UTILIZATION OF ENGINEERS GRADUATED FROM THE UNIVERSITY OF SOUTHERN CALIFORNIA

A Thesis

Presented to the Faculty of

the Graduate School of Business Administration

University of Southern California

In Partial Fulfillment

of the Requirements for the Degree

Master of Business Administration

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by

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under the guidance of the Faculty Committee, and approved by all its members, has been presented to and accepted by the Faculty of the Graduate School of Business Administration in partial fulfillment of the requirements for the degree of

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Approved

James S. Ford
Chairman

PREFACE

In weaving together the pages of a book there must, of necessity, be an ideal toward which to strive. An effort has been made to assemble in one document a report on the utilization of engineers graduated by the University of Southern California.

This thesis is the outgrowth of a mail questionnaire directed to the engineering alumni. The dean of engineering and the administrative and teaching faculty of the University's engineering school are continually interested in developing and maintaining standards of a caliber which will help to assure a high order of achievement by U.S.C.'s students and graduates. This can be accomplished only by constant review of the engineering school's goal and the accomplishment of their product: the practicing professional engineer.

Man rarely creates unaided, therefore, grateful acknowledgement for the generous assistance provided by the School of Engineering for the survey material and especially Professor Homer H. Grant, Head, Department of Industrial Engineering, for spending hours of his valuable time, for his enlightening suggestions and guidance in development of the survey material. I also wish to thank my thesis adviser, James S. Ford, Ph.D. for his expeditious

review of my rough drafts of this thesis and the suggestions he made for improving its quality.

To my wife, Lorraine, I can only say that I must spend the remainder of my lifetime making up for the sacrifices she made so that I might be able to take advantage of this opportunity.

Finally, to all of our engineering alumni who responded and expressed a genuine interest in this project designed to provide information to the alumni, I am deeply grateful.

John A. Richards

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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

The beginning of engineering work in the University of Southern California dates from 1905 - 1906, when five courses in electrical engineering were taught. Since that time, and up to and including the class of 1959, over 6,000 engineers have been graduated. Not until 1953 was a survey first conducted to find out something about the utilization of these graduates. This survey showed where the graduates were employed, positions obtained and the general type of work being done. From 1953 to 1959 approximately half again as many engineers have been graduated as were graduated in the period 1905 - 1953. The present study reports a second survey covering the last 6,000 engineers graduated from the University of Southern California. This survey was made to determine various trends that may be indicated in the utilization of these graduates.

The Problem

Statement of the problem.--It is the purpose of this study (1) to consider where these engineers have located geographically; (2) to review the group that have stayed in engineering and how they have been utilized;

(3) to compare the employment of engineers in the new areas of technology; and (4) to show relationships between progress made and such factors as major, years since graduation, advance degrees, and area of employment as revealed through a questionnaire study.

Importance of the study.--If an institution is to develop competent top level engineers, it must have reliable guide posts to go by. It should have an awareness of its capabilities and limitations in developing engineers. Although it is not believed that a report of this nature will solve the many problems which confront the educator, it is felt that only through the insights gained by such a study can the educator appreciate and compare the fruits of his labor. Whereas the builders of bridges and machines, and, yes, even the composers of prose, poetry, and music, can see the tangibleness of their labor. However, when the teachers receive at first hand the recorded successes of their products, they begin to recognize the contributions which their efforts have wrought. Then too, they are made aware, in a vivid fashion, of the dents in their armor, the imperfections in their product.

If judgments are to be made, they must, of necessity, rest upon some presupposition about the past as well as on some indications for the future. This study is an attempt to provide a foundation sounder than is

provided by assumption alone in directing education at the professional level of future engineers at the University of Southern California.

In light of the tremendous forward steps in science and technology during the past quarter of a century, it is difficult to project the type of training at the baccalaureate level which can best prepare one for his responsibilities twenty years hence when the full impact of leadership will be felt. Thus through an historical approach by reviewing the careers of alumni, an indispensable point of view is obtained to assist in sound evaluation of the present.

Limitions

This study was limited to engineers graduated from the University of Southern California. It includes all the engineering branches and graduates with advanced degrees.

The survey questionnaire was aimed to determine the utilization of the graduates, position achieved relative to educational foundation and years of actual experience, and conclusions that can be made relative to the engineers who have stayed with their specialty and those who have moved into associated fields of work. No attempt will be made to determine underlying reasons impelling those who have left their original profession.

It is reasonable to assume that those who have made such a significant change in their life have realistic understanding of the forces which led them to move into a different kind of work.

Definitions of Terms Used

Engineer.--The word "engineer" has to be defined, because "While a doctor is a doctor, a lawyer a lawyer, a minister a minister, too often an engineer is all things to all men (7:71)."

Thorndike's definition of "engineer" falls into four categories, however, only two apply to this study:

> 1. Person who plans, builds or manages engines, machines, roads, canals, railroads, forts, etc.; expert in engineering.
>
> 2. Plan, build, direct or work as an engineer. (41:308)

Scientists and engineers are defined by the National Science Foundation as:

> All persons engaged in scientific or engineering work at a level which requires a knowledge of engineering, physical, natural, or mathematical sciences equivalent to at least those acquired through completion of a 4-year professional college course. (11:107)

In distinguishing between engineers and scientists, Cross stated:

> Engineers are not, however, primarily scientists. If they must be classified, they may be considered more humanists than scientists. Those who devote their life to engineering are likely to find themselves in contact with almost every phase of human activity. (2:5)

> The work of engineers deal with human customs as well as material facts. (2:64)

The term "engineer" as used in this study means a person who has acquired a knowledge of engineering principles and sciences by completion of and graduation from a four year professional college course or its equivalent.

Engineering.--With the term "engineer" subject to different definitions, one encounters additional variations in defining "engineering." According to Cowing:

> It is hard to determine just what is meant by the term engineering. Does it mean an educational program, a profession, an attitude of mind, a function, or a process? (20:648)

The following definitions will show "engineering" referred to as an art as well as a profession. According to Cross:

> Engineering is the art of planning for the use of land and air, and for the use and control of water; and of designing, building and operating the works and machines needed to carry out the plan. (2:1)

The Engineers' Council for Professional Development, however, defines the term "engineering" as follows:

> Engineering is the profession in which a knowledge of mathematical and physical sciences gained by study, experience and practice is applied with judgment to develop ways to utilize economically, the materials and forces of nature for the progressive well-being of mankind. (7:15)

Professional Engineering Degree.--This degree as defined by The University of Southern California is:

A degree presented to a graduate of the School of

> Engineering of the University of Southern California who has had at least ten years of professional experience in some branch of engineering and who has done noteworthy engineering work may be considered for one of the Professional Degrees of Civil Engineer, Chemical Engineer, Electrical Engineer, Mechanical Engineer, and Petroleum Engineer. (5:32)

Registered Professional Engineer.--The term "registered professional engineer" as used in this study, refers to graduate engineers who are registered under the engineering registration laws of any one of the several states. The "Civil and Professional Engineers' Act" of the State of California provides the following description:

> "Professional Engineer," within the meaning and intent of this act, refers to a person engaged in professional practice of rendering service or creative work requiring education, training and experience in engineering sciences and the application of special knowledge of the mathematical, physical and engineering sciences in such professional or creative work as consultation, investigation, evaluation, planning or design of public or private utilities, structures, machines, processes, circuits, buildings, equipment or projects, and supervision of construction for the purpose of securing compliance with specifications and design for any such work. (13:7)

The registration of surveyors in the State of California came into effect when "The Land Surveyor's Act" was approved by the Governor, February 3, 1939 (13:15). The Civil and Professional Engineers' Act became effective December 5, 1946. "Professional engineering" within the meaning of this act comprises five branches: chemical engineering, civil engineering, electrical engineering, mechanical engineering, and petroleum engineering (13:27).

Southern California.--Chipman, in his annual

report to the California State Board of Trade listed the following description of the divisions of the State:

> The counties that originally constituted themselves Southern California were Los Angeles, San Diego, San Bernardino, Santa Barbara and Ventura. Two counties have since been carved out of these - Orange and Riverside - but the general territory continues the same. The remaining forty-nine counties constitute Northern California. (1:8)

The School of Engineering.--This is the present designation of this branch of the University of Southern California. The title became effective in 1949 and superseded the organization known as "The College of Engineering."

Organization of the Remainder of the Thesis

The development and growth of a University is the result of the demands of society. The School of Engineering is more specifically concerned with the industrial economy of society. To understand the challenges faced by the School of Engineering, it helps if one knows some of the historical background, the number and kind of trained engineering graduates the University has prepared for industry. Chapter II is concerned with furnishing this information.

Chapter III will cover a detail evaluation of the 1959 survey answers. Emphasis will be placed upon trends that are indicated. It is the intent of the study to dwell mainly upon those areas of engineering activity

which were brought out by the questionnaire and show the distribution of engineers within industry and the progress they have made personally and economically.

The questionnaire--its organization and objectives --comparison between the 1953 - 1959 surveys are reviewed in Chapter IV.

The last chapter presents a summary of the findings and the conclusions which have been drawn from the investigations.

CHAPTER II

THE UNIVERSITY OF SOUTHERN CALIFORNIA

The University of Southern California is an example of a distinctly American type of major university - a private coeducational institution, integrated into a cultural life of a large city and functioning as a center both of teaching and of research (4:7).

Early History

The birth of the University.--On July 29, 1879, 308 lots in West Los Angeles were deeded in trust to the Trustees for an Endowment Fund. Said deed provides:

> The funds received from the sale of said lots, less cost of sales and expenses and improvements, not to exceed fifteen per cent of the price received, shall be and forever remain an Endowment Fund, the net income from which shall be for use and support of said University; provided, that from the first sales of lots the sum not to exceed $500 may be used for expenses of properly placing the property on the market, and from the next money received $500 shall be used for the purpose of erecting a college building on said site or campus. (16:3)

It was duly specified that the University corporation should be "under the control and management of the Southern California Conference of the Methodist Episcopal Church" (10:3). Although it was founded under Methodist sponsorship to provide higher education for the children of the pioneer generation, the University was

regarded as representing the whole community. Land for the site was given jointly by a Jew, a Catholic and an Episcopalian. Since 1926 the University has been officially non-sectarian (4:4).

Actual incorporation became effective August 5, 1880. The corner stone of the first building was laid September 4, 1880. President Bovard was officially inducted into office October 5, and on the following day the University opened its doors to students, in all about fifty, most of them special and preparatory students. The college department offered regular classical, philosophical, and scientific courses leading to the respective degrees customary at that time (4:5).

In 1884 the first class, numbering three, was graduated, among them George Finley Bovard, a younger brother of the University's President and himself destined to be the fourth President and one of the most powerful forces in shaping the future destiny of the institution. Three years later, George F. Bovard attained the degree of Master of Arts and became the first graduate alumnus.

Space will not permit the detailing of the varied experiences of the following years: of the laying the cornerstone of the new main building (now "Old College")* on September 20, 1884; of the dreams of the "boom days"

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*"Old College" is now replaced by the modern building, Founders' Hall.

of the eighties; of the desperate struggle of 1887 - 1893, when the "land-poor" college, owner of a vast tract enormously rich in material potentialities, was obliged to part for a song with widespread acres that it has since been obliged to buy back at a price sufficient to underwrite a full season of symphony (9:2).

The College of Liberal Arts.--The University of Southern California, as in the case of nearly every university was first organized as a college of liberal arts. For years the College and the University were synonymous. In 1895 came the merging of the two corporations known as "The University of Southern California" and "The College of Liberal Arts of The University of Southern California." All properties were conveyed to a new corporation "The University of Southern California" (10:10).

Miss Sadie Johnson and Miss Philene S. Tufts in the "Class of 1887" received the first degree of "Bachelor of Science" conferred by The College of Liberal Arts (14:7).

Engineering Department

Scope.--The southern portion of California has long been known for its leadership in water development, high voltage transmission, and water supply and irrigation work. The beginning of engineering work in the University

of Southern California dates from 1905 - 1906, when five courses in electrical engineering were taught. The degree of Bachelor of Science in Electrical Engineering was offered to properly qualified cnadidates. Two year courses in mining and chemical engineering were available. In 1917 a full course in industrial chemical engineering was added. In 1923 degrees in civil, electrical, and mechanical engineering were offered, as were the first two years of a mining course and a four year course in engineering chemistry. Mechanical engineering was dropped in 1925 and was not restored until 1927. In 1925 - 1926 the degree of Bachelor of Science in Petroleum Engineering was offered.

The College of Engineering.--The demands for education on the part of high school graduates and the insistent calls from the industries for trained engineers resulted in 1927, in the organization by the University Trustees of the College of Engineering, including the five divisions of electrical, mechanical, civil, chemical and petroleum engineering.

In addition to the bachelor's degrees in the five divisions of engineering, the degree of Master of Science was offered in each division, on the satisfactory completion of a year's graduate work in residence. In 1928, there was added the professional degree in each division (10:53-55).

The School of Engineering.--The School of Engineering was established in 1949 and included the eight departments of aeronautical, chemical, civil, electrical, general, industrial, mechanical and petroleum engineering. The department of General Engineering does not give degrees but offers service courses for all other departments.

The School of Engineering offers the following curricula: undergraduate studies leading to the Bachelor of Science degree with a major in Chemical Engineering, Civil Engineering, Electrical Engineering, Industrial Engineering, Mechanical Engineering, Mechanical Engineering (Aeronautical Sequence), and Petroleum Engineering; graduate studies leading to Master of Science degree in Aeronautical Engineering, Chemical Engineering, Electrical Engineering, Industrial Engineering, Mechanical Engineering, Petroleum Engineering, and Industrial Chemistry (jointly with the Department of Chemistry); graduate studies leading to degrees Engineer in Electrical Engineering and Engineer in Mechanical Engineering; and graduate studies leading to the Ph.D. degree. It also offers work leading to the professional degrees Chemical Engineer, Civil Engineer, Electrical Engineer, Industrial Engineer, Mechanical Engineer and Petroleum Engineer. All graduate work in the School of Engineering is under the jurisdiction of the School of Engineering except the PhD., which is

under the supervision of the Graduate School (6:30).

University Graduates

Period 1908 - 1959.--Table 1 shows the number of all students graduated by the University each year during the period 1908 - 1959. The total of 79,956 includes all degrees from all the various schools and departments of the university. This period was selected to enable comparisons to be made with activity of the School of Engineering, whose history starts in 1908 and the survey of engineering graduates conducted in 1959 upon which this study is based.

A review of Table 1 shows an increasing number of graduates each year from 1921 to 1933 inclusive. The period 1930 - 1933 was the great economic depression, the period 1937 - 1939 was an era of economic recession. Increased educational activity occurred during both of these periods. The utilization of youths of this nation for the manpower needs of World War II is reflected in the fall-off of the number of graduates during the period beginning in 1941 and ending in 1945 when a low point in graduates was reached and only 918 degrees were conferred. The impetus given to education after World War II by the G.I. Bill is shown by the rapid increase in graduates starting in 1946 and skyrocketing to a peak of 5,241 in 1950, four years after the ending of hostilities. From this high

TABLE 1

TOTAL NUMBER OF STUDENTS GRADUATED BY THE UNIVERSITY OF SOUTHERN CALIFORNIA IN THE YEARS 1908 - 1959

Year	Total	Year	Total
1908	129	1934	1,550
1909	138	1935	1,482
1910	118	1936	1,531
1911	191	1937	1,450
1912	210	1938	1,534
1913	222	1939	1,690
1914	288	1940	1,608
1915	332	1941	1,546
1916	340	1942	1,387
1917	411	1943	1,187
1918	389	1944	988
1919	369	1945	918
1920	330	1946	1,484
1921	398	1947	2,336
1922	496	1948	3,353
1923	663	1949	4,367
1924	756	1950	5,241
1925	857	1951	4,495
1926	876	1952	3,514
1927	824	1953	3,115
1928	1,089	1954	2,994
1929	1,104	1955	2,995
1930	1,275	1956	3,081
1931	1,402	1957	3,106
1932	1,651	1958	3,203
1933	1,723	1959	3,220
		Total	79,956

Notes:

The above totals for each year do not include the certificates and credentials that were presented.

The statistical data on the number of students graduated were obtained from the files in the Registrar's office, University of Southern California. D. W. Evans, Registrar.

water mark of degrees achieved, the wave of graduates subsided during each of the four following years to a new normal that has leveled off in the range of 3,200 graduates each year. Significantly, this figure is approximately 100 per cent greater than the highest normal reached prior to World War II and reflects our higher standard of living, emphasis on desirability of a college education, and the need for higher education in the business and technical areas of today's and tomorrow's living.

Engineering bachelor degrees granted.--Table 2 shows the Bachelor of Science degrees granted by the University by the engineering department during the years 1908 - 1959. The University's first degree in Engineering was that of Bachelor of Science in Civil Engineering. Until 1920 only sixty-eight degrees had been awarded, all Bachelor of Science degrees in Civil and Electrical Engineering. In 1920 the first degree in Mechanical Engineering was presented. The Chemical Engineering Department gave its first three degrees in 1923. Petroleum Engineering was added and presented their first degree in 1927. In 1931 the first three degrees in General Engineering were awarded; this department was abolished in 1945. The Industrial Engineering Department was added and gave its first degree in 1943. Aeronautical Engineering is the most recent department organized. At

TABLE 2

BACHELOR OF SCIENCE DEGREES GRANTED BY THE UNIVERSITY OF SOUTHERN CALIFORNIA BY ENGINEERING DEPARTMENT IN THE YEARS 1908 - 1959

Year	Department								Total
	A.E.	CH.E.	C.E.	E.E.	G.E.	I.E.	M.E.	P.E.	
1908			1						1
1909									
1910			3						3
1911				1					1
1912			1	4					5
1913			4	4					8
1914			5	2					7
1915			4	4					8
1916			3	5					8
1917			3	3					6
1918			3	3					6
1919			8	7					15
1920			2	3			1		6
1921			4	2			2		8
1922			3	8			2		13
1923		3	11	8			2		24
1924		2	4	12			4		22
1925		4	9	11			1		25
1926		3	16	19					38
1927		4	12	13				1	30
1928		1	7	10				2	20
1929		3	9	11			1		24
1930		7	12	17			3	1	40
1931		8	12	17	3		6	4	50
1932		5	15	14	4		13	7	58
1933		6	13	8	5		8	6	46
1934		4	8	14	8		14	10	58
1935		5	8	12	10		10	5	50
1936		5	12	12	6		11	7	53
1937		10	9	10	9		10	4	52
1938		15	13	8	1		11	5	53
1939		9	10	13	5		18	11	66
1940		21	12	18	6		16	13	86
1941		10	12	12	1		19	11	65
1942		10	4	14	4		19	23	74

TABLE 2 - Continued

Year	Department								Total
	A.E.	CH.E.	C.E.	E.E.	G.E.	I.E.	M.E.	P.E.	
1943		22	21	15	7	1	39	12	117
1944		12	16	31	1	1	26	5	92
1945		11	33	17		2	33	5	101
1946		5	12	5		1	43	3	69
1947		24	53	43		30	98	11	259
1948		25	101	82		60	145	22	435
1949		40	115	121		68	159	34	538*
1950		44	155	142		83	181	38	643
1951		29	111	91		59	137	42	469
1952		15	103	51		27	79	25	300
1953		20	65	34		27	57	14	217
1954		12	75	51		14	62	12	227**
1955		16	44	53		15	70	6	204
1956		22	50	74		20	68	9	243
1957		12	65	62		20	81	20	260
1958		20	70	84		23	95	15	307
1959		17	64	75		28	92	11	287
Total		481	1,405	1,330	70	479	1,636	394	5,797

Notes:

The above totals for each year do not include certificates and credentials that were presented.

The total indicated by the mark (*) includes one double degree in A.E. and M.E. The total indicated by the mark (**) includes one double degree in E.E. and M.E.

The statistical data on the engineering graduates were obtained from the files in the Registrar's office, University of Southern California. D. W. Evans, Registrar.

the bachelor level this degree is in Mechanical Engineering with an Aeronautical Sequence. Its first year of operation was 1949 and seventeen degrees were presented. A total of 5,797 Bachelor of Science degrees have been awarded by the Engineering Department during the period of 1908 - 1959. The Mechanical Engineering Department has been the most popular, presenting 1,636 degrees.

Master of Science Degrees granted.--Table 3 shows the Master of Science degrees granted by the University by engineering departments during the years 1908 - 1959. By 1928 the engineering alumni totaled 254 when the first Master of Science degree was given by the Electrical Engineering Department. Only sixty-six Master of Science degrees were awarded by all of the engineering departments up to and including 1946. However, starting in 1947, the graduate program was greatly accelerated and by 1959 a total of 1,419 Master of Science degrees had been presented. The Electrical Engineering Department has been the most popular, presenting 492 graduate degrees. In comparing the figures on Tables 2 and 3 it will be noted that: (1) in 1957, 1958 and 1959 the Electrical Engineering Department awarded more graduate degrees than bachelor degrees; and (2) all of the engineering departments were affected by this trend to achieve higher education. The Aeronautical Engineering Department confers aeronautical degrees only at the graduate level.

TABLE 3

MASTER OF SCIENCE DEGREES GRANTED BY THE UNIVERSITY OF SOUTHERN CALIFORNIA BY ENGINEERING DEPARTMENT IN THE YEARS 1908 - 1959

Year	Department								Total
	A.E.	CH.E.	C.E.	E.E.	G.E.	I.E.	M.E.	P.E.	
1928				1					1
1929			3						3
1930								1	1
1931		3		1				1	5
1932			2					1	3
1933		1	1	2			1	1	6
1934		1	3				1	2	7
1935		1	3						4
1936			3				1		4
1937		2	2	1					5
1938		2	1	3					6
1939		1	3					5	9
1940								1	1
1941								3	3
1942		4	1						5
1943									
1944									
1945			1						1
1946							1	1	2
1947		10	6				1		17
1948		10	5	1			18	2	36
1949	9	4	6	12			9	3	43
1950	13	10	11	10		1	13	8	66
1951		6	6	21		1	18	2	54
1952		5	10	13			13	5	46
1953	3	2	7	19		1	20	2	54
1954	8	3	12	43		1	36	2	105
1955	10	2	13	35		5	42	2	109
1956	7	3	30	53		14	40	8	155
1957	13	4	26	85		6	56	12	202
1958	22	9	25	117		10	59	6	248
1959	26	11	39	75		9	44	14	218
Total	111	94	219	492		48	373	82	1,419

Notes:

The statistical data on the engineering graduates were obtained from the files in the Registrar's office, University of Southern California. D. W. Evans, Registrar.

Professional and Doctorate Degrees granted.--Table 4 shows the Professional and Doctorate engineering degrees granted by the University engineering departments during the years 1908 - 1959. The first two professional degrees were presented by the Electrical Engineering Department in 1929. The first Doctorate degree was given in Chemical Engineering in 1948; by this time the engineering alumni totaled 2,223. A total of twenty-six Professional and Doctorate degrees have been awarded in the engineering field during 1908 - 1959. Only ten of these were Doctorate degrees.

Engineering Graduate Growth.--Figure 1 shows the relationship between the number of degrees presented by the Engineering Department and the total number of degrees awarded by the University during the period 1908 - 1959. Figure 1 is a graphical representation of the statistics shown on Tables 1, 2, 3, and 4. Comparing these values, it will be noted that from 1908 to 1942 the number of engineering graduates averaged a little above three per cent of the number of students graduated by the University. During the period 1943 to 1959 the ratio of engineering graduates to the total number of students graduated rose to 11.8 per cent. This ratio is 13.75 per cent during the last six years from 1954 to 1959.

Figure 2 shows the surprising growth of advanced level work relative to the total number of engineering

TABLE 4

PROFESSIONAL AND DOCTORATE DEGREES GRANTED BY THE UNIVERSITY OF SOUTHERN CALIFORNIA BY ENGINEERING DEPARTMENT IN THE YEARS 1908 - 1959

Year	Department								Total
	A.E.	CH.E.	C.E.	E.E.	ENG.	I.E.	M.E.	P.E.	
1929				2*					2
1930				1*					1
1931								1*	1
1932									
1933									
1934									
1935									
1936									
1937			1*						1
1938				1*					1
1939									
1940									
1941		1*						2*	3
1942									
1943									
1944									
1945									
1946									
1947									
1948		1					1*		2
1949								1*	1
1950									
1951		2							2
1952		2							2
1953									
1954			1*	1*					2
1955			1*						1
1956		1*							1
1957				1					1
1958				2	1		1*		4
1959					1				1
Total		7	3	3	2		2	4	26

Notes:

Figures followed by an asterisk (*) indicate a Professional Engineering degree.

The statistical data on the engineering graduates were obtained from the files in the Registrar's office, University of Southern California. D. W. Evans, Registrar.

FIGURE 1

NUMBER OF STUDENTS GRADUATED VS ENGINEERS GRADUATED
BY UNIVERSITY OF SOUTHERN CALIFORNIA
1908 - 1959

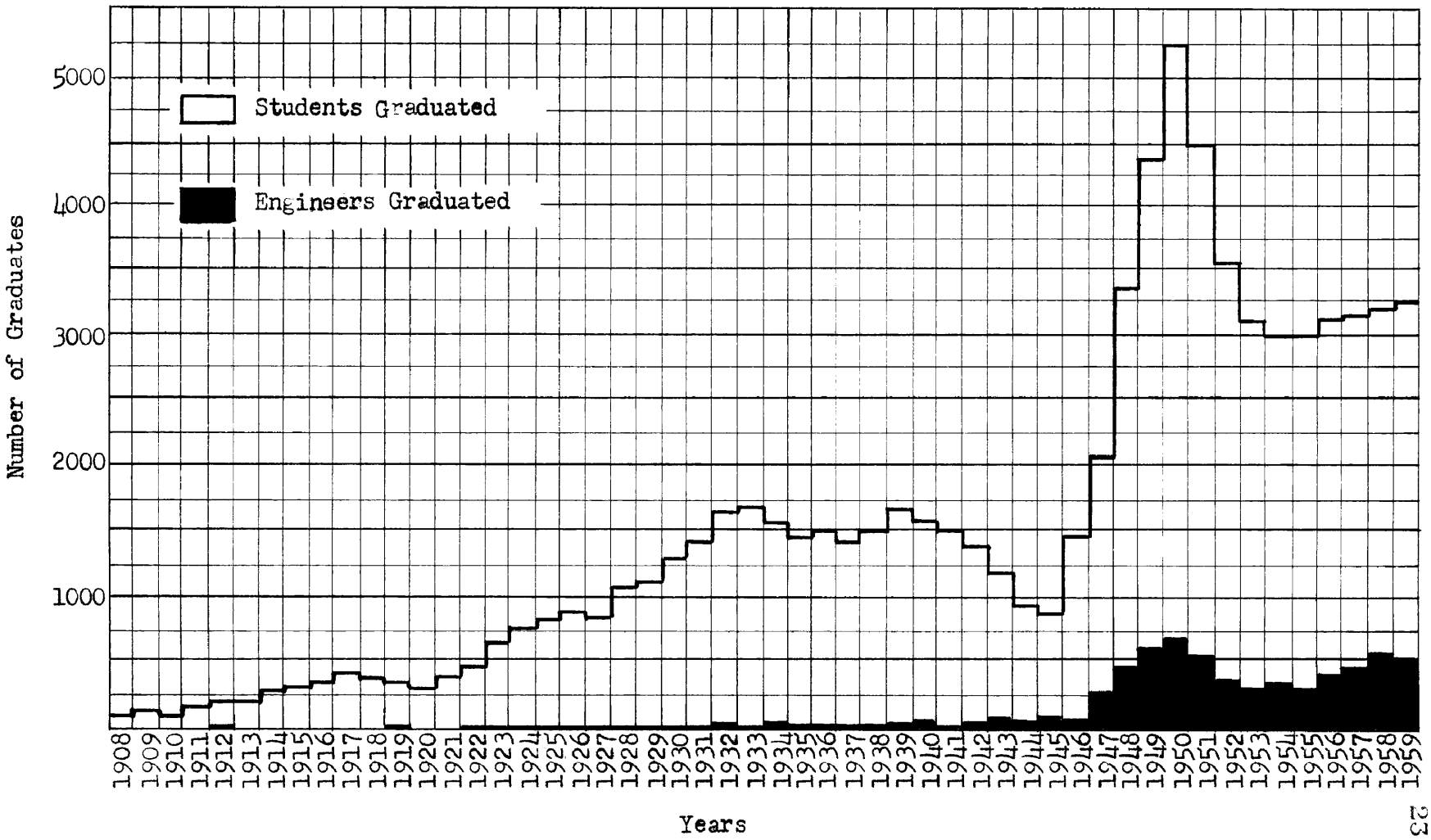
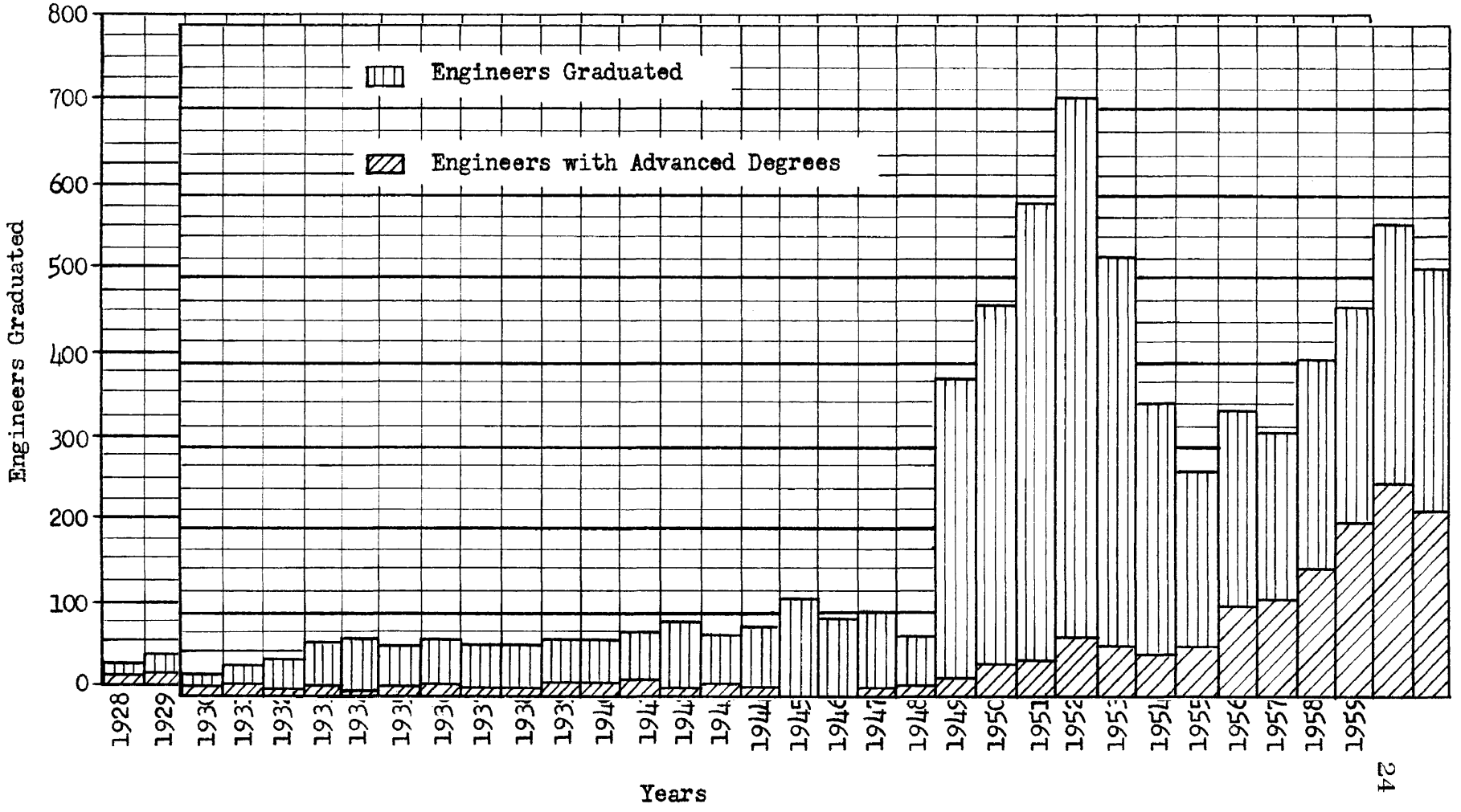


FIGURE 2

ENGINEERS OBTAINING ADVANCED DEGREES AT
THE UNIVERSITY OF SOUTHERN CALIFORNIA



graduates. It graphically illustrates the change that is taking place in the education of engineers and the effects of the demands of industry faced with a rapidly changing technology.

Business Week, in an article titled "The Pressure's on for Top Degrees" makes the following observations:

> Prosperity is part of the reason for this: More and more new graduates can afford to go without a job while they earn a higher degree, because there are many more scholarships available, because their families can stake them, or because their wives can find jobs to help support them.
>
> This is a change from the old pattern of graduate school enrollment; only a decade ago it was still assumed that graduate school enrollments increased when the job market was poor, when the new graduates found they had to wait a year or more for the kind of job they wanted.
>
> But there's more to it than that. The chief reason today is probably, as Wendell Horsley, placement director at Texas A & M College, says: "Entrance to industry requires a bachelor's degree, but the key to advancement is a graduate degree. (38:121)

Robert E. Vivian, Dean of the School of Engineering, University of Southern California has stated:

> The activity and progress of the School of Engineering are dependent in important measure upon two factors completely out of our control. These are:
>
> 1. The industrial activity and growth of the Los Angeles Metropolitan Area.
>
> 2. The population and population growth of the Los Angeles Metropolitan Area.
>
> Upon these two associated factors we place major dependence for students, and for the placement of engineering graduates in jobs. Fortunately, from the standpoint of the School of Engineering, the industrial growth of the area and the continual popula-

tion increases of the past decades have sent us increasing enrollments. Our job has been, and will continue to be in the coming years, to grow with the community and its developing needs if we are to maintain and improve its relative standing among educational institutions in this area. (15)

CHAPTER III

EVALUATION OF THE SURVEY

Introduction

The objectives of this survey were noted in Chapter I. Quantitative values were sought for such questions as; where have the engineering graduates located geographically? how have these engineers been utilized? what level of salary do these former students earn? Partial answers to these questions and some of the highlights of the survey are listed below:

1. Seventy-nine per cent of the graduates are employed in the Southern California area. Eighty-seven per cent in the State of California.
2. Over sixteen per cent of them have gone back to school while being employed and obtained advanced degrees. Two of the alumni obtained advanced degrees twenty-years after they received their bachelor degrees.
3. Forty-one per cent of the alumni are employed by companies that are classified as big business.
4. University of Southern California engineers are in positions of responsibility. Many have

people working for or under them and as such are in positions of leadership, where skill in human relations is a must. This is important for the engineer. The ivory tower of personal and social isolation is no longer possible. To be an engineer means working with people, directing them, and leading them. The technical skill which the engineer has acquired may be largely wasted if he is unable to communicate with others, to work with them, and to inspire them.

5. The median earned income for the U.S.C. engineering graduate as reported in the Fall of 1959 was above the levels for all graduates in the country. Substantially higher in the upper decile groups.

Briefly, these are some of the more important findings of the School of Engineering Survey. A detailed description of these and other interesting results are presented on the following pages.

Per Cent Answering the Survey

Reasonable men may differ as to whether or not we live in an age of affluence or anxiety, or both. But, they will surely agree that ours is a self-conscious society whose members, bereft of the traditional props of

static culture and lifelong propinquity, look more and more to polls and surveys to tell them what others are like and how they themselves are doing (27:18).

Background.--Much has been written in newspapers and magazines on engineering salaries, rates of progress, and utilization of engineers, especially in the fields of administration and management. But some of the reporting was based upon a small sample, and other segments of it were based upon surveys of selected groups.

In an effort to learn the facts relative to their own graduates, the School of Engineering canvassed its alumni. In the Fall of 1959 all living engineering alumni for whom U.S.C. had valid addresses, were invited to answer a simplified questionnaire concerning their work, their salary and salient features of their career.

There were 6,000 questionnaires sent out. In response, 3,456 (or 57.6 per cent) alumni replied - some with personal notes requesting they be provided with a factual backdrop against which they could judge their relative progress and financial well-being.

Comparison of survey response with other schools.--The response of the engineering graduates to the questionnaire was in close agreement with similar surveys conducted by the California Institute of Technology (9:1) and the Ohio State University, College of Engineering (19:3). Georgia Technical Institute, through cooperation

of the National Alumni Association conducted a survey of the 1953 and 1955 classes only and received a very gratifying response from a relatively small number of alumni contacted (27:18). The results of these four surveys are listed in order of descending percentages in Table 5.

TABLE 5

COMPARISON OF OTHER SCHOOL SURVEY

School	Number Surveyed	Response	Per Cent
Georgia Tech.	477	386	81.0
Caltech	5,647	3,800	67.3
U.S.C.	6,000	3,456	57.6
Ohio State	10,992	5,695	51.8

The Georgia Tech and Caltech surveys covered their science and engineering alumni, whereas, the Ohio State and U.S.C. surveys canvassed only the engineering alumni. It is encouraging, therefore, to believe that this study bases itself on as great a proportion of college graduates as can be induced to reply to a questionnaire voluntarily and the results achieved are comparable to other surveys of this nature.

The response to the questionnaire by the engineers from each department is shown in Table 6.

TABLE 6

RESPONSE FROM EACH ENGINEERING DEPARTMENT

Dept.	Persons Receiving Degrees	Survey Response	Per Cent
G.E.	70	30	42.8
Aero.	172	46	26.7
P.E.	480	194	40.4
I.E.	527	226	42.8
Ch.E.	582	273	46.8
C.E.	1627	796	48.8
E.E.	1830	873	47.6
M.E.	1950	1018	52.1

The column "Persons Receiving Degrees" is different from the totals that would be obtained for each department as shown in Tables 2, 3, and 4 of Chapter II. A number of the graduates earned more than one degree, however, these same graduates which answered the survey submitted but one response. As would be expected, more responses were received from the departments with the greater number of graduates. However, the Mechanical and Civil Engineering Departments came in with the highest percentage of returns.

Range of Activity of Engineering Graduates

Geographical location.--The geographical distri-

bution of the U.S.C. engineering alumni in their work is one of the more interesting items of information revealed by the survey. Every society must find ways to retain persons who can be expected to exercise special skills and knowledge. A large majority of the graduates found opportunities in the rapidly growing State of California. Figure 3 shows the heavy concentration of engineers in California, 86.9 per cent and 78.9 per cent stayed in Southern California, the home of their alma mater. The three Pacific Coast states accounted for 88.5 per cent of the graduates.

Probably the simplest and most obvious interpretation of these figures would be to consider them a reflection of the tremendous increase in the population and industrial growth that has taken place in Los Angeles, California, and the other Pacific States in the last two decades.

Georgia Tech. and Ohio State University surveys show a similar heavy concentration of alumni in the geographical areas of the schools, although it is not as pronounced as reflected by the U.S.C. survey. Both of these schools noted a loss of graduates to the Far Western States. Comparative figures are shown in Table 7.

FIGURE 3

GEOGRAPHICAL AREAS OF U.S.C. ENGINEERING GRADUATE LOCATIONS

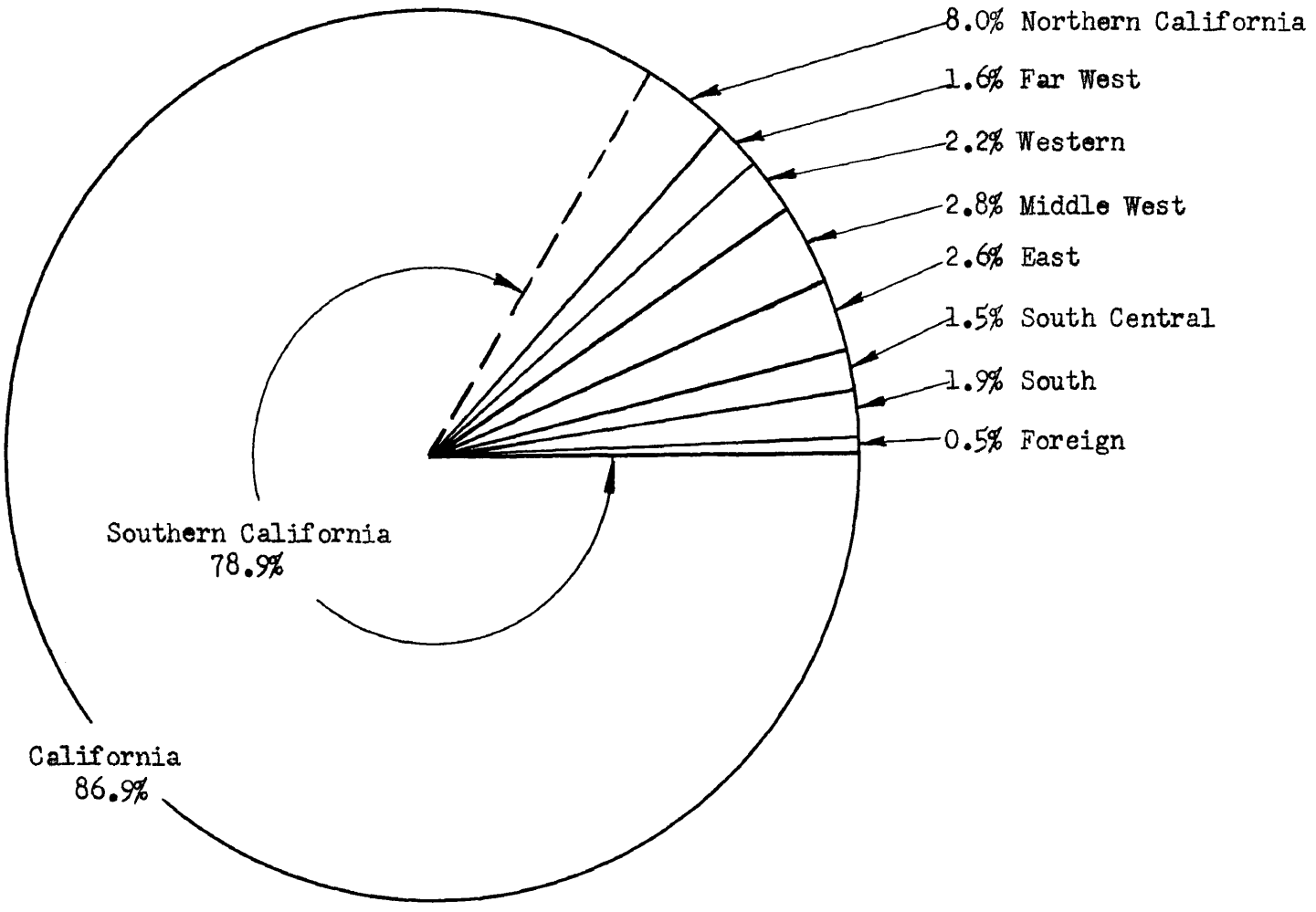


TABLE 7

COMPARISON OF GEOGRAPHICAL AREAS OF ENGINEERING ALUMNI LOCATIONS

University	Per Cent in			
	Home State	Local States	Far Western States	South Atlantic States
U.S.C.	81.0	90.7	---	1.9
Georgia	----	72.5	7.0	---
Ohio	48.4	61.4	6.4	6.1

Continuing education.--It will be noted from Figure 2 in Chapter II that an increased activity in "continuing education" began following the end of World War II. The survey shows that 22.4 per cent of the engineers have acquired additional education. Another 1.4 per cent were in the process of obtaining advanced degrees. An interesting fact was that 12.4 per cent of the engineers secured their advanced degrees at a different school than where they had received their bachelor degree.

The survey shows that a large majority of the advanced work has been accomplished after the graduates have left school and are employed. There are several reasons for this approach:

1. The student is a wage earner and can finance the undertaking.

2. The student having been in industry notes the advantages to be had due to additional education.
3. Some companies encourage their employees to participate in additional educational activities.

Robert E. Vivian, Dean of the School of Engineering, U.S.C. in a paper titled, "Graduate Study in The School of Engineering" covered this third point very capably and the relationship to U.S.C.:

Industrial cooperation with the School of Engineering.--

> The recognition by industry of the private institution as a source of strength of this country which must not be lost as a result of changing economic conditions has been evidenced increasingly in the last year or so. The School of Engineering at present has two arrangements with local industry which are of importance. The first, and the furthest advanced in operation is the arrangement with Hughes Aircraft Co. wherein the School of Engineering and other departments of the University are conducting numerous classes at the Hughes Aircraft plant. Associated with this instruction has been the offering by Hughes Aircraft Co. of one hundred scholarships to be divided between U.S.C. and U.C.L.A., fifty scholarships to each institution for the pursuit by Hughes employees of graduate work; to be done in day time hours at a half full-academic load basis. These students will be putting in one half of a normal work week in execution of duties at Hughes Aircraft plant.
>
> Again it should be kept in mind that while Hughes Aircraft Co. is sympathetic to the needs of private educational institutions, the Hughes Aircraft Co. educational program is motivated primarily by self interest, and the possibility of helping moral and efficiency. (15)

North American Aviation Inc. has a different approach to encourage and aid employees in furthering their education and self-development through courses taken outside of working hours. The following is quoted from the company's handbook titled, "The North American Way:"

> Educational reimbursement plan.--The company's Educational Reimbursement Plan is designed to help you to prepare yourself for a better position with the company through additional education on your own time. Using this plan, you may progress along lines of your choice and complete your education or study towards an advance degree. To encourage you to continue your formal education, we offer liberal financial aid and the possibility of an adjusted work schedule.
>
> In order to be approved, courses must be taken at an accredited and recognized educational institution. These courses do not necessarily have to be related to your present assignment but must be related to one of North American Aviation's operations.
>
> You pay the enrollment and tuition fees for the courses desired, and upon satisfactory completion of each approved course, you will be reimbursed for two-thirds of these fees.
>
> Degree program.--There is also a Bachelor's and advance degree program available. Under this program, when you have completed all necessary courses and obtained a degree, you will be reimbursed for the remaining one-third of tuition for all courses leading to the degree and taken under the Educational Reimbursement Plan.
>
> Educational leave program.--After you have worked continuously for a full year, you may apply for an educational leave of absence for a full year of school. Upon your return to the company after satisfactory completion of the school year, you will be eligible for tuition refund under the Educational Reimbursement Plan. (36:3-4)

In a comparison of Caltech, Georgia and U.S.C. as shown in Table 8, Caltech emerges as an outstanding center

of advanced thought, for the number of alumni who have received advanced degrees is larger than the number who stopped at the bachelor level (29:6).

TABLE 8

BACHELOR DEGREE AND BEYOND

School	Year	Degrees	
		Bachelor %	Advanced %
Caltech	1952	45.0	55.0
U.S.C.	1952	84.0	16.0
	1955	65.0	35.0
	1959	56.7	43.3
Georgia	1955	89.0	11.0

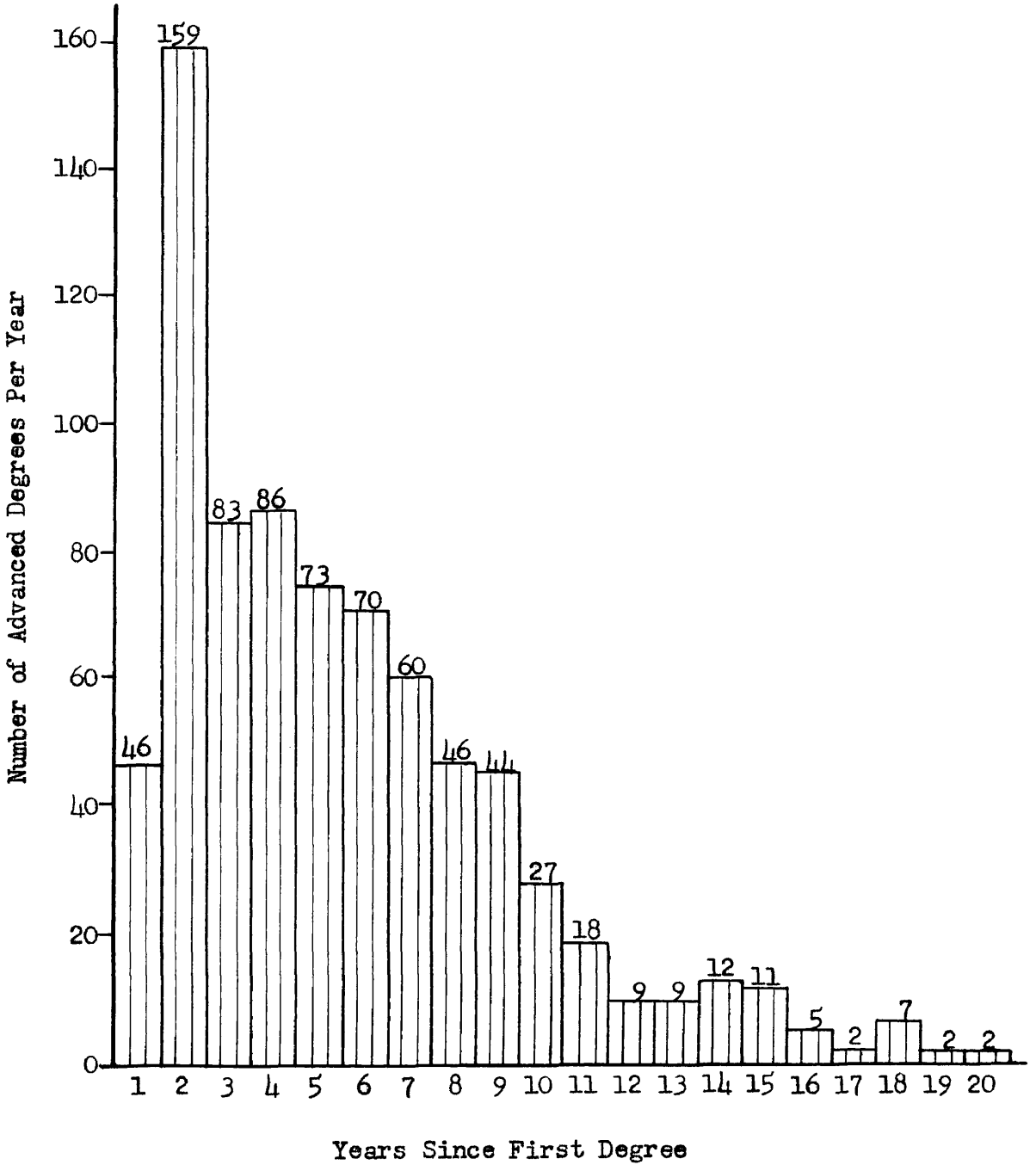
It will be noted that U.S.C. is going through a transition period with an increasing activity in engineering graduate work. Georgia Tech. has held a fairly constant level in graduate study, being eight per cent in 1935 and increasing to only eleven per cent by 1955. (27:22).

Figure 4 shows the advanced degrees earned by the graduates answering the questionnaire. The graph shows that "continuing education" can be continued almost any time after achieving one's bachelor degree.

P. M. Zall, Director of Communications Research Center, Los Angeles State College made the following observation:

FIGURE 4

ADVANCED DEGREES EARNED BY GRADUATES
AFTER LEAVING SCHOOL



> Should a young man go after an advanced degree? - Yes. Everyone agrees that an advanced degree is desirable. In some companies it is absolutely essential to advancement. But even when it is not required for a better job, an advanced degree - or at least continuing study - keeps a young man up in his field. This does not mean that advanced degrees should be pursued at the expense of a happy home or poised nervous system. One night a week or a home study course would be enough for many people. (Study for a Ph.D deserves full time.) Much depends on personal motivation; one observer recalled Joe Louis's reply when asked why there were so few good heavyweights around: "They're not hungry anymore." Many good engineers do not go after advanced degrees because they are doing well without them. However, the experts feel that if things get rough, those with advanced degrees will continue to do well. In fact, the top executive of a small company confessed that he remains unhappy in his present position because he does not have the advanced degrees required to get a position where he would like to work. He is too old, he says, and too busy to get one now. (40:77)

Occupations.--The primary educational mission of the U.S.C. School of Engineering is to prepare students for definite careers in engineering applications to industry. One of the purposes of this survey was to find out how many U.S.C. graduates do actually engage in engineering work, for any indication this might give as to the rate of transfer out of the engineering profession in this country would have obvious bearing on questions of national productivity and defense.

This survey showed that 98.2 per cent of the graduates were currently in engineering work. A similar survey of alumni of Stevens Institute of Technology from 1902 to 1952 disclosed that eighty-two per cent were in engineering work (28:189). A survey of Purdue University

engineering graduates from 1911 to 1956 found eighty-eight per cent of them in engineering work (26:34).

The trouble with these findings, of course, lies in the terms "engineering work" or "engineering functions." Since these terms are used in practice so broadly this survey considers all graduates associated with engineering in any of its many forms as being in engineering.

Product Engineering in an article titled, "Engineering Management" states:

> More engineers keep moving into management. Statistics indicate that the percentage of engineers in management rises from 9% (6 to 10 years after graduation) to 40% (21 to 30 years after graduation), while those in design drop off correspondingly from 37 to 20% in the same period. (31:81)

Another article written by Tangerman comments on two surveys:

> A recent Fortune survey (Nov. 1959, p. 13) of 1700 top executives sheds more light on the subject. It shows that your chances are twice as good for a top job if you went to college (particularly to a "name" school). Engineering or science degrees are favored for top men in oil and gas, utilities, metals-manufacturing, chemicals and transportation equipment fields. Technical men in most industries seem to command the highest salaries. But most of the men surveyed seem to have made their way by dropping their specialty - 86% have been in non-specialist jobs most of their working lives.
>
> The recent survey of Purdue engineering graduates and an endless number of articles by educators bear out these same elements, provide almost a formula for success. The keys seem to be to develop management inclinations early, to keep on studying in new fields after college to broaden the knowledge base, to find a good company and stick with it.
>
> Herein lies a paradox. Presumably a man studies

> engineering to be an engineer, but now social and economic pressures redirect four or more out of ten. We are not unique in this, because in Europe the ratio of engineers to non-engineers in management is even higher. There is considerable sense in it, too, because of the high engineering content of our modern products and the training in analysis and objectivity that engineers receive. (32:35)

One of the key approaches according to Tangerman, in his comments "Everybody Wants to be Boss," was to work for a good company. According to Table 9 a large per cent of the engineering graduates were using this approach.

TABLE 9

DIVISION OF GRADUATES RELATIVE TO SIZE OF BUSINESS

Annual Sales (Dollars)	Degree			Total
	Advanced	Master	Bachelor	
Over 71 Million	8	432	974	1414
1-70 Million	2	61	211	274
Less than 1 Million	7	78	974	1059
Others	7	176	526	709

Industry.--Fortune magazine has for the last six years presented a directory of the firms that account for more than half of the nation's manufacturing and mining output - the 500 biggest U.S. industrials (35:131-48). These businesses are listed in order of their annual dollars in sales, which range from 71 million to over 9 billion dollars. Three additional classifications of

businesses were selected for Table 9, "1-71 million" and "less than 1 million" and others" (3:1-1177). Table 9 shows the distribution of U.S.C. engineering graduates within these divisions of industry. The listing of "others" includes schools, federal, state, and city governments which do not come within the categories of a business that can be identified with annual sales.

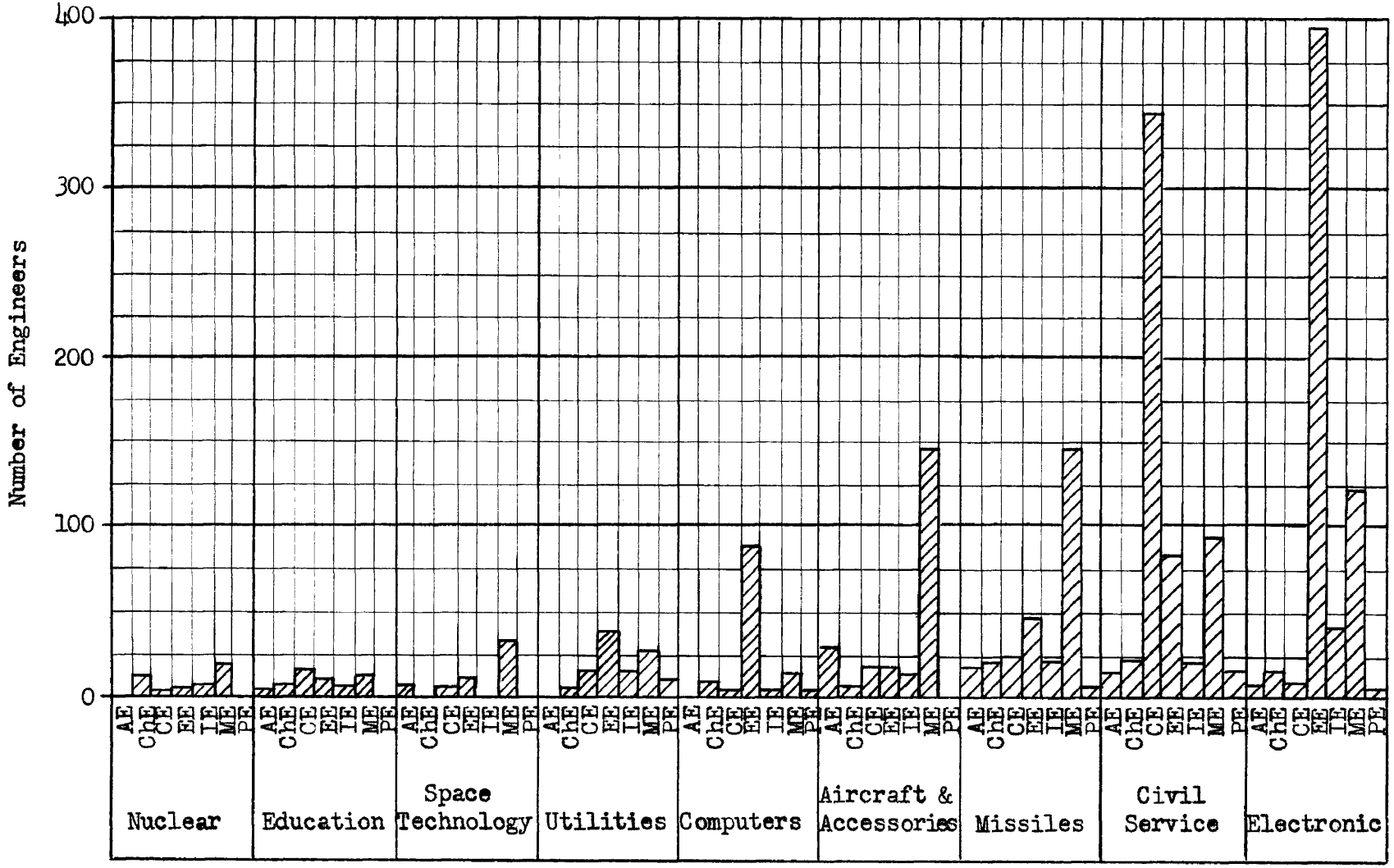
The graduates work in a wide variety of industries represented by 920 employers. These employers cover businesses that employ a couple of persons to giants of the industry with employees in the tens of thousands. The movement of engineers into specific areas of work is noted in Figure 5 which shows the concentration of graduates in the newer fields of engineering. The emergence of these new fields in industry are having their effect on engineering education as noted by Product Engineering.

> So rapid has been the pace of advance in science and technology that educators and students alike are in danger of being engulfed by it. The 4-year engineering education of 30 years must now be crowded into 2-year course for technicians. New discoveries and innovations in industry and research claim a place in already crowded curricula. As a result, every engineering college has its curricula in transition.
>
> Pres. Julius A. Stratton of MIT reported recently: "Nowhere has this crisis in education become more acute than in the field of engineering . . . . We cannot forsee the progress or discoveries of tomorrow. (34:97)

James M. Gavin in a lecture stressed another important facet of the new engineering fields.

FIGURE 5

ENGINEERS IN INDUSTRIES BY ENGINEERING MAJOR



> The engineer's skills, working the many new materials and processes of tomorrow's technology, will bring to our lives many things now undreamed of. It is this conversion of military-space technology to other uses, through materials, methods, and processes, that will provide the basis for a dynamic, growing technology that in turn, will provide the economic base for an adequate space program. Already this process is well under way. In the past few years we have seen developments, from a drug for treating mental ills that was developed from hydrazine (a missile propellant), to heart valves, kitchenware, jet earth-drills, and exceptionally high-performance computers. (22)

Levels of responsibility.--The great majority of the engineers have followed the specific field in which they had received their training, have been in it ever since they left school, and likely will continue in it for the rest of their working careers. Many of them are in positions of importance and influence, as project leaders, supervisors, administrators, and executives, and have the responsibility of directing and controlling other people.

There are several methods for examining the level of responsibility achieved by the U.S.C. engineering graduates. Customarily, the entire population is divided into classifications and the results stated in simple statistical terms. Such an analysis is shown in Table 10.

Analyses such as these, however, are often misleading unless all of the factors are carefully considered. For example, the percentages of total respondents by years of experience as shown in Table 11.

TABLE 10

LEVEL OF RESPONSIBILITY

Classification	Work Subdivision	Per Cent of total
1	Work as an individual in a group	66.3
2	Supervise a minor group	13.8
3	Manage a major group or department	10.4
4	Plant manager or superintendent	1.6
5	Top executive or company officer	7.8
6	Private practice of engineering as an individual	0.1
		100.0

TABLE 11

DISTRIBUTION OF RESPONDENTS BY YEARS OF EXPERIENCE

Years of Experience	Per Cent of Sample	Cumulative Per Cent
0- 4	5.4	5.4
5- 9	22.2	27.6
10-14	27.5	55.1
15-19	15.1	70.2
20-24	11.5	81.7
25-29	9.0	90.7
30-34	4.3	95.0
35-39	1.8	96.8
40 and over	3.2	100.00
	100.0	

Since top executive positions are often achieved late in a man's professional career, the concentration of replies from the younger classes would obviously slant an

over-all breakdown toward those levels of responsibility normally held by the younger engineers. As examination of Table 11 demonstrates, seventy per cent of the respondents had less than twenty year's experience.

A much better picture of the levels of responsibility achieved by the U.S.C. engineering graduate with longer experience record may be seen in Table 12.

TABLE 12

LEVEL OF RESPONSIBILITY OF ENGINEERING GRADUATES WITH 20 YEARS OR MORE OF EXPERIENCE

Classification	Work Subdivision	Per Cent of total
1	Work as an individual in a group	40.6
2	Supervise a minor group	14.0
3	Manage a major group or department	16.2
4	Plant manager or superintendent	3.5
5	Top executive or company officer	24.1
6	Private practice of engineering as an individual	1.6
		100.0

Taken as a group, classification 3, 4, and 5 include all graduates who have managerial or executive responsibilities. These groups total 43.8 per cent of all mature engineers reporting.

Regardless of the forces at work in shaping the careers of these men, it would indicate that engineering education at U.S.C. has not produced narrow specialists

but rather has been the foundation for success in executive areas.

The opportunities for engineering students to obtain some business education as undergraduates vary greatly with the type of college or university. Within most of the engineering colleges there are some limited opportunities. Where the engineering college or school happens to be part of a university, there are usually greater opportunities.

W. G. Ireson, in an article in Mechanical Engineering, noted a new trend:

> Within the last three or four years a new trend has been developing which promises to make more opportunities for business education available to engineering students. A number of engineering colleges have introduced "administration options" into the regular mechanical, civil, electrical, and chemical-engineering curriculums . . . . The objective of this program, as stated by a number of department heads, is to prepare the engineering student who has no interest in research or design for a career in the administration of engineering work. (25:64)

O. S. Carliss, Director of Engineering for the Yale and Towne Manufacturing Company, in an ASME publication stated:

> In this technological civilization of ours, the executive must deal with humanistic problems, since the only tools with which he has to work are people, but he must be able to direct those people effectively if he is to do an efficient job. If the accepted traits of leadership, judgment, foresight, objectivity and dedication are to be used properly and effectively, the rigorous discipline of an engineering education, coupled with the scientific knowledge which forms a part of that discipline, becomes most important in

the development of a manager. (18:3)

A general distribution of changing responsibilities of the graduate engineer from his first job to retirement may be examined in Figure 6. Here the classes have been grouped as follows to make interpretation easier.

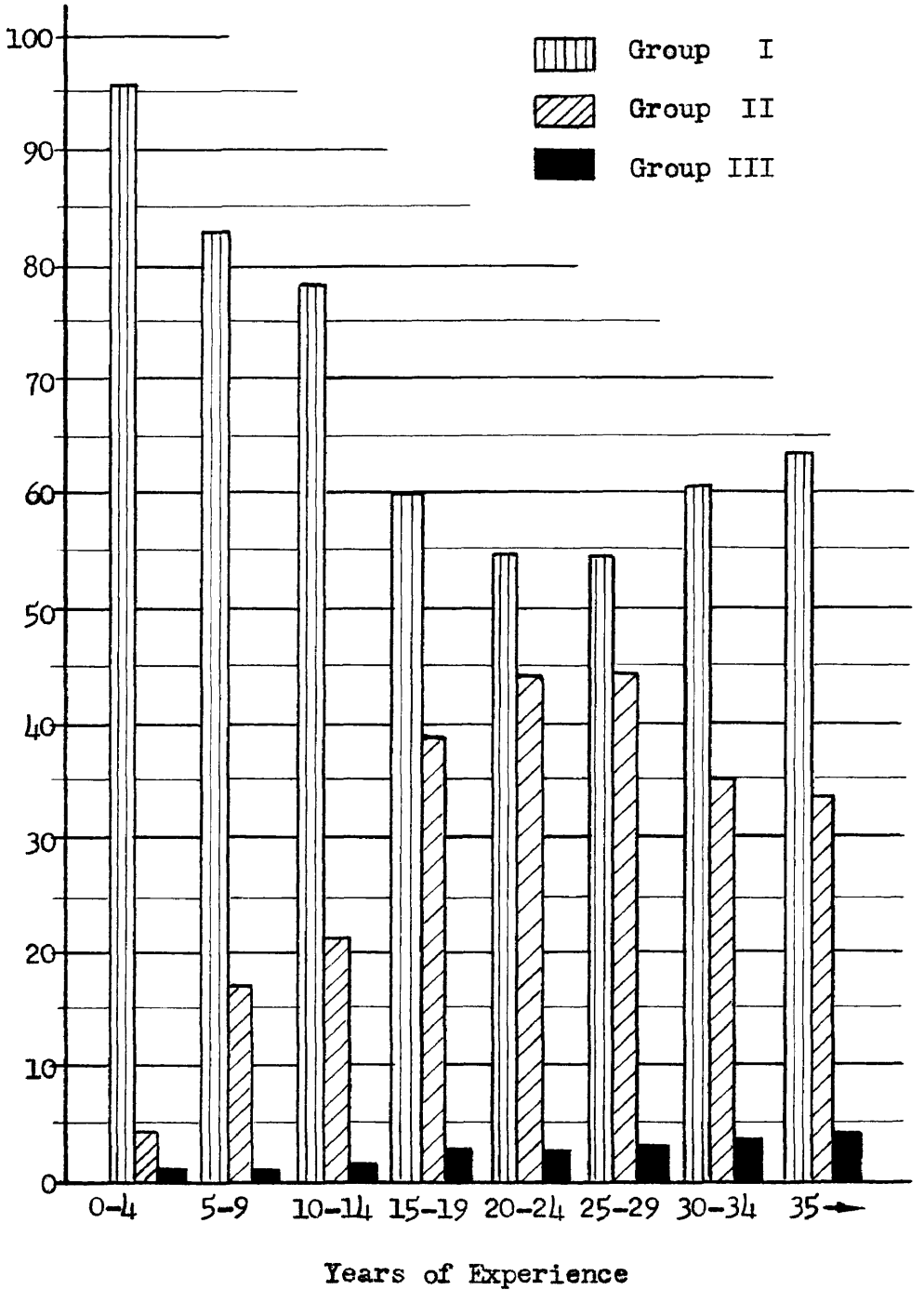
Group	I	Class 1	works as an individual in a group
		Class 2	supervise a minor group
Group	II	Class 3	manage a major group or department
		Class 4	plant manager or superintendent
		Class 5	top executive or company officer
Group	III	Class 6	private practice of engineering

As the young engineer starts his career he begins, normally, as an individual working in a group. Later, it appears evident that assistants are assigned to him and he supervises a minor group. Still later in his carrer, he begins to assume managerial functions from department supervision to top executive responsibilities.

It will be noted in Figure 6 that the number of those who have Group I responsibilities drop from about ninety-six per cent immediately after graduation to about fifty-four per cent twenty-nine years later. The rise in Group I responsibilities after thirty years or more

FIGURE 6

CHANGING LEVELS OF RESPONSIBILITY



evidently reflects the retirement from business fields of the U.S.C. graduates. At the same time, managerial and executive responsibilities move from three per cent on the first job to about forty-five per cent in the twenty-five to twenty-nine year experience area. Group II responsibilities after thirty years and more reflects the same drop as noted in Group I responsibilities. It is also interesting to note that Group III, the private practice of engineering, rises as the engineers gain experience, starting at less than one per cent immediately after graduation, it rises to about five per cent at career end. It appears that some of the engineers extend their period of usefulness and earning power after retirement from industry by entering private practice.

The low percentage figures indicating activity in Group III also highlight the reasons for difficulty in reaching the same kind of professional awareness among engineers as that found in the practice of medicine.

Without a doubt, some highly creative engineers now leave "strictly engineering" work and go into management simply to provide a better standard of living for their families. The fact that they can make this change so readily indicates the inherent power of their engineering education and their native abilities.

William B. Given, Jr., Chairman of the Board of the American Brake Shoe Company commented on this same

trend:

> Today, with progress in technology accelerating and with competition growing still harder, the number of engineers in management has increased amazingly. To use our company again as an example, in our top 25 positions there now are 15 men who are graduate engineers - well over half - and another 6 who have had engineering training in night school or through study at home. The same trend is going on in countless other manufacturing companies, large and small. (23:43)

Earned income.--Much has been written and much inferred about the engineer's earning power. Many of the discussions have centered around "median" or "average" earnings of engineers. This approach is questionable and in this survey a different method was employed.

Men who are at the upper decile of the earners have a totally different pattern than those at the lower decile. The upper quartile has a different set of forces shaping its pattern than does the lower quartile. Conclusions, therefore, must be drawn only after careful analysis is made of all the patterns in the various subdivisions of the population which responded to the questionnaire.

The overall view can be seen in Figure 7 and Table 13. Here the respondents are divided into upper decile, upper quartile, median, lower quartile, lower decile. For those not familiar with statistical techniques, this means that the upper decile had ten per cent of those who responded above it. The upper quartile had twenty-five

FIGURE 7

SALARIES OF U.S.C. ENGINEERING GRADUATES SHOWING DIFFERING TRENDS IN EACH SUBDIVISION OF THE POPULATION

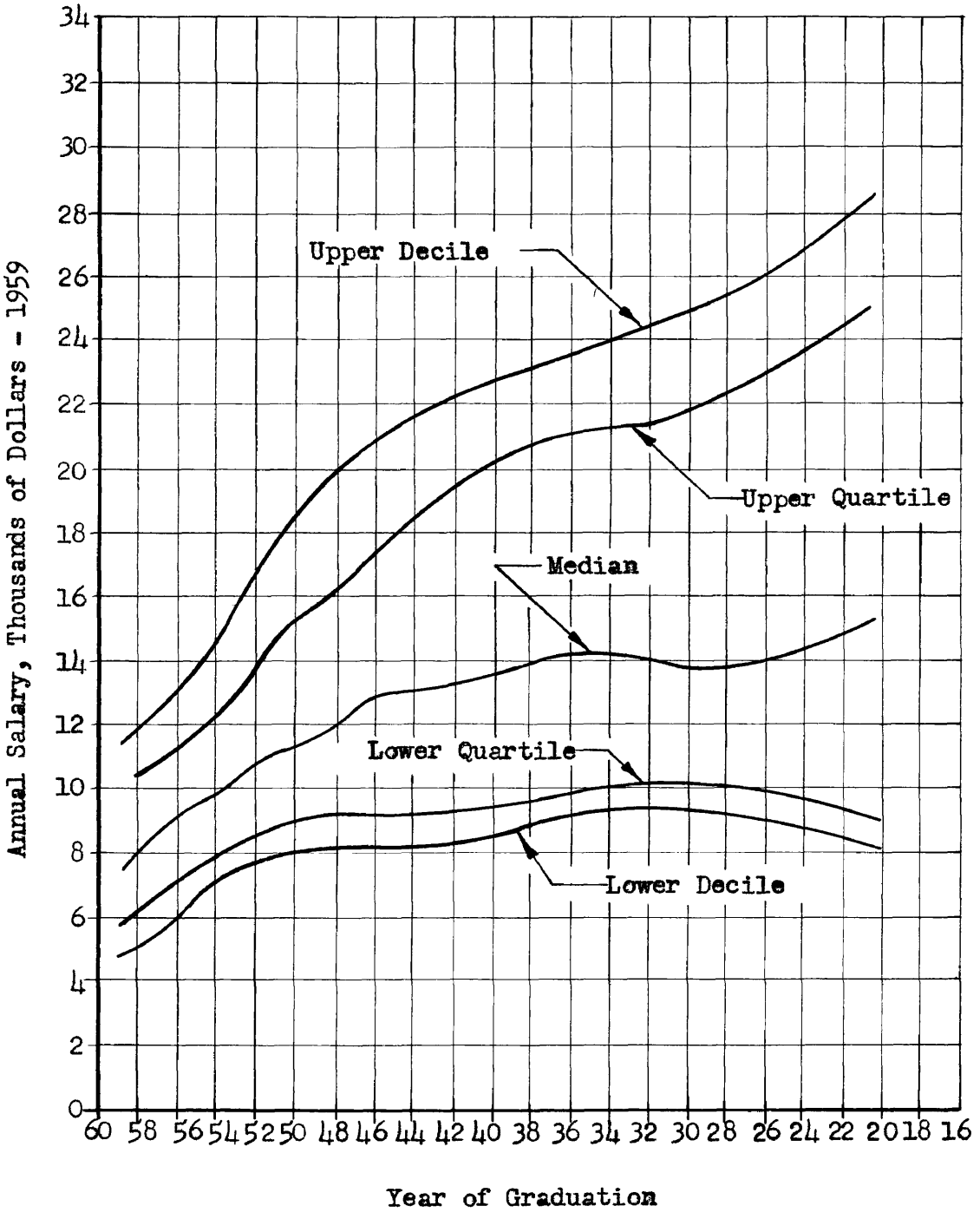


TABLE 13

SALARY SURVEY RESULTS

Grad. Year	Number Reporting	1959 Annual Salaries - Dollars				
		Lower Decile	Lower Quartile	Median	Upper Quartile	Upper Decile
1959	94	5,474	5,876	7,643	9,778	11,340
1958	89	4,117	6,046	7,746	10,311	12,941
1957	88	5,434	6,482	8,798	11,672	14,000
1956	108	5,748	6,667	8,902	10,814	11,620
1955	68	6,532	7,529	9,746	12,105	14,117
1954	80	7,787	7,925	9,801	11,775	12,462
1953	77	7,662	8,001	10,142	12,869	15,181
1952	111	7,130	7,718	10,765	15,223	20,542
1951	137	7,675	8,107	11,131	14,817	17,627
1950	184	8,290	9,002	11,334	14,652	16,927
1949	165	7,830	8,496	11,556	15,852	19,078
1948	112	8,405	9,192	11,747	15,685	18,642
1947	68	8,044	9,023	12,485	17,500	20,647
1946 1945 1944	61	7,967	9,059	13,913	20,318	24,918
1943 1942	52	8,115	9,092	12,955	19,153	24,153
1941 1940 1939	57	8,280	9,484	12,545	16,035	17,403
1938 1937 1936 1935	47	9,183	9,668	14,950	24,570	31,382
1934 1933 1932 1931	25	8,720	9,392	13,490	20,120	22,800
1930 1929 1928	14	9,965	10,494	14,150	18,902	20,471
1927 1926 1925 1924 1923	15	6,428	7,571	13,481	22,348	25,000
1922 1921 1920 1919	7	9,600	9,677	15,968	27,857	30,000

Notes:

1918 to 1908 - Numbers reporting were insufficient for statistical analysis.

per cent above it. The median line had half of the sample above it when the salaries reported were tabulated in ascending order.

In this study the four top salaries were omitted since they were received by students who had graduated in the earlier years when there were few graduates. The responses from these same groups were low. As a result these high salaries biased the upper decile and quartile and median averages for these periods. From 1946 to 1919 the responses for consecutive years are combined into groups as indicated in Table 13, in order to increase the stability of the data for comparative purposes. The curves shown in Figure 7 are trend lines (eliminating year-to-year fluctuations) but they serve to illustrate the difference.

The trends of the upper decile and upper quartile are more typical of professional people than are trend lines of the lower quartile and lower decile. Steadily advancing earning power through active professional life is not untypical of the professions. There are, however, those whose life's work has been chosen in government, teaching, or similar fields of endeavor in which ceilings are imposed which do not reflect the true worth of the job. The median line undoubtedly reflects the influence of such careers.

The lower quartile and lower decile trend lines

are typical of the earning curves of highly skilled technicians. They show rapid rise and an early leveling off of earning power with a decline in the later years.

It is always interesting to see the ordering of high salaries reported. This is shown in Table 14.

TABLE 14

THE TEN TOP SALARIES OF ENGINEERING GRADUATES

	Per Year		Per Year
1	$100,000+	6	$ 48,000
2	100,000+	7	35,000
3	92,000	8	35,000
4	75,000	9	32,000
5	50,000	10	30,000

Judging by the results shown in Table 14, there would appear to be no justification for the accusation sometimes made that an engineering graduate is doomed to a low ultimate salary.

Income comparison with all engineers.--No survey of this kind is complete without reference to the total population of which it is a part. The Engineers Joint Council (EJC) has prepared a report as a result of its surveys (8:15). The most vital comparisons between U.S.C. graduates and all engineers as reported by EJC are shown in Figures 8 through 12.

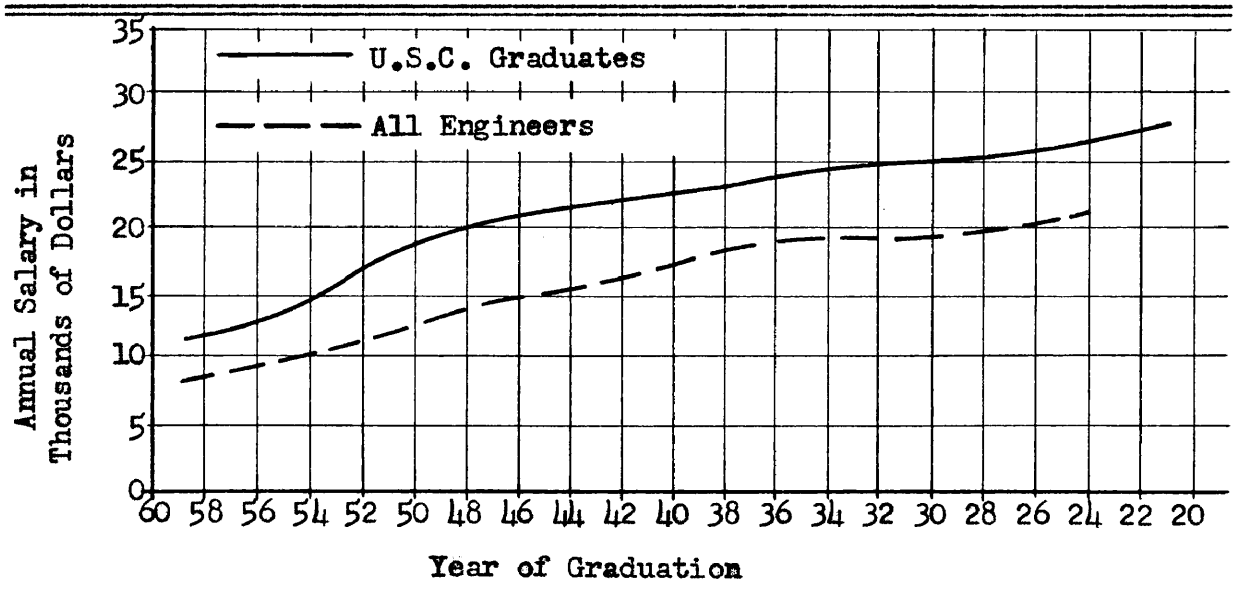
Figure 8 compares the upper decile earners only.

In all of the figures (8 through 12) the graduation years of 1959 through 1924 are all that are included, since the EJC report did not go back further than 1924, and the U.S.C. data from 1918 through 1908 were insufficient to draw comparisons.

In general, the U.S.C. graduate did better than the engineering population as a whole. In Figure 8 the trend line for the upper decile earners of U.S.C. parallels the EJC trend line rather closely. However, the upper decile earners of U.S.C. range about $5,000 a year better than the upper decile earners of all engineers between the years 1959 to 1924. EJC kept no figures over $21,200 a year so that their curves went off their chart for 1924.

FIGURE 8

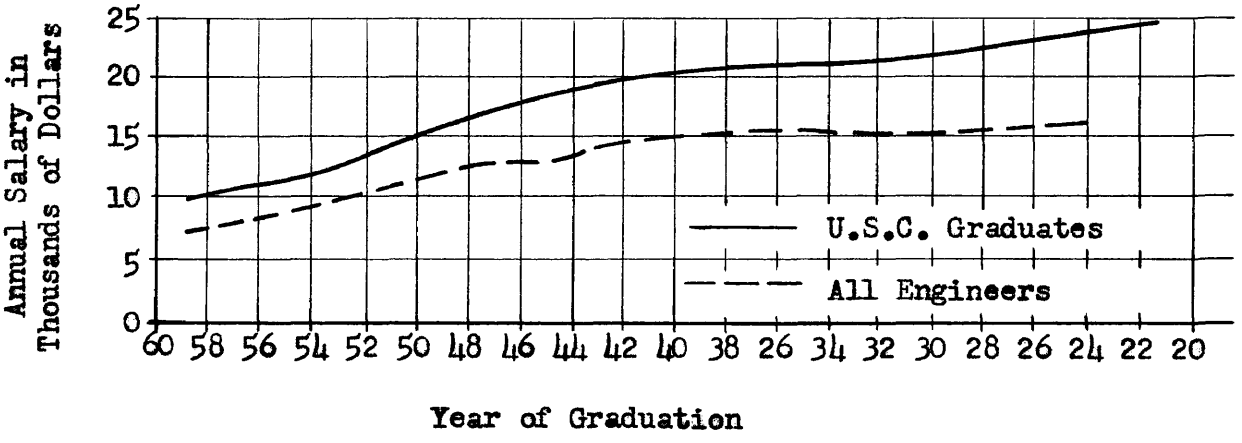
SALARIES IN UPPER DECILE



In Figure 9 the upper quartile earnings are compared. Here the U.S.C. graduates had from about thirty to fifty per cent higher earnings than all engineers as a group, depending upon the year of graduation. The tendency is for the salary difference to increase with experience.

FIGURE 9

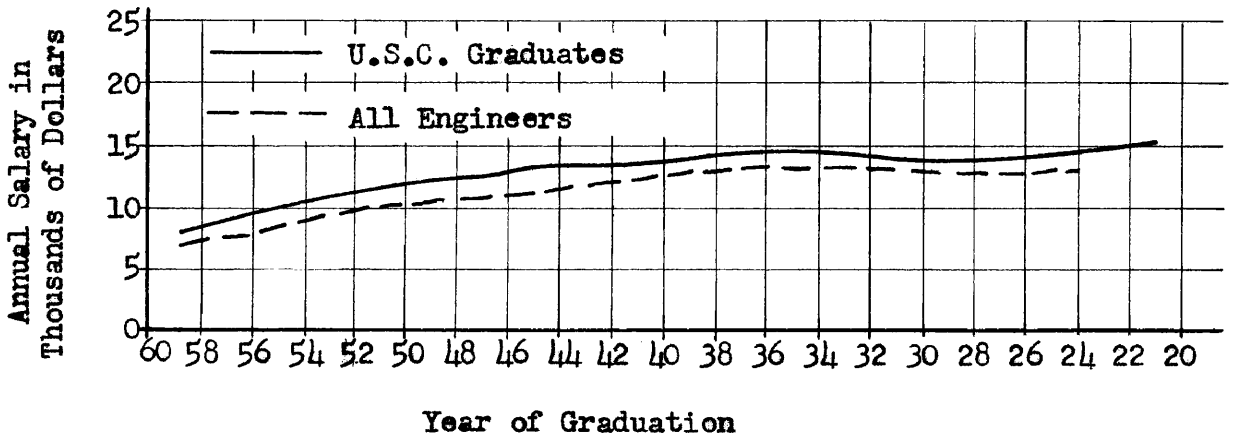
SALARIES IN UPPER QUARTILE



The pattern for the median parallels the trend for all engineers fairly close. Here the U.S.C. engineering graduate has better earnings than the typical median engineer in the EJC survey by eleven to nineteen per cent as noted in Figure 10.

FIGURE 10

SALARY MEDIAN



The gap closes as the lower earning engineers from U.S.C. are compared with the lower earners in the total population. At the start (first year after graduation), U.S.C. graduates earned five per cent less than the lower quartile engineer in the national figure. Thereafter, the U.S.C. graduates were below between five and seven per cent.

Lower decile earners from U.S.C. start at a lower earning level than the lower decile earners among all engineers. After five years the U.S.C. graduate climbs above for eight years then falls below for a ten year period. From 1938 the U.S.C. graduate stays above as shown in Figure 12.

FIGURE 11

SALARIES IN LOWER QUARTILE

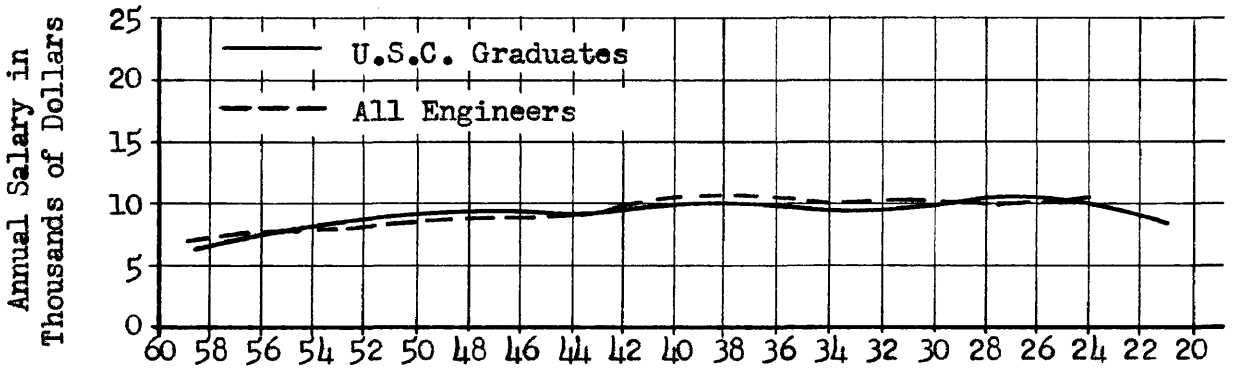
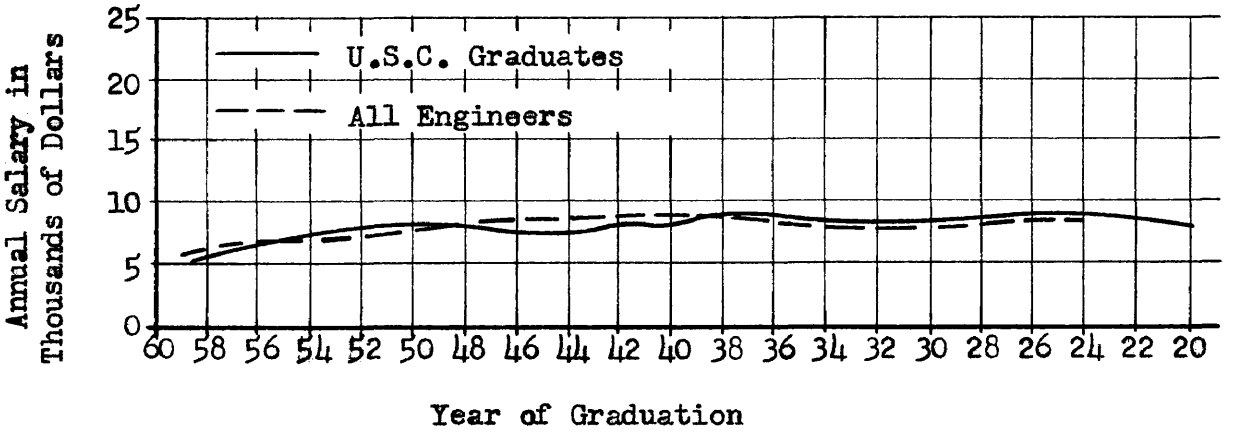


FIGURE 12

SALARIES IN LOWER DECILE



The engineering graduates of U.S.C. compare very favorably at all levels and do as good or better than the national average. The higher earners are outstandingly better than the high earners reported in the EJC survey.

Registered professional engineers.--Figure 13 shows the per cent of respondents who are registered professional engineers relative to receipt of their bachelor degree. Of the respondents 37.5 per cent were either engineers-in-training or professional engineers. The percentage of professional engineers increases sharply with years of experience. The low percentage noted in 1959 and 1958 is evidence of the rules and regulations governing registration by the State.

The State of California requires the applicant for certification as an engineer-in-training shall:

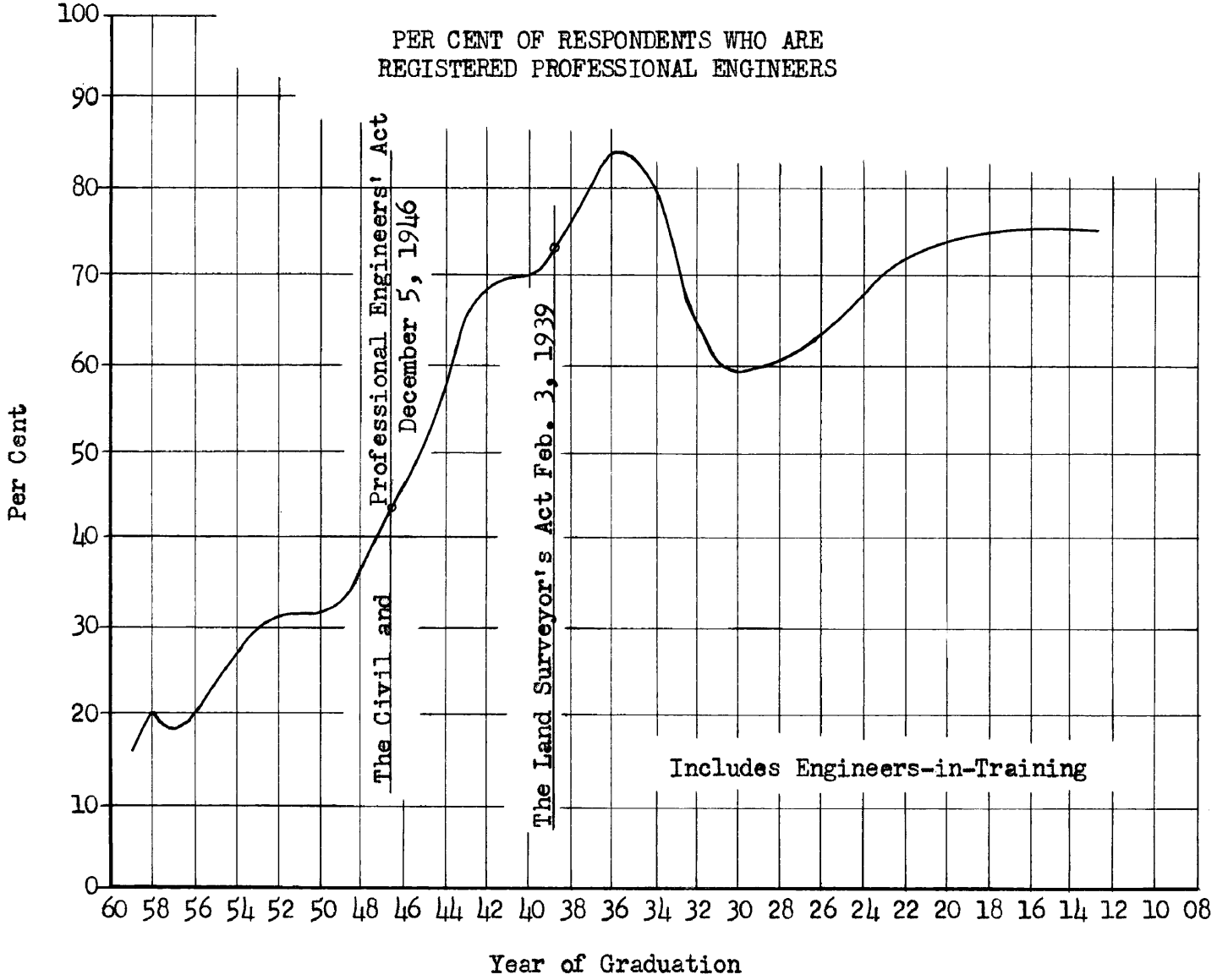
1. Be of good moral character;
2. Successfully pass an examination.

The application for registration as a professional engineer shall:

1. Be of good moral character;
2. Furnish evidence of six or more years of experience in Engineering work satisfactory to the board evidencing that applicant is competent to practice the character of engineering in the branch for which he is applying for registration, and successfully passing an examination. (13:11)

It is, therefore, possible for an engineer-in-training to obtain certification from the State at a

FIGURE 13


PER CENT OF RESPONDENTS WHO ARE
REGISTERED PROFESSIONAL ENGINEERS
Per Cent
100
90
80
70
60
50
40
30
20
10
0
60 58 56 54 52 50 48 46 44 42 40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 08
Year of Graduation
The Civil and Professional Engineers' Act December 5, 1946
The Land Surveyor's Act Feb. 3, 1939
Includes Engineers-in-Training

relatively early date after graduation.

Graduation from an engineering school or college where the curriculum has been approved by the State Board counts as four of the six years of experience required for registration as a professional engineer. Meeting this requirement of necessary experience is evidenced on Figure 13 by the increasing percentage that occurs from 1957 and earlier.

The Civil and Professional Engineer's Act became effective December 5, 1946. Persons actively engaged in the fields of engineering prior to this date and meeting the requirements were recognized as registered professional engineers without taking a State examination through a "Grandfather's Clause." This period is noted on Figure 13 and reflects the large number of applicants who took advantage of this clause.

The Land Surveyor's Act became effective February 3, 1939. This act made it mandatory that any person practicing land surveying in the State shall be licensed under this act. This State regulation caused another increase in the ranks of the registered professional engineers.

Prior to 1930 the number of engineers graduated each year was relatively small and represent alumni with many years of experience. As a consequence the effect of a few respondents who were registered professional

engineers created an artificial high per cent.

CHAPTER IV

COMPARISON OF THE 1953 AND 1959 SURVEYS

Organization of Questionnaire

The form of the questionnaire used is shown in Appendix A. The information requested was simple and direct. This approach was intentional, since it was desirous to make it easy to answer. There were no follow-up letters used to force a high response percentage. The fifteen items when fully answered permit a highly detailed analysis of the graduate engineer, showing where he has located geographically, how he is being utilized, area of technology and economic progress.

Objective of the Survey

Alumni directory.--The original basis for the 1959 survey of engineering graduates was to obtain data to update the alumni directory which was first formulated on the replies and data received in the 1953 survey. The directory is divided into the seven major departments, Chemical, Civil, Electrical, General, Industrial, Mechanical and Petroleum engineering. Within each of these divisions the graduates are listed alphabetically, with home address, degree and year graduated, company affiliation and address and job title. It was in the

preparation of the directory where the information obtained from the survey proves valuable.

Graduate program.--A survey of this nature provides a contact between the graduate and the school and is a formal means whereby the former student can inform his alma mater on the progress he has achieved. The school is afforded an opportunity to see the results that have been achieved from its training. One of the gratifying aspects of teaching is the success achieved by one's students. The success of the graduates can benefit the University as a whole.

1953 - 1959 Surveys

Scope.--The first survey of engineering alumni was made in 1953 and covered the students who had graduated in the period from 1907 to and including 1953. The second survey also covered this same period and in addition the engineering graduates to and including those from 1959. In this period which includes the alumni of 1954 to and through 1959, 2,576 additional students received their degrees from the School of Engineering.

Advanced degrees.--It is significant to note as shown in Table 3, that during this same period, 1,047 of these degrees were presented by the School of Engineering for advanced work which indicates the increasing emphasis being given by students to graduate study.

High lights of the 1953 - 1959 surveys.--The following presentation gives a direct comparison between the results of the 1953 and 1959 surveys in the known areas of the 1953 survey which were available. These results are shown in Table 15. Points of interest are the increases in the number of employers, job titles, and specialities in which these graduates are engaged. The increase in the number of employers appears to be the result of two forces; (1) the increasing number of engineers graduated by the school and now in industry, (2) the large increase in the variety of businesses which have come into existence.

The increases in job titles and specialities reflects the broadening of the engineering field to cover the wider horizons of effort that is required. Elmer J. Tangerman, editor for Product Engineering, explains this concept in one of his editorials:

> Our tremendous recent advances are apparently in the nuclear, missiles and space areas - it's from them that most of the publicity emanates. In actuality, our economy is advancing because of thousands of less - publicized developments, because of thousands of products now available that weren't even heard of a decade ago. The "big push" results from growth industries like titanium sponge, transistors and transducers; servo-mechanisms like power steering and brakes; TV sets; plastics like polyethylene, styrene and synthetic fibers and rubber; electrical appliances like can openers, hair dryers, coffee makers, shavers, air conditioners, stereo tape recorders; power tools like lawnmowers, hay balers; and chemicals like the antibiotics. No single one can claim the credit; these are just the fastest growing fields among dozens. But note that everyone resulted

TABLE 15

GENERAL AREAS OF COMPARISON BETWEEN
THE 1953 - 1959 SURVEYS

Areas of Comparison	1953	1959
Questionnaires sent out	4500	6000
Replies	1913	3456
Chemical Engineers	195	273
Civil Engineers	435	796
Electrical Engineers	425	873
Industrial Engineers	182	256
Mechanical Engineers	557	1064
Petroleum Engineers	119	194
Employers	671	930
Major industry (35)	89	125
Job titles	148	338
Specialities	195	509
Oldest reply	1907	1908
Per cent replies	42.5	57.6

Notes:

General engineers are included with the industrial engineers.

from research, most of it intentional.

> This is a phenomenon of our time-planned and organized research rather than the hit-or-miss approach of the old-time lone inventor. The phenomenon is made even more phenomenal by the billions of dollars being poured in each year. Some of it will inevitably go down the drain, but some will contribute to an increasing flood of new products, new processes, new materials. (33:53)

An increasing trend is indicated of the graduates going into the major industries of our country. These major industries account for more than half the sales of all U.S. manufacturing and mining companies, and for more than seventy per cent of the profits.

Table 16 gives the percentage of graduates replying who are engaged in research, development, and design, and in other activities.

TABLE 16

GRADUATES IN RESEARCH, DEVELOPMENT, DESIGN AND OTHER ACTIVITIES

Occupation	Percentage of Population	
	1953	1959
Graduates engaged in research, development, and design	52.1	39.3
Graduates engaged in other activities	47.9	60.7

Here the trend between the two surveys reflects a strong reversal in graduate engineer's activities.

Time sent questionnaires to one-sixth of those listed in Who's Who in Engineering. Administration, finance, and management were checked by sixty-three per cent of these engineers as areas in which they have occupational responsibilities (29:339). The results of the Time survey compare closely with the answers obtained in the 1959 survey.

The loss of engineers from the areas of research, development, and design is explained by an officer of Union Carbide who states:

> The success bug bites our young fairly early in the game . . . although we provide lines of professional advancement parallel to the lines of advancement in the administrative echelons, many of our young scientists and engineers are convinced that only the administrative positions will reward them financially and with prestige in accordance with their ambitions. We take pains to show them that this is not necessarily so, but if they persist and and are entitled to a shot at being a member of the management team, we give it to them. (31:81)

Table 17 tabulates in percentages the type of work being done by the graduates of each department and also shows two contributing factors for this trend reversal: (1) the increasing use of engineers in management, (2) the significant decrease of graduate engineers in the field of design.

The large increase by the"Composite" department in the area of research and development reflects the utilization of these more highly trained personnel in basic engineering. The general concept of design is

TABLE 17

GENERAL TYPE OF WORK BEING DONE BY GRADUATES FROM THE SIX BASIC DEPARTMENTS

Department	Percentage of Population							
	Research & Development		Design		Operations		Management	
	1953	1959	1953	1959	1953	1959	1953	1959
Chemical	24.8	42.7	17.1	1.7	22.5	18.0	35.6	37.6
Civil	10.2	17.3	52.0	3.5	14.8	27.9	23.0	51.3
Electrical	24.1	55.7	31.3	1.0	17.8	12.2	26.8	31.1
Industrial	7.1	11.7	7.1	0.5	31.8	25.8	54.0	62.0
Mechanical	26.4	41.5	34.4	1.6	12.3	15.4	26.9	41.5
Petroleum	26.1	29.1	9.0	0.0	33.3	33.8	31.6	37.1
Composite	20.3	58.0	31.8	1.6	18.3	11.0	29.6	29.4

Notes:

The "Composite" department includes the engineering graduates with more than one degree.

working on a drafting table and generating layout drawings. Graduate engineers starting in design usually serve only an apprentice type of period on the board. It is easier for these college trained engineers to be utilized in other areas of engineering such as research, development, operations, and management. The industrial engineers still maintained their higher probability of going into management as was also the case in the 1953 survey. Table 17 shows an increasing tendency for the utilization of engineers in management positions. There

are a number of reasons for this trend, which probably can be best summed up by quotes from experts in the field.

Guy R. Cowing, in an article on this subject has cited a statement made by Mr. Sloan* of General Motors Corporation.

> Sloan stated that it is not only employers who regard engineers as a group of brains rather than individuals. The public also has failed to understand the broadened scope of the engineer's activity during the last generation, which has seen the engineer move out of his technical boundaries to assume responsibilities of management and leadership of our economic, social, and national affairs. (20:648-49)

In 1953, Houston listed the following points about the engineer's education as a factor for top management positions:

1. The increasing importance of technology in our growing economy.
2. The excellent background engineering studies afford for other professions, by training a person to think and to organize one's work.
3. The insight and understanding of the world around them gained by engineering studies. (30:70)

Table 18 shows a few of the important positions held by those alumni who sent in their information cards. An increased number of graduates in these top positions was expected since the survey covered a larger population and eighty per cent more replies were received. However,

---

*Mr. Sloan was Chairman of the Board of General Motors Corporation.

TABLE 18

IMPORTANT POSITIONS HELD BY THE ALUMNI REPLYING

Position	Ch E		C E		E E		I E		M E		P E		Total	
	1953	1959	1953	1959	1953	1959	1953	1959	1953	1959	1953	1959	1953	1959
Chairman of the Board	1	..	2	..	..	..	..	..	..	..	..	..	3	..
President	4	10	4	23	3	12	1	9	5	18	..	6	17	78
Vice President	2	4	8	23	7	12	2	13	6	19	2	6	27	77
Chief Engineer	5	7	6	11	19	8	4	7	11	31	2	1	47	65
Consulting Engineer	1	1	2	10	2	7	..	1	6	3	..	3	11	22
Manager or Ass't. Manager	16	25	17	43	22	63	20	37	28	75	6	21	109	263
Owner or Partner	5	14	23	91	12	32	3	23	18	44	7	..	68	204
Project or Plant Engineer	7	11	2	29	18	39	2	8	27	65	2	2	58	154
Professor	1	0	6	5	4	5	..	2	3	4	..	0	14	16
District Engineer	4	1	5	11	2	1	1	..	..	1	6	14	18	28

in seven of the ten positions listed the increases were considerably greater relative to the increased number of replies in the 1959 survey. This increase of U.S.C. engineers in these top positions reflects the trend in utilization of engineers at the management level.

In 1946 the Engineers Joint Council reported on a survey of approximately 38,000 members of six principal national engineering societies. The percentage distribution of engineers among twenty-nine occupational fields listed showed that thirty-four per cent were engaged in administration and management. A survey in 1939 showed 25.3 per cent in this field, the 1943 survey was 29.6 per cent. An increasing trend of engineering activity in administration and management is indicated (17:322).

Rensselaer Polytechnic Institute, in 1949, questioned 561 executives in large industries and reported that (1) ninety-four per cent of managers who have an engineering background, and (2) among the respondents to the survey, thirty-nine per cent of the executive and management positions were held by engineers (29:339).

Gottshall enumerated some of the percentages and numbers of engineers in management. For example, presidents of six U.S. Steel subsidiaries, ten out of twenty presidents of the affiliate companies of American Telephone and Telegraph, over twelve board members of Standard Oil of New Jersey, fifteen top executives of

Anaconda Copper, and ninety per cent of the top executives at Union Carbide are engineers. At that, engineers represent less than one per cent of the entire population of the United States (24:403).

A questionnaire type survey taken in 1956 of the incomes and salaries of 40,000 professional engineers showed that thirty-six per cent of the 17,045 respondents were engaged in executive and administrative work (12:32).

Fortune sent questionnaires to 1,700 top executives covering 834 of the leading companies in the United States. They found:

> The men now bossing the countries biggest business are newcomers to their jobs (half of those in the highest echelons of management have been there less than six years).
>
> They took a long time climbing to the top in their companies (typically, twenty-two years). Their stay from here on will be comparatively short one; their average age is fifty-eight and most of them will be retiring by sixty-five.
>
> They work some fifty-two hours a week and considering the fact that they are responsible for nearly $500 billion of assets, get surprisingly little pay (52 per cent of them earn less than $75,000 a year, 24 per cent make less than $50,000, 2 per cent make less than $25,000).
>
> Those who stayed put have in the main made out better than those who moved around. Those who have been with the same company throughout their careers have a median compensation of roughly $80,000 compared to the job-jumping median of $72,000.
>
> The bigger the company the better the pay: median compensation for executives in companies with sales under $100 million: $59,000 a year; in companies with sales of $250 million to $500 million: $89,000 a year; $1 billion and over in sales: $150,000 a

year.

> Their academic studies were predominantly "practical" ones: 85 per cent of the graduates majored in law, business, economics, engineering, or science. 39 per cent majored in science and engineering, and rank this field ahead of business and economics in popularity.
>
> At the outset of their careers, most of the 1,700 were employed in specialized activities. Finance was the most popular beginning field: 18 per cent of the executives chose that, with engineering (17 per cent) a close second. Law was the first job after school for 9 per cent of the group; research for roughly 4 per cent and teaching for about 2 per cent. Only 6 per cent of them got their start in general administration, though this was ultimately to be the area in which more than a third would spend the greater part of their business life. (37:138-139)

The referenced surveys on the utilization of engineers in administrative and management positions cover a period from 1939 to and including 1959. The per cent of engineers utilized in administration and management as noted by these surveys runs from 25.3 per cent to 39.0 per cent. The U.S.C. 1959 survey shows 31.6 per cent of the engineering graduates in similar positions. A summary of these surveys is outlined in Table 19.

The recording of 31.6 per cent by the U.S.C. survey can be considered rather surprising since it is based entirely on a population comprised of only engineers and includes a majority of graduates with less than thirteen years experience, whereas, the other surveys canvassed a population of engineers who had achieved sufficient professional stature to belong to engineering

societies and those executives who had already reached the top. The Fortune survey is not entirely comparable to the U.S.C. survey since the former included both engineers and scientists.

TABLE 19

UTILIZATION OF ENGINEERS IN ADMINISTRATIVE AND MANAGEMENT POSITIONS

Year	Per Cent in Administration and Management	Survey Conducted by	Population Surveyed
1939	25.3	E.J.C.*	
1943	29.6	E.J.C.	Six Principal National Engineering Societies
1946	34.0	E.J.C.	
1949	39.0	Rensselaer	Executives in Large Industries
1956	36.0	———	Professional Engineers
1959	39.0	Fortune	Top Executives of Leading U.S. Companies
1959	31.6	U.S.C.	U.S.C. Engineering Alumni

Notes:

*E.J.C. is abbreviation for Engineers' Joint Council.

Table 20 is a review of the alumni who have achieved important positions. It should be noted the total numbers are the same as the totals for 1959 in Table 18. Approximately one out of five in these positions

TABLE 20

ADDITIONAL DEGREES AND REGISTERED PROFESSIONAL ENGINEERS AMONG THE IMPORTANT POSITIONS HELD BY THE ALUMNI REPLYING

Position	Total Number	Number That Have Additional Degrees	Number That Are Registered Professional Engineers
		Per Cent	Per Cent
Chairman of the Board	0	0.0	0.0
President	78	18.0	50.0
Vice President	77	13.0	48.0
Chief Engineer	65	27.7	58.5
Consulting Engineer	22	45.5	77.0
Manager or Assistant Manager	263	20.5	36.0
Owner or Partner	204	20.0	56.0
Project or Plant Engineer	154	24.0	40.8
District Engineer	28	10.7	60.7
Average		22.4	53.4

have additional degrees. Better than one out of two are registered professional engineers. It is interesting to note that the consulting engineer, who possibly ranks highest in professional status is noticeably higher in percentages with additional degrees and registered professional engineers.

Little benefit in promotion is derived from a Professional Engineer's license, since employers promote engineers mainly on the basis of the performance of their duties and rarely on the basis of knowledge of their jobs. However, having a Professional Engineer's license is a "must" in those job functions requiring it in order to safeguard life, health, property and public welfare.

People are not fully educated the day they graduate from college. Education is a continuing and irreversible process - each day we must learn a little or die a little (18:3).

C. C. Furnas, Director Cornell Aeronautical Laboratory, has stated:

> Education should be a continuing function, and university work should not end with graduation. After the formal education is completed, educational institutions should follow it into industry or commerce. (21:28)

In this study approximately one out of five of the persons in important positions had additional degrees. With odds this low, it appears to be to one's economic advantage to improve his chances for personal and

financial success to continue beyond the original bachelor degree.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The survey questionnaire responses show, from the large number of employers listed and variety of job titles noted, the increase in industrialization, especially in the western part of the United States, and the diversification which has occurred in business. The birth of new technologies such as nucleonics, computers, missiles, electronics, space and aeronautics have opened new fields for engineers to explore and conquer. The sphere of the engineer has been expanding and changing at an astonishing rate. Engineering education is also regarded as an excellent preparation for living in a technological world. Not to be deplored is the fact that many engineers go into technical sales, management, and many other important functions in the staffing of our complex industrial enterprises. The results of this survey agree with other studies cited herein of the trend for utilization of engineering trained personnel in management or administration positions.

One of the surprising results of the survey was the low number of graduates in the field of design. It is evident that the area of design known as "on the board"

is staffed heavily by personnel classified as technicians. Many of these employees have one, two, and three years of college training. Another reason why the number of graduates in design, in this study, is low, is due to job titles which do not easily define the type of work. A person can be working exclusively in design and have a title such as temperature control engineer, ground support engineer, development engineer, etc. The author of this study has been in the area of production design for twenty years; my title is Engineering Group Leader, Environment Systems. I am on the management team. For the questionnaire item titled "Present work" I filled in, "technical management."

It appears that many of the young engineers are convinced that only the administrative positions will reward them financially and with prestige in accordance with their ambitions. As a result many research-minded men are wooed right out of their natural profession and into the mediocrity of middle management.

There is no excuse for the "engineers for engineering only" attitude which has prevailed. There is no better education for living in a complex technological world than a properly broadened engineering education. Quantitative thinking is the keystone, and engineering practice the structure, upon which much of America's standard of living is and will continue to be based.

Numerous comments added at the foot of the returned questionnaires reveal a strong concern with such matters as being informed on how their own progress compares to the other graduates, belief that they would have been better prepared with more courses in humanities, importance of a more thorough training in English, and a variety of opinions to cure some of the ailments or solve some of the problems related to the professional status. According to the comments, these engineers have noted their weakness in expressing themselves in writing and public speaking. This need becomes even more obvious as the engineer gets into administration, management, and sales. Consideration is required by the employer of the trend in utilization of engineers in administration and management positions in planning future engineering manpower needs.

An increasing number of engineering graduates are returning to school and taking advanced work. Degrees presented for advanced study during 1959 represent almost fifty per cent of the degrees earned. In 1959 three of the seven engineering majors--aeronautical, electrical, and petroleum--had as many or more students doing graduate work as were working for their bachelor's degree. The more interesting aspects of this wave of graduate effort is that it is being done by persons already gainfully employed and in many instances a number of years

after having earned their initial degree.

Conclusions

The objective of this study which concerned the alumni was to discover what the engineering graduates are doing. The conclusions which follow consider this objective as well as other information highlighted by the data so as to provide concrete basis for decisions.

Over three-fourths of the engineering graduates stay in Southern California, the home of their alma mater. This provides a reservoir of prospective candidates for graduate study.

Recent years have seen sharp increases in graduate-level enrollments, which now accounts for approximately half of the engineering enrollment total. This trend reflects the need for greater training due to technological advances and the aid and benefits made available to employees by industry in this area.

A very high percentage of the engineering graduates pursue a career in engineering or engineering functions throughout their active working years. The fact that many were employed in a field of engineering other than their degree area suggests that the specific curriculum provided versatility of training: i.e., graduates were able to move into one or more specialty areas other than the one in which they received their

degree.

The large influx of engineering students began in 1946. The significance of this date is the ending of hostilities of World War II. Better than fifty-five per cent of the respondents graduated since 1946 and have accumulated between 0 - 14 years of experience. Within five years after graduation better than ninety-five per cent of the alumni were engaged as an individual in a group or supervising a minor group, a fact which suggests that engineers are employed in capacities consistent with their training.

The fact that 25 - 29 years after graduation approximately one out of every two graduates was engaged in management, either technical or non-technical, suggests that the college training and subsequent job experiences provided engineers with the background to serve in leadership roles of a technological and fiscal nature. The trend of engineering activities from research, development and design continues strong as evidenced by the twenty-seven per cent increase of graduates engaged in other activities within the last six year period.

When job title is used as the criterion for measuring success it must be concluded that the U.S.C. engineers are successful in their chosen field. This was emphasized by the fact that twenty years after graduation approximately sixty per cent of the graduates were in a

supervisory and higher position of responsibility. Approximately one out of every four alumni was a top executive or company officer.

If salary is used as the success criterion the U.S.C. engineers are above average. Beginning with the first year after graduation, the alumni salaries exceed the national average for all engineers and in almost all instances stay above this average in future years.

Inasmuch as a large number of engineering graduates are predictably headed toward administrative and management duties, colleges are faced with the need to give such students a basic training in business and management. Numerous factors have accounted for this trend, from more complex product technology to the increasing use of statistical techniques in business. Indeed it might be argued that the very importance of conceptual skill in top management favors men who are disciplined in analytical and abstract thinking, as engineers are. Because of their broader concept of what business and management want, such engineers will be valuable to their employers since all through the ranks of management there has grown a need for personal assistance from engineers. The legal staff needs advice of an engineer on patents or in negotiations; the accounting department needs help from engineers on costs and time study; salesmen need to be able to talk with

purchasing agents who are engineers; advertising people need to be able to write in the language of engineering; and so on. Also, the analytical approach of the engineer is becoming increasingly valuable for many specialized business problems such as market research, product planning, and forecasting.

Long term opportunities and recognition count most in an engineer's decision to get into administration, management, and other areas such as sales. Management should set up a program which will make it equally advisable and advantageous for the engineer to proceed along technical and management pursuits.

In education and industry there are a number of "purists," who believe that engineers should stay in engineering and that those who go into management are "lost souls." The best answer to the "purists" it seems to me, is the experience of the many engineers who have gone into management and found success as well as greater personal fulfillment. It is my firm conviction that in a world where the scientific achievements exceed Disraeli's wildest imaginings the engineering school provides the young men with the wealth of experience they need to manage - for the best use of mankind - the developments yet to come.

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A P P E N D I X

APPENDIX A

THE QUESTIONNAIRE

QUESTIONNAIRE

1. Name
2. Street
3. City, Zone, State
4. Home telephone and business
5. Name and street address of employer
6. City, Zone, State
7. Your title
8. Your present specialty
9. Present work: Research ☐ Develop. ☐
   Tech. Mgmt. ☐ Gen. Mgmt. ☐
   Operation ☐
10. Registered prof. engineer in state
11. Approx, salary if wish to state
12. Year graduated and major
13. Highest degree at USC and year
14. Highest degree elsewhere and year
15. Institution

APPENDIX B

All information contained on the three thousand four hundred and fifty-six replies was coded and transferred to cards such as shown by this exhibit. Computations were made from these cards.