of Credits When Offered	
		1957	1961	1957	1961	1957	1961	1957	1961
6.	Gross Credits	130-160	125-162	147.0	146.2	--	--	--	--
7.	Net Credits	118-160	123-154	136.9	138.2	--	--	--	--
8.	Non-Technical Subjects								
9.	Written Communication Skills	0-16	0-12	6.5	5.9	98.8	97.8	6.6	6.0
10.	Oral Communication Skills	0-4	0-3.3	1.1	1.0	43.2	45.6	2.4	2.3
11.	Subtotal, Communication Skills	0-16	0-15	7.6	6.9	98.8	97.8	7.7	7.1
12.	Humanities, Required Courses	0-24	0-20	4.0	5.4	63.0	72.7	6.3	7.6
13.	Social Studies, Required Courses	0-14	0-12	3.1	2.7	59.1	55.4	5.9	4.8
14.	Other Required Cultural Courses	0-18	0-27.3	1.3	1.5	22.2	20.7	5.7	7.3
15.	Non-technical Electives	0-24	0-30	6.4	7.6	76.5	82.6	8.3	9.2
16.	Subtotal, Cultural Courses	3-30	5.7 - 30.7	14.7	17.2	100.0	100.0	14.7	17.2
17.	Physical Education, etc.	0-8	0-8	1.8	1.9	50.6	51.6	3.5	3.7
18.	Military Studies	0-12	0-20	3.1	2.9	48.1	49.0	6.5	6.0
19.	Other non-technical	0-4	0-6.7	0.3	0.3	23.5	14.1	1.3	2.0
20.	Subtotal, Phys.Ed., Military, etc.	0-16	0-24	5.2	5.2	84.0	77.2	6.2	6.6
21.	Total, all non-technical subjects	16-43	15-49	27.5	29.6	100.0	100.0	27.5	29.6
22.	Mathematics, Chemistry, and Physics								
23.	Introductory and Review Mathematics	0-10	0-18	4.4	2.6	79.0	53.3	5.6	4.9
24.	Analytic Geometry and Calculus	8-16	6-22	11.6	11.7	100.0	100.0	11.6	11.7
25.	Differential Equations and Other	0-6	0-14	1.3	3.6	44.4	81.5	2.8	4.3
26.	Subtotal, Mathematics	12-22	12-26	17.3	17.9	100.0	100.0	17.3	17.9
27.	General Chemistry	4-10	4-10	8.0	7.8	100.0	100.0	8.0	7.8
28.	Physical Chemistry	6-13	0-13	8.5	8.1	100.0	98.9	8.5	8.2
29.	Organic Chemistry	5-11	3-11	8.5	7.8	100.0	98.9	8.5	7.8
30.	Quantitative Analysis	0-8	0-8	4.2	3.5	98.8	94.6	4.2	3.7
31.	Qualitative Analysis	0-4	0-5	1.3	1.3	44.4	39.2	3.0	3.3
32.	Other Chemistry	0-5	0-14	0.3	0.5	9.9	9.8	3.3	5.5
33.	Subtotal, Chemistry	24-37	21-38	30.8	28.9	100.0	100.0	30.8	28.9
34.	General Physics	8-18	5.3-16	10.8	10.2	100.0	100.0	10.8	10.2
35.	Modern Physics	0-3	0-6	0.2	1.0	8.6	38.0	2.6	2.7
36.	Subtotal, Physics	8-20	5.3-19	11.1	11.3	100.0	100.0	11.1	11.3
37.	Total, Math., Chemistry, Physics	49-68	49-70	59.2	57.9	100.0	100.0	59.2	57.9
38.	Engineering Graphics								
39.	Total Graphics	0-9	0-9	4.7	3.8	97.5	94.6	4.8	4.0
40.	Economics, Business Law, Business Administration and Allied								
41.	Economics, Principles of	0-6	0-7.3	2.2	2.1	55.6	58.7	3.9	3.5
42.	Economics, Engineering	0-6	0-3	0.7	0.5	23.5	22.8	2.8	2.2
43.	Bus. Law, Bus. Admin., etc.	0-6	0-8	0.5	0.3	18.5	8.7	2.9	3.0
44.	Total Eco., Bus. Law, Bus. Admin.	0-11	0-12.5	3.4	2.7	70.4	68.5	4.8	4.1
45.	Mechanics of Solids								
46.	Mechanics	0-7	0-10	3.7	3.9	97.5	97.8	3.8	4.0
47.	Mechanics of Materials	0-5	0-6	3.1	2.5	97.5	80.4	3.2	3.1
48.	Total Mechanics of Solids	2-10	0-10	6.8	6.4	100.0	97.8	6.8	6.6
49.	Elementary Electrical Engineering								
50.	Elementary Electrical Engineering	0-8	0-10	4.7	4.0	98.8	93.5	4.8	4.3
51.	Elementary Electronics	0-3	0-4.5	0.3	0.9	9.9	38.0	2.6	2.5
52.	Electrical Engineering, Total	0-9	0-10	5.0	5.0	100.0	95.7	5.0	5.2
53.	Nature and Properties of Materials A and B								
54.	Physical Metallurgy	0-4	0-6	1.2	0.6	40.7	20.6	2.9	3.1
55.	Other Category A Courses	0-3	0-4	0.1	0.3	5.0	11.9	2.0	2.6
56.	Metallurgy	0-5	0-6	0.4	0.6	12.7	21.7	2.9	3.0
57.	Other Category B Courses	0-5	0-4	0.6	0.3	28.4	11.9	2.1	2.6
58.	Total, Materials	0-8	0-8	2.3	1.9	67.9	55.4	3.4	3.4
59.	Supplementary Sciences and Practices								
60.	Biology and Geology	0-8	0-8	0.2	0.2	4.9	4.3	3.8	4.0
61.	Heat Power	0-6	0-4.7	0.8	0.2	23.5	8.7	3.4	2.3
62.	Shop Practice	0-3	0-2	0.4	0.1	23.5	8.7	1.7	1.3
63.	Other	0-4	0-6	0.4	0.3	13.6	15.2	2.8	2.2
64.	Total, Supplementaries	0-8	0-8	1.8	0.8	45.7	29.3	3.9	2.8
65.	Chemical Engineering								
66.	Material and Energy Balance	0-8	0-8	3.8	3.1	98.8	91.3	3.9	3.3
67.	Thermodynamics	2-10	1-9	4.8	5.0	100.0	100.0	4.8	5.0
68.	Chemical Kinetics	0-5	0-4	0.5	1.2	18.5	53.2	2.5	2.3
69.	Subtotal, Chem. Process Principles	5-17	2.7-17	9.1	9.2	100.0	100.0	9.1	9.2
70.	Unit Operations Theory	4-13	0-16	7.6	8.2	100.0	97.8	7.6	8.4
71.	Unit Operations Laboratory	2-7	0-8	4.1	3.9	100.0	98.9	4.1	4.0
72.	Subtotal, Unit Operations	8-16	0-20	11.7	12.1	100.0	98.9	11.7	12.2
73.	Chemical Engineering Design	0-12	0-8.7	3.7	3.5	90.1	86.9	4.1	4.0
74.	Chemical Technology	0-7	0-7	2.7	1.8	75.3	53.2	3.6	3.3
75.	Investigational Skills	0-12	0-8	2.5	1.5	70.4	50.0	3.5	3.1
76.	Introduction to Chemical Engrg	0-4	0-10	0.8	0.9	38.3	39.1	2.0	2.3
77.	Instrumentation	0-5	0-4	0.7	1.1	32.1	41.3	2.3	2.5
78.	Unit Processes	0-3	0-7.5	0.6	0.7	27.2	23.9	2.2	3.0
79.	Trips	0-3	0-8	0.3	0.3	21.0	17.4	1.5	1.7
80.	Fuels and Lubricants	0-4	0-3	0.3	0.1	13.6	4.3	1.9	1.5
81.	Other	0-8	0-20	0.6	1.7	19.8	42.3	2.9	3.9
82.	Subtotal	5-23	0-25	12.1	11.5	100.0	98.9	12.1	11.6
83.	Total, Chemical Engineering	23-45	20-53	32.9	32.8	100.0	100.0	32.9	32.8
84.	Technical Electives								
85.	Total Technical Electives	0-12	0-24	3.6	5.2	65.4	75.0	5.5	7.0

WHAT DOES DU PONT LOOK FOR IN ITS CHEMICAL ENGINEERS

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While the program implies that I will be "speaking for Du Pont, " I am sure you realize that no one can really "speak-for" an organization on a subject of this sort. In preparing the talk I have had discussions with many people covering a wide range of interests and responsibilities and found no strong disagreement with the points of view expressed here. However, I am sure that had any one of these people prepared the paper, it would differ in many ways. I quickly found that every person polled had a different opinion, in fact, I soon despaired of producing an "opinion" useful to you. Most seemed to feel that the current graduate was not so bad but certainly could be better. There was some thought but little, if any, firm evidence that today's graduate may not be as broadly useful as those of some years ago, though the opposite view was also met. Eventually I came around to asking "What does Du Pont look for in its Chemical Engineers"? It is to this specific question that I will now address myself.

In what follows I will first attempt to give you a brief picture of what Du Pont looks for in its chemical engineers. This will, in effect, attempt to describe a product we want to obtain, and it will be <u>your</u> product I will be talking about. Next I will raise some questions regarding your responsibility for certain important aspects in the education of chemical engineers. Finally, I will make a few suggestions looking toward more emphasis on some of these aspects.

To provide background let us look at Slide 1 which shows, for 1961, the distribution of technically trained people in Du Pont among a number of disciplines.

DISTRIBUTION OF TECHNICALLY TRAINED PEOPLE IN DU PONT-1961

	%
CHEMICAL ENGINEERS	28
CIVIL "	4
ELECTRICAL "	5
INDUSTRIAL "	4
MECHANICAL "	16
OTHER "	4
CHEMISTS "	31
OTHER SCIENCES	8
	100

(TECHNICALLY TRAINED MAKE UP 14% OF ALL EMPLOYEES)

You will note that people trained as chemical engineers make up 28% of all technical employees, while mechanical engineers and chemists are the other major groups. Slide 2 shows the distribution of chemical engineers in a few areas of Du Pont effort.

DISTRIBUTION OF CHEMICAL ENGRS IN SOME AREAS OF DU PONT (1961) AS PERCENT OF TECHNICALLY TRAINED

	%
COMPANY AS A WHOLE	28
TOP ADMINISTRATION	42
GENERAL AND ASSISTANT GENERAL MANAGERS	38
SALES AND SALES DEVELOPMENT	29
CENTRAL ENGINEERING DEPT.	23

I give these figures only to show that the chemical engineer is found in many areas of Du Pont activity, including management. Other areas such as production and research activities were not surveyed but I would not expect the distribution there to depart significantly from the company average. These figures, unfortunately, can no more than hint at the destinies in Du Pont for present graduates. They do suggest, however, that the long-time usefulness of your graduates will depend much more upon their abilities to cope with problems which require integration of people, science, engineering, and economics than upon their abilities, however excellent, to design equipment or plan the technical aspects of a research study. I do not suggest that excellence in chemical engineering design, or a sound basis in thermodynamics or an adequate background in solid state physics, as example, are no longer important. I am suggesting that such excellence is not enough. Indeed, it has little utility until it has been applied. Application is so important that the man who has only a little knowledge but who has learned to employ it effectively can become the most useful; i.e., the best paid, man in the organization. As time goes on such a man develops a wide ranging knowledge because part of his effectiveness depends upon recognizing areas where his knowledge is inadequate and then doing something about it. In other words he grows. We want men who will grow and continue to grow throughout their whole lifetimes, men with insatiable curiosities, men who meet the broad problems of our industry and recognize them for what they are, exciting, challenging, and rewarding.

Remember, now, that our problems involve a combination of people, science, engineering, and economics. This is true whether the area be management, research, sales, product development, or plant design. These problems do not necessarily require the attention of chemical engineers, and there are many cases where people without chemical engineering training have become exceedingly able as solvers of chemical industry problems. Is there any unique value, then, in a chemical engineering education? I believe there is. A chemical engineer entering the chemical industry will usually start with reasonably well defined assignments not too far removed from his classroom experience. He is expected to handle them effectively. It is most important that his initial efforts be successful. Sound training in chemical engineering including as much experience in handling problems as is practical in his schooling are the best preparation he can have. At this point he can have a distinct advantage over, for instance, a man trained in mechanical engineering, but also can be at a disadvantage if the latter has learned much more effectively to employ his knowledge. Assuming equal effectiveness the chemical engineer will start with an advantage and should be able to grow more rapidly provided only that he has as good an aptitude and has received through his living and educational experiences the same sort of incentives to grow. But note that effectiveness in the use of knowledge can more than take the place of specialization.

Perhaps from all this you begin to see some picture of what we want in chemical engineers. First we want men well prepared to handle defined problems -- problems not too far removed from the kind met with at school but problems which may involve many phases of scientific knowledge or experimental approach. "Well prepared" includes undertaking with confidence of success relatively simple scientific or engineering application work in fields foreign to their academic experience. In the end we want men who will grow rapidly till they can handle quickly and effectively not only the multidiscipline problems so common in the chemical industry but also the multiaspect problems -- people, science, engineering, and economics -- which are common to all industry.

How your current product "stacks-up" against these wants I am not prepared to say. Many of the people with whom this paper was discussed are concerned that the current emphasis on "engineering science" will take emphasis away from the application of science. Science is of value to us only as it is applied. The schools have a real responsibility for turning out graduates who are as well prepared as possible to help us solve our immediate technical problems; they have a much larger responsibility, I feel, for turning out people who will grow; people with insatiable curiosity, people with a vision of exciting, challenging and rewarding work ahead.

I suspect this statement of our "wants" while possibly interesting may not be very helpful to you. Let me be more specific. When we employ a chemical engineer (or any person for that matter), we want a man who will solve our problems, a producer, an effective worker. We tend to take for granted the items of his formal education and focus on those aspects that determine whether he can and will use his formal training effectively. Can he write, talk, listen? Does he possess initiative? Curiosity? Confidence? Reliability? We suspect that the effectiveness of chemical engineers in doing our work is more dependent on the experience they have had in using their knowledge than on the knowledge itself. It may be that the problem work required in the "chemical engineering" courses provides "experience" to a greater degree than is found in other engineering disciplines, and that this experience is a factor behind the chemical engineers' reputation for versatility. If so what an opportunity there should be to turn out a much improved strain of chemical engineers simply by ensuring still better experience during school years in the application of knowledge!

Let me be very emphatic concerning problems. I am not confining myself to problems involved in equipment selection design, fabrication or operation. We want men who will also tackle effectively cost analyses, product development, patent prosecution or sales effort -- to name a few areas -- when problems in these areas require their attention; but we do not expect trained experts in all these and other fields. We want people who will employ effectively what they know; and people who expect to acquire new knowledge as their work requires it.

Warren K. Lewis has stated the objective of chemical engineering training in somewhat this manner "to so prepare a man that, when faced by a new and unusual situation whether technical, social, or economic, he will handle it with confidence and effectiveness." If we accept such a statement for our guide, we are led to two questions, (1) "What knowledge and experiences does a man require in order that he will tackle the new and unusual situations of the future with confidence and effectiveness?" and then, (2) "What part should the school play in ensuring that the student acquires both the essential knowledge and experiences"?

No one will disagree that a person must have a reasonable grasp of all cogent factors before he can take competent action; I wonder if it is as self-evident that he must also have some confidence of success before he will take action. Such confidence, for most of us I dare say, comes only as the result of previous successful achievements. If you will grant me this conclusion, we are led to three secondary objectives for chemical engineering education which back up the main objective, these are:

1. To help the student acquire as sound as possible a grasp of the sciences, the humanities, and the engineering disciplines. It is of equal importance to stimulate him to continue his self-education.
2. To provide experience in meeting successfully new and unusual experiences and situations which may require information from many disciplines.
3. To make the student aware that problems in engineering (and in life) seldom have single answers; what we seek is the best answer, even though we may have to settle for less.

Under item (1), the student acquires the basic knowledge that makes it possible for him to handle the practical problems; with this knowledge he can tackle the unusual problem if he will. With the background of experience gained under item (2) the student acquires the confidence he must have before he will tackle the unusual problem. Finally with some experience under item (3) the student becomes aware that most practical problems involve people, science, engineering, and economics. Am I correct in believing that current teaching emphasizes item (1) and almost excludes from active consideration items (2) and (3)? Coming back to item (1) -- here is the field of curricula. What subject matter must the student be exposed to; how can a proper choice be made of the most essential bits from the mass of new and old material? Once chosen there are time-tested teaching methods which, however, tend to rely heavily or entirely on illustrative problems with a single correct answer. Let me return later to the problems of choice of material and of the one correct answer.

What kind of experiences are needed (item 2) to develop confidence leading to action? For this, I suppose, personal success in handling analogous problems is the necessary experience. I recall the first church fund drive in which I participated. This I would have avoided almost by any means but in the situation I could not do so and finally with actual dread I approached the first call. You know what happened, it was a pleasant, not an unpleasant, experience. That one experience opened the door to me for all kinds of personal contacts which I otherwise might have hesitated to make. By the same token, the student who has successfully employed energy and material balances to solve problems ranging from the efficiency of a coal fired boiler plant to the heat of reaction in a fluidized bed converter, should now be confident that the same tools can be usefully employed in any area where there is a transfer of mass and energy. As I have indicated before, experience in this specific area may be back of the chemical engineers' willingness to tackle problems outside the scope of his direct experience. Under item (2), I would suggest that, among other things, a student should meet a few problems where he must supply missing data; others where there is unnecessary information; and still others where the actual problem turns out, after analyzing the information, to be different than that originally stated. Moreover the student should have practice in thinking his way through problems to obtain approximate answers quickly -- to size the problem before spending time to get the exact solution. I feel that ability and initiative in thinking through problems in a quantitative way is of sufficient importance both for developing confidence, for stimulating curiosity, and for increasing effectiveness that no one should be allowed to graduate in chemical engineering without formally demonstrating such ability. Note, however, that facility at mental mathematics is essential. Do you ask for proof that a student has achieved even this facility?

Tom Sherwood, some years ago, published a paper in the ASEE Journal on the subject "Should Engineering Schools Teach Engineering." He was talking about item (3). It seems unlikely, to me, that many of the illustrative problems used in teaching can be of the open ended sort because the staff effort required to handle them would be too great. There should, however, be enough such examples and with the proper emphasis so that the student appreciates he is dealing with problems more nearly like those to be met with in industry. I believe this can be done if the need is recognized and the effort made. I would expect that implementation of items (2) and (3) would not require more courses, but would be handled by the way in which existing courses are taught. Note that AIChE's Chemical Engineering contest problem has at times constituted a step in this direction.

Let me recapitulate what we think we want in chemical engineers.

We in the chemical industry see continual increase in the variety as well as the depth of the problems our chemical engineers must face, with the new and unusual the daily fare for many. We need men who have a sound basing in the sciences and mathematics, a reasonable acquaintance with technology, enough experience in applying their knowledge to problems requiring bits from several disciplines including economics so that they will know it can be done, some acquaintance with the open-ended problem -- the one requiring a "best" answer, a well developed curiosity, -- and the ability to communicate. I have emphasized the importance of "people, science, engineering, and economics." We all work for some one and others work for us. The importance of science, engineering and economics are, no doubt, readily apparent to the student. He cannot, however, possibly understand the importance of people until he has had organizational experience in working for another or in directing others. While nothing can take the place of actual experience, he should be aware of the problem, particularly of the problem of communication, to the extent that he will expect it and look for it. Perhaps you could use every report or examination paper as a specific example of a problem in communications. Individual conferences with student could appraise the students' deficiencies and emphasize communications difficulties.

Now let me conclude with a few thoughts regarding curriculum -- the material largely contained in item (1) of the slide. This may be "old stuff." If so, I apologize in advance. One may organize the material a student will encounter into the categories of:

Tools - mathematics; physical and chemical laws; communication which includes spelling, writing, speaking, listening, languages; etc.

Knowledge - the sciences, technologies -- organized information in general

Information - largely how things are done, mechanical and electrical devices, pipefitting, maching, equipment generally

Experience - knowledge derive from one's own action.

The tools are the student's most basic asset. They are used to manipulate knowledge -- to put it to use. Choice of the tool subjects required is relatively easy and good methods of teaching are available with the single exception of communication which seldom, if ever, is adequately covered.

Knowledge covers an enormous span and here there is real trouble deciding what areas should and can be included. Minimum coverage of important areas should include emphasis on general principles with enough application to specific problems so that the student will be confident that, with a little study, he can handle practical problems. Many important areas cannot be covered even to this extent but contact should be carried to the point that the student will remember he has heard of it, and will carry away the impression that this area too can be mastered by study if need be. In considering the "what to cover" and "how to cover it," the prime consideration should be "what does the student need to establish his confidence that he can find his way around in this field."

Information covers a far wider field than knowledge. Here, I feel, we have much to learn regarding choice of material and teaching methods. For example, there are many physical tools which the student may well need to use in later life but which time is too short for him to experience with his own hands. Orsat analysis, surveying tools and methods, pipefitting, lathe operation, operation of a distilling column, excavating equipment, pile drivers; or information retrieval systems, and computers. Here is needed only some kind of mental index that tells him yes, I saw that, I am sure I can find the information. For example -- when I was a student at M.I.T., all chemical engineers had a year of machine tool lab; today that laboratory does not exist. I feel that both approaches missed the point. One doesnot need a year's lab work on machine tools to convey an understanding of what can be done -- yet no engineers' education can be considered complete without some such understanding. Here a carefully prepared movie series in perhaps three, one-hour periods, could, I believe, give a broadly, useful understanding of the whole field and leave in the student an adequate feeling of confidence that he understand the essential features of the technology. Application of this principle to many existing courses could, I would hope, reduce the amount of effort required and at the same time provide a very much broadened base of information.

As I am sure you are aware most everything I have said could be applied to other engineering disciplines equally well. This would be fine -- it could provide Du Pont with better engineers in every field.

To Summarize:

We look for men, including chemical engineers, who will apply their knowledge effectively to the wide range of unusual, multidiscipline problems that they will be exposed to in the chemical industry; problems that cannot possibly be anticipated during their school years. We want men who will continue to grow in breadth and depth. We want men with insatiable curiosity.

We suspect that confidence in his ability to handle unusual problems, confidence based upon experience in actually handling unusual problems, is necessary before the man can be confident of ultimate success. Without such confidence it is unlikely that effective action will result. The schools have a high degree of responsibility for providing such experience.

We suggest that in choosing what to teach and how to teach it the guiding principle should be "how much need the student know and how much practice must he have to gain a soundly based confidence that, given time, he can master the unusual problem." We would hope, as a result of such an approach, that curricula could be simplified but at the same time be greatly strengthened.

You may probably feel that the suggestions just made are naive and impractical -- perhaps they are. They are offered only in the hope that somehow you can find the ways to give us engineers -- chemical engineers -- who both can and will tackle still more effectively the broad range of unusual, exciting, challenging and rewarding problems which characterize the chemical industry. Such men will have curiosity of a high order and will grow in usefulness to themselves and to industry throughout their lifetimes.

In closing, I would like to leave two different but related questions in your minds. (1) Do you make a real attempt to bring to your students a feeling for their responsibilities as professional men and as citizens? Perhaps personal example would be the best teacher here. How many of your staff take active parts in professional society, civic, or a church work? (2) Are you looking to the secondary schools for long-range help in your own curricula? Is there not a good chance that some share of the time spent by college freshmen could be covered in high school? Are you doing something about it?

THE CHEMICAL ENGINEER AND HIS PLACE IN THE LONG RANGE GOALS OF INDUSTRY

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My topic, "The Chemical Engineer and His Place in the Long Range Goals of Industry", raises many questions. What are industry's goals? Which industries? When? What implications do these goals have for the Chemical Engineer? For his education? These are the questions I should like to discuss with you today.

I believe it is most pertinent to these questions to focus specifically on the period when the students of the sixties will be assuming their highest levels of responsibilities. This will be some 20-25 years from now.

In order to obtain some answers to the questions posed, I believe we would do well to heed the advice of Abraham Lincoln, who said:

> "If we could know first where we are, and whither we are tending, we could then judge what to do and how to do it."

With this advice as a guide, let us look at some data. Many of the figures that I shall present are necessarily estimates. They have been derived from many sources, including studies by Departments of Commerce and Labor plus factors that we have developed over the years.

Let us consider first the growth in Gross National Product (Exhibit 1). The line for the G.N.P. is in terms of fixed (1954) dollars; it reflects the changes in actual goods and services. Since the war, the increase per year has varied from 2.5% for the past 5 years to 3.2% for the past 15 years. There is much attention these days to goals for America that visualize increases in the G.N.P. Optimistically, and I hope realistically, I shall assume an annual increase for the G.N.P. between now and 1985 at least equal to that actually achieved on the average since the end of the war - 3.2%. In order to put the G.N.P. in perspective, the population growth is shown at the bottom of the chart.

Exhibit 2 shows the industries employing Ch.E.'s and the approximate number and percent of Ch.E.'s in each of these industries. The classifications used here are those used in studies by the National Science Foundation, Departments of Labor and Commerce, and others. Chemical Companies are those producing products generally recognized as chemicals or pharmaceuticals. They employ approximately one-half of the Chemical Engineers.

Chemical Process Companies, as used here, are those producing products not generally recognized as either chemicals, pharmaceuticals, or petroleum, but whose technology is based primarily on chemistry - foods, paper, textile manufacturers, detergents, cement, glass, etc. They employ approximately one-eighth of the Chemical Engineers.

Petroleum Companies include exploration as well as refining, and products of coal as well as petroleum. These companies employ about one-fourth of the Chemical Engineers.

Others - metal, electrical, aircraft, etc. - employ about one-eighth of the Chemical Engineers.

Exhibit 3 shows the growth of these industries which I shall call Chemical Engineering Industries. The figures shown here were calculated from the average sales growths of 8 chemical companies as a group, of 8 chemical process companies as a group, and of 8 petroleum companies as a group. Each group average was then weighted in proportion to the percent of Ch.E.'s it employs; namely, the 50%, 12.5%, and 25% shown in Exhibit 2. All figures were then converted to fixed (1954) dollars. During the past 10 years the annual fixed dollar growth has averaged 3.6% per year. This is 25% greater than the 2.9% growth of the G.N.P. in the same period shown on the preceding slide.

What are the goals for these "Ch.E. Industries" for the next 20-25 years? These, of course, will be influenced by the goal for the G.N.P. The record of the past decade, current activities, and the aggressive managements of the "Ch.E. Industries" make me feel that when one talks goals, he must assume a goal for these industries higher than the goal for the G.N.P. A reasonable 1985 goal would seem to be one at least comparable to the record of the past ten years, namely an annual growth in sales 25% greater than the assumed 3.2% annual growth in G.N.P., or 4.0% for these industries on a fixed dollar basis. Exhibit 4 shows the results of such growth along with the estimated population growth. By 1985, the population will be up 50% from that of 1961. The G.N.P. on a fixed dollar basis will be up twice that. The goals for "Ch.E. Industries" are sales up about one-half again as much as the G.N.P.

Exhibit 5 shows the number of Chemical Engineering college graduates in industry from 1930 through 1961. During the past ten years, the number of Ch.E.'s in industry has increased on the average 5.7% per year.

Exhibit 6 gives a comparison of this growth rate with other growth rates. Population will continue to grow 1.9% per year. G.N.P. fixed dollars, 2.9% past 10 years; 3.2% for 1961-85. Ch.E. Industries Sales, 25% faster than G.N.P. in each period: 3.6% past 10 years; 4.0% for 1961-85. Ch.E.'s in industry: 5.7% past 10 years; what will be the rate of increase 1961-85? The other figures on this chart have implications with respect to the answer to this question. (Exhibit 7) This shows the possible needs and possible supply of Chemical Engineers.

The black lines are two estimates of the number of Ch.E.'s needed if "Ch.E. Industries" are to achieve their 1985 goals. Each of these black lines recognizes that these industries have achieved specific sales with a specific number of Ch.E.'s in 1961. The lower black line - labelled +4% - assumes also that if sales in fixed dollars are to increase 4% per year, a similar 4% increase will be required in the number of Ch.E.'s The upper black line - labelled +6.3% - on the other hand, recognizes the fact shown on the preceding chart that it required a 5.7% annual increase in Ch.E.'s in industry to increase the fixed dollar sales 3.6% (1951-1961) and, therefore, assumes that it will take a 6.3% annual increase in Ch.E.'s to increase sales 4.0% in 1961-85. Many companies have indicated they will need an increase of this magnitude. The overall estimate given by the Chemical Industry to Department of Labor for N.S.F. study of future needs shows that between 1959 and 1970 an average 5.6% increase of engineers would be needed per year.

Now let's look at the gray lines. These are estimates of the number of Ch.E.'s that would be available to industry under three different conditions. Each estimate includes allowances for attrition over the years based on approximations that seem reasonable in view of what has happened generally from 1930 to 1961 and other related information. The lower gray line - marked 100% - assumes also that the same percent of 20-24 year males will obtain B.S. degrees in Ch.E. as in the past 5 years: just under .05%. Under this condition, the "Ch.E. Industries Sales" will be growing faster than the number of Ch.E.'s employed by these industries. Note the 4.0% black line is above the 100% gray line. This is a good trick if it can be done; but it is contrary to the past and indications given by "Ch.E. Industries" managements in personal conversation that I have had, as well as in their estimates for N.S.F. studies that I have mentioned.

To achieve the middle gray line - marked 140% - which in effect duplicates the industry sales increase in fixed dollars of 4% per year, would require a 40% increase by 1970 in the 20-24 year male population graduating as Ch.E.'s and a continuation at that level to 1985. To get this kind of increase, industries, academic institutions, and A.I.Ch.E. must do more than they have done in the past to interest boys in Ch.E. I believe such an increase could be obtained; it will, however, be most difficult. It means 6000 B.S. degrees per year in the early '70's vs about 3000 this year.

To achieve the upper gray line - marked 250% - which in effect duplicates the 6.3% increase per year needed to maintain the same increase in Ch.E.'s relative to the increase in sales as occurred in 1951-1961 would require a 150% increase in the 20-24 year males graduating as Ch.E.'s, or about 11,000 B.S. degrees per year in the early '70's vs 3000 this year. This would be nice, perhaps; but I believe we should face the fact that this <u>is not going to happen</u>.

Ch.E.'s have brought many benefits to industry. Future benefits will be less obvious and will require a more complex technology and better organized effort to achieve. This is the history of all industrial progress. For instance, our basic steel industry which is older than "Ch.E. Industries", at one time used only rich ores, largely surface mined with surface mined coal. Today, this industry is compelled to dig deeper for its ore and coal, and devise methods to process lower grade ores to finished products of higher specifications. So it is and will be with "Ch.E. Industries". Overall, it seems safe to assume, therefore, that the work to be done will increase faster than industries' fixed dollars sales and that the supply of Ch.E.'s <u>will not grow</u> as fast as the work to be done. This is very interesting; it is Parkinson's law in reverse.

Chemical Engineers perform various functions in industry as shown in Exhibit 8. The lines between Adm.-Mgt. and Supervisors-Technologists-Specialists are not sharp and vary company to company up and down from those shown in this exhibit. Also, there are similar overlappings among R&D, Production-Operations-Exploration, and Others. The lines in this exhibit are based on definitions and data in the National Science Foundation report on a 1959 Survey of Scientific and Technical Personnel in American Industry.

The future will bring changes in the job details and some reapportioning among R&D, Production, and Others. Also, there will be a greatly increased work volume in the various functions. In Exhibit 9, the areas of the two charts are proportional to the sales in the two years. The area for 1985 is 2½ times the size of that for 1961. As indicated previously, the actual work volume to be handled may be even greater than this and with a much smaller increase in Ch.E.'s.

Who are the Ch.E.'s that perform these functions in 1961 and who will they be in 1985? This is shown by Exhibit 10.

Absorb this chart slowly, please, one piece at a time. Focus your attention first on the lower 4/5ths of the charts; notice that in 1985 about 90% of the area is light gray, meaning that these functions must be performed by the graduates of 1962-1985. The other 10% will be performed by those shown in black who are all that will be left of those that carried out these functions in 1961. In total, the Chemical Engineers must be able to carry out the functions, regardless of whether the 41%-44%-15% distribution remains as shown here or changes. Further, they must be able to handle the job details not as they are today, but as they will be then. And finally, they must be able to handle the <u>increased volume</u> of responsibilities <u>per man</u>. Effective utilization of new tools such as computers and better project and personnel management techniques will be mandatory.

Now focus your attention on the top of the chart representing the Adm.-Mgt. groups in 1961 and 1985. The 1985 group is made up of about 10% that performed this function in 1961 (shown in black), and about 20% that were in the Supervisor-Technologist-Specialist group in 1961 (shown in dark gray). There are no others from 1961. About 70% of the <u>Adm.-Mgt.</u> group (shown in light gray) must come from graduates of the next 10 years. If these functions in 1965 are carried out badly or inadequately, "Ch.E. Industries" will not achieve their goals and the Ch.E. and the Chemical Engineering profession will have lost an opportunity for stature in our society.

In total, this chart reflects what I believe are the basic problems confronting Ch.E.'s and Ch.E. Education, namely quantity and quality of Ch.E.'s. The problem of quantity is obvious. Can it be solved? So far there has been lethargy or, at best, talk, and even then much of it has been pretty much as you and I are doing now - talking to each other instead of to high school boys and councilors and college freshmen. Industry can offer opportunity, lend encouragement and support; but this is a grass roots problem and needs a direct attack by people close to the grass roots. It seems to me that the Ch.E. faculties are close to those roots; but they need a tool in order to make better contact. I believe the A.I.Ch.E.'s proposed movie might well be such a tool. It warrants support by industry and vigorous use by faculties when available. Perhaps with it and similar positive action we can obtain some of the needed increase in Ch.E.'s.

The problem of quality is not so obvious. It is only when one weighs the implications of each color and each line of this chart that he fully appreciates it. With this appreciation comes realization that although the problem of quantity is a major one, that of quality is at least as great. Can the problem of quality be solved? I believe the answer is yes if the Chemical Engineering graduates, in addition to having achieved specific scores when tested in the subjects included in the Ch.E. curriculum, are truly educated men.

What is an educated man? Many definitions have been given, varying from the cynical by Martin Fischer - "The educated man is one who has had a set of prejudices driven down his throat," to the exalted by Aristotle - "An educated man is to the uneducated as the living is to the dead." Somewhere in between these two, and in a more practical vein, I offer for your consideration the definition, "An educated man is one who is able to contribute his maximum potential to society." -- Let me repeat - "An educated man is one who is able to contribute his maximum potential to society." If we accept this definition, then the educated Ch.E. must have four characteristics.

(1) (Exhibit 11) Knows technique of learning. Although some students are educated on this subject when they enter college, most are not. For all practical purposes, the undergraduate level is the last chance for education in this area. There is a pitfall - namely, that the student get the impression that mastery of methodology is all there is to being educated. I believe that almost everyone in this group knows some of the bitter aftermaths that we have experienced in our primary and secondary school systems, particularly in the math and science areas, as a result of overemphasis of methodology.

(2) Has acquired specific knowledge. The student must learn enough facts to enable him with some additional training to perform his immediate specific assignments. He must, therefore, be taught facts. The trend toward teaching underlying concepts that has followed the Grinter report is an important stride toward covering this area of education for the Chemical Engineer. Here, again, there is a danger. The mere acquisition of facts, as was the fashion among learned men before the Renaissance, can be greatly overdone to the detriment of true education.

The Chemical Engineering faculties have a major responsibility in this area, particularly where broad principles are involved. Industry, too, has a responsibility. It can and must teach the specific facts of its industry. Industry must provide, also, the atmosphere and facilities that will encourage the graduate to keep himself knowledgeable in his field as new engineering and scientific principles evolve.

(3) Can recognize pertinence of acquired knowledge. In former years, when less basic concepts were taught, specific applications were seen easily, and frequently were used to teach the concepts themselves. Now that the concepts are

more basic, their pertinence to specific problems is seen less readily. It is important, therefore, that a special effort be made by the faculties lest the student feel that the objective of Chemical Engineering education is merely the acquisition of knowledge of the broad underlying concepts. He should understand that in addition he must be able to recognize the pertinence of a concept in any situation.

(4) Has the will to achieve. This requires the toughness of mind and spirit to compel the application of knowledge to any condition; and, - if this knowledge is inadequate to control the condition, to acquire whatever knowledge is needed to bring the condition under control. This desire for accomplishment comes from an inner source, inherent in the man himself, his heritage, and his early environment. It is a frame of mind, or a spiritual value, if you will. In youth it is intertwined with and almost inseparable from faith, hope, and expectation. When limited failures and frustrations begin to repeat - and they do - little is left of faith, hope and expectation unless there is this will to achieve. Its importance increases exponentially with time for many years. The faculties have a responsibility in this area. They must find a way to do a better job of screening out before enrollment, or at least in the first year, those who do not have this will to achieve. They must also develop and not bury this will to achieve in those that have it.

Industry has an equal or perhaps greater responsibility because the individual is with industry longer. Industry must not stifle or destroy whatever will-to-achieve there is in the young graduate it employs, and, in addition, must nurture this will to achieve. This, I believe, is possible only when the man is encouraged to grow. This in turn means industry as well as educators must treat the man as an individual, a separate personality in full recognition of his innate personal characteristics. This is easier to say than do, for the pressures today are mostly in the opposite direction. Classification of Chemical Engineers by industry into groups such as Levels I, II, III, etc., for instance, is very attractive. It makes administrative problems simpler, for then the company can make major decisions by considering what to do with just a few classifications rather than what to do with a great number of individuals. Some of this is good and necessary; much of it can be harmful, such as restricting certain types of work to certain classifications.

Society does not move forward by ideas and actions determined by groups. Rather, an individual provides the initial spark or spearheads the action of groups from a mere handful to large numbers. Putting individuals into categories for purposes other than those essential for administration, lessens the identity of each individual, with a resultant loss in his drive, his toughness of mind, and his creativity. Industry must avoid this for with it comes a plodding ponderous inching forward by the group in place of the big step, the finesse step that only the individual can provide.

The establishment of an environment and a modus operandi conducive to the preservation of the identity of the individual and the development of his will to achieve is industry's major responsibility.

In conclusion, I should like to leave you with the thought that the future of the Profession of Chemical Engineering, like that of any Profession, will depend on just one factor - the quality of its individual members. Quality is not a happenstance. It develops from the standards sought and achieved by the educators and by those utilizing the talents of the Profession. My personal opinion is that the Chemical Engineering faculties and "Chemical Engineering Industries" have done a good job but much remains to be done. Let each of us accept this challenge and not shrink from it.

GROSS NATIONAL PRODUCT & POPULATION 1940 - 1985

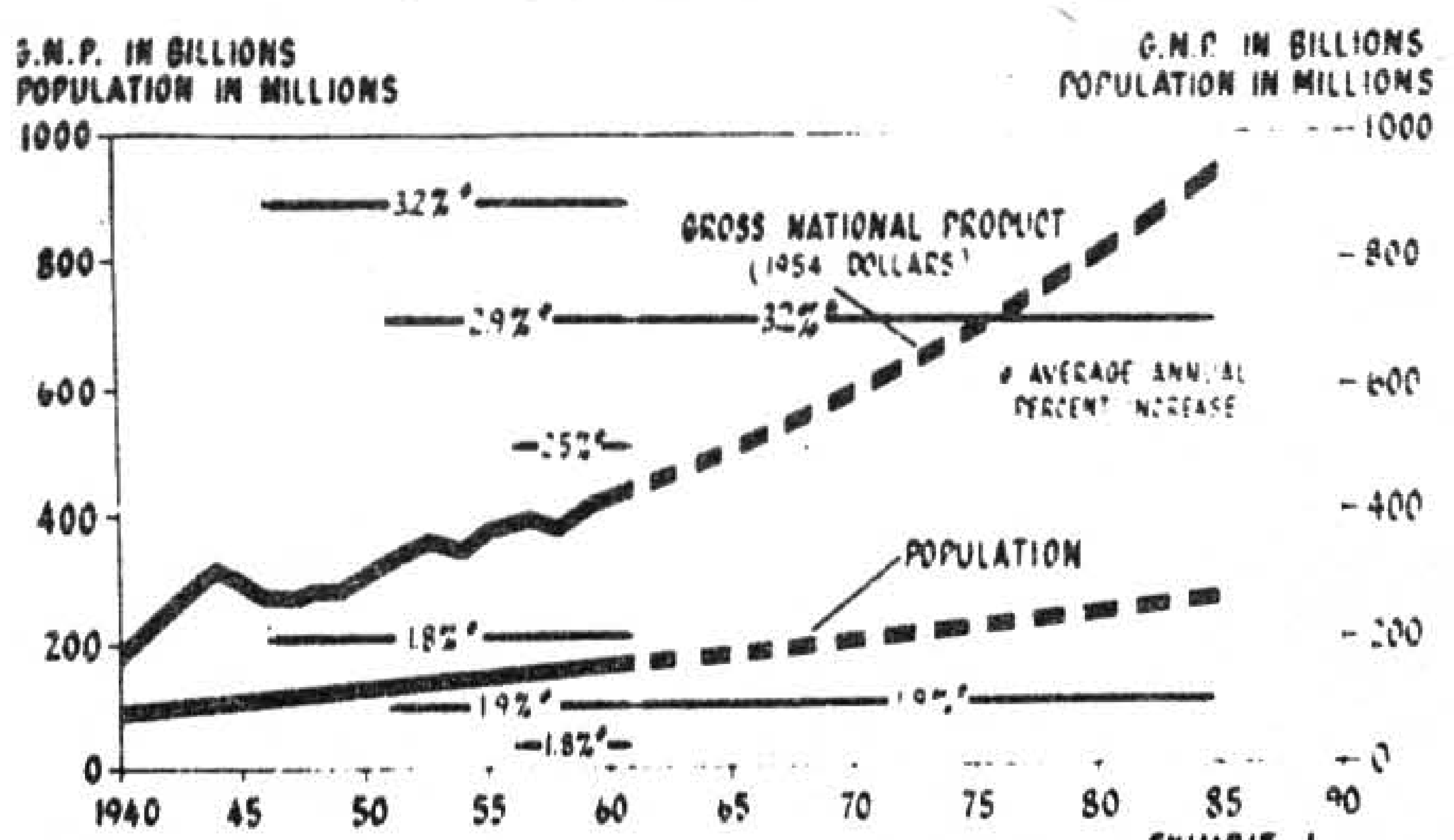

EXHIBIT I

Industries Employing Chemical Engineers - 1961

Industry	Chemical Engineers Number	Chemical Engineers %
Chemical	27,000	50.0%
Chemical Process	6,750	12.5%
Petroleum	13,500	25.0%
Other	6,750	12.5%
Total	54,000	100.0%

EXHIBIT 2

PERCENT GROWTH, 1946-1961

SALES OF INDUSTRIES EMPLOYING ChE's (FIXED 1954 DOLLARS)

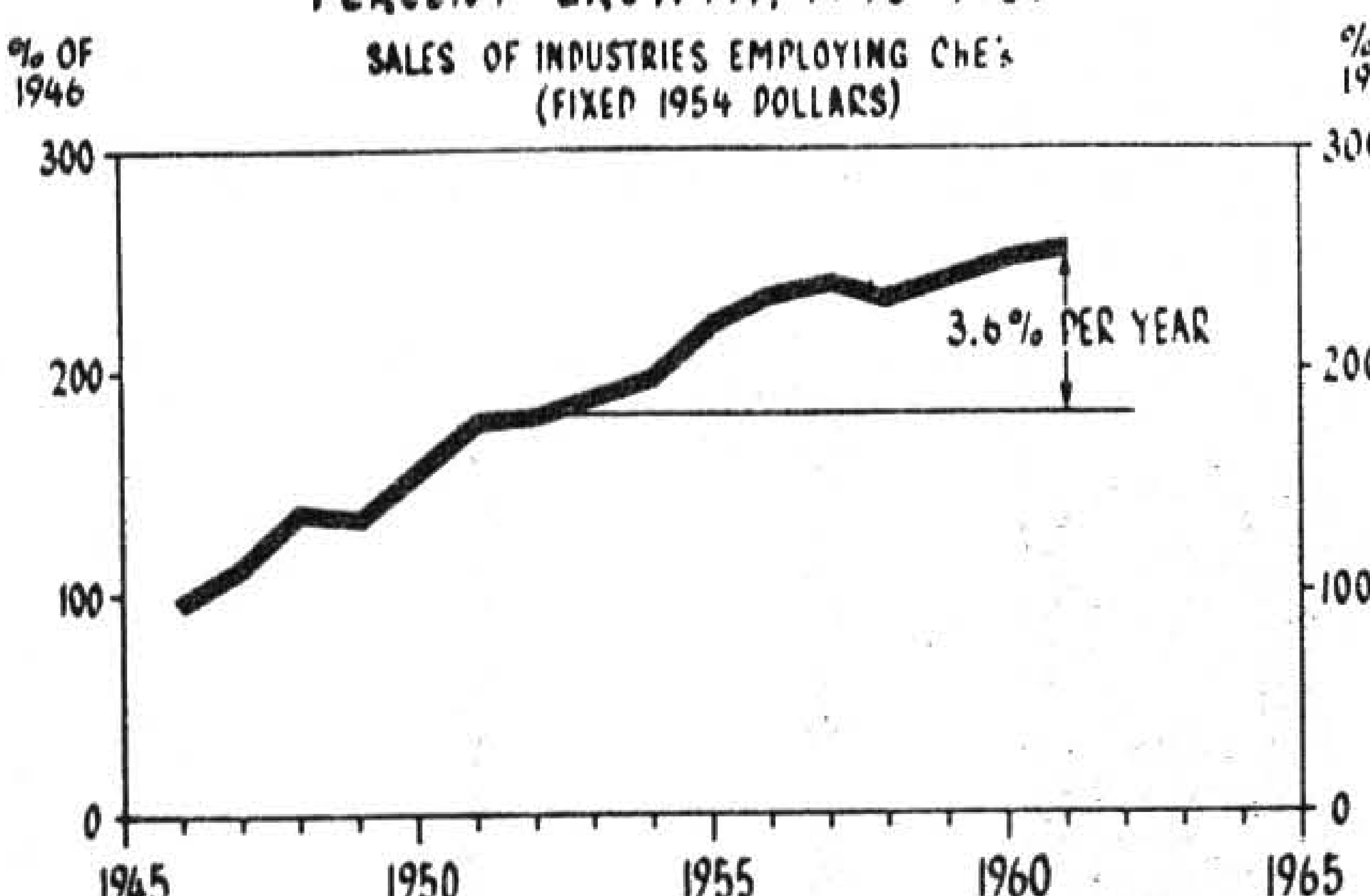

EXHIBIT 3

PERCENT GROWTH 1961-1985

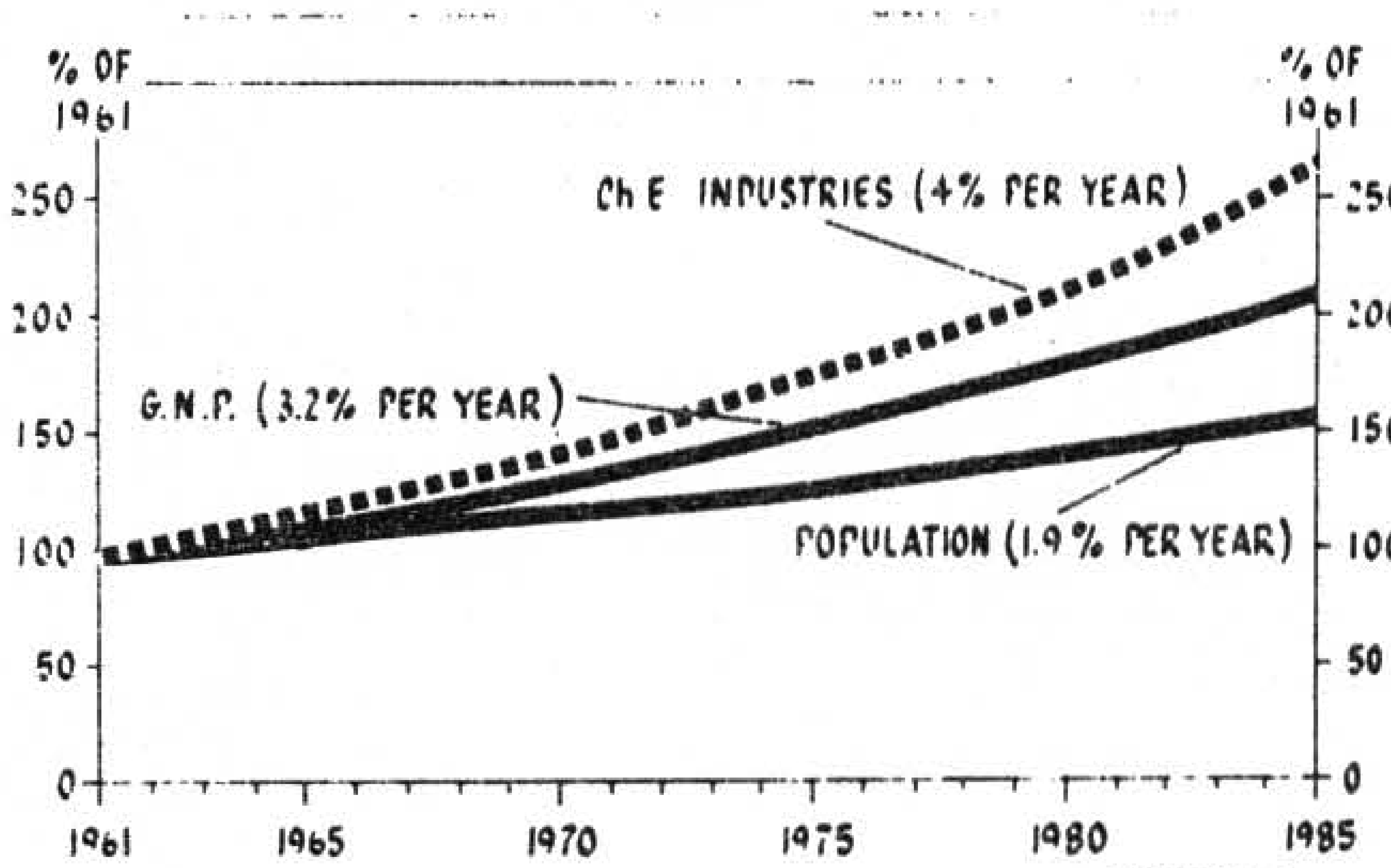

EXHIBIT 4

CHEMICAL ENGINEERS IN INDUSTRY

(COLLEGE GRADUATES)

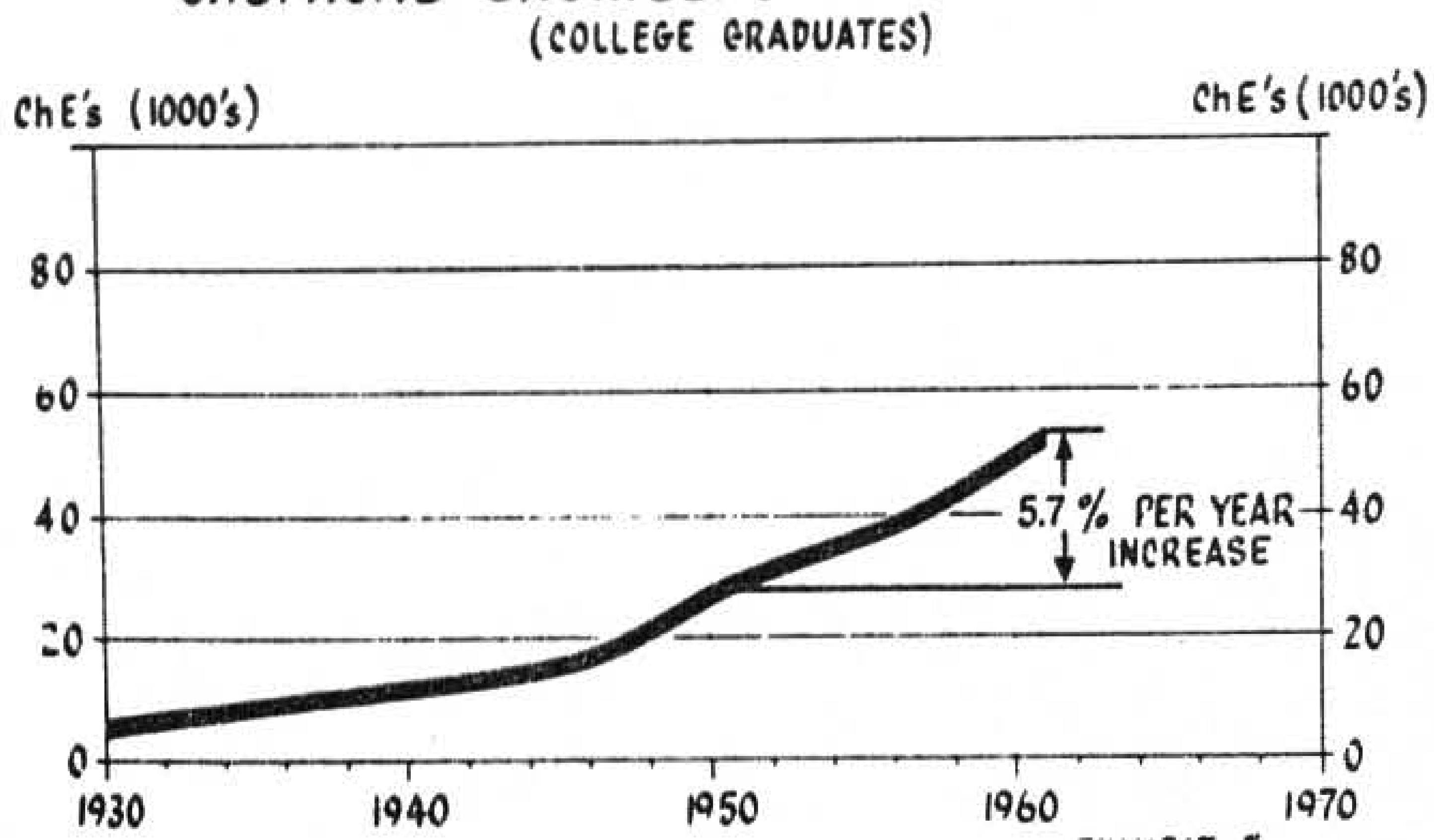

EXHIBIT 5

GROWTH RATES

	Average Annual Per Cent Increase Actual 1951-1961	Goals 1961-1985
Population	1.9%	1.9%
G.N.P. (fixed dollars)	2.9%	3.2%
Ch.E. Industries Sales (fixed dollars) 25% more than G.N.P.	3.6%	4.0%
Ch.E.'s employed in Ch.E. Industries	5.7%	?

EXHIBIT 6

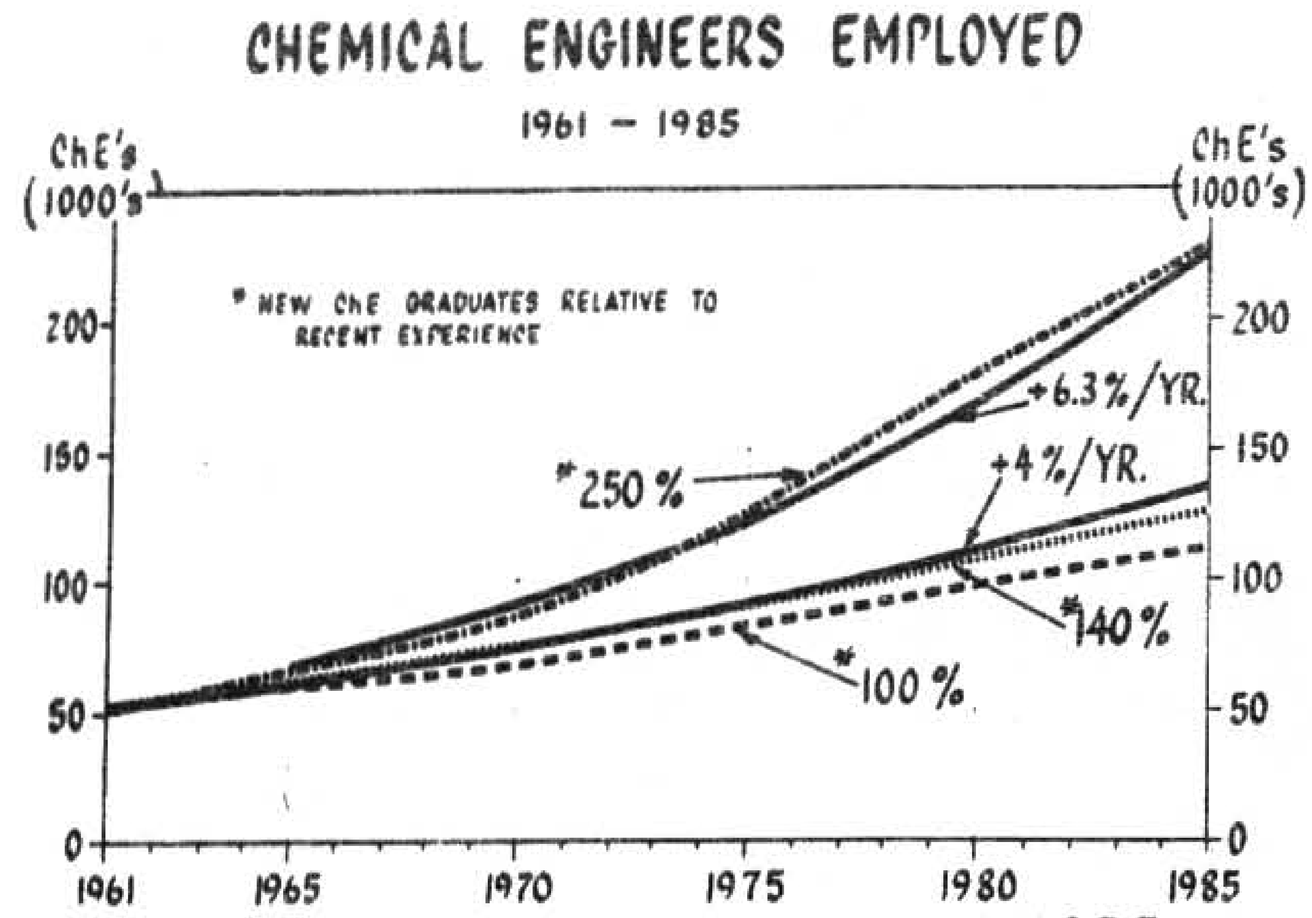

EXHIBIT 7

FUNCTIONS

PERFORMED BY CHEMICAL ENGINEERS

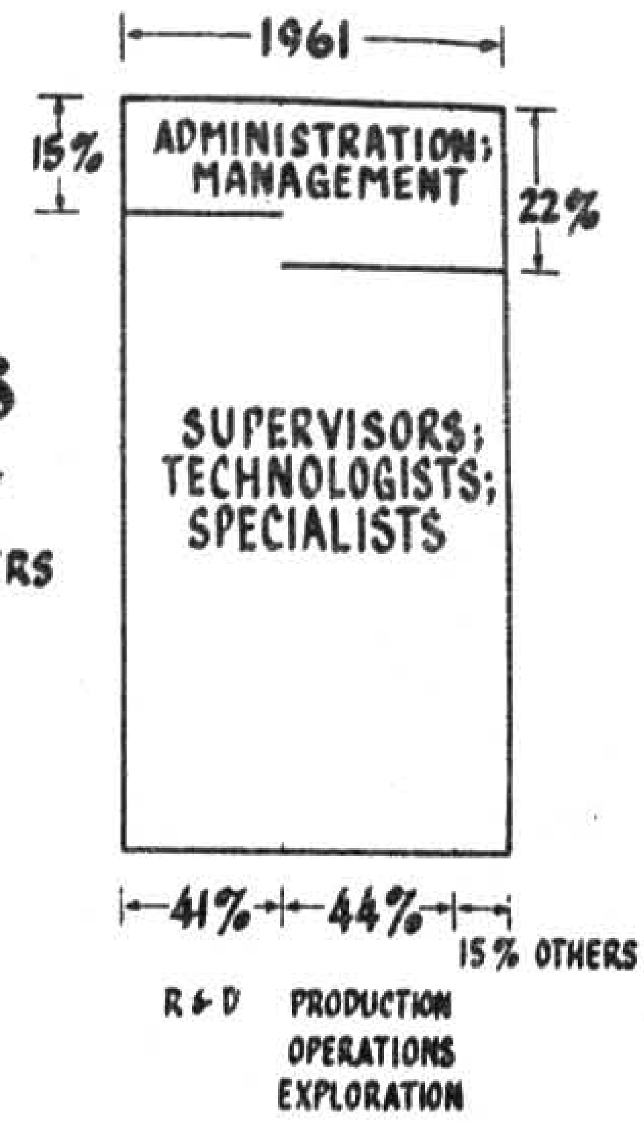

EXHIBIT 8

FUNCTIONS

PERFORMED BY CHEMICAL ENGINEERS

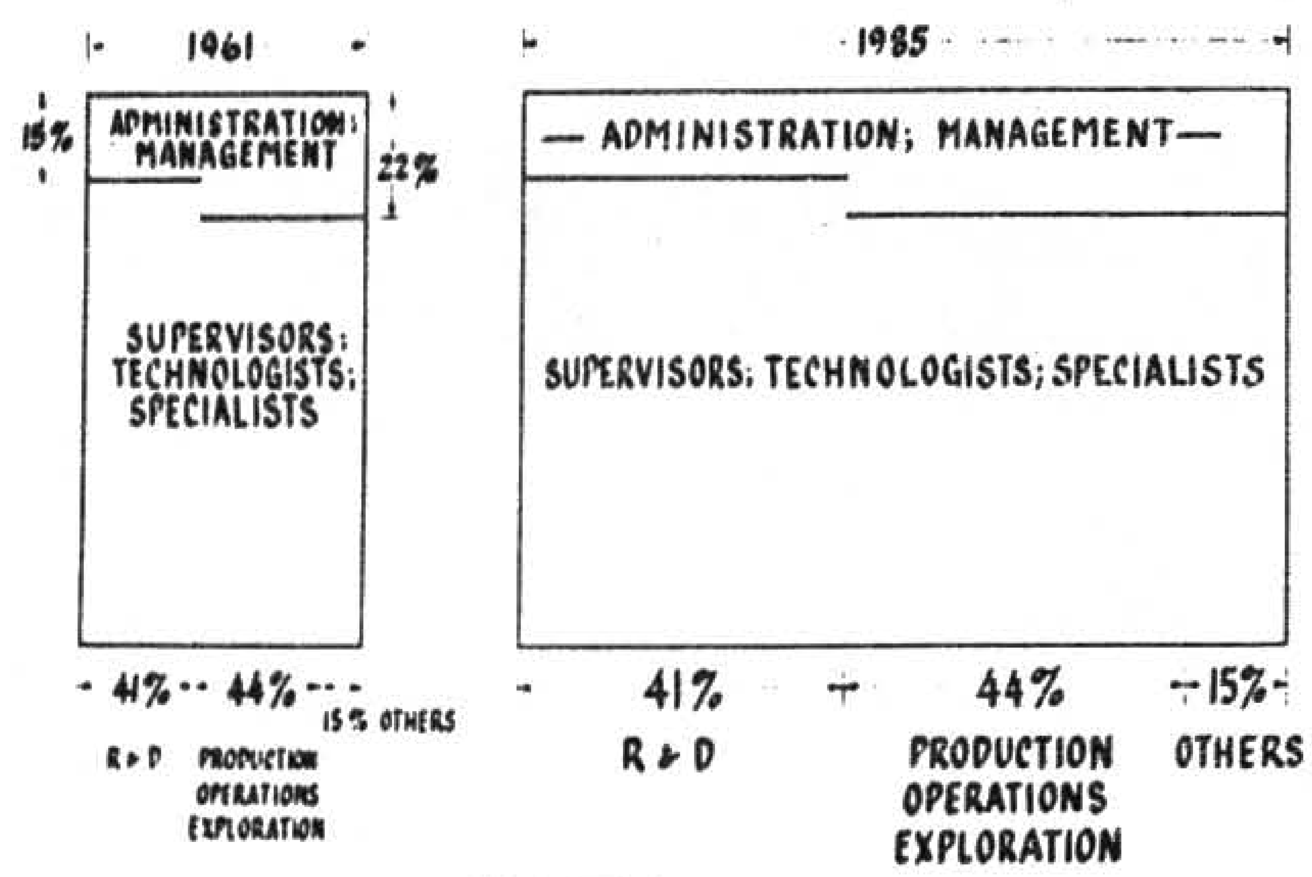

EXHIBIT 9

FUNCTIONS

PERFORMED BY CHEMICAL ENGINEERS

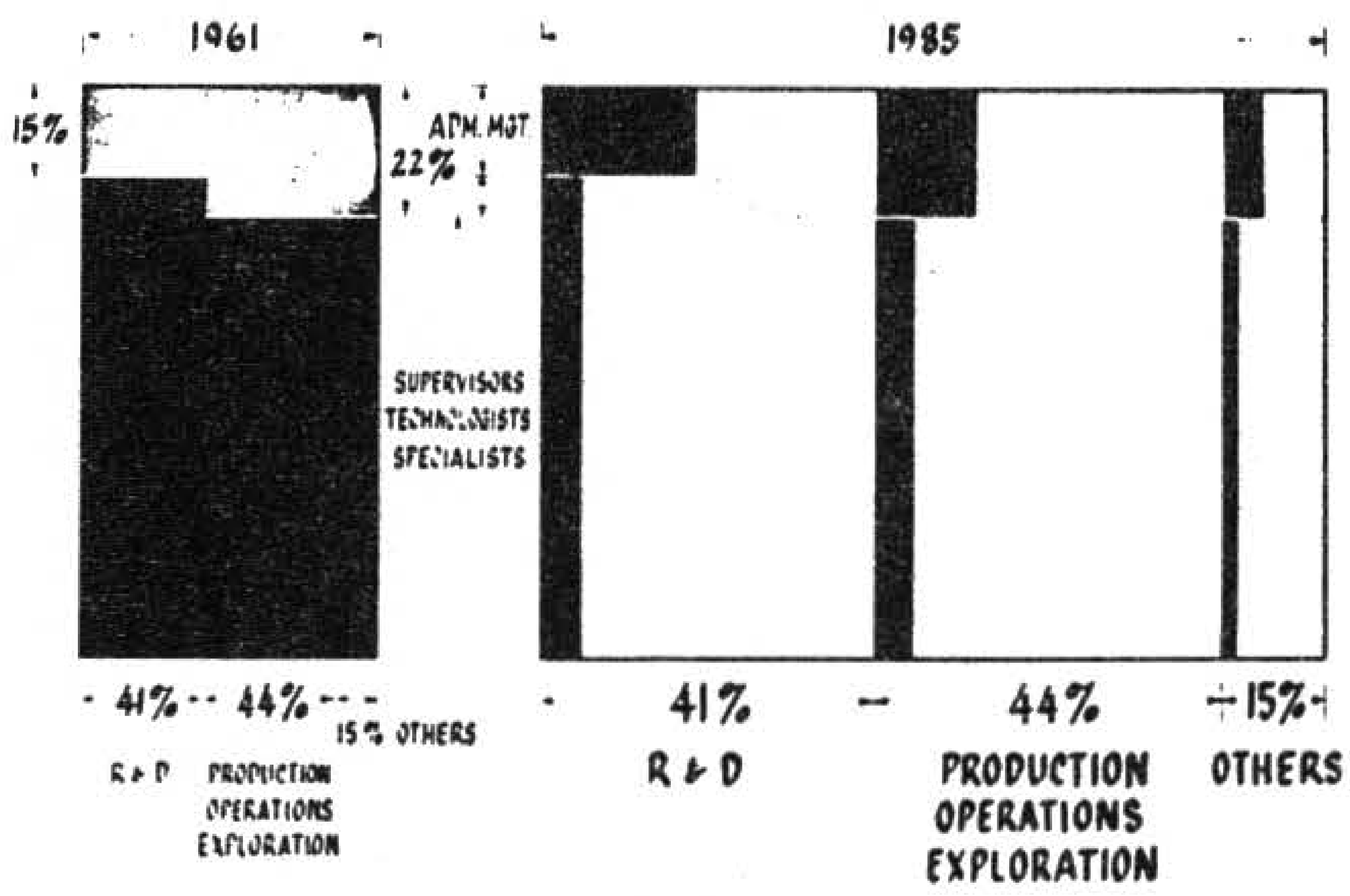

EXHIBIT 10

Chemical Engineer
suitable to the requirements of his profession, he--

1. knows technique of learning;
2. has acquired specific knowledge;
3. can recognize pertinence of acquired knowledge;
4. is eager for accomplishment.

EXHIBIT 11

THE IMPORTANCE OF ATTITUDE IN YOUNG ENGINEERS

by A. L. Frye

Minnesota Mining and Manufacturing Company
St. Paul, Minnesota

I know how Rip Van Winkle felt after being out of touch for 20 years, for like our friend, it has been 20 years since I left the University. Under these circumstances, it would be very impertinent to tell this outstanding audience how the students of today should be taught.

On the other hand, I do not believe it would be out of order for me to report certain observations that my colleagues and I have made on the products of your universities. From these remarks, it is hoped you will find an idea or two for reflection.

Having personally hired several dozen young chemical engineers and having worked with scores of others, one cannot help but classify or develop a pattern of thinking (or perhaps you may add "or get into a rut"). I have noted together with some of my contemporaries that three characteristics are important to becoming a successful engineer in most companies including our own. These characteristics are ability, drive and attitude. Although I will discuss all three characteristics, most of the time will be spent on the latter.

ABILITY

By the term ability, I mean inherent aptitude plus its cultivation (i.e. knowledge gained by experience and knowledge gained by formal training.) These characteristics are absolutely second to none for the most responsible jobs in industry either at the top of the administrative pyramid or at the top of the purely technical pyramid. I won't be-labor a discussion on inherent aptitude, however, since my definition of inherent aptitude would rule out anything being done to improve this characteristic and any deficits will have to be made up with additional cultivation which comes with experience.

Relative to knowledge gained by experience, industry is looked to in this area. The one obvious exception to this is the cooperative plan offered by many universities. No purpose is served by stirring controversy in this area other than to say cooperative schools have their merits and my company participates in a program of at least two major universities. I don't believe anyone could disagree that the cooperative program provides a vision for the young student (let me add, I think the instructor can provide a better balanced one.) Broadly speaking, however, the schools that are in the greatest need for cooperative programs are most likely located in areas where industry is sparse and cooperative programs are more difficult to arrange. (Even though historically, they did not grow up in this manner.)

Relative to formal academic training, I would be considered a coward, unless I gave you at least a thought or two on this subject. While it is recognized that great advances have been made in putting chemical engineering more on a theoretical basis, I believe the concept that was popular 20 years ago that "we simply teach engineers how to think" is not as old fashioned as some may believe. For example, I can recall that some companies years ago would ask young engineers the best way to crush a ton of rock. A good many students would recite the chapter on crushing and grinding in Badger and McCabe or Walker, Lewis and McAdams with unbelieveable accuracy. Often times, however, one of the sharper students would say "Get a sledge hammer if all you want to crush is 1 ton of rock!" Fortunately, trick questions are for the most part taboo in these times. (In jest, if anyone dared ask a young engineer such a question today, he would suggest the crusher be programmed to a high speed computer. He might expect a bonus if he suggested buying time on the "Stretch" computer located at the Lawrence Laboratories.)

The point is simply this: It is as important to keep in mind the overall objective and use good judgment in 1962 as it was in 1932. Slide rules, computers, courses in Astro-Physics are for the engineer to use and to control. He should not let any of these tools control him--not if he wants to be an engineer. More on this later.

DRIVE

From a practical point of view, one is often inclined to brush the factor of drive aside with the comment that you have it or you don't. Of course, we all know that nothing can be further from the truth. You have all seen students or technical people who will respond under a particular type of environment and be completely unresponsive in another set of circumstances. Drive (the word motivation is much better) is a specialty of industry and a responsibility of industry. As an example, I have a Section Head who has the philosophy which runs something like this, "My job is to see that each of my Chemical Engineers has the greatest challenge that he is capable of accepting."

As to suggestion for the academic area to help out, there are two: First: I cannot over-emphasize the value of good counseling. An example of this can best be illustrated by a Chemical Engineering student from a large midwestern university, who was 6 months away from getting his Ph.D. He did not seem to know what he wanted to do and after considerable discussion, he stated what he really wanted to do was to become a minister. He would have made a wonderful minister, but the demand for those with 8 years of Chemical Engineering is not very large! Good counseling can reduce the number of heart-breaking experiences such as this.

Second: I suggest that you watch what motivates your students. Tips to their employer (after jobs have been accepted) could save years in the development of engineers especially for those who have exceptional abilities and are somewhat temperamental as far as motivation is concerned. (I find some of the best graduate engineers are temperamental.)

An example of how tips to an employer can be useful can best be demonstrated as follows: During the Korean War, our Company had the responsibility of starting up a government plant. In a 3-week period I had to hire all of the people for the technical department.

One man interviewed had been discharged from his past job. The past employer readily admitted it was partly his fault and gave an objective analysis of the individual concerned. His past employer stated there was one problem that would have to be improved, namely the ability to get along with others. After a long talk about this problem during the interview and by keeping a watchful eye during the first few months, this man turned out to be the best of six men hired. The main point is that if one can go to work right away on problems instead of taking several months to define them, the odds of a mutually successful employer-employee relationship are greatly improved.

ATTITUDE

Nothing is more important than a good attitude in getting the young engineer off on the right foot on any job and especially his first one. The following six characteristics are examples of a good attitude for the young engineer.

1. A real desire to get a job done.
2. Positive thinking.
3. Eye on the ball--not be overly concerned with the machinery
4. Show more concern for what you can do for the company, than what the company can do for you.
5. Not leave opinion that he is too good to do a given job.
6. Ethics and integrity.

The most important characteristic of a good attitude is a real desire to get a job done. Whereas talking about what one is going to do may buy time, it suffices to say that for the long run it is the results that count. I have seen few performance rating sheets that do not ask for a comment on the results and also a desire to get a given job completed.

Positive thinking is a very strong asset for a young engineer. It is very easy to get in the frame of mind that our job as engineers is to be the watch dog of the scientist and tell him what cannot be done. The only thing that can be worse than this is to have no ideas of our own.

Relative to Item #3, I have to admit that the phrase of keeping the eye on the ball sounds trite. What I'm trying to say is the young engineer should not become overly enamored with any one phase of his engineering training. Kinetics is very useful for scaling up a process, but it is only a tool to get a job done. Although I do not want to get into the controversy over the amount of theoretical and applied mathematics that are given in the Ch.E. curricula, let me say that it is possible to become so involved in solving problems that one loses sight of defining the problem in its broadest terms or for the accuracy of the data used.

A couple points of illustration: Recently a Department Head of Ch.E. of one of the Eastern schools told me that it was very common for his engineers to tell him the thermometer reads such and such a value without seeming to care about the accuracy.

As long as a number was available, it made the manipulation of the mathematics possible. (I might add, I'm sure this professor has now solved this problem since recognizing and defining problems, as we all know, is often as difficult as solving them.)

Relative to the student becoming overly enthralled with computers, one midwestern university with which I am very well acquainted, a few years back started introducing computers in the Sophomore or Junior year in order for the engineer to look at the computer as a very wonderful tool in the way we used to look at our slide rules. I might add, that I notice the students from this university are very well balanced.

I do not mean to imply by this that there is no room for specialization in the field of Chemical Engineering, particularly for those who go on to graduate school, but I believe that the mark of the experienced specialist is the ability to use the field of specialty to the proper degree in solving problems.

Item #4, show more concern for what you can do for your company than what your company can do for you. This statement would have needed no comment even though President Kennedy had not borrowed my comment and made a parallel statement to the nation a year or so ago.

It seems obvious that the young engineer should not leave the opinion that he is too good to do a given job, however, this mistake is made quite often.

I have a friend who tells the story that as the top man of his Chemical Engineering class from a large midwestern university, he was employed by one of the large chemical companies and put in a department along with several top Chemical Engineers who had graduated from neighboring colleges. There was one man in the group who was different.

In the language of today's juvenile crowd, he would have been known as a "queer" as he was the first to volunteer for a job whether it be one that he could make himself look good on or not.

Regardless of how insignificant the job or how difficult, this "eager beaver" would jump at the chance. The rest of the young engineers including my friend were more selective. In the end, however, the fellow who was willing to do any job ended up as President of the Company.

Contrast the attitude of the young engineer in the previous story to that of "I am too good to be supervised by industrially oriented supervisors." Yet, a certain Department Head of a prominent Chemical Engineering college has repeatedly made this statement of his students. We all know this is true, but it only aggravates a situation when this attitude shows up in his students.

Humility is not out of style at the top level of a company and although I'm afraid it is found less often in the lower echelons, nevertheless, I feel it is still in good taste.

The last item, ethics and integrity, in my opinion, can be taught only by example in the classroom. I wouldn't go so far to advocate a complete honor system, but this is one way to help the student build a background to meet temptations when they occur.

No discussion of attitude would be complete without injecting the thought that the young engineer as well as his employer, has a responsibility in his development.

Since the Engineers' Council for Professional Development has made kits available to help guide the young engineer during the early years of his career, I will not elaborate on this point.

I agree with the suggestion that the young engineer as he leaves college should have the pre-graduation kit and know how additional literature on professional development can be procured just in case his employer is not familiar with the good work of the Council. Above all, however, I believe you should make him aware that he has a responsibility for his development.

SUMMARY

In summation, I recognize, as does industry in general, that young engineers are better trained academically than ever before. (I might add that it is fortunate for those of us who graduated 20 to 30 years ago that we do not have to compete with your young students of today.)

I would like to emphasize the value of Counselor guidance to assure as best one can that the time of students, professors and industry are not wasted by those who are not cut out to be Chemical Engineers.

Most important, however, I believe that you more than anyone else, control the attitude of our graduating engineers. I believe there is much room for improvement. Professional orientation, appreciation for economics, and the recognition of the importance of other professions in addition to the items covered previously would at least be a start on the problem. Above all, we should be careful about mimicking the scientist.

If I could leave only one thought with you, it would be this: more emphasis on human relations - call it humanities if you will - not formal courses which are all too often considered a waste of time by the young engineering student--but informal education by example of ethics, integrity and chemical engineering philosophy woven in during the daily classes by their own chemical engineering faculty - with whom they have placed their trust.

WHAT INDUSTRY EXPECTS OF THE CHEMICAL ENGINEER

by Mott Souders

Shell Development Company, Emeryville, California

You have spent a week of concentrated effort on the content of courses in chemical engineering education. As a finale to this strenuous week of looking at the trees, perhaps it is well to take a few minutes to look at the forest.

Much has been said about the diverse occupations of chemical engineers and the wide scope of chemical engineering activities in industry. On the surface, the multiplicity of duties seem to elude classification. They seem to deny any simple statement of what industry expects of the chemical engineer and what should be his education.

The chemical engineer is one who realizes that local temperatures differ from bulk temperatures; that laboratory experiments are neither adiabatic nor isothermal; that a slender pressure vessel is cheaper than a fat one; that the heart of a control system is the primary signal; that mixing is not instantaneous. He knows that the container walls are part of a reaction system; that dq is not a perfect differential; that a major part of the cost of heat is the cost of transfer surface; that all practical materials contain minor and perhaps unknown impurities that can build up in a process or alter the reactivity of a catalyst or surface. He knows that problems of mechanical fabrication require a compromise with requirements of physical chemistry; that designs technically feasible are often unacceptable economically; that actual process plants are subject to leaks, mechanical failures and mis-operation.

The chemical engineer knows these things and many more. He has learned them partly from fundamental courses, but mainly from solving design problems in school and in practice. If he hasn't learned them, he's in trouble no matter how thorough his theoretical science.

Through all of these diverse bits of knowledge there is a thread of continuity, a unifying theme. That theme is process development and design. The career of the chemical engineer is process centered. He may be measuring transport properties, correlating reaction data, doing research on fluid mechanics, operating a pilot plant but always the goal of his team is new or improved processes.

Process design is much more than heat and mass transfer and reaction chemistry, more than a series of black boxes interconnected by heat and material balances the insides of which are the responsibility of some equipment supplier. Processes have become increasingly complex, involving more specialized hardware, more sophisticated control and advanced techniques of optimization. More and more players are on the team and the chemical engineer is the focal point of communication among them. He is required to understand and interpret the data and ideas of the chemist, mechanical engineer, instrument engineer, applied mathematician.

Now, let us look at the forest instead of the trees.

There appear to be two aspects to what industry expects of the chemical engineer. First there are the functions he is expected to perform, and second there are the attitudes he is expected to have.

As to functions, industry expects the chemical engineer to be able to participate in various parts and stages of process development and design. In some situations he is expected to be a specialist in those fields of knowledge that are traditionally identified with chemical engineering. He is also expected to be the generalist who brings to a focus the work of many specialists. The focus is a commercial process that will operate efficiently, safely and economically.

The chemical engineer doesn't have to be an expert in everything. We don't expect him to compete with chemists, mathematicians or electrical engineers. We hire organic chemists to synthesize new compounds, physical chemists to develop new catalysts, electrical engineers to design amplifiers and pulse generators, mechanical engineers to design tube sheets. But we do expect the chemical engineer to be able to talk to all these people, to understand their functions and above all to know how to use their help.

What does this signify for education? It means first of all, that the young man learning to be a chemical engineer must spend a large part of his academic career solving problems related to design, simple ones and specific ones, complex ones, and varied ones. The problems begin in engineering science courses for mechanics, thermodynamics, and transfer fundamentals and continue into courses specifically for design. But first he has to learn the fundamentals of physics, chemistry and mathematics, an array of difficult and demanding courses.

These requirements don't leave much room in the curriculum for courses with such labels as Biochemical Engineering, High-Polymer Technology, Ceramic Processes, and Cryogenic Engineering. What is needed is not a proliferation of novel courses, but rather that his science courses be up-to-date and that his concepts of the nature of the physical world be modern. We in industry can teach him biochemical engineering as applied to the biochemical process we are designing or high-polymer technology as applied to the polymer we are developing, and we can probably do it better than a college course since we are likely to know much more about our process or product than any author of a general text on the subject. But if to make use of a specialized cryogenic engineer we in industry have to teach him the fundamentals of thermodynamics, mass transfer, and fluid mechanics, the situation is hopeless.

We need both scientists and engineers, but we don't expect a scientist when we hire an engineer. The engineer differs from the scientist in interests, motivation, goals and accomplishments. The scientist strives to know, the engineer to produce. Understanding is the goal of the scientist, utilization the goal of the engineer. The accomplishments of the scientist are based on analysis, those of the engineer on synthesis. If the education of the chemical engineer shifts to science, even engineering science, at the sacrifice of the arts of design, industry will use the future "chemical engineer" as a scientist, but will have to look elsewhere for process engineers. Does anyone really expect industry to be happy with two curricula in chemical engineering, one in engineering science for the good students and one in process design for the poor students? Industry must have good process engineers. Some industrialists go so far as to say that quality in process engineers is even more important than quality in applied scientists. In any case to give up design in chemical engineering education is to give up engineering. But an industrial society cannot give up engineering.

It was stated earlier that industry expects the chemical engineer to have developed some well-defined and essential attitudes. In addition to the general attitudes of the professional man industry expects the chemical engineer to have the attitudes characteristic of the engineer. Most important among these engineering attitudes are:

1. Willingness to proceed in the face of incomplete and often contradictory data and inadequate knowledge of the problem.

2. Recognition of the need to develop and use intuitive judgment.

3. Questioning of every bit of data, every method, every result.

4. Recognition of experiment as the ultimate arbiter.

5. Willingness to accept responsibility for the ultimate result.

There is no need, I think, to enlarge on the significance of these attitudes. They are generally acknowledge and have been often discussed.

It is generally agreed that the goal of the engineer is to use knowledge of the physical world for the benefit of mankind. He reaches his goal by designing apparatus, processes, and systems with sufficient precision to permit actual construction. The design problem forecasts action and ultimate physical hardware; operation "in principle" is not enough.

It is characteristic of the design problem that there is no one perfect solution, Usually there are incompatibilities, compromises and alternatives. And the solution finally chosen is profoundly influenced by social values, economics, safety, effect on neighbors (air pollution, etc.). Design usually involves several different disciplines, mechanics, electricity, as well as reaction chemistry, thermodynamics and transport processes, and skill in design is proportional to the designer's ability to focus various disciplines on the immediate problem. This focus is binocular, knowledge of science in one orb and art of application in the other.

"The obvious content of an engineering education is a body of knowledge (from science and experiment) and a set of skills (techniques and experience) useful in solving design problems. But education is much more than this. Students acquire attitudes and habits as well as information and techniques.

"College courses in chemistry, mathematics and physics, in mechanics, thermodynamics and transport processes have a common characteristic; they present to the student a series of single-answer problems. Such problems are those which can be answered with numbers or functional relationships, those which have answers generally agreed upon.

"Examination of the effect on engineering attitudes of single-answer problems reveals:

1. Incomplete or contradictory data have little place in single-answer problems;

2. Engineering judgment is not required of either the student or the instructor;

3. The existence of a standard answer puts the instructor in an impregnable position where skepticism and the challenging attitude are not encouraged. Neither the data, the method, nor the result are open to question.

4. The single-answer problem usually suggests the infallibility of logic rather than the ultimate rule of experiment. The early history of science bears witness to the paralyzing effect of this attitude."*

Would this difficulty be lessened by crowding the curriculum with more specialized courses? Or is it more likely to be resolved by making room for comprehensive problems in design? These are loaded questions, I know. Also I well realize that it is much easier to call attention to problems in education than it is to solve them, especially when there is no pat answer. And I know, too, that you are well aware of this problem and have long been struggling with it. I merely recommend it to you as currently the dominant problem in chemical engineering education, as it has been in the past and probably will be in the future.

* Quoted from "Report on Engineering Design", J. Eng. Education, V. 51, p. 645 (April 1961).

MINUTES OF THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION
CHEMICAL ENGINEERING DIVISION

The Annual Meeting of the Chemical Engineering Division was held on August 21, 1962 at Boulder, Colorado. Seventy-eight members of the Chemical Engineering Division were in attendance.

The meeting was called to order by Chairman Charles Littlejohn, Clemson College. Chairman Littlejohn introduced the Officers for the coming year. These officers are: Dean Max Peters, University of Colorado, Chairman; Professor J. J. Martin, University of Michigan, Chairman-Elect; Professor John B. West, Oklahoma State University, Secretary-Treasurer; Professor M.H. Chetrick, University of Louisville, Council Representitve. Following the introduction of the new officers the meeting was turned over to Chairman Max Peters.

Dean Peters announced the appointment of the nominating committee for the coming year. Members of the nominating committee are: Professor Charles Littlejohn, Chairman; Professor S. W. Churchill, University of Michigan, and Professor Charles R. Wilkie, University of California.

Chairman Peters then announced the appointment of a program committee for the next annual meeting to be held in Philadelphia in June, 1963. Members of the Program Committee are: Professor Robert Beckmann, University of Maryland, Chairman; Professor Robert E. White, Vilinova University; Professor Vincent Uhl, Drexel Institute; Professor J. T. Banchero, University of Notre Dame, and Professor Robert N. Maddox, Oklahoma State University.

The Chairman introduced Professor J. J. Martin, who presented a revision of the Constitution of the Chemical Engineering Division. Professor Martin pointed out that the Constitution had not been revised in a number of years. He discussed, in detail, various revisions of the constitution, and moved the adoption of the revised constitution. The motion was seconded by Professor M. C. Molstad of the University of Tokyo. Professor H. D. Sims , Bucknell University, moved the adoption of an amendment, changing Paragraph 2 of Article VII from "the new officers shall take office following the meeting of the National Society" to "the new officers shall take office 10 days after the close of the annual meeting."

Professor Sims pointed out that this amendment would bring the division constitution into harmony with the constitution of the National Society. The motion was seconded by Professor Baker of the University of South Carolina. After a short discussion, it was approved. The revised constitution was brought to a vote and the motion for adoption passed.

Chairman Peters then pointed out that under the newly adopted constitution the executive committee was increased to six members through the election of two members to the executive committee. He pointed out that Professor Robert Beckmann, University of Maryland, and Professor Lloyd Berg of Montana State College had been serving in the capacity on the executive committee. Professors Beckmann and Berg were elected to the executive committee by acclamation.

Professor Robert Beckmann was introduced and he discussed briefly the program for the Philadelphia meeting. Professor Beckmann suggested the general theme for the meeting be "Graduate Programs in Chemical Engineering." He also stated that it is not necessary that the entire program be devoted to this theme and asked for suggestions from members of the Division.

Professor M. H. Chetrick of the University of Louisville called the attention of the membership to the fact that the official publication of the Chemical Engineering Division is the Journal of Chemical Engineering Education. Professor Albert H. Cooper, the University of Connecticut, Storrs, has been editor of this journal for many years. Professor Chetrick then suggested that the publication policy presented to the Executive Committee be adopted as the publication policy of the Chemical Engineering Division. The proposed policy is: (1) That the Journal of Chemical Engineering Education be the official publication of the Chemical Engineering Division of the American Society of Engineering Education. (2) That the Journal of Chemical Engineering Education be a quarterly starting with the June, 1962, edition. The Journal will appear in March, June, September, and December. (3) That the Chemical Engineering Division of ASEE cooperate with the Education Projects Committee of the American Institute of Chemical Engineers in publishing papers, reports and news of the Projects Committee activities; (4) That the contents of the Journal include papers from the School for Chemical Engineering Teachers, papers from the Annual Meeting of the Society, and other papers submitted to the Editor as individual contributions, news and of trends in Chemical Engineering education and of the programs in Chemical Engineering at the various schools and colleges. (5) The Journal will be distributed free to all of the members of the Chemical Engineering Division and all Chemical Engineering teachers who are members of the AIChE. The 1962-63 issues containing papers presented at the School of Chemical Engineering Teachers will be will be distributed free to all registrants of the School. A subscription price of $2.00 per year will be charged to all others.

It was moved by Professor Chetrick that the policy statement be adopted as the policy of the Chemical Engineering division. The motion was seconded and considerable discussion ensued. In particular, the discussion centered around the suitability of some of the papers from the 1962 Summer School and book reviews as material for the journal. It was generally agreed that it would not be appropriate to publish papers which had appeared elsewhere. Professor Berg stated that it was his understanding that the Chemical Engineering Division was not obligated to the National Science Foundation to publish every paper presented at the School for Chemical Engineering Teachers. Professor Robert Lemlich of the University of Cincinnati stated that he felt the Journal of Chemical Engineering Education and the independent journal of which he is editor, fulfilled complimentary roles and that he hoped both publications would prosper in this role.

On being brought to a vote, the motion adopting the policy statement was passed. Professor Don White, Vice-Chairman of the Chemical Engineers discussed briefly the relationship of the Education Projects Committee to the Chemical Engineering Division of ASEE. He asked the cooperation and participation of members of the Chemical Engineering Division in the activities of the Education Projects Committee of AIChE. He noted the interest of the Education Projects Committee in publishing papers and reports of committee activities in the Journal of Chemical Engineering Education.

Chairman Peters noted that members of the division should begin thinking toward the next Summer School for Chemical Engineering Teachers which will be held in about 7 years. He urged division members whose school would like to host the School for Chemical Engineering Teachers to contact Professor Lloyd Berg.

John B. West
Secretary-Treasurer

CHEMICAL ENGINEERING DIVISION
OF THE
AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Adopted by the Chemical Engineering Division at Minneapolis, June 20, 1947. Revised June 25, 1951 and August 21, 1962.

Article I - Name

The name of this division shall be the Chemical Engineering Division of the American Society for Engineering Education.

Article II - Membership

Membership shall be composed of all members of the American Society for Engineering Education interested in the teaching of chemical engineering subjects.

Article III - Objects

The objects of the Division are those of the National Society as they pertain to chemical engineering education and the promotion of educational intercourse, friendly cooperation, and mutual help among its members.

Article IV - Officers

The officers shall consist of a Chairman, Chairman-elect, Secretary-Treasurer, and a Representative to the National Society, all of whom shall be members of the American Society for Engineering Education. The Chairman-elect shall be elected annually and shall automatically become Chairman the year after his election. The Secretary-Treasurer and the Representative shall be elected bi-annually, the former in the even-numbered years and the latter in the odd-numbered years. Should any officer or member of the Executive Committee be unable to serve, the vacency shall be filled by the Executive Committee until the time of the next election.

Article V - Executive Committee

The affairs of the Division shall be administered by an Executive Committee of seven members; the officers, the immediate past-chairman and two persons elected from the Division membership in alternate years for two-year periods. The Chairman of the Division shall serve as chairman of the Executive Committee.

Article VI - Meetings

There shall be at least one meeting a year open to all persons interested in chemical engineering. The Executive Committee shall arrange the place, the time, and the program for all meetings. Insofar as practicable the required annual meeting shall be held in connection with the annual meeting of the National Society. The secretary of the National Society shall be supplied upon his request with copies of all papers presented at Division meetings. The Secretary-Treasurer shall notify all members at least three weeks in advance of any scheduled meeting. A quorum to conduct business shall consist of 15 members of the Division.

Article VII - Elections

The officers shall be elected by mail ballot. The Nominating Committee shall supply the Secretary-Treasurer with the names of two nominees for each office or Executive Committee position at least 90 days before the annual meeting of the National Society. The Secretary-Treasurer shall mail a ballot to each member of the Division at least 60 days before said date. The returns from the mail ballot shall be mailed to the Secretary not later than 15 days before said date. In case of a tie the Executive Committee shall cast the deciding ballot.

The new officers shall take office ten days after the close of the annual meeting of the National Society.

Article VIII - Committees

The Chairman may appoint committees, and the scope of their work shall be strictly defined at the time of their appointment. The Nominating Committee shall be appointed and its membership announced before the close of the annual meeting.

Article IX - Amendments

This constitution may be amended by two-thirds vote of members responding to a mail ballot. Amendments may be proposed by the Executive Committee or by majority vote of members attending a scheduled meeting of the Division.

Article X - Dues

The dues of the Division shall be determined each year by the Division in session and shall be only for such incidental items as are not supplied by the National Society.