DOCUMENT RESUME

ED 022 020 08 VT 004 907

By- Lee, Arthur M.

ENGINEERING AND TECHNOLOGY IN ARIZONA; A REPORT ON THE EDUCATION OF ENGINEERS, TECHNICIANS, AND SKILLED CRAFTSMEN AND THE EDUCATIONAL NEEDS OF INDUSTRY.

Arizona Occupational Research Coordinating Unit, Phoenix.; Arizona State Dept. of Vocational Education, Phoenix.

Spons Agency- Office of Education (DHEW), Washington, D.C.

Bureau No- BR-6-3029

Pub Date 68

Grant- OEG-4-7-063029-1595

Note- 288p.

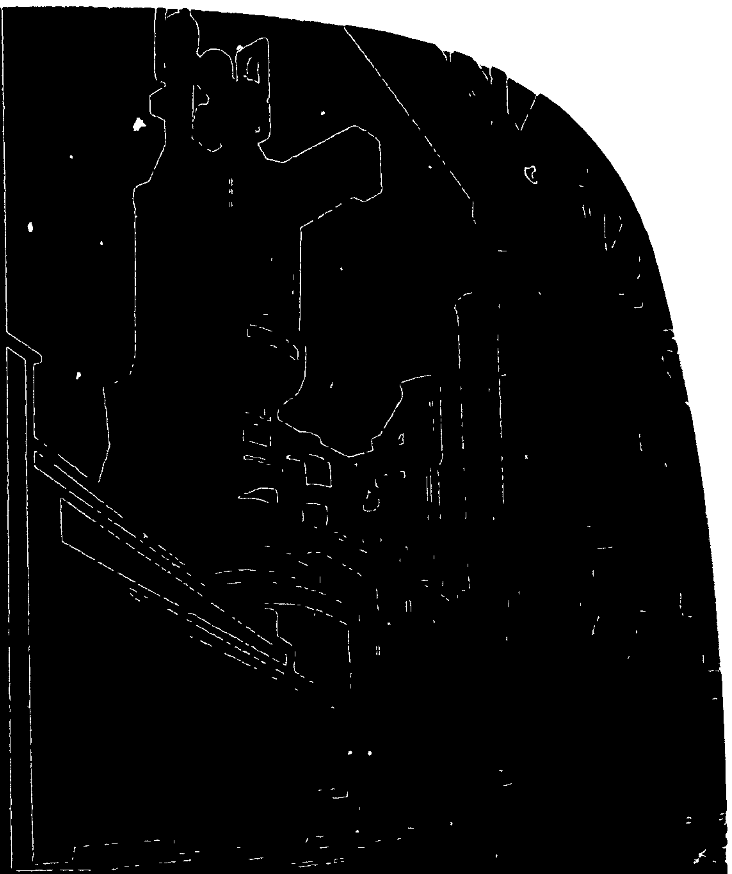
EDRS Price MF-$1.25 HC-$11.60

Descriptors- *EDUCATIONAL NEEDS, EDUCATIONAL PLANNING, EDUCATIONAL TRENDS, EMPLOYER ATTITUDES, EMPLOYMENT QUALIFICATIONS, ENGINEERING EDUCATION, *ENGINEERS, INDUSTRY, *OCCUPATIONAL INFORMATION, OCCUPATIONAL SURVEYS, PROGRAM DESCRIPTIONS, QUESTIONNAIRES, SCHOOL SURVEYS, *SKILLED OCCUPATIONS, *SUBPROFESSIONALS, TECHNICAL EDUCATION, TRADE AND INDUSTRIAL EDUCATION

Identifiers- Arizona

Data are provided to help educators plan educational programs for engineering, technical, and skilled occupations based on the needs of industry. "State of the Art" outlines the existing educational system and identifies problems and needed changes. "Educational Resources" describes the course offerings of secondary and postsecondary schools and colleges in the state and reports a student survey. "A Survey of Industry" reports the findings of a survey of 580 employers and 3,926 employees in 36 occupations which sought to identify major and minor job functions. "Occupational Profiles" contains 30 profiles of occupations giving educational level, knowledge and skill requirements, personal characteristics, previous experience, and salary range. These profiles were developed on the basis of the industrial survey. "Advice from Industry" presents suggested improvements for current educational programs from employers. "Industrial Development in the Decade Ahead" discusses Arizona's manpower requirements and projections for engineering, technical, and skilled manpower. "Educational Changes and Trends" reviews related educational literature. Recommendations, a sample questionnaire, and a bibliography are also included. (EM)

ENGINEERING and TECHNOLOGY in ARIZONA



A report on the education of engineers, technicians and skilled craftsmen and the educational needs of industry

by Arthur M. Lee

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A report on the education of engineers, technicians and skilled craftsmen and the educational needs of industry

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NORTHERN ARIZONA UNIVERSITY
Flagstaff, Arizona

1968

Library of Congress No. 68-63910

This report was prepared by
OCCUPATIONAL RESEARCH COORDINATING UNIT
SCHOOL OF APPLIED SCIENCE AND TECHNOLOGY
NORTHERN ARIZONA UNIVERSITY

with assistance from
U.S. OFFICE OF EDUCATION
Grant No. OEG-4-7-063029-1595
and
ARIZONA STATE DEPARTMENT OF VOCATIONAL EDUCATION
J. R. CULLISON, DIRECTOR

Special assistance and facilities of Northern Arizona University
were generously contributed under the direction of
CHESTER B. AINSWORTH, DEAN
School of Applied Science and Technology.

Collection of the data and preparation of the report
were carried out by the
Occupational Research Coordinating Unit
ARTHUR M. LEE, DIRECTOR
with the voluntary assistance of
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who served on two panels associated with this project
listed on the following page.

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In addition to the expert knowledge provided by the two panels, numerous other individuals were generous in their assistance and counsel. Included among these are: Dr. Howard S. Coleman, Dean of Engineering, U of A; Dr. James Donald Forrester, Dean, College of Mines, U of A; Dr. Richard Edwards, Assistant Dean, College of Mines, U of A; Dr. Lee P. Thompson, Dean, College of Engineering Sciences, ASU; Dr. George C. Beakley, Jr., Assistant Dean, College of Engineering Sciences, ASU; Dr. Edward F. Shaifer, Jr., Chairman, Construction Department, ASU; Dr. Walter C. Brown, Professor of Industrial Education, ASU; Dr. Ian Braley, Professor of Engineering and Technology, NAU; Dr. John W. Glenn, Associate Professor of Industrial Education, NAU; Mr. Robert B. Beeman, Manpower Research Supervisor, Arizona State Employment Service; Mr. William J. McGinn, Supervisor of Data Processing, State Department of Public Instruction; Dr. Daniel Noble, Vice Chairman of Board of Directors, Motorola, Inc.; Mr. Leo Contois, Manager, Employer Relations, General Electric Company; Mr. R. W. Field, Manager New Business Development, Arizona Public Service Co.; Mr. Bert Fireman, Executive Vice President, Arizona Historical Foundation.

The chambers of commerce of Phoenix and Tucson provided valuable aid in encouraging participation of their members in the industrial survey. The interest and encouragement of these additional organizations was also particularly helpful: Arizona Development Board; Joint Committee on Economic Development; and the Certified Technicians of Arizona.

The Industrial Survey was conducted by a staff under the direction of Carl Squires, Department Chairman of Applied Science and Technology, Glendale Community College, and included: Joseph Bolander, Gordon Furnish, Kenneth Goldstein, Dan Gustafson, Cles Leonard, Rheinhardt H. Lukas, Donavan McConn, Robert Noll, Chester A. Parks, Charles Paris, Duane L. Smith, and Carl Swift. Data from the industrial survey and the student survey were processed in the Data Processing Center at Northern Arizona University under the direction of Dr. Lawrence Casto, Director of the Bureau of Educational Research, and Graduate students Richard Dickerson and Dart Peavy.

The management and many individual supervisors and personnel in Arizona industrial establishments contributed substantially in time and support to the industrial survey. To all of these, and to many others who also contributed time and assistance, are due the credit for what has been from the beginning a cooperative research project.

FOREWORD

We at Northern Arizona University appreciate the role we have had as sponsoring institution for the Occupational Research Coordinating Unit which, as an arm of our School of Applied Science and Technology, produced this report with widespread support from industry and educators throughout Arizona. It is the function of the University to lend its facilities and staff to meaningful research which may — as this report does in several ways — challenge its very own procedures and curricula. We recognize this as a responsibility of growth. We welcome the opportunity for critical and constructive self-examination, recognizing that the University must be ever capable of adaptation to new needs and changing times.

We commend this report to your most careful study. We hope its implications are widespread for industry and to all educators involved in the growing disciplines of engineering and technology. The data compiled, the opinions and comments offered by employers and students, the recommendations of the experts who served as panelists in preparation of the study and its analysis; all these aspects call for thoughtful and unhurried investigation. There are in this report a multitude of ideas for your review as an educator or as an industrialist.

During the last ten years, special emphasis has been placed on the training of space-age scientists. This was done with haste and with a limited commitment of resources. Many have questioned the overemphasis on technology at the expense of adequate understanding and development in the humanities. In the report, engineers, technicians and skilled craftsmen have indicated a need for training in communications, social science, business and humanities to give their scientific knowledge a more practical application in human and personnel relations and in salesmanship. Leadership in industry confirms this attitude and need.

At the same time it is pointed out that it is equally true that education must be related to the working world in which we live. This is especially true of engineering and industrial education. In our concern for knowledge we sometimes overlook the practical uses to which it must be applied in the professions, in business and industry, and in other areas of employment. This study focuses its main attention on the needs of industry for what the schools can provide. We in the universities want to know how we can best serve those needs. We are deeply conscious of the public responsibility we have to the economic strength of our state and nation. We are equally conscious of the obligation we have to our students to give them the best preparation it is possible to provide for successful careers in their respective fields.

This report hopes to provide some suggestions as to ways to help to bring about closer coordination. It attempts to build another bridge from the campus to the world of work, one which is particularly needed at this time.

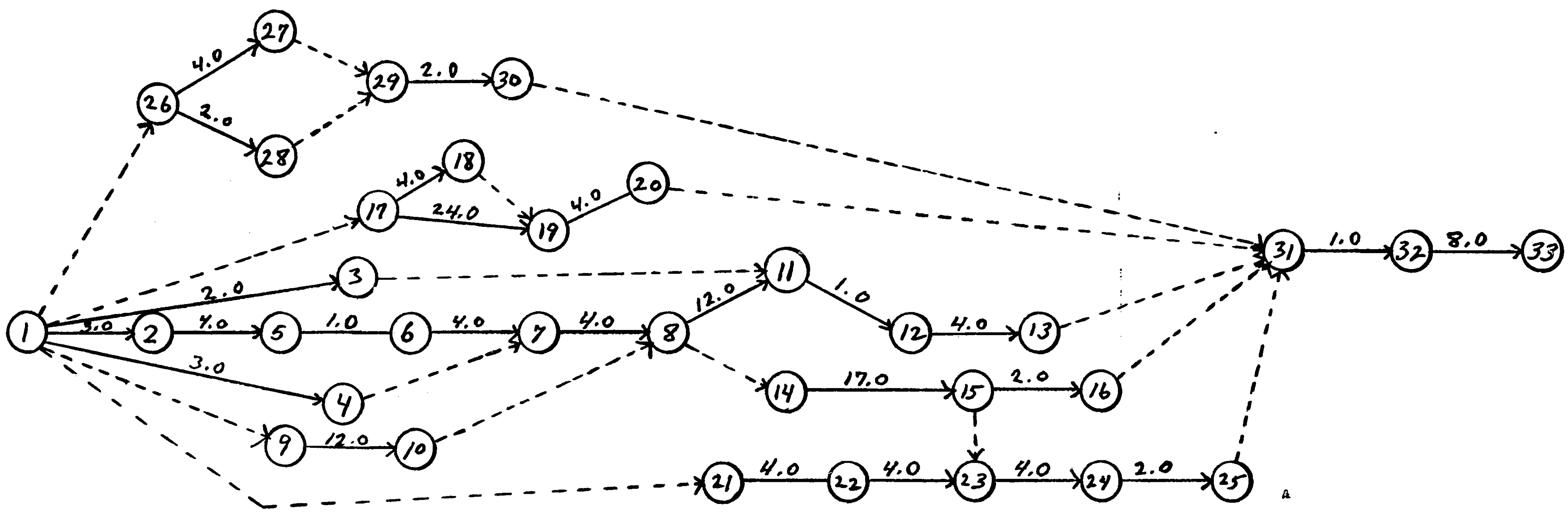
J. Lawrence Walkup

J. LAWRENCE WALKUP, *President*
Northern Arizona University

FIGURE 1

ENGINEERING AND TECHNOLOGY IN ARIZONA
NEEDS AND RESOURCES STUDY

PERT NETWORK



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2. Complete List of Occupations
3. Complete Review Panels
4. Complete List of Arizona Employers
5. Complete First Draft Survey Instruments
6. Complete Review of Survey Instruments
7. Complete Field Test of Survey Instruments
8. *Complete Survey Instruments* (June 2)
9. Begin Printout Tables and Computer Program
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CHAPTER I

INTRODUCTION

Modern industry is built around engineering and technology. It depends on engineers, technicians, and skilled craftsmen for most of its key manpower -- from research to sales, from product development and production through supervision and management. The personnel who staff these positions are the products of an educational system that increasingly has come to play a major role in the nation's economic life. Colleges and universities, along with other educational institutions, are as important today in industrial development as an energy supply and transportation were in the past.

This report deals with that educational system and with the manpower it produces for industrial employment. The primary purpose of the study is to assist educators in meeting the needs of industry as well as those of their students. Neither group can be properly served unless the other is also recognized. Engineering and technology in recent years have changed so rapidly, with many of the changes so basic and far-reaching that a complete reassessment is becoming necessary.

A central question is: What kinds of educational programs are needed to prepare students for engineering, technical, and skilled industrial employment in the years ahead? In this aspect the main focus is on the needs of industry. What programs do we have now which should be modified or updated? Must new programs be added? Which are significant areas in present curricula that may need strengthening or critical re-examination? Should new curricula and perhaps new programs be designed to educate students for new combinations of engineering and technical specialization? Can employment requirements in industry be better served by schools through modifications in engineering and technical education? Can the experience and professional judgment of men on the job help educators in efforts to produce better trained and better educated persons? What are the employment practices, job requirements, and career opportunities that should be made known to young people planning educational programs and careers? These questions have important relevancies to both education and industry. In this report, industry has been asked to supply the answers.

An outline of the existing educational system is presented first. This encompasses problems which have arisen and the extensive soul-searching that has been engendered in consideration of needed changes. This is the "State of the Art" described in Chapter II. Arizona's educational resources are identified against this background in Chapter III, which includes the telling results of an in-depth survey of engineering and technology students enrolled in Arizona's three state universities and six junior colleges.

Three chapters contain results of a survey of industry. All employers and employees in the state who could be identified with engineering, technical, and skilled occupations were interviewed or asked to complete questionnaires. Chapter IV contains computer printout tables of data from this survey and a general summary of the results. A series of occupational profiles and the statistical data on which they are based are given in Chapter V. Chapter VI is a report of the suggestions and recommendations for education made in the survey by employers and employees based on their own experiences.

Chapter VII was prepared by the Arizona State Employment Service to provide the economic context within which engineering and technology operate today and may be expected to develop in years ahead. A considerable amount of relevant information has been assembled and analyzed dealing with population and employment trends, geographic distribution within the state, and critical factors affecting the future development of industry in Arizona and the manpower resources upon which it depends.

Finally, some of the possible changes and trends taking place nationally are explored in Chapter VIII through reports of current research and related literature.

Conclusions and recommendations presented in the last chapter are suggestive only. No single analysis would be adequate. The information alone which has been gathered and presented is by far the most important product of the research. This compilation may serve educators, industrial management, students and the public for several years, and from time to time may be brought up to date with less effort than was required initially. Moreover, its use need not be confined to this state. Arizona's industrial structure is fairly representative of present trends, therefore information assembled here may apply in varying degrees elsewhere.

The major research for this report was the industrial survey. In carrying it out, a list of all employers in Arizona using engineering or technical personnel was first compiled with the assistance of the State Employment Service. Thirty-three standard industrial classifications (SIC) were used as the basis of the list. These included mining, contract construction, transportation, communications, utilities, services, and government agencies. To this list were added self-employed engineers from the rosters of the Arizona Society of Professional Engineers and the Technical Board of Registration for Consulting Engineers. Altogether, 4,099 employers were identified. This number was reduced in several stages by eliminating those who did not employ engineers or related personnel. Further refinements were made in consultation with the Employment Service and through mail and personal contacts. The ultimate select list included 610 employers with an estimated total employment (engineering and non-engineering) of 140,000.

Survey questionnaires were designed with the assistance of two review panels meeting together. One consisted of key educators representing each of the state's three universities, six junior colleges, several major high school districts, the State Department of Vocational Education, and the State Board for Junior Colleges. The second panel was made up of representatives of industry, professional, technical, and labor groups. (The panel members are listed at the beginning of this report).

Two questionnaires were designed for the survey, one for employer interviews and the other for employees to answer privately. Parallel questions were included where similar data were to be gathered. Some of the data represented statements of fact regarding salary levels, employment practices, and educational qualifications. Other data were the personal opinions of management and employees. They dealt with career choice, conditions of employment, job satisfaction, educational requirements, and changing technical skills and knowledge. The employer interview contained 32 questions seeking 139 separate items of information and additional voluntary comments or suggestions. The employee questionnaire had 27 questions directed toward 108 separate items of information and also solicited confidential comments and suggestions.

Thirty-six basic occupational categories were used in the survey. These were derived from a list of 357 titles in 15 categories listed in the Worker Traits Section of the Dictionary of Occupational Titles (DOT).[1] They were selected in conferences with the State Employment Service and the personnel departments of several representative firms in the Phoenix area. The purpose was to arrive at a limited number of occupations which would be inclusive rather than specific and together would cover the entire range of industrial employment from skilled craftsmen to professional engineers.

It must be emphasized that when the survey was carried out the classification of each employee was made solely by his employer. Employers were asked to include all engineers, technicians, and skilled craftsmen and to identify each of them in one of the thirty-six categories. In doing so, they were asked to consider primarily the nature of the work performed and the education normally required, regardless of the formal education an employee might have.

A staff of twenty persons conducted the survey. This staff included technical and vocational faculty members from two junior colleges and two high schools and graduate and undergraduate students from two universities. Each of the 610 employers on the final survey list was contacted in person by a member of the research staff and asked to participate. Ninety-five per cent did so, including all major employers in the state. They were interviewed separately for each occupation in which they had persons employed, and altogether 1,570 interviews were completed. At the time of the interview, arrangements were made for the employer to distribute questionnaires to all employees in each occupation. A total of 13,589 questionnaires were distributed. Of these, 3,926 were completed and returned, representing an employee response of 29%.

Several control measures were used in conducting the survey. Employee questionnaires were serialized and assigned to field interviews in numerical blocks. The interviewers gave them to the employers in the required quantity for each occupation and recorded the serial numbers on the employer interview forms. Serial numbers assigned to all occupations in a company were recorded on an employer identification card and then transferred to a master list in numerical order. Two sets of employer cards were maintained. One was kept on file in the research office and one was assigned on a daily or weekly basis to the field interviewers. These cards were recorded when assigned, and they were checked in when returned. They contain the name of the field

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[1] U.S., Department of Labor, Dictionary of Occupational Titles (3rd ed.; Washington: U.S. Government Printing Office, 1965), II, 214-529.

interviewer, the dates of the interviews, the name of the company representative who had arranged the interviews, and the serial numbers of the employee questionnaires distributed. In the case of employers who said they had no engineers or technical personnel, their cards were marked "none" and filed separately. Employer forms and personnel questionnaires were checked for coding and the responses key punched for data processing. At the end of the survey a hand count was made of all employer cards, completed questionnaires, and sets of key punched cards, and the totals checked with corresponding figures in the computer printout.

Employer responses were tabulated by the number of persons employed totaling 13,589 engineering, technical, and skilled personnel. Employee responses represent 3,926 of these. These are the employment figures upon which the data in this report are based. They are not necessarily complete for any particular occupation or for the state as a whole for several reasons: they represent the employers' own listing of personnel by occupations rather than an objective classification based on education or any other criteria; some employers may not have included all of their personnel due to oversight or other reasons; and some employers with engineers or technicians may have been omitted from the survey in spite of every effort to develop a complete list.

All of the data collected in the survey were key punched and processed in the data processing center at Northern Arizona University. They were printed out in a set of basic data tables listing numbers and percentages of responses to each question, and in a series of summary tables giving percentages of employer and employee responses side by side for purposes of comparison. There are 43 pages of data arranged in 20 summary tables containing the major results and findings of the industrial survey.

In the student survey, registration lists for the fall semester of 1967 were used and questionnaires were sent to nearly all undergraduate and graduate students in engineering and technology at the three universities and six junior colleges.[2]

Altogether, 6,130 questionnaires were sent out, and 2,092 (34%) were returned. Information was gathered about each student's current educational status, college program, high school preparation, work experience, career choice, career goals, and opinion as to the reasons for other students dropping out. The printout tables in Chapter III contain the percentages of responses to each question tabulated for the entire group and for each of twenty-nine subdivisions representing individual institutions, year in school, type of program, and students with certain kinds of background experience.

Industrial expansion and technological advances for many years have created heavy demands on engineering and technical education. This report is intended to help educators and industry understand the nature of those demands and find ways of working together to meet them. It should serve as a guide to educators in program planning and development. It should provide administrators, governing boards, and the legislature with information upon which decisions may be made and policies established. It should be useful to

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[2]Engineering students in two junior colleges and graduate students at the University of Arizona could not be included because registration lists were unavailable at the time.

employers both as a guide in developing their own educational services and as an assessment of the educational resources available in this state. The interest of many readers of this report may be simply in the detail with which a significant feature of modern society is documented -- the interdependence of industry and education.

CHAPTER II

STATE OF THE ART

Overview

"Engineering and Technology in Arizona" must be considered both as a study of a vital interest in an advancing western state, and as a reflection -- if not a microscopic view -- of problems facing industry and education the nation over. In 1963 the American Society for Engineering Education (ASEE) began a study of the goals of engineering education. It was no ordinary project. The President of Pennsylvania State University, Eric A. Walker, was chairman of the Goals Committee. Joseph M. Pettit, Dean of Engineering at Purdue University, headed the undergraduate section. The National Science Foundation provided financing with two grants totalling $307,190. Professional staffs were assembled at Purdue and Stanford, and their work was reviewed by graduate and undergraduate boards of analysts representing a blue ribbon list of the nation's leading industrial corporations and outstanding universities. A preliminary report was published in October, 1965, and an interim report in April, 1967. The final report appears in the January, 1968, issue of the Journal of Engineering Education.

Similar intensive study is going on at all levels of technical and industrial education. Science and technology are forcing such fundamental changes in industry, and industry is expanding so rapidly, that the education of all personnel is undergoing substantial reorganization. The educational needs of engineers, technicians, and skilled craftsmen are closely related, one to the other. Decisions affecting one inevitably will have direct repercussions on others.

"Engineering" is defined by the Engineer's Council for Professional Development (ECPD) as "the profession in which a knowledge of the mathematical and natural 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 benefit of mankind."[1] Engineering education is primarily a four-year program in our colleges and universities which has evolved during a century of American development paralleling the Industrial Revolution. In 1967 there were 185 institutions in the United States offering accredited baccalaureate engineering degree programs.

"Technology" is a comparatively new occupational area related to engineering. According to ECPD, it combines scientific and engineering knowledge with technical skills in support of engineering; "it lies in the occupational spectrum between

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[1]Engineer's Council for Professional Development, 35th Annual Report for the Year Ending September 30, 1967 (New York: ECPD, 1967), definition on back cover.

the craftsman and the engineer at the end closest to the engineer."[2] The President's Committee on Scientists and Engineers defines a technician as one who "assumes the more routine engineering functions necessary in a growing technologically based economy."[3] The education of technicians has evolved from more than a half-century of industrial education in the secondary schools and colleges. It emerged as a post-high school program in the 1940s, largely as a result of World War II. Twenty years of constantly accelerating expansion since then have given it a well recognized academic role.

Next to technicians are skilled craftsmen, who require a high level of proficiency in the use of tools and machines. Their education has been provided largely through a combination of high school industrial arts, vocational education, apprenticeship programs, and on-the-job training.

Engineering Education

Present Characteristics: Two particular trends have been influencing the development of engineering education in the past half-century. One is specialization, with ever increasing curricula designed to produce engineers in specific fields. In 1966 ECPD listed 17 major categories of accredited curricula leading to first degrees in engineering. These were divided into 54 sub-categories by the institutions in which they were offered.[4] In 1967 major categories were dropped, but the number of sub-categories was increased to 59.[5] Three years ago there were literally 899 different kinds of accredited engineering curricula in the United States, and the number continues to grow each year.[6]

As contrasted to specialization, the second trend is to expand the curricula to add more context. This comes partly from the increasing volume of scientific and technical knowledge, and partly from an effort within the profession to achieve greater unity.

A series of landmark reports have been issued by the American Society for Engineering Education and its committees, especially during the past 20 to 30 years, emphasizing technical and general course material.[7] The most influential of these is known as the Grintner Report, published in 1955. Its aims and philosophy have become so widespread that they probably describe the main features of engineering education in most schools at the present time. The following

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[2] Ibid.

[3] Quoted in William John Schill and Joseph Paul Arnold, Curricula Content for Six Technologies (Urbana, Illinois: Bureau of Educational Research and the Department of Vocational and Technical Education, College of Education, University of Illinois, 1965), p. 5.

[4] ECPD, 34th Annual Report, pp. 42-48.

[5] ECPD, 35th Annual Report, pp. 75-80.

[6] American Society for Engineering Education, Goals of Engineering Education Interim Report (Lafayette, Indiana: ASEE, April, 1967), p. 23.

[7] ASEE, Goals of Engineering Education Preliminary Report (Lafayette, Indiana: ASEE, October, 1965), Appendix A, p. 84.

summary illustrates what has happened:

> Engineering Education must contribute to the development of men who can face new and different engineering situations with imagination and competence. Meeting such situations invariably involves both professional and social responsibilities. The Committee considers that scientifically oriented engineering curricula are essential to achieve these ends and recommends the following means of implementation:
>
> 1. A strengthening of work in the basic sciences, including mathematics, chemistry, and physics.
> 2. The identification and inclusion of six engineering sciences, taught with full use of the basic sciences, as a common core of engineering curricula, although not necessarily composed of common courses.
> 3. An integrated study of engineering analysis, design and engineering systems for professional background, planned and carried out to stimulate creative and imaginative thinking, and making full use of the basic and engineering sciences.
> 4. The inclusion of elective subjects to develop the special talents of individual students, to serve the varied needs of society, and to provide flexibility of opportunity for gifted students.
> 5. A continuing, concentrated effort to strengthen and integrate work in the humanities and social sciences into engineering programs.
> 6. An insistence upon the development of a high level of performance in the oral, written, and graphical communication of ideas.
> 7. The encouragement of experiments in all areas of engineering education.
> 8. The strengthening of graduate programs necessary to supply the needs of the profession, conducted in those institutions that can:
>   a. provide a specially qualified faculty,
>   b. attract students of superior ability, and
>   c. furnish adequate financial and administrative support.
> 9. Positive steps to insure the maintenance of faculties with the intellectual capacity as well as the professional and scholarly attainments necessary to implement the preceding recommendations. These steps include:
>   a. well-established recruitment, development, and evaluation procedures,
>   b. favorable intellectual atmosphere, reasonable teaching loads, and adequate physical facilities, and
>   c. salary scales based on the recognition that the required superior faculty can be secured only by competitive remuneration, since professional practice in industry and government is inherently attractive to the best minds in engineering.
> 10. The consideration of these recommendations at this time before the problems of educating greatly increased numbers of

engineers become critical.[8]

Efforts by engineering educators to realize these objectives have strengthened the core of engineering sciences; they have broadened engineering to include more liberal arts; and thus they have added to an already overburdened curriculum. It is this last feature of engineering education that causes its most difficult problems. Engineering has the most heavily loaded curriculum of any baccalaureate program on campuses today. Compared to a bachelor's degree in mathematics, physics, and chemistry, engineering demands nearly an additional semester's work. Table 1 contains semester-hour requirements for the baccalaureate in engineering and science at a randomly selected sample of 52 public and private colleges and universities:

TABLE 1[9]

SEMESTER HOUR REQUIREMENTS FOR THE BACCALAUREATE IN ENGINEERING AND SCIENCE

SCHOOL	CHEM. ENGR.	CIVIL ENGR.	ELEC. ENGR.	MECH. ENGR.	ENGR. AVG.	CHEM.	MATH	PHYSICS	SCIENCE AVG.
	mean range	mean range	mean range	mean range	mean range	mean range	mean range	mean range	mean range
PUBLIC	144.4 131-157	143.4 127-156	142.7 131-152	142.6 131-152	143.1 130-153	131.2 106-151	129.6 115-151	129.6 118-151	130.2 113-151
PRIVATE	140.5 120-152	142.9 129-156	130.7 120-152	140.1 123-152	140.8 120-152	128.9 117-143	125.7 117-144	125.7 117-144	126.8 117-142
PUBLIC and PRIVATE	142.9 120-157	143.1 127-156	137.2 120-152	141.5 123-152	142.0 120-152	130.0 106-151	127.8 115-151	127.8 117-151	128.6 113-151

Most universities require a core of general education courses in communications, social studies, and humanities. The engineering student completes most of these in his first two years and at the same time fulfills a heavy program of mathematics and basic sciences. Specialization in engineering sciences occupies most of the junior and senior years. The total program is about one-fourth general education, one-fourth mathematics and basic sciences, and one one-half engineering sciences. Typically an engineering student carries 17 or 18 credit hours each semester. Many educators feel this is an excessive load which prevents engineering students from engaging in other worthwhile campus activities. It also precludes courses outside their major fields which might provide perspective and develop the creative imagination needed by engineers.

Accreditation: The Engineers Council for Professional Development (ECPD) is recognized by the National Commission on Accrediting as the sole agency responsible for the accreditation of engineering education. ECPD follows ten basic policies in carrying out this responsibility:

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[8] Ibid., "Summary of the Report on Evaluation of Engineering Education," Appendix F, p. 111.

[9] ASEE, Interim Report, p. 24.

1. The accrediting of curricula rather than institutions, for it is well recognized that curricula of quite different standards may sometimes be found at the same institutions.

2. Accreditation of an institution by its respective regional accrediting agency or association is prerequisite to evaluation and accreditation of an engineering curriculum.

3. The consideration for accrediting of only those curricula leading to first degrees in engineering at an institution -- generally undergraduate curricula. Except for curricula in which the master's degree is awarded as the first engineering degree accreditation of graduate programs is not included at the present time pending further stabilization of the objectives and operation of graduate engineering education among the institutions and the profession.

4. The invitation to institutions to submit curricula without persuasion or pressure brought to bear by the committee.

5. Accreditation may be granted only if students have been graduated from a curriculum by the date of action by Council.

6. The avoidance of rigid standards as a basis for accrediting, in order to prevent standardization and ossification of engineering education and to encourage well-planned experimentation.

7. As a safeguard to the public and without setting any rigid standards the nonaccrediting of curricula which omit a significant portion of a subject in which the public may reasonably expect engineers of that field to have competence.

8. The careful consideration of qualitative as well as quantitative factors through a visit by a competent committee of engineers and engineering educators.

9. The review of the findings and recommendations of the visiting committee by the appropriate regional chairman or vice-chairman, by the Engineering Education and Accreditation Committee, and finally by ECPD.

10. The publication of a list of accredited curricula only, with no information available to any person (other than proper officials of an institution concerned) as to whether any curriculum or institution not on the accredited list had been under consideration by ECPD.[10]

An engineering curriculum acceptable to ECPD usually requires two and one-half years of mathematics, basic sciences, and engineering sciences. One-half year of this should be in mathematics beyond trigonometry. Another half year should be basic sciences. At least a year of engineering sciences not limited to the major field is advised. There must be at least one-half year to one full year of

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[10] ECPD, "Accredited Curricula Leading to First Degrees in Engineering in the United States," <u>35th Annual Report</u>, p. 66.

humanities and social science. A broad basic undergraduate program is favored "which will prepare a student to take advantage of as many different opportunities as possible."[11]

Goals Committee Report: The Preliminary Report of the ASEE Goals Committee, published in 1965, was followed by what its sponsors describe as the most widespread discussion of engineering education of all time.[12] It contained 14 recommendations, several highly controversial. The first professional degree was to be the master's degree following an integrated program of at least five years. The four-year bachelor's degree was to be offered, but only as an introductory degree. This would be accompanied by a reduction in requirements and a broadening of curriculum. The master's degree would be simply a Master of Engineering, with accreditation of institutions rather than of curricula.[13]

The proposals for the five-year master's degree and disregard for traditional fields of specialization were largely opposed by the engineering profession and many educators. The American Institute of Chemical Engineers suggested that "an entirely new set of recommendations should be drawn up."[14] The American Society of Civil Engineers declared some of the proposals were "not in the best interest of the engineering profession."[15] The American Society of Mechanical Engineers spent six months in an intensive study of the Goals Report. ASME asked for opinions from its members, and the response was an almost unanimous disapproval. In a hard-hitting report to its membership, ASME concluded that the matters the Goals Committee had dealt with "are adequately resolved through the existing system and demand no revision by pedagogical legislation."[16]

The Goals Committee restated its recommendations in the Interim Report of April, 1967, and in the Final Report published in January, 1968. Considerably more care has gone into the writing of the later documents, but the recommendations are essentially the same. Both the recommendations and the controversy surrounding them reflect basic issues in engineering education today involving content, philosophy, purpose, and methods as well as the length of time required.

Technology Education

Present Characteristics: Diverse opinions and disagreements also exist in the education of technical support personnel. Many presently employed received

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[11] Ibid., pp. 67-68.

[12] ECPD, 34th Annual Report, p. 24.

[13] ASEE, Preliminary Report, pp. 1-2.

[14] ECPD, "Reports of Directors from the Participating Bodies," 34th Annual Report, p. 22.

[15] "ASEE Position on Goals in Engineering Education," Civil Engineering, XXXVI (June, 1966), p. 87.

[16] "Goals of Engineering Education: ASME's Critical Analysis," Mechanical Engineering, DXXXVIII (August, 1966), p. 34.

training in specialized programs in the armed services or private technical institutes. Two-year junior college programs roughly parallel engineering education in dependence on mathematics and science and a tendency to overload the curriculum with a concentration of technical courses plus liberal arts. This has led to development of three- and four-year college programs. Some institutions are offering baccalaureate degrees in technology which tend to be confused with engineering degrees. Technical training programs are also provided at the high school level, but the majority in existence today require high school graduation or equivalency as a prerequisite to enrollment.

The major developing trend is two-year associate degree programs in junior colleges. Typically these require 70 or more semester hours, with about 60% of the work in technical courses, 25% in mathematics and basic science, and 15% in general education.[17] The American Society for Engineering Education recommends 50% technical courses, 25% mathematics and science, and 25% general education.[18] Specialization in particular fields of technology begins early.[19] Non-degree certificates are often given to students who want only technical courses without liberal arts.

The educational distinction between technology and engineering is a major problem. Technology is usually described as that part of the engineering field between the craftsman and the engineer and closer to the engineer than to the craftsman. As noted earlier, according to ASEE, "a technician differs from a craftsman in his knowledge of scientific and engineering theory and methods and from an engineer in his more specialized background and in his use of technical skills in support of engineering activities."[20] The distinctions, however, are often blurred in actual practice. In education they are not easy to maintain, because technology curricula necessarily may contain mathematics, science, and general education courses also taken by first and second-year engineering students. The line drawn between engineering and technology curricula by engineering educators is based primarily on a different sequence of mathematics, science, and technical material, and emphasis in the technology area on application rather than principles. ASEE describes it this way:

> An engineering technology curriculum differs significantly from a pre-engineering curriculum, which is equivalent to the first two years of an engineering program. The one is the preparatory part of a more inclusive program; the other a complete program in its own right. The first two years of an engineering curriculum are devoted primarily to mathematics, science and a general education. They contain relatively few specialized technical courses. An

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[17] U.S., Office of Education, Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs, Vocational Division Bulletin No. 296, Area Vocational Education Program Series No. 4 (Washington: U.S. Government Printing Office, 1965), p. 12.

[18] ASEE, Characteristics of Excellence in Engineering Technology Education, 1962, p. 25.

[19] Aaron J. Miller, "Characteristics of the Technical Education Student," presented at the American Technical Education Association, Denver, Colorado, December 4, 1966.

[20] ASEE, Characteristics of Excellence . . ., p. 12.

engineering technology curriculum, on the other hand, must initiate specialized technical courses early in the program if it is to cover its material within the short short span of two or three years.[21]

Distinction between technology and engineering becomes more difficult in four-year technology programs. At the annual meeting of the Engineer's Council for Professional Development in 1966, the matter was debated at length. The baccalaureate technology program was defined as "appreciably less intensive than its counterparts in engineering."[22] Opposition was based on the assumption that since at least half the graduates with a bachelor's degree in engineering would not be going on to graduate school, baccalaureate degrees in technology were unnecessary. Baccalaureate engineers would be employed in the "practical development of engineering, as they have done since the beginning of engineering education." It was argued that four-year technology programs would be competing with traditional engineering, thereby creating "confusion and infiltration when graduates of technology programs assume positions in industry."[23] A selected jury decided that a sufficient difference between the two programs could be identified, therefore both are needed.

Another problem is that engineering and technology are moving up the academic ladder at the same time. Many educators who believe engineering should be a five-year program see a trend from two- to three-year and even four-year technology programs emerging simultaneously for the same reasons. They envision a continued distinction based on the need for research, design, and development in engineering and the necessity for practical application in technology. Henry M. Armsby, President Emeritus of the Capitol Institute of Technology, describes the difference in this way: "As the engineer becomes more deeply concerned with engineering science, the engineering technician must be qualified to absorb more of the engineer's functions. His education will be expanded to the baccalaureate level and perhaps even beyond. But it will still place its major emphasis on the solution of practical rather than theoretical problems; the technician's degree will still be in technology rather than in engineering."[24]

The variety and diversity in technical education is partly the result of rapid growth. From a small group of schools some 20 years ago, there are now several hundred with a nationwide enrollment of more than 60,000 students.[25] A 1946 survey of technical institutes listed 18 different kinds of curricula. By 1956 there were 694. Three years later the number had jumped to 1,227.[26]

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[21] Ibid., p. 22.

[22] ASEE, "Highlights of the Thirty-fourth Annual Meeting of ECPD," 34th Annual Report, p. 31.

[23] Ibid., p. 32.

[24] Henry H. Armsby, "The Technician and the Engineering Team," Engineering Education, Vol. 57, No. 3, (November, 1966), p. 189.

[25] Walter M. Hartung, "Definitions and the Engineering Technician," Engineering Education, Vol. 57, No. 3, (November, 1966), p. 185.

[26] Characterisitics of Excellence, p. 3.

One of the principal characteristics of technical education has been specialization. This contributes to proliferation of courses and curricula as new schools are being established. A natural tendency in education is to add courses. Too often, however, they are added with little regard for actual results. Curriculum design has been described as largely curriculum construction -- a process of stacking together traditional courses imposed by economic considerations, staff competencies (and prejudices), real and fancied student abilities and interest, instructional facility limitations, and scheduling convenience.[27]

Broader geographical distribution of industry began with World War II and has continued with the westward sweep of population. Arizona is directly involved in this aspect of the spread of industry and the new demands it imposes upon all levels of educational effort.

Probably the rapid expansion, the constant pressure for more kinds of technicians, and the efforts of a variety of institutions to supply the demand all have contributed to a confused picture of technology education. Academic traditions in colleges and universities, including junior colleges, can be credited with much of the standardization that does exist. Two and four-year degree programs particularly tend to follow patterns which industry can recognize and which can be used as foundations for further development. Much remains to be done. The American Society of Engineering Education devoted its entire November, 1966, issue to the technical field and frankly admitted that there is less uniformity and more confusion than at any previous time. The chairman of ASEE's Technical Institute Council concluded: "It is no longer possible to divide education neatly into little boxes labled, 'craftsman,' 'technician,' 'engineer,' and 'scientist.' Nor is it possible to offer clearcut packages of educational programs in institutes, colleges, or univerisities. Nor is it possible to establish firm requirements of two, four, five or more years."[28]

Accreditation: Efforts are being made to establish basic standards in technology education through the same accrediting procedures that govern engineering. ECPD accredits both baccalaureate and associate degree programs, but only 45 schools have taken necessary steps to have their curricula evaluated for ECPD accreditation. These include technical institutes, junior colleges, senior colleges and universities. The American Associations of Junior Colleges has undertaken a study of the needs of accreditation in cooperation with the National Commission on Accrediting, the American Vocational Association, and the U. S. Office of Education. This study has raised doubt in regard to any action by the National Commission to grant a request from ECPD that it be the sole accrediting agency for technology education.

In general, the same ten basic policies are used by ECPD in accrediting technology curricula as in engineering. An exception is amde for private technical institutes which cannot qualify for regional accrediation. In view of greater diversification of technology curricula and types of institutions offering them, each curricula is judged in terms of its own purpose, scope, duration, and content.

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[27] Maurice W. Roney, "Curriculum Design in Technical Education," Oklahoma State University, Stillwater, Oklahoma, 1965, p. 2.

[28] Hartung, op. cit., pp. 185-86.

However, the curriculum must cover two academic years beyond secondary school. It must be "technology in nature, employing the application of physical sciences and the techniques of mathematics to the solution of practical problems." Unlike engineering, the technology curriculum should be in a specific field, "though not excluding a reasonable amount of elective appropriate subject matter."[29] At least the equivalent of one-half academic year of basic sciences is required, half in mathematics, which must be carefully selected for the particular curriculum, and must be of college level above college algebra and trigonometry, including basic concepts of calculus. At least one-fourth an academic year of non-technical subjects must be included, and one academic year of technical courses.

National Studies: The ASEE Goals Committee included among its recommendations that "a national study of engineering technician education be undertaken which would involve representation from technical institutes, community colleges, engineering colleges, as well as the professional organizations concerned with technician, engineering and scientific personnel."[30] Engineering educators have been making studies of their own since 1959. A National Survey of Technical Institute Education was published that year which technicians considered an "educational bench mark."[31] Two years later ASEE began another study under a grant from the National Science Foundation to formulate a set of criteria for engineering technology curricula. It was published in 1962 as Characteristics of Excellence in Engineering Technology Education. From another direction, the American Association of Junior Colleges has received a research grant from the Kellogg Foundation for a five-year project in semi-professional and technical programs including those related to engineering. The American Technical Education Association has a grant to conduct a pilot study of technical education emphasizing the teaching of skills in engineering technology. These activities reflect more than a normal effort to keep up with the changing requirements of industry for support personnel. Technology education, like engineering education, is in a state of flux.

One more pertinent observation should be made about the state of the art of engineering and technology education today. The total product of available personnel is larger than the number of formal graduates and it contains even greater variations than indicated by curricula. This is because of an excessive number of partially trained dropouts. How many of these find work as technicians and engineers -- no one knows. Three-fourths of all students in technology programs do not graduate. Two-thirds of the freshman in engineering programs leave the discipline before graduation. They either fail courses, drop out for other reasons, or transfer to other programs.[32] There can be little doubt that

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[29]ECPD, "Accredited Curricula Leading to First Degrees in Engineering Technology in the United States -- 1967," 35th Annual Report, pp. 81-84

[30]ASEE, Interim Report, p. 16.

[31]Editorial in the November issue of Technical Education News, cited in Harl O. Werwath, "Changing Characteristics of the Technical Institute Curriculum in the United States, 1941-1966," Engineering Education, Vol. 57, No. 3 (November, 1966), p. 197.

[32]Zeno M. Van Erkewyk, "Variables Related to Persistence, Transfer and Attrition of Engineering Students," Research Report No. 9, Center for Research in Vocational and Technical Education, Grand Forks, N. D., University of North Dakota, 1967.

many of these dropouts from technology and engineering education are being employed by industry. The number of bachelor's degrees in engineering conferred annually in the United States has remained almost stationary for the past ten years.[33] Industrial employment has increased by more than ten per cent during that time.

The implications of a sizeable number of students going into industry before completing their training are: (1) educational programs are overloaded with unnecessary content; (2) industry is so short of engineering personnel that employers are willing to make up technical deficiencies of partially trained students through training programs of their own; (3) the actual amount of education needed in many jobs is less than that of a full degree program. In any case, the first two or three years of engineering, and the first year of technology, are more important for these students than the courses that come later in the curricula.

Skilled Industrial Education

Present Characteristics: In the general pattern of industrial employment there are broad overlapping areas between technology and the skilled crafts. Employers sometimes find it difficult to identify their own job descriptions with one or the other of these classifications. For that reason alone a study of technology must include the skilled crafts. They are included here for another reason as well -- their training and education are as important to industry as engineering and technology. Moreover, secondary and post-secondary schools are faced with many of the same problems in expanding and updating vocational education for skilled craftsmen as higher education is for technicians and engineers.

Many large corporations operate apprenticeship programs to maintain a supply of skilled personnel for their own needs. Virtually all employers provide some kinds of on-the-job training through which untrained workers may progress to skilled craftsmen. Since the 1930s the federal government and most states have established joint management-labor apprenticeship committees to develop apprenticeship programs. These programs usually involve three to five years of on-the-job training supplemented by classroom courses in technical and related information.

The major problem with such apprenticesphip training is that not enough youth can be persuaded to enroll. A fourth of those who do enroll drop out. The American Management Association published an article in 1959 by Louis Ruthenburg entitled, "The Crisis in Apprenticeship Training," in which the cause for this was described as lack of incentives. "With the growth of the industrial unions and the high wages they have obtained for their membership, assemblers, machine operators, and the like, whose techniques can be learned

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[33] In 1965-66 there were 35,815 bachelor's degrees conferred, two-thirds the number conferred in the peak year of 1949-50. Since 1956-67 the number has fluctuated between 31,000 and 38,000. Neva A. Carlson, "Survey of Engineering Degrees," American Education, Vol. 3, No. 8 (September, 1967), p. 33.

in a few days, now earn almost as much as skilled workers."[34] George Meany, in an address celebrating the 25th Anniversary of the National Apprenticeship Program in 1962, said it was due to "the lack of a full economy."[35] He said young people did not have enough confidence in the economy to "invest" several years in training for jobs that would not be there when they were ready for them. The Labor Department estimates that one milliom new apprentices are needed each year, and only one-fourth of that number are being enrolled. A high percentage of skilled craftsmen in the United States today are reportedly nearing the retirement age.

As long ago as the turn of the century industrial arts and vocational education were being encouraged in public schools. In 1914 Congress created the Commission on National Aid to Vocational Education. Under the Smith-Hughes Act of 1917, federal funds were allocated to states for several kinds of vocational education including trade and industry and teacher training but largely focused upon the needs of the agricultural economy. Subsequent legislation in the 1930s and the George-Barden Act of 1946 increased the amount of federal support and helped establish programs of national similarity in public schools of every state. Trade and industry programs include machine shop and construction trades as well as a variety of other skilled occupational courses. Students usually spend half days in general education classes and the other half days in shop or on the job through cooperative arrangements with employers. This training does not begin until the junior year of high school.

In spite of the growth of vocational education in public schools, it has lagged far behind the need for trained graduates. In 1963 Congress greatly expanded federal support and liberalized the previously rigid features of the program. Since that time enrollments have accelerated, but nevertheless fall behind both the requirements of industry and the needs of high school graduates for employable skills. Additional federal programs have been enacted in recent years to provide training for special needs and special groups. The Area Redevelopment Act of 1961, the Manpower Development and Training Act of 1962, and the Economic Opportunity Act of 1964 have attacked the same problems. They also have contributed to a growing state of confusion as to what is actually being done and how well, and at this writing are being re-evaluated at the same time that enlarged proposals for overcoming underemployment are being made. Meanwhile, industry reports serious shortages of skilled manpower, and through expediency, employers resort to pirating qualified employees from each other, while the average age of the men on the job increases each year.

National Studies: Several studies of considerable depth and scope are being made of industrial education as well as engineering and technology. A comprehensive review of federally sponsored vocational education, Education for a Changing World of Work, was published by the U. S. Office of Education in 1963. It was the product of a panel of consultants appointed by the President two years before and led to passage of major legislation.

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[34] Louis Ruthenburg, "The Crisis in Apprentice Training," Personnel (July-August, 1959), p. 30.

[35] Address by George Meany, President, AFL-CIO, at the Silver Anniversary Banquet of the National Apprenticeship Program, August 21, 1962, U. S. Department of Labor, Bureau of Apprenticeship and Training.

The most complete, and certainly the most scholarly, research carried out in a single major area of vocational education is The Process and Product of T & I High School Level Vocational Education in the United States, conducted under a Ford Foundation grant by the American Institute for Research. The report is to be published in several volumes, the first of which appeared in 1965, and the second in 1967. Volume I is a follow-up study of T & I vocational education graduates. It is based on a survey of about 10,000 male graduates randomly selected from the graduating classes of 1953, 1958, and 1962 from one hundred high schools offering three or more T & I courses. The high schools were a sample representing the country as a whole stratified by region, school enrollment, and type of school. Volume II is a comparison study of New York state data with national data. If carried through to completion, this project could furnish the basis for a major evaluation of vocational trade and industrial education in the United States.

Most current efforts to re-examine the education of skilled industrial craftsmen emerge from three sources: the U. S. Office of Education; the Ohio State University Center for Vocational and Technical Education; and the University of Wisconsin Center for Studies in Vocational and Technical Education. The Wisconsin Center has undertaken a series of studies of apprenticeship training to identify problems that exist and the continuing role of this traditional form of skilled training. The picture that emerges from these studies is one of increasing need for better methods than have yet been found to close the gap between industry's requirements and our present ability to meet them.

Summary

Engineering and technical education are in a state of flux. Progress is evident. Engineering is moving in the direction of a five-year basic degree program, although there is considerable opposition to this in favor of maintaining the four-year bachelor's degree as is. Most curricula have been strengthened in their core of engineering sciences and in liberal arts courses during the past decade, but they are overloaded with requirements. The typical engineering curriculum contains more than 140 semester hours divided roughly into one-fourth general education, one-fourth mathematics and basic sciences, and one-half engineering sciences. The number of engineers graduating from colleges and universities in the United States has remained about the same for more than a decade, while the demand for engineering personnel increases annually. It can be assumed that the difference is made up with partially-trained students who drop out of engineering education or other personnel being trained by industry.

Engineering technology has emerged in the past two or three decades from a long history of industrial education in schools and technical training programs of World War II to a properly recognized educational area. It is usually a two-year post-secondary program in which students prepare for specialized fields of technology. Pressure on the curriculum is evident here as well as in engineering, and there may be a trend to three-year and four-year technology programs. Some confusion exists between the two-year technology and the first two years of engineering and also between four-year technology and baccalaureate engineering programs. Technology, however, is considered to be less intensive than engineering, deals with the practical rather than theoretical problems, and is more specialized. Considerable variety exists in technology curricula and in the institutions offering them. These include private technical institutes, junior colleges, senior colleges and universities, and the armed forces. Only 45 institutions are accredited by the Engineers' Council for Professional Development, but ECPD is not recognized as the sole accrediting agency for engineering technology curricula.

The education and training of skilled craftsmen for industry is carried on under a variety of programs from on-the-job training to vocational education in schools. The federal governement and most of the states support joint management-labor apprenticeship programs. A nation-wide federally sponsored vocational education program in the high schools, which includes trade and industry, has been in operation since World War I. Several additional federal programs in recent years have provided funds for special training and retraining of adults and youth with special needs. The total effort obviously lags behind industry's requirements.

CHAPTER III

EDUCATIONAL RESOURCES

Overview

Engineering education is offered in 19 fields at the baccalaureate, masters, and doctoral levels in Arizona's three universities. Technology education is offered in 14 fields at the associate and baccalaureate levels in two universities and six junior colleges. Machinist training is offered in five high school vocational education programs, approximately 30 high school industrial arts programs, and 21 apprenticeship programs. Total enrollments in the fall of 1967 were 5,372 in engineering, 2,685 in technology, 129 in vocational machine shop, approximately 2,000 in industrial arts machine shop, and 52 in apprenticeship training. These figures are given for each field in engineering and technology in Tables 2 and 3. Arizona institutions graduated 915 engineers and technicians in 1967 from a total enrollment of 6,779.

The attrition rate from dropouts and transfers appears to be high, due to factors that affect engineering and technology education everywhere. In many cases students have not actually decided on careers when they enter programs. Some lose interest and others find courses too difficult. Arizona students who have not dropped out feel the major reason that others have is the difficulty of the programs. At least 1,000 of those who left without graduating, however, can be classed as partially-trained dropouts. The deans at seven of the twelve colleges and junior colleges reported 1,032 students in 1966-67 who were capable of employment when they left without completion of degree programs. They were sufficiently educated to accept jobs as technicians or engineers-in-training. A better term for them might be "slowdowns." It is apparent that many will continue their education in company-sponsored training programs or in junior college and university evening courses. A few may return as full-time students. How many will eventually receive degrees is impossible to say, perhaps only a small percentage.

Many of the engineering and technology programs in Arizona are relatively new. Engineering at the University of Arizona goes back to the beginning of the institution in 1891, but as late as 1955 there were only twelve degree programs in the entire state, eight in engineering at the U of A, and four in technology at ASU. By 1960 there were degree programs in 23 fields, and by 1967 a total of 53 degree programs in 34 fields of engineering and technology were being offered. The enrollment increase from 1966-67 to the fall term of 1967-68 was nearly 20%, one indication of the rate of growth which has

TABLE 2

TECHNOLOGY EDUCATION IN ARIZONA

FIELD	INSTITUTIONS[1]	DEGREES	TOTAL 66-67 ENROLLMENTS	TOTAL 1967 GRADUATES	TOTAL 67-68 ENROLLMENTS
Aerospace & Aeronautics	ASU	BS	262	15	355
Automotive	AWC EAC	AA AAS	70	15	93
Civil	NAU PC AWC CC	BS AS AA AAS	47	2	59
Communications	ASU	BS	10	0	15
Construction	ASU	BS	187	36	207
Data Processing	PC AWC EAC	AA AAS	451	35	572
Design	ASU	BS	100	6	160
Drafting	NAU PC GCC MC AWC EAC CC	BS AS AA AAS	294	112	540
Electronics	ASU NAU PC MC GCC AWC EAC	BS AS AA AAS	535	79	572
Graphic Arts	ASU	BS	12	2	21
Industrial	EAC	AA	6	2	13
Industrial (Management Option)	NAU	BS	7	1	8
Mechanical	NAU	BS	2	1	7
Tool and Manufacturing	ASU	BS	36	1	35
Welding	ASU AWC	BS AAS	14	9	28
TOTAL			2,033	316	2,685

[1]Abbreviations for Arizona colleges and universities used throughout the report are:

ASU	Arizona State University, Tempe
AWC	Arizona Western College, Yuma
CC	Cochise College, Douglas
EAC	Eastern Arizona College, Thatcher
GCC	Glendale Community College, Glendale
MC	Mesa College, Mesa
NAU	Northern Arizona University, Flagstaff
PC	Phoenix College, Phoenix
UA	University of Arizona, Tucson

TABLE 3

ENGINEERING EDUCATION IN ARIZONA

FIELD	INSTITUTIONS	DEGREES	TOTAL 66-67 ENROLLMENTS	TOTAL 1967[1] GRADUATES	TOTAL 67-68[2] ENROLLMENTS
Aerospace	UA	BS MS PhD	296	32	311
Agricultural	UA	BS MS	14	3	12
Chemical	UA ASU NAU	BS BSE MS BS-Ind Ed MSE PhD	275	27	304
Civil	UA ASU	BS BSE MS BS-Ind Ed MSE PhD	576	96	599
Electrical	UA ASU NAU	BS BSE MS BS-Ind Ed MSE PhD	1463	171	1504
Engineering Math	UA	BS	96	6	113
Engineering Mechanics	ASU	BSE MSE	72	8	85
Engineering Physics	UA	BS	49	4	36
Engineering Science	ASU	BSE MSE	149	30	200
General Engineering	NAU	BS	5	0	61
Geological	UA	BS MS PhD	50	10	54
Industrial	ASU NAU	BSE MSE PhD	247	76	275
Materials	UA	MS	2	0	1
Mechanical	UA ASU NAU	BS BSE MS BS-Ind Ed[3] PhD MSE	773	99	785
Metallurgical	UA	BS MS	62	9	68
Mining	UA	BS MS	73	12	83
Nuclear	UA	BS MS PhD	55	6	82
Systems	UA	MS PhD	44	10	27
Unclassified	UA		54		46
Engineering (2 yrs.)	PC GCC MC AWC[4]		391		726
TOTAL			4,746	599	5,372

[1]Includes 113 graduate degrees.

[2]Fall, 1967 only.

[3]The BS-Ind Ed is awarded to students who have completed 3 years of engineering education at NAU and a fourth year at another institution. Under this program students receive their baccalaureate degree in engineering from the second institution the following year or when degree requirements are completed.

[4]The enrollment figures in engineering at the junior colleges are incomplete. Data are unavailable from Cochise and Eastern, and for 1966-67 from Phoenix College.

been taking place for several years.

Universities

University of Arizona: Fourteen fields of engineering education are offered in the state's oldest and largest university, nine in the College of Engineering and five in the College of Mines. Twelve of these are baccalaureate, twelve are masters, and eight are doctoral programs. Civil and mechanical engineering go back to 1904, electrical to 1910, and mining to 1913. Chemical and geological were established in 1959, agricultural and metallurgical in 1935, nuclear, aerospace, engineering math, and engineering physics in the 1950s. Systems engineering and materials engineering are graduate programs added in the early 1960s.

There are approximately 1,300 undergraduate and 300 graduate students in the College of Engineering, and 300 undergraduate and 50 graduate engineering students in the College of Mines. Electrical and aerospace are the largest fields, followed by civil and mechanical. These account for nearly four-fifths of the enrollment in the College of Engineering. In the College of Mines, chemical engineering is the largest field followed by mining, metallurgical, and geological in that order. Baccalaureate degrees in engineering in 1967 were granted to 153 students in the College of Engineering and 30 in the College of Mines. The civil, electrical, and mechanical fields accounted for more than four-fifths of the university's baccalaureate degrees in engineering and more than half of its graduate degrees in engineering.

Students in any of the engineering curricula must have graduated from accredited high schools in the upper three-fourths of their graduating classes with four years of English, three and one-half years of math through trigonometry, two years of science and two years of social studies. For the first two years, they take a basic curriculum of math, science, English, social studies, and engineering foundation courses. The third and fourth years are largely specialization in engineering curricula. When they graduate they have completed approximately 140 semester hours of college work which includes 6 hours of English, 18 hours of social studies and humanities, 13 hours of math through differential equations, 6 hours of chemistry, 11 hours of physics, 3 hours of drafting, and approximately 75 hours in engineering and technical subjects.

In numbers of students at both the baccalaureate and graduate levels, the leading engineering field at the University of Arizona is Electrical Engineering. From the basic two-year engineering curriculum students go to a third year of electric circuit theory, electromagnetic field theory, electronics, solid state devices, servcmechanisms and automatic control, computers, power systems, communications, and microwaves. In the senior year further specialization takes place, and this may be strengthened or additional specialization developed at the masters and doctoral levels.

The next field in numbers of students is Aerospace Engineering, which the university describes as "directly concerned with the design, research, development, manufacturing, testing, field performance monitoring, and the sales and service of air and space vehicles and systems such as airplanes, helicopters, ground effect machines, rockets and ballistic missiles, satellites, spaceships, and their chemical, electric, solar, and nuclear propulsion and power systems." Undergraduate students take the two-year basic engineering curriculum, a third year in common with mechanical engineering, and a fourth year of aerospace specialization.

Mechanical Engineering, much older than aerospace and one of the four major fields in terms of size in the College of Engineering, is concerned with mechanical devices and the systems which use them. Senior and graduate students select areas of specialization following the two-year basic engineering curriculum and a third year in common with aerospace engineering. They use much of the same laboratory equipment and are prepared for careers in many of the same areas as aerospace engineering, but also in areas not related to aircraft and space vehicles.

The oldest and one of the two orginal engineering fields at the University of Arizona is Civil Engineering, exceeded in number of students only by electrical and aerospace. It is concerned with transportation systems, water resources, public health, and structures drawing on a knowledge of hydraulics, soil mechanics, surveying, structural analysis, sanitary science, and materials science. Students study these subjects in a standard curriculum in their third and fourth years, with further specialization in graduate programs. Design is stressed in the engineering courses. A one-semester project course in the senior year may be research or design oriented, and it is intended to prepare the student for problems he will face throughout his career.

Agricultural Engineering is the organized application of power and materials to agricultural production and processing. Students add courses in the biological and agricultural sciences to a basic engineering curriculum not greatly different from mechanical, civil, or electrical engineering.

Engineering Physics combines two years of basic engineering plus electronic and technical courses with a major in physics. Engineering mathematics does the same with a concentration in mathematics or systems rather than physics. They emphasize fundamental theory to a greator extent than application, and graduates may expect to work more closely with scientists than technicians. Third and fourth year physics laboratories stress individual projects, and graduate research includes elementary particle high energy physics, solid state nuclear physics, atomic physics, molecular beams, biophysics, and theory.

Nuclear Engineering is concerned with the release, control, and utilization of all types of energy from nuclear sources. It is one of the newest baccalaureate programs in the College of Engineering and was first established as a graduate program in 1957.

Systems Engineering is a graduate program built on a standard engineering curriculum emphasizing applied mathematics and adding courses in such fields as psychology, human factors, economics, and business administration. It is one of the most recent additions to the university's engineering programs.

Chemical Engineering is the largest field in the College of Mines in number of students. The major emphasis is on the process industries: those that make fertilizers, plastics, cements, fibers, missile fuels, foods, dyes, rubber, petroleum products, paper, glass, insecticides, drugs, beverages, metals and special chemicals. Chemical engineers develop, design, and operate the plants and processing equipment. Students are given a basic curriculum of English, math, and chemistry the first year; more chemistry and math in the second and third years, plus physics and engineering courses; and a concentration of engineering courses the fourth year. Of special importance is an optional work-study program in which students may spend alternate semesters working for firms that employ chemical engineers.

Mining Engineering has been a major field for more than half a century. Students are given a two-year basic curriculum of mathematics, chemistry, physics, drafting, surveying, and geology followed by two years of predominately mining engineering plus courses in metallurgy, general engineering, and advanced geology. Communications, social studies, and humanities are included to the same extent as in other engineering fields. A cooperative work-study program is offered through which students may elect an alternating sequence of courses at the university and work in the mining industry on a semester basis. This requires slightly over a year of additional time but provides the graduate with two years of valuable on-the-job experience.

Metallurgical Engineering has two major areas of concentration: extractive metallurgy dealing largely with ores, and physical metallurgy concerned primarily with the structure and properties of metals. Students take the basic two-year curriculum followed by specialized engineering courses and both physical and extractive metallurgy with particular emphasis on one or the other.

Geological Engineering is an interdisciplinary field applying the principles and techniques of geology primarily to mining, chemical, and civil engineering. Students take the basic two-year curriculum and specialized engineering courses plus a concentration of geological and related sciences.

Materials Engineering is a graduate program in the College of Mines concerned with the structure, properties, behavior, and uses of all engineering materials. Students must have a baccalaureate degree in metallurgical, chemical, mechanical, or civil engineering with a solid background in chemistry, physics, mechanics, and metallurgy. The curriculum is designed around a core of six courses in physical metallurgy, ceramics, and chemical engineering with added specialization in physical chemistry and other selected areas.

Arizona State University: Baccalaureate degree programs are offered in seven fields of engineering, in construction, and in seven technical areas. Masters and doctoral programs are offered in the seven engineering fields. At the masters level two degrees are available: the MSE (Master of Science in Engineering) for graduates with a baccalaureate degree in the same field; and the MS (Master of Science) for graduates with a baccalaureate degree in another engineering field or in science or mathematics. With the rapid growth of the state following World War II, especially in the Phoenix area, and the accompanying development of an electronics and space-related industry, the demand for engineering education has experienced an almost continuous acceleration. Technology was introduced at ASU twenty years ago, construction five years later, and the full engineering program in 1956. Currently, there are nearly 3,500 students in these programs, more than half of the state's total engineering and technical enrollment in universities and junior colleges.

Engineering accounts for more than 2,500 students in chemical, civil, electrical, industrial, mechanical engineering, mechanics, and engineering science. Entering freshman are required to have had at least one year of high school chemistry, one year of physics, three and one-half years of mathematics including advanced algebra, geometry, trigonometry, and preferably calculus. A year of biology is strongly recommended. Deficiencies must be made up through university courses taken in addition to the full engineering curriculum, a requirement that lengthens some students' baccalaureate program to five years. Engineering students take 6 semester hours of communications, 8 hours each of social studies and humanities, 70 semester hour core of engineering and science courses, and a field of specialization. It is possible to complete these requirements with a minimum of 127 semester hours, but the normal program is close to 140 hours.

A unique feature of the core program is the first-year course, "Introduction to Engineering," in which each student is involved in a realistic design project. He works as a member of an "engineering firm" developing a new design based on ideas provided by students themselves. Weekly lectures by engineers from industry supplement faculty instruction in engineering analysis and computation. The engineering and science core common to all fields of engineering contain 15 semester hours of analytical geometry and calculus, 5 hours of physics and 4 of chemistry, 2 hours each of computer programming and engineering graphics, and the equivalent of one full year of additional engineering courses. The core concept extends through the baccalaureate, masters, and doctoral programs with heavy emphasis on mathematics and science.

Chemical Engineering at ASU embraces the broad range of process industries such as petroleum products, plastics, metals, and chemicals, and also extractive metallurgy, nuclear engineering, and biomedical engineering. Students follow a program of core courses and general education in which they are introduced to engineering during their first year and complete a detailed project as seniors. Chemical specialization requires 42 semester hours. In addition to the core courses, each student may select an additional area of concentration. The options are: fundamentals, metallurgy and materials science, nuclear engineering, systems and control, biomedical engineering, business, and general chemical engineering.

Civil Engineering students, in addition to general education and the engineering core, take 37 to 39 semester hours of surveying, structures mechanics, soil, environment, transportation, and design. The field itself encompasses construction of buildings, bridges, highways, dams, canals, irrigation, and multipurpose hydraulic systems, and also environmental engineering including city planning, water and atmosphere resources, waste treatment, and pollution. Students may direct their specialization into one or more of these areas: structural, hydraulic, soil mechanics, transportation, and environmental engineering.

Electrical Engineering attracts the greatest number of students at Arizona State University, representing nearly half of the enrollment in engineering programs. All take a 23 semester hour common core of electrical engineering courses integrated with the general engineering core. They must also complete 13 semester hours of technical electives for specialization in one of the following areas: computing, semiconductor devices, communications, control systems, power systems, radar, medical electronics, electromechanics, instrumentation, and space electronics.

<u>Industrial Engineering</u> deals with integrated systems of personnel, materials and equipment. At the baccalaureate level it is being replaced after this year by engineering science. Graduate degree programs at the masters and doctoral levels are available to all graduate engineers who want to specialize in this field. They may specialize in the following areas: organizational control, computer sciences, industrial statistics, operations research, human factors, system analysis, production control, or a general option.

<u>Mechanical Engineering</u> is a basic field for many areas of specialization including aeronautical and nuclear engineering. It deals with both the theory and science of power generation, mechanical design, manufacturing, environmental control, nuclear technology, engineering measurements and instrumentation, automatic controls, energy conversion devices, engineering materials, and the general area of aircraft propulsion systems, and manned and unmanned space flight. Undergraduate students are given a mechanics concentration of 27 semester hours integrated with the basic core, and 10 semester hours of electives in one of these areas: aeronautics and astronautics, nuclear, design, engineering materials, measurement systems and controls, energy conversion, or a less specialized option.

<u>Engineering Mechanics</u> differs from mechanical engineering in a greater emphasis on properties of materials and less on design. After the basic engineering core comes specialized concentration of 26 semester hours of prescribed courses and 11 hours of technical electives. Specialization is directed toward dynamics, aeromechanics, fluid mechanics, aerodynamics, material science, solid mechanics, space mechanics, vibration and wave propagation, or a general option.

<u>Engineering Sciences</u> is a broad baccalaureate and graduate program merging principles and approaches from all fields of engineering and other disciplines. It is considerably more flexible than fields of specialization, and is intended for careers in which application of science is combined with physical and social technologies. Undergraduate students take the basic core of engineering and science, and develop concentration in other areas of university curricula with the advice of faculty advisors.

Technology programs leading to Bachelor of Science degrees are offered in seven fields: aeronautical, communication, design, electronic, graphic arts, tool and manufacturing, and welding. Nearly 750 students are enrolled in these programs, chiefly in aeronautical design and electronic technology. They are preparing for careers as senior technical support personnel, with emphasis on design level activities, applied research, and supervisory and management training. Their area differs from engineering in several important respects: entering freshman are not required to have had heavy mathematics and science programs in high school; the technology core contains only nine courses totalling 27 semester hours instead of twenty courses totalling 70 semester hours in engineering; in the core program mathematics includes only college algebra and trigonometry, although aeronautics, electronics, and design technology require analytic geometry and calculus; two courses in general physics are required instead of advanced physics; the remainder of the student's program is tailored more specifically to his technical area than in engineering; and the complete program is more likely to fit into the 126 semester hours required for graduation. Both engineering and technology have the same core of general education courses.

In Aeronautical Technology three options are available: aeronautical, air transportation (flight), and air transportation management (non-flight). Students receive both theoretical and practical instruction in the areas of structures, internal combustion engines and turbomachinery, fuels, lubricants, combustion, design, management, general and commercial aviation, and systems analysis.

Communication Technology offers preparation in four major areas: technical library storage and retrieval, graphic arts, technical writing, and technical editing and publishing.

Design Technology is intended to prepare technical support personnel in the areas of aeronautical design, civil design, electro-mechanical design, industrial design, and mechanical design.

Electronic Technology includes theoretical and practical preparation for electronic-engineering technicians in the areas of computers, quality control, radar, microwaves, instrumentation, commerical broadcasting and television, and other activities associated with electronics.

Graphic Arts Technology covers a wide range of careers in the graphic arts industry including administration and general management, production and quality control, sales and sales management, estimating, and research.

Tool and Manufacturing Technology concerns itself with the technical phases of production including manufacturing processes, tools and machines, and production facilities. It is a professional level program in the area of industrial machines and machine processes.

Welding Technology trains men specifically as supervisors or consultants in welding and related fields. Emphasis is placed on design, graphics, metallurgy, and manufacturing processes in metalworking industries.

In addition to the four-year baccalaureate programs in technology, the Division of Industrial Design and Technology in which they are offered has two-year non-degree programs and a baccalaureate program in Industrial Arts and Technical Teacher Education. The two-year programs are arranged for the special needs of each student by faculty advisors. The industrial arts and technical teacher education program is designed to prepare students for the requirements of teaching at all levels of education. Degree programs are offered at the bachelors, masters, and doctoral levels.

The university's Bachelor of Science degree in Construction is located in the College of Architecture rather than engineering, and strictly speaking, is not an engineering degree. Established in 1952, it has been developed through the assistance and recommendations of the American construction industry to meet particular needs of contract construction. The curriculum is a combination of architecture, business, construction, and engineering, with a minimum of 126 semester hours of course work. There are 11 hours of communications required instead of the 6 required in engineering. Technical courses include 9 hours of applied science, 15 hours of design, 9 hours of drawing and surveying, and 6 hours of materials and equipment. In addition, students may specialize in heavy construction, building construction, industrial construction, mechanical construction, electrical construction, or residential construction. A masters degree program in construction engineering and management is expected to be added in 1969.

Northern Arizona University: Non-degree programs in engineering were first established in 1931 in the Department of Industrial Education. More recently the university has offered two-year Associate of Science degree programs in civil, electronic, and drafting technology. In 1965 baccalaureate degrees in technology were added and the number of fields increased to include mechanical technology. That same year a special "Three-two" plan was instituted in engineering education under which students take three years of course work toward a baccalaureate degree and transfer to an engineering school for two more years. Upon completion of the fourth year they are given a Bachelor of Science in industrial education by Northern Arizona University, and after the fifth year, on completion of graduation requirements, a BS in engineering by the institution to which they transferred.

In 1967 the Board of Regents authorized the university to offer Bachelor of Science degrees in engineering. Civil and Electrical Engineering programs have been established. A baccalaureate degree in applied science established in 1966 is also being developed into a general engineering degree. Two hundred fourteen students are enrolled this year in all programs, representing an increase of 28% in engineering and 45% in technology over the year before.

The main thrust of engineering education at Northern Arizona University is in the direction of a general engineering program at the baccalaureate level to be followed by graduate specialization. The present civil and electrical curricula concentrate on applications of engineering knowledge for students planning professional employment after graduation. The four-year and two-year technology programs are intended for students seeking careers in industry on the technician level. In addition to these the university offers baccalaureate programs in Technology Management and Technology Marketing comprised of courses in both engineering technology and business areas, and both baccalaureate and graduate programs in Industrial Education.

Students in General Engineering or applied science take 9 semester hours of communications, including technical report writing; one semester of drafting; 19 semester hours of social studies and humanities; 26 hours of mathematics through calculus and differential equations, which includes a course in applied mathematics; one year each of chemistry and physics, plus a course in philospphy of science; a semester of data processing; 32 semester hours of basic engineering courses; and 20 hours of specialization either in technical courses or in a related discipline. The total program requires 134 semester hours. Students are advised that an additional year at the masters level is necessary to acquire sufficient specialized technical knowledge to work in the profession.

The four-year and two-year technology programs are designed for particular areas of specialization. Four-year programs have generally the same communications, social studies and humanities courses as engineering; they differ from engineering in offering less mathematics and science and more technical courses. The math is technical and applied rather than theoretical. Two-year programs cover the same areas but require fewer courses, particularly in social studies and humanities, but also in science, technology, and in some cases, mathematics.

Industrial Education serves a number of purposes: to prepare industrial arts teachers; to provide experienced craftsmen and technicians with educational training to qualify as vocational-technical teachers in the schools; to broaden the professional training of elementary teachers with occupational instruction; to give students in other programs at the university first-hand experience in the modern world of technology; and to provide trade extension and other vocational education to men and women in the community to help them advance in industrial occupations. Students preparing for careers in industrial arts or vocational-technical education complete the university's requirements for a baccalaureate degree in education with a major of 35 semester hours or a minor of 20 hours in one of these fields. Those who have a background of industrial experience and pursue a degree in trade and industry education may receive credit for this up to 18 semester hours, and 6 hours additional credit for student teaching if they have taught at least two years under contractual arrangements in public schools.

Junior Colleges

All six junior colleges in the state offer associate degree transfer programs in engineering and terminal programs in several fields of technology. The engineering programs are basically alike and correspond as nearly as possible to the first two years of engineering education in the universities.

Phoenix College: Associate degree programs are offered in four technical areas: civil, electronic, drafting, and data processing. The technical curricula vary according to areas of specialization but contain one year of English, one or two years of social studies and humanities, at least one or two semesters of drafting, a flexible mathematics requirement varying from one to five semesters, one semester of general physics, and approximately 30 to 35 semester hours of technical courses. At least half of the technical courses are electives or prescribed in such a way as to permit specialization in a particular area of the technical field. Drafting technology has three major options: mechanical, electro-mechanical, and architectural. Electronics technology has two options: circuits technician, and communications technician. All of the technical curricula require approximately 70 semester hours of course work, and graduates receive certificates in technology as well as associate of arts degree.

Glendale Community College: Two associate degree programs in technology were established in 1966, electronics and drafting, with a current enrollment of approximately 200 students. The curricula are basically similar to those in the other Maricopa County junior colleges.

Mesa Community College: Approximately 120 students are enrolled in two technical programs, electronics and drafting, both established in 1965. Automotive technology is being added.

Arizona Western College: Technical programs are offered in six fields leading to Associate of Applied Science degrees. Drafting technology was established in 1963; electronics, civil, and automotive in 1964; data processing in 1965; and welding in 1967. More than two hundred students are presently enrolled.

Cochise College: Two technology programs leading to Associate of Arts degrees were established in 1965, and three more are being added in 1968. More than 50 students are currently enrolled in civil technology and drafting technology, The curricula are similar to those at the other two-year colleges, with an interdisciplinary emphasis.

Eastern Arizona College: Four technical programs were established in 1965: industrial, mechanical, drafting, or automotive technology. Electronics was added in 1966, data processing in 1967. Mining and geological technology is planned for 1968. The present programs have approximately 150 students, roughly double the number of a year before.

High Schools

About thirty high schools in the state concentrated in the metropolitan area of Phoenix and Tucson have machine shop instruction in their industrial arts programs. A few have electronic, and many provide mechanical drawing. Students from these programs may go into vocational education in their senior year in preparation for immediate industrial employment. Some become apprentices under the state's joint apprenticeship program with employers and labor unions. Approximately 2,000 high school students in Arizona each year receive machine shop instruction in the industrial arts programs.

Five high schools have machine shop programs in vocational education with an enrollment this year of 129 students. Phoenix Union is the largest with 65 students followed by Winslow with 38, Window Rock with 10, and Amphitheatre and Tucson High School in Tucson with 9 and 7 respectively. Many of these students are enrolled in a cooperative work-study program in which they attend school half-days and work the other half as paid employees in industry. Records indicate that over 90% of the students who take the cooperative program stay in their jobs following graduation.

Student Survey

For that inevitable "tomorrow" of industry's needs -- a tomorrow that may be a year, a decade, or a generation in time -- it must look for engineers and technicians to students now in school. From the large entering classes to depleted ranks of graduates the students' interests, experiences, educational background, and career goals will have a bearing upon industry's progress as well as the individuals' private lives for years to come. Above all, the processes of their selection, both intentional and unintentional, will help determine the quality of industry's most important resource.
Not a great deal is actually known about engineering and technology students, little more than knowledge accumulated by individual teachers about their own particular segments of the student population. It was decided, therefore,

to include in this study of engineering and technology a survey of all engineering and technology students in the state.

Student registration lists were obtained from the three universities and six junior colleges. All baccalaureate and graduate engineering students, baccalaureate and associate degree technology students, and the engineering transfer students at Phoenix College and Glendale College were included. The names of engineering students at other junior colleges were unobtainable. Altogether 6,192 questionnaires were sent in prepaid return envelopes, of which 2,092 or 34% were returned. Tables on following pages contain percentages of responses to questions about the students' current status, college programs, high school preparation, work experience, career choice, career goals, and opinion on the reasons for dropouts.

The students who answered questionnaires were arranged in thirty different ways to analyze responses. Each table contains the percentages of responses to all questions for each of the groups, and they may be studied for the differences that appear. Similarities between groups are far more apparent than differences, however.

While about twice as many engineering students as technology students were included in the survey, seven times as many returned questionnaires. The low responses from technology students may indicate a biased sample representing those with higher academic qualifications and ambitions more closely related to engineering. On the basis of return, the two groups show a number of differences, none very great. Engineering students are older, but this is because many of them are third-year, fourth-year, and graduate students. They receive about the same grades, although engineering students ranked higher in high school graduating classes and took more math and science courses. Engineering students' family backgrounds are slighly higher on the economic and occupational scale.

Differences in students in various schools are generally insignificant, except those at Arizona State University. Students there are older, more are married, and more are employed, which reflects a large number of adults from area industries continuing their education. It reflects the strong commuter nature of the university due to location in the major population center of the state.

The lack of graduate students among the University of Arizona figures indicate they did not receive questionnaires. Responses from undergraduate engineering students in all institutions were proportionately higher from juniors and seniors than from freshman and sophomores, resulting in a sample somewhat older and with more definite career goals than might normally be expected.

The number of students who plan to continue education toward a higher degree appears significant -- more than half in engineering and two-thirds in technology. In the case of technicians this would suggest that many of them intend to become engineers. In engineering it follows the current national trend toward graduate degrees. It may also indicate a recognition by both engineering and technology students that continuing education is necessary in the light of rapid technological change.

TABLE 4
ENGINEERING AND TECHNOLOGY STUDENTS
PERSONAL CHARACTERISTICS
(RESPONSES IN PERCENTAGES)

		AGE						SEX		MARITAL			DRAFT STATUS					
	NUMBER	A	B	C	D	E	F	M	F	A	B	C	A	B	C	D	E	F
ALL STUDENTS	2092	1	43	24	25	6	1	97	3	68	30	1	40	13	5	17	3	16
ENGR STUDENTS	1756	2	41	25	26	6	1	97	2	67	31	1	42	12	6	16	3	16
TECH STUDENTS	232	2	53	18	17	8	1	92	7	73	25	0	33	17	1	22	6	13
ENGR 1ST YR	492	5	67	13	12	2	1	96	4	84	14	1	49	13	2	16	3	10
ENGR 2ND YR	329	0	67	14	15	3	0	98	2	82	17	0	59	8	5	12	2	12
ENGR 3RD YR	263	0	40	30	25	4	0	98	2	67	31	1	45	10	5	19	3	15
ENGR 4TH YR	351	1	3	58	32	5	1	97	2	59	38	2	34	11	7	21	5	19
GRADUATE	275	0	3	13	60	21	4	97	2	26	72	1	12	19	15	12	3	33
TECH 1ST YR	119	3	66	13	10	8	1	91	8	74	24	1	35	17	1	20	5	13
TECH 2ND YR	62	0	56	13	19	8	2	90	8	73	26	0	34	13	3	26	8	10
TECH 3RD YR	13	0	31	46	23	0	0	100	0	69	23	0	54	23	0	15	8	0
TECH 4TH YR	17	0	0	53	29	12	6	100	0	65	35	0	18	24	0	29	6	24
U OF A ENGR	533	1	52	29	14	2	0	98	2	83	17	0	54	12	2	14	5	10
ASU ENGR	975	2	30	25	34	8	1	98	2	57	41	1	36	12	9	17	2	20
ASU TECH	54	2	39	31	22	4	2	98	2	67	31	0	52	15	0	17	4	13
NAU ENGR	55	2	60	22	13	4	0	96	2	85	13	0	55	5	0	13	5	20
NAU TECH	9	0	33	67	0	0	0	100	0	100	0	0	67	0	0	11	22	0
PC ENGR	70	0	56	10	29	4	0	96	4	74	24	0	36	16	1	16	6	20
PC TECH	72	1	47	19	18	10	3	83	14	75	21	1	13	36	1	28	7	11
GCC ENGR	75	7	53	15	19	5	1	92	8	64	31	1	29	15	9	17	5	13
GCC TECH	30	0	63	10	17	10	0	97	3	60	37	0	33	3	0	30	3	23
MC TECH	13	0	46	0	38	15	0	100	0	38	62	0	8	23	0	38	15	15
AWC TECH	27	0	81	0	19	0	0	85	15	85	11	0	37	0	0	15	4	11
CC TECH	18	6	83	0	0	11	0	100	0	89	11	0	39	11	0	28	0	11
EAC TECH	14	0	86	7	0	7	0	86	14	93	7	0	43	14	0	14	0	14
HS IND ARTS	709	2	50	25	18	5	1	99	1	72	25	1	46	10	3	19	3	13
HS VOC ED	218	1	49	16	22	11	1	95	3	64	32	1	32	19	5	19	5	11
HS TECH	245	1	51	17	23	6	0	96	4	72	24	1	40	13	3	18	3	16
EMPL EXP	1235	1	27	27	34	9	2	98	2	57	40	1	33	14	5	18	5	21
MIL EXP	480	0	10	19	51	16	4	99	1	39	58	2	8	30	18	9	6	25

AGE

A UNDER 18
B 18-20
C 21-23
D 24-30
E 31-40
F OVER 40

MARITAL STATUS

A SINGLE
B MARRIED
C SEPARATED

DRAFT STATUS (DEC., 1967)

A STUDENT DEFERMENT
B VETERAN
C ACTIVE DUTY
D 1A (ELIGIBLE)
E PHYSICAL DEFERMENT
F OTHER CLASSIFICATIONS

TABLE 5
ENGINEERING AND TECHNOLOGY STUDENTS
ACADEMIC PROGRAM
(RESPONSES IN PERCENTAGES)

		INSTITUTION									DEGREE							YEAR IN SCHOOL				
	NUMBER	A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	A	B	C	D	E
ALL STUDENTS	2092	26	51	3	7	5	2	3	1	1	8	71	4	3	10	2	1	41	22	14	19	13
ENGR STUDENTS	1756	30	56	3	4	4	1	1	1	0	0	84	0	0	12	3	1	39	21	15	21	16
TECH STUDENTS	232	0	27	5	29	11	5	9	7	6	68	0	32	0	0	0	0	51	27	9	9	0
ENGR 1ST YR	492	35	38	5	8	9	1	1	1	1	0	100	0	0	0	0	0	100	0	0	0	0
ENGR 2ND YR	329	35	44	6	7	6	1	.1	0	0	0	100	0	0	0	0	0	0	100	0	0	0
ENGR 3RD YR	263	30	63	2	3	1	0	0	0	0	0	100	0	0	0	0	0	0	0	100	0	0
ENGR 4TH YR	351	41	57	1	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	100	0
GRADUATE	275	2	96	1	0	0	0	0	0	0	0	0	0	0	78	17	4	69	16	3	5	100
TECH 1ST YR	119	0	17	3	26	18	6	13	9	7	81	0	19	0	0	0	0	100	0	0	0	0
TECH 2ND YR	62	2	23	5	44	3	8	5	3	8	69	0	31	0	0	0	0	0	100	0	0	0
TECH 3RD YR	13	0	77	15	8	0	0	0	0	0	0	0	100	0	0	0	0	0	0	100	0	0
TECH 4TH YR	17	0	88	12	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	100	0
U OF A ENGR	533	100	0	0	0	0	0	0	0	0	0	99	0	0	1	0	0	33	22	15	27	1
ASU ENGR	975	0	100	0	0	0	0	0	0	0	0	73	0	0	21	5	1	38	19	18	22	27
ASU TECH	54	0	100	0	0	0	0	0	0	0	0	0	100	0	0	0	0	28	24	19	28	0
NAU ENGR	55	0	0	100	0	0	0	0	0	0	0	96	0	0	2	2	0	44	38	9	7	4
NAU TECH	9	0	0	100	0	0	0	0	0	0	0	0	100	0	0	0	0	22	22	22	22	0
PC ENGR	70	0	0	0	100	0	0	0	0	0	0	100	0	0	0	0	0	53	33	13	0	0
PC TECH	72	0	0	0	100	0	0	0	0	0	86	0	7	0	0	0	0	49	38	7	3	0
GCC ENGR	75	0	0	0	0	100	0	0	0	0	0	100	0	0	0	0	0	61	27	3	0	0
GCC TECH	30	0	0	0	0	100	0	0	0	0	80	0	7	0	0	0	0	80	7	3	0	0
MC TECH	13	0	0	0	0	0	100	0	0	0	85	0	8	0	0	0	0	62	38	0	0	0
AWC TECH	27	0	0	0	0	0	0	100	0	0	74	0	4	0	0	0	0	70	19	4	0	0
CC TECH	18	0	0	0	0	0	0	0	100	0	89	0	6	0	0	0	0	67	11	6	6	0
EAC TECH	14	0	0	0	0	0	0	0	0	100	86	0	7	0	0	0	0	57	43	0	0	0
HS IND ARTS	709	26	45	4	10	6	2	3	2	3	9	73	4	5	6	1	0	43	22	14	17	7
HS VOC ED	218	23	38	4	12	7	3	6	4	3	12	63	6	7	6	2	1	48	25	9	12	9
HS TECH	245	25	39	4	13	7	2	5	2	2	14	68	5	4	6	2	0	46	21	11	14	8
EMPL EXP	1235	24	57	3	7	4	2	2	1	1	6	66	4	3	15	4	1	37	20	16	23	19
MIL EXP	480	20	59	1	8	6	2	1	0	1	7	65	3	3	16	3	1	39	20	15	22	21

INSTITUTION

- A UNIVERSITY OF ARIZONA
- B ARIZONA STATE UNIVERSITY
- C NORTHERN ARIZONA UNIVERSITY
- D PHOENIX COLLEGE
- E GLENDALE COMMUNITY COLLEGE
- F MESA COMMUNITY COLLEGE
- G ARIZONA WESTERN COLLEGE
- H COCHISE COLLEGE
- I EASTERN ARIZONA COLLEGE

DEGREE

- A AS, AA IN TECHNICAL AREA
- B BS IN ENGINEERING
- C BS IN TECHNOLOGY
- D BS, BA - NON ENGINEERING
- E MASTERS DEGREE
- F DOCTORATE
- G NON-CLASSIFIED GRADUATE

YEAR IN SCHOOL

- A FIRST YEAR
- B SECOND YEAR
- C THIRD YEAR
- D FOURTH YEAR
- E GRADUATE

TABLE 5 (CONTINUED)
ENGINEERING AND TECHNOLOGY STUDENTS
ACADEMIC PROGRAM
(RESPONSES IN PERCENTAGES)

	NUMBER	MAJOR A	B	C	D	E	F	G	H	I	J
ALL STUDENTS	2092	9	0	2	2	9	4	3	3	1	27
ENGR STUDENTS	1756	8	0	1	3	10	5	1	1	0	29
TECH STUDENTS	232	13	0	2	1	5	0	15	10	3	15
ENGR 1ST YR	492	11	0	1	3	7	4	1	2	1	28
ENGR 2ND YR	329	10	1	2	4	11	5	1	1	0	29
ENGR 3RD YR	263	6	2	0	3	13	9	2	1	0	26
ENGR 4TH YR	351	9	1	1	1	13	7	1	1	0	28
GRADUATE	275	1	0	0	3	8	0	1	0	0	36
TECH 1ST YR	119	11	0	3	2	4	0	14	12	3	16
TECH 2ND YR	62	13	0	3	0	5	0	21	5	2	15
TECH 3RD YR	13	38	0	0	0	8	0	0	15	8	8
TECH 4TH YR	17	29	0	0	0	12	0	0	0	0	24
U OF A ENGR	533	18	0	1	0	13	1	1	0	0	29
ASU ENGR	975	3	1	1	4	9	8	1	1	0	31
ASU TECH	54	48	0	0	0	0	0	0	9	2	15
NAU ENGR	55	5	0	0	5	15	0	0	5	0	36
NAU TECH	9	0	0	0	0	33	0	0	11	0	0
PC ENGR	70	6	0	0	0	6	0	3	4	0	20
PC TECH	72	3	0	0	0	6	0	36	10	0	18
GCC ENGR	75	5	0	0	3	1	0	0	3	3	20
GCC TECH	30	3	0	0	3	0	0	0	7	3	40
MC TECH	13	0	0	0	0	0	0	0	15	8	23
AWC TECH	27	4	0	7	4	4	0	11	4	4	0
CC TECH	18	11	0	0	0	17	0	0	11	11	0
EAC TECH	14	0	0	36	0	0	0	29	21	7	0
HS IND ARTS	709	8	0	3	2	9	5	3	4	1	23
HS VOC ED	218	7	1	2	0	7	2	6	6	1	26
HS TECH	245	8	0	2	1	7	5	2	6	0	29
EMPL EXP	1235	7	0	2	2	9	5	2	2	1	30
MIL EXP	480	5	0	1	1	9	4	2	1	1	32

MAJOR

A AEROSPACE
B AGRICULTURAL
C AUTOMOTIVE
D CHEMICAL
E CIVIL
F CONSTRUCTION
G DATA PROCESSING TECHNOLOGY
H DRAFTING TECHNOLOGY
I EDUCATION
J ELECTRICITY

TABLE 5 (CONTINUED)
ENGINEERING AND TECHNOLOGY STUDENTS
ACADEMIC PROGRAM
(RESPONSES IN PERCENTAGES)

MAJOR												PREVIOUS			
K	L	M	N	O	P	Q	R	S	T	U	V	A	B	C	D
5	2	4	5	1	12	0	0	1	1	1	1	17	3	3	1
4	2	4	6	1	14	0	0	1	1	1	0	17	3	3	1
16	2	5	1	0	3	0	0	0	1	1	1	21	5	3	1
7	2	6	3	1	10	0	0	2	2	1	0	12	1	2	1
2	2	4	2	2	15	0	0	3	1	0	0	12	4	3	2
3	2	3	6	1	17	0	0	0	2	2	0	21	7	4	0
3	3	1	4	1	18	0	0	1	1	2	1	25	2	3	1
1	3	2	18	1	12	0	0	0	1	2	0	19	2	4	0
15	1	8	1	0	1	0	0	0	1	2	1	12	4	3	0
18	3	3	0	0	6	0	2	0	0	0	2	24	2	5	3
23	0	0	0	0	0	0	0	0	0	0	0	62	0	0	0
18	6	6	6	0	0	0	0	0	0	0	0	53	18	0	0
1	2	2	1	3	14	0	0	4	3	0	0	12	2	2	0
3	2	2	9	0	15	0	0	0	0	2	0	21	4	4	1
19	2	2	2	0	0	0	0	0	0	2	0	44	6	4	4
13	0	5	0	0	7	0	0	0	0	7	0	16	2	4	0
44	0	0	0	0	11	0	0	0	0	0	0	22	0	0	0
16	0	19	3	0	10	0	0	1	3	0	0	10	0	7	0
10	1	7	0	0	4	0	1	0	0	0	0	13	7	0	0
12	8	20	1	3	7	0	0	0	1	1	0	12	3	4	3
17	0	10	3	0	3	0	0	0	0	3	0	10	0	3	0
38	0	0	0	0	0	0	0	0	0	0	0	15	0	8	0
30	4	7	0	0	0	0	0	0	0	0	7	11	7	0	0
6	0	6	0	0	6	0	0	0	11	0	0	22	6	22	0
0	7	0	0	0	0	0	0	0	0	0	0	7	7	0	0
7	3	4	4	1	13	0	0	1	1	2	1	17	3	2	1
8	1	7	4	1	10	0	0	2	0	2	0	21	4	2	1
9	2	6	4	0	9	0	0	3	2	1	1	20	3	3	2
5	3	4	6	1	14	0	0	1	1	1	0	21	3	3	1
6	4	3	7	1	13	0	0	1	1	1	1	19	3	4	1

K ELECTRONICS
L ENGINEERING TECHNOLOGY - GENERAL
M GENERAL ENGINEERING
N INDUSTRIAL
O MATHEMATICS
P MECHANICAL
Q METALLURGICAL
R MINING
S NUCLEAR
T PHYSICS
U SCIENCE
V WELDING TECHNOLOGY

PREVIOUS MAJOR

A ANOTHER MAJOR IN ENGINEERING OR TECHNOLOGY
B SCIENCE
C MATHEMATICS
D LIBERAL ARTS

TABLE 6
ENGINEERING AND TECHNOLOGY STUDENTS
EDUCATIONAL CHOICE
(RESPONSES IN PERCENTAGES)

	NUMBER	SCHOOL SELECTION A	B	C	D	E	F	G	WHY STUDENTS DISCONTINUE A	B	C	D	E	F	G
ALL STUDENTS	2092	39	28	17	3	4	1	3	3	5	9	4	54	3	3
ENGR STUDENTS	1756	40	28	16	3	4	1	2	3	4	9	4	57	3	3
TECH STUDENTS	232	34	26	22	2	1	1	8	2	8	11	9	35	3	4
ENGR 1ST YR	492	34	29	20	3	0	1	4	2	2	9	4	62	3	1
ENGR 2ND YR	329	40	29	18	2	3	1	1	1	4	7	4	63	2	3
ENGR 3RD YR	263	41	31	14	5	5	1	0	3	4	8	3	61	2	2
ENGR 4TH YR	351	37	30	15	3	7	1	0	4	7	9	4	53	3	4
GRADUATE	275	52	19	12	2	10	0	0	4	4	9	4	45	4	3
TECH 1ST YR	119	33	24	25	1	1	0	9	2	9	8	11	37	3	3
TECH 2ND YR	62	19	37	26	2	2	2	10	3	6	16	6	39	2	5
TECH 3RD YR	13	54	15	15	0	0	15	0	8	15	15	8	15	8	15
TECH 4TH YR	17	65	12	6	12	0	0	6	0	0	12	6	41	6	6
U OF A ENGR	533	32	36	19	4	1	1	0	3	5	8	3	62	3	2
ASU ENGR	975	45	28	12	3	7	1	0	3	3	8	3	56	2	3
ASU TECH	54	56	20	11	6	0	2	0	4	4	15	7	28	6	15
NAU ENGR	55	42	18	7	0	0	2	16	0	9	11	2	56	7	0
NAU TECH	9	11	22	0	0	0	11	33	0	22	22	0	44	0	0
PC ENGR	70	31	16	39	1	1	1	6	3	9	10	10	47	0	1
PC TECH	72	15	29	33	1	0	0	8	0	14	4	10	33	4	0
GCC ENGR	75	45	5	37	0	1	0	4	3	1	19	4	47	3	3
GCC TECH	30	50	23	20	0	3	0	3	0	7	3	7	47	3	7
MC TECH	13	69	8	23	0	0	0	0	8	0	15	15	31	0	0
AWC TECH	27	30	30	19	0	0	0	19	4	4	7	15	44	0	0
CC TECH	18	17	28	33	0	6	0	11	0	0	33	6	28	6	0
EAC TECH	14	29	50	7	0	0	0	14	7	7	21	7	29	0	0
HS IND ARTS	709	35	30	17	3	2	1	4	4	4	9	5	54	2	3
HS VOC ED	218	40	25	20	0	5	0	6	2	5	11	6	49	5	2
HS TECH	245	33	33	19	2	2	0	3	2	5	9	4	53	2	2
EMPL EXP	1235	43	28	15	2	4	1	2	3	5	9	5	50	3	3
MIL EXP	480	44	22	10	4	13	1	1	2	4	9	5	48	4	4

SCHOOL SELECTION

A CONVENIENT LOCATION
B PROGRAM OR COURSE OFFERINGS
C FINANCIAL CONSIDERATIONS
D CLIMATE
E MILITARY ASSIGNMENT
F ADMISSION OR TRANSFER CONSIDERATIONS
G PREFER JUNIOR COLLEGE OR SMALL SCHOOL

WHY STUDENTS DISCONTINUE PROGRAM

A LACK PROPER EDUCATIONAL BACKGROUND
B LACK ABILITY
C LACK INTEREST
D LACK TIME OR FINANCES
E DIFFICULTY OF PROGRAM
F CHANGING INTERESTS
G DISLIKE PROFESSORS

TABLE 7
ENGINEERING AND TECHNOLOGY STUDENTS
HIGH SCHOOL PREPARATION AND EMPLOYMENT EXPERIENCE
(RESPONSES IN PERCENTAGES)

		GRADE AVERAGE				HIGHER DEGREE			HS CLASS RANK					HIGH SCHOOL MAJOR						
	NUMBER	A	B	C	D	A	B	C	A	B	C	D	E	A	B	C	D	E	F	G
ALL STUDENTS	2092	10	45	35	3	58	27	11	31	31	25	8	2	20	25	1	18	10	2	3
ENGR STUDENTS	1756	11	45	34	3	58	27	11	35	31	23	7	2	19	26	1	19	10	1	2
TECH STUDENTS	232	10	50	34	2	64	23	10	14	30	34	13	4	26	17	2	16	9	3	6
ENGR 1ST YR	492	9	38	35	3	66	19	11	28	34	22	10	2	15	22	1	25	9	2	4
ENGR 2ND YR	329	13	47	34	3	64	20	12	33	33	22	7	2	17	16	1	19	15	1	3
ENGR 3RD YR	263	9	40	45	4	57	24	13	35	29	25	7	2	20	28	0	20	13	1	1
ENGR 4TH YR	351	12	46	40	2	62	26	11	35	29	28	6	1	19	40	1	15	7	1	1
GRADUATE	275	12	59	16	1	28	57	9	48	28	15	2	3	29	27	0	14	10	1	1
TECH 1ST YR	119	9	50	34	3	64	24	12	14	30	35	12	3	27	15	3	18	8	3	8
TECH 2ND YR	62	16	53	27	0	66	16	15	19	31	29	13	3	26	13	2	18	8	5	3
TECH 3RD YR	13	0	46	46	8	38	54	0	8	38	46	0	8	8	38	0	15	23	0	8
TECH 4TH YR	17	0	35	65	0	71	29	0	6	35	29	18	6	35	47	0	0	6	0	0
U OF A ENGR	533	21	48	21	1	63	20	14	42	27	21	7	1	13	26	0	24	10	2	2
ASU ENGR	975	4	41	43	4	51	34	10	36	33	22	5	2	22	29	0	17	11	1	2
ASU TECH	54	4	39	50	6	54	35	9	9	41	30	15	4	30	24	0	19	11	2	6
NAU ENGR	55	9	60	22	2	78	16	4	22	22	36	9	2	24	9	2	18	2	0	7
NAU TECH	9	0	78	22	0	56	33	11	0	44	56	0	0	0	67	0	0	6	0	0
PC ENGR	70	4	67	24	0	66	16	10	13	30	21	17	4	10	17	4	17	7	1	6
PC TECH	72	15	51	31	0	71	17	10	14	22	42	7	4	24	17	1	19	7	1	1
GCC ENGR	75	20	52	25	1	73	13	9	15	35	28	15	3	28	9	1	27	9	0	4
GCC TECH	30	3	60	30	0	63	23	13	13	17	40	17	7	33	10	0	23	17	0	7
MC TECH	13	23	46	31	0	77	15	8	15	23	31	15	0	46	8	0	15	8	0	23
AWC TECH	27	7	44	41	0	63	22	15	11	41	37	0	4	26	11	7	4	0	7	19
CC TECH	18	17	56	28	0	61	28	6	17	11	44	28	0	11	11	11	11	11	11	11
EAC TECH	14	14	36	43	0	93	7	0	21	21	29	21	0	29	21	7	7	7	14	0
HS IND ARTS	709	9	45	38	3	59	26	11	27	32	27	9	1	21	22	0	18	10	2	6
HS VOC ED	218	7	46	35	3	60	25	12	26	27	31	11	2	19	18	3	12	11	9	4
HS TECH	245	10	47	31	4	65	21	11	27	31	30	9	1	18	20	0	18	12	4	9
EMPL EXP	1235	11	47	34	3	56	29	11	31	30	25	8	2	21	28	0	17	10	2	3
MIL EXP	480	9	51	33	2	58	29	9	24	28	29	9	3	32	26	1	14	7	2	2

GRADE AVERAGE

NUMERICAL GRADES HAVE BEEN CONVERTED TO LETTER GRADES A-B-C-D

HIGHER DEGREE

A PLAN TO CONTINUE TOWARD HIGHER DEGREE AFTER PRESENT PROGRAM.
B DO NOT PLAN TO CONTINUE TOWARD HIGHER DEGREE.
C UNDECIDED

HS CLASS RANK

A UPPER 1/10
B UPPER 1/4
C SECOND 1/4
D THIRD 1/4
E LOWER 1/4

HIGH SCHOOL MAJOR

A GENERAL EDUCATION
B COLLEGE PREPARATORY
C BUSINESS
D MATHEMATICS
E SCIENCE
F VOCATIONAL EDUCATION
G OTHER MAJORS

TABLE 7 (CONTINUED)
ENGINEERING AND TECHNOLOGY STUDENTS
HIGH SCHOOL PREPARATION AND EMPLOYMENT EXPERIENCE
(RESPONSES IN PERCENTAGES)

		PROGRAM IN HS			HIGH SCHOOL COURSES [1]									HS MATH			
	NUMBER	A	B	C	A	B	C	D	E	F	G	H	I	A	B	C	D
ALL STUDENTS	2092	34	11	12	3	6	1	13	11	9	10	1	14	4	12	18	65
ENGR STUDENTS	1756	33	9	11	2	6	1	11	10	8	9	1	13	3	10	16	70
TECH STUDENTS	232	40	18	20	2	8	3	23	19	10	13	2	17	6	22	33	37
ENGR 1ST YR	492	38	12	15	2	7	1	17	13	8	11	1	13	3	8	16	71
ENGR 2ND YR	329	35	9	10	2	5	1	10	12	8	11	1	14	2	9	14	74
ENGR 3RD YR	263	34	6	10	3	5	1	11	10	7	10	1	13	3	12	13	72
ENGR 4TH YR	351	32	7	8	3	5	1	9	7	9	8	0	11	2	11	15	70
GRADUATE	275	20	7	7	2	4	1	4	4	9	4	2	10	5	11	22	61
TECH 1ST YR	119	44	18	23	3	6	1	32	22	8	15	1	22	6	24	33	36
TECH 2ND YR	62	40	26	19	2	13	8	16	16	10	13	3	11	6	21	35	35
TECH 3RD YR	13	31	23	8	0	0	0	8	23	31	8	0	8	8	23	31	38
TECH 4TH YR	17	18	0	18	0	0	0	0	18	6	0	0	12	0	24	29	41
U OF A ENGR	533	33	9	11	2	5	1	8	11	6	14	0	12	3	8	11	78
ASU ENGR	975	31	7	9	2	5	1	11	8	10	6	1	12	3	9	18	70
ASU TECH	54	28	13	15	0	7	4	19	17	15	7	0	9	7	17	28	46
NAU ENGR	55	29	16	9	2	0	0	16	13	7	13	0	22	0	16	20	62
NAU TECH	9	78	0	33	0	0	11	22	0	0	0	0	44	22	0	44	33
PC ENGR	70	53	17	21	4	10	1	19	26	14	13	1	14	9	20	14	57
PC TECH	72	40	21	25	3	14	0	17	19	4	10	0	10	6	21	32	39
GCC ENGR	75	29	12	13	5	11	3	21	11	1	11	3	15	4	17	25	53
GCC TECH	30	50	13	20	3	10	0	27	23	3	20	3	23	17	20	30	33
MC TECH	13	54	23	23	0	0	0	46	15	0	8	0	23	8	38	8	31
AWC TECH	27	37	19	22	0	11	4	22	41	19	26	4	26	0	26	44	30
CC TECH	18	39	33	17	11	6	6	39	11	17	39	11	22	6	39	22	33
EAC TECH	14	57	21	14	0	7	14	36	14	21	21	0	43	0	29	50	21
HS IND ARTS	709	101	12	16	3	14	3	30	23	21	25	2	38	4	13	21	61
HS VOC ED	218	39	101	28	19	16	3	22	27	20	23	3	18	5	25	25	43
HS TECH	245	47	26	100	3	13	2	30	40	20	16	2	20	4	15	22	58
EMPL EXP	1235	33	11	12	3	7	1	12	11	9	10	1	13	5	13	19	62
MIL EXP	480	29	14	12	4	7	2	12	9	8	9	1	14	7	21	23	47

PROGRAMS IN HIGH SCHOOL

A INDUSTRIAL ARTS
B VOCATIONAL EDUCATION
C TECHNICAL EDUCATION

HIGH SCHOOL COURSES [1]

A AGRICULTURE
B AUTO MECHANICS
C ARTS AND CRAFTS
D DRAFTING
E ELECTRICITY-ELECTRONICS
F GENERAL SHOP
G METALWORK
H PRINTING
I WOODWORK

HIGH SCHOOL MATH

A 1 YEAR
B 2 YEARS
C 3 YEARS
D 4 YEARS

[1] Courses taken by students in industrial arts, vocational education, or technical education.

TABLE 7 (CONTINUED)
ENGINEERING AND TECHNOLOGY STUDENTS
HIGH SCHOOL PREPARATION AND EMPLOYMENT EXPERIENCE
(RESPONSES IN PERCENTAGES)

	NUMBER	HS CHEM A	HS CHEM B	HS PHYSICS A	HS PHYSICS B	HS DRAFTING A	HS DRAFTING B	HS DRAFTING C	EMPLOYMENT EXP A	EMPLOYMENT EXP B	EMPLOYMENT EXP C	EMPLOYMENT EXP D	EMPLOYMENT EXP E
ALL STUDENTS	2092	74	7	71	4	31	15	5	14	10	4	51	23
ENGR STUDENTS	1756	77	8	76	4	32	14	5	16	10	3	52	24
TECH STUDENTS	232	63	5	50	3	29	18	9	4	16	5	51	20
ENGR 1ST YR	492	77	7	74	3	31	17	6	5	9	2	37	17
ENGR 2ND YR	329	79	8	76	4	32	12	5	4	8	5	47	20
ENGR 3RD YR	263	76	11	79	5	35	13	6	8	15	5	54	25
ENGR 4TH YR	351	79	8	75	6	32	14	4	11	16	5	63	27
GRADUATE	275	74	6	76	5	34	14	2	63	2	1	69	36
TECH 1ST YR	119	61	3	44	0	24	18	11	2	12	4	42	19
TECH 2ND YR	62	60	10	45	6	40	16	8	2	11	3	48	23
TECH 3RD YR	13	69	0	77	0	23	23	8	0	23	0	85	15
TECH 4TH YR	17	82	0	76	12	29	12	6	18	35	18	88	29
U OF A ENGR	533	80	8	82	5	34	11	4	7	11	3	45	18
ASU ENGR	975	77	9	77	5	32	16	5	23	9	4	57	27
ASU TECH	54	69	7	69	2	31	17	9	6	30	4	65	22
NAU ENGR	55	78	4	62	4	36	7	4	4	7	9	35	13
NAU TECH	9	67	0	44	11	33	44	0	0	11	11	78	0
PC ENGR	70	63	3	47	1	40	7	4	6	13	16	57	26
PC TECH	72	63	3	38	6	22	14	11	1	11	3	46	26
GCC ENGR	75	72	3	60	1	27	19	8	7	17	1	39	28
GCC TECH	30	47	10	53	0	27	30	7	3	20		40	27
MC TECH	13	38	8	31	0	23	23	15	0	23	0	69	46
AWC TECH	27	63	0	44	4	26	15	4	0	11	0	41	11
CC TECH	18	61	6	50	6	39	17	11	6	6	0	39	6
EAC TECH	14	64	0	36	0	43	7	7	0	0	14	29	7
HS IND ARTS	709	73	6	67	5	37	21	7	10	10	5	50	20
HS VOC ED	218	62	5	51	6	29	16	5	11	12	5	54	29
HS TECH	245	68	7	63	8	34	18	9	11	13	8	52	23
EMPL EXP	1235	72	7	71	5	32	15	6	24	18	6	87	30
MIL EXP	480	66	5	65	5	32	13	5	21	19	5	67	100

HS CHEMISTRY
- A 1 YEAR
- B 2 YEARS

HS PHYSICS
- A 1 YEAR
- B 2 YEARS

HS DRAFTING
- A 1 YEAR
- B 2 YEARS
- C 3 YEARS

EMPLOYMENT EXP
- A PRESENT EMPLOYED ENGINEER
- B PRESENT EMPLOYED TECHNICIAN
- C PRESENT EMPLOYED SKILLED CRAFTSMAN
- D PREVIOUS INDUSTRIAL OR MECHANICAL EMPLOYMENT
- E SKILLED TRAINING OR EXPERIENCE IN THE ARMED SERVICES

TABLE 8
ENGINEERING AND TECHNOLOGY STUDENTS
CAREER SELECTION
(RESPONSES IN PERCENTAGES)

		CAREER OBJECTIVE									
	NUMBER	A	B	C	D	E	F	G	H	I	J
ALL STUDENTS	2092	46	25	0	14	1	3	3	0	85	13
ENGR STUDENTS	1756	49	22	0	15	2	3	4	0	85	13
TECH STUDENTS	232	29	46	0	9	0	4	2	0	86	9
ENGR 1ST YR	492	53	26	0	8	2	2	1	0	82	15
ENGR 2ND YR	329	53	22	1	14	2	1	2	0	88	11
ENGR 3RD YR	263	54	19	0	17	1	0	3	0	84	15
ENGR 4TH YR	351	44	22	1	17	2	2	7	0	89	10
GRADUATE	275	39	15	0	24	1	10	7	0	86	11
TECH 1ST YR	119	31	45	1	7	1	5	2	0	83	12
TECH 2ND YR	62	29	50	0	8	0	3	2	0	94	5
TECH 3RD YR	13	15	62	0	15	0	8	0	0	77	23
TECH 4TH YR	17	29	24	0	24	0	0	6	0	94	6
U OF A ENGR	533	53	23	0	11	2	1	2	0	84	14
ASU ENGR	975	48	18	1	18	2	4	5	0	86	13
ASU TECH	54	35	39	0	11	2	2	4	0	89	9
NAU ENGR	55	49	36	2	7	2	2	0	0	85	9
NAU TECH	9	44	44	0	11	0	0	0	0	100	0
PC ENGR	70	41	34	1	10	0	1	0	0	81	13
PC TECH	72	26	46	0	10	0	1	0	0	86	7
GCC ENGR	75	41	39	0	8	3	1	0	0	87	13
GCC TECH	30	30	47	3	3	0	3	3	0	90	0
MC TECH	13	8	62	0	15	0	8	0	0	100	0
AWC TECH	27	26	48	0	15	0	4	0	0	74	22
CC TECH	18	44	28	0	11	0	11	0	0	44	39
EAC TECH	14	7	79	0	0	0	14	0	0	93	7
HS IND ARTS	709	42	31	0	14	1	3	2	0	85	12
HS VOC ED	218	38	31	1	18	1	2	2	0	82	14
HS TECH	245	41	35	0	11	0	3	3	0	88	9
EMPL EXP	1235	45	24	0	17	1	3	3	0	86	11
MIL EXP	480	40	25	0	16	2	3	9	0	88	10

CAREER OBJECTIVE

A PROFESSIONAL
B TECHNICAL
C SKILLED
D MANAGEMENT
E RESEARCH
F TEACHING
G MILITARY
H NONE
I OBJECTIVE QUITE FIRM
J OBJECTIVE NOT FIRM

TABLE 8 (CONTINUED)
ENGINEERING AND TECHNOLOGY STUDENTS
CAREER SELECTION
(RESPONSES IN PERCENTAGES)

TIME CAREER CHOSEN					CAREER INFLUENCE								
A	B	C	D	E	A	B	C	D	E	F	G	H	I
10	45	15	13	2	23	7	8	3	26	2	3	23	4
11	46	14	12	2	24	7	7	3	25	2	3	24	4
7	41	19	16	0	18	7	9	5	30	3	3	25	1
13	60	8	5	0	26	8	10	2	19	2	3	25	4
10	52	15	9	0	24	6	6	3	23	2	4	26	5
12	42	17	14	1	21	7	7	3	29	4	2	22	6
12	34	12	23	2	25	6	5	3	27	3	3	22	3
7	33	23	17	8	20	9	8	3	34	2	2	20	3
6	50	14	11	0	18	6	13	4	23	2	3	27	2
6	32	27	16	2	13	8	6	5	29	6	3	26	2
15	31	23	23	0	31	8	0	23	31	0	0	23	0
6	29	12	53	0	24	12	12	0	53	0	0	24	0
14	52	8	8	1	26	5	4	2	20	3	4	30	5
10	42	17	16	3	23	8	9	4	27	2	3	21	4
17	31	22	26	0	20	15	7	6	31	2	4	28	2
7	58	5	11	0	18	4	9	0	31	0	4	24	4
0	44	11	33	0	33	0	11	0	44	0	0	0	0
19	40	19	6	0	21	9	1	1	27	3	3	27	1
4	38	17	7	0	15	6	7	3	31	1	3	28	0
5	49	16	4	0	29	11	9	1	29	4	5	12	1
7	30	27	17	0	20	3	3	7	27	7	0	17	0
0	38	23	23	8	8	0	8	8	38	0	0	31	8
4	48	22	11	0	19	15	22	7	26	4	0	22	4
6	61	6	22	0	28	11	0	11	22	0	6	28	0
0	57	21	7	0	14	0	43	0	21	7	0	7	0
11	48	15	12	1	21	7	9	3	25	2	3	23	4
9	42	17	11	2	20	7	9	4	37	4	1	16	3
11	48	17	8	2	24	10	7	2	26	0	3	20	7
11	37	18	14	3	21	7	6	3	34	2	3	20	4
7	24	30	13	4	16	5	5	3	42	7	3	15	3

TIME CAREER CHOSEN

A BEFORE HIGH SCHOOL
B WHILE IN HIGH SCHOOL
C BETWEEN HIGH SCHOOL AND COLLEGE
D WHILE IN COLLEGE
E AFTER PREVIOUS COLLEGE

CAREER INFLUENCE

A FAMILY
B FRIENDS AND ACQUAINTENCES
C HIGH SCHOOL EXPERIENCE
D COLLEGE EXPERIENCE
E WORK EXPERIENCE
F MILITARY SERVICE
G TV, BOOKS, ETC.
H PERSONAL INTEREST

TABLE 9
ENGINEERING AND TECHNOLOGY STUDENTS
FAMILY BACKGROUND
(RESPONSES IN PERCENTAGES)

		FATHER'S OCCUPATION									FAMILY INCOME						
	NUMBER	A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G
ALL STUDENTS	2092	11	3	22	9	9	12	21	4	5	4	14	23	18	14	9	14
ENGR STUDENTS	1756	11	3	21	9	9	13	21	4	5	4	13	22	18	14	9	15
TECH STUDENTS	232	8	4	26	13	12	9	16	3	3	3	20	29	15	12	6	11
ENGR 1ST YR	492	13	3	22	7	7	13	22	5	5	3	13	22	20	10	13	14
ENGR 2ND YR	329	10	2	25	9	9	14	20	5	4	2	11	22	18	16	9	16
ENGR 3RD YR	263	13	3	20	10	10	13	21	5	3	6	13	18	19	17	8	16
ENGR 4TH YR	351	10	3	24	5	10	13	21	4	5	2	11	25	15	17	9	17
GRADUATE	275	13	4	12	13	11	12	24	1	7	8	14	23	18	12	6	14
TECH 1ST YR	119	6	4	28	13	13	10	16	2	4	3	24	29	18	11	3	8
TECH 2ND YR	62	10	3	29	8	16	5	13	8	3	5	16	29	15	16	10	8
TECH 3RD YR	13	8	8	8	15	0	15	38	0	0	0	8	38	0	8	8	38
TECH 4TH YR	17	18	0	12	35	0	12	24	0	0	6	0	29	18	18	12	12
U OF A ENGR	533	13	3	26	4	10	15	18	6	4	3	10	23	17	14	12	16
ASU ENGR	975	12	3	17	11	8	13	25	3	5	4	13	21	18	15	9	16
ASU TECH	54	17	4	17	17	2	13	26	0	0	6	7	24	9	20	7	20
NAU ENGR	55	7	0	33	4	16	13	11	4	5	0	15	36	11	16	9	5
NAU TECH	9	11	22	11	0	0	0	33	11	0	0	22	22	11	22	11	0
PC ENGR	70	10	4	37	1	16	6	10	7	1	7	24	23	16	7	9	7
PC TECH	72	4	1	40	3	24	6	6	6	6	3	21	26	18	11	6	11
GCC ENGR	75	11	7	24	11	9	9	16	4	7	8	17	24	33	7	3	3
GCC TECH	30	0	3	27	23	13	7	17	3	3	0	33	33	17	7	7	3
MC TECH	13	15	8	31	8	0	8	15	0	8	0	8	31	23	15	15	8
AWC TECH	27	7	7	15	15	4	11	22	7	4	4	37	22	22	4	0	4
CC TECH	18	0	11	28	17	0	17	17	6	6	0	28	33	22	0	11	6
EAC TECH	14	7	0	36	7	21	7	14	0	0	0	7	50	14	21	0	7
HS IND ARTS	709	9	4	22	10	11	11	21	4	5	3	14	23	20	14	9	12
HS VOC ED	218	8	4	28	12	14	9	15	3	3	4	17	29	19	10	5	10
HS TECH	245	9	5	25	9	9	14	16	3	3	3	15	21	25	13	7	11
EMPL EXP	1235	11	3	22	10	9	12	21	3	5	4	14	24	16	14	9	14
MIL EXP	480	10	3	21	11	13	10	18	4	5	5	16	25	17	10	8	10

FATHER'S OCCUPATION

A ENGINEER
B TECHNICIAN
C SKILLED
D SEMI-SKILLED
E UNSKILLED
F A DIFFERENT PROFESSION
G BUSINESS
H MILITARY
I GOVERNMENT

FAMILY INCOME

A LESS THAN $300 PER MONTH
B $300 - $500 PER MONTH
C $500 - $700 PER MONTH
D $700 - $900 PER MONTH
E $900 - $1100 PER MONTH
F $1100 - $1300 PER MONTH
G MORE THAN $1300 PER MONTH

Another significant observation is the amount of work experience reported by students in both engineering and technology. More than half have been employed as industrial workers, technicians, or engineers. One-fourth have received technical training or experience in the armed services. Nearly one-third are now employed, predominately in the Phoenix and Tucson areas. The importance of work experience as an influence in career selection is evident in the percentages of first year students who have had industrial or mechanical employment -- 37% of the first year engineering students, and 42% of the first year technology students.

In selecting careers, nearly half made the choice while in high school, and 10% even before that. The three principal influences, representing approximately one-fourth of the students in each case, were family, work experience, and personal interest. For technology students, the influence of families was a little less and work experience a bit more. An overwhelming majority of all students are confident of their career choices.

Nearly one-fourth of the students' fathers were skilled craftsmen and nearly one-fifth semi-skilled or unskilled. Their parents' family income ranged rather evenly from $300 per month to more than $1,300 per month, with nearly one-fourth in the $500 to $700 bracket.

One-third of all students had industrial arts courses in high school, and 10% took either vocational or technical education. No significant differences appear in the responses of these students from those without such preparatory high school training.

Half of all students have had one to three years of drafting in high school. More engineering students than technical students had taken several years of mathematics and science in high school, but the percentages are high for both.

When engineering students were asked why others drop out of the program, more than half said it was too difficult for them. A third of the technology students gave the same answer.

The interpretations that may be drawn from this phase of the survey are endless. The data compiled are the best yet obtained, and as such are valuable although not to be considered dogmatic or permanent. As the report went to press, changes in the Selective Service program made the data for draft status largely obsolete. Patterns may be seen, however, which will enable educators to review recruiting and admission policies and industry to examine its own interests in these areas.

CHAPTER IV

SURVEY OF INDUSTRY

How the Survey Was Made

All employers of engineering or technical personnel in Arizona who could be identified were contacted and asked to participate. This included mining, manufacturing, contract construction, transportation, communications, utilities, services, military installations, educational institutions, and other government agencies. Altogether 610 companies and organizations were contacted, and 580 participated in the survey including all major employers.

A list of thirty-six occupational categories was used to include all personnel from professional engineers to skilled craftsmen. Employers were interviewed separately for each occupation in which the company employed personnel. Classification of employees was left entirely to employers, who were asked to identify each of their engineering, technical, and skilled employees in one or another of the 36 occupations according to the nature of the job and the educational qualifications normally required. Questionnaires were given to all employees according to the occupations in which they were identified by their employers. From early June to mid-October (1967), 1,570 employer interviews were completed, 13,589 employee questionnaires distributed, and 3,926 employee questionnaires returned.

The data were key punched and printed out in basic tables showing the number and percentages of responses to each question within each occupational classification. Summary tables were printed out using percentages only, and the data in these are arranged by major subject to include employer and employee responses to similar questions. The employer percentages are of total employees in each occupation rather than of the employers themselves. The employee percentages are of the number in each occupation who returned questionnaires. Table 10 contains the number of employees who received questionnaires, the number returned, and the percentage of returns by occupation and major classification. The number receiving questionnaires is the total number of employees represented by the employer data.

Results

Technical Skills Required and Used: A list of eighteen skilled activities was used in the survey to gather data on job functions. Employers were asked which are major skills, which are minor skills, and which are not used. Employees were asked the approximate percent of time they spend in each activity. It was not the purpose of the survey to arrive at job descriptions,

TABLE 10

EMPLOYEES REPRESENTED IN THE SURVEY

	Questionnaires Distributed	Questionnaires Returned	Percent
Aerospace Engineers	184	16	8
Chemical Engineers	258	89	34
Civil Engineers	871	445	51
Electrical Engineers	919	185	20
Electronic Engineers	1299	465	35
Geological Engineers	64	35	54
Industrial Engineers	330	73	22
Mechanical Engineers	1008	334	33
Metallurgic Engineers	86	54	62
Mining Engineers	118	62	52
Nuclear Engineers	3	06	200
Total Engineers	5140	1764	34
Chemical Asso. Engineers	21	09	42
Civil Asso. Engineers	411	168	40
Electrical Asso. Engineers	235	91	38
Mechanical Asso. Engineers	231	29	12
Mining Asso. Engineers	04	06	150
Construction Asso. Engineers	302	89	29
Total Asso. Engineers	1204	392	32
Aeronautical	372	58	15
Chemical	151	65	43
Civil	1255	436	34
Data Process	361	142	39
Drafting	513	171	33
Electrical	339	68	20
Electronics	1271	425	33
Geological	25	14	56
Industrial	243	66	27
Mechanical	514	119	23
Metallurgic	41	14	34
Total Technicians	5085	1578	31
Experimental Machinist	439	22	05
Instrument Maker	70	15	21
Instrument Man	140	30	21
Lay Out Man	199	17	08
Machine Set Up	758	27	03
Machine Repair	320	47	14
Tool and Die Maker	234	34	14
Total Skilled Craftsmen	2160	192	08

but to learn the extent to which these particular activities make up the actual practice of different kinds of engineering, technology, and skilled industrial employment.

The results are summarized in the following nine-page table. Employer and employee responses in each occupation are given for each activity as major, minor, and not used. Apparently engineers, and to a considerable extent technicians and skilled craftsmen, do not perform many tasks which their employers say are part of the job. Employers have described what <u>might</u> be required and employees have stated only what <u>is</u> required in their present positions.

The relative importance of these activities in all occupations is shown by the extent to which both employers and employees agree. In the series of graphs beginning on page ,solid lines represent employer responses and broken lines employee responses. On the side of each graph are the percentages. Major and minor responses have been combined to form two single lines, representing employees whose companies say the activity is either a major or minor one and employees who have reported time spent in that activity. In this way, each activity is traced through thirty-three occupations beginning with engineers on the left followed by associate engineers, technicians, and skilled craftsmen on the right. Three occupations which were included in the survey have been omitted here because of insufficient responses for statistical analysis.

From the graphs it is possible to observe variations in the importance of each activity in different occupations. Jagged lines with alternating peaks and lows indicate only partial commonality of a skill in various fields. The activity may be quite important in some fields and not in others. Surveying is a good example. Nearly everyone may be expected to use this skill in civil, geological and mining engineering and in the corresponding technologies. It is almost never used in nineteen other engineering and technical fields.

Differences and similarities between employer responses on the one hand and employee responses on the other are apparent in nearly every activity listed. In addition to the greater importance attached to most activities by employers than by employees, employers also make sharper distinctions between skills in each occupation. This is seen in the often jagged appearance of the employer line compared with the employee line below. In most activities the greatest differences between employer and employee responses occur in the engineering fields. This may be accounted for by the nature of engineering as compared with both technology and the skilled crafts. The latter are more manipulative than mental, requiring manual skills to a greater extent than intellectual. Plant or shop jobs are more specific than desk jobs.

For the most part, sharp distinctions between the work of engineers, associate engineers, technicians, and skilled personnel are not evident here because the nature or level of the activity is not identified. The graphs and the data on which they are based, however, show activities that are more important in engineering than in the supporting occupations. Graph lines for these have a sloping pattern from left to right. This is evident, for instance, in the case of research and supervision although not as much as might have been expected. There are no activities significantly important in the technical and skilled occupations that are not equally important or very nearly so in engineering. There are activities in the skilled crafts that technicians as a rule do not perform and others that may be required of certain technicians but not of skilled craftsmen. The work of engineers apparently extends on a broad scale

TABLE 11
TECHNICAL SKILLS REQUIRED AND USED
(RESPONSES IN PERCENTAGES)

	TOTAL EMPLOYEES		RESEARCH EMPLOYER RESPONSE			RESEARCH EMPLOYEE RESPONSE			SUPERVISION EMPLOYER RESPONSE			SUPERVISION EMPLOYEE RESPONSE		
			MAJOR	MINOR	NONE	MAJOR	MINOR	NONE	MAJOR	MINOR	NONE	MAJOR	MINOR	NONE
ENGINEERS														
AEROSPACE	184	16	93	2	0	31	25	38	4	7	85	56	31	6
CHEMICAL	258	89	77	22	2	39	28	31	80	15	5	55	24	20
CIVIL	871	445	16	30	51	11	31	55	74	21	5	59	23	16
ELECTRICAL	919	185	81	11	7	18	31	50	11	80	8	45	21	34
ELECTRONIC	1299	465	64	33	2	20	32	48	49	38	13	34	31	35
GEOLOGICAL	64	35	44	47	9	20	49	31	36	56	8	43	34	23
INDUSTRIAL	330	73	43	35	22	10	34	56	55	27	19	30	32	38
MECHANICAL	1008	334	46	47	7	17	36	47	33	34	33	34	28	37
MATALLURGIC	86	54	60	36	1	37	44	19	74	13	10	57	19	24
MINING	118	62	28	52	2	8	27	65	50	29	1	56	8	35
NUCLEAR	3	6	0	100	0	83	0	17	100	0	0	83	17	0
ASSC.ENGINEERS														
CHEMICAL	21	9	48	29	0	11	44	44	29	19	29	22	33	44
CIVIL	411	168	1	11	83	4	29	68	78	12	6	59	21	20
ELECTRICAL	235	91	0	29	69	11	35	53	3	79	16	14	36	48
MECHANICAL	231	29	11	5	83	21	21	59	7	6	86	28	28	45
MINING	4	6	0	25	0	17	67	17	0	25	0	0	67	33
CONSTRUCTION	302	89	3	19	70	7	33	61	71	13	7	47	18	35
TECHNICIANS														
AERONAUTICAL	372	58	16	5	79	9	22	62	37	38	24	12	33	48
CHEMICAL	151	65	26	40	32	15	37	46	25	35	38	26	20	52
CIVIL	1255	436	1	4	95	8	24	66	6	73	20	24	30	44
DATA PROCESS	361	142	14	2	83	4	15	77	5	80	15	23	25	49
DRAFTING	513	171	3	10	85	17	35	48	3	24	70	11	28	61
ELECTRICAL	339	68	3	7	87	12	21	65	27	25	45	26	25	46
ELECTRONICS	1271	425	13	45	41	15	26	58	14	62	23	18	31	50
GEOLOGICAL	25	14	48	36	12	36	43	14	12	64	20	14	29	50
INDUSTRIAL	243	66	8	20	72	12	20	64	19	76	5	35	26	35
MECHANICAL	514	119	8	42	47	13	30	55	11	35	48	20	26	52
METALLURGIC	41	14	7	83	10	21	36	43	32	56	12	50	29	21
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN														
EXP. MACHINE	439	22	5	4	90	5	18	73	3	14	84	9	27	59
INSTRU MAKER	70	15	19	14	67	20	33	40	13	16	71	20	7	67
INSTRU MAN	140	30	2	45	53	0	40	60	13	53	34	13	47	40
LAY OUT MAN	199	17	13	21	66	0	12	88	33	28	40	24	18	59
MACH. SET UP	758	27	50	3	45	0	33	63	5	12	81	22	22	52
MACH. REPAIR	320	47	2	4	94	6	13	72	11	65	23	13	32	47
TOOL AND DIE	234	34	3	16	80	0	26	68	9	33	57	6	18	71

TABLE 11 CONTINUED
TECHNICAL SKILLS REQUIRED AND USED
(RESPONSES IN PERCENTAGES)

ENGINEERS	TOTAL EMPLOYEES		PRODUCTION DESIGN EMPLOYER RESPONSE MAJOR	MINOR	NONE	PRODUCTION DESIGN EMPLOYEE RESPONSE MAJOR	MINOR	NONE	SYSTEMS ANALYSIS EMPLOYER RESPONSE MAJOR	MINOR	NONE	SYSTEMS ANALYSIS EMPLOYEE RESPONSE MAJOR	MINOR	NONE
AEROSPACE	184	16	88	8	4	25	0	69	91	6	3	13	6	75
CHEMICAL	258	89	15	61	24	3	8	88	12	59	24	3	10	85
CIVIL	871	445	17	24	57	19	13	66	13	21	64	2	7	89
ELECTRICAL	919	185	5	33	63	15	13	72	41	54	5	24	20	56
ELECTRONIC	1299	465	63	29	8	30	14	56	64	33	2	23	31	46
GEOLOGICAL	64	35	2	30	59	14	3	83	3	11	80	0	9	91
INDUSTRIAL	330	73	58	23	19	21	19	60	59	22	19	15	27	58
MECHANICAL	1008	334	74	17	9	24	22	54	54	33	12	15	21	64
MATALLURGIC	86	54	55	37	6	9	28	63	35	60	2	0	15	85
MINING	118	62	33	36	8	26	18	56	19	42	20	6	10	84
NUCLEAR	3	6	0	0	100	0	0	100	0	100	0	0	0	100
ASSC.ENGINEERS														
CHEMICAL	21	9	10	57	10	0	0	100	10	29	38	0	0	100
CIVIL	411	168	4	2	90	13	8	79	2	4	90	2	5	93
ELECTRICAL	235	91	21	11	66	25	11	63	63	30	4	8	18	74
MECHANICAL	231	29	89	5	5	21	17	62	9	48	42	10	24	66
MINING	4	6	0	25	0	17	17	67	0	0	25	0	0	100
CONSTRUCTION	302	89	11	29	52	6	26	69	13	19	59	2	15	83
TECHNICIANS														
AERONAUTICAL	372	58	6	38	55	2	9	83	4	49	47	10	16	67
CHEMICAL	151	65	5	19	74	2	3	94	0	19	79	3	6	89
CIVIL	1255	436	2	2	95	2	7	89	2	4	93	1	5	92
DATA PROCESS	361	142	0	65	35	2	6	89	24	71	4	25	20	51
DRAFTING	513	171	19	37	42	14	19	67	5	11	82	2	6	92
ELECTRICAL	339	68	17	10	68	3	7	87	14	27	55	3	18	76
ELECTRONICS	1271	425	1	19	77	5	12	82	24	9	66	7	20	72
GEOLOGICAL	25	14	0	0	96	14	7	71	0	0	96	7	14	71
INDUSTRIAL	243	66	2	30	67	6	14	76	7	18	75	5	11	80
MECHANICAL	514	119	11	44	41	3	9	86	11	13	72	5	6	87
METALLURGIC	41	14	49	10	41	0	36	64	0	2	98	0	14	86
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN														
EXP. MACHINE	439	22	3	48	50	5	27	64	1	5	95	0	5	91
INSTRU MAKER	70	15	20	11	69	0	20	73	16	9	76	0	0	93
INSTRU MAN	140	30	5	24	71	0	7	93	18	26	56	0	30	70
LAY OUT MAN	199	17	37	20	44	12	12	76	17	9	74	0	12	88
MACH. SET UP	758	27	7	64	27	0	19	78	5	10	83	7	19	70
MACH. REPAIR	320	47	9	29	62	2	9	81	23	8	69	2	11	79
TOOL AND DIE	234	34	15	29	56	6	18	71	2	3	94	0	12	82

TABLE 11 CONTINUED
TECHNICAL SKILLS REQUIRED AND USED
(RESPONSES IN PERCENTAGES)

	TOTAL EMPLOYEES		QUALITY CONTROL EMPLOYER RESPONSE			QUALITY CONTROL EMPLOYEE RESPONSE			TESTING MATERIALS ETC EMPLOYER RESPONSE			TESTING MATERIALS ETC EMPLOYEE RESPONSE		
ENGINEERS			MAJOR	MINOR	NONE	MAJOR	MINOR	NONE	MAJOR	MINOR	NONE	MAJOR	MINOR	NONE
AEROSPACE	184	16	89	2	9	6	6	81	10	6	84	19	0	75
CHEMICAL	258	89	53	43	4	12	13	73	69	26	0	9	16	74
CIVIL	871	445	22	41	34	5	19	74	47	40	13	2	15	82
ELECTRICAL	919	185	1	31	68	2	13	85	5	40	54	8	14	78
ELECTRONIC	1299	465	30	67	2	7	15	78	78	20	2	17	23	60
GEOLOGICAL	64	35	19	34	44	6	14	80	6	52	33	0	14	86
INDUSTRIAL	330	73	43	35	22	10	22	68	33	32	35	8	14	78
MECHANICAL	1008	334	17	65	15	6	18	76	60	33	5	19	25	57
MATALLURGIC	86	54	73	22	2	4	20	76	76	21	1	17	22	61
MINING	118	62	18	55	8	10	15	76	19	58	4	2	10	89
NUCLEAR	3	6	0	0	100	0	0	100	0	0	100	0	0	100
ASSC.ENGINEERS														
CHEMICAL	21	9	29	48	0	0	22	78	48	19	10	11	11	78
CIVIL	411	168	3	72	20	15	27	58	74	8	13	7	24	70
ELECTRICAL	235	91	75	13	9	3	13	82	85	7	5	5	13	80
MECHANICAL	231	29	8	85	6	7	21	72	85	11	3	17	10	72
MINING	4	6	0	0	25	17	17	67	0	0	25	0	17	83
CONSTRUCTION	302	89	43	13	36	9	29	62	21	40	31	2	24	74
TECHNICIANS														
AERONAUTICAL	372	58	51	36	13	19	21	53	78	8	14	22	26	45
CHEMICAL	151	65	26	29	43	25	18	55	56	21	21	43	17	38
CIVIL	1255	436	7	61	32	16	13	69	66	16	17	14	16	68
DATA PROCESS	361	142	4	78	17	10	28	58	64	4	30	38	4	54
DRAFTING	513	171	7	43	48	1	11	88	1	6	90	1	8	91
ELECTRICAL	339	68	32	11	52	4	9	84	25	24	45	12	18	68
ELECTRONICS	1271	425	18	61	20	10	20	70	80	10	9	34	21	45
GEOLOGICAL	25	14	12	12	72	7	7	79	8	24	64	29	14	50
INDUSTRIAL	243	66	70	22	8	35	20	41	75	8	16	17	17	62
MECHANICAL	514	119	28	34	34	4	11	83	60	18	21	44	8	46
METALLURGIC	41	14	71	27	2	14	21	64	54	32	15	29	7	64
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN														
EXP. MACHINE	439	22	23	11	67	5	18	73	4	12	84	0	23	73
INSTRU MAKER	70	15	24	0	76	0	40	53	83	7	10	0	20	73
INSTRU MAN	140	30	32	29	39	0	20	80	39	18	43	13	23	63
LAY OUT MAN	199	17	47	25	28	6	18	76	19	34	47	0	29	71
MACH. SET UP	758	27	17	64	18	0	30	67	55	13	27	4	22	70
MACH. REPAIR	320	47	6	34	60	0	15	77	27	44	29	11	13	68
TOOL AND DIE	234	34	36	35	29	6	21	68	16	32	52	3	18	74

TABLE 11 CONTINUED
TECHNICAL SKILLS REQUIRED AND USED
(RESPONSES IN PERCENTAGES)

ENGINEERS	TOTAL EMPLOYEES		INSTRUMENTATION ETC EMPLOYER RESPONSE MAJOR	MINOR	NONE	INSTRUMENTATION ETC EMPLOYEE RESPONSE MAJOR	MINOR	NONE	PRODUCTION INSPECT EMPLOYER RESPONSE MAJOR	MINOR	NONE	PRODUCTION INSPECT EMPLOYEE RESPONSE MAJOR	MINOR	NONE
AEROSPACE	184	16	6	13	82	0	6	88	7	3	91	6	0	88
CHEMICAL	258	89	35	62	3	4	13	81	42	28	30	3	12	83
CIVIL	871	445	17	35	45	0	8	90	25	23	50	7	18	73
ELECTRICAL	919	185	30	14	56	1	16	84	2	29	64	1	14	85
ELECTRONIC	1299	465	64	36	1	3	15	82	21	46	32	0	8	92
GEOLOGICAL	64	35	28	52	14	0	14	86	5	33	53	0	11	89
INDUSTRIAL	330	73	6	50	44	1	3	96	25	37	37	0	16	84
MECHANICAL	1008	334	16	73	7	1	17	82	22	27	47	2	13	84
MATALLURGIC	86	54	27	66	5	4	19	78	41	37	20	6	28	67
MINING	118	62	1	54	26	2	3	95	15	30	36	8	18	74
NUCLEAR	3	6	0	100	0	0	33	67	0	0	100	0	0	100
ASSC.ENGINEERS														
CHEMICAL	21	9	0	67	10	0	11	89	0	67	10	11	11	78
CIVIL	411	168	4	4	87	2	11	88	7	6	83	14	19	67
ELECTRICAL	235	91	70	20	8	0	7	92	2	11	83	2	19	78
MECHANICAL	231	29	41	12	47	3	10	86	6	9	84	0	21	79
MINING	4	6	0	0	25	0	17	83	0	0	25	0	33	67
CONSTRUCTION	302	89	7	21	63	0	7	93	36	22	34	18	36	46
TECHNICIANS														
AERONAUTICAL	372	58	62	29	8	5	29	59	7	60	33	10	17	66
CHEMICAL	151	65	40	45	13	3	23	72	11	8	79	0	14	85
CIVIL	1255	436	5	11	84	1	14	83	5	6	89	10	15	73
DATA PROCESS	361	142	0	13	86	1	8	87	0	2	97	0	9	87
DRAFTING	513	171	2	16	80	1	2	97	1	39	58	4	11	85
ELECTRICAL	339	68	57	7	32	6	24	68	20	6	69	1	19	76
ELECTRONICS	1271	425	90	5	3	12	27	60	39	24	35	2	11	87
GEOLOGICAL	25	14	40	20	36	7	29	57	8	16	72	7	7	79
INDUSTRIAL	243	66	53	35	17	8	14	74	63	28	14	6	21	68
MECHANICAL	514	119	63	23	12	14	18	66	22	18	56	6	8	84
METALLURGIC	41	14	5	80	15	7	7	86	27	71	2	7	21	71
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN														
EXP. MACHINE	439	22	13	8	79	9	14	73	14	17	69	9	14	73
INSTRU MAKER	70	15	77	14	9	27	20	47	80	13	7	0	7	87
INSTRU MAN	140	30	76	5	19	70	13	17	27	12	61	0	7	93
LAY OUT MAN	199	17	30	26	40	0	24	76	56	20	19	18	24	59
MACH. SET UP	758	27	14	22	62	4	19	74	18	7	73	11	22	63
MACH. REPAIR	320	47	15	65	21	6	11	74	13	27	60	4	11	77
TOOL AND DIE	234	34	23	26	51	3	21	71	48	18	34	3	29	62

TABLE 11 CONTINUED
TECHNICAL SKILLS REQUIRED AND USED
(RESPONSES IN PERCENTAGES)

			PRODUCTION LAYOUT						DRAFTING					
			EMPLOYER RESPONSE			EMPLOYEE RESPONSE			EMPLOYER RESPONSE			EMPLOYEE RESPONSE		
ENGINEERS	TOTAL EMPLOYER	TOTAL EMPLOYEE	MAJOR	MINOR	NONE	MAJOR	MINOR	NONE	MAJOR	MINOR	NONE	MAJOR	MINOR	NONE
AEROSPACE	184	16	6	0	94	0	0	100	6	91	3	6	13	81
CHEMICAL	258	89	7	57	36	0	4	94	4	49	47	1	9	89
CIVIL	871	445	30	15	55	3	12	83	56	41	3	7	31	60
ELECTRICAL	919	185	3	30	62	1	7	92	4	39	57	6	22	72
ELECTRONIC	1299	465	7	48	44	1	6	93	8	78	14	1	9	89
GEOLOGICAL	64	35	2	25	64	0	14	86	42	39	13	11	43	46
INDUSTRIAL	330	73	70	13	18	14	33	53	22	32	46	0	21	79
MECHANICAL	1008	334	21	20	48	6	7	87	59	34	4	6	22	72
MATALLURGIC	86	54	30	45	22	0	20	80	16	70	12	0	13	87
MINING	118	62	39	26	16	10	16	74	26	54	1	16	32	52
NUCLEAR	3	6	0	0	100	0	0	100	0	0	100	0	0	100
ASSC. ENGINEERS														
CHEMICAL	21	9	0	38	38	0	0	100	29	10	38	11	22	67
CIVIL	411	168	6	5	84	5	16	79	87	7	2	17	35	48
ELECTRICAL	235	91	0	69	27	15	15	68	6	85	6	30	27	42
MECHANICAL	231	29	10	3	86	3	14	83	89	9	2	24	24	52
MINING	4	6	0	0	25	0	17	83	25	0	0	0	33	67
CONSTRUCTION	302	89	39	21	31	10	36	54	31	55	13	4	43	53
TECHNICIANS														
AERONAUTICAL	372	58	7	7	86	2	5	86	22	43	35	2	12	79
CHEMICAL	151	65	2	3	93	3	3	92	9	16	74	0	8	91
CIVIL	1255	436	9	7	84	3	13	82	82	15	4	20	27	50
DATA PROCESS	361	142	0	1	97	0	4	93	0	66	33	0	1	95
DRAFTING	513	171	17	7	73	6	13	80	100	0	0	84	8	8
ELECTRICAL	339	68	1	15	64	7	13	76	8	49	38	15	16	66
ELECTRONICS	1271	425	1	14	82	2	7	90	34	36	28	1	17	81
GEOLOGICAL	25	14	0	12	84	0	7	86	0	68	28	7	29	57
INDUSTRIAL	243	66	9	84	11	6	12	77	33	44	27	2	20	74
MECHANICAL	514	119	10	18	68	4	3	91	35	43	18	7	17	75
METALLURGIC	41	14	15	41	44	0	14	86	2	51	46	0	29	71
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN														
EXP. MACHINE	439	22	21	51	28	9	9	77	14	23	63	5	9	82
INSTRU MAKER	70	15	13	14	73	13	7	73	69	27	4	0	27	67
INSTRU MAN	140	30	9	26	62	0	13	87	16	46	38	7	13	80
LAY OUT MAN	199	17	88	4	4	41	35	24	30	49	16	6	6	88
MACH. SET UP	758	27	25	7	66	4	15	78	57	18	23	0	19	78
MACH. REPAIR	320	47	12	28	60	2	6	83	12	59	29	4	4	83
TOOL AND DIE	234	34	40	28	32	3	24	68	21	48	31	3	29	62

TABLE 11 CONTINUED
TECHNICAL SKILLS REQUIRED AND USED
(RESPONSES IN PERCENTAGES)

ENGINEERS	TOTAL EMPLOYEES		COMPUTER PROGRAMMING EMPLOYER RESPONSE			COMPUTER PROGRAMMING EMPLOYEE RESPONSE			ELECTRONIC SYSTEMS EMPLOYER RESPONSE			ELECTRONIC SYSTEMS EMPLOYEE RESPONSE		
			MAJOR	MINOR	NONE	MAJOR	MINOR	NONE	MAJOR	MINOR	NONE	MAJOR	MINOR	NONE
AEROSPACE	184	16	88	3	6	0	13	88	0	2	94	0	0	100
CHEMICAL	258	89	7	20	73	1	7	91	7	27	67	0	2	97
CIVIL	871	445	5	39	54	2	5	91	2	19	77	0	0	98
ELECTRICAL	919	185	6	35	59	7	8	85	12	27	57	3	8	89
ELECTRONIC	1299	465	44	37	19	3	23	74	86	13	1	6	14	80
GEOLOGICAL	64	35	0	38	59	0	6	94	8	36	47	0	3	97
INDUSTRIAL	330	73	20	31	49	0	10	90	11	23	66	0	1	99
MECHANICAL	1008	334	9	60	28	2	7	91	8	31	50	0	3	96
MATALLURGIC	86	54	15	29	53	0	6	94	6	53	38	0	9	91
MINING	118	62	4	35	42	2	10	89	2	35	45	0	0	100
NUCLEAR	3	6	0	0	100	0	0	100	0	0	100	0	0	100
ASSC.ENGINEERS														
CHEMICAL	21	9	0	19	57	0	11	89	0	10	67	0	0	100
CIVIL	411	168	0	13	83	1	4	96	3	1	92	0	2	98
ELECTRICAL	235	91	3	77	18	2	16	80	86	2	10	13	9	77
MECHANICAL	231	29	0	4	95	3	10	86	35	1	62	3	3	93
MINING	4	6	0	0	25	0	0	100	0	0	25	0	0	100
CONSTRUCTION	302	89	3	19	69	0	1	99	0	12	80	0	0	100
TECHNICIANS														
AERONAUTICAL	372	58	0	4	96	3	3	86	58	25	17	5	21	67
CHEMICAL	151	65	0	1	97	0	0	98	3	29	67	3	8	88
CIVIL	1255	436	0	3	96	2	2	93	0	3	96	0	1	96
DATA PROCESS	361	142	96	3	1	23	40	33	67	16	16	15	15	67
DRAFTING	513	171	0	2	96	0	1	99	0	1	96	0	1	99
ELECTRICAL	339	68	0	14	81	0	4	93	54	4	38	19	12	66
ELECTRONICS	1271	425	31	22	45	3	5	92	70	27	3	34	19	46
GEOLOGICAL	25	14	0	40	56	7	0	86	0	40	56	0	14	79
INDUSTRIAL	243	66	2	11	91	0	3	92	24	39	42	0	11	85
MECHANICAL	514	119	0	1	94	0	0	98	12	44	38	8	3	87
METALLURGIC	41	14	0	0	100	0	0	100	0	2	98	0	0	100
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN														
EXP. MACHINE	439	22	0	1	99	0	0	95	0	0	99	0	0	95
INSTRU MAKER	70	15	0	4	96	0	0	93	63	4	33	0	7	87
INSTRU. MAN	140	30	6	16	79	0	0	100	44	14	41	17	40	43
LAY OUT MAN	199	17	2	2	91	0	0	100	0	5	91	0	6	94
MACH. SET UP	758	27	0	0	97	15	0	81	3	6	89	4	0	93
MACH. REPAIR	320	47	0	0	100	2	0	89	13	3	83	15	2	74
TOOL AND DIE	234	34	0	2	97	0	6	88	2	3	95	3	3	88

TABLE 11 CONTINUED
TECHNICAL SKILLS REQUIRED AND USED
(RESPONSES IN PERCENTAGES)

			AUTOMATED EQUIPMENT						PRECISION MACHINERY					
			EMPLOYER RESPONSE			EMPLOYEE RESPONSE			EMPLOYER RESPONSE			EMPLOYEE RESPONSE		
ENGINEERS	TOTAL EMPLOYEES	Respondents	MAJOR	MINOR	NONE	MAJOR	MINOR	NONE	MAJOR	MINOR	NONE	MAJOR	MINOR	NONE
AEROSPACE	184	16	4	0	96	0	0	100	4	2	93	0	6	94
CHEMICAL	258	89	4	41	55	0	4	94	9	5	86	1	2	96
CIVIL	871	445	3	6	89	0	1	97	3	16	78	0	2	96
ELECTRICAL	919	185	2	31	62	1	1	98	4	30	61	0	3	97
ELECTRONIC	1299	465	2	63	35	1	2	97	2	22	76	0	2	98
GEOLOGICAL	64	35	0	2	89	0	0	100	0	31	59	0	0	100
INDUSTRIAL	330	73	20	24	55	0	11	89	21	13	61	0	7	93
MECHANICAL	1008	334	11	24	54	1	3	96	14	27	55	1	4	95
MATALLURGIC	86	54	9	50	38	2	7	91	12	19	67	0	2	98
MINING	118	62	2	7	73	0	2	98	2	18	62	0	0	98
NUCLEAR	3	6	0	0	100	0	0	100	0	0	100	0	0	100
ASSC. ENGINEERS														
CHEMICAL	21	9	0	10	67	0	0	100	0	10	67	11	0	89
CIVIL	411	168	2	2	92	0	1	99	2	2	92	1	2	97
ELECTRICAL	235	91	1	8	89	0	4	95	10	15	72	0	0	99
MECHANICAL	231	29	3	2	94	0	7	93	42	2	55	3	14	83
MINING	4	6	0	0	25	0	0	100	0	0	25	0	0	100
CONSTRUCTION	302	89	2	11	79	0	1	99	5	11	75	0	1	99
TECHNICIANS														
AERONAUTICAL	372	58	1	1	97	2	2	90	2	20	78	19	5	69
CHEMICAL	151	65	0	17	81	0	6	92	2	17	79	2	6	91
CIVIL	1255	436	0	0	98	0	0	97	1	4	94	1	5	92
DATA PROCESS	361	142	1	2	95	3	4	89	1	0	98	0	2	94
DRAFTING	513	171	0	2	73	0	0	100	0	11	64	0	1	99
ELECTRICAL	339	68	3	10	82	1	4	91	18	9	67	3	6	88
ELECTRONICS	1271	425	5	12	81	3	7	89	32	17	49	4	6	90
GEOLOGICAL	25	14	0	0	96	7	0	86	0	0	96	0	0	93
INDUSTRIAL	243	66	7	29	69	3	3	89	7	44	53	8	9	79
MECHANICAL	514	119	11	11	74	3	4	92	27	26	42	7	12	80
METALLURGIC	41	14	0	17	83	0	0	100	0	27	73	0	0	100
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN														
EXP. MACHINE	439	22	44	10	46	9	5	82	88	4	8	73	5	18
INSTRU MAKER	70	15	10	1	89	7	7	80	87	1	11	40	20	33
INSTRU MAN	140	30	25	24	51	13	13	73	33	17	48	3	17	80
LAY OUT MAN	199	17	18	19	59	18	12	71	36	14	45	12	24	65
MACH. SET UP	758	27	70	14	14	0	15	81	80	11	9	41	15	41
MACH. REPAIR	320	47	59	2	39	30	6	55	53	31	16	34	17	40
TOOL AND DIE	234	34	19	31	50	6	12	76	85	7	8	50	18	26

TABLE 11 CONTINUED
TECHNICAL SKILLS REQUIRED AND USED
(RESPONSES IN PERCENTAGES)

			SURVEYING						WRITING TECH REPORTS					
			EMPLOYER RESPONSE			EMPLOYEE RESPONSE			EMPLOYER RESPONSE			EMPLOYEE RESPONSE		
ENGINEERS	TOTAL EMPLOYEES		MAJOR	MINOR	NONE	MAJOR	MINOR	NONE	MAJOR	MINOR	NONE	MAJOR	MINOR	NONE
AEROSPACE	184	16	0	1	96	0	0	100	95	1	0	19	44	38
CHEMICAL	258	89	1	24	75	2	8	89	82	18	0	15	45	39
CIVIL	871	445	66	27	6	7	26	65	64	34	2	21	39	38
ELECTRICAL	919	185	2	29	69	2	5	93	42	55	3	19	49	32
ELECTRONIC	1299	465	0	7	93	0	3	97	81	18	1	25	53	21
GEOLOGICAL	64	35	36	50	11	9	46	46	72	28	0	43	51	6
INDUSTRIAL	330	73	3	6	91	1	10	89	72	18	10	21	47	33
MECHANICAL	1008	334	2	24	70	1	5	93	74	22	2	25	46	29
MATALLURGIC	86	54	0	42	56	0	0	100	77	20	0	26	57	17
MINING	118	62	34	47	1	10	18	73	56	25	0	10	44	47
NUCLEAR	3	6	0	0	100	0	0	100	100	0	0	0	33	67
ASSC.ENGINEERS														
CHEMICAL	21	9	0	0	76	22	33	44	67	10	0	11	33	56
CIVIL	411	168	83	8	5	18	32	49	17	73	6	9	33	58
ELECTRICAL	235	91	0	57	41	7	23	69	3	91	3	8	35	56
MECHANICAL	231	29	0	3	96	0	10	90	83	10	6	24	24	52
MINING	4	6	25	0	0	50	17	33	25	0	0	0	33	67
CONSTRUCTION	302	89	21	57	20	1	33	66	22	39	31	6	28	66
TECHNICIANS														
AERONAUTICAL	372	58	0	0	99	0	5	88	25	67	8	5	29	59
CHEMICAL	151	65	2	6	90	2	5	92	11	67	21	3	34	62
CIVIL	1255	436	89	8	3	34	19	45	4	19	75	7	30	61
DATA PROCESS	361	142	0	1	98	0	1	95	16	79	.4	8	29	60
DRAFTING	513	171	5	22	71	5	13	82	3	55	39	4	16	80
ELECTRICAL	339	68	0	5	89	1	12	84	15	42	39	9	22	66
ELECTRONICS	1271	425	0	5	94	0	2	97	15	71	14	8	33	58
GEOLOGICAL	25	14	40	44	12	14	14	64	16	48	32	7	50	36
INDUSTRIAL	243	66	5	25	74	0	5	91	5	40	59	5	27	64
MECHANICAL	514	119	1	5	89	1	4	93	40	31	27	20	18	61
METALLURGIC	41	14	0	2	98	0	0	100	10	27	63	0	50	50
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN														
EXP. MACHINE	439	22	0	0	100	0	0	95	0	41	59	0	5	91
INSTRU MAKER	70	15	3	3	94	0	0	93	0	11	89	0	13	80
INSTRU MAN	140	30	29	1	69	20	0	80	4	57	39	0	27	73
LAY OUT MAN	199	17	2	6	88	0	6	94	6	25	69	0	18	82
MACH. SET UP	758	27	0	0	98	0	7	89	1	7	90	0	19	78
MACH. REPAIR	320	47	0	1	99	0	0	91	4	34	62	4	9	79
TOOL AND DIE	234	34	0	7	92	0	3	91	0	14	85	0	12	82

TABLE 11 CONTINUED
TECHNICAL SKILLS REQUIRED AND USED
(RESPONSES IN PERCENTAGES)

			SALES CONSULTING PR						OTHER					
			EMPLOYER RESPONSE			EMPLOYEE RESPONSE			EMPLOYER RESPONSE			EMPLOYEE RESPONSE		
ENGINEERS	TOTAL EMPLOYEES		MAJOR	MINOR	NONE	MAJOR	MINOR	NONE	MAJOR	MINOR	NONE	MAJOR	MINOR	NONE
AEROSPACE	184	16	0	9	87	13	13	75	83	0	3	6	19	75
CHEMICAL	258	89	20	72	7	15	20	74	0	0	1	18	7	64
CIVIL	871	445	35	43	22	15	28	71	18	2	1	19	8	56
ELECTRICAL	919	185	4	37	58	15	25	63	7	0	1	20	15	59
ELECTRONIC	1299	465	48	39	13	8	18	75	49	0	0	18	6	75
GEOLOGICAL	64	.35	27	55	13	17	23	54	28	0	0	37	9	60
INDUSTRIAL	330	73	25	19	56	11	15	38	1	1	0	56	5	74
MECHANICAL	1008	334	21	31	44	11	27	69	2	1	2	23	8	62
MATALLURGIC	86	54	26	35	35	6	17	78	0	0	1	13	9	78
MINING	118	62	30	21	31	3	18	76	0	0	2	18	6	79
NUCLEAR	3	6	100	0	0	17	33	57	0	0	0	17	17	50
ASSC.ENGINEERS														
CHEMICAL	21	9	29	19	29	33	22	56	0	0	0	33	11	44
CIVIL	411	168	5	80	12	7	19	79	7	0	4	17	4	74
ELECTRICAL	235	91	1	79	17	3	26	68	6	0	1	22	9	69
MECHANICAL	231	29	3	9	87	7	28	69	2	0	1	21	10	66
MINING	4	6	0	25	0	17	17	67	0	0	0	17	17	67
CONSTRUCTION	302	89	46	16	30	29	30	66	10	2	3	27	7	40
TECHNICIANS														
AERONAUTICAL	372	58	4	5	91	7	5	64	6	0	8	24	3	81
CHEMICAL	151	65	5	8	85	5	11	75	7	0	13	20	3	83
CIVIL	1255	436	2	65	32	2	11	75	1	1	2	17	6	85
DATA PROCESS	361	142	3	5	80	1	5	82	0	0	3	7	7	89
DRAFTING	513	171	3	38	56	1	12	76	1	10	4	12	11	88
ELECTRICAL	339	68	15	9	71	6	18	66	24	0	0	24	7	74
ELECTRONICS	1271	425	1	7	91	2	6	82	2	0	10	10	7	91
GEOLOGICAL	25	14	40	8	48	21	14	57	32	0	0	21	14	57
INDUSTRIAL	243	66	3	22	79	0	8	79	1	0	5	12	5	88
MECHANICAL	514	119	11	10	74	7	7	79	6	0	3	13	6	85
METALLURGIC	41	14	0	22	78	36	0	71	0	0	0	14	14	64
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN														
EXP. MACHINE	439	22	0	1	99	0	0	82	5	0	2	9	5	95
INSTRU MAKER	70	15	3	4	93	0	13	73	3	0	61	20	0	80
INSTRU MAN	140	30	5	4	91	0	7	83	0	1	4	7	10	93
LAY OUT MAN	199	17	9	16	76	0	12	71	11	0	14	24	6	88
MACH. SET UP	758	27	1	4	93	4	15	74	0	0	5	22	0	78
MACH. REPAIR	320	47	6	8	86	0	0	68	24	0	5	19	4	91
TOOL AND DIE	234	34	0	2	97	0	3	50	10	0	15	38	6	91

FIGURE 2
PERCENTAGES OF TOTAL RESPONSE BY EMPLOYERS AND EMPLOYEES
IDENTIFYING SKILLED ACTIVITIES WITH OCCUPATIONS

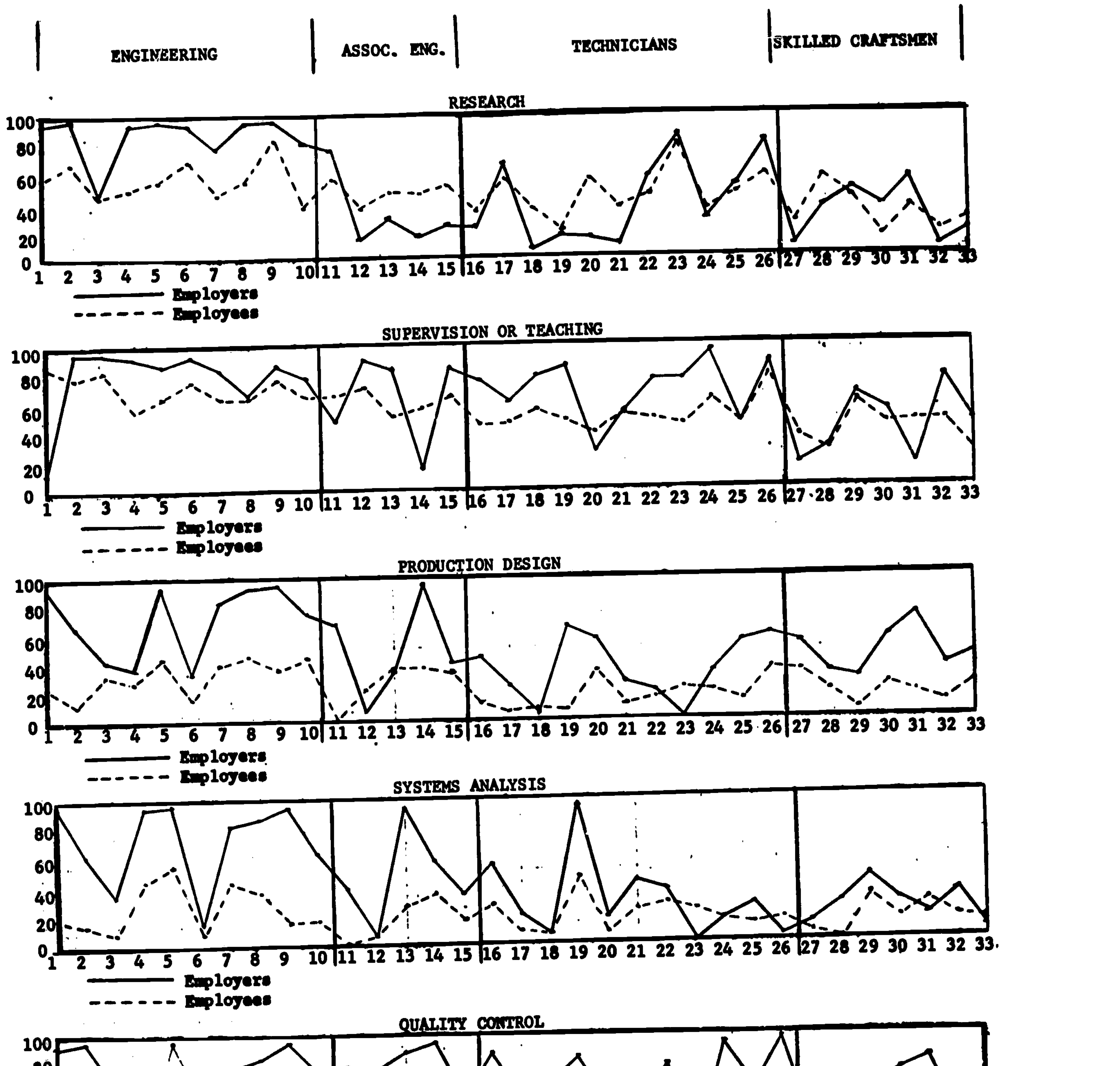


FIGURE 3
PERCENTAGES OF TOTAL RESPONSE BY EMPLOYERS AND EMPLOYEES
IDENTIFYING SKILLED ACTIVITIES WITH OCCUPATIONS

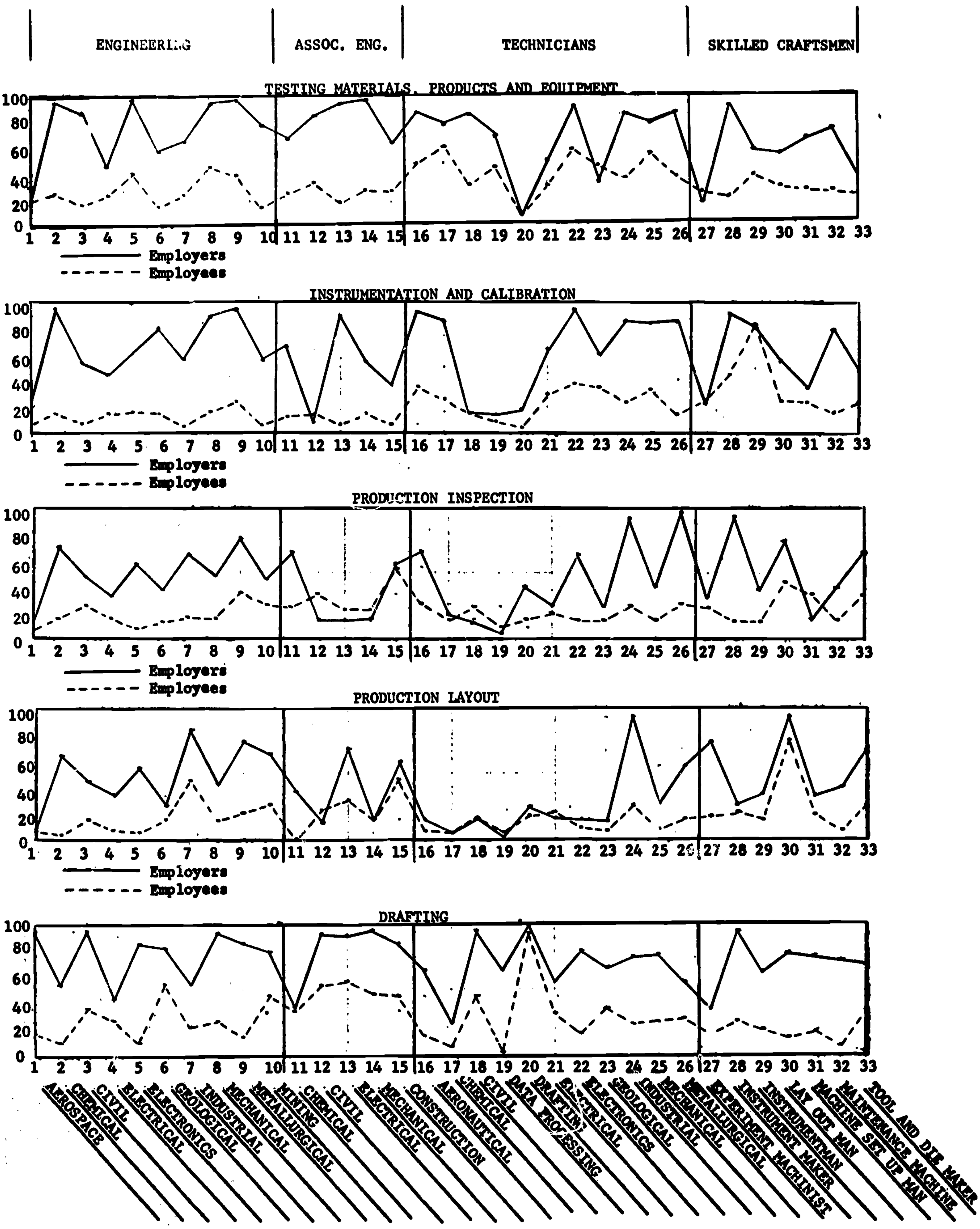


FIGURE 4
PERCENTAGES OF TOTAL RESPONSE BY EMPLOYERS AND EMPLOYEES
IDENTIFYING SKILLED ACTIVITIES WITH OCCUPATIONS

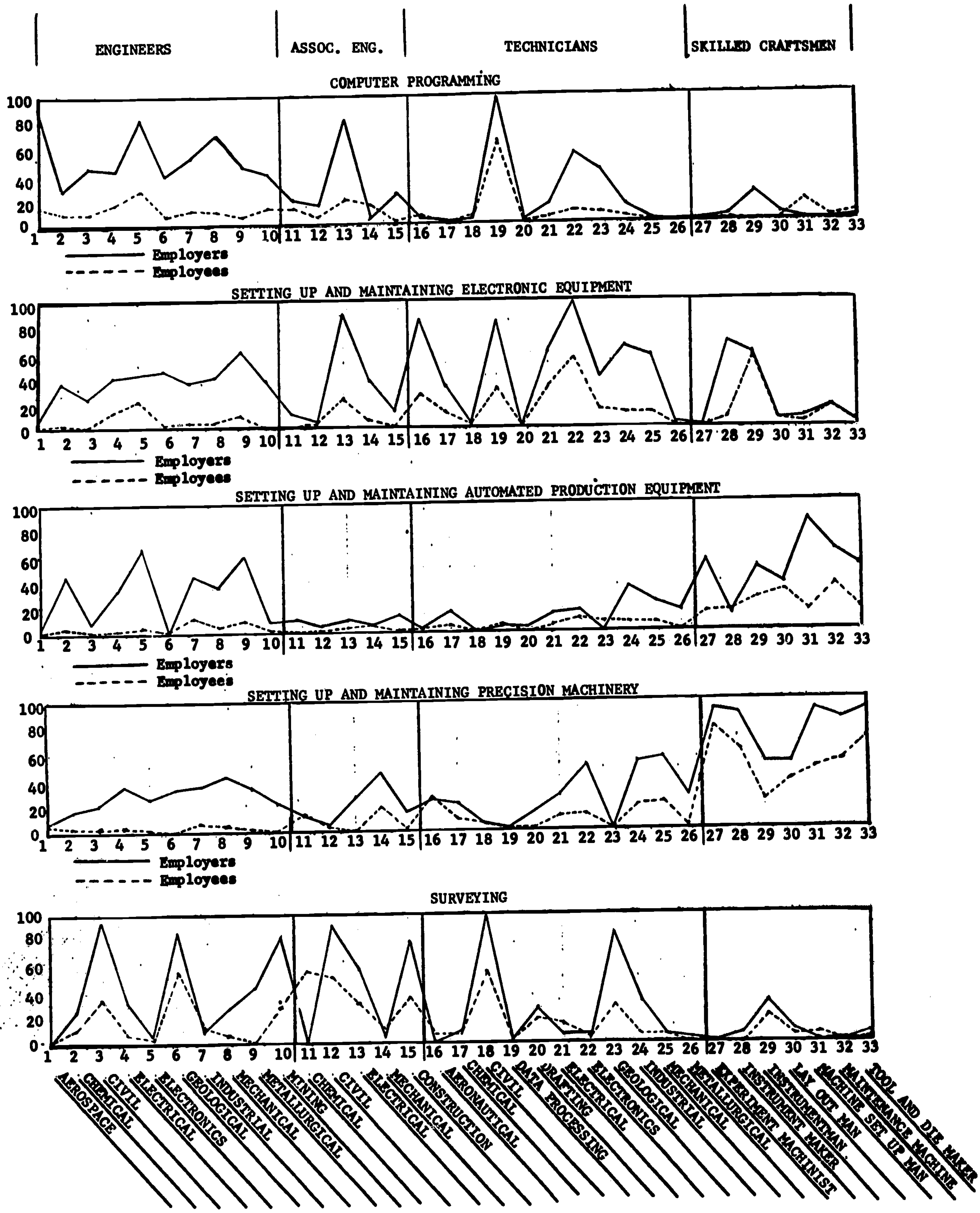
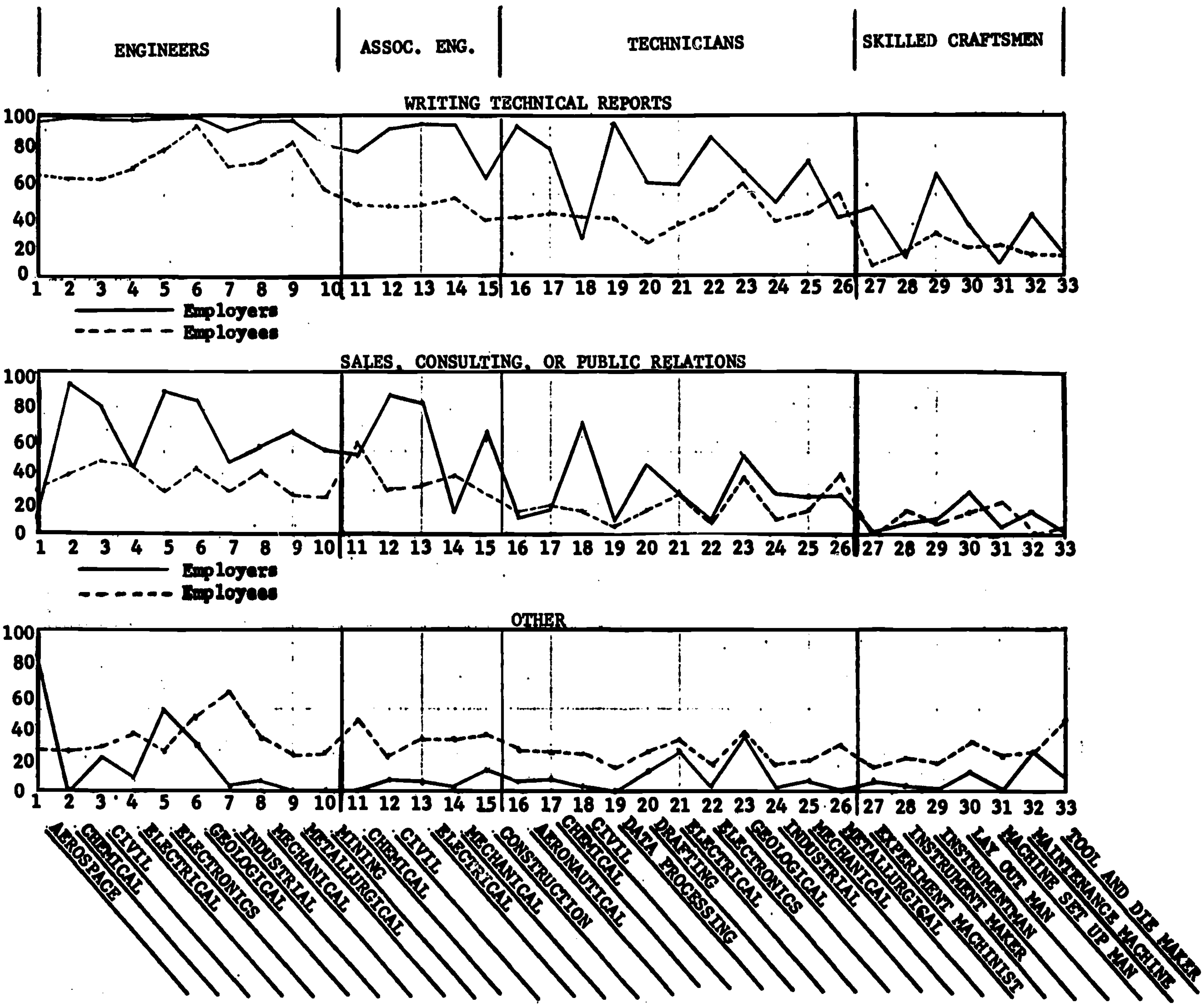


FIGURE 5
PERCENTAGES OF TOTAL RESPONSE BY EMPLOYERS AND EMPLOYEES
IDENTIFYING SKILLED ACTIVITIES WITH OCCUPATIONS



into most of the work that technicians and craftsmen do, but technicians and craftsmen are more confined to their specific fields.

In this connection most of the graphs indicate a break in the pattern between engineers and associate engineers rather than between associate engineers and technicians. The associate engineer seems to be more often identified with technology than with engineering.

In some activities, like computer programming and setting up and maintaining automated equipment, neither employers nor employees indicate the extent of importance which might have been expected. It cannot be assumed, however, that training in these activities is unimportant. The response reflects the relatively recent emergence of these activities. Their future importance cannot be measured by the experience found in industry today.

The last skilled activity graph, which is a catchall, is the only one with consistently higher responses by employees than by employers. It represents additional activities not listed in the questionnaires. Those that were listed apparently cover most of what employers consider necessary, but about one-third to one-half of the engineers and one-fourth of the technicians and craftsmen are doing other things as well. The one activity omitted from the list which was mentioned most frequently in engineering and technology was "paper work." In the skilled crafts it was operating machines. "Operating" had been left out of the questionnaire.

It is apparent from Table 11 and the series of graphs showing technical skills required and used that engineers as a group perform all of the activities listed, while separate questionnaires show that as individuals they work within narrow ranges of specialized activity. To a considerable extent the same is true of technicians, and to some extent even of skilled craftsmen. The graphs further show that these narrow ranges of specialized activity cut right across existing recognized fields. For example, instrumentation is <u>not</u> identified as part of the job by 78% to 95% of all engineers, but there are some engineers in <u>seven different fields</u> who listed instrumentation as a major activity. Computer programming is another example: Engineers who reported <u>no time at all</u> spent in computer programming ranged from 74% in electronics to 94% in geological and metallurgical engineering. Yet some engineers in <u>six different fields</u> -- chemical, civil, electrical, electronics, mechanical, and mining -- reported it as a <u>major</u> activity. Nearly 10% or more of the engineers in all fields reported enough time spent in computer programming for this to be a necessary part of their job. These examples are repeated with varying percentages for each activity on the list.

<u>Courses Required</u>: The need for twenty-eight educational courses was measured in the survey by asking both employers and employees if a general knowledge or advanced knowledge or no knowledge at all was necessary. The percentages of responses are given under each subject in Table 12. Negative responses are not shown, but they were usually given and the percentages of negative responses nearly equal the difference between 100% and the figures in the table. Thus, when 20% of the civil technicians say they need at least a general knowledge of calculus, 80% have said no knowledge is necessary.

The combined percentages of general and advanced knowledge in each case indicates the extent to which the subject has some direct application to the job. The percentages of those who report a need for advanced knowledge is an

TABLE 12
EDUCATIONAL COURSE REQUIRED FOR EACH OCCUPATION
(RESPONSES IN PERCENTAGES)

A General knowledge recommended by employers
B Advanced knowledge recommended by employers
C General knowledge recommended by employees
D Advanced knowledge recommended by employees

ENGINEERS	TOTAL EMPLOYEES		ALGEBRA				GEOMETRY				TRIGONOMETRY				CALCULUS			
			A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
AEROSPACE	184	16	97	1	63	31	97	1	75	19	93	1	81	19	91	1	56	19
CHEMICAL	258	89	78	22	54	36	82	17	52	26	76	21	48	25	36	59	30	27
CIVIL	871	445	63	36	59	37	63	36	58	38	64	35	53	43	59	24	47	16
ELECTRICAL	919	185	63	37	53	44	63	37	61	30	63	37	57	39	62	37	47	34
ELECTRONIC	1299	465	26	74	48	47	92	8	58	31	79	21	54	38	10	74	38	45
GEOLOGICAL	64	35	58	33	71	23	58	33	71	26	58	33	57	37	84	14	43	11
INDUSTRIAL	330	73	69	31	64	23	75	25	64	15	54	44	59	18	44	42	33	12
MECHANICAL	1008	334	82	17	69	27	86	13	67	26	84	15	67	28	64	22	50	15
METALLURGIC	86	54	66	31	74	22	72	26	63	22	66	31	61	20	62	30	41	28
MINING	118	62	47	32	60	29	47	34	53	32	47	32	52	39	62	18	48	8
NUCLEAR	3	6	100	0	17	83	100	0	33	67	100	0	17	83	100	0	0	83
ASSC. ENGINEERS																		
CHEMICAL	21	9	29	38	78	11	38	19	67	0	38	19	33	11	19	19	33	0
CIVIL	411	168	85	10	62	31	86	10	59	32	85	10	54	39	80	6	27	5
ELE TRICAL	235	91	40	60	73	9	24	59	66	5	82	3	52	11	69	2	16	11
MECHANICAL	231	29	94	5	62	14	61	5	55	14	94	4	45	21	50	3	21	10
MINING	4	6	0	25	50	33	0	25	17	67	0	25	33	50	0	0	17	0
CONSTRUCTION	302	89	73	13	56	15	66	15	53	13	67	7	38	10	21	1	18	2
TECHNICIANS																		
AERONAUTICAL	372	58	28	38	41	10	27	38	41	5	21	32	22	5	52	0	10	3
CHEMICAL	151	65	89	5	63	15	52	3	42	8	51	2	31	8	2	0	15	5
CIVIL	1255	436	87	2	72	17	87	3	60	20	94	3	52	27	9	0	17	3
DATA PROCESS	361	142	80	17	56	19	78	14	36	13	79	14	35	13	11	15	20	11
DRAFTING	513	171	79	10	70	20	82	10	68	22	85	11	63	23	15	5	24	5
ELECTRICAL	339	68	39	35	68	10	35	28	57	7	40	19	37	10	30	4	12	4
ELECTRONICS	1271	425	42	55	65	27	78	13	58	10	82	10	54	19	16	13	33	6
GEOLOGICAL	25	14	72	0	64	21	96	0	71	14	72	0	64	14	40	0	36	7
INDUSTRIAL	243	66	91	0	68	15	67	0	56	11	83	2	42	11	19	0	20	8
MECAHANICAL	514	119	76	1	64	7	78	1	58	3	65	1	48	1	6	0	17	3
METALLURGIC	41	14	15	5	64	14	15	2	57	7	15	5	36	7	5	2	14	7
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN																		
EXP. MACHINE	439	22	83	5	50	0	88	4	64	0	79	14	73	0	1	1	18	0
INSTR MAKER	70	15	87	4	67	7	94	4	73	13	93	4	87	7	4	3	7	7
INSTRU MAN	140	30	66	29	77	10	66	14	53	7	60	16	43	10	11	11	10	10
LAYOUT MAN	199	17	71	11	41	12	56	15	29	12	49	18	24	6	7	3	6	0
MACH. SET UP	758	27	68	1	59	15	73	1	48	7	71	1	52	19	1	0	15	19
MACH. REPAIR	320	47	75	2	49	11	77	2	53	4	63	2	40	6	19	0	13	0
TOOL AND DIE	234	34	59	23	53	18	60	21	56	24	72	17	59	35	8	0	15	3

TABLE 12 CONTINUED
EDUCATIONAL COURSE REQUIRED FOR EACH OCCUPATION
(RESPONSES IN PERCENTAGES)

A General knowledge recommended by employers
B Advanced knowledge recommended by employers
C General knowledge recommended by employees
D Advanced knowledge recommended by employees

ENGINEERS	TOTAL EMPLOYEES		DIFF EQUA				PHYSICS				CHEMISTRY				GEOLOGY			
			A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
AEROSPACE	184	16	2	88	31	19	95	1	81	13	87	0	31	31	1	0	0	0
CHEMICAL	258	89	25	61	27	21	24	72	45	37	9	88	40	51	21	0	24	4
CIVIL	871	445	52	19	26	9	67	27	69	17	71	9	58	9	77	4	66	8
ELECTRICAL	919	185	61	37	35	28	64	35	65	26	46	3	54	8	3	0	16	1
ELECTRONIC	1299	465	19	63	38	36	67	33	59	34	74	11	59	7	8	0	6	1
GEOLOGICAL	64	35	36	8	23	3	47	52	69	23	58	42	69	26	23	77	17	74
INDUSTRIAL	330	73	31	38	21	10	72	23	62	11	72	17	60	7	10	0	11	0
MECHANICAL	1008	334	32	50	36	8	82	16	69	23	87	6	69	8	10	1	9	1
METALLURGIC	86	54	59	27	31	17	57	41	52	46	29	69	31	67	53	2	56	15
MINING	118	62	58	17	26	6	42	40	61	16	53	26	63	15	31	51	35	56
NUCLEAR	3	6	100	0	0	83	0	100	0	100	100	0	17	83	0	0	17	0
ASSC. ENGINEERS																		
CHEMICAL	21	9	29	0	11	11	48	19	78	11	29	48	56	22	19	0	44	0
CIVIL	411	168	10	4	24	2	82	6	56	5	77	5	49	2	80	1	58	1
ELE TRICAL	235	91	68	2	19	5	79	3	46	8	9	2	24	0	0	0	10	0
MECHANICAL	231	29	5	2	7	10	91	3	55	7	11	2	55	3	1	0	24	0
MINING	4	6	0	0	0	0	25	0	33	33	25	0	17	33	25	0	17	33
CONSTRUCTION	302	89	12	1	18	2	47	7	39	6	32	2	26	3	37	2	28	6
TECHNICIANS																		
AERONAUTICAL	372	58	5	32	12	3	30	32	36	16	54	0	26	9	6	0	0	0
CHEMICAL	151	65	1	0	22	2	64	22	57	14	30	60	49	42	2	0	26	5
CIVIL	1255	436	5	1	15	2	74	0	29	2	69	0	22	1	67	0	31	2
DATA PROCESS	361	142	11	15	17	19	82	1	34	8	1	0	16	1	0	0	5	0
DRAFTING	513	171	7	1	16	3	23	0	47	4	8	0	26	2	6	0	13	3
ELECTRICAL	339	68	27	0	24	3	33	27	50	9	30	4	38	3	1	0	10	0
ELECTRONICS	1271	425	14	8	29	5	82	8	62	10	57	1	38	4	3	0	3	0
GEOLOGICAL	25	14	0	0	7	7	72	0	71	7	96	0	57	7	28	44	57	14
INDUSTRIAL	243	66	9	0	20	5	54	10	39	15	24	11	52	9	4	1	8	0
MECAHANICAL	514	119	6	0	24	2	68	7	50	9	13	12	40	5	2	0	8	0
METALLURGIC	41	14	2	0	7	0	51	5	57	14	49	5	43	21	10	0	36	7
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN																		
EXP. MACHINE	439	22	4	1	32	0	14	0	27	0	4	0	9	0	0	0	5	0
INSTR MAKER	70	15	4	3	13	0	20	0	53	7	11	0	13	7	6	0	7	0
INSTRU MAN	140	30	17	1	23	3	61	1	53	10	39	0	43	3	9	0	10	0
LAYOUT MAN	199	17	7	3	18	0	30	2	41	0	16	3	18	0	4	2	0	0
MACH. SET UP	758	27	1	0	22	11	19	0	26	0	2	1	15	0	1	0	4	0
MACH. REPAIR	320	47	2	0	21	2	67	2	36	4	62	0	30	2	1	0	2	0
TOOL AND DIE	234	34	20	0	26	3	28	0	50	0	13	0	21	3	4	0	9	0

TABLE 12 CONTINUED
EDUCATIONAL COURSE REQUIRED FOR EACH OCCUPATION
(RESPONSES IN PERCENTAGES)

A General knowledge recommended by employers
B Advanced knowledge recommended by employers
C General knowledge recommended by employees
D Advanced knowledge recommended by employees

ENGINEERS	TOTAL EMPLOYEES		APPLIED MET				NON METALL				HYDR PNEUM				MFG PROCESS			
			A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
AEROSPACE	184	16	92	0	50	13	91	0	38	6	13	82	56	13	11	0	44	25
CHEMICAL	258	89	39	39	31	9	77	3	30	18	48	19	37	16	69	10	49	13
CIVIL	871	445	27	2	23	2	47	4	38	6	58	13	47	23	16	2	27	2
ELECTRICAL	919	185	39	0	24	5	36	0	34	5	33	1	37	3	34	1	38	6
ELECTRONIC	1299	465	64	5	33	2	76	6	43	3	75	2	23	2	91	0	66	10
GEOLOGICAL	64	35	63	8	37	6	33	41	46	20	28	39	40	11	36	0	31	3
INDUSTRIAL	330	73	62	5	42	18	45	3	55	12	40	21	49	8	31	60	38	58
MECHANICAL	1008	334	86	3	68	8	77	9	72	8	70	19	58	22	61	17	64	19
METALLURGIC	86	54	9	88	15	83	63	33	57	28	73	8	70	9	41	42	46	24
MINING	118	62	63	16	60	8	67	11	39	13	50	25	44	18	50	4	34	5
NUCLEAR	3	6	0	0	67	0	0	0	67	0	0	0	17	0	0	0	50	0
ASSC. ENGINEERS																		
CHEMICAL	21	9	48	0	0	0	57	0	11	0	29	0	22	0	57	10	33	0
CIVIL	411	168	3	0	6	0	6	0	24	3	17	3	32	8	5	0	15	1
ELECTRICAL	235	91	10	0	12	0	14	0	13	1	0	0	10	0	27	0	35	3
MECHANICAL	231	29	85	1	41	7	83	1	55	3	80	4	52	7	54	4	52	28
MINING	4	6	25	0	33	0	0	0	17	0	0	0	33	17	0	0	17	17
CONSTRUCTION	302	89	11	1	19	1	35	2	30	9	44	4	31	3	23	4	38	6
TECHNICIANS																		
AERONAUTICAL	372	58	7	38	36	10	35	6	40	9	61	38	41	40	38	0	40	7
CHEMICAL	151	65	38	3	38	11	26	4	45	3	24	0	17	3	26	3	31	5
CIVIL	1255	436	3	0	7	0	5	0	18	2	9	0	19	1	2	0	12	0
DATA PROCESS	361	142	0	0	7	0	0	0	11	1	0	0	13	2	66	0	36	5
DRAFTING	513	171	6	0	19	2	44	0	31	4	8	2	28	5	43	4	40	10
ELECTRICAL	339	68	28	3	18	3	27	3	31	4	35	3	31	4	6	1	34	3
ELECTRONICS	1271	425	9	0	17	1	33	4	28	2	13	1	15	3	47	1	47	5
GEOLOGICAL	25	14	4	0	0	0	16	0	29	0	8	8	7	21	12	0	7	0
INDUSTRIAL	243	66	15	8	32	3	41	9	45	6	37	0	26	2	77	8	52	23
MECAHANICAL	514	119	21	4	27	8	17	4	27	7	48	11	44	13	27	8	45	10
METALLURGIC	41	14	71	29	71	7	61	0	43	0	17	27	29	7	73	7	29	29
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN																		
EXP. MACHINE	439	22	20	0	55	0	9	0	50	0	48	0	27	0	64	9	68	5
INSTR MAKER	70	15	81	6	67	7	74	6	67	7	14	0	20	7	80	6	53	20
INSTRU MAN	140	30	2	0	23	3	26	0	23	3	49	16	50	20	36	4	37	0
LAYOUT MAN	199	17	32	2	18	0	36	4	24	6	21	2	29	6	62	18	71	12
MACH. SET UP	758	27	70	2	22	11	65	2	37	4	20	3	30	4	84	7	52	15
MACH. REPAIR	320	47	20	6	36	2	52	6	40	4	49	32	53	9	45	26	45	6
TOOL AND DIE	234	34	56	2	62	6	40	2	56	6	47	1	41	3	44	24	53	24

TABLE 12 CONTINUED
EDUCATIONAL COURSE REQUIRED FOR EACH OCCUPATION
(RESPONSES IN PERCENTAGES)

A General knowledge recommended by employers
B Advanced knowledge recommended by employers
C General knowledge recommended by employees
D Advanced knowledge recommended by employees

	TOTAL EMPLOYEES		MACH TOOLS				MACHIBILITY				MACH ECON				INSTR CALIB			
ENGINEERS			A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
AEROSPACE	184	16	7	0	44	13	9	0	50	13	4	0	38	0	14	1	44	19
CHEMICAL	258	89	16	0	22	4	14	0	24	2	16	0	11	2	66	7	43	19
CIVIL	871	445	18	1	18	1	16	0	16	1	18	1	16	2	36	12	41	7
ELECTRICAL	919	185	8	0	29	4	8	0	24	3	8	0	26	3	39	6	48	22
ELECTRONIC	1299	465	24	0	45	2	45	0	36	2	28	0	25	2	90	9	62	21
GEOLOGICAL	64	35	16	2	14	3	16	2	11	6	38	0	17	0	53	22	46	6
INDUSTRIAL	330	73	68	32	63	21	64	29	51	25	42	36	44	36	53	5	42	11
MECHANICAL	1008	334	47	8	60	14	71	13	59	13	32	16	42	11	56	9	66	12
METALLURGIC	86	54	51	3	43	0	55	5	39	4	38	8	33	2	71	14	67	20
MINING	118	62	36	0	29	2	36	0	23	2	61	1	31	5	62	6	42	6
NUCLEAR	3	6	0	0	33	0	0	0	17	0	0	0	17	0	100	0	50	33
ASSC. ENGINEERS																		
CHEMICAL	21	9	10	10	11	0	10	0	11	0	10	0	11	0	48	19	44	11
CIVIL	411	168	4	0	10	0	2	0	10	0	4	0	8	0	7	3	45	13
ELE TRICAL	235	91	24	0	23	0	23	0	20	1	16	0	15	1	89	3	34	12
MECHANICAL	231	29	13	3	62	21	45	2	55	21	52	3	34	21	44	2	45	21
MINING	4	6	0	0	17	0	0	0	17	0	0	0	17	0	0	0	0	33
CONSTRUCTION	302	89	36	4	42	3	20	1	37	2	18	2	26	7	31	9	39	4
TECHNICIANS																		
AERONAUTICAL	372	58	53	33	50	19	22	32	47	16	12	32	24	5	55	32	48	26
CHEMICAL	151	65	31	0	14	6	8	0	14	3	3	0	12	2	70	4	46	15
CIVIL	1255	436	3	2	13	0	1	2	13	0	2	0	8	0	17	2	41	12
DATA PROCESS	361	142	0	1	25	1	0	0	23	1	0	1	18	1	65	12	47	11
DRAFTING	513	171	29	1	43	8	44	1	39	8	41	1	29	4	15	0	30	6
ELECTRICAL	339	68	35	6	50	6	21	6	41	6	3	3	19	3	26	24	53	13
ELECTRONICS	1271	425	48	1	47	5	11	0	30	4	2	0	12	1	27	57	46	41
GEOLOGICAL	25	14	20	0	36	0	8	0	29	0	8	0	0	0	64	0	71	7
INDUSTRIAL	243	66	73	2	50	8	69	4	50	3	25	3	24	5	46	14	47	21
MECAHANICAL	514	119	27	16	51	10	17	13	46	9	18	11	25	3	64	13	63	13
METALLURGIC	41	14	34	2	36	0	44	2	36	7	2	2	21	14	12	27	36	7
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN																		
EXP. MACHINE	439	22	54	45	50	41	45	53	50	41	20	36	50	5	51	2	36	27
INSTR MAKER	70	15	86	14	40	53	89	11	33	60	83	11	20	20	84	14	40	40
INSTRU MAN	140	30	31	2	47	13	31	0	37	13	2	0	27	3	28	64	43	53
LAYOUT MAN	199	17	59	21	53	18	42	20	47	12	27	16	24	6	36	13	47	12
MACH. SET UP	758	27	86	13	59	15	75	18	56	22	66	7	33	15	73	4	48	15
MACH. REPAIR	320	47	60	35	70	15	76	14	60	13	32	13	34	9	62	19	47	17
TOOL AND DIE	234	34	47	50	38	56	44	50	44	50	41	24	44	18	45	15	53	29

TABLE 12 CONTINUED
EDUCATIONAL COURSE REQUIRED FOR EACH OCCUPATION
(RESPONSES IN PERCENTAGES)

A General knowledge recommended by employers
B Advanced knowledge recommended by employers
C General knowledge recommended by employees
D Advanced knowledge recommended by employees

ENGINEERS	TOTAL	EMPLOYEES	ELECTRIC ON A	B	C	D	INTEG CIRC A	B	C	D	COMPUT PRO A	B	C	D	COMPT TECH A	B	C	D
AEROSPACE	184	16	11	0	50	13	1	0	19	6	10	82	38	13	3	82	44	6
CHEMICAL	258	89	81	5	44	13	45	4	15	2	33	7	22	13	22	3	21	7
CIVIL	871	445	42	2	35	5	11	2	8	1	44	3	35	5	30	2	29	3
ELECTRICAL	919	185	9	90	28	63	10	33	30	17	62	5	42	15	9	5	39	12
ELECTRONIC	1299	465	8	88	19	78	21	73	42	47	72	7	56	17	68	11	42	22
GEOLOGICAL	64	35	67	8	37	11	16	0	9	6	56	9	31	0	45	3	31	0
INDUSTRIAL	330	73	71	13	62	18	40	7	45	7	45	25	44	5	25	23	36	7
MECHANICAL	1008	334	47	8	61	11	30	4	23	3	61	6	35	5	60	3	30	3
METALLURGIC	86	54	69	17	61	15	37	5	33	6	30	15	43	4	43	0	31	6
MINING	118	62	54	7	45	3	23	0	16	2	31	10	44	6	31	10	32	6
NUCLEAR	3	6	100	0	33	50	0	0	33	0	100	0	67	0	100	0	50	0
ASSC. ENGINEERS																		
CHEMICAL	21	9	29	0	22	0	19	0	11	0	19	0	11	0	19	0	11	0
CIVIL	411	168	9	0	14	1	1	0	2	0	10	0	17	1	7	0	11	1
ELE TRICAL	235	91	37	63	38	47	74	3	32	14	67	0	37	9	80	0	25	4
MECHANICAL	231	29	41	0	59	17	4	0	24	7	4	0	28	7	3	0	34	7
MINING	4	6	0	0	33	0	0	0	17	0	0	0	0	0	0	0	0	0
CONSTRUCTION	302	89	41	1	35	8	4	0	6	1	22	6	13	0	8	1	8	0
TECHNICIANS																		
AERONAUTICAL	372	58	56	38	50	26	42	0	26	16	5	0	10	3	5	0	10	2
CHEMICAL	15[illegible]	65	36	0	31	8	3	0	9	2	1	0	6	2	16	0	5	3
CIVIL	1255	436	7	2	9	0	1	0	3	0	4	0	10	3	3	0	10	1
DATA PROCESS	361	142	19	67	29	42	19	66	37	15	7	89	49	47	12	88	36	56
DRAFTING	513	171	30	1	41	12	10	1	20	7	3	0	10	2	3	0	10	2
ELECTRICAL	339	68	42	55	44	49	31	19	38	13	32	0	24	3	19	0	13	4
ELECTRONICS	1271	425	32	68	23	73	20	56	42	36	54	1	29	5	50	6	35	9
GEOLOGICAL	25	14	48	0	36	0	0	0	14	0	0	40	36	0	16	0	36	0
INDUSTRIAL	243	66	30	19	45	30	19	1	35	8	5	6	21	0	18	3	20	0
MECAHANICAL	514	119	64	7	58	8	19	1	18	6	3	25	10	0	3	26	10	1
METALLURGIC	41	14	44	27	14	0	0	27	7	0	0	0	21	7	0	0	14	7
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN																		
EXP. MACHINE	439	22	39	0	5	0	1	0	0	0	1	0	5	0	1	0	5	0
INSTR MAKER	70	15	17	0	33	13	9	0	27	7	4	0	7	0	4	0	7	0
INSTRU MAN	140	30	36	39	43	43	19	31	43	20	21	0	20	7	21	0	20	7
LAYOUT MAN	199	17	16	2	18	12	2	2	12	6	8	2	12	0	3	2	0	0
MACH. SET UP	758	27	9	1	19	4	6	0	11	4	0	0	4	19	0	0	15	7
MACH. REPAIR	320	47	69	14	23	21	27	1	26	13	1	0	17	0	1	0	19	0
TOOL AND DIE	234	34	28	0	29	3	11	0	12	0	4	0	3	6	4	0	6	9

TABLE 12 CONTINUED
EDUCATIONAL COURSE REQUIRED FOR EACH OCCUPATION
(RESPONSES IN PERCENTAGES)

A General knowledge recommended by employers
B Advanced knowledge recommended by employers
C General knowledge recommended by employees
D Advanced knowledge recommended by employees

ENGINEERS	TOTAL EMPLOYEES		DRAFTING				COMPUTRGRAPH				WRITING				READING			
			A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
AEROSPACE	184	16	94	5	38	19	1	0	13	0	93	3	50	38	12	3	56	38
CHEMICAL	258	89	37	0	62	7	6	0	17	0	69	31	54	40	69	30	54	40
CIVIL	871	445	68	31	57	36	13	1	11	1	75	24	59	36	73	25	57	36
ELECTRICAL	919	185	39	3	59	18	6	0	22	1	46	5	62	35	47	4	61	35
ELECTRONIC	1299	465	49	1	70	7	22	0	26	2	39	61	65	31	78	20	63	31
GEOLOGICAL	64	35	56	30	71	29	9	0	14	0	39	61	37	63	47	53	46	54
INDUSTRIAL	330	73	56	5	58	15	13	4	26	3	50	50	64	32	47	37	58	38
MECHANICAL	1008	334	80	13	68	21	19	0	13	1	84	15	68	29	54	14	65	30
METALLURGIC	86	54	90	6	70	9	28	0	19	2	63	35	52	44	62	29	61	35
MINING	118	62	47	33	60	27	14	0	16	3	23	58	55	35	23	58	50	35
NUCLEAR	3	6	100	0	50	0	0	0	17	0	100	0	67	33	100	0	33	67
ASSC. ENGINEERS																		
CHEMICAL	21	9	57	0	22	11	0	0	0	0	38	38	33	56	10	38	44	33
CIVIL	411	168	82	11	51	33	4	0	5	1	86	7	68	17	83	9	64	21
ELE TRICAL	235	91	93	2	78	11	58	0	11	3	82	3	68	23	79	3	63	24
MECHANICAL	231	29	92	4	59	31	5	0	14	3	61	5	45	34	17	6	45	38
MINING	4	6	0	25	50	33	0	0	0	0	0	25	67	33	0	25	50	50
CONSTRUCTION	302	89	62	20	64	24	3	0	6	0	59	21	60	20	73	21	61	22
TECHNICIANS																		
AERONAUTICAL	372	58	64	0	47	17	5	0	5	0	86	0	52	10	86	0	52	17
CHEMICAL	151	65	23	4	25	5	16	0	5	0	79	7	58	9	83	7	54	12
CIVIL	1255	436	83	12	54	24	2	0	4	1	89	2	60	12	91	1	64	13
DATA PROCESS	361	142	65	0	28	1	2	80	42	9	99	0	61	10	99	1	61	19
DRAFTING	513	171	23	75	21	76	33	2	7	1	83	6	65	13	84	6	63	16
ELECTRICAL	339	68	58	9	53	12	19	0	6	1	58	5	65	6	79	7	66	12
ELECTRONICS	1271	425	73	4	53	4	14	0	13	1	86	3	62	14	90	3	65	18
GEOLOGICAL	25	14	68	0	64	0	40	0	7	0	72	16	64	21	84	8	64	29
INDUSTRIAL	243	66	52	6	55	8	1	0	9	0	75	15	61	18	81	10	56	24
MECAHANICAL	514	119	76	7	45	13	3	0	8	0	72	13	54	14	47	11	59	14
METALLURGIC	41	14	59	29	21	21	0	0	7	7	56	7	50	29	88	7	29	50
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN																		
EXP. MACHINE	439	22	81	2	59	9	1	0	0	0	54	0	23	5	54	0	27	5
INSTR MAKER	70	15	94	4	73	7	6	0	0	0	24	0	33	7	90	0	53	7
INSTRU MAN	140	30	46	21	40	7	3	0	10	7	76	3	60	0	75	3	60	3
LAYOUT MAN	199	17	74	9	53	6	3	2	0	0	36	10	53	0	39	10	59	0
MACH. SET UP	758	27	71	6	44	7	0	0	11	4	24	1	33	7	24	9	41	7
MACH. REPAIR	320	47	78	2	45	11	1	0	11	0	60	0	32	4	80	0	36	9
TOOL AND DIE	234	34	64	13	47	38	4	0	9	3	46	0	41	0	47	13	47	6

TABLE 12 CONTINUED
EDUCATIONAL COURSE REQUIRED FOR EACH OCCUPATION
(RESPONSES IN PERCENTAGES)

A General knowledge recommended by employers
B Advanced knowledge recommended by employers
C General knowledge recommended by employees
D Advanced knowledge recommended by employees

ENGINEERS	TOTAL EMPLOYEES		SPEAKING				BUS AD				SOC STUDIES				HUMANITIES			
			A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
AEROSPACE	184	16	12	3	63	31	88	0	44	13	90	0	31	6	8	0	31	6
CHEMICAL	258	89	67	30	53	39	90	5	53	9	28	0	40	6	26	0	34	2
CIVIL	871	445	77	22	61	33	59	11	63	13	48	1	45	3	39	1	33	1
ELECTRICAL	919	185	49	3	61	36	42	1	65	10	37	0	44	2	13	0	31	1
ELECTRONIC	1299	465	79	20	64	30	95	1	59	8	52	0	30	1	51	0	20	1
GEOLOGICAL	64	35	55	45	51	49	47	25	63	11	69	0	43	9	55	0	34	6
INDUSTRIAL	330	73	46	46	56	42	81	14	66	16	62	1	45	1	35	0	22	0
MECHANICAL	1008	334	56	13	64	29	52	33	56	9	35	0	37	2	29	2	24	1
METALLURGIC	86	54	65	26	61	33	58	17	52	11	73	0	52	2	51	0	43	0
MINING	118	62	45	36	55	29	61	14	50	13	64	7	42	0	58	5	29	0
NUCLEAR	3	6	100	0	17	83	100	0	50	0	100	0	67	0	100	0	50	0
ASSC. ENGINEERS																		
CHEMICAL	21	9	19	29	44	44	0	10	22	33	29	0	44	11	29	0	44	0
CIVIL	411	168	83	9	64	18	83	2	51	3	8	0	28	1	8	0	18	0
ELE TRICAL	235	91	94	3	66	21	64	0	49	12	4	1	24	3	2	1	14	2
MECHANICAL	231	29	17	4	41	41	13	1	34	24	8	1	38	3	5	0	31	0
MINING	4	6	0	25	50	50	0	25	50	0	0	25	17	17	0	0	0	17
CONSTRUCTION	302	89	67	26	60	30	65	13	46	21	38	3	34	3	36	0	21	2
TECHNICIANS																		
AERONAUTICAL	372	58	65	0	43	21	46	0	29	2	40	0	16	2	39	0	10	0
CHEMICAL	151	65	74	1	60	11	40	0	29	3	17	0	14	3	5	0	12	2
CIVIL	1255	436	91	1	61	14	63	0	26	5	10	0	16	2	8	0	10	1
DATA PROCESS	361	142	99	0	66	14	27	1	34	7	1	0	20	0	1	0	11	1
DRAFTING	513	171	86	6	57	15	41	0	22	3	39	0	13	1	37	0	16	1
ELECTRICAL	339	68	64	3	62	16	25	0	35	4	22	0	25	0	22	0	13	0
ELECTRONICS	1271	425	89	3	66	16	57	0	28	2	57	0	21	0	55	0	12	0
GEOLOGICAL	25	14	84	8	50	29	20	0	43	0	12	0	36	0	12	0	7	0
INDUSTRIAL	243	66	89	10	65	18	11	0	35	8	35	3	33	3	11	0	26	0
MECAHANICAL	514	119	42	6	65	11	16	2	23	3	13	2	16	3	11	0	9	2
METALLURGIC	41	14	59	7	36	43	54	7	21	29	27	10	43	7	27	10	36	7
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN																		
EXP. MACHINE	439	22	57	1	32	9	6	0	5	0	3	0	0	0	3	0	0	0
INSTR MAKER	70	15	89	1	47	7	9	0	0	13	9	0	7	7	9	0	7	7
INSTRU MAN	140	30	77	3	63	7	20	1	23	0	19	0	17	0	9	0	17	0
LAYOUT MAN	199	17	42	11	65	0	23	2	24	0	18	0	6	0	11	0	0	0
MACH. SET UP	758	27	25	9	48	7	7	0	22	0	6	0	22	0	6	0	26	0
MACH. REPAIR	320	47	62	0	49	9	12	0	15	2	11	0	9	0	28	0	4	0
TOOL AND DIE	234	34	38	14	56	9	13	0	9	0	8	0	9	0	7	0	6	0

indication of specialization. Drafting, for example, is needed by a substantial majority of almost all personnel, but the only occupational group in which more than a third of them require advanced knowledge -- from both the employer and employee point of view -- are drafting technicians. Similarly, instrument calibration and measurements is needed by a majority of persons in nearly all engineering, technical, and skilled occupations; but only in one -- that of the instrumentman -- do a majority require advanced knowledge in the opinion of employers and employees alike. No attempt was made in the survey to define "general" and "advanced," and in some respects they mean different things in engineering than in the supporting occupations. The results of the survey strongly suggest, however, that it is necessary for most engineering and related personnel to have a general knowledge of a wide range of subjects, but it is not necessary for most of them to have an advanced knowledge of more than a very few.

Responses of employers and employees show an apparently higher correlation in required subjects than in activities performed in each occupation, both in the general and advanced ranking of the subjects. When the responses are approximately the same, a fairly reliable judgment has been made of the importance of each subject in preparing for any of these occupations. If 50% -- or perhaps even less in some cases -- of the men on the job and their employers consider at least a general knowledge of a subject necessary, it may be assumed anyone preparing for the occupation would be seriously handicapped without that subject.

The subject matter data in Table 12 have been converted to graphs on the following pages in the same way that skilled activities were shown. General knowledge and advanced knowledge responses are combined in single lines indicating the extent to which some preparation is considered necessary. Solid lines (employer) represent percentages of employees whose employers feel that either a general or advanced knowledge of the subject is necessary. Broken lines (employee) represent percentages of employees who consider a general or advanced knowledge of the subject necessary in the performance of their jobs.

Of five mathematics courses listed, algebra, geometry and trigonometry show high levels of importance in virtually all occupations. A sharp drop occurs in the importance of calculus and differential equations for associate engineers, technicians and skilled craftsmen; although approximately one-fourth of employees in almost all occupations consider some knowledge necessary. Also, in certain fields of engineering, calculus is considered necessary by only about half of the engineers and differential equations by a third. These are instances in which opinions of employers and employees do not agree, possibly because the work actually performed by many engineers does not involve higher mathematics. On the other hand, their work may require engineering knowledge based on higher mathematics.

In basic sciences, physics and chemistry are highly important in engineering and in certain technical occupations. There are substantial requirements for these subjects, especially physics, in the skilled crafts also. Geology varies sharply according to occupation. The same is true of most of the fourteen engineering sciences or technical courses listed. It should be noted, however, that most of these show significant levels of importance in some additional occupations with which they are not directly associated.

Six non-technical or general education courses were listed, three dealing with communications. Consistently high levels of importance are attached to reading writing, and speaking for all occupations. Even in the skilled crafts

FIGURE 6
PERCENTAGES OF TOTAL RESPONSE BY EMPLOYERS AND EMPLOYEES
IDENTIFYING COURSES REQUIRED WITH OCCUPATIONS

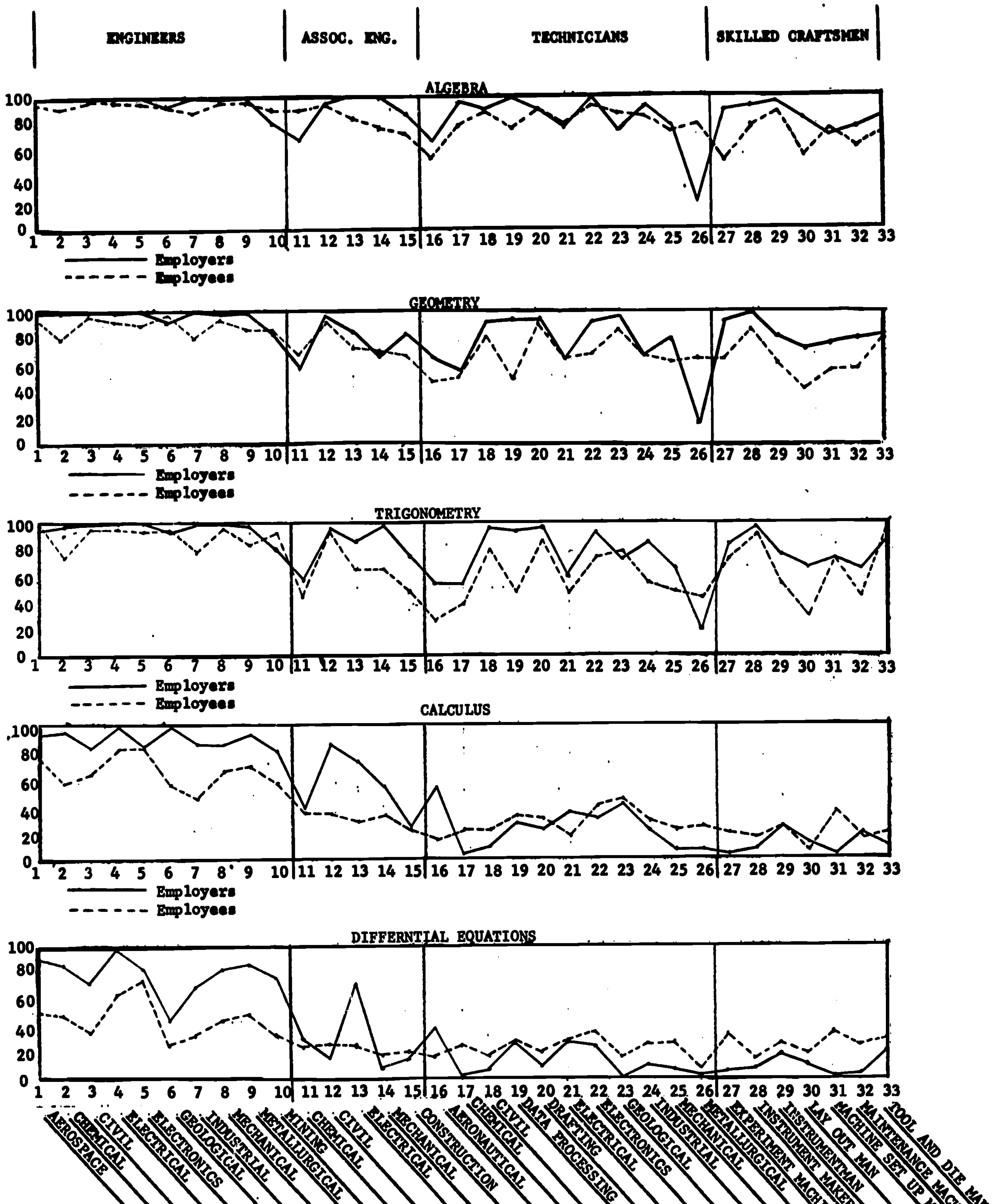


FIGURE 7
PERCENTAGES OF TOTAL RESPONSE BY EMPLOYERS AND EMPLOYEES
IDENTIFYING COURSES REQUIRED WITH OCCUPATIONS

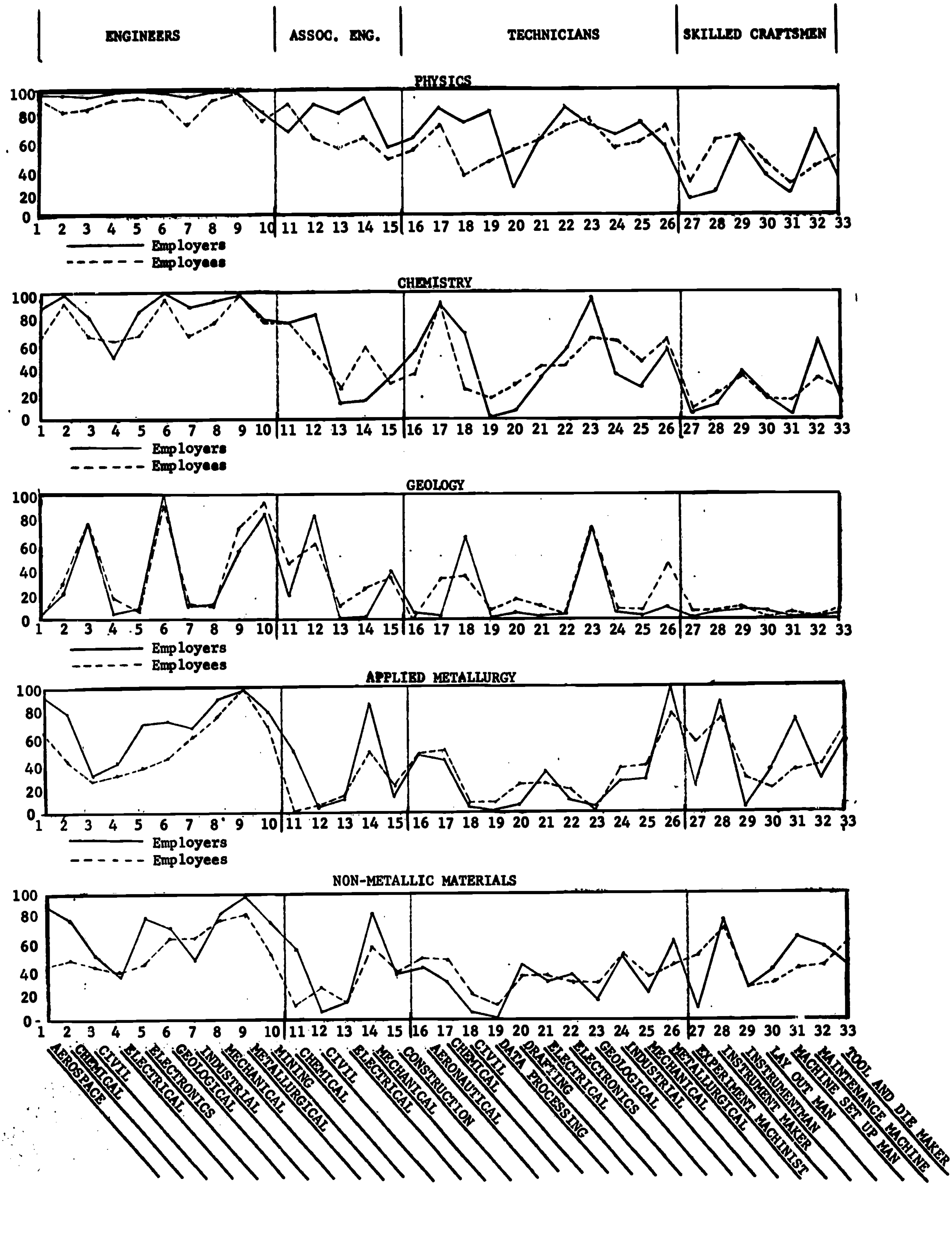


FIGURE 8
PERCENTAGES OF TOTAL RESPONSE BY EMPLOYERS AND EMPLOYEES
IDENTIFYING COURSES REQUIRED WITH OCCUPATIONS

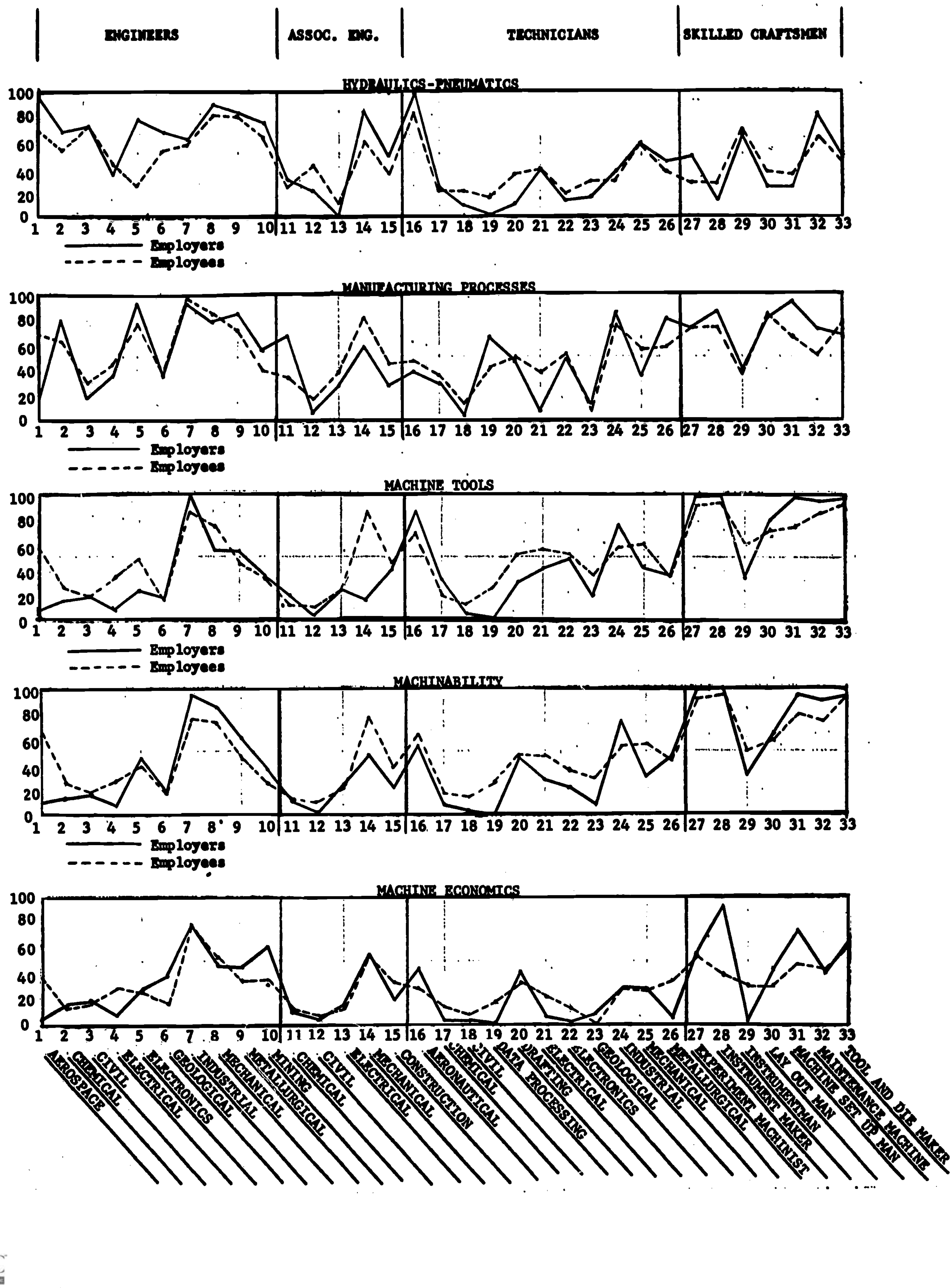


FIGURE 9
PERCENTAGES OF TOTAL RESPONSE BY EMPLOYERS AND EMPLOYEES IDENTIFYING COURSES REQUIRED WITH OCCUPATIONS

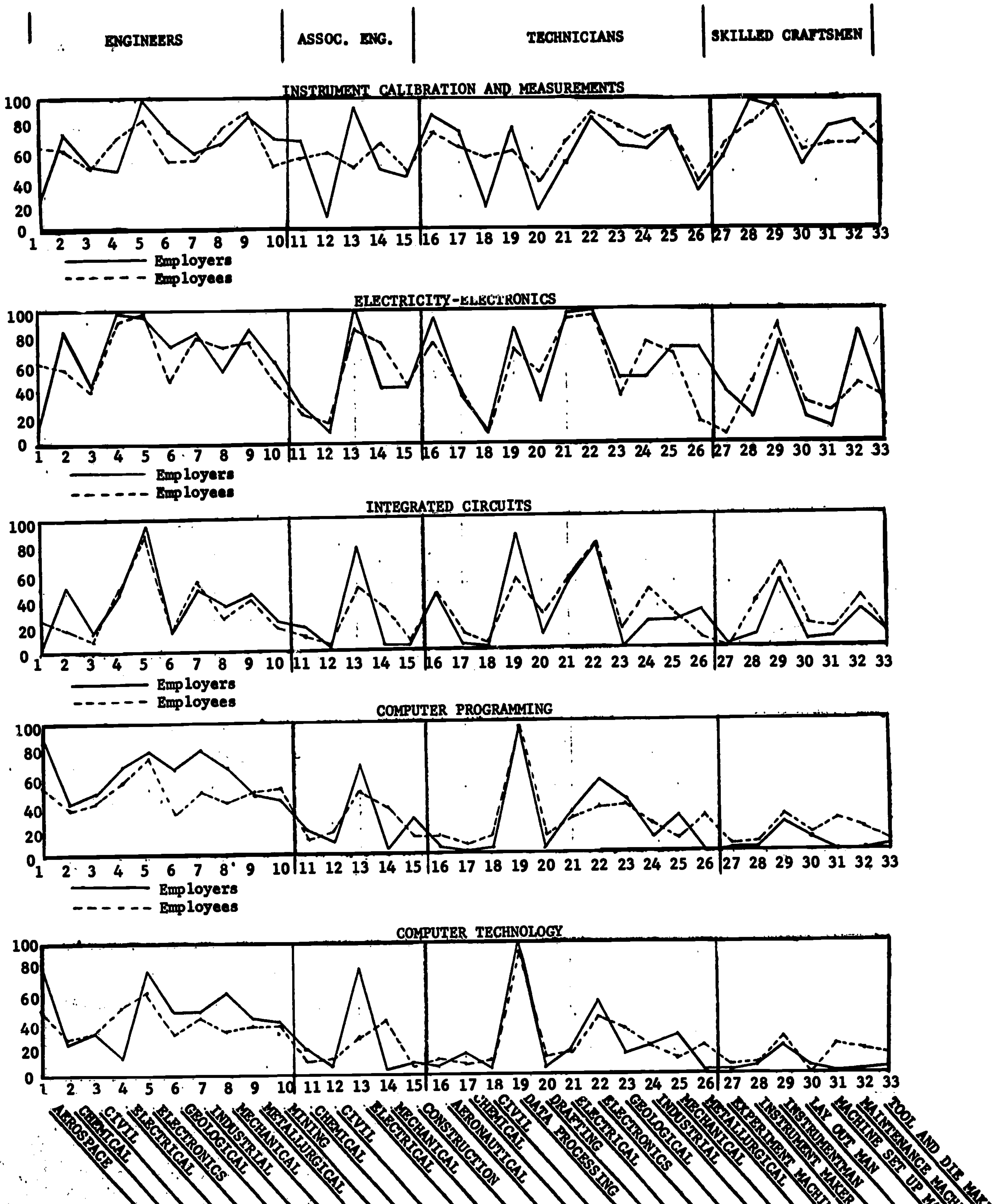


FIGURE 10
PERCENTAGES OF TOTAL RESPONSE BY EMPLOYERS AND EMPLOYEES
IDENTIFYING COURSES REQUIRED WITH OCCUPATIONS

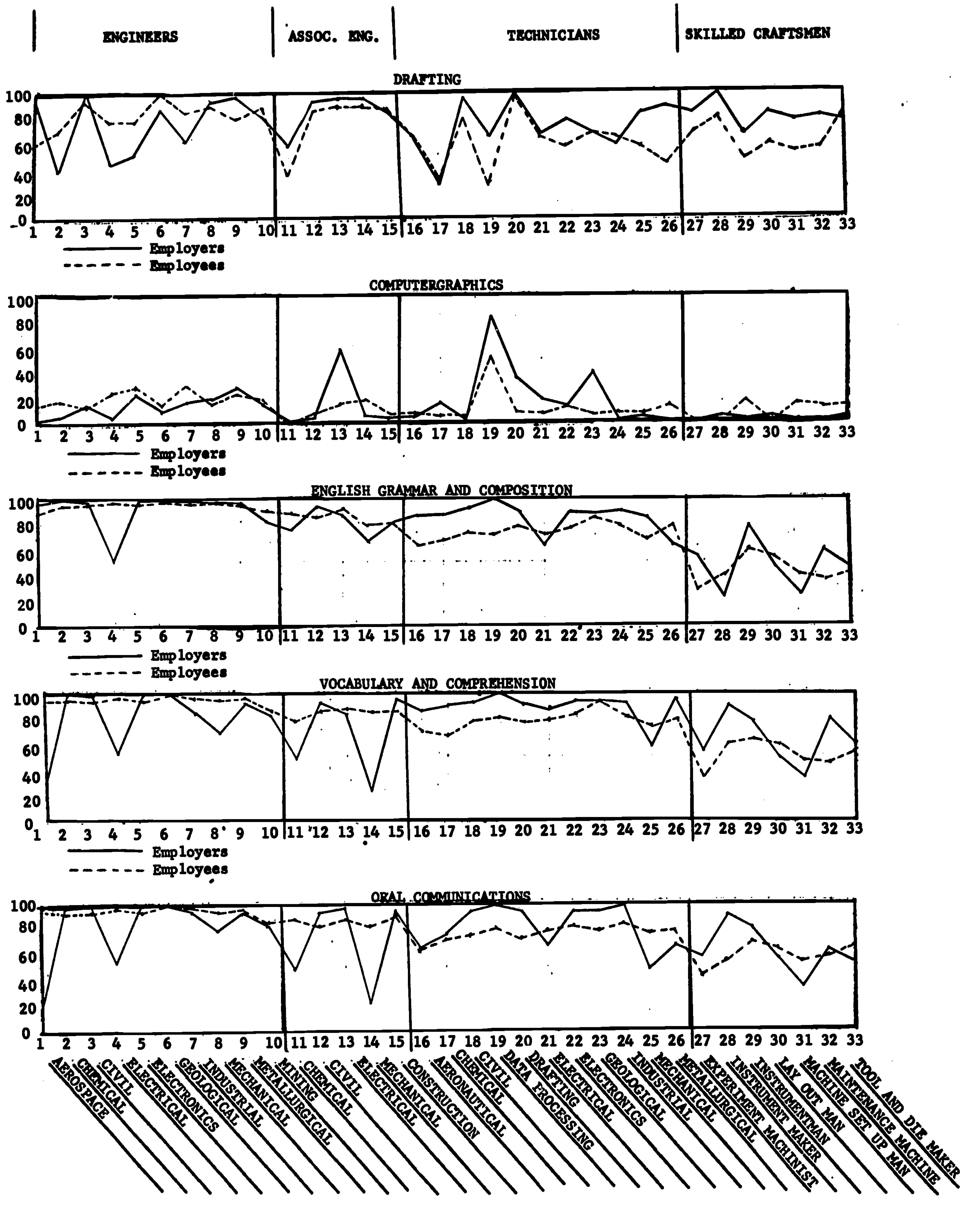
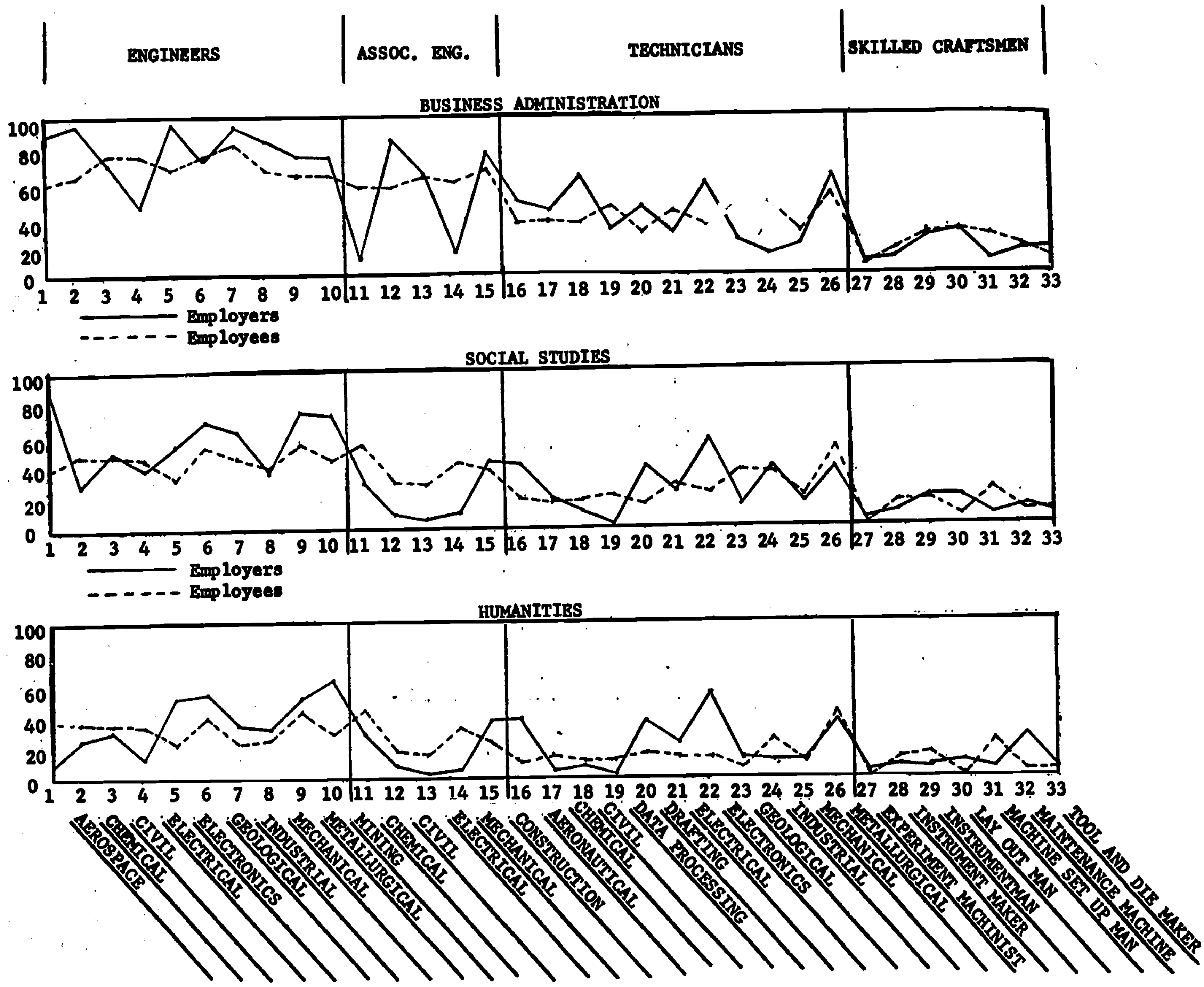


FIGURE 11
PERCENTAGES OF TOTAL RESPONSE BY EMPLOYERS AND EMPLOYEES IDENTIFYING COURSES REQUIRED WITH OCCUPATIONS



the use of both written and oral language is considered a major requirement by employers and employees alike. Business courses are fairly high in importance for engineers and to a considerable extent for technicians. Social studies and humanities rank lowest, but careful attention should be given to those occupations in which one-fourth to one-half of employees and employers report the need for at least a general knowledge.

Levels of Education: Employers were asked the level of education they required and the level they preferred when employing personnel. Employees were asked the highest level they had actually reached. Ten levels were identified: less than high school; high school diploma or equivalent; vocational-technical school; armed services school; more than one year of college without a degree; associate degree; baccalaureate degree in engineering; non-engineering baccalaureate degree; masters degree; and doctorate. The responses are shown for each occupation in Table 13. Under each level of education are the percentages of employees whose employers require that level, the percentages whose employers prefer that level, and the percentages of employees who have actually reached that level.

Employer requirements and preferences are considerably broader than might be expected, especially for engineers. They vary from one field to another depending on the kind of work required and the attitude of the individual employers. The educational level of most employees is found between the minimum required and the employer's preference. The Charts in Figure 12, page 81, show the percentages for each educational level in the four basic classifications of employment used in the survey. Employers of 66% of all engineers require a baccalaureate degree in engineering, and 55% of the engineers have this degree. An additional 10% have non-engineering baccalaureate degrees. The preference for a master's degree is 30% and a doctor's degree 8%, with the number of engineers holding these degrees representing 15% and 5% respectively.

These charts illustrate a close similarity in educational qualifications for associate engineers and technicians. There is a slightly higher preference for the baccalaureate in associate engineering, and a correspondingly higher percentage of associate engineers than technicians who have this degree. The major pattern in both cases, however, is a minimum requirement of high school or vocational-technical school, an associate degree preferred, and more than one year of college with no degree the actual education of the men on the job.

The difference in educational qualifications between associate engineers and technicians on the one hand and skilled craftsmen on the other is also apparent. Except for a very small minority, the skilled occupations do not involve college preparation. Most employers prefer vocational training either in school or in the armed forces, and a substantial number of employees have this kind of training.

Probably the most significant observation to be made from these data on levels of education is in reference to the current controversy regarding a four-year baccalaureate or five-year master's degree as the basic requirement in engineering. If Arizona is representative, industry gives only minority support to raising the present level. There are areas, however, in which a graduate degree is preferred for more than half of the engineers. In aerospace, geological and nuclear engineering it is preferred almost unanimously. Fewer engineers have graduate degrees in any field than their employers would prefer, but actual percentages in some fields are significant and are undoubtedly increasing. Figure 13 contains a breakdown of the educational levels in engineering at the present time.

TABLE 13
LEVELS OF EDUCATION REQUIRED, PREFERRED, AND ACHIEVED
(Responses in Percentages)

ENGINEERS	TOTAL EMPLOYEES	SUB-HIGH SCHOOL	HIGH SCHOOL	VOC-TECH SCHOOL	ARMED SERVICE	COLLEGE-NO DEGREE	ASSOCIATE DEGREE	BS-ENGINEERING	BA-BS NON ENGINEERING	MA-MS	DOCTORATE
Aerospace	184 16										
REQUIRED		0	1	4	0	2	0	5	5	82	0
PREFERRED		0	0	0	0	0	0	4	0	9	84
ACHIEVED		0	0	6	0	13	0	19	6	25	31
Chemical	258 89										
REQUIRED		0	4	1	0	51	0	24	3	0	17
PREFERRED		0	0	0	0	0	0	7	16	44	2
ACHIEVED		0	3	2	6	7	3	10	22	24	21
Civil	871 445										
REQUIRED		1	20	0	0	9	0	62	1	1	0
PREFERRED		0	0	0	0	1	0	34	1	22	8
ACHIEVED		0	2	1	1	13	2	63	6	9	2
Electrical	919 185										
REQUIRED		0	0	0	0	1	0	94	0	4	0
PREFERRED		0	0	0	0	0	0	2	0	28	5
ACHIEVED		0	3	1	0	6	0	60	7	15	8
Electronic	1299 465										
REQUIRED		0	3	16	0	11	0	68	0	0	0
PREFERRED		0	0	0	0	0	12	19	0	61	0
ACHIEVED		0	1	2	1	10	2	56	8	19	1
Geological	64 35										
REQUIRED		0	0	0	0	3	6	63	38	6	0
PREFERRED		0	0	0	0	0	0	8	8	13	19
ACHIEVED		0	0	0	0	3	0	43	23	29	3
Industrial	330 73										
REQUIRED		0	8	11	0	29	0	32	2	9	0
PREFERRED		0	0	0	0	1	0	39	18	6	9
ACHIEVED		1	5	1	4	18	7	41	15	5	1
Mechanical	1008 334										
REQUIRED		0	6	8	0	1	5	72	0	2	2
PREFERRED		0	1	0	0	6	0	14	1	50	3
ACHIEVED		0	4	4	0	10	2	58	6	12	3
Metallurgic	86 54										
REQUIRED		0	5	6	0	0	0	74	13	1	0
PREFERRED		0	3	5	0	3	3	13	0	23	19
ACHIEVED		0	2	0	0	6	0	57	6	11	15
Mining	118 62										
REQUIRED		0	0	0	0	3	0	83	0	6	0
PREFERRED		0	2	2	0	0	0	6	0	9	6
ACHIEVED		0	2	0	0	5	2	66	16	5	3
Nuclear	3 6										
REQUIRED		0	0	0	0	0	0	100	0	0	0
PREFERRED		0	0	0	0	0	0	0	0	100	0
ACHIEVED		0	0	0	0	0	0	0	0	17	83

TABLE 13 CONTINUED
LEVELS OF EDUCATION REQUIRED, PREFERRED, AND ACHIEVED
(Responses in Percentages)

ASSC. ENGINEERS	TOTAL EMPLOY	SUB-HIGH SCHOOL	HIGH SCHOOL	VOC-TECH SCHOOL	ARMED SERVICE	COLLEGE-NO DEGREE	ASSOCIATE DEGREE	BS-ENGINEERING	BA-BS NON ENGINEERING	MA-MS	DOCTORATE
Chemical	21 9										
REQUIRED		0	24	29	0	0	0	29	0	0	0
PREFERRED		0	0	0	0	24	0	0	48	29	0
ACHIEVED		0	0	11	11	33	0	0	33	11	0
Civil	411 168										
REQUIRED		1	75	1	0	10	0	9	0	0	0
PREFERRED		0	0	2	1	7	68	14	0	6	0
ACHIEVED		1	29	5	3	34	4	18	5	1	0
Electrical	235 91										
REQUIRED		0	86	4	0	4	1	5	0	0	0
PREFERRED		0	0	15	15	19	66	6	3	1	0
ACHIEVED		0	14	9	13	44	4	11	4	0	0
Mechanical	231 29										
REQUIRED		0	11	79	0	6	0	2	0	0	0
PREFERRED		0	0	3	0	4	37	46	3	1	0
ACHIEVED		0	14	7	7	38	10	3	14	0	0
Mining	4 6										
REQUIRED		0	25	75	0	0	0	0	0	0	0
PREFERRED		0	0	0	0	75	0	25	0	0	0
ACHIEVED		0	17	0	0	67	17	0	0	0	0
Construction	302 89										
REQUIRED		20	33	6	0	6	0	6	2	0	0
PREFERRED		1	16	14	0	35	0	18	12	1	0
ACHIEVED		8	24	10	3	28	4	16	6	0	0
TECHNICIANS											
Aeronautical	372 58										
REQUIRED		13	15	52	0	19	0	0	0	0	0
PREFERRED		0	75	42	17	33	13	37	1	0	0
ACHIEVED		2	10	33	17	26	7	0	2	0	0
Chemical	151 65										
REQUIRED		5	77	1	0	11	2	1	1	0	0
PREFERRED		0	2	7	7	40	6	2	28	1	1
ACHIEVED		2	14	8	9	40	2	5	14	2	3
Civil	1255 436										
REQUIRED		6	87	2	0	2	0	0	0	0	0
PREFERRED		0	1	5	0	17	64	5	0	0	0
ACHIEVED		3	35	7	5	36	4	3	8	0	0
Data Process	361 142										
REQUIRED		3	27	66	64	3	1	1	2	0	0
PREFERRED		0	0	6	1	9	67	1	13	1	0
ACHIEVED		0	13	10	15	30	14	1	11	4	1

TABLE 13 CONTINUED
LEVELS OF EDUCATION REQUIRED, PREFERRED, AND ACHIEVED
(Responses in Percentages)

TECHNICIANS (cont'd)	TOTAL EMPLOYEES	SUB-HIGH SCHOOL	HIGH SCHOOL	VOC-TECH SCHOOL	ARMED SERVICE	COLLEGE-NO DEGREE	ASSOCIATE DEGREE	BS-ENGINEERING	BA-BS NON ENGINEERING	MA-MS	DOCTORATE
Drafting	513 171										
REQUIRED		3	54	31	0	4	0	0	0	0	0
PREFERRED		0	3	15	2	33	40	1	2	0	0
ACHIEVED		1	19	11	3	48	9	6	4	0	0
Electrical	339 68										
REQUIRED		6	59	13	0	5	0	0	0	0	0
PREFERRED		0	8	12	19	14	1	15	0	0	0
ACHIEVED		3	25	24	10	26	7	3	1	0	0
Electronics	1271 425										
REQUIRED		2	39	46	2	6	0	1	0	0	0
PREFERRED		1	3	15	14	21	46	3	0	0	0
ACHIEVED		0	9	19	19	36	8	1	4	1	1
Geological	25 14										
REQUIRED		0	68	0	0	40	0	0	0	0	0
PREFERRED		0	0	4	0	16	0	0	64	0	0
ACHIEVED		0	7	0	0	43	21	0	21	7	0
Industrial	243 66										
REQUIRED		6	82	11	8	9	0	2	0	0	0
PREFERRED		0	0	55	0	37	14	0	0	0	0
ACHIEVED		3	21	11	12	36	8	6	3	0	0
Mechanical	514 119										
REQUIRED		35	48	5	0	2	0	1	0	0	0
PREFERRED		0	13	25	10	26	31	2	0	2	0
ACHIEVED		3	21	14	14	30	7	2	4	1	3
Metallurgic	41 14										
REQUIRED		34	37	0	0	2	0	0	0	0	0
PREFERRED		0	59	29	0	7	12	20	0	0	0
ACHIEVED		0	14	0	7	50	14	0	7	0	7
Nuclear	0 0										
REQUIRED		0	0	0	0	0	0	0	0	0	0
PREFERRED		0	0	0	0	0	0	0	0	0	0
ACHIEVED		0	0	0	0	0	0	0	0	0	0

TABLE 13 CONTINUED
LEVELS OF EDUCATION REQUIRED, PREFERRED, AND ACHIEVED
(Responses in Percentages)

SKILLED CRAFTS	TOTAL EMPLOY.		SUB-HIGH SCHOOL	HIGH SCHOOL	VOC-TECH SCHOOL	ARMED SERVICE	COLLEGE-NO DEGREE	ASSOCIATE DEGREE	BS-ENGINEERING	BA-BS NON ENGINEERING	MA-MS	DOCTORATE
Exp. Machine	439	22										
REQUIRED			22	33	37	0	0	0	1	0	0	0
PREFERRED			0	21	42	0	8	0	0	0	0	0
ACHIEVED			23	14	45	5	9	5	0	0	0	0
Instr Maker	70	15										
REQUIRED			0	79	1	0	0	0	0	0	0	0
PREFERRED			3	4	87	1	4	0	0	0	0	0
ACHIEVED			0	13	27	7	53	0	0	0	0	0
Instru Man	140	30										
REQUIRED			17	50	10	0	6	0	9	0	0	0
PREFERRED			1	12	48	11	21	1	0	0	9	0
ACHIEVED			0	37	27	20	13	0	0	3	0	0
Layout Man	199	17										
REQUIRED			23	47	3	0	0	0	4	0	0	0
PREFERRED			2	29	55	2	7	5	2	0	2	0
ACHIEVED			24	18	35	0	18	6	0	0	0	0
Mach. Set Up	758	27										
REQUIRED			55	32	0	0	0	0	0	0	0	0
PREFERRED			0	19	33	49	2	0	0	0	0	0
ACHIEVED			15	26	22	7	15	0	4	0	7	0
Mach. Repair	320	47										
REQUIRED			19	58	8	0	0	0	0	0	0	0
PREFERRED			2	25	73	7	6	0	0	0	0	0
ACHIEVED			9	26	17	28	17	0	2	2	0	0
Tool & Die	234	34										
REQUIRED			32	53	9	0	0	0	2	0	0	0
PREFERRED			0	26	62	13	20	0	0	0	0	0
ACHIEVED			3	32	41	12	9	0	0	0	0	0

FIGURE 12
EDUCATIONAL LEVELS OF INDUSTRIAL EMPLOYMENT

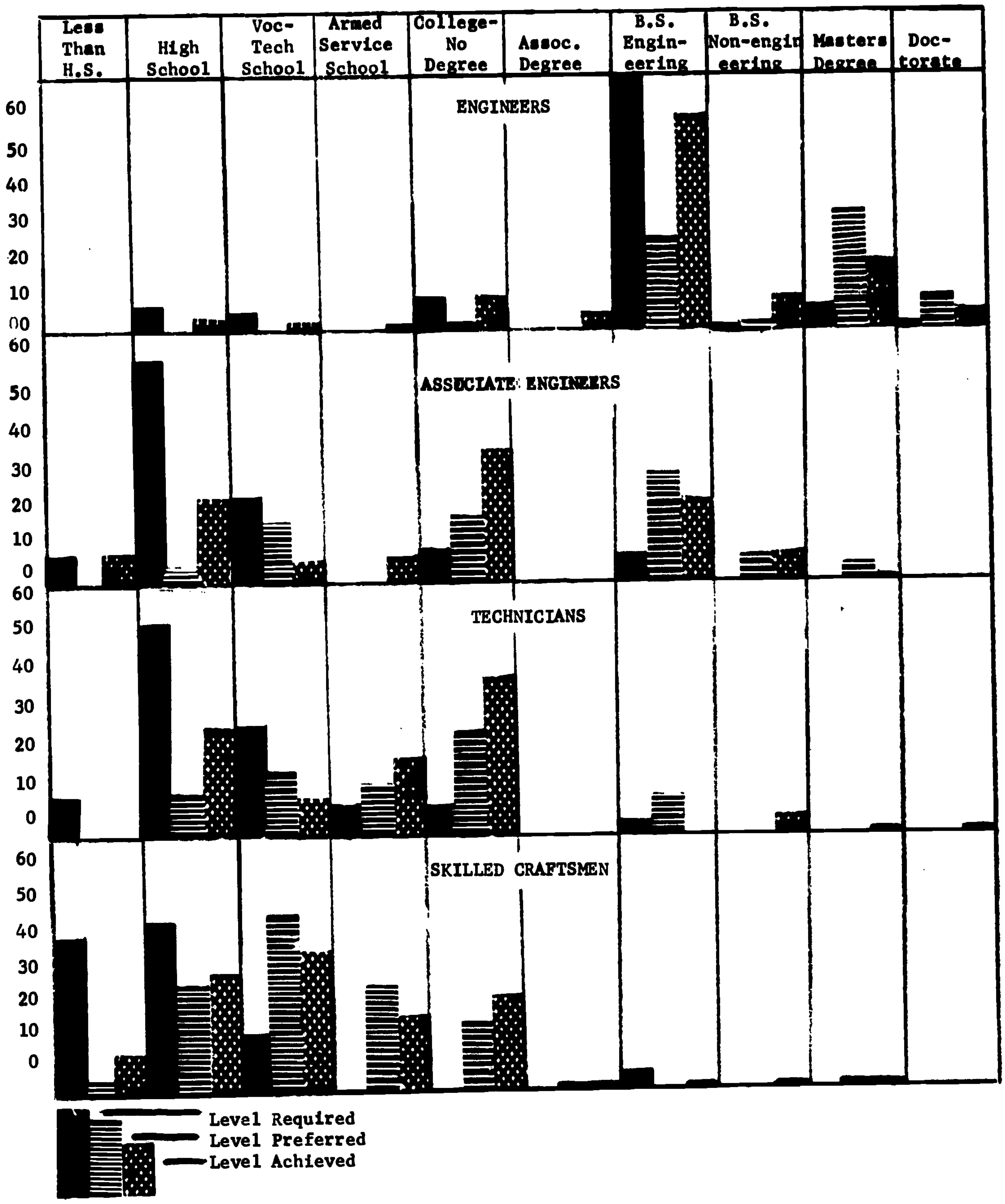


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FIGURE 13

EDUCATIONAL LEVELS IN ENGINEERING
(PERCENTAGES OF PERSONNEL)

	Baccalaureate Degree Required *	Present Employees With Baccalaureate Degree *	Graduate Degree Preferred **	Present Employees With Graduate Degree **
Aerospace	92	81	93	56
Chemical	44	53	46	45
Civil	64	80	30	11
Electrical	98	90	33	23
Electronic	68	84	61	20
Geological	91	98	32	32
Industrial	43	62	15	6
Mechanical	76	79	53	15
Metallurgical	88	89	42	26
Mining	89	90	15	8
Nuclear	100	100	100	100

* Includes baccalaureate and graduate degrees. Remaining percentages are less than baccalaureate.

** Includes master's and doctor's degrees. Remaining percentages are less than master's.

The percentages of engineers are shown in each field whose employers require a baccalaureate degree or higher, those who have a baccalaureate or higher degree, the percentages whose employers prefer a master's or doctor's degree, and those who have these degrees. In two fields -- technical and industrial -- the baccalaureate requirements and achievement are unusually low, indicating that employers have included disproportionate numbers of personnel in these fields who are in the lower educational range. This is true of industrial engineering altogether, resulting in even lower percentages preferring and achieving graduate degrees. Some parts of industry, apparently do not consider professional standards as important in these two fields, especially industrial engineering, as in other fields.

High School Major and Academic Rank: An attempt was made to trace the educational background of all personnel from high school through technical or professional training. Each respondent was asked to identify his major course of study in high school from a list of seven: general education; college preparatory; vocational-technical; industrial arts; agriculture; business; and other. The question might as well have been omitted. The number of high school students taking any course other than general education or college preparatory has always been quite small, and this is clearly the pattern that appears in the survey. The percentages are found in Table 14.

The only other information sought concerning high school experience was academic rank. Employees were asked if they had been in the lower one-fourth, upper three-fourths, upper one-half, upper one-fourth, or upper 10% of their classes. The question could have been easily misunderstood, and persons answering it might have been rather sensitive in regard to revealing their rank, even though their identity would not have been known. Nevertheless, the responses were distributed in such a way that some credence may be given to them. They are shown as a series of bar charts in Figure 14. Very few persons in any occupation identified themselves as having been in the lowest quarter or even the bottom half of their high school classes. More engineers were in the top 10% than in any other category, and more associate engineers, technicians, and skilled craftsmen were in the second quarter. Fairly sizeable numbers in all occupations were in the upper quarter. Assuming the information given is reasonably reliable, none of the engineering or supporting fields is well suited for poor students. While low scholastic achievement in high school is not an absolute barrier to a career in engineering, undoubtedly it is a severe handicap.

Technical Education: Teaching the skills and knowledge required by modern industry is a responsibility shared by several institutions. Employers were asked which of these should increase their responsibility, which should accept less responsibility, and which should continue as they are. Employees were asked where they had acquired most of their technical skills and knowledge. Table 15 contains the percentages of employees whose employers feel more responsibility should be assumed by any of seven institutions, and the percentages of employees who received most of their technical education in any of six institutions. Figure 15 shows industry's position on the need for strengthening the present role of the schools, of labor unions, and of industry itself in preparing men for industrial employment. The strongest opinions expressed advocated more help to prepare skilled craftsmen, this to come both from high schools and vocational-technical schools, and from on-the-job training by industry. The need for increasing junior college responsibility in preparing associate engineers and technicians was strongly recommended. Universities should increase efforts in associate engineering, engineering, and graduate engineering. A substantial number of employers feel that industry's own responsibility should be increased in all areas of technical education. They also believe labor unions should increase their responsibility in training skilled craftsmen.

Surprisingly, more than half of the associate engineers and technicians employed today and three-fourths of the skilled craftsmen say they learned most of their technical knowledge and skills on the job. More than a third of the engineers say the same thing. Slightly more than half of the engineers learned most of what they know in college, and roughly a third of the associate engineers acquired their technical knowledge there. Technicians are about evenly divided between vocational-technical schools, military service, and college. In other words, the major source of technical knowledge for those employed today in all occupations

TABLE 14
EMPLOYEES' HIGH SCHOOL MAJOR AND ACADEMIC RANK
(RESPONSES IN PERCENTAGES)

GEN ED	General Education
COLL PREP	College Preparatory
VOC TECH	Vocational or Technical
IND ARTS	Industrial Arts
AGRI	Agriculture
BUS	Business

LOW 1/4	Lowest Quarter
UP 3/4	Third Quarter
UP 1/2	Second Quarter
UP 1/4	First Quarter
UP 1/10	Upper Ten Percent

ENGINEERS	TOTAL EMPLOYEES	GEN ED	COLL PREP	VOC TECH	IND ARTS	AGRI	BUS	LOW 1/4	UP 3/4	UP 1/2	UP 1/4	UP 1/10
AEROSPACE	16	6	87	6	0	0	0	0	12	6	31	50
CHEMICAL	89	23	61	6	1	0	2	3	10	13	26	42
CIVIL	445	28	62	4	0	1	0	4	8	26	31	27
ELECTRICAL	185	26	63	5	1	0	0	3	7	27	22	38
ELECTRONIC	465	27	64	4	1	0	0	3	5	20	28	41
GEOLOGICAL	35	22	68	0	2	0	2	2	0	31	28	37
INDUSTRIAL	73	30	53	8	1	1	1	1	9	34	28	26
MECHANICAL	334	21	60	8	1	1	0	4	8	24	27	33
METALLURGIC	54	18	68	11	0	0	1	3	1	20	24	48
MINING	62	30	62	0	1	1	1	4	4	22	30	33
NUCLEAR	6	0	83	0	0	0	0	0	0	0	50	50
ASSC. ENGINEERS												
CHEMICAL	9	44	44	0	0	0	0	0	11	33	33	22
CIVIL	168	41	42	4	6	0	1	8	13	40	24	11
ELECTRICAL	91	25	51	13	1	1	5	4	13	32	23	25
MECHANICAL	29	31	41	10	6	6	3	0	13	34	37	6
MINING	6	0	100	0	0	0	0	0	0	33	50	16
CONSTRUCTION	89	41	30	10	3	1	5	4	19	33	21	15
TECHNICIANS												
AERONAUTICAL	58	34	29	17	1	3	5	1	24	44	17	5
CHEMICAL	65	30	56	4	3	0	1	1	10	26	23	35
CIVIL	436	46	37	4	3	1	2	8	16	39	18	14
DATA PROCESS	142	38	45	7	0	2	4	2	10	41	23	20
DRAFTING	171	32	37	16	7	0	1	2	16	42	23	10
ELECTRICAL	68	32	26	17	5	2	5	11	13	33	25	8
ELECTRONICS	425	41	36	13	1	1	3	7	14	38	22	15
GEOLOGICAL	14	21	64	7	0	7	0	7	7	50	28	7
INDUSTRIAL	66	43	25	13	6	3	1	4	12	43	19	13
MECHANICAL	119	42	23	15	6	6	0	5	16	36	20	13
METALLURGIC	14	28	57	14	0	0	0	0	0	42	50	7
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN												
EXP. MACHINE	22	54	9	18	4	0	0	9	27	13	27	13
INSTR MAKER	15	26	33	20	13	6	0	0	6	40	13	33
INSTRU MAN	30	53	16	10	0	13	3	10	23	40	16	3
LAYOUT MAN	17	35	11	23	0	5	11	11	11	47	17	0
MACH. SET UP	27	55	11	14	0	3	7	3	11	37	14	18
MACH. REPAIR	47	42	17	14	4	4	4	8	10	53	8	8
TOOL AND DIE	34	38	29	17	5	0	0	2	8	52	23	8

FIGURE 14
HIGH SCHOOL ACADEMIC RANK
(RESPONSES IN PERCENTAGES)

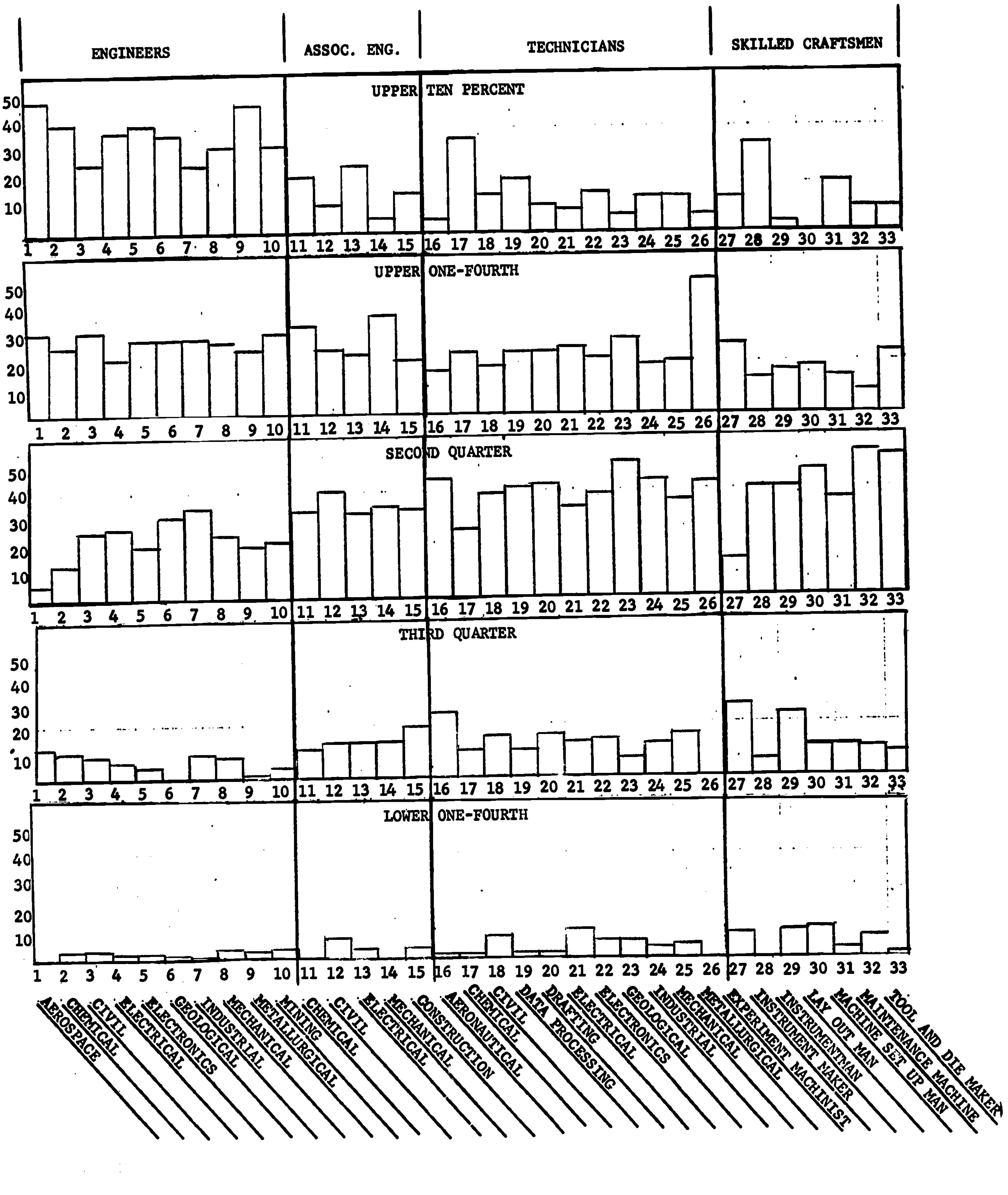


TABLE 15
TECHNICAL EDUCATION: RESPONSIBILITY AND MAJOR SOURCES
(RESPONSES IN PERCENTAGES)

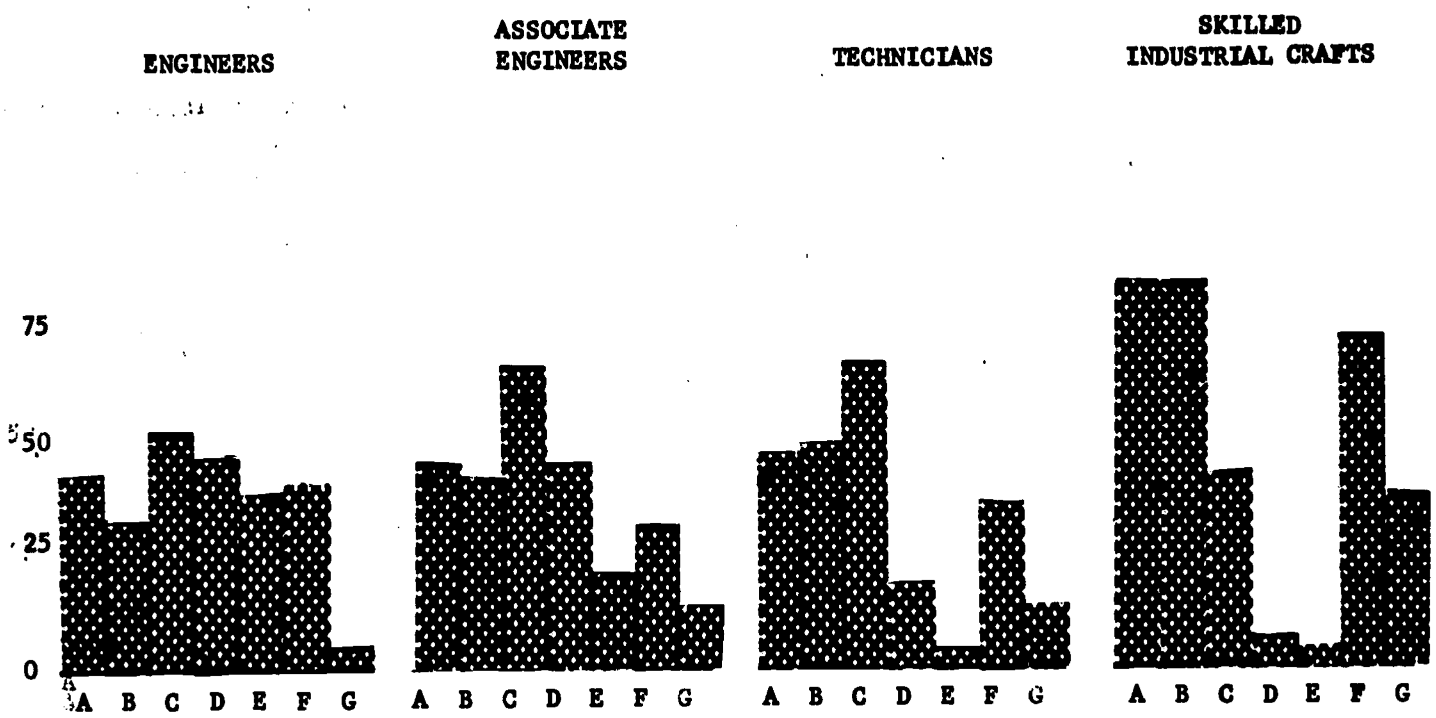
HS High Schools
VT Vocational-Technical Schools
JC Junior Colleges
UN Universities
GR Graduate Schools
OJ Industry (on-the-job)
LU Labor Unions

HS High School
VT Vocational-Technical Schools
COL College (all levels)
MIL Armed Service Schools
OJ On the Job
OTR Other Sources

ENGINEERS	TOTAL EMPLOYEES		EXTENT INDUSTRY FEELS RESPONSIBILITY FOR EDUCATION SHOULD BE INCREASED							SOURCE EMPLOYEES ACQUIRED MOST TECHNICAL SKILLS					
			HS	VT	JC	UN	GR	OJ	LU	HS	VT	COL	MIL	OJ	OTR
AEROSPACE	184	16	93	88	84	93	85	91	2	0	6	56	6	19	0
CHEMICAL	258	89	40	44	59	38	40	57	36	1	1	56	6	28	1
CIVIL	871	445	27	19	29	47	23	27	9	0	1	55	2	36	1
ELECTRICAL	919	185	78	52	54	90	82	58	1	1	0	50	1	41	4
ELECTRONIC	1304	465	33	19	65	18	12	22	0	0	2	55	3	36	2
GEOLOGICAL	64	35	47	14	38	45	41	44	5	0	0	60	0	31	3
INDUSTRIAL	330	73	60	26	52	52	38	33	12	1	1	36	0	52	7
MECHANICAL	993	334	28	45	66	65	58	62	3	0	1	47	1	44	1
METALLURGIC	86	54	26	31	44	41	42	42	5	0	0	65	0	22	2
MINING	118	62	26	13	18	31	17	46	11	2	0	55	3	37	2
NUCLEAR	3	6	0	0	0	100	100	0	0	0	0	100	0	0	0
ASSC. ENGINEERS															
CHEMICAL	21	9	29	38	67	57	10	48	0	0	0	33	11	56	0
CIVIL	411	168	11	18	85	17	10	14	6	4	4	24	0	65	1
ELE TRICAL	235	91	89	68	76	69	7	9	3	1	4	8	2	75	2
MECHANICAL	231	29	58	60	60	55	49	58	9	0	7	21	7	52	7
MINING	4	6	0	0	0	0	0	0	0	0	0	50	0	50	0
CONSTRUCTION	302	89	62	54	44	40	15	47	38	1	1	8	1	79	3
TECHNICIANS															
AERONAUTICAL	372	58	59	62	55	21	0	52	38	0	29	12	12	41	0
CHEMICAL	151	65	77	71	77	38	3	72	14	0	3	12	2	80	0
CIVIL	1255	436	17	22	75	6	2	10	4	3	1	14	2	77	0
DATA PROCESS	361	142	89	94	93	75	3	11	2	0	11	14	27	41	4
DRAFTING	513	171	61	51	63	10	1	47	22	5	9	22	2	57	1
ELECTRICAL	339	68	41	42	46	19	2	45	39	3	18	9	6	63	0
ELECTRONICS	1268	425	57	60	84	22	3	53	11	1	20	8	24	37	4
GEOLOGICAL	25	14	48	48	56	16	8	16	0	0	0	36	7	50	7
INDUSTRIAL	253	66	61	59	56	9	7	82	49	2	3	6	9	74	2
MECAHANICAL	516	119	44	57	39	14	7	28	24	3	13	11	11	55	3
METALLURGIC	41	14	49	80	63	44	29	63	5	0	0	0	0	93	0
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN															
EXP. MACHINE	439	22	85	91	48	6	5	73	43	0	5	5	0	82	5
INSTR MAKER	70	15	91	24	84	16	10	93	9	0	7	0	0	87	0
INSTRU MAN	140	30	64	70	60	9	4	56	40	0	20	3	17	50	0
LAYOUT MAN	200	17	77	84	58	14	12	61	46	0	29	6	0	59	0
MACH. SET UP	758	27	91	89	25	3	2	83	20	0	15	7	4	70	0
MACH. REPAIR	320	47	81	87	57	4	1	74	69	0	4	6	13	72	0
TOOL AND DIE	234	34	78	78	52	24	17	70	56	0	6	0	6	79	6

FIGURE 15

INCREASED EDUCATIONAL RESPONSIBILITY
RECOMMENDED BY INDUSTRY



A - HIGH SCHOOLS
B - VOCATIONAL-TECHNICAL SCHOOLS
C - JUNIOR COLLEGES
D - UNIVERSITIES
E - GRADUATE SCHOOLS
F - ON-THE-JOB TRAINING
G - LABOR UNIONS

has been the job itself, surpassed only by college for engineers, and followed by college, vocational-technical schools, and military service for technicians and skilled craftsmen.

<u>Non-Technical Education</u>: Both employers and employees were asked if they felt that non-technical or liberal arts courses contributed to a successful career. Employers were asked if certain non-technical courses should be strengthened in the degree programs. Their responses to these questions are shown in Table 16. Generally, employers expressed a little more interest in non-technical education than did employees, but substantial numbers of both agreed that non-technical education does contribute to career success. In engineering, associate engineering, and technology one-half to three-fourths of the responses took this position. Even in the skilled crafts a third or more of those employed and their employers feel the same way.

Employers of engineers were overwhelming in their opinion that communications should be strengthened in the degree programs. They were almost as much in agreement about strengthening business courses. The same concern was expressed by fewer employers of associate engineers and technicians, but here again the need to strengthen these areas was clearly evident. A similar need to strengthen social studies, humanities, and other non-technical courses was not revealed for any of the engineering or technology degree programs.

TABLE 16
IMPORTANCE OF GENERAL EDUCATION AND LIBERAL ARTS
(RESPONSES IN PERCENTAGES)

A Communications D Humanities
B Business E Other
C Social Studies

ENGINEERS	TOTAL EMPLOYEES		CONTRIBUTES TO CAREER: EMPLOYER RESPONSES		CONTRIBUTES TO CAREER: EMPLOYEE RESPONSES		COURSES WHICH SHOULD BE STRENGTHENED IN DEGREE PROGRAMS				
			YES	NO	YES	NO	A	B	C	D	E
AEROSPACE	184	16	95	1	63	38	100	85	2	2	0
CHEMICAL	258	89	37	63	57	39	32	29	6	7	2
CIVIL	871	445	67	27	66	32	88	70	23	13	7
ELECTRICAL	919	185	45	55	69	30	95	13	3	2	1
ELECTRONIC	1304	465	92	7	66	32	84	23	2	3	6
GEOLOGICAL	64	35	81	19	74	23	92	67	0	0	0
INDUSTRIAL	330	73	74	26	58	42	98	75	8	10	0
MECHANICAL	993	334	77	23	66	32	87	67	5	7	5
METALLURGIC	86	54	79	17	70	28	93	59	21	14	0
MINING	118	62	76	5	71	27	92	75	17	15	2
NUCLEAR	3	6	100	0	83	17	100	100	100	0	0
ASSC. ENGINEERS											
CHEMICAL	21	9	76	0	67	33	76	38	19	19	10
CIVIL	411	168	25	73	46	51	17	10	2	2	2
ELECTRICAL	235	91	89	10	53	46	65	64	1	1	2
MECHANICAL	231	29	52	43	55	41	84	48	3	3	1
MINING	4	6	0	0	67	33	0	0	0	0	0
CONSTRUCTION	302	89	61	38	55	36	30	33	15	10	0
TECHNICIANS											
AERONAUTICAL	372	58	61	13	28	66	17	3	2	2	0
CHEMICAL	151	65	56	24	42	55	40	9	3	0	0
CIVIL	1255	436	32	67	38	57	5	4	4	1	0
DATA PROCESS	361	142	92	8	40	58	89	90	64	0	0
DRAFTING	513	171	89	10	43	54	9	5	1	1	0
ELECTRICAL	339	68	38	62	41	54	24	15	14	7	0
ELECTRONICS	1268	425	67	28	40	58	14	6	2	1	0
GEOLOGICAL	25	14	8	88	64	36	48	8	0	0	0
INDUSTRIAL	253	66	77	16	50	48	15	0	4	0	0
MECHANICAL	516	119	69	26	40	56	9	2	1	1	0
METALLURGIC	41	14	34	66	71	29	20	15	17	17	0
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN											
EXP. MACHINE	499	22	16	72	14	77	9	1	2	1	0
INSTRU MAKER	70	15	26	13	33	53	17	4	3	3	0
INSTRU MAN	140	30	29	68	23	70	14	8	2	2	0
LAY OUT MAN	200	17	38	45	41	53	12	4	4	2	0
MACH. SET UP	758	27	60	33	37	56	1	1	0	0	0
MACH. REPAIR	320	47	36	54	21	62	18	17	17	17	0
TOOL AND DIE	234	34	32	53	15	76	7	0	2	0	0

Employer Sponsored Education: The amount of education provided by industry to engineering and related personnel is greater than may be realized. Employers in the survey were asked several questions about the training they provide on the job and the continuing education they make available to their employees in college and high school classes. Their responses are shown in Table 17.

Figure 16 shows in graphic form the extent of such employer sponsored education. The first graph represents employees who are given additional education to keep up with new technical knowledge. The second graph represents education for advancement to higher positions. The third graph represents education to make up for previous deficiencies and simply to help employees acquire a broader educational background. The fourth graph shows percentages of employees whose expenses are paid if they take additional courses in school.

A repeating pattern is evident, based on occupational variations rather than level of employment, kinds of education or the purposes for which it is provided. Technicians and skilled craftsmen are given just about the same opportunities for further education, and for the same reasons, as engineers. Policies within an industry or a company often apply equally to all. And occupations in which one kind of education is provided are likely to have other kinds of educational support also. This is illustrated by the similarity of both lines in the first three graphs.

Employee Acquired Education: Employees were asked the kinds and purpose of the additional education they have had in their present occupations. Their responses, shown in Table 18, are summarized here.

1. Those who have received on-the-job training: one-half to three-fourths of all engineers, associate engineers, technicians, and skilled craftsmen. Percentages of technicians are slightly higher than the others.

2. Those who have had courses in public or private schools arranged and paid for by their employers: Less than one-fourth. Percentages of engineers are slightly higher than the others. Three occupations report none at all (aerospace engineers, associate mining engineers, and lay-out men).

3. Those who have had courses of their own choosing in public or private schools, but paid for by their employers: Percentages vary from none to about one-third in most occupations. Experimental machinists and lay-out men report none. Aerospace engineers, associate civil engineers, and civil technicians report 5 - 6%. Occupations reporting more than one-third are electrical, electronic, and mechanical engineers.

4. Those who have had courses in public or private schools chosen and paid for without assistance from their employers: One-third of the engineers, nearly half of the associate engineers and technicians, and less than one-third of the skilled craftsmen.

The purposes in acquiring additional education do not vary significantly for different levels of employment, except that advancement to a higher position is less important to skilled craftsmen than to technicians or engineers. Five

TABLE 17
EDUCATION AND TRAINING PROVIDED BY EMPLOYERS
(RESPONSES IN PERCENTAGES)

A Given to all new employees
B Given to employees needing special training
C To help employees advance to higher positions
D Other reasons
E Could training be provided in schools?
F Employers who subsidize additional education in schools
G Employers who arrange special courses for employees in the schools

H To make up deficiencies in previous education
I To help keep up with changing skills and knowledge
J To help prepare for more advanced positions
K To increase value to company with broader education
L Other reasons

	TOTAL	ON-THE-JOB TRAINING				KINDS OF ADDITIONAL EDUCATION						REASONS FOR ADDITIONAL EDUCATION				
						E		F		G						
ENGINEERS	EMPLOYEES	A	B	C	D	YES	NO	YES	NO	YES	NO	H	I	J	K	L
AEROSPACE	184	84	88	84	0	7	8	92	4	86	10	1	92	86	89	0
CHEMICAL	258	28	70	60	0	17	14	23	74	69	28	5	75	58	76	0
CIVIL	871	56	54	52	1	6	46	68	30	39	58	38	56	67	60	6
ELECTRICAL	919	34	41	37	0	5	62	91	6	35	61	30	90	88	90	1
ELECTRONIC	1304	70	91	91	10	1	51	96	4	23	77	69	92	87	96	0
GEOLOGICAL	64	55	52	16	0	13	77	38	63	25	75	31	44	47	50	0
INDUSTRIAL	330	51	72	58	1	12	44	72	28	40	60	51	68	71	56	6
MECHANICAL	993	69	72	68	11	38	35	85	15	60	39	34	81	73	82	0
METALLURGIC	[illegible]	23	34	38	0	10	42	55	45	55	45	20	67	41	77	0
[illegible]ING	118	30	25	33	0	6	51	35	65	36	64	10	47	58	60	8
NUCLEAR	3	0	100	100	0	0	100	0	100	100	0	100	100	100	0	0
ASSC. ENGINEERS																
CHEMICAL	21	67	100	100	0	67	[illegible]	90	10	57	43	71	81	90	90	0
CIVIL	411	27	21	22	2	6	18	[illegible]	13	10	89	16	17	85	20	0
ELECTRICAL	235	72	93	83	0	7	68	89	10	82	17	80	87	83	91	0
MECHANICAL	231	51	89	84	0	55	6	87	13	84	16	86	89	90	92	0
MINING	4	0	75	75	0	0	0	75	0	[illegible]	75	75	75	75	75	0
CONSTRUCTION	302	51	36	47	4	14	49	34	65	27	71	19	24	21	43	0
TECHNICIANS																
AERONAUTICAL	372	91	68	66	0	21	42	45	55	21	79	22	23	24	53	0
CHEMICAL	151	54	60	46	1	21	46	50	50	32	68	24	52	46	60	0
CIVIL	1255	33	34	32	0	18	10	82	18	73	27	22	24	81	27	0
DATA PROCESS	361	84	94	94	12	4	5	89	11	81	19	70	83	83	72	0
DRAFTING	513	74	61	58	1	21	37	65	35	14	84	55	54	61	64	1
ELECTRICAL	339	86	48	53	0	11	50	75	21	54	42	46	58	59	78	0
ELECTRONICS	1268	82	91	73	3	3	54	75	25	15	84	56	65	71	75	2
GEOLOGICAL	25	56	92	88	0	12	16	40	60	44	56	76	84	60	80	0
INDUSTRIAL	253	80	89	48	23	28	53	80	14	34	60	31	62	60	85	0
MECHANICAL	516	66	78	70	2	45	16	64	33	48	48	57	53	63	64	0
METALLURGIC	41	39	51	73	15	10	5	29	71	41	59	27	32	32	63	2
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN																
EXP. MACHINE	439	46	75	48	1	18	14	44	55	16	83	38	37	38	8	0
INSTRU MAKER	70	74	89	23	0	11	73	76	24	11	81	70	83	83	86	61
INSTRU MAN	140	65	79	79	4	21	28	54	44	37	61	38	59	44	52	0
LAY OUT MAN	200	55	68	54	0	25	31	30	69	22	77	26	31	28	41	0
MACH. SET UP	758	73	94	71	1	54	29	65	35	66	34	63	68	63	76	0
MACH. REPAIR	320	50	72	67	17	31	17	57	35	26	67	36	55	56	55	0
TOOL AND DIE	234	26	54	30	6	26	29	30	70	4	95	14	34	21	26	3

FIGURE 16
EDUCATION PROVIDED, SPONSORED, OR SUPPORTED
BY INDUSTRY

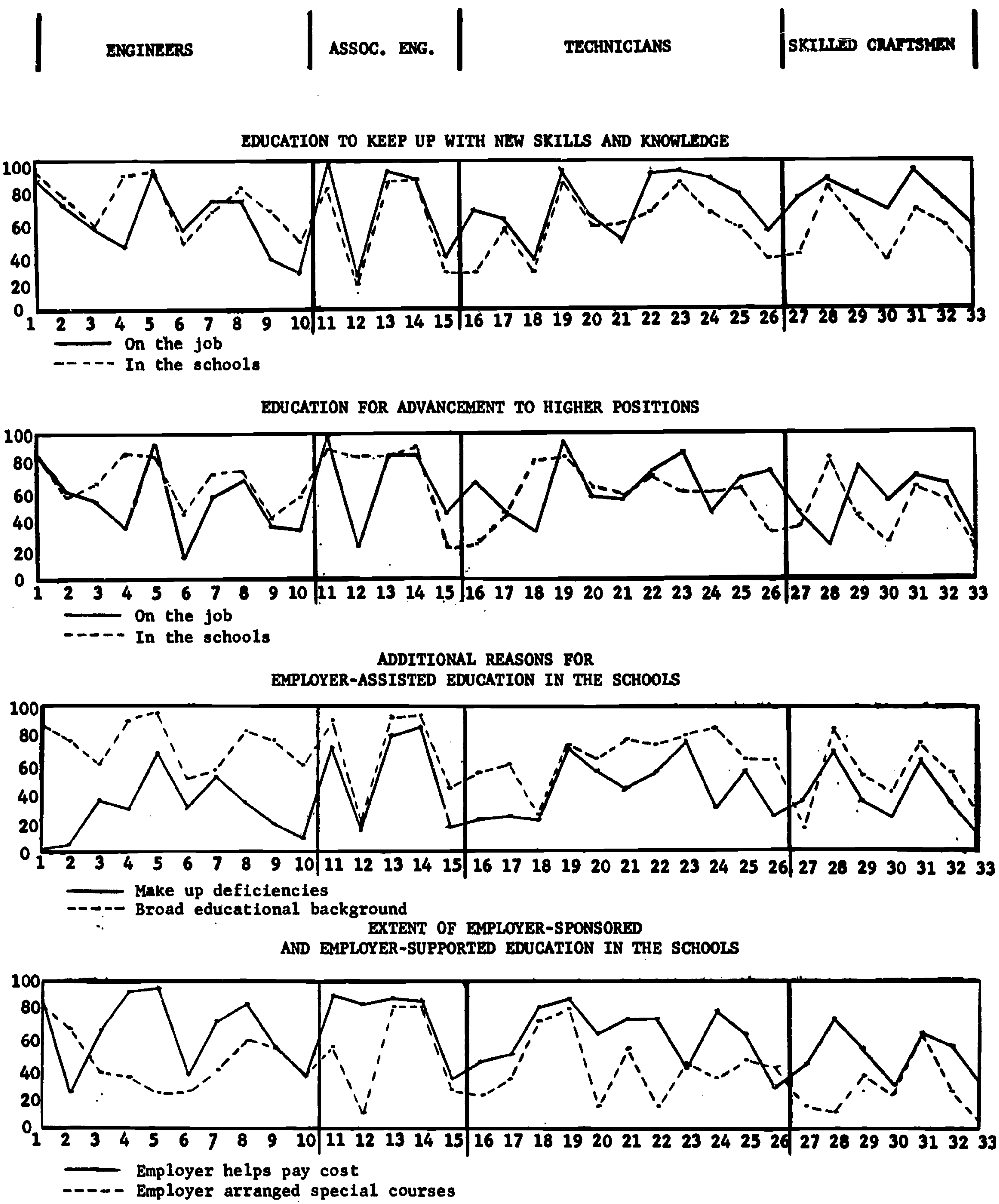


TABLE 18
ADDITIONAL EDUCATION ACQUIRED BY EMPLOYEES
(RESPONSES IN PERCENTAGES)

A On the Job
B Courses arranged by employers
C Courses supported by employers
D Employee's own responsibility

E Company orientation and policy
F Additional knowledge needed on the job
G Additional skills needed on the job
H Advancement to higher position
I Personal interest

	TOTAL	HOW ACQUIRED				PURPOSE				
ENGINEERS	EMPLOYEES	A	B	C	D	E	F	G	H	I
AEROSPACE	16	56	0	6	31	31	56	50	19	44
CHEMICAL	89	48	18	22	33	24	67	45	24	52
CIVIL	445	58	19	16	37	36	66	52	32	66
ELECTRICAL	185	56	31	36	43	34	75	54	41	72
ELECTRONIC	465	77	31	56	26	49	86	60	39	79
GEOLOGICAL	35	63	20	20	31	43	60	37	23	74
INDUSTRIAL	73	68	26	29	36	44	78	62	42	82
MECHANICAL	334	64	24	37	37	39	72	56	43	71
METALLURGIC	54	44	20	17	28	19	56	39	24	63
MINING	62	61	19	13	34	35	60	35	31	60
NUCLEAR	6	33	17	33	17	0	67	17	17	67
ASSC.ENGINEERS										
CHEMICAL	9	78	22	11	44	33	100	67	44	67
CIVIL	168	65	11	6	53	33	75	59	57	73
ELECTRICAL	91	92	27	20	44	49	85	72	48	76
MECHANICAL	29	31	17	31	41	21	55	41	41	76
MINING	6	50	0	17	67	33	67	67	67	67
CONSTRUCTION	89	49	13	11	26	33	56	45	33	54
TECHNICIANS										
AERONAUTICAL	58	91	17	10	26	40	83	69	33	59
CHEMICAL	65	60	14	12	38	17	62	51	34	68
CIVIL	436	66	14	5	40	33	74	61	60	71
DATA PROCESS	142	84	25	18	43	35	89	70	48	65
DRAFTING	171	65	11	20	49	22	72	55	49	74
ELECTRICAL	68	75	18	16	44	37	76	68	47	75
ELECTRONICS	425	79	24	28	45	27	82	67	49	77
GEOLOGICAL	14	64	14	29	21	43	93	64	36	71
INDUSTRIAL	66	76	20	33	44	38	83	62	56	79
MECHANICAL	119	73	24	19	34	26	70	61	39	74
METALLURGIC	14	64	14	29	29	21	71	64	43	64
NUCLEAR	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN										
EXP. MACHINE	22	32	5	0	36	0	41	27	18	59
INSTRU MAKER	15	53	27	20	13	13	67	40	33	60
INSTRU MAN	30	70	13	13	47	33	70	63	37	63
LAY OUT MAN	17	18	0	0	29	18	24	24	18	53
MACH. SET UP	27	52	19	19	30	33	59	44	30	67
MACH. REPAIR	47	57	13	13	19	17	60	57	30	64
TOOL AND DIE	34	53	12	15	26	24	53	59	38	71

purposes were listed in the survey, and the responses to each ranged from about one-fourth to three-fourths of all personnel. Their relative importance as reported in the survey are shown below in average percentages of response.

1.	Orientation and instruction in company policy	30%
2.	To acquire technical or professional knowledge needed on the job	68%
3.	To acquire special skills needed on the job	53%
4.	Advancement to a higher position	37%
5.	Self-improvement	66%

Career Selection: The next eight sections deal with the men and their careers in industry today who provide engineering, technical, and skilled services. Eleven pages of data (Tables 19 - 26) present a composite of some of their personal characteristics and work experience. This information should be useful to schools in developing student guidance programs and admission policies. It may be of assistance to high school and college students, not only in the selection of their careers, but also in the successful pursuit of such careers.

The choice of a career was made rather late for most of those in industry today, and the predominant influence in making it was the experience of another job. However, 85 to 90% are satisfied that they made a good choice. Figure 17 lists seven periods when the choice was made and the average percentages of engineers, associate engineers, technicians and skilled craftsmen who made the choice in each period. Very few in any occupation decided on their present

FIGURE 17

PERIOD IN WHICH EMPLOYEES SELECTED PRESENT CAREER

Average Percentages of Response

		Engineers	Assc. Engineers	Technicians	Skilled Craftsmen
1.	Before High School	5%	5%	5%	7%
2.	During High School	22%	13%	12%	17%
3.	While in Armed Services	13%	11%	15%	10%
4.	During First Two Years of College	15%	8%	5%	3%
5.	During Third and Fourth Years of College	13%	9%	4%	1%
6.	While Employed in Another Occupation	24%	45%	46%	46%
7.	Some Other time	7%	8%	11%	13%

TABLE 19
CAREER SELECTION
(RESPONSES IN PERCENTAGES)

A Before high school
B During high school
C In armed services
D First two years college
E 3rd or 4th year college
F While employed
G Other
H Family Occupation
I Friends and acquaintances
J High school influence
K Armed forces or employment
L Advertising or public relations
M Other reasons

	TOTAL	TIME OF CAREER CHOICE							REASON FOR CHOICE						SATISFIED
ENGINEERS	EMPLOYEES	A	B	C	D	E	F	G	H	I	J	K	L	M	YES
AEROSPACE	16	6	19	19	6	25	19	6	0	25	0	50	19	25	81
CHEMICAL	89	1	12	10	13	17	35	11	7	34	11	27	11	25	88
CIVIL	445	6	23	10	16	14	22	8	16	35	12	27	13	21	86
ELECTRICAL	185	7	22	19	10	10	26	6	16	25	10	38	13	22	84
ELECTRONIC	465	7	34	21	9	6	18	4	10	21	13	36	21	22	87
GEOLOGICAL	35	6	17	11	31	14	14	6	11	37	14	11	9	60	91
INDUSTRIAL	73	0	19	15	10	8	33	15	5	37	10	37	5	33	86
MECHANICAL	934	6	28	10	11	11	27	8	11	28	15	26	16	27	88
METALLURGIC	54	2	26	7	19	13	30	4	15	43	6	15	7	31	78
MINING	62	10	24	8	27	11	13	6	19	31	10	16	15	34	71
NUCLEAR	6	17	50	0	0	17	17	0	0	33	17	0	17	50	100
ASSC.ENGINEERS															
CHEMICAL	9	0	11	11	11	22	44	0	11	33	0	22	11	22	89
CIVIL	168	5	17	6	11	5	42	13	8	40	8	32	6	21	85
ELECTRICAL	91	4	8	11	10	7	52	9	11	48	5	31	9	18	86
MECHANICAL	29	7	14	14	0	10	45	10	3	28	3	45	10	24	86
MINING	6	0	0	17	0	17	67	0	17	33	0	33	0	17	67
CONSTRUCTION	89	9	16	11	10	3	43	8	27	31	3	25	6	22	93
TECHNICIANS															
AERONAUTICAL	58	9	21	28	3	3	29	7	7	26	5	53	17	14	88
CHEMICAL	65	0	15	3	5	3	57	17	5	35	9	18	8	38	83
CIVIL	436	3	11	7	11	4	53	12	10	36	6	32	8	19	82
DATA PROCESS	142	4	12	34	8	5	30	8	4	19	2	49	25	18	88
DRAFTING	171	8	22	8	12	3	35	12	9	30	18	27	12	26	81
ELECTRICAL	68	10	13	16	1	1	37	21	9	38	7	41	12	16	90
ELECTRONICS	425	9	15	33	6	3	28	6	5	24	6	53	21	20	85
GEOLOGICAL	14	0	0	7	7	21	50	14	0	14	0	21	21	57	79
INDUSTRIAL	66	5	6	17	6	2	56	9	5	33	5	45	5	21	82
MECHANICAL	119	2	10	18	4	0	56	9	10	30	3	46	12	17	87
METALLURGIC	14	0	14	0	0	0	79	7	7	57	14	21	14	7	86
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN															
EXP. MACHINE	22	14	23	0	5	0	50	9	14	41	9	32	14	14	59
INSTRU MAKER	15	7	27	0	0	0	53	13	27	40	33	20	13	0	93
INSTRU MAN	30	0	7	30	3	0	43	17	10	30	3	60	13	13	90
LAY OUT MAN	17	0	18	12	6	0	47	18	12	29	12	29	0	29	71
MACH. SET UP	27	19	11	7	4	7	37	15	30	30	0	26	7	33	85
MACH. REPAIR	47	6	15	19	4	0	40	15	13	32	11	38	6	23	85
TOOL AND DIE	34	6	26	6	3	0	53	6	21	35	12	32	6	21	85

career before they reached high school, and except for those in engineering, not a great many more made up their minds in high school. Nearly half of all associate engineers, technicians, and skilled craftsmen, and one-fourth of all engineers were already employed when they decided to enter their present fields.

Figure 18 lists six reasons for selecting the career and the average percentages of response for each choice. The decision was often made for more than one reason, and additional reasons than these could have been listed. The results, therefore, are only indications of the relative importance of these factors. High school counseling and advertising both rank low, while work experience and persons in the occupation are predominant influences.

FIGURE 18

REASONS FOR CAREER CHOICE

Average Percentages of Response

	Engineers	Assc. Engineers	Technicians	Skilled Craftsmen
1. Family Occupation	11%	12%	6%	18%
2. Influenced by Persons in the Occupation	32%	36%	31%	34%
3. Influenced by high school teachers or counselors	10%	4%	7%	7%
4. Influenced by military service or work experience	28%	31%	36%	22%
5. Influenced by media advertising	13%	8%	14%	5%
6. Other reasons	35%	24%	23%	12%

Career Success: To provide some indication of advancement possibilities and future expectations, employees were asked the number of promotions they have had in their present occupation and what they expect to be doing ten years from now. The number of promotions should be correlated with time spend in the occupation to be meaningful. This averages ten years or more in all occupations. More than half of the personnel in all occupations have had five promotions during their careers and nearly half have had more than five. Nearly half of the engineers and associate engineers expect to be working in higher supervisory or management positions ten years from now. Almost that many technicians have the same hope, and most of the others are planning to be engineers. Only in the skilled crafts were sizeable numbers who expected to be working in the same jobs. There were also appreciable numbers in the skilled crafts who wrote in that they expected to be retired ten years from now.

Career Advancement Factors: Employers and employees were both asked which of six factors are major, minor, or not a consideration in the promotion of persons in the occupation. Employers of all occupations ranked performance at the

TABLE 20
CAREER SUCCESS
(RESPONSES IN PERCENTAGES)

A Present occupation
B Supervision or management
C Higher occupation requiring more education
D Higher occupation without more education
E Different occupational field
F Another activity

*More than five

ENGINEERS	TOTAL EMPLOYEES	NUMBER OF PROMOTIONS IN PRESENT OCCUPATION							POSITION EXPECTED IN TEN YEARS					
		0	1	2	3	4	5	UP*	A	B	C	D	E	F
AEROSPACE	16	6	19	19	13	0	0	44	19	44	13	6	0	19
CHEMICAL	89	8	11	10	22	15	10	21	17	34	20	11	3	12
CIVIL	445	6	9	9	10	10	8	47	10	44	11	11	4	17
ELECTRICAL	185	4	6	9	8	4	5	62	10	42	18	12	7	9
ELECTRONIC	465	4	8	8	8	9	7	55	4	49	27	7	6	6
GEOLOGICAL	35	9	6	11	20	9	9	37	9	54	6	11	6	14
INDUSTRIAL	73	10	8	15	14	12	8	33	4	60	18	3	5	8
MECHANICAL	334	3	7	9	10	11	5	52	7	45	18	12	5	10
METALLURGIC	54	22	15	11	4	7	7	30	17	48	9	9	6	9
MINING	62	10	10	15	11	11	6	35	2	61	8	10	5	10
NUCLEAR	6	0	0	17	0	0	0	83	33	50	0	0	0	17
ASSC.ENGINEERS														
CHEMICAL	9	11	33	11	22	11	0	11	0	56	33	11	0	0
CIVIL	168	2	4	7	5	8	10	61	5	31	29	20	6	8
ELECTRICAL	91	3	12	15	11	10	5	43	14	44	19	8	3	9
MECHANICAL	29	14	3	24	3	17	0	38	10	48	14	3	17	3
MINING	6	0	0	33	33	0	0	33	0	33	17	33	17	0
CONSTRUCTION	89	8	15	10	4	4	12	42	19	51	9	7	1	10
TECHNICIANS														
AERONAUTICAL	58	7	5	10	9	17	10	36	14	43	22	7	5	2
CHEMICAL	65	5	17	15	12	17	5	28	22	29	22	12	8	6
CIVIL	436	5	8	9	14	11	11	42	6	29	31	12	8	11
DATA PROCESS	142	13	13	9	20	12	6	25	3	37	42	6	7	5
DRAFTING	171	9	9	10	14	11	6	40	6	21	49	11	6	5
ELECTRICAL	68	13	10	13	10	10	3	40	7	44	19	7	6	12
ELECTRONICS	425	9	6	8	10	12	7	48	8	28	39	8	7	10
GEOLOGICAL	14	14	29	29	7	21	0	0	0	21	50	7	7	14
INDUSTRIAL	66	5	11	11	15	9	6	44	8	36	30	9	9	6
MECHANICAL	119	10	11	12	16	12	4	34	12	18	27	14	10	16
METALLURGIC	14	7	14	7	14	29	0	29	0	71	7	7	7	0
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN														
EXP. MACHINE	22	9	14	0	5	9	5	55	23	18	5	14	14	18
INSTRU MAKER	15	0	0	0	20	0	0	73	47	33	7	0	0	13
INSTRU MAN	30	17	13	20	13	7	3	23	13	37	27	7	7	7
LAY OUT MAN	17	6	24	0	12	6	12	35	24	18	6	6	35	12
MACH. SET UP	27	22	7	7	4	26	0	33	15	33	15	15	4	15
MACH. REPAIR	47	15	13	11	19	13	4	21	13	32	23	15	2	9
TOOL AND DIE	34	15	9	6	6	26	3	32	18	35	21	6	3	12

TABLE 21
MAJOR AND MINOR FACTORS IN CAREER ADVANCEMENT
(RESPONSES IN PERCENTAGES)

A Employers consider major
B Employers consider minor

C Employees consider major
D Employees consider minor

ENGINEERS	TOTAL EMPLOYEES		EXAMINATION A	B	C	D	EDUCATION A	B	C	D	EXPERIENCE A	B	C	D
AEROSPACE	184	16	0	88	6	25	89	7	50	13	95	5	69	6
CHEMICAL	258	89	0	66	11	19	16	55	39	26	73	7	57	19
CIVIL	871	445	10	24	16	22	56	20	42	24	75	12	73	13
ELECTRICAL	919	185	0	31	3	25	32	57	28	36	91	7	56	25
ELECTRONIC	1304	465	2	44	2	20	60	38	22	39	98	1	55	20
GEOLOGICAL	64	35	3	25	0	11	42	45	26	23	77	13	63	23
INDUSTRIAL	330	73	2	32	4	19	78	14	25	37	88	6	64	16
MECHANICAL	993	334	2	71	2	20	66	23	30	28	93	5	58	17
METALLURGIC	86	54	0	27	0	22	50	15	26	35	87	7	65	11
MINING	118	62	0	26	0	34	61	32	34	37	77	23	68	10
NUCLEAR	3	6	0	0	0	17	0	100	50	17	100	0	67	17
ASSC. ENGINEERS														
CHEMICAL	21	9	10	57	11	22	81	10	33	44	81	10	56	44
CIVIL	411	168	67	8	63	13	11	72	35	35	85	5	68	15
ELE TRICAL	235	91	5	87	1	38	65	29	37	25	94	1	57	20
MECHANICAL	231	29	0	54	0	21	83	9	41	14	94	2	52	14
MINING	4	6	0	0	0	50	75	0	33	50	100	0	50	33
CONSTRUCTION	302	89	0	36	2	29	11	41	20	26	63	16	66	13
TECHNICIANS														
AERONAUTICAL	372	58	6	60	21	34	20	72	31	29	97	3	62	7
CHEMICAL	151	65	21	15	3	26	32	46	35	22	54	28	66	18
CIVIL	1255	436	56	9	58	14	14	70	35	35	81	7	68	16
DATA PROCESS	361	142	12	5	0	17	11	81	11	17	92	7	33	7
DRAFTING	513	171	34	14	16	36	53	15	35	34	79	9	65	15
ELECTRICAL	339	68	14	32	9	38	32	25	29	31	68	10	76	10
ELECTRONICS	1268	425	37	34	8	37	52	39	36	31	75	22	67	14
GEOLOGICAL	25	14	0	56	0	7	84	12	7	43	100	0	43	43
INDUSTRIAL	253	66	0	71	6	30	25	64	36	32	88	2	77	9
MECAHANICAL	516	119	0	62	5	30	45	36	43	22	85	10	69	13
METALLURGIC	41	14	0	63	0	43	20	78	36	21	83	15	71	21
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN														
EXP. MACHINE	439	22	0	55	0	32	56	25	5	36	74	8	77	5
INSTR MAKER	70	15	0	79	0	27	14	73	20	33	90	4	73	7
INSTRU MAN	140	30	23	39	13	37	39	48	33	20	81	14	60	10
LAYOUT MAN	200	17	0	43	6	18	5	54	12	18	63	17	47	35
MACH. SET UP	758	27	4	77	7	22	12	71	33	11	88	5	70	7
MACH. REPAIR	320	47	17	57	4	38	27	58	21	32	86	9	70	9
TOOL AND DIE	234	34	0	35	9	35	20	38	29	29	76	7	65	18

TABLE 21 CONTINUED
MAJOR AND MINOR FACTORS IN CAREER ADVANCEMENT
(RESPONSES IN PERCENTAGES)

A Employers consider major
B Employers consider minor

C Employees consider major
D Employees consider minor

ENGINEERS	TOTAL EMPLOYEES		SENIORITY				PERFORMANCE				PERSONALITY			
			A	B	C	D	A	B	C	D	A	B	C	D
AEROSPACE	184	16	3	92	19	31	96	0	75	0	87	8	13	50
CHEMICAL	258	89	49	34	20	37	99	0	76	8	29	49	11	43
CIVIL	871	445	16	57	18	46	99	0	82	11	32	55	21	42
ELECTRICAL	919	185	25	60	26	32	99	1	81	11	6	34	23	39
ELECTRONIC	1304	465	12	39	9	42	99	1	81	3	18	75	17	41
GEOLOGICAL	64	35	9	58	9	46	100	0	94	0	44	47	9	43
INDUSTRIAL	330	73	30	37	7	45	98	0	82	3	41	54	26	41
MECHANICAL	993	334	13	69	9	42	97	0	81	3	54	36	24	35
METALLURGIC	86	54	2	57	15	43	100	0	76	11	27	65	24	30
MINING	118	62	25	32	34	32	100	0	77	8	23	58	26	44
NUCLEAR	3	6	0	100	17	33	100	0	100	0	100	0	0	67
ASSC. ENGINEERS														
CHEMICAL	21	9	43	48	33	33	100	0	89	0	29	48	11	44
CIVIL	411	168	6	84	21	48	98	0	72	15	8	82	29	42
ELE TRICAL	235	91	3	88	10	49	100	0	67	16	68	23	37	36
MECHANICAL	231	29	6	53	7	41	99	0	59	0	5	53	31	17
MINING	4	6	75	0	67	33	100	0	50	33	0	25	17	67
CONSTRUCTION	302	89	17	47	10	42	86	11	84	3	40	26	21	34
TECHNICIANS														
AERONAUTICAL	372	58	2	60	50	24	94	0	57	9	29	65	19	31
CHEMICAL	151	65	15	40	23	34	100	0	78	6	16	66	20	37
CIVIL	1255	436	5	75	17	50	100	0	69	17	4	78	19	48
DATA PROCESS	361	142	1	74	9	20	100	0	38	5	9	74	8	21
DRAFTING	513	171	9	62	23	40	100	0	74	13	43	19	26	44
ELECTRICAL	339	68	31	37	31	40	63	35	68	6	34	19	40	26
ELECTRONICS	1268	425	11	77	19	48	99	0	77	7	61	24	24	45
GEOLOGICAL	25	14	4	48	14	29	100	0	79	7	36	20	7	50
INDUSTRIAL	253	66	12	54	20	50	94	0	88	5	38	29	41	29
MECAHANICAL	516	119	10	70	20	43	93	0	81	8	17	56	29	31
METALLURGIC	41	14	2	98	7	50	100	0	100	0	59	39	36	29
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN														
EXP. MACHINE	439	22	40	36	18	27	99	0	77	5	12	66	18	18
INSTR MAKER	70	15	61	31	33	33	100	0	80	7	1	81	20	53
INSTRU MAN	140	30	29	47	40	23	91	0	63	7	31	58	33	30
LAYOUT MAN	200	17	28	50	6	24	95	0	71	0	22	51	12	24
MACH. SET UP	758	27	23	68	15	37	99	1	78	0	7	78	19	33
MACH. REPAIR	320	47	34	59	17	43	94	5	79	4	53	33	17	43
TOOL AND DIE	234	34	34	48	21	32	100	0	71	6	22	41	26	24

very top followed by experience, personality, seniority, and examination in that order. Personality was ranked ahead of seniority for engineers and technicians, and seniority ahead of personality for associate engineers and technicians.

Occupational Satisfaction: While 85 to 90% of all personnel expressed overall satisfaction with their career choices, they also indicated likes and dislikes pertaining to specific aspects. Satisfaction with salaries was reported in a ratio of more than 2 to 1. The highest ratio of satisfaction was in the kind of work performed and the lowest in opportunities for advancement. There was considerable similarity in the ratios for all occupations except in three instances: fringe benefits, working facilities, and job security were less satisfactory to engineers and skilled craftsmen than to associate engineers and technicians. The ratios in all occupations for these six job characteristics ranged from 2 to 1 who were satisfied with opportunities for advancement to 27 to 1 who were satisfied with the nature of the work they perform.

Employee Characteristics: The data gathered on the present ages of employees and the number of years since they reached their highest educational level is shown in Table 23. The first column under "Age" lists percentages of employees below the age of 20; the second column those between 20 and 30; the third column those between 30 and 40; the fourth column those between 40 and 50; and the fifth column those above 50 years of age. The first column under "Education" lists percentages of employees who have received their highest degree, diploma, or certificate less than one year before the survey; the second column those who received them between one and two years before, etc.

The great majority of engineers and associate engineers are in their 30s and 40s. Most technicians are in their 20s and 30s. The oldest occupational group are the skilled craftsmen. More than two-thirds are over 40, and more than one-third over 50. Three-fourths of all personnel reached their highest level of education more than five years ago. Half of them reached it more than ten years ago.

Years of Technical Experience: The ages of industrial personnel are reflected in their expreience as craftsmen, technicians, or engineers. Each employee was asked the number of years experience at each level. Very few engineers have had experience as technicians or craftsmen. Generally, their years of experience as engineers correspondended with the time since reaching their highest educational level. Most of those with graduate degrees apparently received them before or soon after they began their working careers.

A substantial number of associate engineers have had experience as technicians and skilled craftsmen, indicating an employment route of promotion to present positions. Technicians report fewer years of experience than any other group, evidence of their younger age. Many also report experience as skilled craftsmen and a few as engineers. Skilled craftsmen again report the heaviest concentration at the upper levels of experience; many also cite experience as technicians and a few even as engineers.

Salary Ranges: The minimum salary range for most engineering and associate engineering positions is $500 - $700 per month. For many engineers it

TABLE 22
EMPLOYEE SATISFACTION WITH CONDITIONS OF EMPLOYMENT
(RESPONSES IN PERCENTAGES)

ENGINEERS	TOTAL EMPLOYEES	SALARY YES	SALARY NO	OPPORTUNITIES FOR ADVANCEMENT YES	OPPORTUNITIES FOR ADVANCEMENT NO	FRINGE BENEFITS YES	FRINGE BENEFITS NO	WORKING FACILITIES YES	WORKING FACILITIES NO
AEROSPACE	16	38	19	50	13	50	38	75	13
CHEMICAL	89	61	18	54	25	45	26	73	15
CIVIL	445	61	23	60	23	60	19	79	10
ELECTRICAL	185	58	27	52	26	64	15	75	16
ELECTRONIC	465	71	8	57	17	63	5	60	14
GEOLOGICAL	35	31	40	37	31	69	9	69	14
INDUSTRIAL	73	59	15	55	22	56	15	63	12
MECHANICAL	334	72	13	53	23	72	7	68	14
METALLURGIC	54	44	37	37	43	61	15	65	20
MINING	62	31	45	45	34	68	8	76	8
NUCLEAR.	6	33	67	17	17	17	83	100	0
ASSC.ENGINEERS									
CHEMICAL	9	33	33	56	11	56	22	89	11
CIVIL	168	46	36	68	18	60	24	78	8
ELECTRICAL	91	60	20	48	27	76	5	78	4
MECHANICAL	29	34	14	31	10	34	7	55	3
MINING	6	50	17	50	33	50	33	83	17
CONSTRUCTION	89	78	10	65	11	52	21	79	6
TECHNICIANS									
AERONAUTICAL	58	60	26	45	22	60	17	67	9
CHEMICAL	65	55	23	40	42	86	8	77	18
CIVIL	436	42	36	61	22	66	18	74	10
DATA PROCESS	142	35	7	32	6	30	4	35	6
DRAFTING	171	54	20	51	26	70	7	72	9
ELECTRICAL	68	68	18	51	25	84	7	85	4
ELECTRONICS	425	57	23	53	25	74	5	76	6
GEOLOGICAL	14	64	14	79	7	79	0	93	0
INDUSTRIAL	66	61	23	56	27	80	9	76	14
MECHANICAL	119	71	20	45	37	71	14	80	12
METALLURGIC	14	64	14	79	14	50	7	71	0
NUCLEAR	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN									
EXP. MACHINE	22	45	18	27	23	36	14	55	14
INSTRU MAKER	15	87	0	27	33	80	7	60	27
INSTRU MAN	30	77	17	50	33	73	13	73	10
LAY OUT MAN	17	65	18	18	59	47	12	29	29
MACH. SET UP	27	67	7	48	26	37	15	59	4
MACH. REPAIR	47	64	13	49	30	79	4	62	17
TOOL AND DIE	34	29	38	24	32	41	21	53	18

TABLE 22 CONTINUED
EMPLOYEE SATISFACTION WITH CONDITIONS OF EMPLOYMENT
(RESPONSES IN PERCENTAGES)

ENGINEERS	TOTAL EMPLOYEES	EMPLOYER RELATIONS YES	EMPLOYER RELATIONS NO	NATURE OF WORK YES	NATURE OF WORK NO	JOB SECURITY YES	JOB SECURITY NO	IMPORTANCE OF WORK YES	IMPORTANCE OF WORK NO
AEROSPACE	16	50	13	94	6	44	25	63	6
CHEMICAL	89	63	15	93	3	47	16	78	0
CIVIL	445	70	11	93	3	65	9	66	4
ELECTRICAL	185	66	17	90	4	59	12	61	8
ELECTRONIC	465	57	11	79	5	44	15	55	3
GEOLOGICAL	35	57	14	97	0	49	11	71	3
INDUSTRIAL	73	64	12	74	7	44	15	49	7
MECHANICAL	334	64	14	86	3	47	18	59	3
METALLURGIC	54	50	26	93	2	37	9	54	7
MINING	62	68	15	89	2	52	3	53	3
NUCLEAR	6	67	17	100	0	50	17	83	0
ASSC.ENGINEERS									
CHEMICAL	9	89	11	89	11	67	11	67	11
CIVIL	168	67	11	93	2	76	5	60	4
ELECTRICAL	91	64	13	88	0	74	3	55	2
MECHANICAL	29	62	0	69	0	38	7	38	3
MINING	6	33	33	83	0	50	17	17	0
CONSTRUCTION	89	76	8	92	1	56	12	49	0
TECHNICIANS									
AERONAUTICAL	58	60	14	86	2	67	7	59	0
CHEMICAL	65	77	14	92	3	80	6	58	5
CIVIL	436	64	11	89	3	85	2	56	3
DATA PROCESS	142	23	9	43	3	30	3	29	1
DRAFTING	171	64	11	78	8	63	8	56	1
ELECTRICAL	68	69	13	97	0	87	1	65	1
ELECTRONICS	425	67	10	86	3	60	11	62	3
GEOLOGICAL	14	86	0	86	0	71	0	57	7
INDUSTRIAL	66	67	17	82	3	62	14	64	2
MECHANICAL	119	58	17	96	3	71	10	62	2
METALLURGIC	14	86	0	100	0	57	0	79	0
NUCLEAR	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN									
EXP. MACHINE	22	55	14	77	14	32	23	55	5
INSTRU MAKER	15	67	7	93	0	20	20	60	0
INSTRU MAN	30	83	7	100	0	87	7	47	3
LAY OUT MAN	17	47	29	65	18	29	29	24	0
MACH. SET UP	27	52	0	81	0	44	11	52	4
MACH. REPAIR	47	66	17	91	0	68	13	53	0
TOOL AND DIE	34	56	15	79	3	41	24	62	0

TABLE 23
EMPLOYEE AGE AND YEARS SINCE GRADUATION
(RESPONSES IN PERCENTAGES)

20 Under twenty
30 Twenty to thirty
40 Thirty to forty
50 Forty to fifty
UP Over fifty

1 Less than one year
2 One to two years
5 Two to five years
10 Five to ten years
UP More than 10 years

	TOTAL EMPLOYEES	AGE					EDUCATION				
ENGINEERS		20	30	40	50	UP	1	2	5	10	UP
AEROSPACE	16	0	0	44	50	6	13	6	13	25	44
CHEMICAL	89	0	12	35	30	21	6	9	9	24	52
CIVIL	445	0	12	34	29	26	4	4	7	21	62
ELECTRICAL	185	0	16	32	38	13	4	2	18	21	56
ELECTRONIC	465	0	24	43	25	9	9	10	15	21	45
GEOLOGICAL	35	0	14	43	31	11	6	11	3	34	46
INDUSTRIAL	73	0	19	27	42	12	5	4	15	21	53
MECHANICAL	334	0	18	37	30	16	5	6	9	22	56
METALLURGIC	54	0	19	24	31	26	9	6	13	17	56
MINING	62	0	21	26	34	19	6	11	10	15	58
NUCLEAR	6	0	0	33	67	0	0	0	0	33	67
ASSC. ENGINEERS											
CHEMICAL	9	0	11	56	22	11	0	0	11	33	56
CIVIL	168	0	21	35	24	22	4	2	13	17	63
ELE TRICAL	91	0	10	38	38	16	9	3	8	12	65
MECHANICAL	29	3	31	31	21	24	10	3	10	31	34
MINING	6	0	17	33	33	17	0	17	0	0	83
CONSTRUCTION	89	0	12	24	40	24	2	2	9	9	76
TECHNICIANS											
AERONAUTICAL	58	0	29	24	33	16	5	7	16	21	47
CHEMICAL	65	0	22	29	29	22	2	5	9	25	57
CIVIL	436	1	33	30	19	19	7	3	8	22	57
DATA PROCESS	142	1	46	32	17	5	11	16	17	25	29
DRAFTING	171	1	36	34	19	13	10	6	12	20	49
ELECTRICAL	68	0	22	32	25	22	4	3	13	29	49
ELECTRONICS	425	0	29	40	19	13	9	7	16	23	44
GEOLOGICAL	14	7	29	50	7	7	0	7	29	21	43
INDUSTRIAL	66	0	27	30	21	20	11	2	12	23	53
MECAHANICAL	119	0	14	39	25	24	6	0	8	17	67
METALLURGIC	14	0	14	29	29	29	0	0	7	14	79
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN											
EXP. MACHINE	22	0	18	23	27	36	5	0	9	14	68
INSTR MAKER	15	0	13	7	47	33	0	0	7	7	87
INSTRU MAN	30	0	20	40	27	13	7	7	13	20	53
LAYOUT MAN	17	0	24	24	41	18	6	0	12	12	65
MACH. SET UP	27	0	22	4	33	52	7	4	7	15	56
MACH. REPAIR	47	2	9	26	28	40	2	2	4	11	77
TOOL AND DIE	34	0	6	26	35	32	0	0	0	15	85

TABLE 24
YEARS OF CAREER EXPERIENCE
(RESPONSES IN PERCENTAGES)

1 Less than one year
3 One to three years
5 Three to five years
10 Five to ten years
UP More than 10 years

ENGINEERS	TOTAL EMPLOYEES	CRAFTSMAN					TECHNICIANS					ENGINEER				
		1	3	5	10	UP	1	3	5	10	UP	1	3	5	10	UP
AEROSPACE	16	0	0	0	0	0	0	6	0	0	0	0	0	13	19	63
CHEMICAL	89	1	1	0	1	6	3	12	2	1	13	0	6	4	18	38
CIVIL	445	1	2	1	1	2	2	7	8	4	5	2	6	7	24	56
ELECTRICAL	185	2	2	4	1	1	3	10	6	4	2	1	6	11	20	56
ELECTRONIC	465	2	3	2	1	2	3	8	9	6	4	3	13	11	25	42
GEOLOGICAL	35	0	3	3	0	3	3	9	0	0	6	3	3	6	29	40
INDUSTRIAL	73	0	3	3	4	5	4	0	8	4	4	3	11	8	22	47
MECHANICAL	334	1	4	4	4	4	4	5	5	5	1	2	9	8	22	51
METALLURGIC	54	2	2	2	0	0	6	7	2	4	0	2	15	9	13	59
MINING	62	2	3	2	0	0	3	6	5	0	3	5	13	3	18	55
NUCLEAR	6	0	0	0	0	0	0	17	0	0	0	0	0	0	17	83
ASSC.ENGINEERS																
CHEMICAL	9	0	0	0	0	11	11	11	33	11	22	0	0	0	0	11
CIVIL	168	1	2	2	3	8	1	7	8	18	29	2	8	9	5	21
ELECTRICAL	91	1	3	4	5	11	1	13	9	13	9	5	7	10	19	34
MECHANICAL	29	0	0	3	7	21	7	3	10	14	7	0	17	7	3	21
MINING	6	0	0	0	0	17	0	17	33	0	17	33	33	0	0	17
CONSTRUCTION	89	3	2	2	2	31	1	4	3	8	10	1	1	9	0	28
TECHNICIANS																
AERONAUTICAL	58	3	3	5	9	36	2	9	12	5	14	0	5	0	0	0
CHEMICAL	65	0	2	3	2	6	3	18	5	12	35	5	2	2	5	5
CIVIL	436	1	4	2	4	7	3	8	11	24	21	2	3	2	4	10
DATA PROCESS	142	0	4	1	6	4	5	16	16	21	20	4	3	1	1	3
DRAFTING	171	1	8	8	12	20	2	12	8	12	8	2	4	4	4	9
ELECTRICAL	68	1	6	10	9	28	4	6	7	15	19	1	4	1	4	4
ELECTRONICS	425	1	4	4	2	5	2	9	10	22	43	2	4	2	3	3
GEOLOGICAL	14	0	0	0	0	7	21	43	14	0	14	0	14	7	0	0
INDUSTRIAL	66	0	6	2	5	9	3	6	18	20	12	3	12	3	2	9
MECHANICAL	119	0	4	6	8	22	3	6	8	12	26	3	2	1	3	8
METALLURGIC	14	0	0	0	0	29	7	0	14	21	14	0	0	0	7	7
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN																
EXP. MACHINE	22	0	14	9	5	55	0	0	0	0	14	0	5	0	0	0
INSTRU MAKER	15	0	0	7	7	80	0	7	7	13	0	0	0	0	0	0
INSTRU MAN	30	0	3	3	7	10	3	17	0	23	30	0	0	0	0	3
LAY OUT MAN	17	0	6	6	18	47	6	6	6	6	12	0	0	0	0	0
MACH. SET UP	27	0	0	7	11	41	0	4	7	0	0	0	11	4	4	7
MACH. REPAIR	47	0	6	2	9	57	4	6	9	11	4	0	0	2	2	0
TOOL AND DIE	34	0	0	6	6	79	0	3	0	3	3	0	6	6	0	3

TABLE 25
SALARY RANGES
(RESPONSES IN PERCENTAGES)

A Minimum
B Maximum
5 Less than $500 monthly
7 $500 to $700 monthly
9 $700 to $900 monthly
12 $900 to $1200 monthly
UP More than $1200 monthly

	TOTAL EMPLOYEES		EMPLOYER 5 A	5 B	7 A	7 B	9 A	9 B	12 A	12 B	UP A	UP B	EMPLOYEE 5	7	9	12	UP
ENGINEERS																	
AEROSPACE	184	16	1	0	7	0	3	1	3	7	82	83	0	0	31	38	31
CHEMICAL	253	89	15	0	50	0	25	36	2	37	2	20	4	18	27	31	17
CIVIL	871	445	3	0	62	2	29	9	5	27	1	61	1	9	29	44	15
ELECTRICAL	919	185	0	0	85	0	9	0	5	34	0	61	0	4	25	46	25
ELECTRONIC	1299	465	1	0	35	12	46	1	1	2	0	69	1	2	20	47	29
GEOLOGICAL	64	35	9	0	56	5	30	14	3	41	0	39	0	14	54	17	14
INDUSTRIAL	330	73	2	0	52	2	36	4	1	32	0	54	1	7	38	44	10
MECHANICAL	1008	334	2	0	31	1	47	2	3	14	2	69	0	1	22	53	22
METALLURGIC	86	54	0	0	44	8	37	8	8	42	1	33	0	13	30	31	26
MINING	118	62	6	0	72	5	15	36	4	36	3	22	2	21	37	27	13
NUCLEAR	3	6	0	0	0	0	0	0	0	0	100	100	0	0	0	33	67
ASSC. ENGINEERS																	
CHEMICAL	21	9	10	0	71	10	19	52	0	10	0	29	11	67	22	0	0
CIVIL	411	168	5	0	90	4	5	90	0	6	0	0	1	52	44	2	1
ELE TRICAL	235	91	3	0	88	0	3	67	0	26	0	0	1	20	66	12	0
MECHANICAL	231	29	36	1	58	2	4	56	1	40	0	0	10	28	45	14	0
MINING	4	6	0	0	100	0	0	75	0	25	0	0	0	83	17	0	0
CONSTRUCTION	302	89	8	0	47	5	22	25	21	40	2	30	3	19	31	29	15
TECHNICIANS																	
AERONAUTICAL	372	58	22	5	40	28	6	32	0	2	0	1	5	43	38	9	0
CHEMICAL	151	65	34	6	42	28	2	35	3	11	2	2	17	42	37	2	2
CIVIL	1255	436	82	1	15	67	2	20	0	10	0	0	22	69	6	2	0
DATA PROCESS	361	142	24	0	74	70	0	10	0	19	0	0	4	71	13	11	1
DRAFTING	513	171	52	1	46	16	1	65	0	16	0	1	22	51	22	4	0
ELECTRICAL	339	68	21	1	33	29	25	64	0	7	0	0	9	46	40	1	3
ELECTRONICS	1271	425	62	0	30	28	3	51	0	10	0	7	11	50	28	8	2
GEOLOGICAL	25	14	60	0	40	12	0	48	0	40	0	0	21	64	14	0	0
INDUSTRIAL	243	66	33	9	37	40	2	19	0	4	0	0	6	62	26	5	2
MECAHANICAL	514	119	55	3	40	51	1	34	0	7	0	0	10	49	34	5	2
METALLURGIC	41	14	63	27	29	37	2	29	0	2	0	0	7	43	29	14	7
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN																	
EXP. MACHINE	439	22	20	3	57	55	3	17	13	15	0	3	27	55	18	0	0
INSTR MAKER	70	15	70	0	17	14	10	77	3	9	0	0	0	13	87	0	0
INSTRU MAN	140	30	23	4	70	42	2	29	1	14	0	8	10	63	27	0	0
LAYOUT MAN	199	17	38	4	52	41	4	20	5	33	0	2	18	41	29	12	0
MACH. SET UP	758	27	65	2	33	80	1	14	1	3	0	0	19	52	15	4	4
MACH. REPAIR	320	47	18	2	62	67	1	9	10	13	0	1	9	77	13	2	0
TOOL AND DIE	234	34	18	2	64	40	7	44	3	6	0	0	12	65	21	3	0

is higher, $700 - $900 monthly, and for a few it is above $900. It is above $700 for a few associate engineers, although for some it drops below $500. The maximum salary range for most engineers is above $1,200 per month, and $900 - $1,200 for nearly all others. For most associate engineers the maximum is $700 to $900, and for most of the remainder $900 - $1,200. Actual salaries received by engineers are found about evenly divided between the $700 - $900 and the $900 - $1,200 brackets, but with substantial numbers above $1,200. Associate engineers' salaries are primarily in the $500 -$700 and $700 - $900 brackets, with a few above $900.

The minimum salary ranges for both technicians and skilled craftsmen are below $500 and $500 - $700 per month. The maximum salaries are $500 - $700 and $700 - $900, with some going above $900. Actual salaries in these occupations are largely in the middle range, $500 - $700, with substantial numbers in the $700 - $900 bracket and quite a few at the other end of the scale below $500. In general, there is a drop of $200 or $300 per month between engineering and associate engineering and another $200 drop to the technical and skilled occupations. Skilled craftsmen are slightly higher than technicians. They are also ten to fifteen years older with that much more experience in their jobs.

The salary levels of all personnel have been compared with their educational levels in Table 26. Of those engineers earning less than $700 per month, 31% do not have baccalaureate degrees, whereas 34% of those earning more than $1,200 have graduate degrees. Associate engineers' salaries apparently are not based on education. The same is true of technicians in the lower income brackets, but 39% of those earning $900 - $1,200 have college degrees (30% are baccalaureate or higher), and 40% of those earning more than $1,200 have college degrees (all baccalaureate or higher). Among skilled craftsmen, 32% of those earning less than $500 have less than a high school education. Education beyond the level of an armed services of vocational-technical school has no appreciable effect on the earning power of the skilled craftsmen. Figure 19 shows the relative effect of education on salaries for all employees in the survey. The figures in each column are the percentages of personnel according to

FIGURE 19

EFFECT OF EDUCATION ON SALARIES OF ENGINEERING RELATED PERSONNEL

		Percentages of Personnel										
Monthly Salary	Total Personnel	SUB HS	HS	Arm Serv	VT	Coll ND	BS AA	BS Eng	BS BA	MS MA	DR
Under $500	272	6	21	13	10	34	5	2	5	2	0
$501 - $700	1267	2	22	13	10	32	7	6	7	1	0
$701 - $900	1023	0	11	8	7	26	4	30	8	5	0
$900 - $1,200	916	1	3	4	2	12	3	53	7	12	3
Above $1,200	419	0	1	1	1	9	0	48	5	20	13

TABLE 26
SALARY RANGES ACCORDING TO LEVELS OF EDUCATION
(RESPONSES IN PERCENTAGES)

SUB HS	Less than high school	AA	Associate degree (any kind)
HS	High school	BS	Baccalaureate in engineering
ARM SERV	Armed services school	BA	Non-engineering baccalaureate
VT	Vocational-Technical school	MS	Master's degree
COLL	Some college but no degree	DR	Doctorate

ENGINEERS	TOTAL EMPLOYEES	SUB HS	HS	ARM SERV	VT	COLL	AA	BS	BA	MS	DR
UNDER $ 500	15	0	7	7	20	7	0	27	13	13	7
501 - 700	112	0	4	3	5	15	4	45	18	4	0
701 - 900	456	0	3	2	1	11	3	57	13	10	1
901 - 1200	787	0	2	2	1	10	2	59	6	14	3
ABOVE 1200	384	0	1	1	0	8	1	50	6	21	13
ASSOCIATE ENGINEERS											
UNDER $ 500	9	0	11	0	0	78	11	0	0	0	0
501 - 700	142	1	32	8	4	30	5	12	6	1	0
701 - 900	178	1	19	6	8	41	4	15	5	1	0
901 - 1200	44	9	11	16	5	27	7	9	14	0	0
ABOVE 1200	14	0	7	0	7	21	0	57	0	0	0
TECHNICIANS											
UNDER $ 500	223	4	22	14	11	36	5	1	5	1	0
501 - 700	901	1	23	12	11	36	8	1	7	0	0
701 - 900	342	1	14	15	13	37	7	4	5	1	0
901 - 1200	80	0	9	14	10	27	9	13	9	4	4
ABOVE 1200	20	5	15	5	5	30	0	5	0	0	35
SKILLED CRAFTSMEN											
UNDER $ 500	25	32	24	16	4	16	4	0	4	0	0
501 - 700	112	8	24	30	16	18	1	0	1	0	0
701 - 900	47	2	32	28	17	17	0	2	0	2	0
901 - 1200	5	0	0	80	0	0	0	20	0	0	0
ABOVE 1200	1	0	0	0	0	0	0	0	0	100	0
ALL ENGINEERING RELATED PERSONNEL											
UNDER $ 500	272	6	21	13	10	34	5	2	5	2	0
501 - 700	1267	2	22	13	10	32	7	6	7	1	0
701 - 900	1023	0	11	8	7	26	4	30	8	5	0
901 - 1200	916	1	3	4	2	12	3	53	7	12	3
ABOVE 1200	419	0	1	1	0	9	0	48	5	20	13

their highest levels of education. The blocked-in area represents salary brackets in which 20% or more are concentrated.

Sources of Personnel: It is of considerable importance both to industry and to schools to know where the present work force was obtained and where employers would prefer to get personnel for each occupation. Employers were asked their first three choices in order of preference from a list of five sources. The first choice in all occupations was promotion from lower level positions in their own organizations. Second and third choices were from the schools and from other employers, with a slight preference toward schools in the case of engineers and toward other employers for other occupations. The fourth and fifth sources, which ranked considerably lower in employer preference, were the armed services and the unemployed.

Employees were asked to indicate their last full-time job before going to work for present employers. The average percentages of responses are shown in Figure 20. Pirating from other employers and changing employers is widespread in all occupations and represents by far the most important single source of recruitment for engineering and related employment in Arizona. The second major

FIGURE 20

LAST PREVIOUS FULL TIME EMPLOYMENT OF INDUSTRIAL PERSONNEL IN ARIZONA

AVERAGE PERCENTAGES OF RESPONSE

	Engineers	Assc. Engineers	Technicians	Skilled Craftsmen
1. Attending School	20%	17%	10%	6%
2. In the Armed Services	8%	13%	15%	8%
3. Similar Job in Another State	31%	12%	19%	28%
4. Similar Job with Another Employer in Arizona	13%	26%	17%	32%
5. Lower level job with Another Employer	14%	20%	25%	1%
6. Higher Level Job	7%	4%	5%	1%

source is out of state, particularly for engineers and skilled craftsmen. The armed services contributed appreciable numbers of associate engineers and technicians. Schools are a major or significant source of engineers, associate engineers, and technicians. The comparatively few associate engineers with degrees suggests again that many employees at this level are engineering school dropouts.

Changing Technical Skills: Employees were asked if the technical skills and knowledge required for their jobs had changed in the past five years. Em-

TABLE 27
SOURCES OF PERSONNEL: EMPLOYERS' PREFERENCES
(RESPONSES IN PERCENTAGES)

A Employers' first preference
B Employers' second preference
C Employers' third preference

		PROMOTION FROM WITHIN			DIRECT FROM SCHOOLS			ARMED SERVICES			FROM OTHER EMPLOYERS			UN-EMPLOYED		
ENGINEERS	TOTAL EMPLOYEES	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
AEROSPACE	184	82	0	1	3	89	2	0	4	8	14	3	82	1	1	2
CHEMICAL	258	63	2	19	4	84	9	0	3	0	25	8	22	0	0	38
CIVIL	871	66	7	8	11	34	27	0	7	8	21	47	24	0	3	23
ELECTRICAL	919	61	1	31	26	12	54	0	1	0	9	79	3	0	1	3
ELECTRONIC	1304	31	5	58	21	66	10	0	6	11	48	23	13	0	1	5
GEOLOGICAL	64	50	2	6	36	42	13	0	9	9	14	47	33	0	0	23
INDUSTRIAL	330	46	30	19	22	14	55	0	2	4	30	49	11	1	0	5
MECHANICAL	993	54	18	12	14	50	28	0	7	2	31	21	36	0	2	11
METALLURGIC	86	56	1	26	19	31	49	0	21	0	24	45	15	0	0	6
MINING	118	47	3	22	22	35	33	0	19	5	31	44	16	0	0	13
NUCLEAR	3	100	0	0	0	0	0	0	0	100	0	100	0	0	0	0
ASSC. ENGINEERS																
CHEMICAL	21	90	0	10	0	76	24	0	0	0	10	24	57	0	0	10
CIVIL	411	88	2	3	3	14	8	0	5	3	7	77	11	0	1	72
ELECTRICAL	235	92	0	0	4	66	4	0	23	59	2	9	26	0	0	4
MECHANICAL	231	90	2	2	1	49	44	0	3	3	8	42	46	1	3	3
MINING	4	0	0	75	75	0	0	0	0	0	0	75	0	0	0	0
CONSTRUCTION	302	68	8	13	4	23	20	0	6	9	23	47	11	4	16	30
TECHNICIANS																
AERONAUTICAL	372	26	34	1	1	46	13	33	0	4	28	12	15	5	1	2
CHEMICAL	151	56	11	0	30	26	34	0	10	6	11	48	29	1	2	25
CIVIL	1255	83	5	2	3	13	15	2	3	4	4	70	11	0	1	65
DATA PROCESS	361	82	13	4	13	71	14	1	0	66	4	15	14	0	0	1
DRAFTING	513	44	7	31	4	42	14	0	0	4	42	28	9	0	7	19
ELECTRICAL	339	71	5	0	8	25	12	4	12	22	17	23	22	1	22	12
ELECTRONICS	1268	62	8	4	2	22	29	17	38	14	16	27	6	1	1	41
GEOLOGICAL	25	100	0	0	0	68	28	0	0	4	0	32	68	0	0	0
INDUSTRIAL	253	70	0	0	20	7	26	0	8	49	0	74	4	0	0	11
MECHANICAL	516	70	8	4	1	45	12	2	9	22	21	26	34	2	4	19
METALLURGIC	41	78	2	0	0	17	34	0	0	0	22	32	46	0	49	2
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN																
EXP. MACHINE	439	29	7	36	0	51	20	1	7	3	63	26	9	6	7	26
INSTRU MAKER	70	83	4	6	0	1	71	0	10	3	14	71	1	0	3	9
INSTRU MAN	140	54	14	6	6	28	29	0	10	31	36	34	13	0	4	11
LAY OUT MAN	200	57	8	2	0	17	33	0	7	18	28	34	23	8	27	13
MACH. SET UP	758	75	8	2	0	11	23	2	48	3	17	27	54	6	4	14
MACH. REPAIR	320	74	7	6	1	17	15	0	8	41	20	55	10	2	10	22
TOOL AND DIE	234	44	8	12	0	21	26	0	6	2	46	39	5	3	17	28

TABLE 27 CONTINUED
SOURCES OF PERSONNEL: EMPLOYEES' LAST FULL TIME JOB
(RESPONSES IN PERCENTAGES)

A Attending school
B Armed services
C Similar job in another state
D Similar job in Arizona
E Lower level job (promoted)
F Higher level job (demoted)

ENGINEERS	TOTAL EMPLE	A	B	C	D	E	F
AEROSPACE	16	13	13	50	13	6	0
CHEMICAL	89	10	11	28	16	17	9
CIVIL	445	22	7	24	18	17	5
ELECTRICAL	185	28	10	19	18	14	6
ELECTRONIC	465	28	6	36	8	16	3
GEOLOGICAL	35	29	3	26	9	6	11
INDUSTRIAL	73	10	5	33	18	15	10
MECHANICAL	334	20	7	31	14	16	5
METALLURGIC	54	20	6	41	9	11	6
MINING	62	24	13	21	5	21	10
NUCLEAR	6	0	0	67	0	17	0
ASSC.ENGINEERS							
CHEMICAL	9	22	11	11	44	0	0
CIVIL	168	17	10	14	20	27	8
ELECTRICAL	91	14	21	13	12	26	7
MECHANICAL	29	24	7	10	21	28	0
MINING	6	17	17	17	0	50	0
CONSTRUCTION	89	11	16	11	31	16	7
TECHNICIANS							
AERONAUTICAL	58	19	22	24	9	14	3
CHEMICAL	65	12	6	15	17	23	8
CIVIL	436	14	8	11	18	32	8
DATA PROCESS	142	18	27	13	16	13	4
DRAFTING	171	15	5	17	20	24	10
ELECTRICAL	68	9	15	24	21	19	7
ELECTRONICS	425	9	22	23	16	19	5
GEOLOGICAL	14	7	14	14	14	43	7
INDUSTRIAL	66	8	18	23	11	24	5
MECHANICAL	119	5	19	19	18	22	2
METALLURGIC	14	0	7	29	29	36	0
NUCLEAR	0	0	0	0	0	0	0
SKILLED CRAFTSMEN							
EXP. MACHINE	22	0	0	23	36	23	14
INSTRU MAKER	15	0	7	40	33	13	7
INSTRU MAN	30	13	20	10	37	13	3
LAY OUT MAN	17	18	6	35	18	6	12
MACH. SET UP	27	4	11	26	30	4	19
MACH. REPAIR	47	4	13	21	30	15	4
TOOL AND DIE	34	3	3	41	38	0	12

TABLE 28
CHANGING TECHNICAL SKILLS
(RESPONSES IN PERCENTAGES)

ENGINEERS	TOTAL EMPLOYEES		PAST FIVE YEARS EMPLOYER		PAST FIVE YEARS EMPLOYEE		NEXT FIVE YEARS EMPLOYER	
			YES	NO	YES	NO	YES	NO
AEROSPACE	184	16	99	1	88	13	100	0
CHEMICAL	258	89	82	17	83	16	100	0
CIVIL	856	445	75	25	69	29	88	12
ELECTRICAL	920	185	99	1	83	16	99	1
ELECTRONIC	1304	465	95	5	91	8	100	0
GEOLOGICAL	64	35	97	3	66	31	97	3
INDUSTRIAL	330	73	97	3	89	10	99	1
MECHANICAL	1007	334	89	11	78	19	95	3
METALLURGIC	86	54	88	8	78	20	97	C
MINING	118	62	80	20	71	29	94	6
NUCLEAR	3	6	100	0	100	0	100	0
ASSC. ENGINEERS								
CHEMICAL	21	9	90	10	100	0	76	0
CIVIL	411	168	91	8	63	35	93	6
ELE TRICAL	235	91	99	1	88	11	100	0
MECHANICAL	230	29	92	8	72	28	94	6
MINING	4	6	75	25	33	67	75	25
CONSTRUCTION	300	89	90	9	75	21	91	8
TECHNICIANS								
AERONAUTICAL	372	58	56	44	84	12	67	33
CHEMICAL	152	65	87	9	69	28	87	9
CIVIL	1253	436	80	19	62	34	82	18
DATA PROCESS	361	142	100	0	91	8	100	0
DRAFTING	526	171	76	23	67	28	80	20
ELECTRICAL	339	68	83	12	84	16	84	11
ELECTRONICS	1272	425	97	3	91	8	98	2
GEOLOGICAL	25	14	100	0	64	36	100	0
INDUSTRIAL	253	66	62	9	85	15	59	9
MECAHANICAL	516	119	85	10	73	24	88	6
METALLURGIC	41	14	100	0	79	21	100	0
NUCLEAR	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN								
EXP. MACHINE	439	22	86	14	55	41	95	5
INSTR MAKER	70	15	93	7	80	20	97	3
INSTRU MAN	140	30	90	9	77	20	91	8
LAYOUT MAN	200	17	54	46	35	65	55	42
MACH. SET UP	758	27	90	10	74	26	92	8
MACH. REPAIR	320	47	80	19	74	21	82	17
TOOL AND DIE	234	34	78	22	71	26	79	21

TABLE 28 CONTINUED
CHANGING TECHNICAL SKILLS
SUBJECTS IN WHICH EMPLOYERS SAY MORE PREPARATION WILL BE NEEDED
(RESPONSES IN PERCENTAGES)

ALG	Algebra	PHYS	Physics	HYDR	Hydraulics-Pneumatics
GEOM	Geometry	CHEM	Chemistry	MFG	Manufacturing Processes
TRIG	Trigonometry	GEOL	Geology	MACT	Machine Tools
CALC	Calculus	AMET	Applied Metallurgy	MACH	Machinability
DIFE	Differential Equations	NONM	Non-Metallic Materials		

ENGINEERS	ALG	GEOM	TRIG	CALC	DIFE	PHYS	CHEM	GEOL	AMET	NONM	HYDR	MFG	MACT	MACH
AEROSPACE	1	7	1	1	88	95	87	0	13	94	86	8	4	7
CHEMICAL	7	6	5	7	10	70	78	4	53	64	46	55	5	5
CIVIL	29	34	37	31	31	34	27	32	8	17	28	11	5	5
ELECTRICAL	28	27	28	30	35	39	10	0	4	9	26	2	0	0
ELECTRONIC	56	14	15	47	47	81	62	2	60	71	59	37	22	11
GEOLOGICAL	13	13	13	16	23	66	58	70	41	38	27	20	2	2
INDUSTRIAL	38	36	18	22	22	35	53	4	30	50	42	98	43	41
MECHANICAL	17	17	18	15	15	37	24	2	29	43	60	72	31	60
METALLURGIC	36	28	30	43	45	79	81	38	81	66	44	48	22	29
MINING	27	27	25	25	31	42	35	42	39	30	36	33	19	19
NUCLEAR	0	0	0	0	0	100	100	0	0	0	0	0	0	0
ASSC. ENGINEERS														
CHEMICAL	29	29	29	19	19	29	76	0	0	0	10	38	19	10
CIVIL	69	69	70	69	69	8	4	5	1	6	10	4	3	2
ELE TRICAL	10	8	10	8	5	9	6	1	7	24	0	20	6	6
MECHANICAL	9	9	8	50	49	85	80	3	80	83	85	84	7	8
MINING	25	25	25	0	0	0	0	0	0	0	0	0	0	0
CONSTRUCTION	29	29	29	17	11	16	9	11	7	25	15	28	14	9
TECHNICIANS														
AERONAUTICAL	47	47	43	8	7	48	42	6	64	67	80	7	66	63
CHEMICAL	48	20	20	1	0	63	84	0	39	24	4	23	26	9
CIVIL	66	66	74	2	0	9	4	4	3	4	4	1	3	2
DATA PROCESS	25	13	77	88	82	68	67	2	0	0	0	66	1	0
DRAFTING	20	22	29	3	2	7	2	3	6	33	7	40	18	29
ELECTRICAL	25	16	14	30	21	21	3	0	14	9	8	9	28	29
ELECTRONICS	74	42	76	22	15	80	51	1	2	11	10	20	33	3
GEOLOGICAL	76	68	52	48	40	60	84	52	0	8	16	0	8	8
INDUSTRIAL	41	41	43	20	13	55	28	2	20	38	22	81	48	31
MECAHANICAL	25	25	21	4	4	37	29	1	25	18	35	27	34	29
METALLURGIC	2	2	2	0	0	17	46	10	100	56	41	93	20	10
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN														
EXP. MACHINE	75	76	43	10	2	51	3	1	37	19	41	72	88	89
INSTR MAKER	24	31	31	17	4	19	10	6	89	86	9	84	97	90
INSTRU MAN	43	26	36	16	16	53	27	1	2	6	44	28	27	12
LAYOUT MAN	31	35	33	8	8	23	16	3	22	21	18	48	45	36
MACH. SET UP	11	16	17	1	1	14	4	0	17	26	17	37	40	39
MACH. REPAIR	27	30	22	2	0	62	28	0	36	58	72	41	76	72
TOOL AND DIE	32	32	49	4	4	18	6	4	46	41	30	63	65	69

TABLE 28 CONTINUED
CHANGING TECHNICAL SKILLS
SUBJECTS IN WHICH EMPLOYERS SAY MORE PREPARATION WILL BE NEEDED
(RESPONSES IN PERCENTAGES)

MACE Machine Economics
CALB Instrument calibration and measurements
ELEC Electricity-electronics
CIRC Integrated circuits
PROG Computer programming
CTCH Computer technology
DRFT Drafting
CGR Computgraphics
ENGL English grammar and composition
VOC Vocabulary and comprehension
ORAL Oral communications
BADM Business administration
SOCS Social studies
HUM Humanities

ENGINEERS	MACE	CALB	ELEC	CIRC	PROG	CTCH	DRFT	CGR	ENGL	VOC	ORAL	BADM	SOCS	HUM
AEROSPACE	4	15	8	2	92	87	4	5	7	14	6	5	0	0
CHEMICAL	5	46	17	46	51	53	5	10	38	36	37	31	23	19
CIVIL	8	19	20	9	49	42	24	20	42	43	43	36	19	11
ELECTRICAL	1	30	91	36	40	11	3	57	34	11	35	33	2	1
ELECTRONIC	12	24	83	98	81	80	3	19	29	28	33	30	9	3
GEOLOGICAL	2	20	42	0	56	53	3	39	78	78	77	63	5	5
INDUSTRIAL	61	25	65	54	68	51	12	18	44	51	42	64	15	11
MECHANICAL	59	28	38	30	71	70	40	23	66	29	42	61	14	6
METALLURGIC	31	58	59	33	43	42	9	10	57	47	59	66	19	15
MINING	29	29	41	15	51	50	2	24	69	69	65	57	20	9
NUCLEAR	0	0	0	0	100	100	0	0	0	0	0	0	0	0
ASSC. ENGINEERS														
CHEMICAL	19	38	10	0	38	38	0	0	48	48	48	48	19	19
CIVIL	3	4	6	2	13	13	10	6	9	10	9	8	5	2
ELECTRICAL	0	73	78	86	93	86	4	73	70	68	66	60	1	1
MECHANICAL	51	41	41	37	4	37	51	34	52	10	8	5	3	2
MINING	0	0	0	0	0	0	0	0	25	25	25	25	0	0
CONSTRUCTION	11	22	33	3	41	18	28	9	44	42	40	46	24	18
TECHNICIANS														
AERONAUTICAL	35	71	81	34	11	13	44	5	75	75	72	13	5	2
CHEMICAL	3	68	19	3	21	18	11	15	72	73	49	7	6	6
CIVIL	3	8	6	2	8	9	24	3	12	11	11	5	1	1
DATA PROCESS	2	65	86	85	98	98	65	86	30	30	28	30	3	3
DRAFTING	32	7	16	14	9	11	44	40	17	17	17	11	5	4
ELECTRICAL	8	51	84	51	17	12	22	11	41	48	51	26	22	1
ELECTRONICS	1	89	94	95	54	54	18	3	65	72	66	17	44	45
GEOLOGICAL	8	72	48	0	40	8	4	40	72	32	56	8	0	0
INDUSTRIAL	30	23	32	22	14	21	10	0	53	53	53	13	2	9
MECAHANICAL	16	52	41	21	4	5	31	4	47	43	44	15	16	10
METALLURGIC	0	41	44	0	12	10	29	0	46	46	44	7	10	10
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN														
EXP. MACHINE	76	19	41	4	3	4	23	2	46	13	14	4	2	1
INSTR MAKER	87	86	9	9	1	1	76	1	23	84	84	7	0	1
INSTRU MAN	9	70	54	45	19	18	28	4	29	16	16	4	11	19
LAYOUT MAN	31	30	12	4	13	8	39	6	29	30	30	20	18	18
MACH. SET UP	29	31	9	6	10	10	25	3	11	19	19	4	4	7
MACH. REPAIR	38	63	63	32	2	2	46	2	23	60	44	3	3	20
TOOL AND DIE	53	33	22	17	5	18	33	17	15	32	39	4	4	3

ployers were asked the same question and also if they believed the skills and knowledge required now would change in the next five years. The results provide both a measure of the extent of change and the particular occupations where change is having its greatest impact. Table 28 contains the percentages of affirmative and negative response by employers and employees. Employers were asked which subjects in the list of 28 previously cited would need to be strengthened in the schools as a result of the changes expected to take place. Their responses to this question are listed in Table 28.

Employers were more inclined to see changes taking place than were men on the job. They were nearly unanimous in most of engineering and associate engineering fields with the exception of chemical, civil and mining; and even in these fields, employers of 75% or more of the personnel reported technical changes in the past five years. Three-fourths or more of all engineers said changes had taken place. Most associate engineers reported changing skills except in mining. Employers and employees in the technical and skilled occupations indicated about as much change as in the engineering fields. Employers were in almost complete agreement that in virtually every occupation changes would take place in the next five years.

The subjects which employers of most personnel feel will need strengthening in the schools are listed in Figures 21,22, and 23. In almost every occupation there is strong agreement that more preparation will be needed in technical

FIGURE 21

SUBJECTS IN WHICH EMPLOYERS SAY MORE PREPARATION WILL BE NEEDED FOR ENGINEERS[1]

ENGINEERING EDUCATION	ENGINEERING FIELDS AND EMPLOYER AGREEMENT[2]
Differential Equations	Aerospace (88%)
Physics	Aerospace (95%), Chemical (70%), Electronics (81%), Geological (66%), Metallurgical (79%)
Chemistry	Aerospace (87%), Chemical (70%), Electronics (82%), Geological (58%), Industrial (53%), Metallurgical (81%)
Geology	Geological (70%)
Applied Metallurgy	Chemical (53%), Electronics (60%), Metallurgcl (81%)
Non-Metallic Materials	Aerospace (94%), Chemical (64%), Electronics (70%), Industrial (50%), Metallurgical (66%)
Hydraulics-Pneumatics	Aerospace (86%), Electronics (59%), Mechanical(60%)
Manufacturing Processes	Chemical (55%), Industrial (98%), Mechanical (72%)
Machinability	Mechanical (60%)
Machine Economics	Industrial (61%), Mechanical (59%)
Instrument Calibration & Measurement	Metallurgical (58%)
Electricity - Electronics	Electrical(91%), Electronics (83%), Industrial (65%) Metallurgical (59%)
Integrated Circuits	Electronics (91%), Industrial (54%)
Computer Programming	Aerospace (92%), Chemical (51%), Electronics (81%), Geological (56%), Industrial (68%), Mechanical(71%)

Figure 21, contd.

Computer Technology	Aerospace (87%), Chemical (51%), Electronics (80%), Geological (53%), Industrial (51%), Mechanical(70%) Mining (50%)
Computergraphics	Electrical (57%)
English (writing)	Geological (78%), Mechanical (66%), Metallurgical (57%), Mining (69%)
Vocabulary (reading)	Geological (78%), Industrial (51%), Mining (65%)
Oral (speaking)	Geological (77%), Metallurgical (59%), Mining (65%)
Business Courses	Geological (63%), Industrial (61%), Metallurgical (66%), Mining (57%)

[1]These are the subjects in which employers of 50% or more of present personnel say additional preparation will be needed as a result of changes expected in the occupation in the next five years.

[2]Percentages are given of present employees whose employers believe more preparation will be necessary.

subjects related to the field. A need for more preparation in mathematics and science is indicated in some occupations at each level of employment. The subjects in which more preparation will be needed for a majority of engineering fields are physics, chemistry, non-metallic materials, computer programming, computer technology, and business courses. Those for a majority of technical fields are physics, instrument calibrations and measurements, English grammar and composition (writing), and oral communications (speaking). For a majority of the skilled crafts they are machine tools and machinability.

FIGURE 22

SUBJECTS IN WHICH EMPLOYERS SAY MORE PREPARATION WILL BE NEEDED FOR TECHNICIANS[1]

TECHNICAL EDUCATION	TECHNOLOGY FIELDS AND EMPLOYER AGREEMENT[2]
Algebra	Civil (66%), Electronics (74%), Geological (76%)
Geometry	Civil (66%), Geological (68%)
Trigonometry	Civil (74%), Data Processing (77%), Electronics (76%), Geological (52%)
Differential Equations	Data Processing (82%)
Physics	Chemical (63%), Data Processing (68%), Electronics (80%), Geological (60%), Industrial (55%)
Chemistry	Chemical (84%), Data Processing (67%), Electronics (51%), Geological (84%)
Geology	Geological (52%)
Applied Metallurgy	Aeronautical (64%), Metallurgy (100%)
Non-Metallic Materials	Aeronautical (67%), Metallurgical (59%)
Hydraulics-Pneumatics	Aeronautical (80%)
Manufacturing Processes	Data Processing (66%), Industrial (81%), Metallurgical (93%)
Machine Tools	Aeronautical (66%)
Machinability	Aeronautical (63%)

Figure 22, contd.

Instrument calibration and Measurements	Aeronautical (78%), Chemical (68%), Data Processing (65%), Electrical (51%), Electronics (89%), Geological (72%), Mechanical (52%)
Electricity-Electronics	Aeronautical (81%), Data Processing (86%), Electrical (84%), Electronics (98%)
Integrated Circuits	Data Processing (85%), Electronics (94%)
Computer Programming	Data Processing (98%), Electronics (54%)
Computer Technology	Data Processing (96%), Electronics (54%)
Drafting	Data Processing (65%)
Writing	Aeronautical (75%), Chemical (72%), Electronics(65%) Geological (72%), Industrial (54%)
Reading	Aeronautical (75%), Chemical (73%), Electronics(72%) Industrial (53%)
Speaking	Aeronautical (72%), Electrical (51%), Electronics (66%), Geological (56%), Industrial (53%)

[1]These are the subjects in which employers of 50% or more of the present personnel say additional preparation will be needed as a result of change expected in the next five years.

[2]Percentages are given of present employees whose employers believe more preparation will be necessary.

FIGURE 23

FIELDS IN ASSOCIATE ENGINEERING AND SKILLED CRAFTS IN WHICH EMPLOYERS SAY MORE PREPARATION WILL BE NEEDED[1]

ASSOCIATE ENGINEERING	SUBJECTS AND EMPLOYER AGREEMENT[2]
Chemical	Chemistry (76%)
Civil	Algebra (69%), Geometry (69%), Trigonometry (70%), Calculus (69%), Differential Equations (69%)
Electrical	Instrument Calibration and Measurement (73%), Electricity-Electronics (78%), Integrated Circuits(86%) Computer Programming (93%), Computer Technology (86%), Computergraphics (73%), Writing (70%), Reading (68%), Speaking (66%), Business Courses (60%)
Mechanical	Calculus (50%), Physics (85%), Chemistry (80%), Applied Metallurgy (80%), Non-Metallic materials(83%) Hydraulics-Pneumatics (84%), Manufacturing Process (84%), Machine economics (51%), Drafting (51%), Writing (52%)

SKILLED CRAFTS	SUBJECTS AND EMPLOYER AGREEMENT[2]
Experimental Machinist	Algebra (75%), Geometry (76%), Physics (51%), Manufacturing process (72%), Machine tools (88%), Machinability (89%), Machine economics (76%)

Figure 23, contd.

Instrument Maker	Applied metallurgy (89%), Non-metallic materials (86%), Manufacturing processes (84%), Machine tools (97%), Machinability (90%), Machine economics(87%), Instrument Calibration and Measurements (86%), Drafting (76%), Reading (84%), Speaking (84%)
Instrumentman	Physics (53%), Instrument Calibration and Measurement (70%), Electricity-Electronics (54%)
Maintenance Machine Repairman	Physics (62%), Non-Metallic Materials (58%), Hydraulics-Pneumatics (72%), Machine tools (76%), Machinability (72%), Instrument Calibration and Measurements (63%), Electricity-Electronics (63%) Reading (60%)
Tool and Die Maker	Manufacturing processes (63%), Machine tools (65%) Machinability (69%), Machine economics (53%)

[1]These are the subjects in which employers of 50% of more of present personnel say additional preparation will be needed as a result of changes expected in the occupation in the next five years.

[2]Percentages are given of % employees whose employers believe more preparation will be necessary.

Suggested Educational Development in Arizona: Employers were asked for opinions on several subjects affecting the education and training of personnel. Their responses are shown in Table 29, and also in graphic form in Figure 24. They are given as percentages of employees in each occupation whose employers are in favor of the action. The numbers on the graphs correspond to the same occupations included on previous graphs in this chapter.

Cooperative school-industry programs in which students spend part of their time in school and part on the job are favored by the employers of a majority of engineers except those in electronics and mining. They are favored for associate chemical and mechanical engineers and construction engineers, but the employers of only a minority in civil and electrical engineering favor such programs. The technical fields in which employers of a majority of the personnel favor cooperative work-industry programs are aeronautical, data processing, industrial, mechanical, and metallurgical. All of the skilled crafts are in the majority except instrument makers.

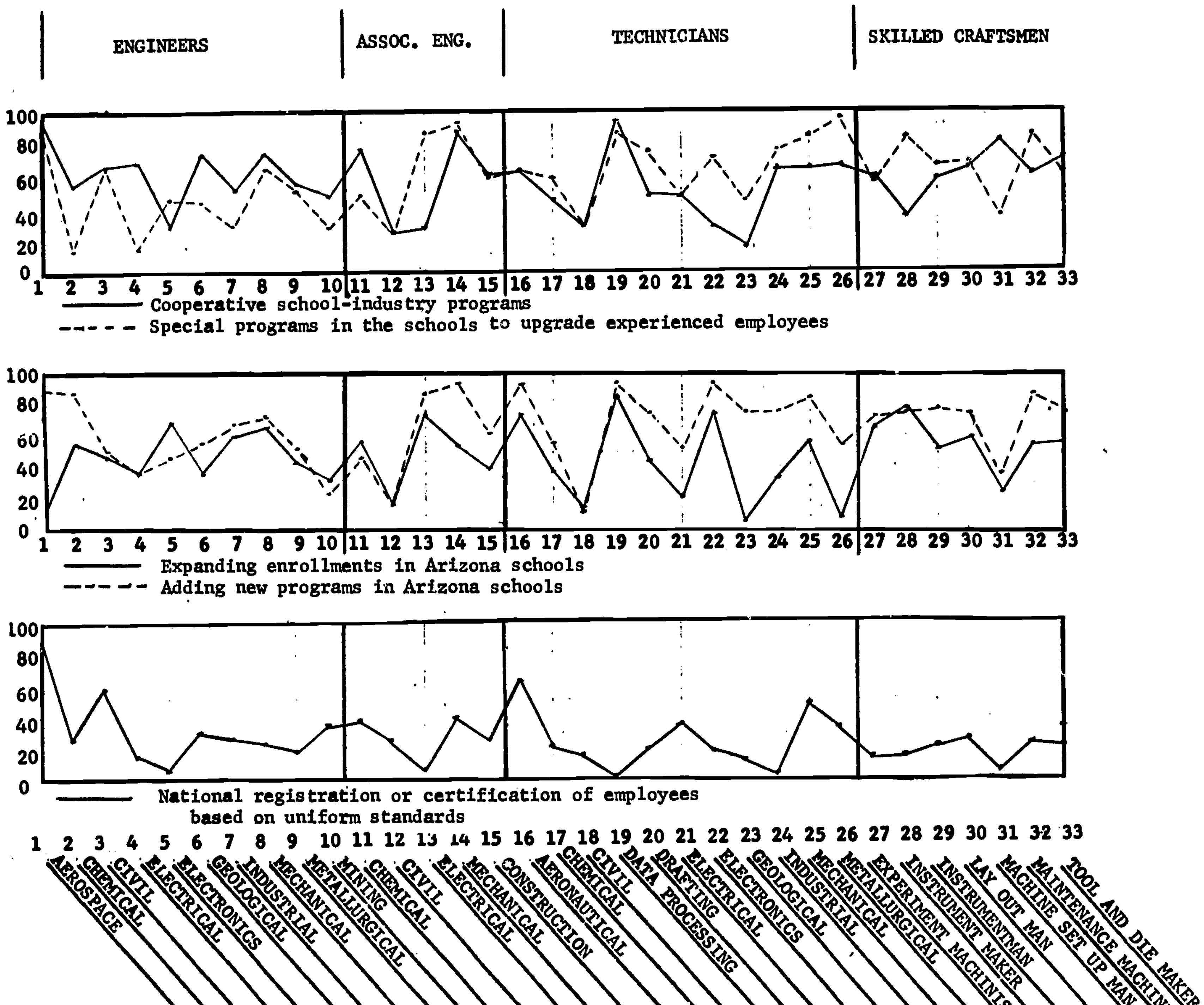
Special programs in schools to upgrade experienced employees from lower level occupations are generally not favored in engineering except for aeronautical, civil and mechanical. They are generally favored for associate engineers, technicians, and skilled craftsmen except to some extent in civil technology, electrical technology, geological technology, and machine set-up men categories. Employers in three occupations are in such agreement in favor of both programs that either they are having unusual difficulties in getting properly trained men or they recognize a particularly urgent need for closer cooperation with schools. These occupations are aeronautical engineering, associate mechanical engineering, and data processing technology. A desire for programs in schools to upgrade metallurgical technicians is also nearly unanimous

TABLE 29
SUGGESTED EDUCATTONAL DEVELOPMENT IN ARIZONA
(RESPONSES IN PERCENTAGES)

A Cooperative work-study programs
B Expand present enrollment
C Add new programs
D Establish special programs to upgrade present employees
E National registration or certification

ENGINEERS	TOTAL EMPLEE	A		B		C		D		E	
		YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
AEROSPACE	184	97	2	7	0	89	0	91	3	89	8
CHEMICAL	258	52	20	55	4	88	4	12	21	26	7
CIVIL	871	64	12	47	12	50	19	62	11	57	13
ELECTRICAL	919	68	28	37	53	38	55	13	4	15	6
ELECTRONIC	1304	28	19	58	5	47	1	45	50	5	34
GEOLOGICAL	64	72	22	36	22	56	13	42	16	30	52
INDUSTRIAL	330	50	31	60	8	68	8	29	30	27	15
MECHANICAL	993	72	16	65	13	71	4	62	27	23	52
METALLURGIC	86	53	23	42	12	51	19	50	9	19	20
MINING	118	47	16	31	19	23	16	27	17	35	31
NUCLEAR	3	0	0	100	0	100	0	100	0	0	100
ASSC.ENGINEERS											
CHEMICAL	21	76	0	57	19	48	29	48	10	38	10
CIVIL	411	24	6	18	8	19	11	25	4	26	3
ELECTRICAL	235	28	67	72	4	87	4	86	3	8	26
MECHANICAL	231	88	8	52	5	92	5	91	4	40	53
MINING	4	0	0	0	0	0	0	0	0	0	0
CONSTRUCTION	302	60	22	40	16	61	6	59	8	27	44
TECHNICIANS											
AERONAUTICAL	372	61	13	72	2	91	0	62	5	61	6
CHEMICAL	151	44	42	39	13	56	6	58	3	21	58
CIVIL	1255	29	66	16	10	23	6	28	4	17	11
DATA PROCESS	361	93	2	85	2	93	2	86	9	2	81
DRAFTING	513	48	17	45	17	73	11	73	14	20	22
ELECTRICAL	339	46	13	22	17	51	14	48	8	34	25
ELECTRONICS	1268	28	29	75	6	92	3	70	13	19	30
GEOLOGICAL	25	16	40	8	8	76	8	44	0	12	8
INDUSTRIAL	253	64	4	43	10	77	11	74	17	3	15
MECHANICAL	516	64	22	58	12	83	4	82	5	49	32
METALLURGIC	41	66	32	10	0	54	0	95	0	32	5
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN											
EXP. MACHINE	439	59	2	65	1	71	2	55	19	15	29
INSTRU MAKER	70	33	0	79	0	77	0	81	0	17	0
INSTRU MAN	140	58	9	51	12	79	4	65	5	21	17
LAY OUT MAN	200	62	23	60	8	75	8	67	8	28	38
MACH. SET UP	758	80	11	27	52	38	48	32	54	7	64
MACH. REPAIR	320	60	26	56	26	88	2	84	8	22	45
TOOL AND DIE	234	70	15	58	14	69	11	60	21	21	35

FIGURE 24
ARIZONA EMPLOYERS WHO FAVOR
CERTAIN EDUCATIONAL SUGGESTIONS



among employers.

Support for increasing enrollments in present programs and adding new programs follows a similar pattern except in fields where Arizona does not have educational programs at the present time such as geological and metallurgical technology. Employers of a substantial majority of personnel in these occupations are in favor of adding new programs. Only minor support was expressed for either expanding enrollments or adding programs in five occupations: electrical engineering, mining engineering, associate civil engineering, civil technology, and the machine set-up craft. Considerable support was expressed, especially for adding new programs, in nine occupations: aerospace and chemical engineering, associate electrical engineering, associate mechanical engineering, aeronautical technology, data processing technology, electronics technology, mechanical technology, and the maintenance machine repair craft. Employers of a majority of personnel favor expanding enrollments or adding new programs in fifteen occupations in addition to the nine with the strongest support. These include four engineering fields: electronics, geological, industrial and mechanical; associate chemical engineering; construction; six technical fields: chemical, drafting, electrical, geological, industrial, and metallurgical; and five skilled crafts: experimental machinist, instrumentman, instrument maker, lay-out man and tool and die maker.

The employers of only a minority in all but three occupations were in favor of national registration or certification based on uniform standards. The three exceptions were aerospace engineers, civil engineers, and aeronautical technicians. In five occupations support was less than 10%: electronic engineering, electrical associate engineering, data processing technology, industrial technology, and the machine set-up craft.

Educational Choice: Employees were asked to identify the schools from which they received their highest degree, diploma, or certificate, and to state the reasons for their choice. Less than one-third of the personnel in Arizona industry are represented since data are available only on those who returned questionnaires. From these data, however, the leading educational institutions are listed in Table 30, with a statistical tabulation of the reasons for their selection. Arizona schools are well represented in all occupations. Heading the list of engineering graduates are the University of Arizona with 259 and Arizona State University with 126, followed by UCLA with 43 and Purdue with 26. Twelve engineers received their highest degrees in the two-year technology programs at Northern Arizona University and Phoenix College. Eleven are Arizona high school graduates with no college degrees.

The U of A and ASU have also produced the largest number of associate engineers with 25 and 20 respectively, followed by 13 from Phoenix College and 10 from the International Correspondence School in Illinois. Five associate engineers have degrees from NAU, and 29 are Arizona high school graduates with no college degrees. Phoenix College and ASU lead in the number of technicians reporting with 85 from PC and 81 from ASU. Next are the armed services with 43, the U ofA with 25 and NAU with 15. Seventy-two technicians are Arizona high school graduates with no degrees and 6 are graduates of other Arizona junior colleges. Of the skilled craftsmen who answered the survey, 15 were Arizona high school graduates and 10 have degrees from Arizona junior colleges or universities.

TABLE 30
EDUCATIONAL CHOICE
(RESPONSES IN PERCENTAGES)

A B C D Schools are listed on following pages of table ranked by largest number of graduates in occupation
E Convenient location
F Financial reasons
G Family Influence
H Reputation of school
I Influenced in high school
J Influenced by friends
K Influenced by the school
L Would make same choice today

ENGINEERS	TOTAL EMPLOYEES	SCHOOLS A	B	C	D	REASONS FOR CHOICE E	F	G	H	I	J	K	TODAY L
AEROSPACE	16	6	0	0	0	38	44	0	50	0	6	0	44
CHEMICAL	89	6	4	3	2	39	26	4	46	7	4	7	56
CIVIL	445	18	7	4	2	56	23	9	49	6	7	3	67
ELECTRICAL	185	23	7	4	4	57	21	11	42	3	9	3	64
ELECTRONIC	465	10	7	3	3	58	26	8	37	3	5	4	57
GEOLOGICAL	35	34	9	6	3	34	20	6	54	3	6	3	63
INDUSTRIAL	73	7	3	1	0	45	22	7	41	8	11	5	45
MECHANICAL	334	17	7	4	2	55	24	9	43	7	7	4	60
METALLURGIC	54	19	7	4	2	41	30	6	56	4	4	2	54
MINING	62	29	6	3	2	58	18	10	61	11	11	8	63
NUCLEAR	6	17	0	0	0	17	33	0	83	0	0	0	50
ASSC. ENGINEERS													
CHEMICAL	9	22	11	0	0	33	22	22	33	0	22	11	44
CIVIL	168	9	7	4	3	44	16	12	24	7	10	5	45
ELECTRICAL	91	7	5	4	3	46	12	11	27	7	8	5	41
MECHANICAL	29	7	3	0	0	52	24	3	10	7	14	7	52
MINING	6	17	0	0	0	67	17	17	33	33	17	0	33
CONSTRUCTION	89	8	4	3	2	48	8	13	29	7	3	2	46
TECHNICIANS													
AERONAUTICAL	58	5	3	2	0	48	16	12	36	5	9	9	59
CHEMICAL	65	6	5	3	2	49	14	14	14	5	14	5	40
CIVIL	436	6	5	3	2	48	12	12	19	7	8	6	46
DATA PROCESS	142	6	4	4	2	45	17	8	23	6	6	4	45
DRAFTING	171	11	6	6	2	57	16	8	19	6	9	8	52
ELECTRICAL	68	6	3	1	0	43	16	12	24	6	7	6	37
ELECTRONICS	425	7	4	3	2	39	18	4	29	6	7	7	40
GEOLOGICAL	14	14	7	0	0	57	0	0	36	7	0	7	43
INDUSTRIAL	66	6	5	2	0	53	18	11	15	3	8	11	41
MECHANICAL	119	5	4	2	1	44	12	7	17	6	5	8	42
METALLURGIC	14	7	0	0	0	36	21	7	29	0	0	0	43
NUCLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0
SKILLED CRAFTSMEN													
EXP. MACHINE	22	5	0	0	0	18	5	14	18	0	9	0	32
INSTR MAKER	15	7	0	0	0	47	20	7	47	20	0	20	33
INSTRU MAN	30	10	7	3	0	43	3	10	20	3	10	7	43
LAYOUT MAN	17	18	6	0	0	18	18	0	24	6	0	6	35
MACH. SET UP	27	7	4	0	0	41	7	4	30	4	4	0	56
MACH. REPAIR	47	4	2	0	0	28	17	9	15	0	4	9	34
TOOL AND DIE	34	6	3	0	0	38	15	9	21	12	6	6	38

TABLE 30 CONTINUED
EDUCATIONAL CHOICE
SCHOOLS RANKED BY NUMBER OF GRADUATES IDENTIFIED IN SURVEY

The schools listed below for each occupation are those from which the largest number of graduates were identified from questionnaires returned.

ENGINEERS

AEROSPACE
- A. Ten schools, including ASU (1 each)

CHEMICAL
- A. UCLA (5)
- B. U of A, Purdue (4 each)
- C. Ohio State, U of Michigan, Northwestern, ASU, Texas A & M (3 each)
- D. Illinois, NAU, Cincinnati (2 each)

  Add. Ariz. Schools: PC (1); Ft. Thomas HS (1); Nogales HS (1).

CIVIL
- A. U of A (82)
- B. ASU (29)
- C. Iowa State U (16)
- D. UCLA (10)

  Add. Ariz. Schools: PC (7); PUHS (2); Tucson HS (2); Nogales HS (1); Prescott HS (1)

ELECTRICAL
- A. U of A (42)
- B. ASU (13)
- C. Purdue (8)
- D. UCLA (7)

  Add. Ariz. Schools: Tucson HS (1)

ELECTRONICS
- A. ASU (45)
- B. U of A (32)
- C. UCLA (14)
- D. Illinois (12)

GEOLOGICAL
- A. U of A (12)
- B. N.M. Inst. of Mining & Tech., Colorado School of Mines (3 each)

  Add. Ariz. of Schools: ASU (1)

INDUSTRIAL
- A. ASU (5)
- B. U of Pittsburgh, PC NAU, Mohawk Valley Community College, U of A, GE (2 each)

MECHANICAL
- A. U of A (57)
- B. ASU (22)
- C. Purdue (14)
- D. UCLA (7)

  Add. Ariz. Schools: Tucson HS (1); PC (1)

ENGINEERING (Continued)

METALLURGICAL
- A. U of A (10)
- B. U of Missouri, Colorado School of Mines (4 each)
- C. St. Paul's Bible College (2)
- D. Fifteen schools, including PC (1 each)

MINING
- A. U of A (18)
- B. Colorado School of Mines (4)
- C. U of Mo, Montana College of Mineral Science, Wisconsin State U, U of Idaho, U of Washington (2 each)
- D. Fifteen schools, including Tempe Union HS (1 each)

NUCLEAR
- A. Six schools, none in Arizona.

ASSOCIATE ENGINEERS

CHEMICAL
- A. U of A (2)
- B. Seven schools, including ASU (1 each)

CIVIL
- A. U of A (15)
- B ASU (11)
- C. International Correspondence School-Ill. (6)
- D. PC ICS-Penn, Flagstaff HS (5 each)

  Add. Ariz. Schools: NAU (4); Miami HS (3); West HS (2); PUHS (2); Tucson HS (2); Holbrook HS (2)

ELECTRICAL
- A. Asu (6)
- B. PC (5)
- C. ICS-Ill., U of A (4 each)
- D. Phoenix Union HS (3)

  Add. Ariz. Schools: Tucson HS (2); NAU (1)

MECHANICAL
- A. Phoenix Union HS, ASU (2 each)
- B. Six schools, including U of A (1 each)

MINING
- A. Six schools, including Mohave County HS (1 each)

CONSTRUCTION
- A. ASU (7)
- B. Phoneix Union HS (4)
- C. U of A, PC (3 each)
- D. Iowa State U (2)

  Add. Ariz. Schools: Glendale Union HS, Apprenticeship Council, Tucson HS (1 each)

TECHNICIANS

AERONAUTICAL

A. Spartan Institute of Tech., PC (3 each)
B. Reedley, PUHS, Pittsburg Institute of Tech., Northrup Institute of Tech. (2 each)
C. Thrity-one schools, including Washington HS, ASU, Prescott HS (1 each)

CHEMICAL

A. ICS-Penn. (4)
B. ASU (3)
C. USAF-Intelligence, ICS-Ill. (2 each)
D. Thirty-nine schools, including PUHS, St. Mary's HS, Catalina HS, Bisbee HS, U of A, EAJC (1 each)

CIVIL

A. PC (27)
B. ASU (22)
C. NAU (12)
D. U of A (10)
Add. Ariz. Schools - (18)

DATA PROCESSING

A. PC (8)
B. DeVry Technical Institute, USAF (6 each)
C. ASU, Central Technical Institute (5 each)
D. U of A, North HS, USN-Electronics, USA (3 each)
Add. Ariz. Schools: Yuma HS (2)

DRAFTING

A. PC (18)
B. ASU (11)
C. Phoenix Union HS (18)
D. North HS, ICS-ILL (3 each)
Add. Ariz. Schools: (8)

ELECTRICAL

A. PC (4)
B. ICS-Penn., USAF, U of A (2 each)
Add. Ariz. Schools: Grand Canyon College, North HS, Ricon HS, Yuma HS (1 each)

ELECTRONIC

A. ASU (28)
B. PC (16)
C. USN-Electronic (11)
D. Federal Aviation Academy (10)
Add. Ariz. Schools: U of A (6); Mesa Community College (3); NAU (2)

GEOLOGICAL

A. ASU U of A (2 each)
B. Glen's Falls HS, Calif. State Polytechnic College, Palomar College, College of Southern Utah (1 each)
Add. Ariz. Schools: Valley Union HS, Globe HS (1 each)

TECHNICIANS (Continued)

INDUSTRIAL

A. PUHS, ASU (4 each)
B. PC (3)
   Add. Ariz. Schools: (7)

MECHANICAL

A. PC (6)
B. ASU (5)
C. EAJC, USA, USN, U of A, USAF (2 each)
D. Sixty-four schools, including Winslow HS, Mohave Union HS, Prescott HS, Union HS, Tucson HS (1 each)

METALLURGICAL

A. Thirteen schools, including Miami HS, U of A, NAU (1 each)

NUCLEAR

None

SKILLED CRAFTSMEN

EXPERIMENTAL MACHINIST

A. Four schools, including Scottsdale HS, PC, PUHS (1 each)

INSTRUMENT MAKER

A. Eight schools, none in Arizona

INSTRUMENT MAN

A. Spartan School of Aeronautics (3)
B. Tucson HS, Union HS (2 each)
C. Fourteen schools, including ASU, Yuma HS, Cochise College (1 each)

LAYOUT MAN

A. PC (3)
B. Seven schools, including Sheet Metal Apprentice School, West HS (1 each)

MACHINE SET-UP MAN

A. ASU (2)
B. Thirteen schools, including North HS (1 each)

MACHINE REPAIRMAN

A. USA, PUHS, USAF (2 each)
B. Twenty-three schools, including PUHS, Casa Grande HS, North HS, Glendale Community College, Tucson HS, U of A (1 each)

TOCL & DIE MAKER

A. ICS-Ill., Tucson HS (2 each)
B. Twenty-five schools, none in Arizona.

Arizona institutions rank first in 30 of the 35 occupations reporting graduates in the survey, and rank first or second in all but two. They account for approximately 20% of the engineering, technical, and skilled industrial employees in the state. The leading out-of-state schools with engineering gradautes reported in the survey are UCLA with 43 and Purdue with 26. The only out-of-state schools contributing any number of associate engineers are the International Correspondence Schools in Illinois and Pennsylvania, with 10 from Illinois and 5 from Pennsylvania. Six technicians came from the ICS in Pennsylvania and 6 from DeVry's Technical Institute in Chicago. The largest number of technicians reporting out-of-state training are 28 graduates of armed services schools. No out-of-state educational institution was listed by more than two skilled craftsmen.

Roughly half of the engineers, associate engineers, and technicians said they attended their particular schools for two reasons: convenience of location, and the reputation of the school. A substantial number also listed financial aid or scholarships as a reason. Relatively few reported that their choice was greatly influenced by their families, friends, high school counselors or teachers, or representatives of the college. Most engineers would make the same choice again if they were doing it today, but less than half of the associate engineers, technicians, or skilled craftsmen say they would do so.

Summary

A survey of employment characteristics and educational needs was conducted in all fields of engineering, technology, and the skilled industrial crafts in Arizona during the summer of 1967. Participating were 95% of the employers of engineering and related personnel representing 98% of such employees. Completed employer interviews number 1,570, and 13,589 questionnaires were given to employees. Of these, 29%, or 3,926, were completed and returned. The data were processed and tabulated in twenty summary tables containing forty-three pages of statistics. Thirty-six basic occupational categories were studied. The importance of eighteen skilled activities was examined in each occupation, and the need for twenty-eight educational courses was assessed. Educational levels required, preferred, and actually achieved by present employees were identified separately for each occupation. Considerable data were collected regarding employee characteristics, employment practices, continuing education, career success, and changing skill requirements.

Employers of 66% of all engineers say they require a baccalaureate degree in engineering, and 55% of engineers have this degree. An additional 10% have non-engineering baccalaureate degrees. The preference by employers for a master's degree is 30% and a doctor's degree 8%, and the number of engineers holding these degrees represent 15% and 5% respectively. The minimum requirement for most associate engineers and technicians is high school or vocational-technical school and the preference is an associate degree. Most of the personnel in these occupations have high school diplomas and more than one year of college without a degree. The skilled crafts require high school or less. Employers prefer vocational training either in school or in the armed forces, and most employees have this kind of training.

Nearly half of the engineers report that they were in the upper 10% of their high school classes and nearly three-fourths were in the upper quarter. Nearly half of the technicians and skilled craftsmen identified themselves in the top quarter and between 80 and 90% in the top half of their high school classes.

Mathematics through trigonometry is considered necessary for almost all engineers and three-fourths of technicians and skilled craftsmen. Calculus and differential equations are needed by 50 to 75% of the engineers and by one-fourth of personnel in every occupation. The need for physics and chemistry ranges from nearly all engineers and half to three-fourths of technicians to between one-fourth and one-half of skilled craftsmen. Physics is used more than chemistry. Various engineering sciences and technical courses are required by substantial majorities in some occupations and used very little in others. A strong need was expressed in all occupations -- strongest in engineering but by more than three-fourths of the technicians and half of the skilled craftsmen -- for every form of communications: graphic, written, oral and reading. Business courses were reported necessary by two-thirds of the engineers, one-third of the technicians, and 20% of the skilled craftsmen.

The skilled activities performed by engineers, technicians, and craftsmen differ a great deal according to the field or area of specialization, but considerable overlapping occurs. There are no activities significantly important to technicians and skilled craftsmen that are not equally important, or very nearly so, to engineers. Activities performed by substantial numbers of personnel in nearly all occupations include: research; supervision; quality control; testing; instrumentation; drafting; and writing technical reports. Most of the technical knowledge and skills used on the job were learned on the job by a third of the engineers, more than half of the associate engineers and technicians, and three-fourths of the craftsmen. Work experience is surpassed as the major source of technical knowledge only by college for engineers, and followed by college, vocational-technical schools, and military service for technicians and skilled craftsmen.

On-the-job training and continuing education in the schools are made available by the employers of a majority of personnel in nearly all occupations. Employers are about equally concerned with updating skills and knowledge, advancement to higher positions, and providing their employees with a broad educational background. They are less concerned with making up deficiencies in the previous education their employees have received. The major purposes for which all personnel continue their education after employment are to acquire technical or professional knowledge needed on the job and their own self-improvement.

The majority of engineers and associate engineers in Arizona are in their 30s and 40s, have had ten years or more experience, and earn $900 to $1,200 or more per month if they are engineers, $700 to $900 if they are associate engineers. Technicians as a group are younger, have had less experience, and earn less money. Most of them are in their 20s and 30s, and many have had experience as skilled craftsmen. Their salaries for the most part range from $500 to $900 per month. Skilled craftsmen are older and have had more experience than either engineers, associate engineers, or technicians. More than two-thirds are over

40 and more than one-third are over 50. They earn slightly more than technicians. Wages and salaries of all personnel show a noticeable relationship with educational levels reached.

Pirating from other employers or changing employers is widespread in all occupations and represents by far the most important source of recruitment for engineering and related employment in Arizona. The second major source is out of state, particularly for engineers and skilled craftsmen. The armed services contribute appreciable numbers of associate engineers and technicians. The schools are a major or significant source of engineers, associate engineers, and technicians.

The technical skills and knowledge required in all occupations have changed for substantial majorities of employees in the past five years and there is virtually unanimous agreement that additional changes will take place in the next five years. The occupations in which changes have been fewer than in others are chemical, civil and mining, but even in these fields 75% or more the employees have been affected. In almost every occupation the changes expected in the next five years will require more preparation in technical subjects related to the field. More preparation in mathematics and science will be needed in some occupations at each level of employment -- engineering, technology, and skilled. The subjects in which a need for more preparation is indicated for most engineering fields are physics, chemistry, non-metallic materials, computer programming, computer technology, and business courses. For a majority of technical fields they are physics, instrument calibrations and measurements, writing, and speaking. For the skilled crafts they are machine tools and machinability.

Arizona employers are generally in favor of developing cooperative school-industry educational programs in which students spend part of their time in school and part of their time on the job. Special programs in the schools to upgrade experienced employees from lower level occupations are favored in most of the skilled and technical occupations and three fields in engineering. Employers of a majority of personnel in twenty-three occupations are in favor of expanding enrollments or adding new programs or both in Arizona schools. National registration or certification of engineers and technicians has the support of a minority of employers.

Approximately 20% of the engineers, technicians, and skilled craftsmen who completed questionnaires in the survey received their highest degree or diplomas from Arizona institutions. The four leading schools with numbers of graduates reported in engineering were the U of A (259), ASU (126), UCLA (43), and Purdue (26). In associate engineering they were the U of A (25), ASU (20), Phoenix College (13), and the ICS in Illinois (10). In technology the leading schools reported were Phoenix College (85), ASU (81), armed services schools (43), and the U of A (25). Half of those reporting said the convenient location and reputation of the school were major reasons for their choice. Only a small percentage indicated family influence or the influence of friends, high school faculty, or college representatives in choosing the school from which they graduated. Between 50 and 60% of the engineers, and 40 to 50% of the associate engineers and technicians said they would select the same school if they were making their choice today.

The data presented here are subject to all of the questions and criticism that may be raised about the results of any survey, especially one in which personal opinions and judgments are asked for. In addition to the subjective nature of many of the responses, the information received from employees represents only one-third of the entire group. In the skilled crafts less than 10% of all employees are represented. Employer information also is not completely representative, because it was provided by single individuals whose views might differ from other management personnel in the same companies.

Nevertheless, the volume alone of the data gathered tends to level out the variations, and in most cases the results represent predominate views and prevailing practices. Changes in the picture from additional questionnaires returned or interviews with different management personnel would probably be very slight. The questions themselves and the evaluation of the results were reviewed by many educators and employment supervisors who are experienced in this kind of research. Collectively they developed the survey with sufficient care to justify considerable confidence in the results. In many of the facts and views collected these are the first data of their kind on a scale as extensive as this to appear anywhere. The results of the survey, of course, are not universally applicable, and noticeable changes will appear even in this state from year to year. But these variations are probably not as great as the consistency with which details revealed in the survey will be repeated geographically and over a period of time. The net result at least, is to open up areas of knowledge about the educational needs of industry which have not been available to this extent before.

CHAPTER V

OCCUPATIONAL PROFILES

Thirty-three occupational studies have been combined in the industrial survey described in the preceding chapter. The data collected in each study give an up-to-date profile of the occupation with its educational requirements, skilled activities, characteristics of present personnel, and other significant features. These profiles offer educators a basis for evaluating current programs designed to prepare students for such careers. They give employers an industry-wide perspective from which to appraise their own requirements and employment practices. And they enable public attention to focus on the critical relationships that exist between educational institutions and industry in our modern technological society.

Each profile is given as a statistical table from data collected in the survey. It contains percentages of employer and employee responses to questions in the survey arranged in descending order of agreement. Employer information is given, as before, in the percentages of employees who returned questionnaires. Minor responses have been omitted and profiles of three of the occupations included in the survey are omitted because of insufficient data. Accompanying the tables are brief summaries which highlight some of the principal features of each occupation.

It must be emphasized that these are not profiles of specific jobs, but of occupations. Within the occupations there may be considerable variation between companies and industries. The profiles here reveal characteristics of each occupation arranged on descending scales of probability as reported by all industry.

All of the profiles in engineering and many of those in the supporting occupations have one characteristic that needs further explanation. They show major activities as writing technical reports, supervision and research. These are the time-consuming tasks often required, but they are the tasks which follow or parallel the use of technical skills without which reports could not be written, technical personnel could not be supervised and research in highly technical areas could not be carried on. In other words, when the profile shows writing technical reports as the principal activity in an occupation and omits others which would also seem appropriate, this may be true in relative amounts of time spent but not in an absolute sense.

TABLE 31
PROFILE OF AEROSPACE ENGINEERING

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
MS-MA	82	Ph.D	84	Ph.D	31
BS-BA	10	MS-MA	9	MS-MA	25

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Drafting	99	Metallurgy	92
Algebra	98	Comput Prog	92
Geometry	98	Non-metal	91
Physics	98	Dif Equa	90
Hyd-Pneu	95	So Studies	90
Writing	96	Business Ad	88
Trig	94	Chemistry	87
Calculus	92	Comput Tech	85

Employee Opinion

Trig	100	Mfg Process	69	Comput Prog	52
Algebra	94	Metallurgy	63	Dif Equa	50
Geometry	94	Machinablty	63	Comput Tech	50
Physics	94	Instr Calib	63	Non-metal	44
Reading	94	Electric	63	Mach Econ	38
Speaking	94	Chemistry	62	So Studies	37
Writing	88	Machine Tool	57	Humanities	37
Calculus	75	Drafting	57	Integ Circ	25
Hyd-Pneu	69	Business Ad	57		

SUBJECTS IN WHICH AN ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Dif Equa	88	Comput Prog	82
Hyd-Pneu	82	Comput Tech	82

Employee Opinion

Writing	38	Algebra	31	Speaking	31
Reading	38	Chemistry	31	Mfg Process	25

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Systems Anal	97	Tech Reports	95
Drafting	97	Research	95
Design	96	Supervision	95

Employee Practice

Supervision	87	Sales	26
Tech Reports	63	Design	25

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	88	56
Subsidize in schools	92	6
Arrange in schools	86	0
Personal choice and cost		31

(Purpose)	Emplr	Emple
Make up educ deficiency	1	
Keep up with adv tech	92	56
Prep for higher position	36	19
Better educ background	89	44

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy

Performance	96	Personality	87
Experience	95	Seniority	3
Education	89		

Employee Opinion

Performance	75	Seniority	19
Experience	69	Personality	13
Education	50		

JOB SATISFACTION: (81% feel they made a good career choice)

Nature of work	94	Fringe Benefits	50
Facilities	75	Emplr Relations	50
Importance of work	63	Job Security	44
Opport for Advance	50	Salary	44

JOB DISSATISFACTION:

Fringe Benefits 38

Cont. Aerospace Engineering

SOURCES OF RECRUITMENT:
(Employers' Preference)

1st: Promotion from within	82
2nd: Direct from school	89
3rd: Other Employers	92

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Similar Job out of State	50
School	13
Similar Job in Arizona	13
Armed Services	13

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Class Rank	HS Major
40s: 50	More than 10: 44	Upper ¼: 31	Coll Prep: 87
30s: 44	5 to 10 yrs: 25	Upper 10%: 50	General : 6

PREVIOUS EXPERIENCE: (two highest responses)

Skilled	Technical	Engineering
-0-	1 to 3 yrs: 6	More than 10 yrs: 63
-0-	-0-	5 to 10 yrs: 19

MONTHLY SALARY RANGES: (two highest responses)

	Employers' Schedule		Present Personnel
Min:	More than 1,200: 82	500 to 700: 7	900 to 1,200: 38
Max:	More than 1,200: 83	900 to 1,200: 7	700 to 900: 37

Aerospace Engineers: Employers expect aerospace engineers to handle research, production design, systems analysis, quality control, drafting, computer programming, and writing technical reports. Most men on the job report their main activities are supervision and technical report writing, with some research, design, sales and consulting. Technical report writing, which appears as a major activity in many engineering and technical occupations, is based on other engineering activities not necessarily reported. Aerospace engineers use a general knowledge of nearly every subject included in the survey. Future requirements are expected to increase their need for differential equations, physics, chemistry, non-metallic materials, hydraulics-pneumatics, computer programming, and computer technology.

Nearly all employers require graduate degrees, preferably doctorates, and more than half of aerospace engineers in the survey have graduate degrees. Salaries start at around $900 per month, and this is one of the less desirable features of the job in the opinion of the engineers. The work itself is considered highly gratifying. Half of the aerospace engineers who returned questionnaires were in their 40s and most of the others were in their 30s. Nearly half of them received their highest degree more than ten years ago, have had more than five promotions, and came to their present jobs from similar positions outside of Arizona. Employers' first preferance in filling positions in the field is through promotion from within their organization. Their second preference is from graduate schools and their third from other employers. Advancement is based largely on experience, performance and education in that order.

TABLE 32
PROFILE OF CHEMICAL ENGINEERING

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
Coll-NO-degree	51	MS-MA	44	BS-BA	32
BS-BA	27	BS-BA	23	MS-MA	24

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Algebra	100	Non-metal	80
Writing	100	Mfg Process	79
Geometry	99	Metallurgy	78
Reading	99	Inst Calib	73
Speaking	97	Hyd-Pneumat	67
Trig	97	Integ Circ	49
Chemistry	97	Comput Prog	40
Physics	96	Drafting	37
Calculus	95	So Studies	28
Business Ad	95	Humanities	26
Dif Equa	86	Comput Tech	25
Electric	86		

Employee Opinion

Reading	94	Instr Calib	62	Metallurgy	40
Writing	94	Mfg Process	62	Humanities	36
Speaking	92	Business Ad	62	Comput Prog	35
Chemistry	91	Calculus	57	Comput Tech	28
Algebra	90	Electric	57	Geology	28
Physics	82	Hyd-Pneumat	53	Mach Tools	26
Geometry	78	Dif Equa	48	Machinablty	26
Trig	73	Non-met	48		
Drafting	69	So Studies	46		

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Chemistry	88	Metallurgy	39
Physics	72	Writing	31
Dif Equa	61	Reading	30
Calculus	59	Speaking	30

Employee Opinion

Chemistry	51	Algebra	36
Writing	40	Calculus	27
Reading	40	Geometry	26
Speaking	39	Trig	25
Physics	37		

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Tech Reports	100	Design	76
Research	99	Systems Anal	71
Testing	97	Prod Inspect	70
Instrument	97	Prod Layout	64
Qual Control	96	Drafting	53
Supervision	95	Aut Equipment	45
Sales	92	Electronic Equip	34

Employee Practice

Supervision	79
Research	67
Tech Reports	60
Sales	35
Testing	27

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	70	48
Subsidize in schools	23	22
Arrange in schools	69	18
Personal choice and cost		33

(Purpose)	Emplr	Emple
Make up educ deficency	5	
Keep up with adv tech	75	67
Prep for higher position	58	24
Better educ background	76	52

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy

Performance	99
Experience	73
Seniority	49
Personality	29

Employee Opinion

Performance	76
Experience	57
Education	39
Seniority	20

Cont. Chemical Engineering

JOB SATISFACTION: (88% feel they made a good career choice)

Nature of work	93	Salary	61
Importance of work	78	Opp for Adv	54
Facilities	73	Job Security	47
Emplr Relations	63	Fringe Benefits	45

JOB DISSATISFACTION:

Fringe Benefits	26
Opp for Adv	25

SOURCES OF RECRUITMENT:
(Employers' Preference)

1st: Promotion from within	63
2nd: Direct from school	84
3rd: Other Employers	22

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Similar Job out of State	28
Lower level, same emplr	17
Similar Job in Arizona	16

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Class Rank	HS Major
30s: 35	More than 10: 52	Upper 10%: 42	Coll Prep : 61
40s: 30	5 to 10 yrs: 24	Upper ¼: 26	General : 23

PREVIOUS EXPERIENCE: (two highest responses)

Skilled	Technical	Engineering
More than 10 yrs: 6	More than 10 yrs: 13	More than 10 yrs: 38
1 to 10 yrs: 3	1 to 3 yrs: 12	5 to 10 yrs: 18

MONTHLY SALARY RANGES: (two highest responses)

	Employers' Schedule		Present Personnel
Min:	500 to 700: 50	700 to 900: 25	900 to 1,200: 31
Max:	900 to 1,200: 37	700 to 900: 36	700 to 900: 27

Chemical Engineers: In this profile a somewhat disproportionate number of personnel at the lower end of the educational and salary scale have been included. It is the only field of engineering in the survey in which the employers of half of the engineers require less than a baccalaureate degree. They indicate a preference for college graduates, especially those with graduate degrees. Nearly half of the chemical engineers who answered questionnaires have graduate degrees, but 21 percent have less than the baccalaureate. Chemical engineers report activities very similar to those in most other fields - - research, supervision, and writing technical reports. They require the same broad education in mathematics, science and communications. More knowledge of the physical sciences, metallurgy, non-metallic materials and computer operation will be needed in the future.

Salaries generally run between $700 and $1,200 per month. The large majority of the chemical engineers who responded to the survey indicated satisfaction with their earnings as well as all other aspects of the job, especially the work itself. More than half have had at least ten years' experience, and three-fourths have had at least five years. Nearly one-third of the chemical engineers in the survey have had experience as technicians. Employers prefer to get new personnel by promotion from within their organizations or from college. Nearly half of the chemical engineers who returned questionnaires have come to present positions from similar employment in other companies.

TABLE 33
PROFILE OF CIVIL ENGINEERING

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
BS-BA	63	BS-BA	35	BS-BA	69
HS	20	MS-MA	22	Coll-NO-degree	13

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Algebra	100	Calculus	83	So Studies	49
Geometry	100	Geology	81	Instr Calib	48
Trig	99	Chemistry	80	Comput Prog	47
Drafting	99	Hyd-Pneu	71	Electric	44
Writing	99	Dif Equa	71	Humanities	40
Speaking	99	Business Ad	70	Comput Tech	32
Reading	98	Non-metal	51	Metallurgy	29
Physics	94				

Employee Opinion

Algebra	96	Calculus	63
Geometry	96	Instr Calib	48
Trig	96	So Studies	48
Writing	95	Non-metal	44
Speaking	94	Electric	40
Reading	93	Comput Prog	40
Drafting	93	Dif Equa	34
Physics	86	Humanities	34
Business Ad	76	Comput Tech	32
Geology	74	Mfg Process	29
Hyd-Pneu	70	Metallurgy	25
Chemistry	67		

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Algebra	36	Drafting	31
Geometry	36	Physics	27
Trig	35	Reading	25

Employee Opinion

Trig	43	Writing	36
Geometry	38	Reading	36
Algebra	37	Speaking	33
Drafting	36		

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Tech Reports	98	Sales	78	Prod Layout	45
Drafting	97	Qual Control	63	Comput Prog	44
Supervision	95	Instr Calib	52	Design	41
Surveying	93	Prod Inspect	48	Systems Anal	34
Testing	87	Research	46		

Employee Practice

Supervision	79	Drafting	38
Tech Reports	60	Surveying	33
Sales	43	Design	32
Research	42	Prod Inspec	25

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	56	58
Subsidize in schools	68	16
Arrange in schools	39	19
Personnel choice and cost		37

(Purpose)	Emplr	Emple
Make up educ deficency	38	
Keep up with adv tech	56	66
Prep for higher position	67	32
Better educ background	60	66

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy

Performance	99	Personality	32
Experience	75	Seniority	16
Education	56		

Employee Opinion

Performance	82	Personality	21
Experience	76	Seniority	18
Education	42		

JOB SATISFACTION: (86% feel they made a good career choice)

Nature of work	93	Job Security	65
Facilities	79	Salary	61
Employer Relations	70	Opp for adv	60
Importance of work	66	Fringe Benefits	60

JOB DISSATISFACTION:
-0-

Cont. Civil Engineering

SOURCES OF RECRUITMENT:
(Employers' Preference)

1st: Promotion from within	66
2nd: Other Employers	47
3rd: Direct from school	27

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Similar job out of State	24
School	22
Similar job in Arizona	18
Lower level, same employer	17

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
30s: 34	More than 10 yrs: 62	Upper ¼: 31	Coll Prep
40s: 29	5 to 10 yrs: 21	Upper 10%: 27	General

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
More than 10 yrs: 2	3 to 5 yrs: 8	More than 10 yrs: 56
1 to 3 yrs: 2	1 to 7 yrs: 7	5 to 10 yrs: 24

MONTHLY SALARY RANGES: (two highest responses)

	Employers' Schedule		Present Personnel
Min:	500 to 700: 62	700 to 900: 29	900 to 1,200: 44
Max:	More than 1,200: 61	900 to 1,200: 27	700 to 900: 29

Civil Engineers: Civil engineers spend most of their time in supervisory activities and writing technical reports. They also do some drafting, surveying, and sales-consulting-public relations. The last is a field in which employers would like civil engineers to excel since the nature of the work often brings them into contact with the public.

The minimum educational level required for two-thirds of the civil engineers in Arizona is a baccalaureate degree or higher, and for nearly one-third the preference is a masters or doctorate. Civil engineers appear to have the lowest percentage of graduate degrees of any field of engineering in the state, although three-fourths of those who returned questionnaires have at least a B.S. Salaries range largely from $700 to more than $1,200 per month, with nearly half of those reporting in the $900 to $1,200 bracket. The age distribution is broader than in most engineering fields, and civil engineering has the highest percent of men who received their highest degrees more than ten years ago. It is also the most stable field in engineering, with the lowest percent of both employers and employees who report that technical skills and knowledge used on the job had changed in the last five years or are expected to change in the next five years. Of the employers who do believe changes will take place, less than half consider additional preparation necessary in any of the courses listed.

TABLE 34
PROFILE OF ELECTRICAL ENGINEERING

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
BS-BA	94	MS-MA	28	BS-BA	67
MS-MA	4	Ph.D	5	MS-MA	15

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Algebra	100	Chemistry	49
Geometry	100	Instr Calib	45
Trig	100	Integ Circ	43
Calculus	99	Business Ad	43
Physics	99	Drafting	42
Electric	99	Metallurgy	39
Dif Equa	98	So Studies	37
Comput Prog	67	Non-metal	36
Speaking	52	Mfg Process	35
Writing	51	Hyd-Pneu	34
Reading	51		

Employee Opinion

Algebra	97	Drafting	77	Mfg-Process	44
Writing	97	Business Ad	75	Hyd-Pneu	40
Speaking	97	Instr Calib	70	Non-metal	39
Reading	96	Dif Equa	64	Mach Tool	33
Trig	95	Chemistry	62	Humanities	32
Physics	91	Comput Prog	57	Metallurgy	29
Electric	91	Comput Tech	51	Mach Econ	29
Geometry	91	Integ Circ	47	Machinablty	27
Calculus	81	So Studies	46		

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Electric	90	Calculus	37
Algebra	37	Dif Equa	37
Geometry	37	Physics	35
Trig	37	Integ Circ	33

Employee Practice

Electric	63	Reading	35
Algebra	44	Calculus	34
Trig	39	Geometry	30
Speaking	36	Dif Equa	28
Writing	35	Physics	26

SKILLED ACTIVITIES: (25% or more response)

Employer

Tech Reports	99	Drafting	43	Aut Equip	33
Systems Anal	95	Comput Prog	41	Prod Layout	33
Research	92	Sales	41	Qual Control	32
Supervision	91	Design	38	Prod Inspect	31
Testing	46	Elect Equip	39	Surveying	31
Instr Calib	44	Precis Mach	34		

Employee Practice

Tech Reports	78
Supervision	66
Drafting	54
Research	49
Systems Anal	44
Sales	40
Design	28

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	41	56
Subsidize in schools	91	36
Arrange in schools	35	31
Personal choice and cost		43

(Purpose)	Emplr	Emple
Make up educ deficency	30	
Keep up with adv tech	90	75
Prep for higher position	88	41
Better educ background	90	72

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy		Employee Opinion	
Performance	99	Performance	81
Experience	91	Experience	56
Education	32	Education	28
Seniority	25	Seniority	26
Personality	6	Personality	23

Cont. Electrical Engineering

JOB SATISFACTION: (84% feel they made a good career choice)

Nature of work	90	Import of work	61
Facilities	75	Job Security	59
Emplr Relations	66	Salary	58
Fringe Benefits	64	Opp for advancement	52

JOB DISSATISFACTION:

Salary	27
Opp for advancement	26

SOURCES OF RECRUITMENT:
(Employers' Preference)

1st: Promotion from within	61
2nd: Other Employers	79
3rd: Direct from school	54

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

School	28
Similar job out of State	19
Similar job in Arizona	18
Lower level, same employer	14
Armed Services	10

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Class Rank	HS Major
40s: 38	More than 10 yrs: 56	Upper 10%: 38	Coll Prep: 63
30s: 32	5 to 10 yrs: 21	Upper ½: 27	General: 26

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
More than 3 yrs: 5	Up to 3 yrs: 13	More than 10 yrs: 56
Up to 3 yrs: 4	More than 3 yrs: 12	5 to 10 yrs: 20

MONTHLY SALARY RANGES: (two highest responses)

Employers' Schedule		Present Personnel:
Min: 500 to 700: 85	700 to 900: 9	900 to 1,200: 46
Max: More than 1,200: 61	900 to 1,200: 34	More than 1,200: 25

Electrical Engineers: Supervision and writing technical reports head the list of activities in electrical engineering, followed by research, systems analysis, and drafting. These activities require technical knowledge in the field supported by courses in mathematics through differential equations, physics, instrument calibration, electricity-electronics, drafting and communications. Changes in technology are expected to require more preparation in the future in electronics and in various kinds of computer application. An engineering degree is required for this occupation; and there is some preference for applicants with gradaute degrees. Employers are almost unanimous in recommending that communications be strengthened in the degree programs.

Job satisfaction is quite high, especially with the immediate working conditions-facilities, employer relations, and the work itself. Minimum salaries tend to be lower than other fields of engineering, starting between $500 and $700 per month, but go up to $1,200 and beyond. Nearly half of the EE's in Arizona who returned questionnaires earn between $900 and $1,200 and one-fourth of them earn more than $1200. Employers like to get new employees by promoting men in the ranks, from other employers, or from the schools in that order. The typical EE identified in the survey came to his present job from a similar position elsewhere or direct from school, is in his 30s or 40s, has more than ten years' experience and may have worked at one time as a technician, received his highest degree (BS or MSO more than ten years ago, has had more than 5 promotions, and expects to be in a higher position ten years from now, probably in management.

TABLE 35
PROFILES OF ELECTRONIC ENGINEERING

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
BS-BA	68	MS-MA	61	BS-BA	64
Tech Certificate	16	BS-BA	19	MS-MA	19

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Algebra	100	Business Ad	96	Hyd-Pneu	77
Geometry	100	Speaking	95	Metallurgy	69
Trig	100	Integ Circ	94	Comput Tech	68
Physics	100	Mfg Process	91	So Studies	51
Instr Calib	99	Chemistry	85	Humanities	50
Dif Equa	99	Calculus	84	Drafting	50
Writing	99	Non-metal	82	Machinablty	45
Reading	98	Comput Prog	79	Mach Econ	28
Electric	96				

Employee Opinion

Electric	97	Business Ad	67
Writing	96	Chemistry	66
Algebra	95	Mfg Process	66
Reading	94	Comput Prog	56
Speaking	94	Mach Tools	47
Physics	93	Non-metal	46
Trig	92	Comput Tech	42
Geometry	89	Machinablty	36
Calculus	83	Metallurgy	35
Instr Calib	83	So Studies	31
Drafting	77	Comput Graph	26
Dif Equa	74	Hyd-Pneu	25
Integ Circ	69	Mach Econ	25

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Electric	88	Dif Equa	63
Algebra	74	Writing	61
Calculus	74	Physics	33
Integ Circ	73		

Employee Opinion

Electric	78	Dif Equa	36
Algebra	47	Physics	34
Integ Circ	47	Writing	31
Calculus	45	Reading	31
Trig	38	Geometry	31

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Instr Calib	100	Systems Anal	97	Drafting	86
Elect Equip	99	Qual Control	97	Comput Prog	81
Tech Report	99	Design	91	Prod Inspect	67
Testing	98	Supervision	87	Aut Equip	65
Research	97	Sales	87	Prod Layout	55

Employee Practice

Tech Reports	78	Testing	40
Supervision	65	Comput Prog	26
Systems Anal	56	Sales	26
Research	52		

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	91	77
Subsidize in schools	96	26
Arrange in schools	23	31
Personal choice and cost		26

(Purpose)	Emplr	Emple
Make up educ deficency	69	
Keep up with adv tech	92	86
Advancement	87	39
Better educ Background	96	79

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy		Employee Opinion	
Performance	99	Performance	81
Experience	98	Experience	55
Education	60	Education	22
Personality	18	Personality	17
Seniority	12	Seniority	9

Cont. Electronic Engineering

JOB SATISFACTION: (87% feel they made a good career choice)

Nature of work	79	Facilities	60	Import of work	55
Salary	71	Emplr Relations	59	Job Security	44
Fringe Benefits	63	Opp for advancement	57		

JOB DISSATISFACTION: -0-

SOURCES OF RECRUITMENT:
(Employers' Preference)

1st: Other employers	48
2nd: Direct from school	66
3rd: Promotion from within	58

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Similar job out of State	36
School	28
Lower level, same employer	16
Similar job in Arizona	8
Armed Forces	6

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Class Rank	HS Major
30s: 43	More than 10 yrs: 45	Upper 10%: 41	Coll Prep: 64
40s: 25	5 to 10 yrs: 4	Upper ¼: 28	General: 27

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
1 to 5 yrs: 7	1 to 5 yrs: 20	More than 10 yrs: 42
1 to 3 yrs: 3	3 to 5 yrs: 9	5 to 10 yrs: 25

MONTHLY SALARY RANGES: (two highest responses)

Employers' Schedule	Present Personnel
Min: 700 to 900: 46	900 to 1,200: 47
Max: More than 1,200: 69	More than 1,200: 29

Electronics Engineering: Electronics engineers are involved in supervision and writing technical reports, and to some extent in research and systems analysis. Training for this occupation includes math through differential equations, physics, some chemistry, instrument calibrations, electronics, integrated circuits, and communications. Future requirements are expected to be higher in most of the same areas, plus non-metallic materials, computer programming, and computer technology. Most employers require at least a bachelor's degree in engineering and prefer graduate degrees. Nearly all employers subsidize additional education for electronics engineers, and this field has the highest combined interest by employers and employees in education for the purpose of a broader educational background.

Salaries run from $700 monthly to over $1,200. Nearly half of the engineers who returned questionnaires earn between $900 and $1,200, and nearly one-third earn more than $1,200. This field had the highest level of satisfaction with salaries reported in the survey, and fairly high levels of satisfaction with other aspects of employment. It is the youngest group of any engineering field, and has the highest level of ambition for advancement. It is the only field in which employers would rather hire engineers away from other employers than to promote men from lower level positions in their own companies, possibly because the field is relatively new. Changes in skills and knowledge required in the next five years are expected to have the greatest impact on the educational program of any field of engineering.

TABLE 36
PROFILE OF GEOLOGICAL ENGINEERING

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
BS-BA	91	Ph.D	19	BS-BA	66
AS-AA	6	BS-BA	16	MS-MA	29

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion				Employee Opinion			
Chemistry	100	Electric	75	Drafting	100	Calculus	54
Geology	100	Business Ad	74	Writing	100	Instr Calib	52
Writing	100	Metallurgy	72	Reading	100	So Studies	52
Reading	100	So Studies	69	Speaking	100	Hyd-Pneu	51
Physics	99	Hyd-Pneu	67	Geometry	97	Electric	48
Calculus	98	Comput Prog	65	Chemistry	95	Metallurgy	43
Algebra	91	Humanities	55	Algebra	94	Humanities	40
Geometry	91	Comput Tech	48	Trig	94	Mfg Process	34
Trig	91	Dif Equa	44	Physics	92	Comput Prog	31
Drafting	86	Mach Econ	38	Geology	91	Comput Tech	31
Instr Calib	75	Mfg Process	36	Business Ad	74	Dif Equa	26
				Non-metal	66		

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion									
Geology	77	Speaking	45	Algebra	33	Geology	74	Trig	37
Writing	61	Chemistry	42	Geometry	33	Writing	63	Drafting	29
Reading	53	Non-metal	41	Trig	33	Reading	54	Geometry	26
Physics	52	Hyd-Pneu	39	Drafting	30	Speaking	49	Chemistry	20
				Business Ad	25				

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements						Employee Practice	
Tech Reports	100	Drafting	81	Prod Insp	38	Tech Reports	94
Supervision	92	Instr Calib	80	Comput Prog	38	Supervision	77
Research	91	Testing	58	Design	32	Research	69
Surveying	86	Qual Contr	53	Precis Mach	31	Surveying	55
Sales, etc	82	Elec Equip	44	Prod Layout	27	Drafting	54
						Sales, etc	40

CONTINUING EDUCATION:

(Extent)	Emplr	Emple	(Purpose)	Emplr	Emple
On the job	55	63	Make up educ deficiency	31	
Subsidize in schools	38	20	Keep up with adv tech	44	60
Arrange in schools	25	20	Prep for higher position	47	23
Personal choice and cost		31	Better educ background	50	74

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy				Employee Opinion			
Performance	100	Education	42	Performance	76	Personality	24
Experience	77	Personality	27	Experience	63	Seniority	9
Seniority	54			Education	26		

JOB SATISFACTION: (91% feel they made a good career choice)

Nature of work	97	Emplr Relations	57
Importance of job	71	Job Security	49
Fringe Benefits	69	Opp for advance	37
Facilities	69	Salary	31

JOB DISSATISFACTION:

Salary	40
Opp for advancement	31

SOURCES OF RECRUITMENT: (Employers' preference)

1st: Promotion from within	50
2nd: Other Employers	47
3rd: Direct from the schools	42

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

School	29
Similar job out of state	26
Similar job in Arizona	9
Lower level, same employer	6
Armed Service	3

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
30s: 43	More than 10: 46	Upper 10%: 37	Coll Prep 68
40s: 31	5 to 10: 34	Upper ½: 31	General 22

PREVIOUS EXPERIENCE: (two highest responses)

Skilled	Technical	Engineering
1 to 5 yrs: 6	1 to 3 yrs: 12	More than 10 yrs: 40
More than 10 yrs: 3	More than 10 yrs: 6	5 to 10 yrs: 29

MONTHLY SALARY RANGES: (two highest responses)

	Employers' Schedule		Present Personnel:
Min:	500 to 700: 56	700 to 900: 30	700 to 900: 54
Max:	900 to 1,200: 41	More than 1,200: 39	900 to 1,200: 17

Geological Engineering: Geological engineers, like other engineers, spend a major part of their time writing technical reports, considerable time in research, supervision, and to some extent drafting and surveying. Their education should include math through calculus, all the physical sciences, drafting, and especially reading, writing and speaking. Requirements in these same areas, with the exception of drafting, are expected to be even higher in the future as a result of changing technology.

Most employers require a baccalaureate degree in engineering, and one-third prefer masters or doctorates. Nearly one-third of the geological engineers in the survey have masters and virtually all have at least a BS. Employers of half say they prefer to promote their own personnel into this occupation, but very few present employees have come into their jobs that way. More than half of them either came directly from college or from a similar job in another state.

Salaries run from $500 to over $1,200 per month with the majority now employed making less than $900. There is considerable employee criticism of salary as well as opportunity for advancement. This field has among the highest percentages of baccalaureate and graduate degrees, years of experience, and promotions of any field in engineering. It also has the highest percent of men who feel they made a good choice in selecting their career of any field in engineering.

TABLE 37

PROFILE OF INDUSTRIAL ENGINEERING

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
BS-BA	34	BS-BA	57	BS-BA	56
Coll-No-Degree	29	Grad Degree	15	Coll-No-Degree	18

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Algebra	100	Electric	84
Geometry	100	Reading	84
Mach Tools	100	Mach Econ	78
Writing	100	Comput Prog	70
Trig	98	Dif Equa	69
Physics	95	Metallurgy	67
Business Ad	95	Soc Studies	63
Machinablty	93	Hyd-Pneumat	61
Speaking	92	Drafting	61
Mfg Proc	91	Instr Calib	58
Chemistry	89	Non-metal	48
Calculus	86	Comput Tech	48

Employee Opinion

Speaking	98	Geometry	79	Instr Calib	53
Mfg Proc	96	Trig	77	Comput Prog	49
Writing	96	Machinablty	76	Calculus	45
Reading	96	Physics	73	Soc Studies	46
Algebra	87	Drafting	73	Comput Tech	43
Mach Tools	84	Chem	67	Dif Equa	31
Business Ad	82	Non-metal	67	Computgraph	29
Mach Econ	80	Metallurgy	60	Integr Circ	52
Electric	80	Hyd-Pneumat	57		

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Mfg Proc	60	Dif Equa	38	Machinablty	29
Writing	50	Reading	37	Geometry	25
Speaking	46	Mach Econ	36	Comput Prog	25
Trig	44	Mach Tools	32		
Calculus	42	Algebra	31		

Employee Opinion

Mfg Proc	58
Speaking	42
Reading	38
Mach Econ	36
Writing	32
Machinablty	25

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Tech Reports	90	Research	78	Aut Equip	44
Prod Layout	83	Testing	65	Sales, etc	44
Supervision	82	Prod Inspect	62	Elec Equip	34
Design	81	Instr Calib	56	Precis Mach	34
Systems Anal	81	Drafting	54		
Qual Control	78	Comput Prog	51		

Employee Practice

Tech Reports	68
Supervision	62
Prod Layout	47
Research	44
Syst Anal	42
Design	40
Qual Contr	32
Sales, etc	26

CONTINUING EDUCATION:

(extent)	Emplr	Emple
On the Job	72	68
Subsidize in schools	72	36
Arrange in schools	40	26
Personnel choice and cost		36

(Purpose)	Emplr	Emple
Make up educ deficiency	51	
Keep up with adv tech	68	78
Prep for higher position	71	42
Better educ background	56	82

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy	
Performance	99
Experience	88
Education	78
Personality	41
Seniority	30

Employee Opinion	
Performance	82
Experience	64
Personality	26
Education	25
Seniority	7

JOB SATISFACTION: (86% feel they made a good career choice)

Nature of work	74	Fringe Benefits	56
Employer Relations	64	Opportunity for adv	55
Facilities	63	Importance of work	49
Salary	59	Job Security	44

JOB DISSATISFACTION:
-0-

SOURCES OF RECRUITMENT:

1st: Promotion from within	46
2nd: Other employers	49
3rd: Direct from schools	55

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Similar job out of State	33
Similar job in Arizona	18
Lower level, same employer	15
School	10

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
40s: 42	More than 10: 53	Upper $\frac{1}{2}$: 34	Coll Prep: 53
30s: 27	5 to 10: 21	Upper $\frac{1}{4}$: 28	General: 30

PREVIOUS EXPERIENCE: (two highest responses)

Skilled	Technical	Engineering
1 to 5 yrs: 6	1 to 5 yrs: 12	More than 10 yrs: 51
More than 10 yrs: 5	More than 5 yrs: 8	5 to 10 yrs: 22

MONTHLY SALARY RANGES: (two highest responses)

	Employers' Schedule		Present Personnel:
Min:	500 to 700: 50	700 to 900: 36	900 to 1,200: 44
Max:	More than 1,200: 52	900 to 1,200: 32	700 to 900: 38

Industrial Engineering: The principal activities of industrial engineers are writing technical reports and supervision, based to a major extent on systems analysis, production design, production layout, and quality control. Their education includes math through calculus, physics, chemistry, manufacturing processes, machine utilization, reading, writing, and speaking. They require a broader knowledge of technical subjects than any other field, with emphasis on machines and processes as well as research and supervision. Fewer employers and employees, however, consider an advanced knowledge necessary in particular subject areas. This field has the highest percentage of personnel reporting the major part of their skills adquired on the job and the lowest percent acquired in school. The future is expected to bring increased emphasis on manufacturing processes, electronics, computer programming, and business administration. Employers see a need for increasing the number of men trained in this occupation, and giving them more communications and business administration.

The salary range for industrial engineers is from $500 to more than $1,200 per month, with three-fourths of those who answered questionnaires in the upper part of the $700 to $1,200 bracket. As a group they are somewhat more experienced, older, and have moved around more than most other engineers. The first preference of most employers in getting new personnel is through promotion from lower level positions but relatively few have come into their present positions in this way. The employers' second choice is from other employers, which is the major source today. The third preference of employers is to hire graduates from the schools, and 10% of those who answered questionnaires were employed directly from school.

TABLE 38

PROFILE OF MECHANICAL ENGINEERING

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
BS-BA	72	MS-MA	50	BS-BA	64
Tech Certificate	8	BS-BA	15	MS-MA	12

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Algebra	99	Dif Equa	82
Geometry	99	Mfg Process	78
Trig	99	Speaking	69
Writing	99	Reading	68
Physics	98	Comput Prog	67
Chemistry	93	Instr Calib	65
Drafting	93	Comput Tech	63
Metallurgy	89	Mach Tools	55
Hyd-Pneumat	89	Electric	55
Calculus	86	Mach Econ	48
Non-metall	86	Soc Studies	35
Business Ad	85	Integr Circ	34
Machinablty	84	Humanities	31

Employee Opinion

Writing	97	Metallurgy	76
Algebra	96	Mach Tools	74
Trig	95	Electric	72
Reading	95	Machinablty	72
Speaking	93	Business Ad	65
Geometry	93	Calculus	65
Physics	92	Mach Econ	53
Drafting	89	Dif Equa	46
Mfg Proc	83	Comput Prog	40
Non-metall	80	Soc Studies	39
Hyd-Pneumat	80	Comput Tech	33
Instr Calib	78	Integ Circ	26
Chemistry	77	Humanities	25

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Dif Equa	50
Business Ad	33

Employee Opinion

Reading	30	Trig	28
Writing	29	Algebra	27
Speaking	29	Geometry	26

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Tech Reports	96	Qual Control	82	Prod Layout	41
Research	93	Comput Prog	69	Precis Mach	41
Drafting	93	Supervision	67	Elect Equip	39
Design	91	Testing	63	Aut Equip	35
Instr Calib	89	Sales, etc	52		
Systems Anal	87	Prod Inspect	49		

Employee Practice

Tech Reports	71	Testing	44
Design	68	Sales, etc	38
Supervision	62	System Anal	36
Research	53	Drafting	28

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the Job	72	64
Subsidize in Schools	85	37
Arrange in schools	60	24
Personal choice and cost		37

(Purpose)	Emplr	Emple
Make up educ deficiency	34	
Keep up with adv tech	81	72
Prep for higher position	73	43
Better educ background	82	71

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy		Employee Opinion	
Performance	97	Performance	81
Experience	93	Experience	58
Education	66	Education	30
Personality	54	Personality	24
Seniority	13	Seniority	9

JOB SATISFACTION: (88% feel they made a good career choice)

Nature of work	86	Emplr Relations	64
Salary	72	Opp for advance	53
Fringe Benefits	72	Job security	47
Facilities	68		

JOB DISSATISFACTION:
-0-

SOURCES OF RECRUITMENT:

1st: Promotion from within	54
2nd: Direct from schools	56
3rd: Other employers	36

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Similar job out of State	31
School	20
Lower level, same employer	16
Similar job in Arizona	14

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
30s: 37	More than 10: 56	Upper 10%: 33	Coll Prep: 60
40s: 30	5 to 10: 22	Upper ¼: 27	General 21

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
1 to 5 years: 9	1 to 5 yrs: 14	More than 10 yrs: 51
More than 10 yrs: 8	More than 5 yrs: 6	5 to 10 yrs: 22

MONTHLY SALARY RANGES: (two highest responses)

	Employers' Schedule		Present Personnel
Min:	700 to 900: 47	500 to 700: 31	900 to 1,200: 53
Max:	More than 1,200: 64	900 to 1,200: 14	More than 1,200: 22

Mechanical Engineering: This field requires knowledge and experience in broad areas of engineering, with an emphasis on experience rather than academic specialization. Neither employers nor the engineers themselves indicated a strong need for advanced preparation in technical courses, but a general knowledge of every course except geology and computergraphics is required. Technological advancement in the next five years is expected to increase the need for manufacturing processes, computer programming, computer technology, and business administration. Employment in this field requires at least a bachelor's degree in engineering, preferably a masters. Most employers subsidize additional education for their employees, would like to see more people trained for mechanical engineering, and more emphasis on communications.

Mechanical engineers have the second highest percentage of any field who report that most of their technical skills and knowledge were acquired on the job rather than in school, next only to industrial engineers. These two fields also have the highest percentages of engineers with previous experience as skilled craftsmen. Job satisfaction is fairly high, especially with the nature of the work. Salaries range from less than $700 to more than $1,200 per month. Mechanical engineers in the survey reported the highest percentage of any field earning more than $900. Employers prefer to fill new positions through promotion from within their own organizations, but most of the men who answered questionnaires have come from similar jobs in other companies or from school.

TABLE 39
PROFILE OF METALLURGICAL ENGINEERING

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
BS-BA	87	MS-MA	23	BS-BA	63
Tech Certificate	6	Ph.D	19	Ph.D	15

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Geometry	98	Reading	91	Geology	55
Physics	98	Speaking	91	Machine Tool	54
Chemistry	98	Dif Equa	86	Humanities	51
Writing	98	Electric	86	Mach Econ	46
Metallurgy	97	Instr Calib	85	Comput Prog	45
Algebra	97	Mfg Process	83	Comput Tech	43
Trig	97	Hyd-Pneumat	81	Integr Circ	42
Non-metal	96	Business Ad	75	Computgraph	28
Drafting	96	Soc Studies	73		
Calculus	92	Machinablty	60		

Employee Opinion

Metallurgy	98	Electric	76
Physics	98	Geology	71
Chemistry	98	Mfg Process	70
Algebra	96	Calculus	69
Writing	96	Business Ad	63
Reading	96	Soc Studies	54
Speaking	94	Dif Equa	48
Instr Calib	87	Comput Prog	47
Non-metal	85	Mach Tools	43
Geometry	85	Machinablty	43
Trig	81	Humanities	43
Hyd-Pneumat	79	Integ Circ	39
Drafting	79	Comput Tech	37
		Mach Econ	35

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED:

Employer Opinion

Metallurgy	88	Writing	35	Calculus	30
Chemistry	69	Non-metal	33	Reading	29
Mfg Process	42	Algebra	31	Dif Equa	27
Physics	41	Trig	31	Geometry	26
				Speaking	26

Employee Opinion

Metallurgy	83	Reading	35
Chemistry	67	Speaking	33
Physics	46	Calculus	28
Writing	44	Non-metal	28

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Tech Reports	97	Design	92	Elect Equip	59
Testing	97	Supervision	87	Aut Equip	59
Research	96	Drafting	86	Comput Prog	44
Syst Anal	95	Prod Inspect	78	Surveying	42
Qual Control	95	Prod Layout	75	Precis Mach	31
Instr Calib	93	Sales, etc	61		

Employee Practice

Tech Reports	83
Research	81
Supervision	76
Testing	39
Design	37
Prod Inspect	34

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	38	44
Subsidize in schools	55	17
Arrange in schools	55	20
Personal choice and cost		28

(Purpose)	Emplr	Emple
Make up educ deficiency	20	
Keep up with adv tech	67	56
Prep for higher position	41	24
Better educ background	77	63

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy		Employee Opinion	
Performance	100	Performance	76
Experience	87	Experience	65
Education	50	Education	26
Personality	27	Personality	24
Seniority	2	Seniority	15

JOB SATISFACTION: (78% feel they made a good career choice)

Nature of work	93	Employer Relations	50
Facilities	65	Salary	44
Fringe Benefits	61	Opp for advancement	37
Importance of work	54	Job Security	37

JOB DISSATISFACTION:

Opp for advancement	43
Salary	37
Employer Relations	26

SOURCES OF RECRUITMENT:

1st: Promotion within	56
2nd: Other employers	45
3rd: Direct from schools	49

EMPLOYEE'S LAST PREVIOUS EMPLOYMENT:

Same job, out of state	41
School	20
Lower level, same employer	11
Same job in Arizona	9
Armed Services	6

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
40s: 31	More than 10 yrs: 56	Upper 10%: 48	Coll Prep: 68
50s: 26	5 to 10 yrs: 17	Upper ¼: 24	General: 18

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
1 to 3 yrs: 4	1 to 3 yrs: 13	More than 10 yrs: 5
3 to 5 yrs: 2	3 to 10 yrs: 6	1 to 3 yrs: 1

MONTHLY SALARY RANGES: (two highest responses)

	Employers' Schedule		Present Personnel
Min:	500 to 700: 44	700 to 900: 37	900 to 1,200: 31
Max:	900 to 1,200: 42	More than 1,200: 33	700 to 900: 30

Metallurgical Engineering: These, like other engineers, spend most of their time in research, supervision, and writing technical reports. Their technical responsibilities include testing, design, inspection, and varying amounts of systems analysis, quality control, instrumentation, equipment utilization, and sales. A general knowledge of every subject covered in the survey is needed for this field according to substantial numbers of both engineers and their employers. The future is expected to bring more emphasis on the physical sciences, materials, and communication, plus instrument calibration, electronics, and business administration. A bachelor's degree is almost mandatory for employment, and a masters or even a doctorate is preferred. One-fourth of the engineers who answered questionnaires reported having graduate degrees, and two-thirds said most of the skills and knowledge required in the occupation were learned in college.

Salaries are not as high as most other fields. The maximum for two-thirds of the metallurgical engineers in Arizona is under $1,200. Job satisfaction is somewhat lower than in other engineering fields with the exception of mining which is even lower. In both cases this may be partly the result of the nationwide copper strike going on when the survey was made.

TABLE 40

PROFILE OF MINING ENGINEERING

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements	Employer Preference	Employee Achievement
BS-BA 83	BS-BA 83	BS-BA 82
MS-MA 6	MS-MA 9	MS-MA 5

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Physics	82	Trig	79	Humanities	63
Geology	82	Chemistry	79	Mach Econ	62
Writing	81	Metallurgy	79	Electric	61
Reading	81	Non-metal	78	Mfg Process	54
Speaking	81	Dif Equa	75	Comput Prog	41
Geometry	80	Hyd-Pneumat	75	Comput Tech	41
Calculus	80	Business Ad	75	Mach Tools	36
Drafting	80	Soc Studies	71	Machinablty	36
Algebra	79	Instr Calib	68		

Employee Opinion

Trig	91	Calculus	56
Geology	91	Non-metal	52
Writing	90	Comput Prog	50
Algebra	89	Instr Calib	48
Drafting	87	Electric	48
Geometry	85	Soc Studies	42
Reading	85	Mfg Process	39
Speaking	84	Comput Tech	38
Chemistry	78	Mach Econ	36
Physics	77	Dif Equa	32
Metallurgy	68	Mach Tools	31
Business Ad	63	Humanities	29
Hyd-Pneumat	62	Machinablty	25

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Writing	58	Drafting	33
Reading	58	Algebra	32
Geology	51	Trig	32
Physics	40	Chemistry	26
Speaking	36	Hyd-Pneumat	25
Geometry	34		

Employee Opinion

Geology	56	Geometry	32
Trig	29	Algebra	29
Writing	35	Speaking	29
Reading	35	Drafting	27

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Surveying	81	Testing	77	Instr Calib	55
Tech Reports	81	Design	74	Sales, etc	51
Research	80	Qual Control	73	Prod Inspec	45
Drafting	80	Prod Layout	65	Comput Prog	39
Supervision	79	Systems Anal	61	Elect Equip	37

Employee Practice

Supervision	64	Surveying	28
Tech Reports	54	Prod Inspt	26
Drafting	48	Prod Layout	26
Prod Design	44	Qual Contr	25
Research	35		

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	33	61
Subsidize in schools	35	13
Arrange in schools	36	19
Personal choice and cost		34

(Purpose)	Emplr	Emple
Make up educ deficiency	10	
Keep up with adv tech	47	60
Prep for higher position	58	31
Better educ background	60	60

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy	
Performance	100
Experience	77
Education	61
Seniority	25
Personality	23

Employee Opinion	
Performance	77
Experience	68
Education	54
Seniority	34
Personality	26

JOB SATISFACTION: (71% feel they made a good career choice)

Nature of work	89	Importance of work	53
Facilities	76	Job Security	52
Fringe Benefits	68	Opp for advancement	45
Emplr Relations	68	Salary	31

JOB DISSATISFACTION:

Salary	45
Opp for advancement	34

SOURCES OF RECRUITMENT:

1st: Promotion from within 47
2nd: Other employers 44
3rd: Direct from schools 33

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

School	24
Same job, out of state	21
Lower level, same employer	21
Same job in Arizona	5

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
40s: 34	More than 10: 58	Upper 10%: 33	Coll Prep: 62
30s: 26	5 to 10 yrs: 15	Upper ¼: 30	General: 30

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
Up to 3 yrs: 5	Up to 3 yrs: 9	More than 10 yrs: 55
3 to 5 yrs: 2	More than 3 yrs: 8	5 to 10 yrs: 18

MONTHLY SALARY RANGES: (two highest responses)

	Employers' Schedule		
Min:	500 to 700: 72	700 to 900: 15	
Max:	900 to 1,200: 36	700 to 900: 36	
	More than 1,200: 22		

Present Personnel	
700 to 900:	37
900 to 1,200:	27
More than 1,200:	13

Mining Engineering: The principal activities reported are supervision and writing technical reports, with a varying amount of drafting, design, research, surveying, production inspection, production layout, and quality control. Employers indicate that future trends in education should emphasize business administration, computer programming, and especially communications. Present requirements include a general knowledge of almost every technical area in engineering sciences, and advanced preparation in math through calculus, the physical sciences, communications, and drafting. A baccalaureate degree is almost universally required for employment, but there is less interest in advanced degrees in mining than in any other field on the part of both employers and the engineers themselves. Support for continuing education is correspondingly low. Employers also report less need to expand enrollments or add educational programs in Arizona than in other fields of engineering.

Since the survey was made during a nation-wide strike in the copper industry, it is not surprising to find 45% of the mining engineers dissatisfied with salaries compared with 30% who are satisfied. However, this field ranks with geological and chemical engineering at the bottom of the salary scale. Not only did the mining engineers who answered the questionnaires report lower salaries than other engineers, but employers reported the lowest maximum salaries of any field. In other respects such as high school class rank, baccalaureate or higher degrees, and experience, mining engineers rank near the top of the profession.

TABLE 41
PROFILE OF ASSOCIATE CIVIL ENGINEERING

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
HS	75	AS-AA	68	Some Coll, No Degree	34
Some Coll	19	BS-BA	20	BS-BA	24

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Geometry	96	Speaking	92
Algebra	95	Physics	88
Trig	95	Calculus	86
Drafting	93	Business Ad	85
Writing	92	Chemistry	82
Reading	92	Geology	81

Employee Opinion

Algebra	93	Instr Calib	58
Trig	93	Business Ad	54
Geometry	91	Chemistry	51
Writing	85	Hyd-Pneumat	40
Reading	85	Calculus	32
Drafting	84	Soc Studies	29
Speaking	82	Non-Metal	27
Physics	61	Dif Equa	26
Geology	59		

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

None

Employee Opinion

Trig	39
Drafting	33
Ceometry	32
Algebra	31

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Drafting	94	Sales, etc	85
Surveying	91	Testing	82
Tech Reports	90	Qual Control	75
Supervision	90		

Employee Opinion

Supervision	80	Prod Inspect	33
Drafting	52	Research	33
Surveying	50	Testing	31
Qual Control	42	Sales, etc	26
Tech Reports	42		

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	27	65
Subsidize in schools	86	6
Arrange in schools	10	11
Personal choice and cost		53

(Purpose)	Emplr	Emple
Make up educ deficiency	16	
Keep up with adv tech	17	75
Prep for higher position	85	57
Better educ background	20	73

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employment Policy	
Performance	98
Experience	85
Education	11
Personality	8
Seniority	6

Employee Opinion	
Performance	72
Experience	68
Education	35
Personality	29
Seniority	21

JOB SATISFACTION: (85% feel they made a good career choice)

Nature of work	93	Employer Relations	67
Facilities	78	Fringe Benefits	60
Job Security	76	Importance of work	60
Opportunity for adv	68	Salary	46

JOB DISSATISFACTION:
Salary 36

SOURCES OF RECRUITMENT:

1st: Promotion from within	88
2nd: Other Employers	77
3rd: None	0

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Lower level, same employer	27
Same job in Arizona	20
Same job, out of state	14
School	17

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
30s: 35	More than 10 yrs: 63	Upper ½: 40	Coll Prep: 42
40s: 24	5 to 10 yrs: 17	Upper ¼: 24	General: 41

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
Up to 10 yrs: 8	Up to 10 yrs: 34	Up to 10 yrs: 24
More than 10 yrs: 8	More than 10 yrs: 29	More than 10 yrs: 21

MONTHLY SALARY RANGES: (two highest responses)

	Employers' Schedule		Present Personnel
Min:	500 to 700: 90	Less than 500: 5	500 to 700: 52
Max:	700 to 900: 90	900 to 1,200: 6	700 to 900: 44

Associate Civil Engineering: This occupation involves supervision, drafting, surveying, and some technical report writing. A general knowledge of physics, chemistry, geology, communications and business administration is needed as well as some advanced knowledge of algebra, geometry, trigonometry, and drafting. Future requirements are expected to be higher in all areas of math, including calculus and differential equations. About three-fourths of the associate civil engineers in the survey received most of their training on the job, the rest in college. The minimum educational requirement in most cases is a high school diploma, but most employers prefer applicants with at least associate degrees. The majority of employers feel the junior colleges should increase their responsibility for developing associate engineers. Employer subsidies for continuing education are available, but comparatively few employees have actually taken additional courses.

Job satisfaction is high as far as the work is concerned but fairly low in the matter of salaries, which start at $500 to $700 per month and go no higher than $900. Employers have only two real preferences of where to get new personnel for this occupation: promote them up from lower level positions or hire them away from other employers. Most associate civil engineers in the survey have come from similar jobs with other employers and no doubt up from the ranks at one time. They are almost evenly divided in age from the twenties to the fifties, and most of them expect to continue to advance to higher positions in civil engineering and management.

TABLE 42
PROFILE OF ASSOCIATE ELECTRICAL ENGINEERING

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
HS	86	AS-AA	66	Coll, No Degree	44
Some Coll	10	Coll, No Degree	19	HS	14

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion				Employee Opinion			
Electric	100	Comput Tech	80	Writing	91	Physics	54
Algebra	100	Integ Circ	77	Drafting	89	Instr Calib	46
Speaking	97	Geometry	73	Reading	87	Integ Circ	46
Drafting	95	Calculus	71	Speaking	87	Comput Prog	46
Instr Calib	92	Dif Equa	70	Electric	85	Mfg Process	38
Trig	85	Comput Prog	67	Algebra	82	Comput Tech	29
Writing	85	Business Ad	64	Geometry	71	Calculus	27
Physics	82	Computgraph	58	Trig	63	Soc Studies	27
Reading	82	Mfg Process	27	Business Ad	61		

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion		Employee Opinion
Electric	63	None
Algebra	60	
Geometry	59	

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements				Employee Practices			
Tech reports	94	Supervision	82	Drafting	57	Prod layout	30
Syst Anal	93	Sales, etc	80	Supervision	50	Surveying	30
Testing	92	Prod Layout	69	Research	46	Sales, etc	29
Drafting	91	Surveying	57	Tech Reports	43	Syst Anal	26
Instr Calib	90	Design	37	Design	36		
Qual Control	88	Research	29				
		Precis Mach	25				

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	93	92
Subsidize in schools	89	20
Arrange in schools	82	27
Personal choice and cost		44

(Purpose)	Emplr	Emple
Make up educ deficiency	80	
Keep up with adv tech	87	85
Prep for better position	83	48
Better educ background	91	76

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy		Employee Opinion	
Performance	100	Performance	67
Experience	94	Experience	57
Personality	68	Personality	37
Education	65	Education	37
Seniority	3	Seniority	10

Cont. Associate Electrical Engineering

JOB SATISFACTION: (86% feel they made a good career choice)

Nature of work	88	Salary	60
Facilities	78	Importance or work	55
Fringe benefits	76	Opportunity for adv	48
Employer Relations	64		

JOB DISSATISFACTION:
Opportunity for adv 27

SOURCES OF RECRUITMENT:

1st:	Promotion from within	92
2nd:	Direct from school	66
3rd:	Other employers	26

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Lower level, same employer	26
Armed Services	21
School	14
Out of state, same job	13

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
30s: 38	More than 10 yrs: 65	Upper ½: 32	Coll Prep: 51
40s: 38	5 to 10 yrs: 12	Upper 10%: 25	General: 25

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
More than 3 yrs: 20	More than 3 yrs: 31	More than 10 yrs: 34
Less than 3 yrs: 4	Less than 3 yrs: 14	5 to 10 yrs: 19

MONTHLY SALARY RANGES: (two highest responses)

	Employers' Schedule		Present Personnel
Min:	500 to 700: 88	700 to 900: 3	700 to 900: 66
Max:	700 to 900: 67	900 to 1,200: 26	500 to 700: 20

Associate Electrical Engineering: The work performed is similar to that of electrical engineers but with more emphasis on applied technology than on supervision, research, and writing technical reports. Drafting, production design, production layout, and surveying are found more frequently in the associate engineer's duties. A general knowledge of virtually all courses in math, science, communications, business administration, liberal arts, and technical subjects pertaining to electricity and manufacturing is considered necessary by both employers and employees. Very little advanced knowledge is needed. The minimum educational requirements for employment is high school. Most employers prefer associate degrees and feel that junior colleges and universities both should increase their responsibility in educating persons for this field. Three-fourths of the associate engineers who answered questionnaires acquired most of their technical knowledge and skills on the job.

Salaries reflect lower educational requirements compared with engineers. They range from $500 per month to $1,200. Two-thirds of those who answered questionnaires are in the $700 to $900 bracket. Job satisfaction is only moderately high, with some noticeable dissatisfaction with opportunities for advancement. The typical associate electrical engineer is about 40 years of age, ranked in the upper half of his high school class, has some college but no degree, is continuing his education -- if at all -- at a slow pace, came to his present job from a similar position in another company or the armed forces, and expects to be working as a full engineer or in management ten years from now.

TABLE 43
PROFILE OF ASSOCIATE MECHANICAL ENGINEERING

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
Voc-Tech	79	BS-BA	50	Some Coll, no degree	33
HS	11	AS-AA	37	BS-BA	17

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Algebra	99	Mfg Process	58
Trig	98	Mach Econ	55
Drafting	96	Calculus	53
Metallurgy	86	Machinablty	47
Non-Metal	84	Instr Calib	46
Hyd-Pneumat	84	Physics	44
Geometry	66	Electric	41
Writing	66		

Employee Opinion

Drafting	90	Geometry	69	Hyd-Pneu	54
Mach Tools	83	Trig	66	Metallurgy	48
Reading	83	Instr Calib	66	Soc Studies	41
Speaking	82	Physics	62	Comput Tech	41
Mfg Process	80	Non-Metal	58	Comput Prog	35
Algebra	76	Chemistry	58	Calculus	31
Machinablty	76	Business Ad	58	Integ Circ	31
Electric	76	Mach Econ	55	Humanities	31
Writing	74				

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion	Employee Opinion	
None	Speaking	41
	Reading	38
	Writing	34
	Drafting	31
	Mfg Process	28

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Drafting	98	Syst Anal	57
Testing	96	Instr Calib	53
Prod Design	94	Precis Mach	44
Qual Control	93	Elect Equip	36
Tech Reports	93		

Employee Opinion

Supervision	56	Sales, etc	35
Drafting	48	Syst Anal	34
Tech Reports	48	Qual Control	28
Research	42	Testing	27
Prod Design	38		

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	89	31
Subsidize in schools	87	31
Arrange in schools	84	17
Personal choice and cost		41

(Purpose)	Emplr	Emple
Make educ deficiency	86	
Keep up with adv tech	89	55
Prep for higher position	90	41
Better educ background	92	76

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy		Employee Opinion	
Performance	99	Performance	59
Experience	94	Experience	52
Education	83	Education	41
Seniority	6	Personality	31
Personality	5	Seniority	7

JOB SATISFACTION: (86% feel they made a good career choice)

Nature of work	69	Importance of work	38
Employer Relations	62	Salary	34
Facilities	55	Fringe Benefits	34
Job Security	38	Opportunity for advancement	31

JOB DISSATISFACTION:
-0-

SOURCES OF RECRUITMENT:

1st: Promotion from within	90
2nd: Direct from schools	49
3rd: Other Employers	46

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Lower level, same employer	28
School	24
Same job in Arizona	21
Same job, out of state	10

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
20s: 31	More than 10 yrs: 34	Upper ¼: 37	Coll Prep: 41
30s: 31	5 to 10 yrs: 31	Upper ½: 34	General: 31

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
More than 10 yrs: 21	Up to 10 yrs: 34	Up to 10 yrs: 27
Up to 10 yrs: 10	More than 10 yrs: 7	More than 10 yrs: 21

MONTHLY SALARY RANGES: (two highest responses)

Employers' Schedule		Present Personnel
Min: 500 to 700: 58	Less than 500: 36	700 to 900: 45
Max: 700 to 900: 56	900 to 1,200: 40	500 to 700: 28

Associate Mechanical Engineering: The duties of associate mechanical engineers include production design, testing, drafting, and writing technical reports. The job requires a general knowledge of math through trigonometry, physics, nonmetallic materials, hydraulics-pneumatics, and machine economics. An advanced knowledge is needed of manufacturing processes, drafting, and communications.

Employers anticipate an increasing demand for trained associate mechanical engineers. They favor cooperative education, increased responsibility for training in high schools, voc-tech schools, junior colleges and universities. Most employers subsidize continuing education. Educational requirements for this occupation are vocational-technical training or high school, but employers prefer a baccalaureate degree or associate degree. Most personnel have some college. Salaries range from below $500 to more than $1,200 per month with the average somewhat under $900. Most personnel are in their 20s or 30s. The overwhelming choice of employers in filling this job is to promote men from lower level positions, but less than one-third of those who answered questionnaires had acquired their positions that way. Nearly one-fourth of them came directly from school, possibly without finishing degree programs.

TABLE 44
PROFILE OF CONSTRUCTION ENGINEERING

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
HS	23	Some Coll	66	Some Coll	52
Less than HS	20	Voc-Tech	14	HS	24

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Reading	94	Electric	42
Speaking	93	Soc Studies	41
Algebra	86	Instr Calib	40
Drafting	82	Mach Tools	40
Geometry	81	Geology	39
Writing	80	Non-metals	37
Business Ad	78	Humanities	36
Trig	74	Chemistry	34
Physics	54	Comput Prog	28
Hyd-Pheumat	48	Mfg Process	27

Employee Opinion

Speaking	90	Mfg Process	44
Drafting	88	Instr Calib	43
Reading	83	Electric	43
Writing	80	Non-metal	39
Geometry	76	Machinablty	39
Algebra	71	Soc Studies	37
Business Ad	67	Hyd-Pneumat	34
Trig	48	Geology	34
Physics	45	Mach Econ	33
Mach Tools	45	Chemistry	29

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion	Employee Opinion
Speaking	None

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Drafting	86	Tech Reports	61	Qual Control	56
Supervision	84	Testing	61	Syst Anal	42
Surveying	78	Prod Layout	60	Prod Design	40
Sales, etc	62	Prod Inspect	58	Instr Calib	28

Employee Practice

Supervision	63	Qual Contr	3
Prod Design	54	Surveying	3
Drafting	47	Tech Report	3
Prod Layout	46	Sales, etc	5
Prod Design	42	Testing	2
Research	40		

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the Job	51	49
Subsidize in schools	34	11
Arrange in schools	27	13
Personal choice and cost		26

(Purpose)	Emplr	Emple
Make up educ deficiency	19	
Keep up with adv tech	24	56
Prep for higher position	21	33
Better educ background	43	54

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy		Employee Opinion	
Performance	86	Performance	84
Experience	63	Experience	66
Personality	55	Seniority	42
Seniority	17	Personality	21
Education	11	Education	20

JOB SATISFACTION: (93% feel they made a good career choice)

Nature of work	92	Opport for adv	65
Facilities	79	Job Security	56
Salary	78	Fringe Benefits	52
Employer Relations	76	Importance of work	49

JOB DISSATISFACTION:
-0-

SOURCES OF RECRUITMENT:

1st: Promotion from within	68
2nd: Other employers	47
3rd: Direct from School	20

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Same job, in Arizona	31
Lower level, same employer	16

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
40s: 40	More than 10: 76	Upper ½: 33	General: 41
50s: 24	5 to 10: 9	Upper ¼: 21	Coll Prep: 30

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
More than 10 yrs: 31	Less than 10 yrs: 16	More than 10 yrs: 28
Less than 10 yrs: 9	More than 10 yrs: 10	Less than 10 yrs: 11

MONTHLY SALARY RANGES: (two highest responses)

	Employers' Schedule		Present Personnel
Min:	500 to 700: 47	700 to 900: 22	700 to 900: 31
Max:	900 to 1,200: 40	More than 1,200: 30	900 to 1,200: 29

Construction Engineering: Construction engineers included in the survey are supervisory personnel in construction companies or self-employed builders. They spend most of their time supervising construction projects, inspecting production, and in sales or public relations. Many of them also do some drafting, production layout, and office work. They need a general knowledge of math through trigonometry, communications, drafting, business administration, social studies, and a number of technical subjects. Virtually no advanced knowledge is required other than what they learn on the job. Most technical knowledge and skill of those in the survey was acquired that way. Approximately half of them have some college, and nearly one-fourth have baccalaureate degrees. High school or even less is the only educational requirement of most employers. Performance and experience are the major factors affecting advancement, with education ranked quite low. The trend, however, is toward higher formal educational requirements. Most employers prefer at least some college, and a degree eventually may be required.

Salaries in construction engineering are slightly lower than in other fields, but those who responded in the survey indicated a fairly high level of satisfaction with their salaries and most other aspects of their job. Most employers prefer to promote men into this occupation from lower level positions and many of those working in Arizona today have come up through the ranks.

TABLE 45
PROFILE OF AERONAUTICAL TECHNOLOGY

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
Voc-Tech	52	BS-BA	38	Voc-Tech	33
Some Coll, No Degree	19	Some Coll, No Degree	33	Some Coll, No Degree	26

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Hyd-pneumat	99	Machinablty	54
Electricity	94	Trig	53
Inst Calib	87	Calculus	52
Mach Tools	86	Business Ad	46
Writing	87	Metallurgy	45
Reading	87	Mach Econ	44
Algebra	66	Integ Circ	42
Geometry	65	Non-metal	41
Speaking	65	Soc Studies	40
Drafting	64	Humanities	39
Physics	62	Mfg Process	38
Chemistry	54	Dif Equa	37

Employee Opinion

Hyd-Pneumat	81	Algebra	51
Electric	76	Non-Metal	49
Inst Calib	72	Mfg Process	47
Mach Tools	69	Geometry	46
Reading	69	Metallurgy	46
Speaking	64	Integ Circ	42
Machinablty	63	Chemistry	35
Drafting	63	Business Ad	31
Writing	62	Mach Econ	29
Physics	52	Trig	27

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Algebra	38	Trig	32
Geometry	38	Physics	32
Metallurgy	38	Dif Equa	32
Electric	38	Machinablty	32
Hyd-Pneumat	38	Mach Econ	32
Mach Tools	33	Instr Calib	32

Employee Opinion

Hyd-Pneumat	40
Instr Calib	26
Electric	26

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Instr Calib	91	Supervision	75
Qual Control	87	Prod Inspect	67
Testing	86	Drafting	65
Elect Equip	83	Systems Anal	53
Tech Reports	82	Prod Design	44

Employee Opinion

Testing	48	Research	26
Supervision	45	Prod Inspect	27
Qual Control	40	System Anal	26
Instr Calib	34	Electric Equip	26
Tech Reports	34		

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	91	91
Subsidize in schools	45	10
Arrange in school	21	17
Personal choice and cost		26

(Purpose)	Emplr	Emple
Make up educ deficiency	22	
Keep up with adv tech	23	83
Prep for higher position	24	33
Better educ Background	53	59

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy	
Experience	97
Performance	94
Personality	29
Education	20
Seniority	2

Employee Opinion	
Experience	62
Performance	57
Seniority	50
Education	31
Personality	19

JOB SATISFACTION: (88% feel they made a good career choice)

Nature of work	86	Fringe Benefits	60
Facilities	67	Employer Relations	60
Job Security	67	Importance of work	59
Salary	60	Opportunity for advancement	45

JOB DISSATISFACTION:
Salary 26

SOURCES OF RECRUITMENT:
1st: Other Employers 28
2nd: Direct from Schools 46
3rd: None

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Same job, out of state	24
Armed Services	22
School	19
Lower level, same employer	14

PERSONNEL CHARACTERISTICS:

Age	Years Since Degree	HS Rank	HS Major
40s: 33	More than 10 yrs: 47	Upper ½: 44	General: 34
20s: 29	5 to 10 yrs: 21	Upper 3/4: 24	Coll Prep: 29

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
More than 10 yrs: 36	Up to 10 yrs: 28	1 to 3 yrs: 5
Up to 10 yrs: 20	More than 10 yrs: 14	-0-

MONTHLY SALARY RANGES: (two highest responses)

Employers' Schedule		Present Personnel
Min: 500 to 700: 40	Less than 500: 22	500 to 700: 43
Max: 700 to 900: 32	500 to 700: 28	700 to 900: 38

Aeronautical Technician: Supervision, testing, and quality control make up the principal activities of aeronautical technicians, with an appreciable amount of instrumentation and technical report writing. A general knowledge is needed of algebra, geometry, trigonometry, machine tools, machinability, and drafting, with advanced knowledge of hydraulics-pneumatics, instrument calibration and electronics. In the future, more preparation in all these areas plus applied metallurgy and non-metallic materials may be needed.

Most employers would like to see more people being trained in aeronautical technology, and they favor the vocational-technical schools for this job. The minimum educational requirement is a technical certificate or some college, and employers prefer more college -- many of them a BS degree. Most personnel who answered questionnaires have vocational-technical training or some college without a degree, and they say they acquired their technical skills and knowledge largely on the job. Salaries range from less than $500 to more than $900 per month, with most personnel reporting an average of a little under $800. More than one-fourth of those responding in the survey were dissatisfied with their salary, and fewer than half were pleased with their opportunities for advancement. Most of them expect to be working in higher positions in ten years, chiefly management.

TABLE 46
PROFILE OF CHEMICAL TECHNOLOGY

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
HS	77	Some Coll, No Degree	40	Some Coll, No Degree	40
Some Coll, No Degree	11	BS-BA	32	BS-BA	24

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Algebra	94	Trig	53
Chemistry	90	Metallurgy	41
Reading	90	Business Ad	40
Physics	86	Electric	36
Writing	86	Mach Tools	31
Speaking	75	Non-metal	30
Instr Calib	74	Mfg Process	29
Geometry	55	Drafting	27

Employee Opinion

Chemistry	91	Metallurgy	49
Algebra	78	Non-metal	48
Physics	71	Electric	39
Speaking	71	Mfg Process	36
Writing	67	Business Ad	32
Reading	66	Geology	31
Instr Calib	61	Drafting	30
Geometry	50		

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion		Employee Opinion	
Chemistry	60	Chemistry	42

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Instr Calib	85	Qual Control	55
Tech Reports	78	Elect Equip	32
Testing	77	Drafting	25
Supervision	60		

Employee Practice

Testing	60	Tech Reports	37
Supervision	46	Research	31
Qual Control	43	Instr Calib	26

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	60	60
Subsidize in school	50	12
Arrange in school	32	14
Personal Choice and cost		38

(Purpose)	Emplr	Emple
Make up educ deficiency	24	
Keep up with advancing tech	52	62
Prep for higher position	46	34
Better educ background	20	68

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy		Employee Opinion	
Performance	100	Performance	78
Experience	54	Experience	66
Education	32	Education	35
Personality	16	Seniority	23
Seniority	15	Personality	20

JOB SATISFACTION: (83% feel they made a good career choice)

Nature of work	92	Employer Relations	77
Fringe benefits	86	Importance of work	58
Job security	80	Salary	55
Facilities	77	Opportunity for advancement	40

JOB DISSATISFACTION:
Opportunity for adv 42

SOURCES OF RECRUITMENT:

1st: Promotion from within	56
2nd: Other employers	48
3rd: Direct from school	34

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Lower level, same employer	33
Same job in Arizona	17
Same job out of state	15
School	12

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
30s: 29	More than 10 yrs: 57	Upper 10%: 35	Coll Prep: 56
40s: 29	5 to 10 yrs: 25	Upper ½: 26	General: 30
50s: 22			

PREVIOUS EXPERIENCE:

Skilled		Technical		Engineering	
Up to 10 yrs:	7	Up to 10 yrs:	38	Up to 10 yrs:	
More than 10 yrs:	6	More than 10 yrs:	35	More than 10 yrs:	

MONTHLY SALARY RANGES: (two highest responses)

Employers' Schedule				Present Personnel	
Min: 500 to 700:	42	Less than 500:	34	500 to 700:	42
Max: 700 to 900:	35	500 to 700:	28	700 to 900:	37

Chemical Technology: The educational requirements for this occupation are a high school diploma and in some cases college. Employers prefer college work, many of them baccalaureate degrees, and the technicians who answered questionnaires have these qualifications. They require a general knowledge of algebra, geometry, and in some cases, trigonometry, communications, physical sciences, instrumentation, drafting and business administration. They need advanced knowledge only in chemistry. Their work consists primarily of testing, supervision, quality control, instrumentation and writing technical reports.

The chemical technicians who participated in the survey were in their 30s, 40s and 50s, earning an average of a little under $700 per month, and not too well pleased with their salaries. They liked their work, but nearly half of them were dissatisfied with their opportunities for advancement. Employers prefer to fill this position by promoting personnel within their own organizations, and nearly one-fourth of those in the survey had reached their present positions in that way. The great majority said they had acquired most of their technical knowledge and skills through experience, not in school. Advancing technology, however, is expected to require more preparation in the future, at least in physics, chemistry, and communications.

TABLE 47
PROFILE OF CIVIL TECHNOLOGY

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
HS	87	AS-AA	64	Some Coll, No Degree	36
Less than HS	6	Some Coll, No Degree	17	HS	35

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Trig	97	Algebra	89
Drafting	95	Physics	74
Writing	91	Chemistry	69
Reading	92	Geology	67
Speaking	92	Business Ad	63
Geometry	90		

Employee Opinion

Algebra	99	Writing	72
Geometry	80	Instr Calib	53
Drafting	78	Geology	33
Trig	77	Physics	31
Reading	77	Business Ad	31
Speaking	75		

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion
None

Employee Opinion
Trig 27

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Drafting	97
Surveying	97
Testing	82
Supervision	79
Quality Control	68
Sales, etc	67

Employee Practice

Supervision	54	Research	32
Surveying	53	Testing	30
Drafting	47	Quality Control	29
Tech Reports	37	Prod Inspect	25

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	34	66
Subsidize in school	82	5
Arrange in school	73	14
Personal choice and cost		40

(Purpose)	Emplr	Emple
Make up educ deficiency	22	
Keep up with adv tech	24	74
Prep for higher Position	81	60
Better educ background	27	71

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy

Performance	100
Experience	81
Education	14
Seniority	5
Personality	4

Employee Opinion

Performance	69
Experience	68
Education	35
Personality	19
Seniority	17

JOB SATISFACTION: (82% feel they made a good career choice)

Job Security	85	Employer Relations	64
Nature of work	84	Opportunity for advancement	61
Facilities	74	Importance of work	56
Fringe Benefits	66	Salary	42

JOB DISSATISFACTION:
Salary 36

SOURCES OF RECRUITMENT:

1st: Promotion from within	83
2nd: Other Employers	70
3rd: Direct from school	15

EMPLOYEES' LAST PREVIOUS EMPLOYMENT

Lower level, same employer	32
Same job in Arizona	18
School	14
Same job out of state	11

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
20s: 33	More than 10 yrs: 57	Upper ½: 39	General: 46
30s: 30	5 to 10 yrs: 22	Upper ¼: 18	Coll Prep: 37

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
Up to 10 urs: 11	Up to 10 yrs: 46	Up to 10 yrs:
More than 10 yrs: 7	More than 10 yrs: 21	More than 10 yrs:

MONTHLY SALARY RANGES: (two highest responses)

	Employers' Schedule		Present Personnel
Min:	Less than 500: 82	500 to 700: 15	500 to 700: 69
Max:	500 to 700: 67	700 to 900: 20	Less than 500: 22

Civil Technology: The principal duties in this occupation include supervision, drafting, surveying, and for many technicians, testing and quality control. They must be knowledgeable in algebra, geometry, trigonometry, instrument calibration, drafting, and communications. Advanced preparation is not greatly needed in any subject, however, all mathematics are expected to require more emphasis in the future. At the present time no formal educational requirement is necessary for employment. Employers prefer associate degrees, and most of those who answered the questionnaires have at least a high school diploma and many of them some college. Additional classroom training, either arranged by employers or subsidized by them, is available to most civil technicians.

Salaries in this occupation start at less than \$500 and go to \$900 or more per month. Most of those in the survey earn less than \$700, nearly one-fourth earning less than \$500, and a substantial number expressed dissatisfaction with this feature of the job. Employers prefer to fill positions in this occupation by promotion from within their organization or from other employers, and the great majority of civil technicians in the survey have come into their present jobs in one of these ways. They are largely young men in their 20s and 30s with limited experience, and a substantial majority expect to be in higher positions in engineering or technology ten years from now.

TABLE 48
PROFILE OF DATA PROCESSING TECHNOLOGY

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
Voc-Tech	66	AS-AA	67	Some Coll, No Degree	30
HS	27	BS-BA	14	Armed Services	15

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion				Employee Opinion			
Comput Tech	100	Physics	83	Comput Prog	96	Geometry	49
Reading	100	Computgraph	82	Comput Tech	92	Trig	48
Writing	99	Instr Calib	77	Reading	80	Physics	42
Speaking	99	Mfg Process	66	Speaking	80	Mfg Process	41
Algebra	97	Drafting	65	Algebra	75	Business Ad	41
Comput Prog	96	Business Ad	28	Electric	71	Calculus	31
Trig	93	Calculus	26	Writing	71	Drafting	29
Geometry	92	Dif Equa	26	Instr Calib	58	Dif Equa	27
Electric	86			Integ Circ	52	Mach Tools	26
Integ Circ	85			Computgraph	51		

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion		Employee Opinion	
Comput Prog	89	Comput Tech	56
Comput Tech	88	Comput Prog	47
Computgraph	80	Electric	42
Electric	67		
Integr Circ	66		

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements				Employee Practice			
Comput Prog	99	Qual Control	82	Comput Prog	63	Qual Control	38
Syst Anal	95	Testing	68	Supervision	48	Tech Reports	37
Tech Reports	95	Drafting	66	Syst Anal	45	Electr Equip	30
Supervision	85	Design	65	Testing	42		
Electr Equip	83						

CONTINUING EDUCATION:

(Extent)	Emplr	Emple	(Purpose)	Emplr	Emple
On the job	94	84	Make up educ deficiency	70	
Subsidize in schools	89	18	Keep up with advancing tech	83	89
Arrange in schools	81	25	Prep for higher position	83	48
Personal choice and cost		43	Better educ background	72	65

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy		Employee Opinion	
Performance	100	Performance	38
Experience	92	Experience	33
Education	11	Education	11
Personality	9	Seniority	9
Seniority	1	Personality	8

JOB SATISFACTION: (88% feel they made a good career choice)

Nature of work	43	Fringe Benefits	30
Salary	35	Job Security	30
Facilities	35	Importance of work	29
Opportunity for adv	32		

JOB DISSATISFACTION:
-0-

SOURCES OF RECRUITMENT:

1st: Promotion from within	82
2nd: Direct from schools	71
3rd: Other Employers	14

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Armed Services	27
School	18
Same job in Arizona	16
Promotion	13

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
20s: 46	More than 10 yrs: 29	Upper ½: 41	Coll Prep: 45
30s: 32	5 to 10 yrs: 25	Upper ¼: 23	General: 38

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
Up to 10 yrs: 11	Up to 10 yrs: 58	Up to 10 yrs: 9
More than 10 yrs: 4	More than 10 yrs: 20	More than 10 yrs: 3

MONTHLY SALARY RANGES: (two highest responses)

Employers' Schedule		Present Personnel
Min: 500 to 700: 74	Less than 500: 24	500 to 700: 71
Max: 500 to 700: 70	900 to 1,200: 19	700 to 900: 13

Data Processing Technology: The major activity in this occupation is computer programming, but duties also include supervision, systems analysis, testing, quality control, surveying, electronic equipment, and writing technical reports. These activities require a good general knowledge of mathematics through trigonometry, instrument calibration, electronics, integrated circuits, computergraphics, and communications. Advanced knowledge is required in computer programming and computer technology. The future is expected to bring higher requirements in the same areas, as well as in physics, chemistry, differential equations, manufacturing processes, and drafting. Nearly all employers favor strengthening communications and business courses in data processing education.

Employment in this field requires some voc-tech school training or armed service experience and there is a preference for junior college graduates. Nearly all employers indicate a growing demand for prople trained in data processing, and favor cooperative education programs and greater effort on the part of high schools, voc-tech schools, and junior colleges. They also encourage continuing education after employment, but education ranks at the bottom of all technical fields by both employers and employees as a major factor in advancement. Salaries range from less than $500 per month to around $1,200, with most personnel in Arizona earning between $500 and $700. Those who answered questionnaires reported about the same level of satisfaction with their choice of a career as other technical fields, but considerably lower levels of satisfaction with all of its features. Employers prefer to get new technicians by promoting persons from lower level jobs, but have a strong second preference for applicants from the schools. A substantial number of today's technicians came from the armed services, are young, and ambitious.

TABLE 49
PROFILE OF DRAFTING TECHNOLOGY

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
HS	54	AS-AA	40	Some Coll, No Degree	48
Voc-Tech	31	Some Coll, No Degree	33	HS	19

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Drafting	98	Non-metal	44
Trig	96	Mach Econ	42
Geometry	92	Business Ad	41
Speaking	92	Soc Studies	39
Reading	90	Humanities	37
Writing	89	Computgraph	35
Algebra	89	Electric	31
Mfg Process	47	Mach Tools	30
Machinablty	45		

Employee Opinion

Drafting	97	Mfg Process	50
Algebra	90	Machinablty	47
Geometry	90	Instr Calib	36
Trig	86	Non-metal	35
Reading	79	Hyd-Pneumat	33
Writing	78	Mach Econ	33
Speaking	72	Calculus	29
Electric	53	Chemistry	28
Physics	51	Integ Circ	27
Mach Tools	51	Business Ad	25

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion		Employee Opinion	
Drafting	75	Drafting	76

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Drafting	100	Sales, etc	41
Tech Reports	58	Prod Inspect	40
Prod Design	56	Supervision	27
Qual Control	50	Surveying	27

Employee Practice

Drafting	92
Research	52
Supervision	39
Prod Design	33

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the Job	74	65
Subsidize in schools	65	20
Arrange in schools	14	11
Personal choice and cost		49

(Purpose)	Emplr	Empl
Make up educ deficiency	55	
Keep up with adv technology	54	72
Prep for higher position	61	49
Better educ background	64	74

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy		Employee Opinion	
Performance	100	Performance	74
Experience	79	Experience	65
Education	53	Education	35
Personality	43	Personality	26
Seniority	9	Seniority	23

JOB SATISFACTION: (81% feel they made a good career choice)

Nature of work	78	Job Security	63
Facilities	72	Importance of work	56
Fringe Benefits	70	Salary	54
Employer Relations	64	Opportunity for adv	51

JOB DISSATISFACTION:
Opportunity for adv 26

SOURCES OF RECRUITMENT:
1st: Promotion from within 44
2nd: Direct from schools 42
3rd: None 0

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Lower level, same employer	24
Same job in Arizona	20
Same job out of state	17
School	15

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
20s: 36	More than 10 yrs: 49	Upper ½: 42	Coll Prep: 37
30s: 34	5 to 10 yrs: 20	Upper ¼: 23	General: 33

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
Up to 10 yrs: 29	Up to 10 yrs: 34	Up to 10 yrs: 14
More than 10 yrs: 20	More than 10 yrs: 8	More than 10 yrs: 9

MONTHLY SALARY RANGES: (two highest responses)

	Employers' Schedule		Present Personnel
Min:	Less than 500: 52	500 to 700: 46	500 to 700: 51
Max:	700 to 900: 65	900 to 1,200: 16	700 to 900: 22

Drafting Technology: This is a highly specialized field requiring advanced training only in drafting, but dependent on a broad knowledge of engineering and technology. A common comment by employers in the survey was that drafting technicians are not trained well enough in the use of ink and lettering. General knowledge of mathematics through trigonometry, communications,and equipment of all kinds is needed. The present educational requirements are high school or vocational-technical training, but most employers prefer associate degrees or at least some college. Nearly half of those who answered questionnaires have had some college education.

Salaries are in the same general range as other technical fields, and most of those in the survey are satisfied with the conditions under which they work. About one-fourth of them are dissatisfied with their opportunities for advancement, a characteristic of most technical employment revealed in the survey. Drafting technicians are also comparatively young and ambitious. Employer and employee opinion about factors governing advancement is very similar in all occupations, and this one is no exception. Performance first and experience second rank considerably higher than education, personality, and seniority.

TABLE 50
PROFILE OF ELECTRICAL TECHNOLOGY

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
HS	59	Armed Services	19	Some coll, no degree	26
Voc-Tech	13	BS-BA	15	Voc-Tech	24

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Electric	97	Mach Tools	41
Reading	86	Hyd-Pneumat	38
Algebra	74	Calculus	34
Drafting	67	Chemistry	34
Speaking	67	Metallurgy	31
Writing	63	Comput Prog	32
Geometry	63	Non-metal	30
Physics	60	Dif Equation	27
Trig	59	Machinablty	27
Instr Calib	50	Business Ad	25
Integ Circ	50		

Employee Opinion

Electric	93	Trig	47
Reading	88	Machinablty	47
Algebra	78	Chemistry	41
Speaking	78	Business Ad	39
Writing	71	Mfg Process	37
Instr Calib	66	Non-metal	35
Drafting	65	Hyd-Pneumat	35
Geometry	64	Dif Equation	27
Physics	59	Comput Prog	27
Mach Tools	56	Soc Studies	25
Integ Circ	51		

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion		Employee Opinion	
Electric	55	Electric	49
Algebra	35		
Geometry	28		
Physics	27		

SKILLED ACTIVITIES: (25% or more response)

Employer Requirement

Instr Calib	64	Qual Control	43
Elect Equip	58	System Anal	41
Drafting	57	Prod Design	27
Tech Reports	57	Precis Mach	27
Supervision	52	Prod Inspect	26
Testing	49		

Employee Practice

Supervision	51	Tech Reports	31
Research	33	Testing	30
Drafting	31	Instr Calib	30
Elect Equip	31		

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	86	65
Subsidize in schools	75	20
Arrange in schools	54	11
Personal choice and cost		49

(Purpose)	Emplr	Emple
Make up educ deficiency	46	
Keep up with advancing tech	58	76
Prep for higher position	59	47
Better educ Background	78	75

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy		Employee Opinion	
Experience	68	Experience	76
Performance	63	Performance	68
Personality	34	Personality	40
Education	32	Seniority	31
Seniority	31	Education	29

JOB SATISFACTION: (90% feel they made a good career choice)

Nature of work	97	Employer Relations	69
Job Security	87	Salary	68
Facilities	85	Importance of work	65
Fringe Benefits	84	Opportunity for adv	51

JOB DISSATISFACTION:
Opportunity for adv 25

SOURCES OF RECRUITMENT:
1st: Promotion from within 71
2nd: Direct from Schools 25
3rd: Other Employers 22

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:
Same job out of state 24
Same job in Arizona 21
Lower level, same employer 19
Armed Services 15

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
30s: 32	More than 10 yrs: 49	Upper ½: 33	General: 32
40s: 25	5 to 10 yrs: 29	Upper ¼: 25	Coll Prep: 26

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
More than 10 yrs: 28	Up to 10 yrs: 32	Up to 10 yrs: 10
Up to 10 yrs: 26	More than 10 yrs: 19	More than 10 yrs: 4

MONTHLY SALARY RANGES: (two highest responses)

	Employers' Schedule		Present Personnel
Min:	500 to 700: 33	700 to 900: 25	500 to 700: 46
Max:	700 to 900: 64	500 to 700: 29	700 to 900: 40

Electrical Technology: The principal activity of electrical technicians seems to be supervision, followed by testing, instrumentation and calibration, setting up and maintaining electronic equipment, and writing technical reports. Electricity and electronics are the only areas requiring advanced knowledge. A general knowledge is needed of algebra, geometry, trigonometry, physics, instrument calibration, integrated circuits, drafting and communications.

Employment usually requires completion of high school or vocational-technical training. Employers are not particularly concerned about educational qualifications beyond that level although a few would prefer baccalaureate degrees. Most electrical technicians in the survey received their training on the job, and the only real preference employers have in getting new personnel in this occupation is to promote them from lower level positions. A substantial number are hired from similar jobs elsewhere. They tend to be somewhat older than personnel in other technical fields, earn somewhat higher salaries, and generally are satisfied with their careers. One-fourth are dissatisfied with their opportunities for advancement.

TABLE 51
PROFILE OF ELECTRONICS TECHNOLOGY

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
Voc-Tech	46	AS-AA	46	Some Coll, No Degree	36
HS	39	Some Coll, No Degree	21	Voc-Tech	19

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Electric	100	Chemistry	58
Algebra	97	Business Ad	57
Reading	93	Soc Studies	57
Speaking	92	Comput Tech	56
Trig	92	Comput Prog	55
Geometry	91	Humanities	55
Physics	90	Mach Tools	49
Writing	89	Mfg Process	48
Instr Calib	84	Non-metal	37
Drafting	77	Calculus	29
Integ Circ	76		

Employee Opinion

Electric	96	Mfg Process	52
Algebra	92	Mach Tools	52
Instr Calib	87	Comput Tech	44
Reading	83	Chemistry	42
Speaking	82	Calculus	39
Integ Circ	78	Dif Equa	34
Writing	76	Machinablty	34
Trig	73	Comput Prog	34
Physics	72	Non-metal	30
Geometry	68	Business Ad	30
Drafting	57		

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion		Employee Opinion	
Electric	68	Electric	73
Instr Calib	57	Instr Calib	41
Integ Circ	56	Integ Circ	36
Algebra	55	Algebra	27

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Elect Equip	97	Drafting	70
Instr Calib	95	Prod Inspect	63
Testing	90	Research	58
Tech Reports	86	Comput Prog	53
Qual Control	79	Precis Mach	49
Supervision	76	Systems Anal	33

Employee Practice

Elect Equip	53	Testing	35
Supervision	49	Qual Control	20
Tech Reports	41	Systems Anal	27
Research	41		
Instr Calib	39		

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	91	79
Subsidize in schools	75	28
Arrange in schools	75	24
Personal choice and cost		45

(Purpose)	Emplr	Empl
Make up educ deficiency	56	
Keep up with advancing tech	65	82
Prep for higher position	71	49
Better educ background	75	77

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy		Employee Opinion	
Performance	99	Performance	77
Experience	75	Experience	67
Personality	61	Education	36
Education	52	Personality	24
Seniority	11	Seniority	19

JOB SATISFACTION: (85% feel they made a good career choice)

Nature of work	86	Importance of work	62
Facilities	76	Job Security	60
Fringe benefits	74	Salary	57
Employer Relations	67	Opportunity for adv	53

JOB DISSATISFACTION:

Opportunity for adv	25

SOURCES OF RECRUITMENT:

1st: Promotion from within	62
2nd: Other Employers	27
3rd: Direct from schools	29

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Same job out of state	23
Armed Services	22
Lower level, same employer	19
Same job in Arizona	16

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
30s: 40	More than 10 yrs: 44	Upper ½: 38	General: 41
20s: 29	5 to 10 yrs: 23	Upper ¼: 22	Coll Prep: 36

MONTHLY SALARY RANGES: (two highest responses)

	Employers' Schedule		Present Personnel
Min:	Less than 500: 62	500 to 700: 30	500 to 700: 50
Max:	700 to 900: 51	700 to 900: 28	700 to 900: 28

Electronics Technology: The primary responsibility of electronic technicians is setting up and maintaining electronic equipment. Their other activities include research, supervision, testing, instrumentation and calibration, and writing technical reports. The subjects they must know best are instrument calibration, electronics, and integrated circuits. They also need a general knowledge of mathematics through trigonometry, physics, drafting, and communications. The training of future electronic technicians should put more emphasis on algebra, trigonometry, physics, instrument calibration, electronics, integrated circuits, and communications.

Most employers of electronics technicians require high school or vocational technical training, and prefer junior college graduation. Employers feel more people should be trained in electronics technology, and they strongly favor junior colleges doing the job. At the present time they prefer to get new personnel for this occupation by promoting lower level employees. Most of those in the survey came to their present positions from similar jobs elsewhere or from the armed services.

Salaries range from below $500 to more than $900 per month, with the average somewhat below $700. Electronics technicians are younger than electrical technicians, have about the same high school background, have more college education, about the same amount of continuing educational interest, have less experience in the skilled crafts but more in technical employment, and acquired more of their technical knowledge and skills in the armed service or vocational technical school and less on the job.

TABLE 52
PROFILE OF INDUSTRIAL TECHNOLOGY

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
HS	82	Voc-Tech	55	Some Coll, No Degree	36
Voc-Tech	11	Some Coll, No Degree	37	HS	21

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Speaking	99	Physics	64
Algebra	91	Instr Calib	60
Reading	81	Drafting	58
Writing	90	Non-metal	50
Trig	85	Electric	49
Mfg Process	85	Soc Studies	38
Mach Tools	75	Hyd-Pneumat	37
Machinablty	73	Chemistry	35
Geometry	67	Mach Econ	28

Employee Opinion

Algebra	83	Trig	53
Speaking	83	Machinablty	53
Reading	80	Non-metal	51
Writing	79	Integ Circ	43
Mfg Process	75	Business Ad	43
Electric	75	Soc Studies	36
Instr Calib	68	Metallurgy	35
Geometry	67	Mach Econ	29
Drafting	63	Hyd-Pneumat	28
Chemistry	61	Calculus	28
Mach Tools	58	Humanities	26
Physics	54	Dif Equation	25

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion	Employee Opinion
None	Electric 30

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Supervision	95	Precis Mach	51
Prod Layout	93	Tech Reports	45
Qual Control	92	Aut Equip	36
Prod Inspect	91	Prod design	32
Instr Calib	88	Surveying	30
Testing	83	Research	28
Drafting	77	Syst Anal	25
Electr Equip	63	Sales, etc	25

Employee Practice

Supervision	61
Qual Control	55
Testing	34
Research	32
Tech Reports	32
Prod Inspect	27

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the Job	89	76
Subsidize in schools	80	33
Arrange in schools	34	20
Personal choice and cost		44

(Purpose)	Emplr	Emple
Make up educ deficiency	31	
Keep up with advancing tech	62	83
Prep for higher position	60	56
Better educ background	85	79

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy		Employee Opinion	
Performance	94	Performance	88
Experience	88	Experience	77
Personality	38	Personality	41
Education	25	Education	36
Seniority	12	Seniority	20

JOB SATISFACTION: (82% feel they made a good career choice)

Nature of work	82	Importance of job	64
Fringe Benefits	80	Job Security	62
Facilities	76	Salary	61
Employer Relations	67	Opportunity	56

JOB DISSATISFACTION:

Opportunity for adv 27

SOURCE OF RECRUITMENT:

1st: Promotion from within	70
2nd: Other Employers	74
3rd: Direct from School	26

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Lower level, same employer	24
Same job out of state	23
Armed Services	18
Same job in Arizona	11

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
30s: 30	More than 10 yrs: 53	Upper ½: 43	General: 43
20s: 27	5 to 10 yrs: 23	Upper ¼: 19	Coll Prep: 25

MONTHLY SALARY RANGES: (two highest responses)

Employers' Schedule		Present Personnel
Min: 500 to 700: 37	Less than 500: 33	500 to 700: 62
Max: 700 to 900: 40	500 to 700: 19	700 to 900: 26

Industrial Technology: Industrial Technicians spend most of their time in quality control and supervision, with considerable time in testing and writing technical reports. They require advanced knowledge of manufacturing processes, instrumentation and calibration, and electronics. They need a general knowledge of algebra, geometry, trigonometry, physics, chemistry, non-metallic materials, machine tools, machinability, and communications. Future industrial technicians will need more training in physics, manufacturing processes, reading, writing, and speaking.

Three-fourths of the industrial technicians who responded to the survey indicated they were trained on the job. The great majority of employers require high school graduation and prefer vocational-technical training or college. They favor on the job training programs, and provide rather strong support for continuing education through company-subsidized courses. Salaries are about the same as in other technical fields, and job satisfaction is generally high except in opportunities for advancement.

TABLE 53
PROFILE OF MECHANICAL TECHNOLOGY

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
HS	48	AS-AA	31	Some Coll, no Degree	30
Less than HS	35	Some Coll, no Degree	26	HS	21

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion				Employee Opinion			
Writing	85	Speaking	48	Instr Calib	76	Hyd-Pneumat	57
Drafting	83	Mach Tools	43	Speaking	76	Mfg Process	55
Geometry	79	Mfg Process	35	Reading	73	Machinablty	55
Algebra	77	Machinablty	30	Algebra	71	Trig	49
Instr Calib	77	Mach Econ	29	Writing	68	Chemistry	45
Physics	75	Comput Tech	29	Electric	66	Metallurgy	35
Electric	71	Comput Prog	28	Geometry	61	Non-metal	34
Trig	66	Chemistry	25	Mach Tools	61	Mach Econ	28
Hyd-Pneumat	59	Metallurgy	25	Physics	59	Dif Equa	26
Reading	58			Drafting	58	Business Ad	26

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion		Employee Opinion
Comput Tech	26	None
Comput Prog	25	

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements				Employee Practice	
Instr Calib	86	Prod Design	55	Testing	52
Testing	78	Precis Mach	53	Supervision	46
Drafting	78	Research	50	Research	43
Tech Reports	71	Supervision	46	Tech Reports	38
Qual Control	62	Prod Inspect	40	Instr Calib	32
Elect Equip	56	Prod Layout	28		

CONTINUING EDUCATION:

(Extent)	Emplr	Emple	(Purpose)	Emplr	Emple
On the job	78	73	Make up educ deficiency	57	
Subsidize in schools	64	19	Keep up with advancing tech	53	70
Arrange in schools	48	24	Prep for higher position	63	39
Personal choice and cost		34	Better educ background	64	74

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy		Employee Opinion	
Performance	100	Performance	100
Experience	85	Experience	69
Personality	59	Education	43
Education	45	Personality	36
Seniority	10	Seniority	20

JOB SATISFACTION: (87% feel they made a good career choice)

Nature of work	96	Job Security	71
Facilities	80	Importance of work	68
Fringe Benefits	71	Employer Relations	58
Salary	71	Opportunity for adv	45

JOB DISSATISFACTION:

Opportunity for adv 37

SOURCES OF RECRUITMENT:

1st: Promotion from within	70
2nd: Direct from Schools	45
3rd: Other Employers	34

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Lower level, same employer	22
Same job out of state	19
Armed Services	19
Same job in Arizona	18

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
30s: 39	More than 10 yrs: 67	Upper ½: 36	General: 42
40s: 25	5 to 10 yrs: 17	Upper ¼: 20	Coll Prep: 23

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
More than 10 yrs: 22	Up to 10 yrs: 29	Up to 10 yrs: 9
Up to 10 yrs: 18	More than 10 yrs: 26	More than 10 yrs: 8

MONTHLY SALARY RANGES: (two highest responses)

	Employers' Schedule			Present Personnel
Min:	Less than 500:	55	500 to 700: 40	500 to 700: 49
Max:	500 to 700:	51	700 to 900: 34	700 to 900: 34

Mechanical Technology: The principal activities of mechanical technicians are testing, research, supervision, and for many of them instrumentation and calibration, drafting, and writing technical reports. They need a general knowledge of mathematics through trigonometry, physics, hydraulics-pneumatics, instrument calibration, electronics, drafting, and communications. More knowledge of instrumentation and calibration is likely to be required in the future. Most employers require mechanical technicians to be high school graduates, but in a third of the field not even high school is required. Associate degrees or some college is preferred for about half of the positions, and the present personnel range all the way from high school graduates to doctorates.

Salaries range for the most part from under $500 to $900 per month, and the technicians who answered the questionnaires reported receiving about the same as most other technicians. Job satisfaction is also similar to that in other fields, but with an even larger percent dissatisfied with their opportunities for advancement. The mechanical technicians in the survey were a little older than in other fields, on a level with electrical technicians in their 30s and 40s. Employers would prefer to get new personnel through promotion from below, and nearly one-fourth of those who answered questionnaires reached their present positions in that way.

TABLE 54
PROFILE OF EXPERIMENTAL MACHINIST

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
Voc-Tech	37	Voc-Tech	42	Voc-Tech	45
HS	33	HS	21	Less than HS	23

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Mach Tools	99	Speaking	58
Machinablty	98	Mach Econ	56
Trig	93	Writing	54
Geometry	92	Reading	54
Algebra	88	Hyd-Pneumat	48
Drafting	83	Electric	39
Mfg Process	73		

Employee Opinion

Mach Tools	91	Non-metal	50
Machinablty	91	Algebra	50
Trig	73	Speaking	41
Mfg Process	73	Reading	32
Drafting	68	Dif Equation	32
Geometry	64	Writing	28
Instr Calib	63	Physics	27
Metallurgy	55	Hyd-Pneumat	27
Mach Econ	55		

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion		Employee Opinion	
Machinablty	53	Machinablty	41
Mach Tools	45	Mach Tools	41
Mach Econ	36	Instr Calib	27

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Precis Mach	92	Drafting	37
Prod Layout	72	Qual Control	34
Aut Equip	54	Prod Inspect	31
Prod Design	51		
Tech reports	41		

Employee Practice

Precis Mach	78
Supervision	36
(Prod Design	23)
(Testing	23)
(Instr Calib	23)
(Prod Inspect	23)

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	75	32
Subsidize in schools	44	0
Arrange in schools	16	5
Personal choice and cost		36

(Purpose)	Emplr	Emple
Make up educ deficiency	38	
Keep up with adv tech	38	41
Prep for higher position	37	18
Better educ background	8	59

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy		Employee Opinion	
Performance	99	Performance	77
Experience	74	Experience	77
Education	56	Seniority	18
Seniority	40	Personality	18
Personality	12	Education	5

JOB SATISFACTION: (59% feel they made a good career choice) JOB DISSATISFACTION:

Nature of work	77	Salary	45
Importance of work	55	Fringe Benefits	86
Facilities	55	Job Security	32
Employer Relations	55	Opportunity for adv	27

SOURCES OF RECRUITMENT:

1st:	Other Employers	63
2nd:	Direct from schools	51
3rd:	Promotion from within	36

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Same job in Arizona	36
Same job out of state	23
Lower level, same employer	23

PERSONNEL CHARACTERISTICS:

Age		Years Since Degree		HS Rank		HS Major	
Over 50:	36	More than 10 yrs:	68	Upper ¼:	27	General:	34
40s:	27	5 to 10 yrs:	14	Upper 3/4:	27	Voc-Tech:	[illegible]

PREVIOUS EXPERIENCE:

Skilled		Technical		Engineering	
More than 10 yrs:	55	More than 10 yrs:	14	1 to 3 yrs:	5
Up to 10 yrs:	28				

MONTHLY SALARY RANGES: (two highest responses)

Employers' Schedule				Present Personnel	
Min: 500 to 700:	57	Less than 500:	20	500 to 700:	55
Max: 500 to 700:	55	700 to 900:	17	Less than 500:	27

Experimental Machinist: The job of experimental machinist is largely one of working with precision machinery, with some time required in the related functions of production layout, production inspection, instrumentation and calibration, testing, and quality control. A thorough knowledge of machine tools, machinability, and instrumentation and calibration is required, with a general knowledge of manufacturing processes, machine economy, mathematics through trigonometry, drafting, and oral and written communications. Most machinists receive their training on the job, but employers are looking toward the high schools and vocational-technical schools for more trained machinists. High schools or vocational-technical schools training is required for employment in most cases, although nearly one-fourth of those who participated in the survey do not have a high school education.

Machinists can generally expect a starting salary of $500 - $700 per month, with top earnings approaching $1,000. More than one-third of those in the survey were nearing retirement age (over 50), and a substantial number were in their 40s. Job satisfaction is somewhat lower than in the other skilled industrial trades but there was also less dissatisfaction expressed.

TABLE 55
PROFILE OF INSTRUMENTMAKER

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
HS	79	Voc-Tech	87	Some Coll, No Degree	53
(No other level)		HS	4	Voc-Tech	27

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Mach Tools	100	Algebra	91
Machinablty	100	Reading	90
Instr Calib	98	Speaking	90
Drafting	98	Metallurgy	87
Geometry	98	Mfg Process	86
Trig	97	Non-metal	80
Mach Econ	94		

Employee Opinion

Trig	94	Mfg Process	73
Mach Tools	93	Physics	60
Machinablty	93	Reading	60
Geometry	86	Speaking	54
Instr Calib	80	Electric	46
Drafting	80	Writing	40
Algebra	74	Integ Circ	34
Metallurgy	74	Hyd-Pneumat	27
Non-metal	74		

SUBJECTS IN WHICH ADVANCED KNOWELDGE IS REQUIRED: (25% or more response)

Employer Opinion

None

Employee Opinion

Machinablty	60
Mach Tools	53
Instr Calib	40

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Drafting	96	Prod Design	31
Prod Inspect	93	Supervision	29
Instr Calib	91	Prod Layout	27
Precis Mach	88	Systems Anal	25
Elect Equip	67		
Research	33		

Employee Practice

Precis Mach	60
Research	53
Instr Calib	47
Qual Control	40
Supervision	29

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	89	53
Subsidize in schools	76	20
Arrange in schools	11	27
Personal choice and cost		13

(Purpose)	Emplr	Emple
Make up educ deficiency	70	
Keep up with adv technology	83	67
Prep for higher position	83	33
Better educ background	86	60

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy	
Performance	100
Experience	90
Seniority	61
Education	14
Personality	1

Employee Opinion	
Performance	80
Experience	73
Seniority	33
Education	20
Personality	20

JOB SATISFACTION: (93% feel they made a good career choice)

Nature of work	93	Facilities	60
Salary	87	Importance of work	60
Fringe Benefits	80	Opportunity for adv	27
Employer Relations	67	Job Security	20

JOB DISSATISFACTION:

Opportunity for adv	33
Facilities	27

SOURCES OF RECRUITMENT:

1st: Promotion from within	54
2nd: Other employers	28
3rd: Direct from schools	29

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Same job out of state	40
Same job in Arizona	33
Lower level, same employer	13
Armed Services	7

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
40s: 47	More than 10 yrs: 87	Upper ½: 40	Coll Prep: 33
Over 50: 33	Less than 10 yrs: 14	Upper 10%: 33	General: 26

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
More than 10 yrs: 80	Up to 10 yrs: 27	None
Up to 10 yrs: 14	More than 10 yrs: None	

MONTHLY SALARY RANGES: (two highest responses)

Employers' Schedule		Present Personnel
Min: Less than 500: 70	500 to 700: 17	700 to 900: 87
Max: 700 to 900: 77	500 to 700: 14	500 to 700: 13

Instrumentmaker: Instrument making involves machining, and some time is spent in instrumentation and calibration. Performance of these duties requires advanced knowledge of machine tools, machinability, and instrument calibration, as well as a general knowledge of applied metallurgy, non-metallic materials, manufacturing processes, machine economics, drafting, reading, writing, and speaking. Future requirements will include more knowledge in all of these areas, especially in communications.

Nearly all employers require instrument makers to be high school graduates, and there is preference for vocational-technical school experience as well. At the present time, nearly all instrument makers are trained on the job, and most employers subsidize or arrange classes to supplement this training.

A high percentage of instrumentmakers indicate satisfaction with their work, surroundings, benefits, and importance. Less satisfactory aspects of the job are the opportunities for advancement and job security.

New instrumentmakers generally earn about $500 per month, expect top earnings in the area of $1,000.

TABLE 56
PROFILE OF INSTRUMENTMAN

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference	Employee Achievement	
HS	50	Voc-Tech	HS	37
Voc-Tech	10	Some Coll, No Degree 21	Voc-Tech	27

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Algebra	95	Hyd-Pneumat	65
Instr Calib	92	Physics	62
Geometry	80	Integr Circ	50
Speaking	80	Mfg Process	40
Writing	79	Chemistry	39
Reading	78	Mach Tools	33
Trig	76	Machinablty	31
Electric	75	Non-metal	26
Drafting	67		

Employee Opinion

Instr Calib	96	Trig	53
Algebra	87	Machinablty	50
Electric	86	Drafting	47
Hyd-Pneumat	70	Chemistry	46
Speaking	70	Mfg Process	37
Physics	63	Mach Econ	30
Integr Circ	63	Comput Prog	27
Reading	63	Comput Tech	27
Geometry	60	Metallurgy	26
Mach Tools	60	Dif Equa	26
Writing	60	Non-metal	26

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion		Employee Opinion	
Instr Calib	64	Instr Calib	53
Electric	39	Electric	43
Integr	31		

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Instr Calib	81	Aut Equip	49
Supervision	66	Research	47
Drafting	62	Systems Anal	44
Qual Control	61	Prod Layout	35
Tech Reports	61	Prod Layout	35
Elect Equip	58	Surveying	30
Testing	57	Prod Design	29
Precis Metals	50		

Employee Practice

Instr Calib	83	Testing	30
Supervision	60	Systems Anal	30
Elect Equip	57	Tech Reports	27
Research	40	Aut Equip	26

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	79	70
Subsidize in schools	54	13
Arrange in schools	37	13
Personal choice and cost		47

(Purpose)	Emplr	Emple
Make up educ deficiency	38	
Keep up with adv Tech	59	70
Prep for higher position	44	37
Better educ background	52	63

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy		Employee Opinion	
Performance	91	Performance	63
Experience	81	Experience	60
Education	39	Seniority	40
Personality	31	Education	33
Seniority	29	Personality	33

JOB SATISFACTION: (90% feel they made a good career choice)

Nature of work	100	Fringe Benefits	73
Job Security	87	Facilities	73
Employer Relations	83	Opportunity for adv	50
Salary	77	Importance of work	47

JOB DISSATISFACTION:
Opportunity for adv 33

SOURCES OF RECRUITMENT:

1st: Promotion from within	54
2nd: Other employers	34
3rd: Direct from schools	29

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Same job in Arizona	37
Armed Services	20
Lower level, same employer	13
School	13

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
30s: 40	More than 10 yrs: 53	Upper ½: 47	General: 53
40s: 27	5 to 10 yrs: 20	Upper ¼: 17	Coll Prep: 16

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
Up to 10 yrs: 13	Up to 10 yrs: 43	More than 10 yrs: 3
More than 10 yrs: 10	More than 10 yrs: 30	

MONTHLY SALARY RANGES: (two highest responses)

Employers' Schedule		Present Personnel
Min: 500 to 700: 70	Less than 500: 23	500 to 700: 63
Max: 500 to 700: 42	700 to 900: 29	700 to 900: 27

Instrumentman: Instrumentmen are concerned with instrumentation and calibration and secondarily with setting up and maintaining electronic equipment and supervision. These duties involve a thorough knowledge of instrument calibration and electronics, as well as a general knowledge of algebra, geometry, physics, trigonometry, hydraulics-pneumatics, integrated circuits, drafting, oral and written communications.

Most employers require high school graduation or some vocational-technical school training for instrumentmen. About half of those now employed received their training on the job. However, the armed services and vocational-technical schools provide significant numbers of personnel trained in this occupation.

Beginning instrumentmen earn $500 - $700 per month and increase their earnings to around $900 per month during their career. High percentages of instrumentmen who responded to the survey indicated satisfaction with all phases of their occupation.

TABLE 57
PROFILE OF LAYOUT MAN

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
HS	47	Voc-Tech	55	Voc-Tech	35
Less than HS	23	HS	29	Less than HS	24

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Drafting	83	Instr Calib	49
Algebra	82	Reading	49
Mfg Process	80	Writing	46
Geometry	80	Mach Econ	43
Trig	71	Non-metal	40
Machinablty	67	Metallurgy	34
Speaking	53	Physics	32
		Business Ad	25

Employee Opinion

Mfg Process	83	Writing	53
Mach Tools	71	Geometry	41
Speaking	65	Physics	41
Machinablty	59	Hyd-Pneumat	35
Instr Calib	59	Trig	30
Drafting	59	Non-metal	30
Reading	59	Mach Econ	30
Algebra	53	Electric	30

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion	Employee Opinion
None	None

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Qual Control	72	Prod Layout	35
Drafting	62	Research	34
Supervision	61	Prod Inspect	31
Prod Design	57	Tech Reports	31
Precis Mach	50	Systems Anal	26
Aut Equip	37	Sales, etc	25

Employee Practice

Supervision	42
Precis Mach	36
Aut Equip	30

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	68	18
Subsidize in schools	30	0
Arrange in schools	22	0
Personal choice and cost		29

(Purpose)	Emplr	Emple
Make up educ deficiency	26	
Keep up with advancing tech	31	24
Prep for higher Position	28	18
Better educ Background	41	53

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy	
Performance	95
Experience	63
Seniority	28
Personality	22
Education	5

Employee Opinion	
Performance	71
Experience	47
Personality	12
Education	12
Seniority	6

JOB SATISFACTION: (71% feel they made a good career choice)

Salary	65	Employer Relations	47
Nature of work	65	Facilities	29
Fringe benefits	47		

JOB DISSATISFACTION:

Opportunity for adv	59
Facilities	29
Employer Relations	29
Job Security	29

SOURCES OF RECRUITMENT:

1st: Promotion from within	57
2nd: Other Employers	34
3rd: Direct from Schools	33

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Same job out of state	35
Same job in Arizona	18
School	18
Lower level, same employer	6

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
40s: 41	More than 10 yrs: 65	Upper ½: 47	General: 35
30s: 24	5 to 10 yrs: 12	Upper ¼: 17	Voc-Tech: 23

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
More than 10 yrs: 47	Up to 10 yrs: 18	None
Up to 10 yrs: 30	More than 10 yrs: 12	

MONTHLY SALARY RANGES: (two highest responses)

Employers' Schedule		Present Personnel
Min: 500 to 700: 57	Less than 500: 20	500 to 700: 55
Max: 500 to 700: 55	700 to 900: 17	Less than 700: 27

Layout Man: The work of layout men includes production layout, setting up, maintaining, and testing automated production equipment and precision machinery, and supervision of these activities. The knowledge required is algebra and geometry, manufacturing processes, machine tools, machinability, instrument calibration, drafting, and oral and written communications.

Vocational-technical schools have trained about one-third of the layout men who answered questionnaires, most employers prefer vocational-technical school experience in addition to high school graduation. Most of the training for this occupation, however, is still provided on the job. The salary for layout men runs between $400 and $900 per month, with the majority of those now employed earning around $700.

Response to the survey indicated an average amount of employee satisfaction with the various aspects of the job, except for opportunities for advancement.

TABLE 58
PROFILE OF MACHINE SET UP MAN

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employer Achievement	
Less than HS	55	Armed Services	49	HS	26
HS	32	Voc-Tech	33	Voc-Tech	22

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Mach Tools	99	Trig	72
Machinablty	93	Metallurgy	72
Mfg Process	91	Algebra	69
Instr Calib	77	Non-metal	67
Drafting	77	Speaking	34
Geometry	74	Reading	33
Mach Econ	73	Writing	25

Employee Opinion

Machinablty	78	Reading	48
Algebra	74	Mach Econ	48
Trig	71	Writing	40
Mfg Process	67	Calculus	34
Mach Tools	64	Hyd-Pneumat	34
Instr Calib	63	Dif Equa	33
Geometry	55	Metallurgy	33
Speaking	55	Physics	26
Drafting	48	Humanities	26

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion
None

Employee Opinion
None

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Precis Mach	91	Supervision	61
Aut Equip	84	Research	53
Qual Control	81	Instr Calib	36
Drafting	75	Prod Layout	32
Prod Design	71	Prod Inspect	25
Testing	68		

Employee Practice

Precis Mach	56	Qual Control	30
Supervision	42	Systems Anal	26
Prod Inspect	33	Testing	26
Research	33		

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	94	52
Subsidize in schools	65	19
Arrange in schools	66	19
Personal choice and cost		30

(Purpose)	Emplr	Emple
Make up educ deficiency	63	
Keep up with adv tech	68	59
Prep for higher position	63	30
Better educ background	76	67

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy	
Performance	99
Experience	88
Seniority	23
Education	12
Personality	7

Employee Opinion	
Performance	78
Experience	70
Education	33
Personality	19
Seniority	15

JOB SATISFACTION: (85% feel they made a good career choice)

Nature of work	81	Importance of work	52
Salary	67	Opportunity for adv	48
Facilities	59	Job Security	44
Employer Relations	52	Fringe Benefits	37

JOB DISSATISFACTION:
Opportunity for adv 26

SOURCES OF RECRUITMENT:

1st: Promotion from within	75
2nd: Other employers	27
3rd: None	0

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Same job in Arizona	30
Same job out of state	26
Armed Services	11
Lower level, same employer	4

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
50s: 52	More than 10 yrs: 56	Upper ½: 37	General: 55
40s: 33	5 to 10 yrs: 15	Upper 10%: 18	Voc-Tech: 14

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
More than 10 yrs: 41	Up to 10 yrs: 11	Up to 10 yrs: 19
Up to 10 yrs: 18	More than 10 yrs: None	More than 10 yrs: 7

MONTHLY SALARY RANGES: (two highest responses)

	Employers' Schedule		Present Personnel
Min:	Less than 500: 65	Less than 500: 33	500 to 700: 52
Max:	500 to 700: 80	700 to 900: 14	Less than 500: 19

Machine Set-Up: Machine set-up men perform and supervise the set-up and maintenance of precision machinery. To do this, they need a general knowledge of algebra, geometry, trigonometry, manufacturing processes, machine tools, machinability, instrumentation and calibration, and drafting.

Formal schools provide relatively few trained set-up men. Almost three-quarters of those now employed were trained on the job. Since preference for trade school graduates is not as strong here as it is in some other skilled occupations, on the job training will probably continue to provide most of the personnel for this occupation. The majority of employers subsidize or arrange classes to supplement on the job training.

Set-up men indicate a generally high degree of satisfaction with their occupations, especially with the work itself. Salaries range from less than $500 to around $900 per month.

TABLE 59
PROFILE OF MACHINE REPAIRMAN

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
HS	58	Voc-Tech	73	Armed Services	28
Less than HS	19	HS	25	HS	26

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Mach Tools	95	Physics	69
Machinablty	90	Trig	65
Electric	83	Chemistry	62
Hyd-Pneumat	81	Speaking	62
Instr Calib	80	Writing	60
Drafting	80	Non-metal	58
Reading	77	Mach Econ	45
Algebra	74	Integ Circ	28
Geometry	71	Humanities	28
Mfg Process	69	Metallurgy	26

Employee Opinion

Mach Tools	85	Reading	45
Machinablty	73	Electric	44
Instr Calib	64	Non-metal	44
Hyd-Pneumat	61	Mach Econ	43
Algebra	60	Physics	40
Speaking	58	Integ Circ	39
Geometry	57	Metallurgy	38
Drafting	56	Writing	36
Mfg Process	51	Chemistry	32
Trig	46		

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Mach Tools	35
Hyd-Pneumat	32
Mfg Process	26

Employee Opinion

None

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Precis Mach	84	Qual Control	40
Instr Calib	80	Prod Inspect	40
Supervision	76	Prod Layout	40
Testing	71	Design	38
Drafting	71	Tech Reports	38
Aut Equip	61	Systems Anal	31

Employee Practice

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job		
Subsidize in schools		
Arrange in schools		
Personal choice and cost		

(Purpose)	Emplr	Emple
Make up educ deficiency	36	
Keep up with adv technology	55	60
Prep for higher Position	56	30
Better educ background	55	64

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy

Performance	94
Experience	86
Personality	53
Seniority	34
Education	27

Employee Opinion

Performance	79
Experience	70
Education	21
Personality	17
Seniority	17

JOB SATISFACTION: (85% feel they made a good career choice)

Nature of work	91	Salary	64
Fringe benefits	79	Facilities	62
Job Security	68	Importance of work	53
Employer Relations	66	Opportunity for adv	49

JOB DISSATISFACTION:
Opportunity for adv 30

SOURCES OF RECRUITMENT:

1st: Promotion from within	74
2nd: Other employers	55
3rd: Direct from schools	15

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Same job in Arizona	30
Same job out of state	21
Lower level, same employer	15
Armed Services	13

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
50s: 40	More than 10 yrs: 77	Upper ½: 53	General: 42
40s: 28	5 to 10 yrs: 11	Upper 3/4: 10	Coll Prep: 17

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
More than 10 yrs: 57	Up to 10 yrs: 30	Up to 10 yrs: 4
Up to 10 yrs: 17	More than 10 yrs: 4	More than 10 yrs: 0

MONTHLY SALARY RANGES: (two highest responses)

Employers' Schedule		Present Personnel
Min: 500 to 700: 62	Less than 500: 18	500 to 700: 77
Max: 500 to 700: 67	900 to 1,200: 13	700 to 900: 13

Machine Repair: Machine repairmen are concerned with the maintenance of automated production equipment and precision machinery, and supervision of these activities. These duties demand some knowledge of algebra, geometry, hydraulics-pneumatics, manufacturing processes, machine tools, machinability, instrument calibration, drafting, and communications -- especially speaking. Future requirements are expected to include more thorough knowledge of all of these areas and also physics, non-metallic materials and electronics.

The great majority of machine repairmen were trained on the job. The armed services have been the second largest source of trained personnel. However, employers indicate a marked preference for applicants with vocational-technical school experience in addition to high school graduation. Machine repairmen can earn anywhere from under $500 to nearly $1,000 per month. Most of those who responded to the survey make about $700 per month. Job satisfaction is about average; no aspect of the job is greatly criticized; abd considerable satisfaction is indicated in the work itself.

TABLE 60
PROFILE OF TOOL AND DIE MAKER

EDUCATIONAL LEVEL: (two highest levels identified)

Employer Requirements		Employer Preference		Employee Achievement	
HS	53	Voc-Tech	62	Voc-Tech	41
Less than HS	32	HS	26	HS	32

SUBJECTS IN WHICH AT LEAST A GENERAL KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion

Mach Tools	97	Reading	60
Machinablty	94	Metallurgy	58
Trig	84	Speaking	52
Algebra	82	Hyd-Pneumat	48
Geometry	81	Writing	46
Drafting	77	Non-metal	42
Mfg Process	68	Physics	28
Mach Econ	65	Electric	28
Instr Calib	60		

Employee Opinion

Trig	94	Non-metal	62
Mach Tools	94	Mach Econ	62
Machinablty	94	Reading	53
Drafting	85	Physics	50
Instr Calib	82	Hyd-Pneumat	44
Geometry	80	Writing	41
Mfg Process	77	Electric	32
Algebra	71	Dif Equa	29
Metallurgy	68		
Speaking	65		

SUBJECTS IN WHICH ADVANCED KNOWLEDGE IS REQUIRED: (25% or more response)

Employer Opinion		Employee Opinion	
Mach Tools	50	Mach Tools	56
Machinablty	50	Machinablty	50
		Drafting	38
		Trig	35
		Instr Calib	29

SKILLED ACTIVITIES: (25% or more response)

Employer Requirements

Precis Mach	92	Aut Equip	50
Qual Control	71	Instr Calib	49
Drafting	69	Testing	48
Prod Layout	68	Design	44
Prod Inspect	66	Supervision	42

Employee Practice

Precis Mach	68
Drafting	32
Prod Inspect	32
Qual Control	27
Research	26

CONTINUING EDUCATION:

(Extent)	Emplr	Emple
On the job	54	53
Subsidize in schools	30	15
Arrange in schools	4	12
Personal choice and cost		26

(Purpose)	Emplr	Emple
Make up educ deficiency	14	
Keep up with adv technology	34	59
Prep for higher position	21	38
Better educ background	26	71

MAJOR FACTORS GOVERNING ADVANCEMENT:

Employer Policy		Employee Opinion	
Performance	100	Performance	71
Experience	76	Experience	65
Seniority	34	Education	29
Personality	22	Personality	26
Education	20	Seniority	21

JOB SATISFACTION: (85% feel they made a good career choice)

Nature of work	79	Fringe Benefits	41
Importance of work	62	Job Security	41
Employer Relations	56	Salary	29
Facilties	53	Opportunity for adv	24

JOB DISSATISFACTION:

Salary	38
Opportunity for adv	32

SOURCES OF RECRUITMENT:

1st: Other employers	46
2nd: None	0
3rd: Schools	0

EMPLOYEES' LAST PREVIOUS EMPLOYMENT:

Same job out of state	41
Same job in Arizona	38
Armed Services	3
School	3

PERSONNEL CHARACTERISTICS: (two highest responses)

Age	Years Since Degree	HS Rank	HS Major
40s: 35	More than 10 yrs: 85	Upper ½: 52	General: 38
50s: 32	5 to 10 yrs: 15	Upper ¼: 23	Coll Prep: 29

PREVIOUS EXPERIENCE:

Skilled	Technical	Engineering
More than 10 yrs: 79	Up to 10 yrs: 6	Up to 10 yrs: 12
Up to 10 yrs: 12	More than 10 yrs: 3	More than 10 yrs: 3

MONTHLY SALARY RANGES: (two highest responses)

Employers' Schedule		Present Personnel
Min: 500 to 700: 64	Less than 500: 18	500 to 700: 65
Max: 700 to 900: 44	500 to 700: 40	700 to 900: 21

Tool and Die Maker: The principal activity of tool and die makers is precision machining. The skills necessary for this occupation, however, are a great deal more complex than ordinary machine shop work. The subject fields in which tool and die makers need advanced knowledge are machine tools, and machinability. They require a general knowledge of mathematics through trigonometry, applied metallurgy, manufacturing processes, machine economics, instrument calibration, drafting, reading and speaking. Knowledge requirements in the areas of machine tools, machinability, manufacturing processes, and machine economics, are expected to increase.

Three-fourths of the tool and die makers in the survey were trained on the job. Employers feel that high schools and vocational-technical schools should assume more responsibility for this training, but the level of skill necessary cannot be developed without considerable experience. Most employers favor cooperative education programs, and prefer graduation from vocational-technical school. Salaries run from under $500 to $900 per month. Employee satisfaction with various aspects of the job is comparatively low, especially in salary and opportunity for advancement.

CHAPTER VI

ADVICE FROM INDUSTRY

Each employer and employee was asked if, based on his own experience, he cared to suggest improvements in current educational programs. More than a fourth of the participants in the survey responded with a volume of detailed comment far greater than had been anticipated. Opinions expressed were often in direct conflict. One engineer said, "We are wasting too much time on humanities," and another, "I would suggest greater emphasis on humanities." Many persons felt the schools give too much emphasis to theory and not enough to practical application, but one said, "basic theory is more important than exact application" because it does not change as rapidly. Opposing views were found on virtually every subject covered in the survey and every concept of education in engineering and technology. In some cases agreement would be impossible because different industries and personnel have different educational requirements. In other cases the impact of changes taking place in technology is being felt differently in various segments of employment. New concepts and trends in education also produce variant reactions depending on needs and personal inclinations of students, graduates, experienced employees, and employers. Comments and suggestions on both sides of many issues are presented here in order to reflect the diversity of opinion on education within the industrial community.

On a number of subjects, however, there is an unmistakable consensus of employers and employees alike. The advice of industry, for instance, to offer more practical educational programs represents the overwhelming majority opinion of all responding. The appeal to improve education in communications is repeated so often and with such insistence that it comes almost as a mandate. There are so many requests for additional night courses and special programs in the continuing education of engineers that a new look at this part of the educational system should be taken. In most of these areas and a few others the occasional dissenter is lost in a chorus of strongly united opinion. It is impossible to include here all comments and suggestions which were made or even many that well express particular points of view.[1] A representative selection has been attempted. These views are presented as nearly as possible in the context in which they were made.

[1] The statements cited in this chapter represent approximately one-tenth of those received. All comments and suggestions made were copied from the original questionnaires for further study and consideration. They are identified by occupation, kind and size of company in the case of employers, and education and salary in the case of employees. Further information is available on request.

For A Greater Effort

Begin Early: Many persons in industry feel that education in technical subjects is delayed too long. An electronics engineer: "My observations in the past 25 years indicate that motivation of the student must come at an early age -- at least high school. High school courses in electronics should receive serious consideration by educators." Others felt that even high school was too late to begin: "Start sooner -- expose junior high students to a better understanding of professional careers so they can make a choice early -- rather than coast thru two or three years of college without specific goals." "Teach basic electronics in the early stages of education. It seems imperative in the 7th or 8th grades. Electronics is a part of everyday life and so few have even a basic understanding." "Education in electronics should be offered in high school and general knowledge could be taught in grade school." "I think time should be spent to choose an occupation before high school. This way you would take the subjects needed. I wish I would have known before I graduated."

Men on the job frequently expressed concern that vocational and technical education are not sufficiently emphasized in high school. A machinist: "I feel that too many courses in high school are for college preparatory only and there are not enough occupational courses. Many of my friends, including myself, left high school with no skill at all to help us find a job." And from an engineer: "Our most critical need is an education system which gives high school students an opportunity to learn trades rather than just preparation for college. It should be the policy of every high school to provide complete training opportunities for those who are neither qualified for nor interested in college." Employers were just as concerned: "High schools should encourage students to study for technical areas." "More earth science courses in high school or at least an introduction." "High schools should assume more responsibility for preparing students for trades -- should put less emphasis on college prep." "Not everyone is meant to go to college." "The high schools should set up more extensive courses in manual trades -- e.g., electronics, auto mechanics, and refrigeration." "Early high school students should be taught the advantages of industrial vocations and be accordingly trained." "Promote more vocational-technical training during high school." "There should be more vocational training schools available throughout the state." "Comprehensive coverage of the state with vocational-technical high schools."

Attract More Students: Closely related to earlier technical education is concern that too many students are missing career opportunities entirely although industry needs them. In the words of one technician: "There is a definite need for more technical training in our schools and in industry. The situation will get considerably worse before it can get better." An employer of skilled craftsmen: "Job applicants in this field are all older persons with job stability who realize they must work to get ahead. There does not seem to be any supply of younger persons in this field to fill the needs of the future. Now is the time they should be training for the furure." A machinist wrote: "The youngest man in the model shop I work in is 30 years old, with an average of 42 years. I myself am 52 and there are older employees in my shop. This is a serious situation that needs prompt action or Arizona will really hurt in the near future for skilled help."

The problem, many felt, lies in vocational guidance and counselling. An engineer: "It has been my opinion after teaching in three universities and working for several major companies that the most severe lack in the high school-college system is good guidance and counselling." And from another engineer: "Student counselors are urgently needed at the high school level, who can guide the students in the proper courses to take during high school." Frequently specific advice was offered. "We should try to correct the thinking that a man that works with his hands and is a true skilled craftsmen is a second-class citizen." "Would stress the importance of mathematics early in high school." "The professional engineer today usually winds up behind a desk leaving the numerous technical duties to be handled by his engineering aids. The story of the importance of engineering technicians should be expressed." "Training in school should not specialize greatly, but should be broad, forcing the student to use both his hands and his head, learning the basics of his field." "An engineer must first be taught to think logically. An electrical engineer, especially, must be taught an intuitive feeling for the things with which he will come in contact." "Give a more realistic view of what industry really expects from the grad. All engineering is not research and theory and desk beautification. There is also the business of handling and producing the end product." "Please teach the students to learn to think -- to think with logic. Learn to make use of time to best advantage." And don't overlook the girls: "I think that women should be exposed to the advantages of engineering oriented careers while they are still in high school. Women make excellent draftsmen, and the pay is much higher than secretarial work."

Set realistic goals: There is a feeling that career education from the skilled crafts to engineering needs to be more closely related to the real world of work. One employer said he feels "all the institutions are improving and they have to. Too many engineers have been turned out who are math and formula oriented. Without information to plug in and grind out they are incapable of original thinking." Another employer: "Schools should present a general, basic background in the various phases of engineering. Students should be taught the WHYS as well as the HOWS. For example, a math student should know why he's taking derivatives and their significance, as well as the math mechanics of how to take them. Thus an engineer, who comes out of school with a knowledge of basic concepts and not just sophisticated formulas which he can plug numbers into and arrive at answers with little significance to him, will be better able to cope with new developments and problems." A tool maker expressed his opinion in these words: "I would say that you would need all the math you could absorb, a lot of blueprint reading, a little drafting, and about five years of actually working on the job with a good man that knows what he's doing. I wish I knew some short cuts that would help, but do not."

A common suggestion at all levels was that faculty have industrial experience. One engineer wrote: "In college level teaching of engineering very little importance is attached to the teacher having professional engineering experience. This is a mistake. At least two years and preferably more in engineering practice should be required for promotion above the assistant professor level. In addition, engineering teachers should be encouraged to spend summers in industry." Another: "Arizona needs a college which offers a practical degree in engineering. More applied courses so the B. S. in Engineering is a terminal degree. Train engineers -- not scientists."

There were favorable as well as critical comments about the present educational effort. "In general, the schools are doing a fine job in their area." "I think the educational programs in civil engineering offered in this country are excellent." "Arizona is doing well in engineering education." "I would like to say that overall Arizona has provided excellent opportunities for its citizens to gain new knowledge and skills in their fields." Some of the comments expressed strong personal feelings critical of schools and programs such as this one: "All you people are turning out these days are educated fools, egotistical prima donnas." Most suggestions, however, were constructive. The attitude of probably a majority could be summed up in the statement of an electronics engineer: "I would prefer a no-nonsense school with a good hard-core curriculum and outstanding teachers. I wouldn't give a damn how many research papers the professors had published, nor how many fraternities were on campus, nor how many football games were won or lost. My objectives would be to obtain a sound basis in the skills and knowledge required to prepare me for my chosen profession and my place in society."

For A Better System

More Practical Experience: From every occupation and virtually every employer one suggestion dominated all others: "Give students some kind of practical experience as well as classroom instruction while they are in school." There were a few who felt that a basic education in math and science should be the main concern of the schools and experience can come later. But it was this feature of their own education that employees criticized most. The following statements were made by engineers, technicians, skilled craftsmen, and employers of all kinds:

Civil engineer in management: "In the current educational program, I feel that the emphasis is too strong on theory and that actual application of the theory is sadly lacking. It is of no benefit to employ an engineering graduate who cannot transform his knowledge into useful work. Theory is essential, but should be only a basis. The engineer who cannot convert theory into practice has obtained only partial education. All too often there is not time to train him on the job. The educational system should provide this training and not place the burden on the engineer or the employer."

Civil engineer: "All theory in the world is worthless without some practical experience in the field and the ability of the field engineer to understand and work with the trades and crafts."

Concrete products employer: "Theory taught in college is all right, but tends to make one too conservative. I have shown a profit on jobs which look disastrous on paper -- there is no substitute for practical experience, although college is valuable in teaching one how to think and analyze."

Machine shop employer: "For background, engineers should know how the parts they design are made -- working in a shop while going to school is fine experience."

Electronics engineer: "An engineer cannot design a machine unless he knows how the machinist is going to make it. It's like teaching a student to drive a car from a book."

Mechanical engineer: "There is nothing more frustrating for a new engineer's supervisor or embarassing for the engineer himself than for him to design a part that can't be made -- and this happens more often than you would imagine."

Civil technician: "It is very discouraging to have a man, educated in a line or work, come on the job unable to do the physical and manual parts of this work."

Mechanical engineer: "Place more emphasis on the applied rather than theoretical aspects of engineering."

Here is the other side from an electrical engineer and a mechanical engineer: "Basic theory is more important than exact application. My training was well behind the time even before I graduated, but any loss is simply that the time could have been spent on even more advanced theory." "It is my firm belief that undergraduate engineering curricula should stress the BASICS. There is no need for turbine design, power plant design, or other specific design courses. On the other hand, thermodynamics, strength of materials, physics, and mathematics must not be diluted."

But far more comments stressed the need for practical knowledge and this was especially true of mechanical engineers: "A major characteristic of the daily work of most engineers is design and of lesser importance is analysis. "From a design engineering stand point more emphasis should be put on the practical side of engineering." "Definitely provide more practical courses (machine shop, lab experience, etc.) for mechanical engineers. This is needed very badly because these are the areas ME's live and work in." "Engineering education does a pretty fair job with fundamentals but is lacking much in practical application. Too many professors have advanced degrees and much theoretical knowledge but fail to put this information on a practical plane. This may be due to their own lack of industrial experience."

And civil engineers: "The field of civil engineering requires a great deal of skill in drafting. I feel too much emphasis is put on theory and not enough time devoted to teaching drafting skills." "Civil engineering education can be improved by making sure that students have at least some 'on-the-job' experience -- e.g. summer construction jobs or part time jobs during the school year -- this is about the only way they can gain any real appreciation of their academic work." "Practical on-the-job training should be required along with college courses."

Some of the comments conveyed a note of exasperation: "Please! push for more 'practicality' and a little less 'academicity." "Education in any field would be many times as valuable if practical experience could be acquired with it." "On-the-job training or some form of industrial experience should be included in any engineering education program as a mandatory requirement."

Practical experience was recommended by employers for a number of reasons: "It would be effective to establish training programs for managerial engineering. This would provide experience in the economic aspects of engineering as well as practical work experience. I think Michigan State runs a hotel management program by providing an actual operating hotel for seniors to work in." "Engineers can learn a great deal from laborers and technicians. The PR aspect of learning how to handle these people and gain from their experiences is important." "In placing a great deal of emphasis on math and theoretical research, practical applications are ignored. Thus the firm's everyday problems often baffle the 'ivory tower' engineering graduate, and this necessitates extensive on-the-job training which might be avoided."

Other employers were less constructive and more critical: "In the teaching of engineering students, field work or actual experience is sadly lacking in most college and university graduates." "College men lack a basic knowledge of the practical 'nuts and bolts' end of engineering." "Teach less theory and spend more time on the practical and mechanical aspects of engineering."

The need for practical experience was expressed in all kinds of language. Electronics engineer: "You can teach product engineering but you cannot make good product engineers. A good PE is made up of bits and pieces from the junk-box of experience and natural ability." Electrical engineer: "Teach the students engineering what they can apply in industry." Civil engineer: "There is and has been a need for realization that current formal education in science and technology, however advanced, however technically perfect, however sophisticated, is in itself an idle, almost worthless thing. It is only through purposeful, practical application of this education to the real, physical, practical, and human needs of people that the potential worth of current formal education in areas of technology and science can achieve optimum realization."

A civil engineer in one of the federal agencies sums it up this way: "Bring to the student who is planning a career in engineering an understanding of the real world application of his occupation. Too many classrooms in the universities are geared to the individual who is going into advanced research, therefore the engineer is coming out of college with a lot of theory and technical background that he can't put to use in the field. He needs a certain amount of theory but the universities should realize that by far most of the engineers, at least ME, EE, Arch.E, have to have a certain amount of practical knowledge also. If somehow options could be incorporated into more of the universities, where an engineer could go either to research or to practical engineering, I believe the field would profit."

Cooperative Work-Study Programs: The best way to get practical experience while in school, in the opinion of a major segment of Arizona industry, is through cooperative work-study programs. Employers were asked in the survey if they favored this idea and most of them said they did. Many added their own suggestions. A machine shop supervisor: "There is a gap between the theoretical and practical knowledge of graduating students and the solution is exposure to work while in school. We should have co-op school-industry programs which would expose the student to problems encountered in the shop and not just exercises in a text book." A metals company executive suggested: "More direct active communication between schools and industry and more school-industry type programs." And a chemical company employer recommended "that junior colleges and senior colleges provide technician level courses with less than a bachelor's degree at graduation -- preferably with practical experience. In-plant arrangement with employers as part of the curriculum."

Employers of engineers suggested numerous advantages of co-op programs. "Favor on-the-job training during the last two years of college work. Need to stress oral and written communications more." "An engineer should try to work for a year or so in machine shops while he's a student to gain practical experience." "Students should have actual work experience during first semester of senior year, and also have some courses in business administration." "Need more cooperative school-industry and on-the-job training programs." "Summer jobs in machine shops would provide valuable general experience, and get the student's hands dirty."

Opportunities for co-op programs apparently exist in almost every kind of industry. Machine shop: "This small shop has neither the facilities nor the personnel to train extensively on-the-job, but I would like to see similar small industries join together to set up co-op programs for employees." Electrical equipment manufacturer: "Much is gained by students when they are able to work summer vacation with some company." Engineering firm: "Co-op programs -- more practical experience needed during training." State agency: "Suggest development of an in-service program which will allow the engineering student to work with practicing engineers in his field of interest, allowing him to develop an understanding of the types of problems involved and an introduction to the approach to solutions. This would reduce the long time now required to make a productive man of the new graduate."

Many engineers were familiar with the co-op idea and recommended it highly. Electronics: "I participated in the engineering co-op program with industry during my undergraduate work at Northwestern University. I consider this experience to be of extreme value, particularly during the first few years of my career." Mechanical: "Alternating academic and on-the-job experience has two tremendous advantages: 1) it offers the student the opportunity to see first-hand the type of envoirnment he will be exposed to upon graduation, giving him a much better opportunity and incentive to grasp more firmly the areas of academic material that will be necessary in his job. He will be much better prepared to select the technical and non-technical electives offered in obtaining his degree. And 2) he will usually be able to finance a majority of his education from the earnings obtained during the on-the-job portion of his program, a decided advantage in this day of skyrocketing educational costs." Electrical: "It appears highly desirable in our day to institute a six year engineering education program: Three years basic analytical approach, first year of specialization, one year of apprentice level training, and second year of specialization." Mining: "A program similar to that used by the Drexel Institute in Philadelphia would be beneficial to all. After one year of college a student alternates six months of college with six months working in industry." Electronics: "Consider industry-university cooperative on-the-job type of training for three to six hours of college credit requirements." Civil: "Need a 'work six months -- attend school six months' program to develop engineers and engineering technicians from men who cannot afford full-time college or who are already on the job."

Technicians expressed equally favorable opinions. Civil: "Classroom teaching should be coupled with field problems. The student should try to get all the field experience he can while still in school." Mechanical: "Include co-operative education with industry and a high percentage of 'project' courses necessitating application of knowledge, ingenuity, shop practice, and summary report writing." Electrical: "One should get as much practical experience as possible while attending school in this particular field of electricity and electronics." Mechanical: "There is nothing better than actual experience in understanding. A co-op course is recommended." Civil: "More use of the student's summer employment to work for possible employers. Could and should be arranged through the colleges."

There was only one objection to co-op programs expressed among the hundreds received, and this was from an electronics employer: "Co-op school-industry programs are not feasible because all material is too specialized.

Engineering should be taught in school." The electronics industry reported the lowest support of cooperative programs of any group in the survey, and there may be problems here which make it less attractive. Even in electronics, however, employers would like to see some kind of closer relationship with the schools. One large electronics manufacturer suggested: "Schools should have students visit industry to see course work and how it would be used in actual industry application." Another electronics manufacturer, referring to industrial engineers, recognized the logic in co-op programs: "To a major degree, many of the abilities required to be successful in this occupation must be acquired in the work experience." Others simply added their voices to the majority: "More electrical circuit application and more school-industry co-op programs."

For A Better Product

Modernize Courses and Equipment: The great majority of suggestions were intended to help the schools produce better educated and better trained graduates for industrial employment. Not all of the ideas submitted appear feasible. Some would require major revisions in the educational system, but most of them are realistic. They appear to have been carefully studied and obviously are based on impressive individual experience. They often reflect concern about the gap that many industrial personnel feel exists between what is taught in school and what is needed on the job. Some of that concern was focused on outdated subject matter and obsolete training equipment.

Electrical and electronics engineers were particularly concerned: "Engineering schools are too far behind industry. Colleges are teaching things that industry scrapped a decade ago." "Keep college courses current with industry needs and latest advances. Courses sometimes are ten years behind." "A senior in engineering college should be required to take a course covering the current 'state-of-the-art' in his chosen field; textbooks are out of date by the time they are printed." "Trust that engineering schools keep up to date with the technology -- the one thing I found after getting out of school was that textbooks were about five years out of date. Had a lot of catching up to do." "Courses offered should be current and well coordinated with industry as to content and schedule. State university rules concerning requirements for advanced degrees should be reviewed and updated."

Some of the concern dealt with specific subject areas. A government agency in air traffic control observed: "Tech schools, junior colleges, and universities would train better electronic technicians by developing modern sophisticated courses in such things as range patterns and transmission lines. At the present time, the only place in the world that offers up-to-date training in electronic technology is the FAA Academy in Oklahoma City. Employees with varied educational backgrounds are sent to the academy not only from the FAA, but also from the armed services and various foreign countries. Technicians who are trained there are in demand in private industry. Probably 75% of the Academy's training is general in its application, and could be offered in public schools. Its availability would be of great benefit to both the government and private industry."

A civil engineer made a very practical suggestion: "As a senior course, I would strongly recommend a 'standards' course (say 1 semester hour) to acquaint the student with industry and other standards he will run into his first day on the job, e.g., USA Stds., NEMA Stds., EEE Stds., ASME Stds., UL Requirements, AGA, Nat'l Elect. Code, Nat'l Elect. Safety Code, Building Codes, Dire Protection (NEPA, FIA), Plumbing Codes, Hydraulic Institute, etc."

There were a number who felt that updating engineering and technical courses could only be accomplished by updating the faculty. An electronics technician: "Because of the 'day-to-day' technological advancements, I believe educators should work in large companies one or two months a year in order to stay abreast." An engineer: "Educational courses are not able to keep up with the present state of technology. It would help to have teachers who at the same time are working in the field."

Many employers stated flatly that students coming directly from the schools were not familiar with the products, methods, and equipment of modern industry: "Chemical engineers need more training in the advancing technology, not just specific courses. Where technology changes, so should the training." "Make students aware of new manufacturing processes."

More Technical Education: There is concern in industry that not enough technical courses are being taught. More than 25 specific areas were listed in which educational facilities are felt to be inadequate or do not exist. A metallurgical engineer called attention to one of these: "There is a need for a degree program for Foundry Engineers, similar to curriculums offered in many eastern universities. Why? Ten years ago Phoenix had one foundry. Now it has two large ferrous and three large non-ferrous foundries, along with perhaps a dozen smaller firms. Metallurgy courses in state universities here lean toward geology and mining in emphasis, and perhaps only mention molten materials, casting procedures, spectograph analysis, and other areas for which there is a need in foundries. Companies are now forced to train employees on the job -- this is costly since it involves considerable time and the trainees turn out a lot of 'junk' before they are sufficiently trained. Suggest for the student in junior college that training in X-ray work and fluorescent analysis would be invaluable for going into foundry work."

Several utilities and electrical engineers mentioned the power field: "Universities have about abandoned electric utility's need in teaching power-oriented courses-power transmission, system stability, protective relaying, 'large' synchronous machines. In most cases the professors do not mention utilities as potential employers of engineers, assuming their work as non-challenging or glamourous, all in error." "Public utilities and electrical equipment manufacturers need engineers that have had courses in 'power.'" "We definitely need more power courses in engineering particularly in the field or operation and maintenance of power systems."

Manufacturing processes and other industrial engineering requirements were considered inadequate or lacking altogether in many schools. "More courses should be offered in quality control, i.e., reliability, manufacturing processes, systems, general engineering, etc." "There is a lack of courses pertaining to industrial engineering particularly in time study, labor relations, quality control, and systems analysis." "Need courses related directly to a quality assurance program." "Need more training in statistics and quality control techniques." "More manufacturing processes training in schools."

Other specific areas include plastics: "Schools are deficient in the field of plastics. Courses should be offered to prepare for this field." "Plastics is a new area and needs to be taught in schools and universities." "More courses should be offered in plastics."

Chemistry and natural resources: "The colleges of Arizona should provide special training in the chemical engineering filtration field which is very important in our technological society that is being sadly neglected." "It would be good for one educational facility to offer courses in wood technology and paper making." "Students need work in these areas: microbiology, biochemistry, and organic chemistry." "Only three schools offer training in quartz crystals -- University of Georgia, C.C.N.Y., and Colorado School of Mines." "More courses in non-metallic materials should be offered." "Efforts should be made to provide courses in environmental testing at a vocational school level and at higher levels." "Sheet metal men in the shop should have a short course in metallurgy."

Mechanics and mechanical equipment: "A course in servo-mechanisms is necessary. Where are the classic ME subjects of mechanics, strength of materials, thermodynamics, etc.?" "Mechanics of gasoline computers are needed." "Need fluid flow and heat transfer courses." "The degree field has become so wide that heat and cooling is sometimes left out partially." "Students should be given more varied experiences in electronic controls, dielectrical heating, r.f. heating." "Aircraft mechanics do not get enough technical training on new jet A/C." "In dire need of FAA -- A&P written and practical school courses in Arizona." "A course preparatory to an examination for FCC first class license would be a good idea. None of the schools in this area offers such a course." "Universities should provide more courses which would prepare students for the consulting field -- i.e., codes, air conditioning, design, piping systems, A.C. equipment, specification writing."

Drafting was repeatedly mentioned: "More emphasis should be put on drafting and sketching." "Put more emphasis on drafting -- example, a high school grad who took a few courses at a Minnesota school, MPLS Drafting (voc-tech), can draft circles around an engineering grad." "Desperate need for more training of draftsmen -- freehand lettering." "Engineering students make great draftsmen -- we'd welcome more."

In most cases the suggestions for more technical courses overlooked their effect on already overloaded curricula, but there were few who would sacrifice other parts of the educational program if necessary. "While no one can deny the importance of the humanities, social studies, and communications, the taking of additional technical courses is considered by the author to be more advantageous. Humanities, etc., should be acquired independently." "Don't strengthen non-technical courses if it means deleting technical material or extending the degree program." "More technical courses; fewer social studies and humanities."

<u>More General Education</u>: Those who urged technical courses in place of general education however, were so completely in the minority that they almost lend emphasis to the opposite point of view. Much of the opinion on this point was emphatic. An electronics engineer: "An engineering school should be more than just a 'trade school.'" An engineer must be well rounded -- humanities, liberal arts, non-technical courses of all kinds must be mandatory!" An industrial technician: "Please stress the importance of the social

sciences and humanities, as no man is educated without them." Civil engineer: "I would recommend that there be more, not less, courses in social studies." Electrical engineer: "I strongly feel that engineering students need a stronger background in the social sciences than I got as an undergraduate." Drafting technician: "Emphasis on general education leaves much to be desired. At all costs, avoid turning out graduate engineers or technicians who know little or nothing beyond their immediate speciality." Engineering company: "Educational programs seriously deficient in all humanities, English, personal relationships."

Some of the recommendations for more general education went into considerable detail. One was three pages long. Many of them filled the blank page on the back of the questionnaire which was available for this purpose. From one of the more lengthly dissertations are these comments from a mechanical engineer: "I graduated in 1951 with a technical diploma and had no problems until 1963. Then it was required of me to get the humanities that were required for a BS. In reviewing the present day requirements, don't require a whole lot of 'busy work.' Let the student see why he will need certain items such as English, law, math, American history, medieval history, English literature, and some courses that do not help the student in post student environment. But do show the student why there is a need."

There was a great deal of concern expressed over the tendency in engineering and technical education to crowd courses out of the curriculum which do not contribute directly to the field. An instrument maker wrote: "I feel we have need of more well-rounded persons in the engineering fields. Many in the field seem to be too specialized in one line of work with no feelings or interest in the humanities and social studies." A mechanical engineer touched on a tendency within the profession to resist general education: "Liberal arts and non-technical courses are essential to the development of a well-rounded engineer and individual; those who avoid or complain about these courses are unfortunately penalizing themselves."

Others simply expressed their convictions that engineers, technicians, and skilled craftsmen should be educated for more than simply what their jobs called for. Civil engineer: "Too many engineering schools overlook the importance of the non-technical liberal arts courses." Tool and die maker: "The shop man needs both formal and practical training." Electrical engineers: "Don't give up on humanities courses. Include history and literature." "I think more emphasis should be placed on the humanities and fine arts." "More courses in humanities, social behavior, psychology, etc."

Many employers and employees alike commented on the additional benefits to be gained from general education which contribute to career success. A machine shop owner: "For administrative positions in this company -- if a technician wants to leave the machine for a better position in administration -- then a broader educational background is required, both in technical and business-social areas. Educational needs are increasing all the time, and in a small business, a good man must be a jack of all trades." Mechanical engineer: "The humanities and social studies have no direct bearing in my technical field, but very definitely help in preparing presentations, bridging the personal gap between myself and customer contacts, public speaking and salesmanship in general." Electronics engineer: "Public speaking, psychology, personality development courses or courses of a similar nature contribute largely to individual success. Courses in logic would greatly enhance the individual's ability to present technical arguments in a convincing manner." Copper mine executive: "The technical end of education is pretty good -- it's the human relations part which needs to improve."

There were only a few who thought general education might receive too much emphasis. A mechanical engineer wrote on his questionnaire: "Humanities, social studies, etc., make one 'well-rounded.' A well-rounded person, when pushed, rolls easily. Don't we need a few more well educated 'square' engineers?" A drafting technician expressed it a little more pointedly: "I feel that the importance of liberal arts courses is overrated by most schools. Stick to the meat and season mildly!" There were others, who saw even more gaps in the education of engineers and technicians. An engineering company employer: "This job required physical fitness -- schools should increase P.E. courses." An associate civil engineer recommended a one semester course in law. "The course should cover legal descriptions and court procedures dealing with land ownership and property rights." Another employer: "Graduating seniors in general are poorly prepared for job interviews -- a well-rounded seminar would benefit both the prospective employee and employer." Electronics engineer: "Detail courses are badly needed in human relationships vs. technical operations. For example, standard rules of conduct, methods of approach, friction points, communication breakdown points, etc."

A serious gap frequently mentioned in the education of industrial personnel at all levels, especially engineering, was business and management. An electronics engineer put it this way: "My major suggestion is integration of business (with emphasis) and engineering-science curriculum. Any technical person who is competent must at some point in time manage projects requiring aptitudes in budget and personnel management. Common sense alone does not always produce favorable results." And from a chemical company executive: "Two areas which are neglected in the education of engineers. First, the graduates have a lack of economic reality. They know little about the business aspects of their professions, and they tend to over-rate their value to the employer and what they must do to attain rank in the organization. Secondly, they need more experience with behavioral sciences and PR. This refers again to the ability to handle and get along with people."

Civil engineer: "Most engineers are well versed in the technical aspects of engineering. However, engineers have little or no training in management or supervision." Associate electrical engineer: "Specifically business and social studies tend to help form a personal background conducive to a successful career." Mechanical engineer: "Additional training in industrial management is a necessity for an engineer who has aspirations for the upper echelons in today's industry." Civil engineer: "It is my opinion that in addition to the normal program, any engineering curriculum should be rounded out with courses in economics, accounting, finance, business management, etc." Electronics engineer: "Make business courses required (not elective) in the engineering curriculum." Highway construction company: "More business and communications courses, which are already offered, should be made mandatory for engineers. The guy with technical knowledge in humanities, business, etc., will eventually surpass him."

The biggest gap by far in the education of engineers and all engineering-related personnel apparently is in communications. In the words of a civil engineer: "The most obvious deficiency of engineers and scientists in the U.S.

is their inability to write and speak effectively, concisely, and vividly. Reading technical journals and attending technical conventions has convinced me that this is true. Our educational process, from grammar school through college, does not provide nearly enough criticized practice in using our native tongue; indeed, many Europeans, for whom English is not the mother tongue, surpass us in their ability to use English. What I am after is the ability to use English to communicate, not to obfuscate. Perhaps journalism might teach us how to produce journeyman prose that reaches the reader or listener without necessarily having an artistic content."

An employer in the metals industry commented that "most graduate engineers are technically proficient; in fact, so technically oriented as to render their communication incomprehensible." He suggests "more strenous English requirements stressing clarity and accuracy of expression -- also, make the Sophomore Proficiency Test more stringent." A radio broadcasting engineer: "Most engineers and technicians have difficulties in reading, writing, and comprehension -- they should be taught these subjects with the same emphasis as on the technical courses." Engineering company: "Need more stress on English and communications to sell ideas. Many engineering graduates cannot write a good sentence." Chemical company: "In general, engineering technology graduates have not been trained to express themselves with the level of proficiency they attain in their scientific fields." Government agency: "An engineer must be able to understand and communicate with other employees ranging from the illiterate to professional." City engineering department: "Need more communications. Technical reports should not be bogged down in jargon -- laymen will have to interpret them. Put more stress on basics like drafting."

Engineers and technicians must communicate with each other and with the non-engineering public. The head of an engineering firm: "There exists a basic problem in communication, especially from engineer to layman. Much more emphasis should be given to grammar and general composition as taught to, e.g., English majors. Engineers tend to become entangled in technical jargon and so it sometimes becomes necessary for the laymen to enlist the aid of other engineers to interpret technical reports." Electrical engineer: "Stress fundamentals, stress reading, writing, and communicative arts. Nothing one does is useful unless it can be explained to someone else in terms they can understand." Civil engineer: "Engineering education should put more emphasis on technical writing, public speaking, and management courses." Electronics engineers: "Teach engineers how to write and speak. Also, teach them to work with system concepts as well as with components of systems." "Technical writing is of extreme necessity as is public speaking. These latter must be keyed to the technical profession." "Emphasize English and technical writing in engineering courses. Some public speaking should be required." Tool and die maker: "Tool and die makers need more English and oral communications in their present training." Chemical technician: "Reading and communications are a large industrial problem -- teaching people to read." Civil engineer: "College should provide more and/or better courses in specification writing, engineering business administration, and engineering construction (including cost estimating)." "In my opinion the most neglected part of an engineer's education, and this includes all engineering disciplines, is facility in handling the English language. Probably this fault could not be laid to the universities; I believe it begins in elementary and secondary schools."

An electronics engineer sums up the case for more general education in these words: "All universities I have attended seem to stress the technical (mathematics and theory) aspects of engineering much more than the planning, writing, management, and supervisory aspects. It has been my experience that once an engineer gets into industry he spends a small portion of his time on jobs or phases of his job which require use of his technical abilities. Most of his time is spent on planning, making cost analyses, keeping budgets, writing reports, and supervising technicians. These jobs require skills not normally included or barely touched upon in the engineering curriculum. These are areas in the engineering curriculum which I feel need to be expanded. Or, in other words, I feel that the engineer should be given a look at the real world before he enters it."

New Directions

General Education: Some of the new directions appearing in engineering and technical education were given support by recommendations from industry. A number of engineers, favored the controversial idea of general engineering rather than specialization at the undergraduate level. "Keep BS programs on a general education basis with no particular specialization. Do not reduce requirements in English, speech, business, general engineering, etc." "Establish a practical engineering degree in four years and specialized degrees after that -- requiring the higher math, etc." "I feel we are wrong in graduating so many types of engineers such as civil, mechanical, electric, mining, etc. Let's graduate professional engineers and let them specialize later."

Most support for general engineering education came from electrical and electronic engineers. "I believe more basic physics courses and fewer courses specializing in a particular field of engineering prior to baccalaureate degree are highly desireable. Additional courses in the arts would be worthwhile. Specialization in a particular field of engineering study should be largely limited to post-baccalaureate study." "Don't give a specialized BS degree. This could wait for the MS if at all. Make future job duties **clear** to freshman and sophomores." "More time spent on basic EE. Let the more advanced courses be offered in graduate schools."

There was almost no opposition expressed. One civil engineer said, "There should be a stronger reference to the field of engineering in which the individual wishes to participate." And of course the advocates of more technical education, especially in new degree programs, seemed to be saying that specialization in school is needed. Actual opinions expressed, however, were for an engineering foundation capable of meeting the needs of various kinds of engineers in modern industry. The comment of an electronics engineer: "The technical world is changing too rapidly for educational institutions (both high schools and colleges) to attempt to maintain narrow specialization. These institutions would be serving a far more useful purpose if their educational programs were concentrated on the fundamentals with emphasis on flexability to meet the challenge of this changing technical world. Greater emphasis should be placed on humanities now woefully lacking in most technical educational programs."

Flexibility and Diversity: With or without specialization in the undergraduate years, the need for more flexibility and a broadening of the curriculum was urged repeatedly. Engineering firm: "Schools need more flexibility in the training process so that students may advance at their own rate and be capable of becoming more proficient in areas of interest." Electrical engineer: "College and university training should be more oriented toward fundamentals which are useful in almost all fields of specialization." Electronics engineer: "Engineering education is too scientific-oriented and not related to most engineering jobs. I would prefer basic science plus liberal arts." Civil engineer: "Engineers should have a broader educational curriculum. Specialization without an over-all broad exposure should be avoided if managerial or supervisory skills are to be developed."

The changing needs and interests of professional engineers was often discussed, primarily in fields of electricity, electronics, and consultation, but by others as well. An electronics engineer: "I am not sure many universities adequately acknowledge the interdisciplinary nature of some occupations. Thus, my own interests are more in the applied mathematics and statistics area than in engineering at present. The areas that interest me now -- the general field of operations research or systems science -- are often covered as engineering, but more properly belong in an 'Applied mathematics' or similar department. Similar interdisciplinary work is done in such areas as applied physics, biomedical engineering, adaptive devices, and others. Really adequate training in these fields will have to cross some of the traditional departmental boundaries existing at most schools." Electrical engineer: "We have found that the universities are graduating engineers without knowledge of the consulting field. This field not only requires a basic knowledge of the electrical sciences, but also knowledge of building construction, blueprint reading, and strong engineering economics. Also badly lacking is the knowledge and skill or presentation (drafting, specification writing, and report writing). The consulting field also demands knowledge of human relations." Mechanical engineer: "The wide variety of subjects which must be kept in mind and used to satisfactorily perform one's duties as a draftsman for most copper companies requires a special blend of parts of the curriculum of several types of engineers. The trend of specialization prepares an engineer mostly in his own field without knowledge of other fields. The new engineering graduate is not prepared for such variety."

A few employers felt that technicians and skilled craftsmen should also avoid too narrow specialization. "Insufficient importance appears to be given 'adaptability.' Almost any man can succeed without formal education if he likes his work, is dedicated to it, is industrious, honest, and ambitious." "Teach more vocational subjects, not any specific area. Give well-rounded dexterity." "In a small firm like this, it is difficult to be trained specifically for the specialized jobs found here and multitude of duties one may have. General background will have to suffice." "Students going into work with consulting firms are greatly handicapped by lack of drafting ability, and lack of any concept of engineering planning of municipal and highway fields." "Two-year 'associate degree' with credits applicable to higher degrees later would also attract many students and provide starting technical level jobs." "Encourage all young people to (1) get a college education in any field, and (2) learn a trade."

Degree Programs: Inevitably the question of a five-year engineering degree comes up in a discussion of broadening the curriculum. A number of engineers made it a part of their recommendations in the survey. Mechanical engineer: "Engineering programs should be extended to five years of study with greater emphasis on professionalism, ethics, and management." Industrial engineer: "I feel that the basic requirements of my occupation require five years of college level education. The fifth year should emphasize the business aspects of the engineering profession." Electronics engineer: "I cannot agree with the specialization of the present engineering BS programs. It appears the engineer learns his specialty on the job, often after 'unlearning' many preconceived notions and out of date 'facts.' Let's have a good four-to-five year engineering course, perhaps based on U of A's present engineering physics program -- a broad but highly useful curriculum. Studying circuit design on the way to a bachelor's degree is nonsense."

Chemical engineer: "I would suggest greater emphasis on humanities and management courses. Four years does not seem to provide adequate education for the field. I would suggest a five-year program to allow more non-engineering courses and greater diversification of the engineering education." Electronics engineer: "Engineering schools should have five-year programs of study. The students should take an adequate number of liberal arts courses, and the technical courses should reflect the present needs of industry." Civil engineer: "BSCE program should be either a five-year program or six years, MSCE or CE with further training. Four years of college training cannot produce adequate engineers -- not enough exposure to requirements."

No attempt was made in the survey to determine the actual weight of opinion on this question, but voluntary expressions of support for the four-year program were almost entirely missing. One of the few who did support it was a mechanical engineer who wrote: "I suggest greater emphasis on communication, economics, and use of industry support for up-to-date descriptions of technology level. Retain BS as first professional degree." An electronics engineer perhaps expressed the feelings of many who dislike the trend but do not know what to do about it: "The trend today in engineering programs is to broaden the base of knowledge and require more humanities. This is done at the expense of the technical foundation. I believe that this widening of background has reached a point where an engineer with a BS degree actually knows very little about the field in which he is supposed to be a specialist. I do not believe that every engineer should be required to get a MS degree, yet this is the present trend."

Another electronics engineer described the same kind of frustration: "Would suggest good basic education in the 'hard' sciences, with liberal reading in all fields, areas, and disciplines. I don't think that, with our wasty educational system, there's time to take formal courses in the humanities, etc., while getting the mandatory educational tools for a technical occupation. Things are moving too fast and the accumulation of facts and techniques is outstripping our communications abilities."

Continuing Education: One solution to the problem of burgeoning educational requirements is to remain in school after going to work. Widespread interest in continuing education was a significant development revealed in the survey. Electrical technician: "Continue to expand adult education opportunities for those who must work but want also to learn." Civil technician: "I would like to see more extension courses offered in the field of engineering in my area." Electronics engineer: "More continuing education by the state universities is needed in engineering and it should be made as convenient as possible through local programs, TV, etc." Instrumentman: "The greatest advantages to skilled men interested in improvement in their chosen field would be to have local adult classes in technical and mechanical education, either through the present school system or a junior college in this area." Electronics engineer: "There is a strong need for 'in-plant' short courses in new engineering techniques or refresher courses such as circuit design by use of computers, computer operations, integrated circuits, refreshers in inplace transformers, differential calculus, information theory, control systems and noise theory. Also, management courses." Electrical engineer: "More graduate courses should be made available for the electric utility oriented people." "Offer specialized engineering short courses (seminar type) and encourage industry to send selected key employees." Civil engineer: "Better and more extension courses in engineering subjects, taught by experienced teachers."

Much of the interest in continuing education stems from a need to keep up with changing technology. Electrical engineering, for example: "Periodic short courses in electrical utility and construction engineering should be given to assist practicing engineers in keeping up to date with new products." An electronics engineer: "At age 55 I consider my formal education a continuing program in order to communicate with the younger engineers. I consider this as an obligation, if nothing else." Another electronics engineer felt that continuing education should be on a regular routine basis: "Encourage industry to return all engineers to school for one year full-time every five years to update skills." Numerous comments simply reflected a growing need throughout large areas of industry for "courses for technicians and engineers to keep them abreast with the rapidly changing state-of-the-art in so many technical fields."

Non-technical courses are wanted as well as courses in engineering and technology. Electronics engineer: "Graduate level courses should be given at Fort Huachuca. Several additional courses and labs in English grammar, composition, vocabulary, comprehension, speed reading, and oral communication in place of and or addition to ones presently given are needed because the electronic field is always moving and requires continuous study and reading by the engineer. Also, most engineers spend a large part of their time writing reports and papers. Usually, sufficient courses are not given." Electronics technician: "There should be effective reading and writing courses available in-plant for all employees who spend most of the working day doing both."

The need for continuing education, in fact, embraces entire curriculum offerings at the universities and junior colleges, with considerable interest in off-campus degrees. A metallurgical technician wrote on his questionnaire: "Offer courses so that people who must work 40 hours a week can finish their education. I am still trying, but the university only teaches science subjects, especially chemistry between 10 and 2 p.m." Mechanical engineer: "Need advanced courses in mechanical engineering made available during evening hours. Should be able to obtain master's degree at night school in the Phoenix area." Electronics engineer: "A definite need exists for more liberal graduate engineering programs. Many engineers, myself included, would like to obtain an advanced degree but find the present residency requirements make it virtually impossible to do so without changing jobs and moving." Electronics technician: "Offer night courses leading to a BS in electrical-electronics engineering, engineering physics, and physics." Civil technician: "At present I am enrolled in evening college, working for a two-year technical degree. I have nothing but praise for the technology program."

Continuing education means education at night and this was the constant refrain heard throughout the state: "Need more upper level courses available at night school." "Specialized or general engineering courses at junior college night schools." "More night technical classes for upper levels in physics and engineering." "It would help a great deal if more courses were offered after working hours." "More college evening courses in the first two years of engineering; technical or engineering correspondence courses organized by a state university; joint industry-university organized evening classes acceptable toward a degree." "Need more engineering on the undergraduate level offered at night or on Saturdays." "Evening courses in the various junior colleges or extension courses for those in smaller cities would be helpful." "Make more courses available at night for working people." "I'm very interested in an engineering course of study offered in evening hours." "Evening classes should be made available for older engineers to keep up with the-state-of-the-art." "More lower level engineering courses at night. Also, more variety in the MS program at night." "We need a good evening program in advanced engineering and mathematics. Opportunity for daytime attendance is limited." "Availability of graduate course work in the evening hours is extremely valuable for keeping abreast of the engineering profession."

To a great many persons in industry today the problem of adequate education when and where they need it is becoming critical. One mining engineer wrote: "The working engineer who cannot return to campus for full-time study, yet wishes to maintain disciplined study in advancing techniques such as computer application, systems engineering, ground control, equipment improvements, and many economic analysis techniques, is a lost soul."

Electronics technicians: "At present I have over 60 semester hours of electronic engineering courses, but am unable to attend night classes for additional courses due to working on rotating shifts. Would like to see local universities set up a good correspondence program for people in my position." "Why must the larger portion of the last two years of college be completed on campus? This arrangement makes it very hard for the actively employed family man to finish his degree if he does not reside in a college town." "I have, besides the associate degree, two years toward a BSEE degree. I am disappointed in finding such a limited opportunity to obtain additional credit in night courses in the Tucson area." "Engineering courses in the universities are not readily available for a person (technician) working during the day and trying to attend school at night."

Electronics engineer: "At remote work locations that employ substantial numbers of engineers and scientists, the employers and higher institutions of the state should make graduate level courses available at the work location." Electrical engineer: "It would be a great boon to the Valley if advanced engineering subjects were taught on the 'west side.'" Civil engineer: "At the formal continuing educational level, much needs to be done. Many more short courses and workshops are needed -- designed for the man in practice -- not a piece of a graduate course." "I would like to see either night courses or home study courses made available to people who live out of the two major university areas of Phoenix and Tucson."

Industrial engineer: "I strongly advocate that educational institutions initiate junior and senior level courses in evenings (rather than just post-grad work). A large number of married, full-time employed people are 'stalemated' after two years of undergrad work. These people are serious, stable students unable to go days." Electronics engineer: "I would like to take several physics courses (optics, solid state), but they are never available at times when I could attend. More extension courses at central, convenient locations would be helpful." Electronics engineer: "Provide more degree credit engineering and technical courses in the continuing education divisions of our universities at hours that are useful to adults who hold full-time jobs. Also provide additional courses for adults who are not seeking degree credit but need refreshers or a broad brush of new technology. The non-credit adult courses should not require normal prerequisities." Chemical engineer: "There is a great need for advanced upper division courses in chemistry and electronics in night school -- the employees who work days find it impossible to continue their education at night due to lack of courses."

Mechanical technician: "There are no school facilities close enough to attend without quitting my present job." Mechanical engineer: "I would like to see a BS and MS program in mechanical and electrical engineering in northwestern Arizona. Possibly an extension of correspondence courses from NAU, U of A, ASU. However, since this area makes a small total population, I imagine this idea is impossible." Civil technician: "I have worked in northeastern Arizona for the past 22 years. In this time, no night school or classes were available in any phase of engineering." Drafting technicians: "Have more night courses. I cannot get all the courses I want at night." "A person should be able to get a degree in engineering while going to night classes. At present this is not so in this state." "Provide college education to remote areas such as Fort Huachuca." One employer suggested "a broad university extension service in which instructors would be sent to industrial plants to give courses in such areas as communications, public and employer relations, employee training, leadership, etc. Also give survey courses in broad areas at the universities to give supervisory and professional employees information regarding general trends and an appreciation for other broad areas of business."

Several persons, including an associate engineer, commented on the success of special programs initiated by industry in the schools for men on the job. "Employer sponsored junior college courses have proved very successful and should be continued." Correspondence courses were frequently mentioned as a partial solution. An electronics engineer said: "I would like to see the colleges do more about working up some good correspondence courses. In a lot of supervisory jobs engineers are often out of town and unable to attend classes, and other times family committments prevent class attendance. In my own case I have learned more from good correspondence courses than in residence courses."

Advice to Students

Older men looking back at their own education had some things to say to the students of today. A civil technician wrote: "More stress should be placed on math in lower grades and also be required in high school. Lack of proper math education costs me at least $150 per month." Other civil technicians said: "I suggest that all the math you can get will help." "I wish I would have had the knowledge I have now -- I would have secured a degree in my chosen profession." "To most students I would advise a minor in business administration! To business administration majors I would advise as many technical courses as they are capable of!"

Civil engineer: "The courses in school which I thought were unimportant are the ones I am using the most. Students should realize that no course should be neglected."

Electrical engineer: "Colleges and universities have long presented liberal arts courses such as economics, English, etc., as a part of an engineering course; however, the student is not sufficiently motivated during his school years as to the value of these courses. The engineer does not learn the necessity of this education until he has been practicing for a number of years."

Electronics engineer: "Young persons entering the engineering profession should be informed that they most probably will be a failure if they don't continue their education in some way after graduation from college -- either through formal education or extensive study of current literature on their own time and initiative."

Chemical engineer: "Young graduates in engineering expect too much too soon. There is a tendency among engineering students to slow down, self-satisfied upon attaining their degrees. But they must compete with people who, although they lack formal training, are just as competent and have learned how to fight their way up. There are people with only high school diplomas who are earning two or three times as much per year as graduate engineers in similar positions."

Civil engineer: "Graduating civil engineers should have first-hand field experience (short time as a carpenter and block layer, etc.) in each of the occupations they supervise or work with. Many graduating engineers feel it 'degrading' or beneath them to work in the field, but need such experience to be qualified engineers."

Mechanical engineer: "I observed in college that many classmates fell behind and dropped out when the curriculum reached calculus. Lack of counseling is the culprit. Most young men aren't told that engineering is 90% mathematics."

Electronics engineer: "Most of what is learned in the undergraduate level serves only as a foundation. Everything needed later is beyond or different from what was learned in the undergraduate level."

Mining engineer: "Many years ago a professor told his class in engineering that the most important factor of knowledge was the ability to find the proper information in any particular situation. I was in that class, and have found that factor to be a most reliable truth. Wisdom is the proper application of knowledge and knowledge is the substance of education."

Associate civil engineer: "No one should be in this field without first having a college education. Advancement, experience, and salary are too slow in coming without it." Electronics technician: "Electronics technician is a real good job. Good pay, security, satisfaction." Civil technician: "A young man raised on a farm or ranch where the family does all or most of the work has experience and ability, and complete with a leaning toward mathematics, has an ideal background for field engineering." Geological technician: "It is very important that a person enjoy what he or she does; this benefits the employee, the employer, and the job itself." Electronics manufacturer: "The most important qualities a technician trainee can possess are common sense and patience."

Finally it was an electronics engineer who said it, but there were many who reflected it in the sincerity and enthusiasm of their comments: "I like engineering. It's fun, rewarding, and challenging."

CHAPTER VII

INDUSTRIAL DEVELOPMENT IN THE DECADE AHEAD[1]

Arizona's requirements for engineering, technical, and skilled manpower in the years ahead will depend on the extent and direction of continued economic development. Most observers at this time view the future as a projection of the past, with no major changes anticipated in the industrial patterns and trends of the past two decades. A recent study by the Stanford Research Institute supports this assumption.[2] Economic and industrial trends in Arizona since World War II, therefore, will be used as the basis of a projection of industrial expansion during the next decade. From this a forecast will be made of engineering, technical and skilled manpower requirements for the 1970s.

Population: Economic performance is measured in human terms such as population, labor force, employment, and personal income. Prior to World War II, Arizona's economic growth occurred rather slowly. Since World War II, and particularly after 1950, industrial and economic expansion in this state has been something more than spectacular. In 1950 Arizona's population totaled approximately 750,000. Fifteen years later it had increased by almost one million persons to about 1,648,000.[3] There were 552,000 new residents added between 1950 and 1960, an increase of 73.7%. By 1965 the population had increased another 346,000, approximately 26.4% in only five years. Compared with Arizona's growth in this period, the United States population increased 18.5% between 1950 and 1960. The annual rate of growth between 1960 and 1965 was 1.4% for the United States, 2.1% for the Mountain States, and 3.5% for Arizona. These figures are projected to 1975 in Table 61, using a 40% anticipated increase over the 1965 population. This is a lower rate of growth than that of the previous ten years, but about the same in absolute numbers.

Population distribution in 1950 was 44% in Maricopa County, 19% in Pima County, and 37% in the balance of the state. By 1965 Maricopa County contained 53% of the state's total population and Pima County had 20%. While also growing, but at a less accelerated rate, the remaining 12 counties accounted for only 27% of the new population figure.

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[1] Portions of this chapter were prepared by Edward Heler, Chief of Manpower Research and Analysis, Arizona State Employment Service.

[2] Stanford Research Institute, "Industrial Development in Arizona," Summary of Report prepared for Arizona Public Service Co., APS (Phoenix, 1968).

[3] Arizona Basic Economic Data (Phoenix: Arizona State Employment Service, 1966), p. 66.

Between 1950 and 1960 the median age of Arizona's population decreased from 26.8 years to 25.7 years.[4] Since the median age of the entire United States in 1960 was 29.5 years, Arizona's population is comparatively young. A declining birthrate in the past few years, however, if not reversed, will result in a higher median age by 1975.

TABLE 61

POPULATION

UNITED STATES, MOUNTAIN STATES AND ARIZONA

SELECTED YEARS
(In Thousands)

Region	1950	1955	1960	1965	1975
United States	152,271	165,931	180,684	194,592	222,805
Mountain States*	5,075	N.A.	6,855	7,693	9,399
Arizona	750	1,009	1,303	1,648	2,307

*Mountain States include: Montana, Idaho, Wyoming, Colorado, New Mexico, Utah, Nevada and Arizona.

Sources: U. S. Bureau of Census, Statistical Abstract of U. S. 1967.
Arizona State Employment Service, Manpower Directions '75.

Labor Force: In 1950, Arizona's labor force numbered approximately 258,000. By 1966, it had grown to an annual average of 552,800.[5] In the ten years between 1950 and 1960 it increased 196,000, and in the six year period after 1960, it grew an additional 98,000. This growth rate is expected to equal, or possibly exceed, that of the population. The trend line in Figure 25 indicates that no less than one-third of Arizona's 1975 population is expected to be in the civilian labor force. In other words, about 770,000 persons will be either employed or seeking work in Arizona by 1975.[6] Since Arizona may be expected to continue to have a population younger than the United States average, the labor force will also be younger than average. The principal components of the 1975 labor force are currently in school or already working. By 1975, about 70% of the 25-44 age group, two out of three in the 45-64 age group, and 40% of the 16-24 age group will be in the labor force.[7]

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[4] Statistical Abstract of the United States, 1966 (Washington, D.C.: Government Printing Office), p. 23.

[5] Arizona Labor Force Data (Phoenix: Employment Security Commission of Arizona) Selected Years.

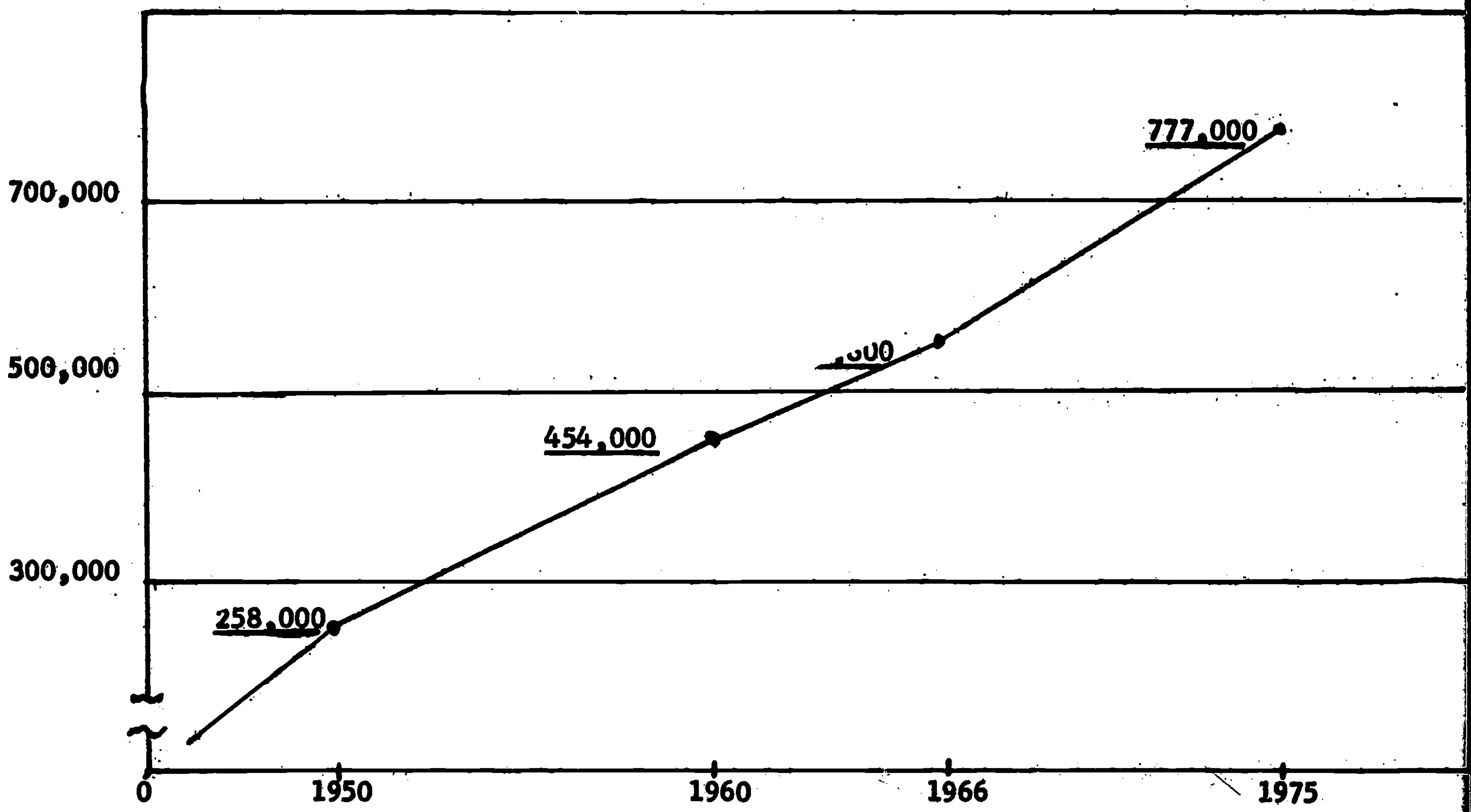
[6] Manpower Directions'75 (Phoenix: State Employment Service, 1967), p.6.

[7] Ibid., p. 7.

FIGURE 25

CIVILIAN LABOR FORCE

ARIZONA
1950 - 1975



Source: Date from 1950 from U. S. Census. Data for 1960 and 1966 from Unemployment Compensation Division, Employment Security Commission of Arizona, 1975 Forecast by the Arizona State Employment Service.

The relative number of women in the labor force is expected to continue to increase at a rapid rate. In 1950 a little more than one-fourth of the civilian employees were women. Nearly one-third were women in 1960, and by 1965 the feminine wave was expected to reach 40%.

Economic Growth: Arizona's economy has expanded at an even greater rate than the population since World War II. Personal income increased from $879 million in 1948 to $3,733 million in 1965, a jump of 325%.[8] The largest part of the increase was by wage and salaried workers. In 1965 this group received an average of $5,035 per employee, slightly less than the national average, but higher than many other states and higher comparatively than at any time in the past.

Two additional indicators of economic growth confirm that business and industrial expansion are primarily responsible for what has happened. Retail sales have more than tripled since 1948. A growth of 42.8% was experienced in the five year period alone from 1958 to 1963. In that same five year period expenditures for new manufacturing plants and equipment increased 78.7%, and for new structures and plant additions 149.7%. These figures are shown in Table 62.

TABLE 62

ARIZONA ECONOMIC GROWTH 1948 - 1963

	(millions of dollars)				% Change
	1948	1954	1958	1963	1958-1963
Value of Retail Sales	$ 658	$1,001	$1,412	$2,016	42.8%
Expenditures for New Mfg. Plants & Equipment-Total	n.a.	13.8	27.7	49.5	78.7%
New Structures & Additions to Plant	n.a.	n.a.	7.7	19.1	149.7%

Note: Data for 1958 and 1963 include expenditures for plants under construction but not in operation, in addition to expenditures at operating establishments. 1954 data represent expenditures at operating manufacturing establishments only.

n.a. means data not available

Source: U.S. Department of Commerce, Bureau of the Census, U. S. Census of Business, Vol. I, "Retail Trade Summary Statistics" (Summaries for 1947, 1954, 1958, and 1963); Census of Manufacturers, 1963, Summary Statistics, General Summary, MC 63(1)-1, Tables 5 and 7, and Area Statistics, Table 3; and Census of Manufacturers, 1958, Summary Statistics, General Summary, Table 4; Stanford Research Institute.

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[8] Survey of Current Business (Washington, D.C.: U. S. Department of the Census, 1966).

Employment: Arizona's rate of employment growth has been correspondingly rapid since World War II. The 1940 Census reported total employment at 148,973. By 1950, this had grown 60.2% to 238,677. During the next ten years, 191,000 new jobs were added for a total of 429,862 recorded in the 1960 Census. The rate of employment growth increased to 72.6% during the latter ten year period.

Average annual employment reached 501,800 by 1965. Agricultural employment declined, but nonagricultural employment increased from 333,800 in 1960 to a 1965 annual average total of 403,700.[9] These figures are shown with projected estimates for 1975 in Tables 63 and 64. The percentage distribution of employment by industry for the same years is shown in Table 65.

The greatest numerical growth since 1950 has been in manufacturing and this is expected to continue until 1975 and beyond. During the 1965-1975 decade, 60,100 new jobs are anticipated. Well over three-fourths can be expected in the durable goods section, with almost half of these in the manufacture of machinery including electrical machinery. Most of the new jobs will be in production of light-weight components for which transportation costs are of little importance. The continuing trend toward miniaturization favors additional expansion of this industry in Arizona.[10]

Other areas in which recent developments should result in employment gains by 1975 are copper products fabrication, airframe manufacturing, food products manufacturing, and the "think-tank" industry developing as research and development laboratories.

Mining employment has been affected to a considerable extent by automation, and this is expected to continue especially in copper mining. A growing demand for copper products, however, will probably more than offset productivity gains resulting in steadily higher employment levels through 1975.

When employment by industry is converted to kinds of occupations, the largest numerical increase and the most rapid rate of growth are expected in the professional, technical, and managerial group. Nearly half of all workers in the state will be employed in "white collar" occupations by 1975. The number of skilled workers will increase, but their proportionate share of total employment will decrease slightly. Semiskilled workers will also increase, but by a slower rate even than skilled. Employment of unskilled workers will increase only slightly. These projections are shown in Table 66.

The demand and supply factors which will determine Arizona's manpower needs to fit this employment picture have been examined by the State Employment Service in its recent publication, Manpower Directions '75. The outlook for 1975 is shown by occupational groups in Table 67, and is described in the following summary from the Fmployment Service report:

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[9] Arizona Labor Force Data, op. cit.,

[10] Manpower Directions '75, . . ., p. 16.

TABLE 63

Employment By Industrial Group

INDUSTRY	EMPLOYMENT 1950[a]	1965[a]	1975[b]
Total Employment	238,700	501,800	750,000
Manufacturing	17,000	64,900	125,000
Mining	11,300	15,800	18,000
Contract Construction	12,000	23,000	40,000
Transportation, Communication, & Public Utilities	18,600	25,000	32,000
Wholesale & Retail Trade	40,300	94,500	140,000
Finance, Insurance, & Real Estate	5,600	21,900	35,000
Services	22,200	66,400	110,000
Government	34,600	92,200	132,000
Agriculture	48,900	36,300	33,000
All Other	28,200	61,800	85,000

[a]Source: Unemployment Compensation Division, Employment Security Commission of Arizona.

[b]Source: Arizona State Employment Service estimates.

TABLE 64

Employment Changes By Industry Group

INDUSTRY	1950-65 CHANGE IN NUMBER EMPLOYED	1950-65 PERCENTAGE CHANGE IN EMPLOYMENT	PROJECTED 1965-1975 INCREASE IN NUMBER EMPLOYED	PROJECTED 1965-1975 PERCENTAGE INCREASE IN EMPLOYMENT
Total Employment	+263,100	+110.2	+248,200	+49.5
Manufacturing	+ 47,900	+281.8	+ 60,100	+92.6
Mining	+ 4,500	+ 39.8	+ 2,200	+13.9
Contract Construction	+ 11,000	+ 91.7	+ 17,000	+73.9
Transportation, Communication, & Public Utilities	+ 6,400	+ 34.4	+ 7,000	+28.0
Wholesale and Retail Trade	+ 54,200	+134.5	+ 45,500	+48.1
Finance, Insurance, & Real Estate	+ 16,300	+291.1	+ 13,100	+59.8
Services	+ 44,200	+199.1	+ 43,600	+65.7
Government	+ 57,600	+166.5	+ 39,800	+43.2
Agriculture	− 12,600	− 25.8	− 3,300	− 9.1
All Other	+ 33,600	+119.1	+ 23,200	+37.5

TABLE 65

PERCENTAGE DISTRIBUTION
OF EMPLOYMENT BY INDUSTRY

1950 - 1965 - 1975

INDUSTRY	1950	1965	1975
TOTAL EMPLOYMENT	100%	100%	100%
Manufacturing	7.1	12.9	16.7
Contract Construction	5.0	4.6	5.3
Mining	4.7	3.1	2.4
Transportation, Communication & Public Utilities	7.8	5.0	4.3
Wholesale & Retail Trade	16.9	18.8	18.7
Finance, Insurance & Real Estate	2.3	4.4	4.7
Services	9.3	13.2	14.7
Government	14.5	18.4	17.6
Agriculture	20.5	7.2	4.4
All Other	11.8	12.3	11.3

Source: 1950 and 1954 data from Unemployment Compensation Division, Employment Security Commission of Arizona. 1975 data from the Arizona State Employment Service Projections.

TABLE 66

ARIZONA'S EMPLOYMENT BY OCCUPATIONAL GROUP

Occupational Group	Employment 1950	1965	1975
Total Employment	238,700	501,800	750,000
Professional, Technical & Managerial	47,100	122,400	201,000
Clerical	22,400	72,300	117,000
Sales	16,500	35,600	51,800
Service	25,800	66,200	108,000
Skilled	30,000	70,700	104,200
Semiskilled	33,400	71,700	103,500
Unskilled	14,600	26,600	31,500
Agricultural	48,900	36,300	33,000

Source: Manpower Directions '75, Arizona State Employment Service.

TABLE 67

PROJECTED MANPOWER DEMANDS, SUPPLY, AND SHORTAGES
1965 - 1975
STATE OF ARIZONA

OCCUPATIONAL GROUP	DEMAND	SUPPLY				SHORTAGE
	1975 PROJECTED EMPLOYMENT	RETAINED[a] FROM 1965 LABOR FORCE	NET[b] INMIGRATION	FORMAL[c] ON-JOB-TRAINING	SCHOOL[d] GRADUATES	DEMAND[e] LESS SUPPLY
Total Employment	750,000	440,000	51,000	55,500	94,000	116,500
Professional,Technical, & Managerial	201,000	106,000	8,000	9,000	37,500	40,500
Clerical	117,000	65,000	6,000	6,500	21,000	18,500
Sales	51,800	31,000	5,000	2,000	12,500	1,300
Service	108,000	56,000	9,000	9,500	11,000	22,500
Skilled	104,200	62,000	5,000	5,000	6,200	26,000
Semiskilled	103,500	65,000	10,000	19,000	1,800	7,700
Unskilled	31,500	23,000	4,000	4,500	—	—
Agricultural	33,000	32,000	4,000	—	4,000	—

[a] The retained labor force is secured by application of current survival rates to 1965 employment.

[b] Net inmigration is the estimate of fully trained workers who will inmigrate to Arizona employment in excess of that number which will replace outmigrating workers.

[c] Formal on-job training estimates are based upon the present rate of output from established programs except for unskilled workers where formal training is not required.

[d] The estimate of school graduates who will enter the local labor force without the need for additional formal on-job-training.

[e] The estimate of unmet need for trained workers if present rates of training output and inmigration are continued.

Source: Manpower Directions '75, Arizona State Employment Service

Total employment in Arizona should reach 750,000 persons during 1975. This number will include about 440,000 members retained from 1965 employment. The remainder, about 310,000 openings, will be available for new entrance to the Arizona labor force. Present patterns and trends indicate 51,000 of these openings will be filled by trained immigrants. Another 55,000 openings will be filled by persons completing on-job training and apprenticeship programs. The current levels of output of both public and private educational institutions will provide 94,000 trained workers. Some simple arithmetic shows the total number of additional workers is far short of the 310,000 available openings. The difference is, in fact, a startling 116,500. This means slightly more than one out of every three additional job openings (38%) will not have trained manpower available.

The quantity of manpower needed to fill the void of 116,500 will be available. The large number of young people reaching labor force age during the decade, supplemented by a number of older persons who do not presently possess competitive skills represent the raw material. Only the quality, the skill level, of the 1975 labor force is in doubt. Some problems are already apparent. For example, a high rate of unemployment now exists among certain groups of the population while there are serious shortages of qualified workers to fill specific available openings. The large number of persons who will enter the labor force must first receive the training required by an increasingly complex economy.

The level of additional education and training required of the 1975 labor force is illustrated below on a quantitative basis by separate examination of demand and supply relationships by occupational groups. In general, each broad occupational group represents a distinct level of training need.

The picture of demand and supply to 1975 professional, technical, and managerial occupations is as follows:

	New Openings	Supply	Deficit
Professional, Technical, Managerial and Kindred	95,000	54,500	40,500

In other words, there are over two out of every five (43%) of the potential job openings for which trained manpower will not be available.

In the clerical field the relationship is:

	New Openings	Supply	Deficit
Clerical and Kindred	52,000	33,500	18,500

Or, about one out of three possible openings (36%) will not find trained manpower available.

The pattern for sales occupations will be:

	New Openings	Supply	Deficit
Sales Occupations	20,800	19,500	1,300

Or, about one out of every 20 (5%) of the new openings face a lack of trained workers.

The outlook for service occupations is:

	New Openings	Supply	Deficit
Service Occupations	52,000	29,500	22,500

Or, more than two out of every five (43%) of the prospective openings may lack trained manpower to fill them.

The supply and demand for skilled workers is expected to look like this:

	New Openings	Supply	Deficit
Skilled Occupations	42,200	16,200	26,000

Thus leaving slightly over three out of every five (62%) potential openings without trained manpower available.

The relationship for semiskilled jobs is:

	New Openings	Supply	Deficit
Semiskilled Occupations	38,500	30,800	7,700

Therefore, there are about one out of five (20%) new job openings for which trained manpower will not be available to take advantage of this opportunity.

Each step taken in the analysis of manpower demand and supply to 1975 makes it increasingly clear that the more serious shortages will be in occupations which require relatively long and complex training. Professional and technical educational requirements are the most rigorous; however, skilled craftsmen also require lengthy and exacting training. The length of time required to prepare for these occupations instills a degree of urgency to the process of finding solutions which might not otherwise exist.

Engineering, Technical, and Skilled Employment: The availability of industrial personnel in the next decade appears uncertain. The State Employment Service has developed anticipated increases in the numbers needed in each field of engineering, technology and the skilled crafts, shown in Table 68. These are based largely on straight line projections of earlier figures. In some cases, such as data processing technology, it is quite possible that a considerably higher employment level will be reached by 1975 than is projected here. For the most part, however, these projections may be reasonably reliable. Availability of personnel to fill these positions will depend on migration of qualified workers from other states and graduates from Arizona educational institutions. As competition for these employees increases all over the country, an increasingly greater responsibility will fall on the schools to supply the demand.

Employment of engineers is expected to increase by 4,000 in the decade from 1965 to 1975. Heading this growth would be electrical and electronics engineers, followed by mechanical, civil, industrial, chemical, aeronautical, mining, and metallurgical in that order. An increase of 3,100 technicians is anticipated, with electrical and electronics accounting for 850 of these, followed by civil, mechanical, drafting, chemical, aeronautical, data processing and industrial. The greatest increase in skilled craftsmen would be in machine tool operators, followed by machinists, and tool and die makers.

TABLE 68

ARIZONA MANPOWER DEMAND FOR SELECTED
ENGINEERING, TECHNICAL & SKILLED OCCUPATIONS
1965 - 1975

Occupational Field	1965	1975	Change 1965-75
Engineers, Technical			
Engineers, Aeronautical	200	350	150
Engineers, Chemical	300	500	200
Engineers, Civil	1,400	1,700	300
Engineers, Electrical	2,500	3,800	1,300
Engineers, Electronic	1,600	2,300	700
Engineers, Industrial	600	800	200
Engineers, Mechanical	1,300	2,000	700
Engineers, Metallurgical	100	150	50
Engineers, Mining	250	400	150
Other Engineers, Technical	450	700	250
TOTALS	8,700	12,700	4,000
Technicians			
Aeronautical	450	700	250
Chemical	200	100	100
Civil	1,450	1,900	450
Data Processing	400	650	250
Drafting	750	1,100	350
Electrical	800	1,300	500
Electronic	1,400	1,750	350
Industrial	300	450	150
Mechanical	650	1,000	350
Other	250	400	150
TOTALS	6,650	9,350	2,600
Skilled Craftsmen			
Airplane Mechanic	1,500	1,700	200
Machine Tool Operator, Skilled	2,000	3,500	1,500
Machinists	1,500	2,000	500
Tool and Die Makers	650	800	150
	5,650	8,000	2,350

Graduates Needed from Arizona Schools: It is virtually impossible to estimate the number of graduates needed from the schools of this or any other single state in future years. There are three very good reasons for the difficulty: (1) Industry does not know its future needs; these depend on the condition of the economy, continued technological developments, national and international politics, the quantity and quality of manpower available and various other factors which industry cannot control. (2) Graduates enter a national labor market rather than the labor market of their own respective states, go into the armed services, go on to graduate school, or change occupations. (3) The need to produce any particular number of graduates even for the national labor market is not based entirely on demand; demand has greatly exceeded the supply in engineering, technology, and the skilled industrial crafts for nearly two decades and except for temporary dislocations for the entire period of modern industrial development. The number of graduates the schools in Arizona should attempt to produce in the next decade, therefore, depends on the share of the national effort they are willing to assume, the number of students available, and the economic or other advantages the state wants to receive.

At the very least, an increasing number of persons should be available each year corresponding to the present ratio of graduates to manpower demand.[11] In 1967, Arizona institutions graduated 599 engineers and 280 technicians in occupational fields for which the State Employment Service has developed manpower demand figures. These were ratios of 63 engineering graduates to each 1,000 engineers in demand and 39 technology graduates to each 1,000 technicians in demand. If Arizona institutions do nothing more in the next eight years than maintain these ratios, the 1975 graduation requirements will be 800 engineers and 365 technicians. This would represent an increase of about one-third, roughly the same as the estimated population growth of the state in the same period. An academic output at this level would be a holding action only with no contribution to the nation's short supply and no assistance to Arizona's industrial growth.

There are compelling reasons for Arizona schools to establish higher levels of academic output than this. The national imbalance between demand and supply is an increasing threat to industrial growth. The National Science Foundation's study of scientists, engineers, and technicians in the 1960's shows a 67% increase in demand for engineers and technicians from 1960 to 1970.[12] This is a realistic projection based on the ratio of engineers to total employment for each sector of the civilian economy in the base year 1960 and all previous years for which data were available. The trend in this ratio was projected to 1970 and applied to independent projections of employment. Technicians projections were based on trends in ratios of technicians to scientists and engineers. Added to the employment increase figures are losses due to death, retirement, and transfer. Projections of losses are based on past experience and age levels in each occupation and each sector of the economy.

Compared with an annual average demand of 71,700 engineers, the NSF study shows a net annual supply of only 45,100. This is based on an annual average projection of 34,700 bachelor degrees in engineering,[13] of which 85% or 29,500 are expected to enter engineering. The remaining 15% go into other fields or become unemployable for a variety of reasons.[14] An additional 7,300 persons annually

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[11]Manpower demand is the number of persons employed plus unfilled job openings.

[12]NSF, op. cit., 63-34, p. 8.

[13]Two parallel studies by the Engineering Manpower Commission projected annual bachelor degree figures at 37,000 and 36,000. Ibid., p. 22. Experience in the first seven years of the decade would tend to support the NSF projection of approximately 35,000.

[14]Idem.

enter engineering with non-engineering degrees, and 10,500 do so without degrees according to the NSF study.[15]

The supply of technicians cannot be estimated as easily as engireers because sufficient quantitative information is not available. However, the NSF study observed that in recent years the available supply of well-trained technicians also appears to have fallen short of meeting the demand for these workers and this situation is expected to continue through the decade of the 1960's.[16] The 1967-68 Technician Education Yearbook estimates an annual average demand for additional technicians from 1963 to 1975 of 86,000, and a supply of 69,000. Considering the increasing use of technicians in industry, and greater dependence of employers on local supply of technicians than of engineers, it would seem that the number of technology graduates should be increased to at least equal engineering graduates.[17]

The number of both to be graduated from Arizona schools should probably be increased substantially by 1975. Simply to close the gap between demand and supply would require nearly doubling the annual output. Additional graduates are needed to reduce an accumulated backlog of more than a decade. And since the rate of Arizona's economic growth is at least twice the national rate, even more graduates should be supplied by our own schools. This is especially true since an important part of Arizona's growth depends on an increasing supply of engineering and technical personnel readily available. The numbers of Arizona graduates needed annually by 1975 on the basis of these factors are shown at three levels in Table 69. The first is the minimum effort required to maintain present ratios to demand. The second includes Arizona's share of the national effort to eliminate current annual deficits in engineering degrees and technology graduates equal to the number of engineering graduates. The third is what may be required to support continued economic expansion at the rate of the past two decades.

The number of skilled craftsmen produced through industrial arts and vocational education programs in the high schools must also be substantially increased. Graduation figures are comparatively meaningless in these occupations since entry to employment does not require graduation in a specific program. Students who acquire machine skills in high school industrial arts courses, for example, may graduate from general education or college preparatory programs. In order to arrive at figures suggesting annual output from the schools of Arizona in the skilled crafts, present manpower demand was used as a base. A national attrition rate of 18% annually was applied, plus an annual growth rate of 5%, to give the number of new personnel required to maintain the present ratio of craftsmen to demand. These are the figures in the first column in Table 69. Figures in the second and third columns are developed in the same way as for engineers and technicians.

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[15] Ibid., pp. 24-26.

[16] Ibid., p. 30.

[17] "Technician Manpower," Technician Education Yearbook 1967-1968, from a 1966 study by the Bureau of Labor Statistics for the National Science Foundation entitled "Technician Manpower: Requirements, Resources, and Training Needs" (Ann Arbor, Michigan: Prakken Publications, Inc., 1968), p. 113.

TABLE 69

ARIZONA GRADUATES NEEDED ANNUALLY 1967 - 1975

OCCUPATIONAL FIELD	1967 GRADUATES	MINIMUM REQUIRED 1975 [1]	TO BALANCE DEMAND AND SUPPLY 1975[2]	TO SUPPORT INDUSTRIAL EXPANSION 1975[3]
Engineers				
Aerospace	32	43	86	129
Chemical	27	36	72	108
Civil	96	128	256	384
Electrical	70	91	182	273
Electronic	101	135	270	405
Geological	10	13	26	39
Industrial	76	101	202	303
Mechanical	99	132	264	396
Metallurgical	9	12	24	36
Mining	12	16	32	48
Nuclear	6	8	16	32
General	61	85	170	255
TOTAL ENGINEERS	599	800	1,600	2,400
Technicians				
Aeronautical	15	111	222	333
Chemical		63	126	189
Civil	2	24	48	72
Data Processing	35	119	288	357
Drafting	114	79	158	237
Electrical	17	48	96	144
Electronics	62	111	222	333
Geological		31	62	93
Industrial	3	80	160	240
Mechanical	2	95	190	285
Metallurgical		39	78	117
Nuclear				
Other	30			
TOTAL TECHNICIANS	280	800	1,600	2,400
Skilled Craftsmen				
Experimental Machinists		136	272	408
Instrument Makers		145	290	435
Instrumentmen		127	254	381
Layout Men		127	254	381
Machine Set-up Men		60	120	180
Machine Repairmen		136	272	408
Tool and Die Makers		119	238	357
TOTAL SKILLED CRAFTSMEN		850	1,700	2,550

[1]Engineers: Present ratio of engineers to manpower demand projected to 1975 manpower demand.
Technicians: Total equal to engineers. Distributed by occupation according to percentage of employer opinion expressed in the survey of Arizona industry supporting expanded enrollments and additional educational programs.
Skilled Craftsmen: Annual attrition rate of 9% (half of national average for skilled crafts), plus annual growth rate for Arizona of 5%, of total 1967 employment reported by State Employment Service. Distributed by occupation according to percentage of employer opinion expressed in the survey of Arizona industry supporting expanded enrollments and additional educational programs. NOTE: Half of the annual attrition rate was used rather than the full rate to allow for automation and some immigration.

[2]Supply equals approximately half of demand nationally in engineering and technology. The same assumption is made for the skilled crafts. This column is therefore double the preceding column.

[3]The economic growth rate in Arizona is approximately twice that of the U. S. as a whole. This column adds an increment equivalent to the minimum required to permit continued growth. Also recognized here is the existence of a national backlog in all occupations from at least a decade of annual deficits.

It is recognized that the ratios of technicians and skilled craftsmen to engineers projected here may not be those that will actually prevail in 1975. These are rough estimates only. The ratios of technicians probably will be higher, and the ratio of skilled craftsmen may be lower.

The universities and junior colleges have shown willingness to assume their full share of responsibility in reaching the highest level of output required. Industry has expressed overwhelming support for adding programs and expanding enrollments, and to the extent this is recognized as a necessary factor in the state's economic growth it probably reflects general support. The remaining requirement is to bring more students into programs that are offered. The NSF study emphasizes a need nationally to do this, and also suggests that colleges and universities "examine carefully the problem of reducing student attrition due to scholastic failure, particularly where students are originally selected from the top third or even tenth of high school graduating classes. A better understanding of the whole process of selection and admission, including preparation and motivation at the high school level and earlier, is necessary if high-talent manpower is to be effectively guided through the nation's educational system."[8] To the extent these and other measures are successful in graduating substantially greater numbers of engineers, technicians, and skilled craftsmen each year, the remarkable growth of Arizona's industrial economy may be sustained.

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[8]NSF, op. cit., p. 31.

CHAPTER VIII

EDUCATIONAL CHANGES AND TRENDS

Research and Related Literature

In the preceding chapters a number of problems in engineering and technology education have been identified and discussed. Research is already underway on a widening front seeking solutions or new approaches to many of these problems. Some of it is basic research in such areas as occupational analysis, learning, theory and practices, attitudes and motivation, instructional techniques, curriculum development, and program organization. Increasing activity is also taking place in applied research, experimentation, and probing new ideas, some of it well designed, some of it simply trial and error. A few good professional studies have been made in which educators, engineers, industrial management personnel, and experts in many fields have joined in proposing changes and developing the rationale upon which they are based. The views of leading authorities on education and manpower requirements are contained in various conference reports, articles, and other publications.

Thus a growing body of literature is available in which some of the changes and trends affecting the education of engineers, technicians, and skilled craftsmen are suggested. The Government Printing Office has published many of these materials originating in the Department of Labor, the U. S. Office of Education, the National Science Foundation, and other agencies. Various universities and professional associations are responsible for others. They are widely scattered and often unrelated, but recently guides to their location have begun to appear. The professional journals report works by educators and other scholars. The Center for Vocational and Technical Education at Ohio State University and the Industrial Relations Research Institute at the University of Wisconsin have both collected and distributed bibliographical guides. The Review and Synthesis of Research in Technical Education by the Ohio State Center is particularly valuable.[1] The Educational Resources Information Center known as ERIC, which the U. S. Office of Education has established, is also becoming increasingly useful. The publications of the American Society for Engineering Education represent a significant point of view as well as a considerable amount of data.

Materials from these and other sources are presented in this chapter to give educators, industry, and the public an idea of some of the principal directions in which they may be moving. It is not an exhaustive review of the literature available, but only of that which seems particularly relevant to the issues raised in the present study. Viewpoints and conclusions, of course, are subject to challenge and criticism, but, they are fairly representative of current knowledge available and opinion based on that knowledge.

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[1] Milton E. Larson, Review and Synthesis in Technical Education, (The Center for Research and Leadership Development in Vocational and Technical Education, The Ohio State University, Columbus, Ohio, August, 1966).

Student and Faculty Shortages

At the rate industry is growing and technology is advancing, the number of youth selecting industrial careers appears too small. A national survey of technical needs by industry was made in 1966 at Northern Illinois University by Eckhart A. Jacobson. Using a sample of 11,000 companies in six major geographical areas, data were gathered on employment needs and educational requirements. Jacobson concluded from the data that the need for technicians would increase approximately 50% by 1971, and at least one-fifth of these would require baccalaureate degrees. Over 40% of the technicians needed will be in the area of electrical and electronics technology. About 30% will be in mechanical technology, and 10% in metals, chemicals, and similar technologies. Jacobson also noted that the number of technicians employed from educational institutions was much lower than the number employers say they would like to have.[2]

Jacobson's figures support an earlier study by the National Science Foundation in which the national need for technicians in industry is expected to exceed 1,290,000 by 1970. This is a 67% increase in the number of technicians employed in 1960.[3] The NSF study estimates that, allowing for retirement and new demand, almost 70,000 technicians will have to be educated each year to meet the 1970 demand.[4] Manpower experts say it is doubtful that the current rate of production by institutions now turning out such technicians, including the armed forces, will produce more than 35,000 or 40,000 technicians a year.[5] The need for new engineers is expected to exceed 70,000 per year by 1970.[6] An annual graduation of approximately half of this number has been the output of the nation's colleges and universities for the past decade.

In a paper presented at the Annual Conference of the American Technical Education Association in 1966, George Whitney pointed out that "there are just so many people born with the ability to become good technicians," and "there is only a limited number of people who want to become technicians no matter what inducements they may be offered."[7] He believes the demand by industry cannot be met under the existing philosophy of educating the best students and eliminating

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[2]Eckhart A. Jacobson, A Survey of the Technical Needs of Industry and Implications for Curriculum Development in Higher Education, (Northern Illinois University, 1966), pp. 199-200.

[3]National Science Foundation, Scientists, Engineers, and Technicians in the 1960's, Requirements and Supply, (National Science Foundation, 63-34, 1963), p. 10.

[4]*Ibid.*, p. 16.

[5]Howard A. Matthews, "A Paper Prepared for Consideration at the Mountain States Manpower Advisory Committe Meeting," Phoenix, Arizona, January 20, 1967.

[6]NSF, Scientists. . . ., p. 16.

[7]George S. Whitney, Challenges of the 70's, presented at the Annual Conference of the American Technical Education Association, December, 1966. (Whitney is Chairman of the Engineering Technologies Division of the State University of New York Agricultural and Technical College, Alfred, New York.

the rest. He suggests that it may be necessary for the schools to re-examine their administrative practices, admission policies, and attrition procedures with the object of providing a greater number of technical students with some training rather than a limited number with ideal training. "Educational institutions cannot be expected to make capable technicians out of everyone who applies - but they must find better ways of selecting prospective sutdents and developing new methods of teaching that keeps utilizing less and less promising applicants."[8]

Increasing consideration is being given by many educators to an earlier beginning of the whole selection process through which students develop an awareness of the world of technology and an interest in technical education. One of the leading exponents of this is Jacob J. Kaufman, Director of the Institute for Research on Human Resources at Pennsylvania State University. Kaufman believes the problem lies in the early years of schooling and "if we would approach it there we might solve the problem of what to do in the secondary school and even of developing education for occupational needs."[9]

Others feel that, even at grades four or five, children could be given some of the elementary principles and content of various occupations, providing an insight into what they are about. Niel W. Chamberlin, professor of economics at Yale, sees this as an integral part of general education rather than merely an earlier introduction to the work of work, with cultural benefits as well as economic:

> We are all aware of the naivete of many of our students with respect to the actual world of economic activities around them. If somehow we could make that world the base on which they build their education, this could be occupational orientation of a very high order indeed. . . . There is no reason to believe that by incorporating this kind of occupational component into our educational mainstream we're likely to short-circuit the cultural activities. The more that we can develop the intellectual vigor of an individual, the more likely that this vigor will spill over into all areas, rather than be confined to any single one.[10]

The problem of students dropping out of engineering and technical programs after enrolling has bothered educators and industry alike. Both would prefer to see them remain in school until a proper foundation for successful employment has been established. If the attrition rate could be reduced, particularly in the case of students going completely out of the program, the number of engineers and technicians going into industry would be increased. The opinion of students who have not dropped out was surveyed in this study. The opinion of students who do drop out is more significant, and this was examined in a

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[8] Ibid., p. 6.

[9] Jacob J. Kaufman, et al., "Occupational Data Requirements for Education Planning," The Journal of Human Resources, (Vol. I, No. 1, Summer, L966), p. 65.

[10] Ibid., pp. 60-61.

doctoral dissertation in 1966 at Oklahoma State University by Aaron J. Miller. He found that more than one-fourth of those who transferred to another program did so because they felt they would gain more prestige and satisfaction. Other reasons given were loss of interest, work different than anticipated, lack of success in course work, and selection of another career with greater financial potential.[11] Miller also found, however, that the dropout scored significantly lower on both achievement and motivation tests than those who stayed in the program.[12]

Compounding the problem of insufficient numbers of students in engineering and technology is the likelihood of an increasing shortage of teachers. The National Science Foundation published a report in May, 1967, indicating a need by colleges and universities for nearly double the number of scientists and engineers on a full-time equivalent basis in the ten-year period, 1965-75. Normal attrition added to this poses a problem that has no ideal solution. The demand for doctorates will greatly exceed the probable supply in the 1960s. By the early 1970s the situation is expected to improve, but "the proportion of science staff holding the doctorate degree will decline for several years after 1965, and even at the end of the decade, will not be as high as the 1965 ratio."[13]

A realistic appraisal of this situation simply means that the effort to meet industry's requirements for skilled manpower will have to be greater, more ingenious, more efficient, and more competitive than this segment of education has been in the past. Its effects on the schools was emphasized by Dr. Daniel E. Noble, Vice Chairman of the Board of Motorola, in a recent address:

> To develop an industrial economy oriented to engineering and science, Arizona needs to spend more money strengthening its universities in these areas. . . . A continuing supply of superior people, with superior training, is essential to the health of the modern, scientifically oriented corporation. . . . We must look to the universities to supply adequately trained engineers to work in our plants . . . to supply study programs which will enable us to update and upgrade the capabilities of our engineers. . . . It is a simple economic fact that only through the constant upgrading of our engineering and scientific capabilities, can we maintain a superior, competitive position in the country and guarantee stable employment for our Arizona personnel. . . . If the State of Arizona is serious about the development of an acceptable environment for scientifically oriented industries, something should be done immediately to bring the faculty salaries to a competitive level with those of other institutions across the country.[14]

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[11]Aaron J. Miller, "A Study of Engineering and Technical Institute Freshman Enrollers and Dropouts in Terms of Selected Intellective and Non-intellective Factors," (Doctoral Dissertation, Oklahoma State University, May, 1960), p. 62.

[12]*Ibid*., pp. 71-77.

[13]*The Prospective Manpower Situation for Science and Engineering Staff in Universities and Colleges, 1965-75*, (National Science Foundation, Washington, U.S. Government Printing Office, May, 1967), p. vii.

[14]*The Phoenix Gazette*, June 30, 1967.

Basic Engineering Education

At all levels of education for industry the most noticeable trend is to prepare students for groups of related occupations rather than single entry jobs. This is, of course, an essential feature of the recommendations for engineering education by the ASEE Goals Committee. In its study of goals of engineering education, the Committee made an exhaustive effort to gather information. Materials and opinions were furnished by engineering college faculties, professional engineering societies, industrial and government organizations, and practicing engineers. Nearly 400 published and unpublished reports were studied. Dr. Archie Higdon, on a 16-month leave from the Air Force Academy, joined the Goals Staff to visit 169 accredited schools, 10 non-accredited schools and several other engineering organizations. A nation-wide "Survey of Engineering Graduates in Industry and Government" was conducted. Three questionnaires were used, one of which went to 4,000 practicing engineers in 150 organizations throughout the country, selected through careful sampling techniques to be as completely representative of the profession as possible. It contained 28 pages of questions, and 85% of the engineers who had been selected in the sample responded. The second questionnaire went to personnel departments, and the third to top managers responsible for long-range manpower planning.

A special "Survey of Industrial Members of ASEE" was added to the industrial-government imput. The graduate phase of the project conducted an additional special survey of faculty, doctoral students, and research in graduate institutions. A detailed study of four sample schools was made in order to investigate the factors contributing to the growth and development of a graduate school. Educational institutions, professional societies, and industrial and governmental organizations were invited to establish undergraduate, graduate or combined study committees to work closely with the Goals Staff. Institutional Study Committees were organized to formulate some of the ultimate goals of engineering education and to comment on current issues and problems.[15]

The Goals Committee describes these emerging patterns of engineering education:"(1) Four-year programs in engineering leading to a bachelor's degree followed by graduate programs leading to a master's degree. (2) Five-year programs in engineering leading to a bachelor's degree that may or may not be followed by graduate work. (3) Five-or-more-year programs in engineering leading to a master's degree in engineering or in a specialized branch of engineering. A bachelor's degree may or may not be awarded at the end of the first four years of this program. This program as well as the previous one is intended primarily for those who intend to practice engineering ay a professional level. (4) Four-year programs leading to a bachelor's degree not necessarily in engineering to be followed by an engineering program, probably of two or more years duration, leading to a master's degree or a higher degree in engineering. Persons have entered the profession of engineering by way of the liberal arts route. Future popularity of this practice is uncertain, but it should be encourages. (5) Four-year programs leading to a bachelor's degree in engineering not necessarily followed by graduate work. There are many engineers who feel that this program

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[15] ASEE, Goals of Engineering Education Final Report, Jounral of Engineering Education, Vol. 58, No. 5 (January, 1968), pp. 432-33.

is still satisfactory for many who properly call themselves engineers."[16]

The Goals Committee Report says there is little doubt that "during the next decade we will witness a rapidly developing consensus that the master's degree should be considered the basic professional degree in engineering."[17] The undergraduate program is expected to be increasingly broad, and even at the master's level combinations of fields as well as traditional fields will be emphasized.[18] Many of the present programs, the Committee feels, are too rigid, tending to delay modernization and discourage experimentation. The Interim Report of the Goals Committee recommends: (1) Existing programs should be made more flexible; (2) Expanded opportunities should be provided for interdisciplinary study; (3) Credit hour requirements should be reduced; (4) Many prerequisite courses should not be required; (5) More provision should be made for "transfer-in" to engineering; and (6) The role of cooperative education -- the actual practice of engineering periodically interwoven with classroom and laboratory instruction -- should be expanded.[19] Diversity rather than uniformity of educational institutions and their programs is recommended. The most important recommendation of the Goals Committee is that "during the next decade basic engineering education be extended to include at least one year of graduate level education leading to the master's degree."[20]

The arguments voiced by several engineering societies against a national policy of this kind present another side of the picture, and their criticisms of the Goals Committee's Preliminary Report throw additional light on the state of engineering education today. Civil Engineers took particular exception to the nondesignated degree -- the Goals Committee's recommendation that degrees in engineering should replace degrees in particular kinds of engineering. "In view of the loyalty of the individuals to specific engineering disciplines, the Committee on Engineering Education (ASCE) recommends that the degree designation according to disciplines of engineering be retained."[21] A basic problem in engineering education was raised by the Civil Engineers in their concluding statement:

> While formal education is an important part of engineering education, it covers only a short period of time and can be little more than a base on which to build. Too often changes are made in the formal education curriculum with the idea that they will change the entire profession of engineering. Such logic borders on the ridiculous. It is imperative that the engineering profession examine the entire engineering educational system rather than just the formal educational portion. When

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[16] Ibid., p. 391-92.

[17] Ibid., p. 376.

[18] Ibid., p. 390.

[19] Ibid., p. 390-91.

[20] Ibid., p. 386.

[21] Civil Engineering, p. 87.

engineering faces the entire education problem it will truly be examining the Goals of Engineering Education.[22]

The American Society of Mechanical Engineers objected to the five-year proposal particularly for engineers who are going into production, maintenance, operations, and sales. ASME pointed out that, according to the Engineering Manpower Commission, these are the employment areas occupying 2/3 of the nation's engineering labor force today and probably will continue to occupy at least 1/2 during the next ten to fifteen years.[23] The Mechanical Engineers felt the Goals Committee recommendations were directed "toward serving the areas of rapidly moving technology where government research money is available, while disregarding the needs of mature technology which will employ the bulk of our graduates of the next decade."[24]

ASME then made some specific recommendations of its own. They touch on problems in engineering education today that concern many educators and employers alike.

1. Stimulate the improvement of grade school and high school education in the areas of rhetoric, composition, and graphics to the same degree that has been accomplished in the areas of chemistry, physics, and mathematics.

2. Continue to upgrade the quality and knowledge of the entering college student by stimulating the improvement of primary and secondary education so that the undergraduate educational process can proceed on a broader spectrum and at a higher level.

3. Promote the cooperation of universities, industry, and government, in encouraging competent, practicing engineers to participate directly in academic instruction, and in furnishing industrially inexperienced teachers with significant commercially oriented experience.

4. Inject a strong spirit of reality into the educational process by broadly utilizing techniques found successful in other areas of education -- such as case studies.

5. Extend part-time graduate programs of high quality for the practicing engineer and stimulate all universities to accept responsibility for their support.

6. Experiment with all aspects and levels of the engineering education process to enhance its effectiveness, to increase its content, to widen its availability, and to interest and stimulate the student.

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[22] Idem.

[23] Mechanical Engineering, p. 34.

[24] Idem.

Regardless of opposition, the trend toward five-year degrees and general education appears evident.

In 1965 there were 177 U.S. educational institutions with accredited programs in engineering. Twenty-five of these institutions had five-year programs leading to a first degree in some field of engineering. In 1966 Cornell University adopted the five-year plan in a statement which follows somewhat the controversial recommendations of the Goals Committee: ". . . the first Cornell degree with an engineering designation is the Master of Engineering degree awarded after a five-year integrated study program in traditional fields."[25] A 1965 Engineering Master Plan Study at the University of California accepted the five-year program in these words:

> . . . The University should, as rapidly as the transition can be effected, establish the master degree as its first professional degree in engineering, and educate students to this level as its principal contribution to the work force. . . . The University should continue to offer undergraduate engineering instruction leading to the Bachelor of Science degree on some campuses. However, the upper division programs and the junior admission requirements should be planned on the assumption that students will proceed directly to the master degree. . . .Undergraduate students should be guided by a broadly outlined engineering curriculum evolved by the engineering faculty of the campus and directed toward the master degree. The BS degree should be awarded when the student has completed 4 full years of academic work directed toward achievement of the master degree is a 5-year program.[26]

The California study was a substantial undertaking. An advisory council of 21 engineers representing major industrial corporations and educational institutions was responsible for the study, which was directed by a five-member steering committee assisted by eight faculty consultants. Seven task groups were appointed with industrial and faculty members on each, bringing to approximately 75 the number of persons engaged in the study.

One and one-half years were spent in gathering information, analysis, and writing the report, which was published in September, 1965. Fifty-seven recommendations were made, chiefly emphasizing graduate degrees in engineering and greater flexibility in the curriculum. One of the recommendations specified that "upper-division students should be allowed to compose and propose major individual curricular modifications to enable them to direct their study toward engineering master degrees by combining engineering with other related fields. . . ."[27] Part of the rationale for this recommendation is that engineers need to be prepared for a very broad range of positions, and "it is

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[25] Engineering: Cornell Quarterly (Cornell University, Spring, 1966), Vol. I, No. 1.

[26] University of California Engineering Advisory Council, An Engineering Master Plan Study for the University of California, (Los Angeles: UCEAC, September, 1965), pp. 81-2.

[27] Ibid., p. 5.

not feasible to know now the state of technical knowledge and human needs 10 to 20 years after graduation from college."[28]

The Cluster Concept in Technology Education

Paralleling the interest in general engineering education is the cluster concept in technology education. This is an attempt to identify the common elements in several similar technologies and develop educational programs around these rather than the specific requirements of a single technical field. Some major research projects have been completed and others are under way in designing curricula for clusters of technical occupations. William Schill and Joseph Arnold combined a doctoral dissertation with a research grant from the U. S. Office of Education to produce the common and peripheral courses in a cluster of six technologies at the University of Illinois in 1965.[29] A major project has been under way at the University of Maryland since 1965 developing a series of curricula for occupational clusters.[30]

Neven Frants, reporting on the Maryland project at a recent research conference, described it as middle ground between two extremes. One is to prepare students for highly-skilled employment in a specific occupation, the other to provide broad programs of general training for a wide variety of occupations. The cluster concept, he said, "will prepare a person to enter a family of occupations rather than a specific occupation. The program will not prove any single occupation in depth, but will instead provide job entry skills and knowledge common to a number of related occupations."[31] He gives four major reasons for developing the cluster concept based on a review and analysis of literature in the areas of education, labor, economics, and industry. They are, first, "a need to provide students with a greater degree of mobility on a geographical basis," second, "a need for increased mobility within an industry or occupation," third, "students must be trained so that they can adapt to technological change," and fourth, "students must be given greater flexibility in their occupational choice patterns."[32]

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[28] Ibid., p. 79.

[29] Schill and Arnold, op. cit.

[30] An Investigation and Development of the Cluster Concept as a Program In Vocational Education at the Secondary School Level, Third Quarterly Report of a Study Conducted by the Industrial Education Department, (College Park: University of Maryland, 1965-66).

[31] Nevin R. Frantz, Jr., "The Cluster Concept as a Program in Vocational Education at the Secondary School Level," Research in Vocational and Technical Education, Proceedings of a Conference June 10-11, 1966, The University of Wisconsin Center for Studies in Vocational and Technical Education (Madison, 1967), p. 83.

[32] Ibid., p. 85.

Another job cluster research project in electronics technology was carried out at Washington State University. A statistical sample of 224 electronics technicians from 549 firms in the Puget Sound area were asked to complete a detailed queationnaire on knowledge and skills they used on their jobs. Eighty-four specific kinds of knowledge and skill were identified with six out of eight principal tasks performed, and a larger list was identified with three to five of the tasks.[33]

N. H. Frank, Professor of Physics at Massachusetts Institute of Technology, suggests that the many components of technical education should be regrouped "using functional operations and processes to provide the guidelines for different curricula instead of organizing them as is presently done according to common techniques." In other words, prepare students to function in "a group of operations all of which have a broad common theme, . . ."[34] He suggests educational programs in: (1) Energy conversion systems and operations; (2) Communications systems and operations; (3) Transportation systems; (4) Materials processing and fabrications systems; and (5) Operations and processes concerned with living organisms. Frank observes that "it is virtually impossible to satisfy in any detail the multiplicity of skills and understanding needed by all industry." He feels that commonality of technical assets would provide "crossover potential from one kind of employment to another, and this ease of transferability should be effective both laterally and vertically."

This idea was based on a 1965 M.I.T. Summer Study on Occupational, Vocational and Technical Education. Another suggestion from the same study was that technical educators enter into cooperative arrangements with engineering educators to establish goal-oriented projects in which "teams of student engineers and student technicians could work together, much as they have to do in practice."[35]

The cluster concept has been a subject of major interest in virtually every conference and meeting on vocational education in recent years. The U. S. Office of Education sponsored three regional conferences on education, training, and employment in 1966 which were conducted by the Research Council of the Great Cities Program for School Improvement. The participants were representatives of management, labor, business, education, local, state and federal government agencies, and various community groups. Several statements taken from the first of these, the Eastern Regional Conference, reflect positions frequently expressed at all of them:

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[33]Boyd C. Mills and Harold F. Rahmlow, Major Task and Knowledge Clusters Involved in Performance of Electronic Technician's Work, Washington State University, 1966 (ERIC Document 016 655), pp. 20-28.

[34]N. H. Frank, "Changing Requirements for Technical Education," Address at the Annual Meeting of the American Technical Education Association, (Denver, Colorado, December 6, 1966).

[35]Idem.

"As technical training increases, a person is much better off getting a generalized background to go from one job to another readily . . . including the three factors - communication, problem solving, and personel responsibility with overtones of work experience which he could attain within his work experience.

"If we don't educate people to recognize that the job they are doing is going to be changing throughout their career several times, then I think we're not doing the necessary education.

"No training should be given unless there is within this training the elements which provide for job upgrading.

"The concept of occupational clusters is nothing new, but we're just beginning to open our eyes to the lower levels of preparation. We are not as familiar with this kind of curriculum, and we don't know much about the required methodology."[36]

The extent to which efforts are now underway to develop the methodology of job cluster training at the vocational level is indicated in the Ohio State Center's Review and Synthesis of Research in Trade and Industrial Education. The authors report that "primary among the objectives which recent research has identified for vocational T & I curricula is that it provides the student with skills which are transferable from one situation to another."[37] They list a number of recent projects, with this additional comment:

> The cluster approach appears to be a necessary and fruitful approach to curriculum development. As the number of occupational titles increases (and changes), it will be incumbent upon curriculum developers in vocational education to build curricula that provide for the possibilities of skill transfer. An analytic approach such as those described will be required. This is an area which requires more effort. Schemes such as those described must be tested on a developmental and pilot basis to evaluate their efficacy and produce refinements in their structure. While the literature abounds with descriptive statements of content-specific curricula that have been built and tried, only few attempts at the structural approach appear. . . . This area cries out for systematic exploration."[38]

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[36]Eastern Regional Conference on Education, Training and Employment, May 12, 13, 14, 1966, The Research Council of the Great Cities' Program for School Improvement (Chicago, 1966), pp. 27-34.

[37]Bruce W. Tuckman and Carl J. Shaefer, Review and Synthesis of Research in Trade and Industrial Education (Columbus: The Center for Research and Leadership Development in Vocational and Technical Education, Ohio State University, August, 1966), p. 8.

[38]Ibid., p. 11.

Core Curricula

With the job cluster concept there is usually a core curricula serving several related educational programs. This is an old idea in education when applied to occupations with more than one field of specialization. Engineering schools rely extensively on a core curriculum, as do most professional schools. There are two current developments in engineering and technology education, however, which should be noted. One is the revision and updating of core curricula to better meet the needs of students preparing for advancing technology in modern industry. Benjamin Mesick in the Mechanical Engineering Department at the University of Arizona discusses one approach to this in a 1965 article, which is simply a re-examination of the need for each of the subject areas in the engineering core. He concludes that "the engineering student must be given a wider background in a common core curriculum, . . ."[39] This is essentially what the University of California's study recommends, and in a sense it changes the traditional concept of a core of standardized courses taught the same way and covering the same basic material year after year to one of greater flexibility.

The other development in engineering and technical core curricula is to develop specific combinations of courses and subject matter for definite clusters of occupations. This is what Schill and Arnold did for the six technical areas of electronics, electro-chemical, chemical, chemical-mechanical, mechanical, and electro-mechanical. They developed a core of thirteen knowledge and skill requirements common to all six areas, and additional requirements for smaller combinations of the areas.[40]

A variation of the core curriculum for a definite cluster of occupations is a core for a single occupation in a variety of schools. Variations in the content of occupational training programs from one school to another are sometimes so great that employers have no way of knowing the actual knowledge and skill a graduate is supposed to have. The University of California at Los Angeles developed a core curriculum for aviation mechanics through a nationwide study in which every critical knowledge and skill required for all types of aircraft were identified.[41]

Broadening the Curriculum

Pressure to enlarge the curricula in engineering and technical education comes from two directions: more technical knowledge is needed to keep up with

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[39] Benjamin S. Messick, "Tomorrow's Engineer," The Tool and Manufacturing Engineer, (May, 1965), p. 41.

[40] Schill and Arnold, op. cit., p. 83.

[41] Davis Allen, John M. Meyer, Alvin Gorenbein, and William K. Bowers, A National Study of the Aviation Mechanics Occupation (Los Angeles: University of California, 1966).

industry; and more general knowledge is needed because occupational success to a considerable extent depends on it. New kinds of technical competence are appearing at every level of industry. The impact of computers alone will be felt in a majority of industrial occupations.[42] Numerical control and computergraphics, together with computer technology, will almost certainly create whole areas of new knowledge and skills to be added to educational programs.[43] A single example is the estimate by the Bureau of Labor Statistics that numerical control requires additional training for more than 50,000 persons in a four-year period.[44]

The need to increase general education is almost equally apparent. In the engineering degree programs efforts to include more communications, social studies, and humanities have been going on for several decades, yet additional requirements in these areas seem greater today than ever. This is implicit in the ASEE Goals Committee Report, the California Master Plan, and many other serious discussions of engineering curricula revision.

At the secondary level there is a similar effort underway to increase the amount of general education in vocational and technical programs. A business executive at the 1966 Midwestern Regional Conference on Education, Training, and Employment quoted Irving Adler's statement made several years ago: "A narrow specialized vocational education was never an adequate substitute for a liberal education. Under automation it will not even be good vocational training."[45] Present thinking along these lines finds expression not so much in crowding more general education courses into the schedule but in a complete merger of vocational education with general education. A team of program associates with the Ford Foundation described it quite well in a 1965 Advanced Administrative Institute sponsored by the Harvard Graduate School:

> In 1965, we can no longer afford the luxury of a separate system. We can no longer afford to let vocational education programs offer a "lick and a

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[42]Ralph W. Gerard, "Shaping the Mind: Computers in Education," Applied Science and Technological Progress, A Report to the Committee on Science and Astronautics, U. S. House of Representatives, by the National Academy of Science, June, 1967 (Washington: U. S. Government Printing Office).

[43]Research Summaries: Trade and Industrial Education, March, 1967, Research Coordinating Unit, California State Department of Education, Sacramento; Milton E. Larson, op. cit., p. 9.

[44]U.S. Department of Labor, Bureau of Labor Statistics, Outlook for Numerical Control of Machine Tools, Bulletin No. 1437, March, 1965 (Washington: U. S. Government Printing Office), p. 3.

[45]Hamilton E. Loring, "Preparation for the World of Work -- What the School Should Do," Midwestern Regional Conference on Education, Training and Employment, May 19, 20, 1966 (Chicago: The Research Council of the Great Cities Programs for School Improvement), p. 31.

promise" of general education, any more than we can allow general education to ignore what vocational education can do to strengthen it. The opportunity before school leaders is a simple one -- merge the two systems together in an appropriate form, so that the values of each can be had by the people whom we serve -- the students. Clearly, we believe that there is an educational value to general education -- after all, we have been telling ourselves and the public that . . . for many years; and there is also an educational value in vocational education. The task before us is to select those features of both which will produce a comprehensive and coordinated education. But first, we must make it clear that we refer to vocational education, and not to vocational training. . . .

No longer can general educators turn their backs to vocational education. For better or worse, it will always be around, separately today, but merged tomorrow; over-emphasizing training today, but emphasizing education tomorrow.[46]

This involves such far-reaching changes in the whole structure of American education that it may develop only slowly, if at all. Nevertheless, pressures to improve education generally, and general education particularly, by adding vocational content are evident. Kaufman analyzes the situation in these words:

There is a tendency to talk about two types of training in our high schools. We talk about vocational education and academic programs, the latter being essentially the preparation of students for college.

There are actually three types of programs. One is vocational education, which is a narrow specific type of training for a certain type of skill. The second is an academic program, training youngsters for college. But there is a large third group which is ignored, but can be described as "general curriculum education." This curriculum consists of a few bits and pieces of technical training, and a hope that the students will either leave school or leave the teachers alone. This group is ignored by our society and ignored by the vocational educators.[47]

There is increasing evidence that the middle group of students whom Kaufman feels are being ignored is actually much larger than educators and society have recognized. It includes substantial numbers of college preparatory students who do not go on to college or who pursue higher education only long enough to realize that what they need most are occupational skills. Since even college-bound youth preparing for business and professional careers often need occupational skills, a trend in this direction may be developing. If it is, all education at the elementary and secondary levels would be affected, which in turn would have substantial effects on engineering and technical education at the post-high school levels. In the 1966 Regional Conferences on Education, Training, and Employment, it was this basic concept of education which emerged. It was summarized at the Midwestern Conference in these words:

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[46]Edward J. Meade, and Marvin J. Feldman, "Vocational Education: Its Place and Its Process," The Journal of Human Resources, Vol. I, No. 1 (Summer, 1966), pp. 71-74.

[47]Kaufman, op. cit., p. 64.

Education for the world of work includes more than specialized vocational and technical education. The preparation of children and youth for the world of work is a process which should begin in the elementary grades and continue throughout the school life of the individual. Education for work includes the basic tool skills of learning - the three R's plus some science and citizenship. Education for work includes general as well as specialized vocational education. The whole faculty of a school should be concerned about educating youth for the world of work. Through specialized vocational programs, all education can be given purpose and meaning.[48]

The need for strengthening general education is also recognized in the apprenticeship programs. A study in depth was made in 1966 of apprenticeship training in Wisconsin which included representative information from other states. One of the conclusions from that study is that successful apprenticeship training today, compared with only a few years ago, is heavily dependent on related classroom instruction. The extent to which this has developed and the underlying reasons are evident in a summary of apprentice and employer comments:

Vocational schools occupy a major position in modern apprenticeship programs, especially in the indentured systems. These programs are modern only because of the related instruction provided by the schools. . . .

Related instruction furnished the "why" as well as the "how" of the apprentice's trade, and the need for this is more urgent than ever before. Technological changes introduce new materials, new products, and new processes, and journeymen need new and more varied technical knowledge and skills. Apprentices must have more than a smattering of scientific and technological training. They must be able to hold tolerances and close specifications that were undreamed of even 10 years ago. The ability to interpret manual dexterity with understanding of scientific principles will be expected. All this points to a need for greater and broader training in the basic principles of the trade. Actually, related instruction has a second objective, although it receives much less attention: to provide apprentices with non-technical knowledge designed to help them become good citizens and responsible employees. It is repeatedly stated that related instruction is "the most important segment of training," and that the real distinction between adequately and poorly trained journeymen lies in their having knowledge which can only come from related classroom instruction. . . ."[49]

Related classroom instruction, of course, does not necessarily mean general education, and the Wisconsin study revealed considerable dissatisfaction with existing programs. Suggestions for improving related instruction included "more night courses, more competent teachers, more varied courses, short courses

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[48]Loring, op. cit., p. 35.

[49]G. Soundara Rajan, A Study of the Registered Apprenticeship Program in Wisconsin (Madison: Center for Studies in Vocational and Technical Education, Industrial Relations Research Institute, The University of Wisconsin, 1966), pp. 109-10.

for fast learners, and more schooling at the beginning of apprenticeship."[50]

The problems confronting schools at every level in expanding their curricula for occupational education may be staggering. Maurice Roney at Oklahoma State University suggests one of the difficulties and the nature of the changes which might be made to correct it:

> Real curriculum design is further restricted by an overriding concern for academic respectability. One of the arguments advanced for using existing courses rather than designing new ones is based on this concern. The idea is to avoid, wherever possible, the taint of specialization. Courses must be pure. Mathematics must be algebra, trigonometry, or calculus; physics must be traditional physics, not applied mechanics; and chemistry must be general chemistry rather than industrial chemistry. Except in terminal courses. Here it is customary to go to the other extreme, carefully aggregating these courses (and ultimately, of course, the students) by the use of adjectives such as "practical," "applied," or "elementary." The idea is to be certain, at all costs, to differentiate between the academic and the practical.
>
> Disturbing as it is for those who like things neat, orderly, and traditional, technical programs cannot operate under this outdated educational philosophy. For the inevitable consequence of educational snobbery is a segregation of students on the basis of academic ability. When this occurs the technical program cannot operate, simply because it must inevitably deteriorate until it has no appeal to able students with well-identified interests. It will then attract only those students who are either not willing or not able to do the work required in college level education. A curriculum designed with this as a guiding philosophy may serve an educational purpose, but it cannot be technical.[51]

Roney's concern with rigid course design is only part of a larger problem. This is educational conservation, or resistance to change. In a paper presented at the International Conference on Employment Problems of Automation and Advanced Technology in 1964, one of the participants discussed this problem and made suggestions for dealing with it:

> Teachers are one of the most conservative influences is any society, since they tend to teach what they were taught as children and tend to value most that for which they were praised most. In a static or only slowly changing society this is a source of strength, for it enables the cultural heritage of a people, the wisdom of the ages, to be transmitted to the next generation. In the rapidly changing conditions of today and the ever more rapidly changing conditions of tomorrow, it can be a source of extreme weakness. This is not to say that we should reject tradition, but that we must investigate again and again,

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[50] _Ibid._, p. 179.

[51] Maurice W. Roney, "Curriculum Design in Technical Education," (unpublished MS, Madison: Center for Studies in Vocational and Technical Education, The University of Wisconsin, 1965), p. 3.

whether it has stood and is standing the test of time. Even valuable matter must have to be discarded so that important new material may be included, always bearing in mind that not all that is new is important. . . . What is needed is a continuously sitting curriculum study group, representative of all the interests involved, such as teachers, parents, the universities, industry, commerce, and the trade unions, to advise on the need for change.[52]

The suggested solution may be an oversimplification, but it is accompanied by a set of guidelines with which many educators and industrial representatives seem to agree.

1. "The teaching of all techniques that have become obsolete through technological innovations should be ruthlessly pruned." The author suggests introducing typewriters and cheap calculating machines in the primary grades as one example of updating education at that level. Also, "excellent and easily available works of reference make much memory work unprofitable. Many other examples exist."

2. "Teaching methods are being developed which make it possible to teach material to children at a much earlier stage than had previously been thought possible." Examples are teaching atomic science to children of 12-15, and teaching languages in primary schools.

3. "Technology is producing new teaching devices which should revolutionize teaching techniques." He notes that "teachers often shown a singular lack of enthusiasm for these . . . It is a pity that propaganda for these devices tends to stress / a solution to/ the chronic teacher shortage which will increasingly afflict all countries. This is true, but what is ignored is that these devices often can be of enormous help to the good teacher too. Thus, for instance, the educative power of good television is beyond question."

4. "If we are to produce citizens with a truly balanced outlook, then it is essential that all pupils carry a general core of subjects . . . throughout their school career." At the secondary level he suggests "a single comprehensive school that caters for all abilities."

5. It is highly desirable that any curriculum should be relevant for the future occupations of the pupils concerned." Vocational training should be emphasized for those not aiming at a university education rather than giving them a "watered down version of an academic education. The argument is generally that it is wrong for them to start on vocational training too soon. Unfortunately youngsters then often fail to see any relevance in their school work. . . . I should be realized that an academic curriculum for academically minded children <u>is</u> vocational."

6. "Higher education . . . is clearly the part of the educational system

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[52] L. R. B. Elton, "Educational Goals for an Age of Advanced Technology," International Institute for Labour Studies Conference on Employment Problems of Automation and Advanced Technology, July 2-24, 1964, (unpublished MS, Madison: Industrial Relations Center, University of Wisconsin), pp. 5-6.

most immediately affected by rapid technological change and it is in fact the part which itself contributes largely to this change." Here the program should be primarily career education, flexible enough to "enable people to switch jobs easily," but sufficiently specialized that it does not "foster the cult of the gentleman amateur, for whom there is no place in a highly professional society."

7. "Further education . . . is the most neglected educational sector in most countries and the one that may in the long run be the most important from the technological point of view." This includes education for adults who "should have gone on to higher education but for one reason or another did not;" refresher courses "at all levels and in all fields to counteract the obsolescence that overtakes us all and to retrain those who have become redundant through technological innovations;" and adult education to inspire and stimulate new interests for the leisure time created by the technological revolution.

8. "From birth to graduation, it takes over 20 years to produce a technologist and this process cannot be speeded up. It therefore requires a great deal of planning - now."[53]

A research project at Stanford University suggests the kinds of changes which are being explored in engineering and technical education and which may be incorporated into future planning. It is described as a "first step in the development of a strategy" for problem solving. Classes in dynamics, design, and introduction to electrical engineering were examined in depth. The students in these classes were observed, tested, and interviewed repeatedly over a period of time. Correlations were developed between a number of variables for each student and for each class, including aptitude, ability, creativity, flexibility, and achievement. The results showed that a considerable amount of time and effort were spent in attempting to learn problem solving techniques through well-established procedures, but that the procedures were largely ineffective.[54] Some of the other conclusions were:

1. "For a narrow range of high ability students there is little or no correlation between academic performance and intellectual aptitude."

2. "There is some evidence which suggests that attitudes having to do with perserverance rather than creativity are highly correlated with success in the engineering surriculum."

3. "Although creativity and flexibility are recognized as unimportant ingredients in the problem solving orientation of engineers, there is little evidence of this being a major focus of attention in the training of engineers."[55]

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[53] Ibid., pp. 6-7.

[54] Harold A. Korn, and Lauress L. Wise, Techniques for Evaluating the Learning Process in Engineering Education, A Research Project Under the Cooperative Research Program of the U. S. Office of Education, 1965-67 (Counselling Center and School of Engineering, Stanford University, ERIC Document 010 099).

[55] Ibid., pp. 22-25.

Another example of the fundamental changes being explored in the education of industrial personnel is found in the skilled crafts. The Wisconsin Apprenticeship Study revealed that "no longer is a single skill sufficient for the worker, for automatic machines can perform any repetitive job faster and cheaper than he can. Workers who were specialists must now fulfill the growing need for men with multiple skills."[56]

Another observer noting the same trend gives this illustration: modern industry does not need "model makers in the classical sense, but a new skill that combines the talents of a designer, set-up man, tool maker, die maker and model maker."[57] Curriculum expansion and reorganization is a trend in education from engineering to the skilled trades, from the universities to apprenticeship training.

Work Experience in the Curriculum

Cooperative work-study arrangements between schools and industry is not a new concept. Some engineering schools recognized the value of actual work experience long ago. Apprenticeship training and on the job training combined with education have always existed in one form or another, but as a requirement in the degree programs for engineering and technology it seems to be taking on new interest. As a feature of vocational education it is assuming new characteristics. Work experience as a part of the curriculum may become one of the major trends in occupational education at every level. It is not merely work experience while going to school, or going to school part-time and working part-time. The importance of this concept as a development in education is in its direct relationship with the rest of the curriculum.

The University of California Engineering Master Plan calls for "6 months of full-time engineering-related experience obtained during the undergraduate and graduate years" as a requirement for the Master of Engineering Degree. An additional year is required for the Doctor of Engineering Degree, "obtained usually in conjunction with meeting the D Engr design project requirement." Each school of engineering is to "arrange with outside engineering organizations to provide appropriate ways of meeting the experience requirement of the professional degrees. University-wide coordination should be provided in the initiation and continued execution of the resultant programs."[58]

At M.I.T. and a few other engineering schools similar arrangements have been made with industry. The schools have full responsibility for coordinating all training experiences -- "the work-site educational experiences with the theory and content into a plan designed to produce highly qualified individuals who can take employment in industries kindred to those in which they obtain

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[56]Rajan, _op. cit._, pp. 20.

[57]_Ibid._, p. 136.

[58]_An Engineering Master Plan . . ._, pp. 5, 6, and 9.

their work experience."[59] The former Dean of Engineering at M.I.T. notes that "industry and business are usually considered the potential counterparts in engineering to the teaching hospital in medicine."[60]

Work-study programs in the junior colleges are growing rapidly as a concept in technical education and "may become a trend in the near future."[61] Jacobson, in his national study of the technical needs of industry, interprets industry's practice of hiring technicians away from other companies as an indication of the premium placed on experience. This suggests to him the importance of industrial internships in programs of higher education.[62]

Grant Venn, Associate Commissioner of the Bureau of Adult, Vocational and Library Program in the U. S. Office of Education, considers work experience as a necessary part of education. "The loss of work experience for most modern adolescents as part of their total educational background must be replaced by a combination of education and related work experience as part of the educational structure. I don't mean for the vocational student -- I mean for all students in our school system"[63] Willard Wirtz, Secretary of Labor, says the same thing. "Some work experience should be part of every person's education."[64]

As a part of vocational education, however, the concept of work experience is significant chiefly in the way it relates to school. It is an essential part of an educational program designed to prepare the student for employment. "More on the job training is inadequate, for it omits related instruction; on the other hand, more theoretical knowledge is also insufficient because it omits job experience."[65]

Continuing Education

A special advisory panel organized by the National Science Foundation and the President's Committee on Scientists and Engineers sponsored a study of the college educated population of the United States in 1960. A review of the report contains this statement: "The first and most striking finding of the study is that for the majority of college graduates education does not terminate with the bachelor's degree. Most graduates in the 1960 population had obtained some

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[59] Matthews, op. cit., p. 3.

[60] C. Richard Soderberg, "A Note on Engineering," Applied Science and Technological Progress, p. 408.

[61] Larson, op. cit., p. 21.

[62] Jacobson, op. cit., p. 198.

[63] Grant Venn, "Shaping Educational Programs for Employability," Western Regional Conference on Education, Training and Employment, p. 24.

[64] AFL-CIO News, "Wirtz Urges 'Bridges' Between School, Work," (Washington, D.C., February 18, 1967).

[65] Rajan, op. cit., p. 20.

further training, although only about one-fourth held another degree."[66] The research in learning techniques at Stanford was based in part on the almost continuous need for additional education by professional engineers. One of the problems was "how to prepare students to continue their professional learning all their lives."[67]

The Vice President of Personnel and Industrial Relations Services at General Electric pointed out in a recent company publication the "need, in an era of pervasive and accelerating change, for education to become a life-long process. It is no longer accurate or appropriate to talk as though a man could 'get educated, then go to work;' the two strands of working and learning are intertwined for the length of a man's career."[68] This concept appears with increasing frequency in conferences on manpower and education. The Arizona report in an eight state project, "Designing Education for the Future," contains this prediction: "Work in 1980 . . . will require more schooling both at the formal and informal, general and technical levels. For that matter the concept of work will be closely intertwined with the idea of school or learning."[69]

The Engineering Master Plan for the University of California contains an entire section of seven recommendations on continuing education. They are listed here primarily because they show the importance which this feature of education is beginning to assume. They also reflect a considerable amount of serious thought in a program designed to meet this need.

> MANDATORY ROLE OF UNIVERSITY IN CONTINUING EDUCATION. It is imperative for the future of California that the schools of engineering of the University accept responsibility for continuing engineering education as a third major educational endeavor, of importance comparable with that of the undergraduate and graduate programs.
>
> PART-TIME AND OFF-CAMPUS GRADUATE STUDY. The University should make available, to the fullest extent of its ability and imagination, part-time and off-campus graduate study leading to master degrees for the very large numbers of qualified working engineers in California.
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> FACULTY ROLE IN CONTINUING EDUCATION. The regular facilities of the schools of engineering should be charged with the central responsibility for the planning and supervision of continuing engineering education.

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[66] Mildred A. Schwartz, "The United States College - Educated Population: 1960, Journal of Human Resources (Bureau of Social Science Research, Inc., Vol.I, No. 1, Summer, 1966), p. 98.

[67] Korn and Wise, op. cit., p. 22.

[68] Virgil B. Day, "A Commitment to Continuing Education," The General Electric Forum (Vol. IX, No. 4, 1966), p. 7.

[69] Robert L. Pickering, Arizona in 1980: Some Questions for Education (State Department of Public Instruction, Phoenix, Arizona, December, 1966), p. 32.

POST DEGREE EDUCATION. The University should develop, teach, and provide to other agencies "delta packages" of engineering knowledge to bring engineers up to date after they have been out of school for given periods of time.

RECOGNITION OF CONTINUING EDUCATION ACHIEVEMENT. Methods should be developed to provide appropriate recognition to engineers who complete planned sequences of continuing education programs not leading to degrees.

PREPARATION FOR LIFELONG EDUCATION. The content and methods of the undergraduate and graduate programs should be planned to have an effective influence in orienting students toward and preparing them for lifelong professional education.

CENTER FOR CONTINUING ENGINEERING EDUCATION. The Council of Engineering Deans and University Extension should take immediate steps to develop by 1 July 1966 a plan for the establishment of a new statewide Center for Continuing Engineering Education. The purpose of the Center will be to stimulate and to coordinate the continuing education activities of the schools of engineering and to develop new instruction methods.[70]

Educational Planning

Regardless of the specific changes and trends which may take place in the years ahead, they will almost certainly result from greater deliberation then educational developments in the past. The studies cited here represent a trend in itself, a trend toward educational planning rather than mere accumulation of courses, curricula, programs, and institutions. An economist at the Eastern Regional Conference on Education, Training, and Employment in 1966 described what is happening in the rest of the world:

> With the exception of the United States, every established nation in the world is engaged in planning its educational system over the long term. In virtually every case, it is planning education on two fundamental criteria. One is the internal efficiency of the educational system defined in terms of the input-output relationships of the system or the ineffectiveness with which scarce educational resources are used in the educational process. The other is the relevance of the educational system to the ultimate purposes of the society.[71]

There are indications that the United States, too, is beginning to engage in this kind of planning. Cost-benefits studies, master planning, goals studies, and similar activities within institutions and at state and even national levels are being undertaken with increasing frequency.

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[70] An Engineering Master Plan . . ., pp. 8-9.

[71] Eastern Regional Conference . . . , p. 13.

CHAPTER IX

CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Summary

Engineering Education: As it appears today, engineering education is predominately a four-year baccalaureate degree program with high academic standards, an overloaded curriculum, and a tendency to emphasize theory ahead of applied technology. For many it is a delayed degree or no degree at all supplemented by on-the-job training and years of experience. For others it is a master's degree or doctorate, usually acquired while employed in the field. For the most part, it is based on a considerable knowledge of mathematics usually through calculus and differential equations, advanced levels of physics and chemistry, various combinations of engineering sciences, and a few courses in communications, social studies, and humanities. Student enrollments are not keeping pace with industrial expansion; the dropout rate is excessive; and the demand for graduates is extremely high.

While the number of baccalaureate degrees obtained in engineering has remained at about the same level each year for the past decade, graduate degrees have been increasing. The American Society for Engineering Education, supported mainly by electronics and aerospace engineers, favors lengthening the program and making the masters degree the first professional degree. They want for the engineering student more non-technical education, less specialization in a single field, more basic theory, more research, and no appreciable increase in applied technology. These recommendations are strongly opposed by other educators and many practicing engineers, especially in the fields of civil, mechanical, and chemical engineering. This group insists on retaining the baccalaureate degree as it is, placing more emphasis on experience, increasing non-technical education through better preparation at the elementary and secondary levels, and developing closer coordination between industry and education. There appears to be a trend toward the five-year basic degree program, but the nature of the dispute confirms a general impression that engineering education today is in a state of flux.

In Arizona the chief characteristic of this area of study is rapid and sustained expansion. Engineering education has grown from eight degree programs at the University of Arizona in 1955 to fifty-two programs at three universities in 1967. Enrollment increased more than 12% from 1966 to 1967, to a total of 5,752. Last year 558 baccalaureate degrees and 113 graduate degrees were awarded. The Arizona programs are largely four-year basic degree programs in specialized fields followed by further specialization at the graduate level. Each of the three universities, however, has variations of its own. ASU is inclined to favor the basic five-year master's degree. The U of A favors the four-year basic degree. Both have extensive graduate programs. NAU tends to emphasize applied engineering and a general baccalaureate degree followed by specialization at the graduate level.

The engineering students at all three Arizona institutions have strong high school backgrounds in mathematics, chemistry, physics, and many of them in drafting. Half have had industrial experience, one-fourth are presently employed as engineers or technicians, and one-fourth have had technical training in the armed services. At least one-third took courses in industrial arts, vocational education, or technical education in high school. More than half plan to continue working toward graduate degrees.

Engineers in industry report a broad range of activities, including those ordinarily performed by technicians and skilled craftsmen. Many do not agree with their employers' description of the nature of their work. They indicate considerable time spent in research, supervision, writing technical reports, and other paper work. They recommended a wide range of courses in school but comparatively few at the advanced level. Advanced courses should include communications, mathematics, and science. Engineers and their employers generally agree on the need for mathematics through calculus and differential equations, physics and chemistry, technical courses chiefly in areas related to their work, drafting, a great deal of reading, speaking, and writing proficiency, and business courses.

Employers of two-thirds of the engineers surveyed require a baccalaureate degree in engineering, and more than one-third prefer a master's or doctorate. Of those answering questionnaires, 55% have baccalaureate degrees in engineering, and 10% have non-engineering baccalaureate degrees; 15% have master's degrees; and 5% have doctorates. Engineering fields in which a graduate degree is preferred by a majority of employers are aerospace (93%), electronics (61%), and mechanical (53%). Employers of approximately half of the engineers felt that increased responsibility for various phases of engineering education should be assumed by the junior colleges, universities, high schools, industry, and graduate schools, in that order.

Half the engineers reported that most of their technical knowledge and skills were learned in college. More than one-third said they learned most of what they know on the job. One-half to three-fourths of engineers and their employers believe non-technical courses contribute to career success, and employers were overwhelming in the opinion that communications should be strengthened in the degree programs. Employers were also strongly in favor of more business courses.

One-half to three-fourths of all engineers have received on-the-job training; substantial numbers have had additional courses in school paid for by their employers; and one-third have taken additional courses on their own. The two most important reasons for continuing their education were (1) to acquire additional technical knowledge needed on the job, and (2) general self-improvement.

Nearly half expect to be working in supervision or management 10 years from now. Promotions are based largely on performance and experience. The great majority of those surveyed were satisfied with their choice of a career and all of its principal features. Most are in theis 30s or 50s, have had more than 10 years experience, and receive salaries above $900 per month. Of those who receive more than $1,200 per month, one-third have graduate degrees.

The first preference of most employers in hiring engineers is to promote them from lower level jobs in their own organization. Their second preference is direct from school, and their third, from other employers. The majority of engineers in the survey had transfered to their present positions from other companies, but about one-fourth had come from school.

Employers were nearly unanimous in the opinion that changes in technology in the next five years will require new knowledge and skills in engineering. Subjects in which more preparation in school will be needed for a majority of engineering fields are physics, chemistry, non-metallic materials, computer programming, computer technology, and business courses.

Cooperative work-study programs with industry are favored by the employers of a majority of engineers except in the fields of electronics and mining. Special education programs to upgrade non-engineering personnel to engineers are favored by employers of aerospace, civil, and mechanical engineers. Arizona employers feel that enrollments should be increased particularly in chemical, electronic, industrial, and mechanical engineering, and that new programs should be added if possible in aerospace, chemical, industrial, and mechanical engineering.

Nearly one-fourth of the engineers who participated in the survey had received their highest degrees from Arizona institutions. Of these engineers, 259 were U of A graduates; 126 were from ASU; and 12 had received their highest degrees from the two-year technology programs at Northern Arizona University and Phoenix College. Eleven others were Arizona high school graduates with no college degrees. The principal reasons given for attending these schools were convenience of location, reputation of the school, and financial consideration, in that order.

More than one-fourth of employers and employees who participated in the survey offered suggestions for improving engineering education. There were conflicting opinions on virtually every subject, but an unmistakeable consensus appeared on a number of points. These were:

That pre-engineering should begin in the elementary and secondary schools;

That more students should be attracted to engineering through better vocational guidance and counselling;

That engineering education should be more closely related to the real world or work;

That practical experience should be included in the curriculum, preferably through cooperative work-study programs with industry;

That many courses, textbooks, and some of the equipment in engineering schools are out of date;

That a number of areas of technology are being overlooked or neglected in the current educational programs;

That non-technical courses especially in communications and business, but also in social studies and humanities, need to be emphasized much more than they are now and that a greater proportion of students' time should be spent on these courses;

That engineering education at the baccalaureate level should be general rather than specialized;

That the basic engineering education program should probably be five years;

And that much greater provisions should be made by the universities for continued education available to practicing engineers in every part of the state.

Current research and related literature in engineering education suggest that both students and faculty shortages exist which will continue for some time. Solutions to this problem are being explored through an earlier introduction to engineering in the lower grades and a reduction of the dropout rate in universities.

The engineering curriculum is undergoing extensive review and reappraisal, primarily along three lines. One is to make it more flexible, with a general rather than specialized degree. This is to open up a wider range of career opportunities for the graduate and to give industry an engineer who can fit more readily into the combination of technical areas that most jobs today require. It will also enable the engineering graduate to adapt his basic education to later changes in technology which cannot be anticipated while he is in school.

The second line of research in engineering curricula, closely related to the first, is to broaden the whole program. Efforts are being made to add more technical content and non-technical courses at the same time. Admittedly this is a difficult thing to do, and it constitutes one of the most challenging problems in engineering education today.

The third approach to curriculum revision is to make it more practical. Work experience as a part of the degree program seems to be the best answer.

Technical Education: Technical Education is considerably less standardized than engineering. It has evolved on the one hand out of industrial arts and vocational education in secondary schools, and from another direction since World War II as a sub-engineering training program in technical institutions. It is rapidly growing as a two-year associate degree program in junior colleges. Typically, this is a 70 semester hour program consisting of 60% technical courses, 25% mathematics and science, and 15% general education including communications, social studies and humanities.

Technical education, like engineering, shows a tendency to move up the academic ladder as demands for knowledge and skills increase. Many colleges and universities offer baccalaureate degrees in technology which differ from engineering chiefly in the depth and intensity of their courses. They are also directed toward applied technology rather than scientific and engineering theory. Graduates may become application engineers, occupying positions previously reached through engineering schools and still classified by industry as engineering. Indications are that three-fourths of the students enrolled in technical education programs drop out before graduating, many of them probably to go to work as partially trained technicians.

In Arizona, technical education is growing even more rapidly than engineering. Since 1955 it has expanded from four baccalaureate programs at ASU to 35 baccalaureate and associate degree programs at ASU, NAU, and the six junior colleges. Total enrollment increased 50% in one year between 1966 and 1967, reaching 2,478. There were 280 graduates in 1967.

The four-year technology programs at ASU and NAU vary according to the field and the purpose for which they are taken. Generally they follow the normal baccalaureate pattern except for a heavy concentration of technology and a minimum of liberal arts courses. The associate degree programs in the junior colleges resemble the national trend but with a little stronger liberal arts content.

Technical students in Arizona differ from engineering students in several respects, but the differences are not great. Their high school background usually includes more industrial arts and vocational or technical education, and less mathematics and science. Those who answered questionnaires ranked a little lower than engineers in their high school graduating classes, but were still considerably above average. Half of them had had industrial or mechanical employment and one-fourth are presently employed as technicians or craftsmen. Two-thirds intend to continue in school toward a higher degree when they complete their present program, and one-third are planning professional careers in engineering.

The work of technicians is restricted more to their fields of specialization than that of engineers. The same is true of associate engineers, whose activities and qualifications in the survey identify them more readily with technicians than with professional engineers. Technicians spend a considerable amount of time in research, supervision, and writing technical reports. Their other major activities are quality control, testing, instrumentation and calibration, and drafting.

For this they need algebra, geometry, trigonometry, physics, drafting, writing, reading, and speaking. For some, chemistry and business courses are necessary. The nature of their work requires specialized preparation in one technical area, but both employers and employees indicated need for combinations of general knowledge of several technical areas. The educational level required by most employers is high school. They prefer associate degrees, and this seems to be the trend. Employers strongly favor increased responsibility by the junior colleges in technical education.

Technical occupations depend even more than engineering on practical experience in the training program. More than half of the technicians in the survey learned most of their technical knowledge and skills on the job. Non-technical education, however, is considered almost as important by employers and by technicians themselves as it is for engineers.

Continuing education, both on the job and in school, is also as characteristic of technical occupations as it is of engineering. Virtually the same pattern exists here in the support by industry, the need for additional technical knowledge and the interest of technicians in self-improvement.

The choice of a career in technology for the majority of those in industry today was made after -- not before -- they went to work. About one-fourth made the decision before or during high school. The importance of work experience in career selection was noticed in engineering, and it seems to be even more evident in technology.

The same satisfaction with their choice of a career was also evident. Both engineers and technicians report high levels of satisfaction with salaries and the kind of work they do and most of the conditions under which they work. Technicians earn an average of $500 to $700 per month, which is only a little more than half the income of engineers. They are also younger, for the most part, than engineers. Most of these who participated in the survey were in their 20s and 30s.

The major area of dissatisfaction on the part of technicians is advancement. The same factors govern promotions as were reported for engineers -- performance and experience, followed by personality, seniority, and sometimes examinacion. But the opportunities for advancement are far more limited for technicians than for engineers; consequently, a fairly high percentage of the technicians in the survey were dissatisfied with this feature of their career.

Employers' first preference in hiring technicians is to promote them from lower level positions within their own organizations. Their second preference is to get them from other employers, and their third is from schools. A substantial number of employers, however, list schools as their second choice and a few as their first choice. This is especially true in drafting technology, a field in which nearly one-third of the employers prefer the schools as their first supplier of employees.

The changes expected to take place in engineering technology in the next five years will affect the education of technicians almost as much as engineers. There is substantial agreement in industry that such changes, in addition to requiring more technical training, will call for more preparation by technical students in physics, instrument calibration and measurements, writing and speaking.

Increased enrollments and additional education programs in technology are favored by a substantial majority of Arizona employers for all fields except civil. This is especially true in aeronautics, date processing, and electronics. The number of Arizona graduates working in Arizona industries is still comparatively small because most of the programs were only recently established. More than 10% of those who answered questionnaires, however, graduated from ASU or Phoenix College, and nearly half that number were Arizona high school graduates with no degrees.

Suggestions from technicians for improving education in their fields closely paralleled those of the engineers. The need for work experience as a part of the educational program was particularly stressed along with updating courses and textbooks. They were equally emphatic about the need for more general education, primarily in communications and business. Continuing education was probably their main concern. They feel that complete degree programs, as well as non-degree technical courses, should be made much more available to men who are working and have family responsibilities.

Significant research in technical education which may lead to changes, is underway in a number of areas throughout the United States. An earlier beginning in the elementary schools and considerably more emphasis on pre-technical education in the secondary schools are suggested to meet the chronic shortage of students. Some exploratory efforts are being made to enlarge the number of eligibles by reexamining established academic requirements. Occupational prestige is a problem in technical education and methods of dealing more successfully with this are being explored.

The most important research in technical education today is probably the cluster concept. Since technology tends to specialize, the number of technical fields is constantly increasing beyond the ability of educational institutions to establish programs. Moreover, students too narrowly trained in a single field cannot adapt as easily to changing job requirements as they must to keep up with industry's needs. An analytic approach to this problem is being made in a number of major research projects through which the skills and technical knowledge required for several occupations may be grouped in each particular education program.

Technical education is receiving much of the same attention being given to engineering in the areas of curriculum expansion and continuing education. Essentially the same problem exists here in the need to add more technical and non-technical institutions at the same time and still keep the programs within reasonable limits. There is considerable interest also in cooperative work-study arrangements with industry as part of the curricula. New curricula are being designed through completely analytic techniques, and increasing activity of this kind may be expected. Technical education as it exists today is almost certain to change with new teaching methods and equipment developed through continued research. And since it is so sensitive to the constant advances of industry, a continual pattern of change may be expected as one of the characteristics of technical education.

Skilled Industrial Education: Traditionally the training of machinists, tool and die makers, layout men, and other skilled personnel in industry has been provided either through apprenticeship programs or simply through on-the-job training. Much of it is still provided largely by industry, especially under apprentice arrangements through government-sponsored joint councils which include both labor and management. The problem with this is that not enough youth are enrolling, and one-fourth drop out before completing the program. Management says apprenticeship suffers from lack of incentive. Labor says it suffers because of a lack of a full economy. In any case, a high percentage of skilled craftsmen in the United States are approaching retirement and completely inadequate numbers of younger men are available to take their places.

Industrial arts courses and vocational education in the secondary schools have contributed to the training of skilled craftsmen for more than half a century. More recently manpower training and retraining programs sponsored by the federal government have provided additional support. There is probably more confusion than knowledge about what is actually being done and how well. The problem of training enough skilled personnel to meet the needs of industry has not yet been solved.

In Arizona there are industrial arts programs with machine shop instruction in 30 schools, chiefly in the Phoenix and Tucson areas, with an enrollment of about 2,000 students. Vocational education, which includes a number of major areas of skilled training, has programs with 129 students enrolled for machinist training at five high schools in the state. There are currently 21 machinist apprentice programs in Arizona with a total enrollment of 52 students, of these

26 are tool and die, and 26 are machinist apprenticeships.

Employers of nearly half the skilled craftsmen in Arizona do not require a high school education. A substantial majority, however, prefer not only high school but vocational-technical education as well. Most of those in the survey have had this kind of academic preparation. They also graduated for the most part in the upper half of their high school classes. Employers feel very strongly that high schools, vocational-technical schools, and industry should each assume more responsibility in preparing skilled craftsmen.

One-third or more of the men in skilled occupations report that non-technical courses in school contribute to career successes. Fairly substantial numbers have taken courses in school since going to work, usually for their own self-improvement.

Both employers and employees report a considerably broader range of activities on the job than the skills primarily associated with their occupations. Supervision and writing technical reports are required of most of them. In connection with their skills they do research, production and product design, systems analysis, quality control, testing, instrumentation, layout, inspection, drafting, and setting up and operating machines. About one-fourth are involved in sales, consulting, or public relations.

They need algebra, geometry, trigonometry, physics, and sometimes chemistry, metallurgy, non-metallic materials, hydraulics-pneumatics, manufacturing processes, machine tools, machinability, machine economics, instrument calibration and measurements, drafting, reading, writing and speaking. In other words, skilled employment in modern industry goes far beyond setting up, maintaining, and operating precision machinery. In their suggestion for improving educational programs, skilled craftsmen and their employers stressed courses in mathematics, science, communications, and many also advocated social studies and humanities.

The major trend in skilled vocational education appears to be toward a closer relationship with the rest of the educational system. Comprehensive high schools, earlier instruction in tools and basic vocational concepts for everyone, and more general education for vocational students related to their work are a few of the research and experimental programs under way. Some are well established in educational systems in many parts of the country. The cluster concept and core curricula for entire industries are receiving serious attention. And continuing education is having an impact on the skilled trades as well as on engineering and technology. It takes the form of retraining and adult education, and although many skilled craftsmen are not affected, the number who are is growing each year.

Conclusions and Implications

Many conclusions may be drawn from the information developed in this study, but several seem almost inescapable. First, there is a significant relationship between work experience and the education of industrial personnel. Half of the students surveyed have been employed in an occupation related to their field, and more than one-fourth are working while in school as engineers, technicians, or skilled craftsmen in industry. Even among first-year students, 37% in engineering report previous related employment experience and 16% are presently employed. In technology 42% of the first-year students report previous employment and 18% are presently employed. One-fourth of the students in both engineering and technology say the major influence in their selection of a career was work experience. From 50 to 75% of the engineers, technicians, and skilled craftsmen in the survey of industry chose their careers primarily because of work experience or the influence of someone else in the occupation.

Work experience is also an indispensible part of the education of engineering and related personnel. The overwhelming preference of employers in filling new positions is through promotion from within their own organizations or by obtaining personnel from other employers, presumably because these are experienced people. Experience is the major consideration in advancement in every field at every level, according to both employers and employees. The most emphatic recommendation offered by employers and employees in their personal comments was to give students more practical experience while in school. A substantial majority of employers said they favor cooperative work-study programs.

The second conclusion from this report is that educational programs at every level should be broadened, with an emphasis on flexibility. This is evident in the strong recommendations by employers and employees to add both technical and liberal arts courses. Many of the recommendations stressed the need for greater flexibility in educational programs so that graduates could adapt more easily to the changes taking place in industry and increase their opportunities for successful careers. Reports of current research, professional studies, conference reports, and other published materials indicate a national trend in this direction.

There also appears to be a consensus in the industrial survey that supports this conclusion. Both employers and employees in all occupations listed numerous courses which they feel are needed in preparation for the job but which are not directly related to the activities associated with the job. For example, the employers of 86% of the data processing technicians and 87% of the technicians themselves reported that instrumentation and calibration are not skills used in this occupation, but 77% of the employers and 58% of the data processing technicians said students preparing for this occupation should have either a general or advanced knowledge of the subject. The implications are that some knowledge is needed to perform other skills associated with the job, and secondly, that the job itself may be changing so that students preparing now for employment in the future will need that kind of knowledge.

This, of course, brings up one of the thorniest problems in both engineering and technical education. To what extent should the schools generalize or specialize? Should engineers have general baccalaureate degrees in their special fields? Should technicians be prepared to work in one specific field or several? The American Society for Engineering Education and a number of universities feel that generalization is more valuable to the engineering student than specialization. There is a great deal of interest and activity in technical education also in preparing students for clusters or groups of occupations. On the other hand, most of the actual work in engineering and technology demands a great deal of specialized knowledge. Practicing engineers in most fields are opposed to general degrees in engineering. It is doubtful if any engineer or technician is really competent if he does not have a knowledge in depth of at least one technical area.

The problem is not easy to deal with and may never be completely resolved, but the need for a broader foundation in engineering, technical, and even skilled vocational education cannot be ignored. One of the most compelling observations in this study is the upward mobility of persons in these occupations. More than three-fourths of all engineers and technicians and half of the skilled craftsmen in the industrial survey expect to be working at higher occupational levels within 10 years, while 29% of the technical students in Arizona schools plan to become engineers. Half of the technicians in the survey who are continuing their education -- and this includes a substantial majority -- are doing so to advance their careers. The manager of technical training and development in one of the largest companies in Arizona reported that 50% of their technicians were promoted to engineers last year.

The most important direction in which curriculum expansion must take place in all educational programs seems to be communications, followed by business courses. Technical report writing is an activity associated with virtually all fields of engineering, most of the technical fields, and to some extent in most of the skilled crafts. Reading, writing, and speaking rank next to mathematics as courses in which advanced knowledge is needed for engineering and technology and a general knowledge is needed for skilled employment. More general education, especially in communications and business was repeatedly and emphatically recommended in the personal comments from industry. The ASEE Goals Report and its critics both agree on the need to strengthen general education in engineering education; they disagree only on how it should be done. The importance of general education in technology and the skilled crafts is receiving major attention in research and professional literature.

One of the observations to be made from this study is the increasing importance attached to college degrees in both engineering and technology. A substantial number of employers prefer higher degrees than they require in all occupations. Many employers prefer baccalaureate degrees in technology, especially for aeronautical, chemical, data processing, electrical, geological, and metallurgical technicians. There are preferences for the doctorate in a few fields of engineering, and these are probably increasing. Much of the interest in continuing education is in earning higher degrees, and there is an apparent correlation between degrees and salaries in both technology and engineering. When they complete their present programs, 58% of the engineering students and 64% of the technology students in Arizona institutions who participated in the survey plan to continue their education toward a higher degree.

There is also evidence from this study that a great neglected area of non-degree education exists from which a substantial number of engineers and technicians are going into industry. The number of baccalaureate degrees in engineering remains the same each year while engineering services in industry are increasing. Nationally, three-fourths of the students enrolled in technology and two-thirds of those in engineering do not graduate. Nearly 40% of the associate engineers and technicians and 10% of the engineers in the survey of Arizona industry have some college but no degree. This non-degree, or less-than-degree, area is largely ignored by educators because their attention is focused on degree programs. Courses are arranged in sequences leading to degrees. There are non-degree programs in technology at ASU, NAU, and some of the junior colleges, but far more students drop out of degree programs than enroll in these. The educational institutions, for the most part, simply do not know either the kind or extent of their contribution to engineering technology through partially trained dropouts. Efforts to assist such students in making the most of their partial education are probably quite limited.

Another area of considerable impact on engineering technology is continuing education. One-half to three-fourths of all engineers and technicians, and nearly half of the skilled craftsmen in the survey of Arizona industry have taken additional courses in school. An analysis of current enrollments in the Phoenix and Tucson areas suggests that a substantial number of third and fourth-year students as well as graduates are either employed full-time and going to school part-time, or have returned to school after dropping out for one or more years. Much of the concern expressed by employees in their personal comments was over the need for more courses at night and in more convenient locations.

Finally, the study revealed a number of areas where industry and the schools should be more closely coordinated in their educational programs. Educators have no reliable information at the present time on either the kinds or extent of on-the-job training provided by industry for their graduates. Nor are systematic analyses made of the effect of work experience before, during, or after formal education programs. Industry has little knowledge of the students going into engineering and technology, their goals, strengths or weaknesses until they complete their education or an important part of it. Employers and employees both feel that engineering and technical faculties should have frequent exposure to industrial experience, and some of them feel that engineers and technicians should have classroom experience in the schools. Industry has only a vague idea of the purposes for which it supports continued education for its employees; and neither the schools nor industry make any appreciable effort at all to direct the great amount of such education toward specific goals.

This study revealed, however, a considerable interest on the part of both industry and the educators in Arizona to work more closely together. The review panel of educators and representatives of industry which assisted with the design of the survey and the evaluation of its results demonstrated a high degree of cooperation. Industry not only contributed substantially to the survey in personnel time and effort, but expressed an overwhelming interest in its purpose. As noted before, a substantial number of employers took a position in favor of cooperative work-study programs. Educators, for their part, were equally interested in working with industry. The junior colleges have industrial advisory committees for most of their programs. Each of the universities has developed close working relations with major segments of Arizona industry. Each of the deans of engineering and technology at the universities and junior colleges and many of their faculty have participated in this study, as have the director and several supervisors in the State Department of Vocational Education and a number of high school administrators. The basis for increasing coordination between the schools and industry in educational programs at all levels is well established.

The Employment Service estimates a total employment at the present time in Arizona of 9,500 engineers, 7,270 technicians, and 6,120 skilled industrial craftsmen. These are estimated ratios of 5.3 engineers, 4.1 technicians, and 3.4 skilled industrial craftsmen per 1,000 population. The ratios are expected to increase slightly by 1975 requiring an increase of 3,200 engineers, 2,480 technicians, and 2,280 skilled industrial craftsmen. It is not possible to project actual numbers of graduates from Arizona schools to meet these demands because individual industries do not know their future needs, graduates enter a national labor market rather than a state labor market, and demand exceeds the supply to such an extent that academic output cannot expect to catch up for some time to come. Nevertheless, it is possible to arrive at estimates of the average annual graduates needed based on the present output and Arizona's rate of industrial growth.

At the very least, Arizona schools should match the economic growth rate, but there are compelling reasons to attempt considerably more. Nationally the engineering schools graduate only about half the number of engineers needed each year, and this situation has prevailed for at least a decade. A similar annual deficit is found in technology education. In the skilled crafts automation tends to absorb some of the deficit, but attrition due to death and retirement is quite high and almost certain to go higher as the age level of these personnel continues to climb. Increasing national shortages of engineers, technicians, and skilled industrial craftsmen require that educational institutions in all states increase their annual output as rapidly as possible. Since Arizona's growth rate is approximately twice that of the nation as a whole, Arizona's schools should expect to assume a proportionately larger share of the responsibility of producing engineering and related personnel. National competition for this kind of manpower will require such an effort to sustain a favorable growth rate.

In estimating Arizona graduation figures sufficient to meet the probable manpower demand in 1975, three levels of effort are determined. The first would be a holding action only, and would depend heavily on immigration to supply most of the need. The second is twice the first, a level sufficient to absorb Arizona's share of the annual deficit. The third takes into consideration the accumulated shortages of previous years and Arizona's growth rate compared with that of the rest of the nation. On this basis, the first level calls for annual graduation by 1975 of 800 engineers, 800 technicians, and 850 skilled industrial craftsmen. The second level calls for 1,600 engineering graduates, 1,600 technology graduates, and 1,700 new skilled craftsmen from Arizona schools each year. The third level would produce 2,400 engineering graduates, 2,400 technology graduates, and 2,550 craftsmen. These figures for 1975 compare with 599 engineers and 280 technicians graduated in Arizona in 1967. Figures for skilled craftsmen in 1967 cannot be determined, but they are considerably lower than the need. Arizona's continued industrial growth will depend increasingly on the ability of the schools to produce these graduates. The schools have demonstrated their willingness, and employers expressed strong support for expanding enrollments and adding new programs in the industrial survey. The critical factor will be to increase substantially the numbers of students entering these educational programs each year.

Recommendations

The following recommendations are based on the conclusions above. They are suggestive only, but in the form in which they are presented here they have the support of the members of the Review Panel representing both the educational institutions and industry in Arizona. In that sense, they are recommendations to ourselves. In a larger sense they are directed to the faculty, administrators, and governing boards of the educational institutions; to the management of industrial firms; and to the public and its representative upon whose support engineering and technology in this state ultimately depend.

Programs and Enrollment: The numbers of engineers, technicians and skilled craftsmen from Arizona schools will have to increase each year. By 1975 annual graduation figures should be 2,400 engineers, 2,400 technicians, and 2,550 craftsmen. In order to attract sufficient numbers of students to meet these demands, three courses of action are suggested:

1. Continue to develop career-oriented guidance services in the high schools and colleges, supplemented by public relations programs by the colleges and industry. With assistance from the State Department of Vocational Education, the universities have added vocational guidance to their counselor education programs. High school counseling is receiving vocational emphasis in some schools with some counselors. Considerably more emphasis is necessary, however.

2. Study the effect of present admission and graduation policies on both enrollment and retention of potentially capable engineers, technicians and skilled craftsmen. This is particularly important in regard to students with special problems. Determine to what extent social, economic, academic and other barriers to careers in engineering technology now exist, and find possible ways to remove them.

3. Since work experience and exposure to industry are the major influences in attracting students to engineering and technology, develop a program of summer jobs in industry for high school students, graduates, and college students. Companies might develop such jobs for a given number of students, advertise them in the high schools, screen the applicants for achievement and aptitude, and stimulate considerable interest in engineering and technical careers.

Work Experience: Each of the universities and junior colleges should explore with industrial firms the most feasible means of incorporating work-study programs in their curricula. Three posible approaches might be made: summer internships between the second and third years, the third and fourth years, and the fourth and fifth years for students going on to graduate work; alternate semesters of course work and employment; and part-time employment during the third, fourth and fifth years. The employment in each case would need to be arranged by the school in such a way that the work experience would contribute directly to the educational program and would be coordinated with it. Experimental or pilot programs may be advisable at the beginning. Eventually, work experience should be a part of every student's curriculum.

General Education: In view of the apparent necessity to strengthen liberal arts in engineering and technology education, especially communications, it is suggested that realistic proficiency tests be developed by each institution to assist in guiding students individually into the courses they require. Such tests might be given to entering students and repeated at the beginning of each succeeding year. They need not be regarded as additional hurdles or obstacles, but merely used as the basis of guidance and counseling so that the students themselves are fully aware of their own deficiencies. They should certainly cover the principal areas of communications - reading, writing, speaking, and graphics - and may well include some basic economics, accounting, business management, statistics, history, sociology, psychology, political science, literature, philosophy, and art.

It is hoped that high schools will at the same time add industrial education in some form to the general education of all students, and encourage potential engineering and technology students particularly to take courses in this area.

Curriculum Research: The problem of expanding curricula can only be met through systematic research and experimentation. The Engineers Council for Professional Development includes this as one of its ten basic policies in accrediting engineering curricula: "The avoidance of rigid standards as a basis for accrediting, in order to prevent standardization and ossification of engineering education and to encourage well-planned experimentation." The same provision is made in accrediting technical curricula: "Well-planned experimentation and development in engineering technology education are to be encouraged." In 1964 ECPD added further emphasis to this policy in a series of amendments governing subject matter in acceptable curricula: "In any case in which the Engineering Education and Accreditation Committee is persuaded that well-considered experimentation in engineering is under way, it shall give sympathetic consideration to departures from the criteria . . ."

On this basis the colleges of engineering and technology in Arizona might well initiate at this time curriculum research and experimentation along several lines. One would be on the relationship of courses and course content to actual practice. No attempt was made in the present study at functional job analysis or coordination of subject matter in school with its need on the job except in a very general way. This needs to be done. Efforts should be made to determine the extent to which all of the material in traditional courses, especially technical courses, is being used. Some courses may be streamlined, shortened, or combined with other courses to make way for additional instruction more relevant to industry's needs today. Since the technical courses make up half the curriculum, a considerable amount of subject matter may be scrutinized. As possibilities for streamlining and replacing materials appear, experimental curricula should be designed and tested.

Another line of curriculum experimentation which should be explored is the concept of knowledge and proficiency as a basis for course credit rather than time spent in a classroom or laboratory. It would not be too difficult using computer technology to test almost any quantitative or qualitative level of achievement in most courses and at any interval. The basic techniques have already been developed in teaching machines and flexible scheduling. There are serious problems involved, especially if common semester terminals in education are disrupted on an individual student basis. But there is no reason course work could not be speeded up or passed over altogether by dividing semester blocks of material into smaller modules and allowing students in a given course to proceed at their own pace. This would have the dual advantage of permitting good students to advance more rapidly through some courses thereby opening up opportunities for additional material, and allowing poor students to advance more slowly, thereby encouraging them perhaps to remain in school instead of dropping out.

Experimentation with this concept would also open up possibilities for easier and more realistic transitions from technology to engineering for those students capable of becoming engineers. There are very good reasons for giving technical students different courses in mathematics, science and technology than the courses engineering students require. Nevertheless, some duplication of material is inevitable for the technicians who later choose to enroll in an engineering program. This is especially true if the technicians have picked up a certain amount of engineering knowledge on the job. Such duplication slows down the education of engineers and prevents them from taking other courses for which they may have greater need.

It is hoped that curriculum experimentation can also be instituted at the elementary and secondary levels which would introduce basic concepts and a foundation of knowledge in engineering technology to all students. Recent federal legislation has made funds available to assist the schools in exactly this kind of innovation. A growing list of professional papers, conference reports and other literature suggests not only that careful thought has been given to the idea but that it may have advantages in strengthening other parts of the curriculum in addition to vocational and technical education. It would almost certainly influence more students to consider careers in engineering and technology.

Student Follow Up Data: The test of any educational system is what happens to the students after they leave. Follow up information is the only means through which faculty and administrators can measure the success of their efforts. Some follow up information about graduates is available at each of the institutions, but it is difficult to gather and keep up to date. Techniques for automatic follow up using computer technology have been developed in several states, and the Arizona State Department of Vocational Education is in the process of developing such a system. In addition to providing educators with more complete information and making it more readily available this enables the schools to maintain closer contacts with former students. A uniform automatic follow up system for all institutions in the state using their own data processing equipment would be reasonably inexpensive and would have considerable value. Such a system would also make it possible to follow up students who do not graduate. In view of the rather considerable number who apparently benefit from a partial education, this kind of information should be available in designing curricula and in counseling students.

Continuing Education: All of Arizona's universities and junior colleges, and several of the high schools, have developed evening programs. The universities have extension courses in many parts of the state. Additional junior colleges are being built which will open up new opportunities for industrial personnel to continue their education. Yet the results of this study would indicate that more needs to be done. Two additional steps might be taken. One would be to take an inventory of evening and extension courses now being offered all over the state by all of the institutions. From this a coordinated state-wide program could be developed by each institution adding courses where obvious needs are not being met. If unnecessary duplications were found to exist, these could be resolved.

The other step would be to create schools of continuing education in the universities with responsibility for complete degree and non-degree programs offered primarily in the evening in both on-campus and off-campus locations. A great deal of care needs to be exercised that such programs meet the same academic standards that are maintained for the regular daytime programs. There are difficult problems involved, especially in obtaining fully qualified faculty and in the use of laboratories, special equipment and library materials. But there is no reason to believe that a new concept in education cannot be created from the combined resources of the schools and industry which will be just as capable of excellence as those now being followed. The need to do so is quite apparent.

A Master Plan: The information developed in this study should be used as a source in exploring more efficient and more effective ways of educating engineers, technicians, and skilled personnel for careers in industry. It offers a foundation upon which future planning may be based. Many of the states have made studies of their engineering programs or their technical and vocational programs and have arrived at plans for developing one or the other separately. This study would indicate that educational planning at all levels should be closely coordinated between schools, school systems, and industry. On that basis a planning program is suggested for Arizona along these lines:

1. Each school individually should make an analysis and review of its programs using both faculty and representatives of industry on special review and planning committees.

2. Individual school plans should incorporate as many of the suggestions from this report as seem feasible and advisable, including: new programs where they are needed; work experience in the curriculum; new combinations of courses based on occupational analysis; new concepts of regulating the time, sequence and content of degree programs; more general education, especially in communications and business; and provisions for continuing education equal to those for full-time students on the campus.

3. Individual school planning programs should be coordinated for the state through the deans of engineering and technology. Regular channels of communications for this purpose should be maintained on a continuing basis, and periodic meetings of the deans should be held to assure a state-wide program of education adequate for all the needs of engineering and technology.

4. Recommendations of the school planning committees, and of the deans of engineering and technology meeting together, should be widely circulated for maximum coordination and participation by the schools, by other public agencies, and by industry.

Periodic Review: The information in this study should be kept up to date probably on an annual basis. The conclusions and recommendations based on the information now current should also be reviewed periodically. An annual conference on engineering technology, preceded by an updated supplement to this report is recommended. It would provide an opportunity each year to reexamine old ideas and propose new ones. It would serve to hold the schools, the public agencies, and industry together in a common effort that involves them all. It would present to the public the progress and achievements to which each institution and company had contributed, and also the needs for public support without which success would be impossible. It would allow educators, students, industrial management, and the public to share ideas and exchange viewpoints.

With this kind of interest and participation in the continued development of engineering technology, industry will be assured of the best product the schools can produce and the schools will be assured of the support they need in carrying out their responsibilities.

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(62-63)	(64-66)
(67-69)	(70-74)
(75-76)	(77-79)

Arizona State Survey of Engineering Technology

Northern Arizona University
Occupational Research Coordinating Unit
1626 W. Washington
Phoenix, Arizona

EMPLOYER INFORMATION

Directions:

1. **Please complete this form for each engineering or related occupation in your organization. Additional forms will be provided as needed. Write the occupation to which this questionnaire refers in the appropriate space below.**
2. **Give an Employee Data questionnaire to each employee in this occupation, and record the questionnaire serial numbers in the appropriate space below.**
3. **Mail the completed information in the prepaid envelope provided.**

1. Employer ____________________
2. Occupation ____________ 3. SIC ________
4. Employee questionnaire ser. No. ____________ 5. Total employees ________
6. Current vacancies ____________ 7. Estimate need 1 year ________
8. Comments or reservations ____________________

Mark Answers Here

9. Monthly salary range for this occupation (if paid by month):

	Minimum (1)	Maximum (2)	Minimum	Maximum
1	___	___	Less than $500	Less than $500
2	___	___	$500-$700	$500-$700
3	___	___	$701-$900	$701-$900
4	___	___	$901-$1,200	$901-$1,200
5	___	___	More than $1,200	More than $1,200

10. Hourly range for this occupation (if paid by hour):

	Minimum (3)	Maximum (4)	Minimum	Maximum
1	___	___	Less than $2.50	Less than $2.50
2	___	___	$2.50-$3.00	$2.50-$3.00
3	___	___	$3.01-$4.00	$3.01-$4.00
4	___	___	$4.01-$5.00	$4.01-$5.00
5	___	___	More than $5.00	More than $5.00

11. What level of education is **REQUIRED** by your organization, and what level is **PREFERRED** for this occupation? (Mark only one of each)

Required 1	Preferred 2		
___	___	(5)	Less than High School
___	___	(6)	High School diploma or equivalent
___	___	(7)	Vocational-Technical School ________ Training Specialty
___	___	(8)	Armed Services school ________ Training Specialty
___	___	(9)	One or more years of college without degree ____ Years
___	___	(10)	Associate degree ________ Major
___	___	(11)	Baccalaureate degree in engineering
___	___	(12)	Baccalaureate degree (other than engr.) ________ Major
___	___	(13)	Masters degree ________ Major
___	___	(14)	Doctorate ________ Major

12. Is experience, in addition to education, either **REQUIRED** or **PREFERRED** or **NOT NECESSARY** for persons being employed in this occupation?

Req. 1	Pref. 2	Not Necessary 3	
___	___	___	(15)

13. What evidence of proficiency do you require when employing persons in this occupation:

Required		
___	(16)	Statement of education and/or experience?
___	(17)	School certificate or degree?
___	(18)	Standard proficiency test ________ (Name of test)?
___	(19)	Practical skill test or trade test?
___	(20)	Other ________?

14. Do you feel that a **GENERAL KNOWLEDGE** of the following subjects is necessary in preparing for this occupation? In which subjects do you feel **ADVANCED COURSES** should be taken in preparing for this occupation? (Mark only one preference for each course)

General Knwlg. 1	Advanced Crs. 2	Not Necessary 3		
___	___	___	(21)	Algebra
___	___	___	(22)	Geometry
___	___	___	(23)	Trigonometry
___	___	___	(24)	Calculus
___	___	___	(25)	Differential Equations
___	___	___	(26)	Physics
___	___	___	(27)	Chemistry
___	___	___	(28)	Geology
___	___	___	(29)	Applied metallurgy
___	___	___	(30)	Non-metallic materials
___	___	___	(31)	Hydraulics-Pneumatics
___	___	___	(32)	Manufacturing processes
___	___	___	(33)	Machine tools
___	___	___	(34)	Machinability
___	___	___	(35)	Machine economics
___	___	___	(36)	Instrument calibration and measurements
___	___	___	(37)	Electricity-electronics
___	___	___	(38)	Integrated circuits
___	___	___	(39)	Computer programming
___	___	___	(40)	Computer technology
___	___	___	(41)	Drafting
___	___	___	(42)	Computergraphics
___	___	___	(43)	English grammar and composition (writing)
___	___	___	(44)	Vocabulary and comprehension (reading)
___	___	___	(45)	Oral communications (speaking)
___	___	___	(46)	Business administration (accounting, economics, law)
___	___	___	(47)	Social studies (history, political science, sociology, psychology)
___	___	___	(48)	Humanities (literature, philosophy, fine arts)

15. Which of the following are **MAJOR** skills used in this occupation? which are **MINOR** skills? Which are **NOT USED** in this occupation?

Major 1	Minor 2	Not Used 3		
___	___	___	(49)	Research
___	___	___	(50)	Supervision or teaching
___	___	___	(51)	Production design
___	___	___	(52)	Systems analysis
___	___	___	(53)	Quality control
___	___	___	(54)	Testing materials, products and equipment
___	___	___	(1)	Instrumentation and calibration
___	___	___	(2)	Production inspection
___	___	___	(3)	Production layout
___	___	___	(4)	Drafting
___	___	___	(5)	Computer programming
___	___	___	(6)	Setting up and maintaining electronic equipment
___	___	___	(7)	Setting up and maintaining automated production equipment
___	___	___	(8)	Setting up and maintaining precision machinery
___	___	___	(9)	Surveying
___	___	___	(10)	Writing technical reports
___	___	___	(11)	Sales, consulting, or public relations
___	___	___	(12)	Other ________

Mark Answers Here				
Yes 1	No 2	No Opinion 3		
___	___	___	(13)	
___	___	___	(14)	
___	___	___	(15)	
___	___	___	(16)	
___	___	___	(17)	

16. (Answer only for degree programs) Do you feel any of the following non-technical courses should be strengthened in the degree programs preparing persons for this occupation?
- (13) Communications (reading, writing, speaking)
- (14) Business (economics, accounting, law, taxes)
- (15) Social Studies (history, political science, sociology, psychology)
- (16) Humanities (literature, philosophy, art)
- (17) Other ______

Yes 1 / No 2

17. Do you feel that non-technical or liberal arts courses contribute to a successful career in this occupation? ___ ___ (18)

Yes 1 / No 2

18. Does your organization provide training on the job in this occupation? (Answer all that apply)
- ___ ___ (19) For all new employees?
- ___ ___ (20) For employees who need special training?
- ___ ___ (21) For employees to be advanced to higher positions?
- ___ ___ (22) Other? ______

Yes 1 / No 2 / Partly 3

19. Could this kind of training be provided just as easily in the schools? ___ ___ ___ (23)

Yes 1 / No 2

20. Do you subsidize additional university, junior college, or high school education for your employees in this occupation? ___ ___ (24)

Yes 1 / No 2

21. Do you arrange special courses at public or private institutions for your employees in this occupation? ___ ___ (25)

Assistance

22. Why do you assist your employees in acquiring additional education? (Answer all that apply)
- ___ (26) To make up deficiencies in their previous education?
- ___ (27) To help them keep up with changing technical skills and knowledge?
- ___ (28) To help them prepare for more advanced positions?
- ___ (29) To increase their value to your organization with a broader educational background?
- ___ (30) Other? ______

More 1 / Less 2 / Same 3

23. Do you feel that the following institutions should assume MORE responsibility, LESS responsibility, or the SAME responsibility as now in preparing persons for this occupation? (Mark one choice for each)
- ___ ___ ___ (31) High Schools (vocational, pre-technical, pre-professional)
- ___ ___ ___ (32) Vocational-Technical Schools
- ___ ___ ___ (33) Junior Colleges
- ___ ___ ___ (34) Senior Colleges and Universities
- ___ ___ ___ (35) Graduate Schools
- ___ ___ ___ (36) Industry (in-service and on-the-job training)
- ___ ___ ___ (37) Labor Unions (schools and apprenticeship programs)

Yes 1 / No 2 / No Opinion 3

24. In the education of persons for this occupation, do you favor:
- ___ ___ ___ (38) Cooperative school-industry programs in which students spend part of their time in school and part of their time on the job?
- ___ ___ ___ (39) Expanding enrollments in Arizona schools?
- ___ ___ ___ (40) Adding programs in Arizona schools where they are not presently offered?
- ___ ___ ___ (41) Special programs in Arizona schools to upgrade experienced employees from lower level occupations?
- ___ ___ ___ (42) National registration or certification based on uniform standards?

Preference: 1st (43) / 2nd (44) / 3rd (45)

25. In hiring employees in this occupation, where do you prefer to get them? (give first three preferences only)
- 1.___ ___ ___ Promoted from lower level positions in your own organizations.
- 2.___ ___ ___ Directly from the schools.
- 3.___ ___ ___ From the armed services.
- 4.___ ___ ___ From other employers.
- 5.___ ___ ___ From the unemployed.

Mark Answers Here — Demoted or Discharged

26. Approximately what percent of employees in this occupation are demoted or discharged each year because of unsatisfactory performance? (Answer only one)
- 1.___ (46) a. Less than 1%
- 2.___ b. 1% - 5% (1 out of 20)
- 3.___ c. 5% - 10% (1 out of 10)
- 4.___ d. 10% - 25% (1 out of 4)
- 5.___ e. More than 25%

Yes 1 / No 2 / Uncertain 3

27. Of those demoted or discharged in the past year, did they have:
- ___ ___ ___ (47) Approximately the same amount of formal education as other employees at the same level?
- ___ ___ ___ (48) Approximately the same amount of work experience as other employees at the same level?
- ___ ___ ___ (49) Vocational or technical training in school?
- ___ ___ ___ (50) Personality or discipline problems unrelated to their education and training?

Major 1 / Minor 2

28. What are the MAJOR and MINOR factors you consider in giving promotions to employees in this occupation? (Mark all that apply)
- ___ ___ (51) Examination
- ___ ___ (52) Education
- ___ ___ (53) Experience
- ___ ___ (54) Seniority
- ___ ___ (1) Job performance
- ___ ___ (2) Personality
- ___ ___ (3) Other ______

Yes 1 / No 2

29. Have the technical skills and knowledge used in this occupation changed in the past five years? ___ ___ (4)

30. Do you believe they will change in the next five years? ___ ___ (5)

Yes 1 / No 2

31. If changes are taking place, do you feel that students preparing for this occupation will need more work in the following subjects than is now needed?
- ___ ___ (6) Algebra
- ___ ___ (7) Geometry
- ___ ___ (8) Trigonometry
- ___ ___ (9) Calculus
- ___ ___ (10) Differential equations
- ___ ___ (11) Physics
- ___ ___ (12) Chemistry
- ___ ___ (13) Geology
- ___ ___ (14) Applied metallurgy
- ___ ___ (15) Non-metallic materials
- ___ ___ (16) Hydraulics - pneumatics
- ___ ___ (17) Manufacturing processes
- ___ ___ (18) Machine tools
- ___ ___ (19) Machinobility
- ___ ___ (20) Machine economics
- ___ ___ (21) Instrument calibration and measurements
- ___ ___ (22) Electricity - electronics
- ___ ___ (23) Integrated circuits
- ___ ___ (24) Computer programming
- ___ ___ (25) Computer technology
- ___ ___ (26) Drafting
- ___ ___ (27) Computergraphics
- ___ ___ (28) English grammar and composition (writing)
- ___ ___ (29) Vocabulary and comprehension (reading)
- ___ ___ (30) Oral communications (speaking)
- ___ ___ (31) Business administration (accounting, economics, law)
- ___ ___ (32) Social studies (history, political science, sociology, psychology)
- ___ ___ (33) Humanities (literature, philosophy, fine arts)

32. Additional employer comments or suggestions ______

№ 11239

Arizona State Survey of Engineering Technology

Northern Arizona University—Occupational Research Coordinating Unit
1626 W. Washington—Phoenix, Arizona

EMPLOYEE DATA

You are being asked to participate in a survey of engineering technology and industrial skills in Arizona, which is needed by the educational institutions to update and improve their programs. All information will be kept strictly confidential, and will be used in statistical analysis only. Please answer all questions as accurately and frankly as you can. If you are in doubt about any question, answer it to the best of your ability. When finished, please mail the completed questionnaire to the Occupational Research Coordinating Unit in the postage paid envelope provided. **DO NOT SIGN YOUR NAME.** Remember, this information is confidential. IT WILL NOT BE SEEN BY YOUR EMPLOYER.

DIRECTIONS: 1. Give written information as briefly as possible on the appropriate lines provided.
2. Answer all other questions by marking the appropriate space in the answer column.

Mark Answers Here	
(1-5)	1. What is your job title? ________
	2. Approximately what percent of your time on this job do you spend in the following activities? (Please check the entire list before answering)
____% (6)	Research
____% (7)	Supervision or teaching
____% (8)	Production design
____% (9)	Systems analysis
____% (10)	Quality control
____% (11)	Testing materials, products and equipment
____% (12)	Instrumentation and calibration
____% (13)	Production inspection
____% (14)	Production layout
____% (15)	Drafting
____% (16)	Computer programming
____% (17)	Setting up and maintaining electronic systems
____% (18)	Setting up and maintaining automated production equipment
____% (19)	Setting up and maintaining precision machinery
____% (20)	Surveying
____% (21)	Writing technical reports
____% (22)	Sales, consulting, or public relations
____% (23)	Other ________
(24)	3. If you are a salaried employee or self-employed, what is your present monthly salary? (Mark only one)
1____	Less than $500
2____	$500 - $700
3____	$701 - $900
4____	$901 - $1,200
5____	More than $1,200
(25)	4. If you are an hourly employee, what is your present base pay? (Mark only one)
1____	Less than $2.50
2____	$2.50 - $3.00
3____	$3.01 - $4.00
4____	$4.01 - $5.00
5____	More than $5.00

Mark Answers Here		
(26)		5. What is the highest level of education you have reached, either in school, the armed forces, correspondence, or self-study? (Mark only one)
	1____	Less than high school
	2____	High school diploma or equivalent
(28-29)	3____	Vocational-technical school ________ Training Specialty
(30-31)	4____	Armed Services School ________ Training Specialty
(32)	5____	More than one year of college without degree ____ Years
(33-34)	6____	Associate degree ________ Major
	7____	Baccalaureate degree in engineering
(35-36)	8____	Baccalaureate degree (non-engineering) ________ Major
(37-38)	9____	Masters degree ________ Major
(39-40)	1____(27)	Doctorate ________ Major

6. What is the present name and location of the institution from which you received your highest degree, diploma, or certificate?

____

____

(41-44) Yes 1	No 2	
____	____(45)	7. If you were selecting a school today to prepare for your present occupation, would it be the same choice that you made before?

Major Reason 1	Minor Reason 2	8. Why did you attend that institution? (Mark each reason as **MAJOR, MINOR,** or leave blank)
____	____(46)	Convenient location
____	____(47)	Scholarship or other financial benefits
____	____(48)	Family influence
____	____(49)	Reputation of the school in your field
____	____(50)	Influenced by high school teachers or counsellors
____	____(51)	Influenced by friends
____	____(52)	Influenced by representatives of the school
____	____(53)	Other ________

(54)

9. What is your present age?

1____ Less than 20
2____ 20 - 29
3____ 30 - 39
4____ 40 - 49
5____ 50 or older

(55)

10. What was your major course of study in high school? (Mark only one)

1____ General education
2____ College preparatory
3____ Vocational-technical
4____ Industrial arts
5____ Agriculture
6____ Business
7____ Other ________

(56)

11. What was your approximate academic class rank in high school? (Mark only one)

1____ Lower ¼
2____ Upper ¾
3____ Upper ½
4____ Upper ¼
5____ Upper 10%

12. Does your present job require a **GENERAL KNOWLEDGE** or **ADVANCED COURSES** in the following subjects? (Mark one choice for each subject)

General Knwlg. 1	Advanced Crs. 2	Not Necessary 3		
___	___	___	(1)	Algebra
___	___	___	(2)	Geometry
___	___	___	(3)	Trigonometry
___	___	___	(4)	Calculus
___	___	___	(5)	Differential equations
___	___	___	(6)	Physics
___	___	___	(7)	Chemistry
___	___	___	(8)	Geology
___	___	___	(9)	Applied metallurgy
___	___	___	(10)	Non-metallic materials
___	___	___	(11)	Hydraulics-pneumatics
___	___	___	(12)	Manufacturing processes
___	___	___	(13)	Machine tools
___	___	___	(14)	Machinability
___	___	___	(15)	Machine economics
___	___	___	(16)	Instrument calibration and measurements
___	___	___	(17)	Electricity-electronics
___	___	___	(18)	Integrated circuits
___	___	___	(19)	Computer programming
___	___	___	(20)	Computer technology
___	___	___	(21)	Drafting
___	___	___	(22)	Computergraphics
___	___	___	(23)	English grammar and composition (writing)
___	___	___	(24)	Vocabulary and comprehension (reading)
___	___	___	(25)	Oral communications (speaking)
___	___	___	(26)	Business administration (accounting, economics, law)
___	___	___	(27)	Social studies (history, political science, sociology, psychology)
___	___	___	(28)	Humanities (literature, philosophy, fine arts)

(29)

13. How many years has it been since you received your highest degree, diploma, or certificate? (Mark only one)

1____ One year or less
2____ Two years
3____ Three to five years
4____ Five to ten years
5____ More than ten years

Yes 1 ____ No 2 ____ (30)

14. Have the technical skills and knowledge used in your job changed during the past five years?

Yes 1 ____ No 2 ____ (31)

15. Do you feel that non-technical or liberal arts courses contribute to a successful career in this occupation?

16. How long have you worked either as an engineer, technician, or skilled craftsman? (Answer all that apply)

Engr. 1	Tech. 2	Skilled Cftsmn. 3		
___	___	___	(32)	Less than 1 year
___	___	___	(33)	1 - 3 years
___	___	___	(34)	3 - 5 years
___	___	___	(35)	5 - 10 years
___	___	___	(36)	More than 10 years

(37)

17. What was your last full time job before going to work for your present employer? (Mark only one)

1____ Attending school
2____ In the armed services
3____ A similar job in another state
4____ A similar job with another employer in Arizona
5____ A lower level job with another employer
6____ A higher level job
7____ Other ________

(38)

18. Where did you learn most of the skills and technical knowledge needed in your job? (Mark only one)

1____ High school
2____ Vocational-technical school
3____ Junior college, senior college, or university
4____ Armed services
5____ On the job
6____ Other ________

Yes 1	No 2	
		19. Have you had additional training or education since working in your present occupation? (Mark each item)
______	______(39)	In-service or on-the-job training provided by your employer
______	______(40)	Courses in public or private schools arranged and paid for by your employer
______	______(41)	Courses in public or private schools of your own choosing but paid for by your employer
______	______(42)	Courses in public or private schools chosen and paid for without assistance from your employer
______	______(43)	Other ______

Yes 1	No 2	
		20. Was this training or education for the purpose of: (Answer every item)
______	______(44)	Orientation and instruction in company policy?
______	______(45)	Acquiring technical or professional knowledge needed on your job?
______	______(46)	Acquiring special skills needed on your job?
______	______(47)	Advancement to a higher position
______	______(48)	Your own self-improvement
______	______(49)	Other ______

(50)	
	21. How many promotions (salary or grade or both) have you had in your present occupation? (Answer only one)
1______	None
2______	One
3______	Two
4______	Three
5______	Four
6______	Five
7______	More than five

Major Reason 1	Minor Reason 2	
		22. What are most promotions based on in this occupation? (Mark each reason as MAJOR, MINOR or leave blank.)
______	______(51)	Examination
______	______(52)	Education
______	______(53)	Experience
______	______(54)	Seniority
______	______(55)	Job performance
______	______(56)	Personality
______	______(57)	Other ______

Like 1	Do Not Like 2	No Opinion 3	
			23. What is it that you LIKE about your occupation, and what do you NOT LIKE? (Answer every item)
____	____	____(1)	Wages or salary
____	____	____(2)	Opportunities for advancement
____	____	____(3)	Fringe benefits (retirement, hospitalization, etc.)
____	____	____(4)	Working environment and facilities
____	____	____(5)	Employer-employee relations
____	____	____(6)	Nature of the work (the kind of work you do)
____	____	____(7)	Job security
____	____	____(8)	The importance of the job in our technological society
____	____	____(9)	Other ______

(10)	
	24. When did you decide to go into your present occupation? (Mark only one)
1______	Before high school
2______	During high school
3______	While in the armed services
4______	During the first two years of college
5______	During the third or fourth year of college
6______	While employed in another occupation
7______	Other ______

	25. What was the major reason you decided to go into your present occupation? (Mark all that apply)
______(11)	Your father or other members of your family were in similar occupations
______(12)	You were influenced by someone else in this occupation
______(13)	You were influenced by your high school teacher or counselor
______(14)	You developed an interest in this occupation in the Armed Forces or in another job.
______(15)	You developed an interest in this occupation from advertisements or articles in newspapers, magazines, radio and television.
______(16)	Other ______

Yes 1	No 2	
		26. After working in this occupation, are you satisfied that you made a good choice?
______	______(17)	

(18)	
	27. What do you expect to be doing ten years from now? (Answer only one)
1______	Continuing at your present occupational level
2______	Working in a higher supervisory or management position
3______	Working at a higher occupational level in engineering or technology requiring additional education
4______	Working at a higher level without additional education
5______	Working in a different occupational field
6______	Other ______

28. If you have additional comments or suggestions for improving edcation programs for this occupation, they will be appreciated. You may also use the back of this page for comments.______

Arizona State Survey of Engineering Technology

OCCUPATIONAL RESEARCH COORDINATING UNIT — 1626 WEST WASHINGTON — PHOENIX, ARIZONA

ENGINEERING AND TECHNOLOGY STUDENTS

TO STUDENTS OF ENGINEERING AND TECHNOLOGY: The three state universities and six junior colleges are cooperating in a statewide study of engineering and technical education to assist in future development and planning. All students currently enrolled in engineering and technical programs are being asked to participate. Please supply the appropriate answers to the questions below. Mail the completed questionnaire in the postage paid envelope in which you receive it. You will not be identified. The information will be used for statistical purposes only. Do not sign your name.

______Your age? ______Sex? ______Marital status? ______Draft status?

________________1. Name of the school you now attend?

________________2. Degree program in which you are presently enrolled (Associate, Bachelor's, Master's, Doctorate)? If you are a junior college pre-engineering student in a transfer program, indicate Bachelor's degree.

________________3. How many semester hours have you completed toward this degree?

________________4. What is your major or intended major?

________________5. What previous majors, if any, had you selected?

________________6. What is your present grade average in all subjects?

________________7. Do you anticipate working toward a higher degree when you have completed your present program?

________________8. What was your high school major?

How many years in each of these subjects did you have in high school:

9.______Mathematics? 10.______Chemistry? 11.______Physics? 12.______Drafting?

13. Did you take any of the following programs in high school:

______Industrial arts? ______Vocational education? ______Technical education?

14.-15. If you took industrial arts, vocational or technical education in high school, please list the subjects and number of years in each:

________________ ________________ ________________

________________ ________________ ________________

16. What was your class rank in high school?

______Upper 10% ______Upper ¼ ______Second ¼ ______Third ¼ ______Lower ¼

17. Are you now employed as an engineer ______? technician ______? skilled craftsman ______?

________________18. Have you ever had industrial or mechanical employment?

________________19. Have you had skilled training or experience in the armed services?

________________20. What is your present career objective (professional or technical employment, management, teaching, etc.)?

________________21. Are you fairly sure this is the career you want to pursue?

22. Approximately when in your life did you first decide on your present career objective?

____

23. Who or what influenced you most in making this decision (family, high school counselor, friends, work experience, etc.)? ________________

24. In your opinion, why do many students leave this program and go in to something else? ________________

25. Why did you select the school you now attend in preparing for your career? ______

____

26. What is (or was) your father's occupation? ________________

27. In which of the following monthly income brackets do (or did) your parents belong?

______Less than $300 ______$700 - $900 ______$1100 - $1300

______$300 - $500 ______$900 - $1100 ______More than $1300

______$500 - $700

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