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 is not going to happen.

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 will not grow 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 $2\frac{1}{2}$ 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 increased volume of responsibilities per man. 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 Adm.-Mgt. group (shown in light gray) must come from

graduates of the next 10 years. If these functions in 1985 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 concept[illegible]

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

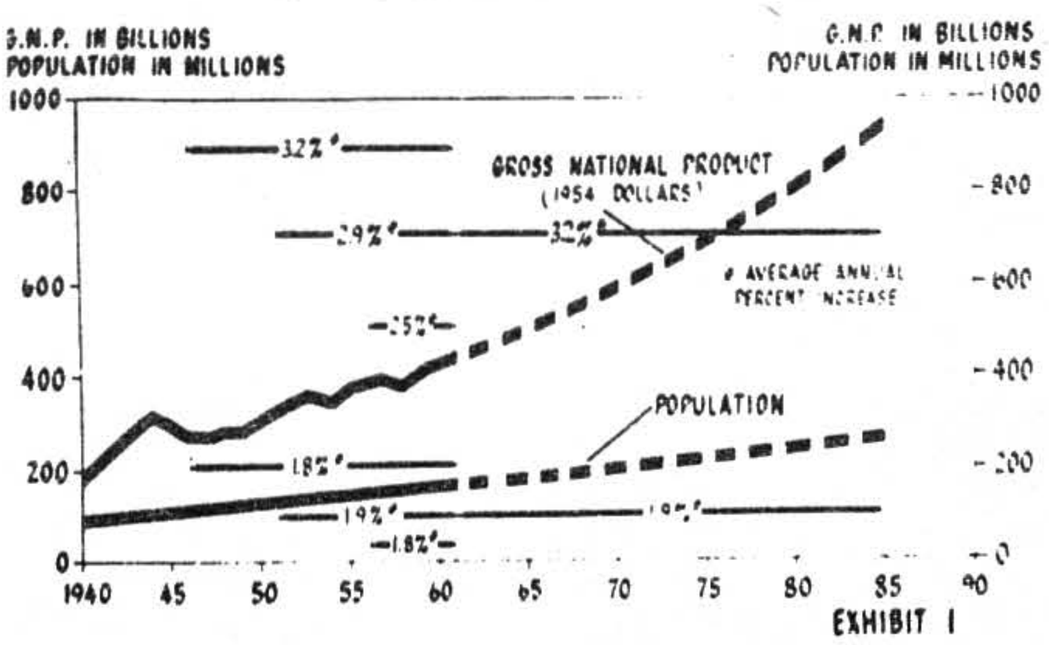


EXHIBIT 1

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

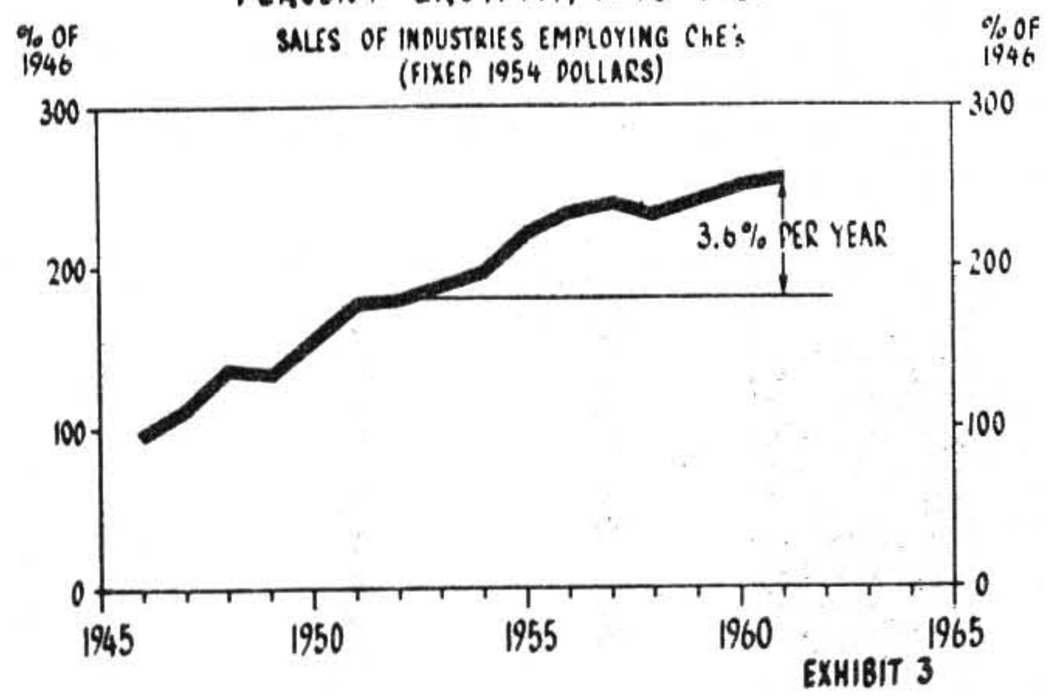


EXHIBIT 3

PERCENT GROWTH 1961-1985

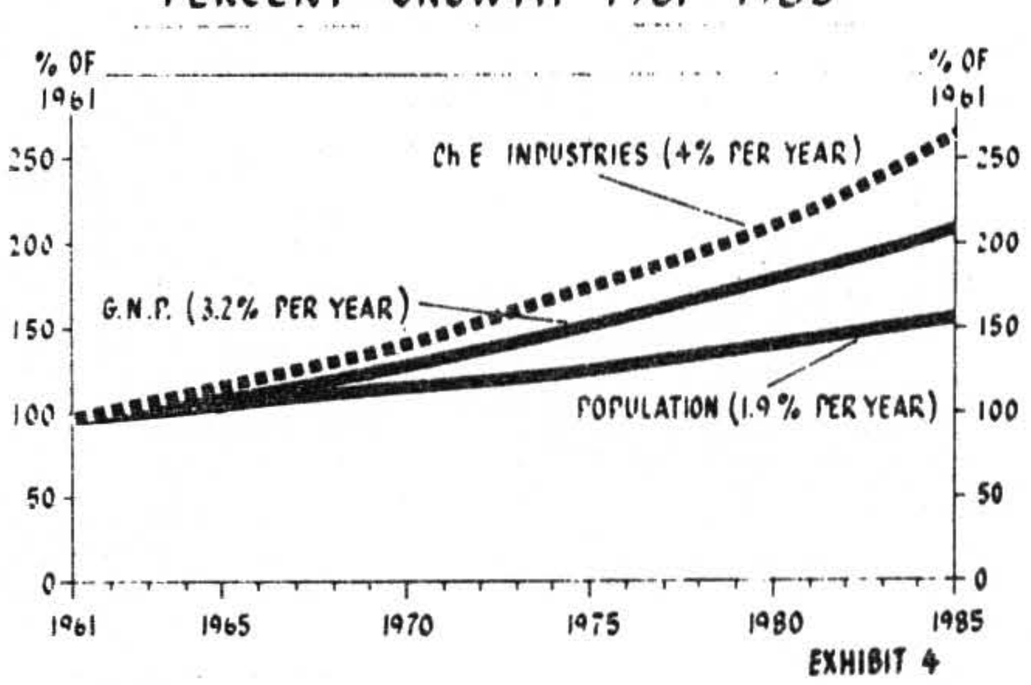


EXHIBIT 4

CHEMICAL ENGINEERS IN INDUSTRY
(COLLEGE GRADUATES)

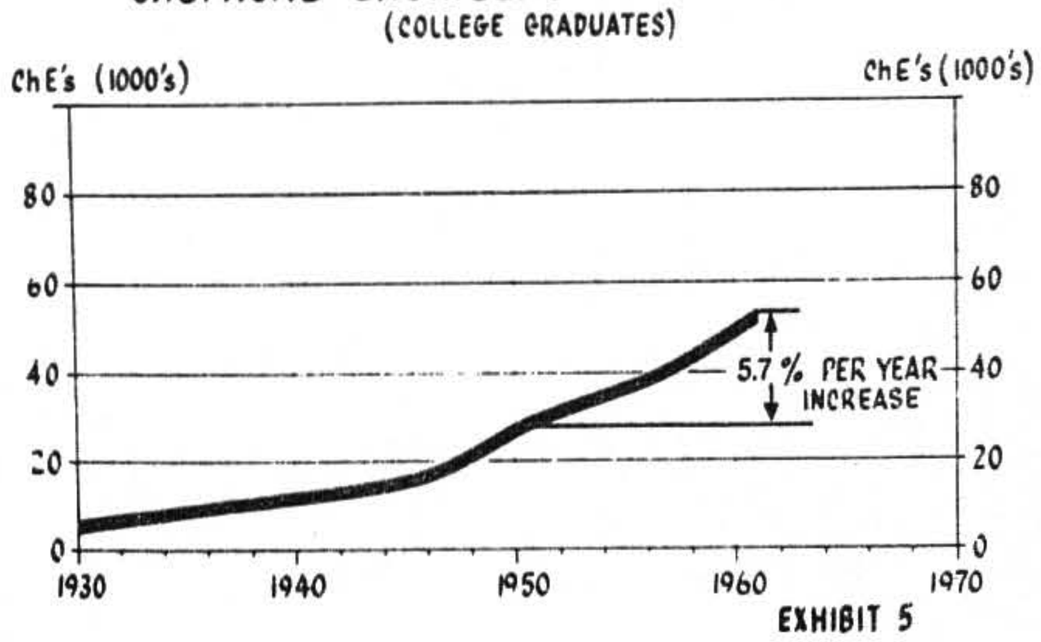
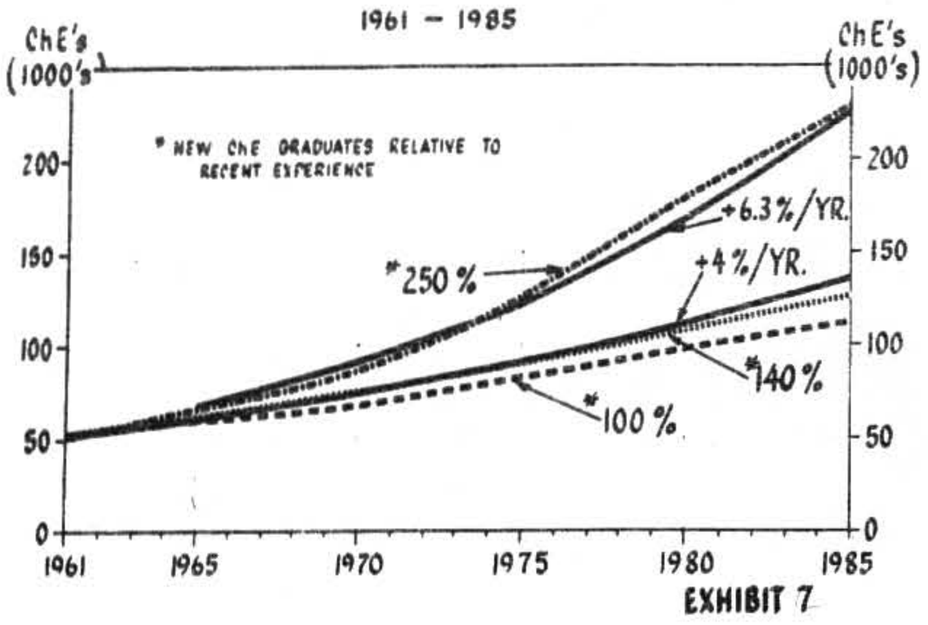


EXHIBIT 5

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



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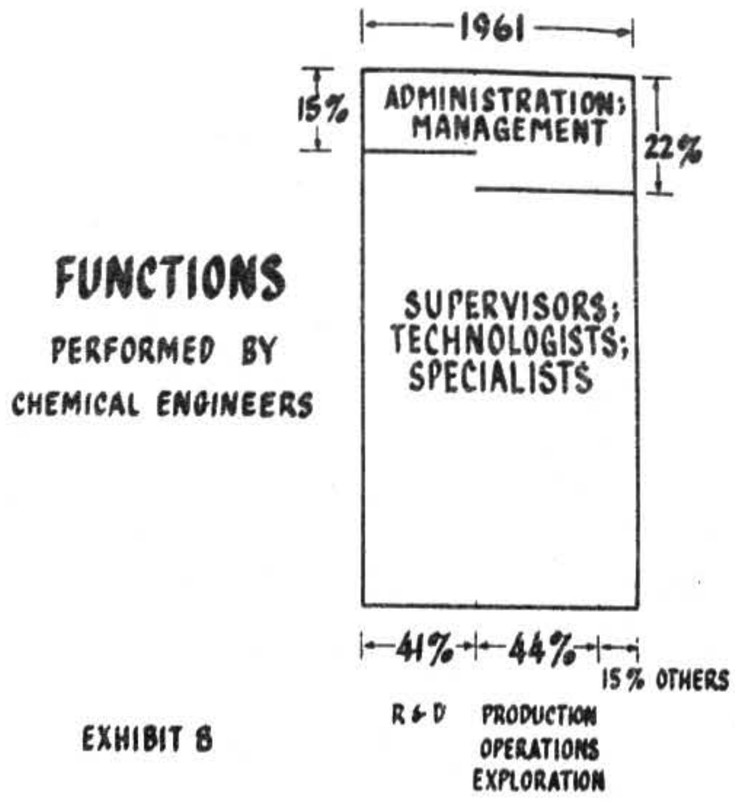

EXHIBIT 8

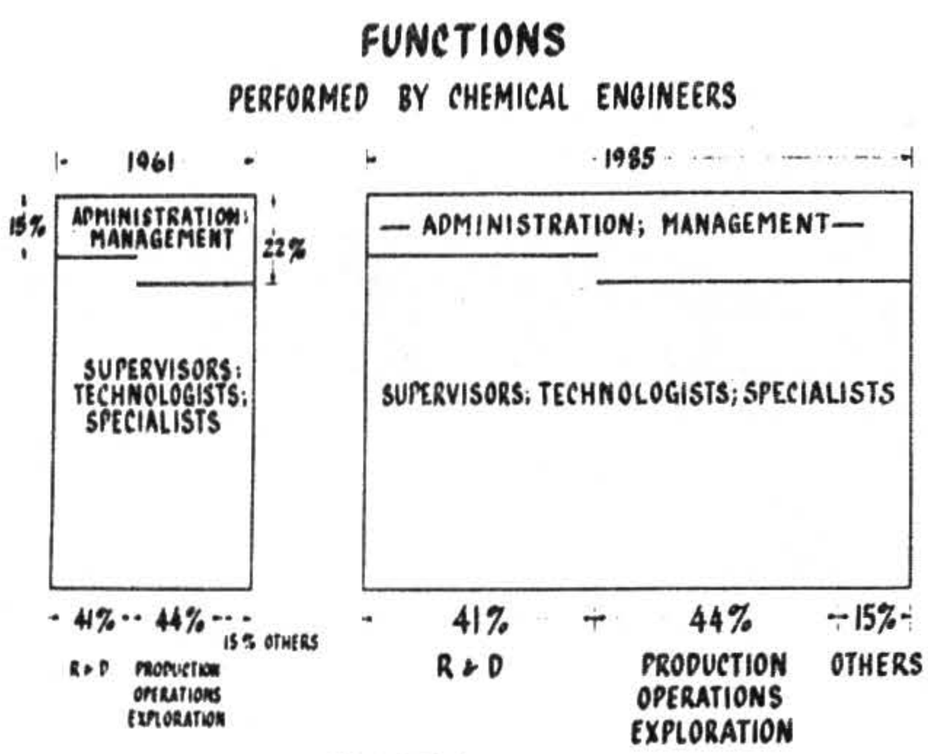

EXHIBIT 9

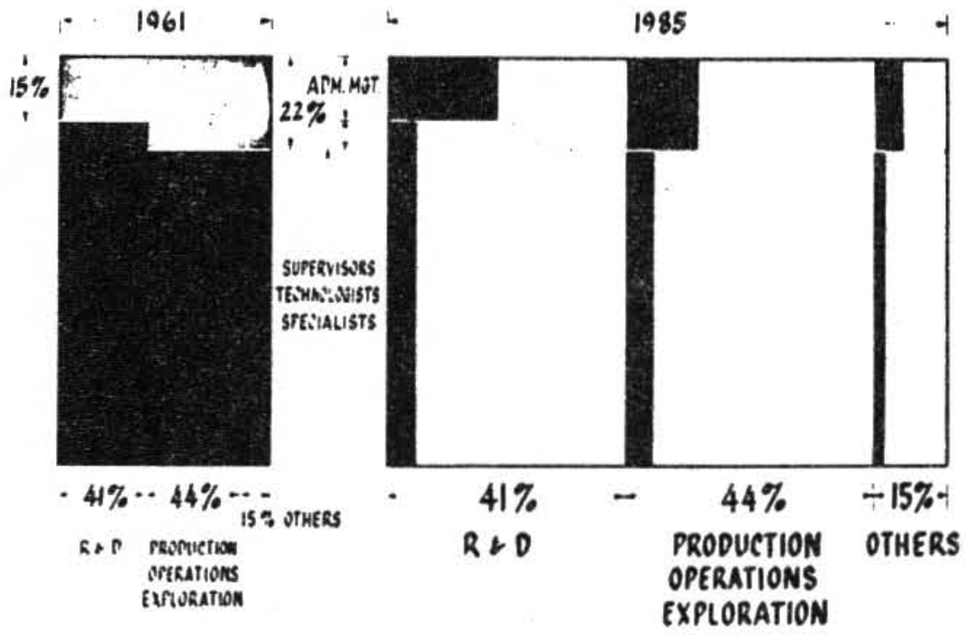

EXHIBIT 10

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