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CHARACTERISTICS OF OUTSTANDING ENGINEERING TECHNICIANS IN ARIZONA.

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THE PURPOSE OF THIS STUDY WAS TO IDENTIFY THE KNOWLEDGE, SKILLS, AND JOB RESPONSIBILITIES OF SUCCESSFUL ENGINEERING TECHNICIANS AS INDICATED BY TECHNICIANS AND THEIR EMPLOYERS, TO EXAMINE THE RELATIONSHIPS BETWEEN THE EMPLOYER'S AND THE TECHNICIAN'S VIEWS OF NEEDED KNOWLEDGE AND SKILLS AND TO ASSESS THE IMPLICATIONS OF THE FINDINGS FOR ADJUSTMENTS IN CURRICULUMS FOR ENGINEERING TECHNICIANS. TWO HUNDRED AND TWENTY-ONE PERSONS, IDENTIFIED BY MANAGEMENT PERSONNEL AS THEIR MOST ABLE AND SUCCESSFUL TECHNICIANS, AND 142 IMMEDIATE AND SECOND LEVEL SUPERVISORS WERE INTERVIEWED AND ASKED TO SORT A PACK OF 99 CARDS, EACH CONTAINING DESCRIPTIVE TECHNICAL DATA CONCERNING THINGS TECHNICIANS DO IN VARIOUS SPECIALITIES. THE CARDS WERE SORTED AS DIRECTLY RELATED TO JOB, SOMEWHAT RELATED TO JOB, AND NOT RELATED TO JOB. TECHNICIANS VIEWED THEIR JOBS IN A VERY BROAD SENSE. RESEARCH, DESIGN, OR DEVELOPMENT AND TESTING WERE THEIR MOST FREQUENTLY MENTIONED ACTIVITIES. THE TECHNICAL KNOWLEDGE REQUIRED INVOLVED PRINCIPLES OF ELECTRICITY-ELECTRONICS, MATHEMATICS, AND DRAFTING AND DESIGN AND WAS GENERALLY ACQUIRED ON THE JOB. HOWEVER, TECHNICIANS GENERALLY BELIEVED THAT A 2- OR 4-YEAR FORMAL DEGREE PROGRAM WAS THE BEST PREPARATION FOR THEIR JOBS. MANAGERS AND TECHNICIANS TEND TO AGREE ON INFORMATION, SKILLS, AND KNOWLEDGE IMPORTANT TO THE WORK OF THE TECHNICIANS AND ON THE IMPORTANCE OF EDUCATIONAL PREPARATION. IT WAS CONCLUDED THAT BOTH EDUCATIONAL INSTITUTIONS AND INDUSTRY SHOULD INVESTIGATE THEIR ROLES IN ON-THE-JOB TRAINING FOR TECHNICIANS. (HC)

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CHARACTERISTICS OF OUTSTANDING ENGINEERING TECHNICIANS IN ARIZONA

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IN COOPERATION WITH

THE ARIZONA RESEARCH

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AND THE

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FOREWARD

The need for a definitive study dealing with successful technicians in Arizona has been obvious for some time.

Program development, with all its various concomitant ramifications, depends on results of such a study for direction.

The present study attempts to clarify the status of the technician in Arizona today. It further identifies in part the direction technician programs should develop.

It is anticipated that industrial personnel; junior college, college and university personnel; and secondary school administrators, counselors and vocational-technical instructors will find the study of considerable interest and value.

The principal investigator wishes to extend special thanks and recognition to Mr. Rheinhardt Lukas and Mr. Kenneth Loggans, both faculty members of Phoenix Union High School, for their untiring efforts to complete the interviews in this study.

Mr. J. R. Cullison, State Director of Vocational Education and his staff also provided invaluable assistance in completing the study.

Bill Wesley Brown
19 July 1967

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Introduction

Statement of the Problem:

The rapid change taking place in industry today creates a need to re-examine the educational program provided in colleges and universities offering curricula in Engineering Technology.

Those who employ Engineering Technologists have been consulted very little concerning the content of the curriculum that should be provided for them in the educational program. Again, successful technologists have not been contacted in sufficient number to determine the degree to which their educational program has contributed to their demonstrated success.

Purpose of the Study:

The purpose of this study is to answer the following questions:

1. What knowledges do industrial employers believe to be a necessary part of the education of successful Engineering Technologists?

2. What skills are needed by Engineering Technologists to be successful as employees in modern industry?

3. What are the things that Engineering Technologists must do on the job (operations, skills, calculations, report writing, etc.)?

4. What knowledges are needed to be successful as an Engineering Technologist as indicated by successful Engineering Technologists?

5. What skills are needed by Engineering Technologists as indicated by successful Engineering Technologists presently employed?

6. What relation exists between the knowledges and skills needed by Engineering Technologists as expressed by employers of these persons vs. what successful Engineering Technologists express as their needs?

7. What implications do the answers to the above questions have for adjustments in present day college and university curricula for Engineering Technologists?

Definitions

For the purposes of this research project the definition of technician used was the one proposed by the President's Committee on Scientists and Engineers:

The engineering or scientific technician is usually employed in (1) research, design, or development; (2) production, operation, or control; (3) installation, maintenance, or sales. When serving in the first of these functional categories, he usually follows a course prescribed by a scientist or engineer but may or may not work closely under his direction. When active in the third category, he is frequently performing a task that would otherwise have to be done by an engineer.

In executing his function, the scientific or engineering technician is required to use a high degree of rational thinking and to employ post-secondary-school mathematics and principles of physical and natural science. He thereby assumes the more routine engineering functions necessary in a growing technologically based economy. He must effectively communicate scientific or engineering ideas mathematically, graphically, and linguistically.

Mentioned above is the need to identify the basic area in which the technician functions, i.e., (1) research, design, or development; (2) production, operation, or control; (3) installation or maintenance; (4) sales; or (5) supervision.

For the purposes of this research project, managers were defined as individuals whose primary responsibilities involved directing, supervising, coordinating and planning work and the work force. Some managers were in a direct supervisory capacity; others were two, three or four steps removed from direct supervision functions.

Procedures:

Top management of representative industrial firms in Arizona were apprised of the research effort and asked to participate. Full cooperation was received almost without exception.

Participating managers arranged schedules for interviews and other activities connected with the research project. Two research assistants conducted the majority of data gathering. As data were assembled, a third research assistant tabulated the materials. A total of 221 technicians and 142 managers were included in the study.

Management personnel were asked to identify their most able and successful technicians for inclusion in the study.

Immediate supervisors and second level supervisors of technicians were asked to complete the Q Sort and interviews. Successful technicians were asked to complete the Q Sort and interviews.

Items which has been included in the Illinois study by Schill and Arnold[1] were selected as tentative questions for this study. Schill and Arnold had developed a pack of 99 cards with specific information concerning things technicians from various specialities performed on the job. The present research effort used these same 99 cards and are referred to as the Q Sort. During the interview, the technician or manager was asked to sort the cards into three piles. That is, the information found on the card was either directly related to their job, somewhat related to their job, or not related to their job. The individual being interviewed was then instructed to choose, from the directly related stack of cards, the three most important cards, and the next eight most important cards.

A preliminary information form was constructed and submitted to a panel of Northern Arizona University research specialists who were familar with the goals of the present research effort. Revision of this preliminary form resulted. This revised form was then submitted to a group of professional research workers, again revised, and once again submitted to the Northern Arizona University personnel for recommendations. The schedules were revised according to the principal investigators concepts of these recommendations.

These interview schedules were then duplicated for use in a pilot plant. A complete trial use of the total research system and techniques was run in the pilot plant. The instruments were found to be workable. Certain minor modifications were made in the final instrument.

Related Studies

Two sources were of considerable importance in planning the present study. Portions of the methodology and techniques of the study by Schill and Arnold titled: "Curricula Content for Six Technologies" were considered appropriate for this Arizona research study.

Among other findings, Schill and Arnold reported that the type of program pursued in high school was found to be related to the level of employment on the first job. They also indicated that "the traditional, or college-directed program, with its emphasis on science and mathematics, is more in line with the needs of the technicians positions than is the occupationally-oriented program with its emphasis on crafts."

Schill and Arnold also found that the "knowledges functionally related to all the (six) technologies (the core program) were found to include technical writing, engineering graphics, mathematics through trigonometry, and the use of test equipment."

A publication of the U. S. Department of Health, Education and Welfare, Office of Education (OE-80015) titled: "Occupational Criteria and Preparatory Curriculum Patterns in Technical Education Programs" was of considerable value in preparing the information forms used in the present study.

Part I: The Technicians

As shown in Table I, the ages of technicians included in this study varied widely. Technicians tended to cluster around the ages between 26 and 37. Over one-half, 115, or 52 per cent of the technicians, were in this category. The mean age of the technicians was 35.77.

A total of 92 of the technicians had only a high school education, as revealed in Table II, yet none of the technicians interviewed could, by reason of age, be considered a recent high school graduate.

The Technician

The participating technicians and managers are compared as to age and educational achievement in this portion of the report.

The implication appears obvious: among other factors, experience on the job exerts considerable influence in becoming a successful technician.

The mean age of managers was 43.55. Seventy six managers, or 53 per cent clustered between the ages of 34 and 45. Managers below the ages of 34 were not common. Only 19, or thirteen per cent, were in this category.

It is of no little interest that the mean age of the managers was between 42 and 45 (43.55). This same age bracket represented the upper age group for technicians before a sharp drop in their numbers occurred.

The educational attainment of the technicians and managers included in this study is of interest. Approximately five per cent of the managers had not completed high school. Both technicians and managers had finished high school at about the same rate. Of the technicians, 92, or 41 per cent had stopped with high school graduation, 55, or 39 per cent of the managers were in this group.

The sharpest difference in educational achievement between technicians and managers was in attaining the baccalaureate degree. Only 15, or seven

TABLE I

AGE

Technicians		Managers	
Age	Frequency	Age	Frequency
18 - 21	1	18 - 21	0
22 - 25	27	22 - 25	3
26 - 29	39	26 - 29	4
30 - 33	37	30 - 33	12
34 - 37	39	34 - 37	29
38 - 41 (Mean = 35.77)	28	38 - 41	25
42 - 45	21	42 - 45	22
46 - 49	14	46 - 49 (Mean = 43.55)	17
50 - 53	8	50 - 53	12
54 - 57	8	54 - 57	8
58 - 61	0	58 - 61	7
62 - 65	1	62 - 65	2
Unreported	0	Unreported	1
	N = 221		N = 142

per cent of the technicians had the four year degree; 66, or 47 per cent of the managers had the degree.

As shown in Table II, 54, or 24 per cent of the technicians had completed the Associate Science degree program at junior colleges. Aside from high school graduation, this represents the single largest category of educational achievement for technicians. These data also indicate that two years of junior college or more was obtained by a majority of the successful technicians.

TABLE II

HIGHEST GRADE COMPLETED

Grade Completed	Technicians	Managers
Less than H. S. Graduate	11	7
H. S. Graduate	92	55
1 Year College	29	0
2 Years College (degree)	54	13 (degree)
3 Years College	20	0
4 Years College (degree)	15	66
M. A. or M. S.	0	1
	221	142

These data indicate that the majority of both groups have graduated from high school. Since 55, or 39 per cent of the managers had only a high school diploma (and an additional 80 had continued their formal education), it seems reasonable to assume that high school graduates who acquire necessary work experience skills, and education, and who have the ability may be promoted to managerial-supervisory endeavors.

From Table II, it is also readily apparent that successful technicians were not identified on the basis of formal education alone. Almost as many technicians had not completed high school (11) as had completed the baccalaureate degree (15).

Technicians come from a wide variety of family backgrounds. Using the occupational classification of the Bureau of the Census and the Department of Labor, the occupation of the technicians father's are identified in Table III. The greatest number of fathers were engaged in skilled work. Two other groups were about equal, proprietors and managers and farm and farm workers.

From the preceding data, it seems reasonable to assume that there is little relationship between successful technicians and the occupation of their fathers. One technician did not know his father's occupation.

The great majority of technicians mothers were not employed outside the home, 172, or 78 per cent were in this classification. From Table IV, it is apparent that the 45 who were employed were generally employed within the top three categories of the occupations listed.

TABLE III

OCCUPATIONS OF TECHNICIANS FATHERS

Occupations	Number	Per Cent
Professional	14	6.33
Proprietors and managers	27	12.22
Clerical and sales	18	8.14
Skilled	84	38.01
Semi-skilled	7	3.17
Service workers	17	7.69
Unskilled	8	3.63
Farm and farm workers	33	14.93
Deceased	8	3.62
Military	4	1.81
Unknown	1	0.45
	221	100.00

As Table V reveals, the technicians included in this study generally did not follow a vocational-technical program in high school. A total of 188, or 85.07 per cent, had not followed vocational or technical programs in high school. According to data found in the Summary Report of the Governor's Committee on Technical -Vocational Education, "Education for

TABLE IV

OCCUPATIONS OF TECHNICIANS MOTHERS

Occupations	Number
Professional and Technical	10
Proprietors and Managers	6
Clerical and Sales	18
Skilled	4
Semi-skilled	3
Service	3
Unskilled	1
Farmer and farm workers	0
Housewife	172
Deceased	4
	221

a Changing World of Work", these figures were not unusual:

> "Total state expenditure for vocational training for wage-earning occupations in 1961-62 was $295,973 -- or 2.3% of the total state appropriation to Arizona high school. In contrast to the 6.42% enrolled in training to acquire suitable skills for entering the labor force, approximately 80% of those gainfully employed in Arizona are employed in work that requires some kind of technical-vocational training. Only 10%

of our total work force are employed in professional work that requires a college education; and 9.2% are employed in unskilled occupations that require no formal education. Obviously 80% are not receiving adequate technical-vocational education."[2]

TABLE V

TECHNICIANS HIGH SCHOOL PROGRAM

Program	Number	Per Cent
General Academic	95	42.98
College Preparatory	93	42.08
Vocational-Technical	31	14.03
Not applicable	2	0.91
	221	100.00

In the same publication, only 17,152, or 24 per cent of the total end of year high school enrollment of 71,459 in 1961-62 were enrolled in some kind of vocational-technical education. These data include 12,562 students enrolled in Homemaking. Deleting these from the total vocational-technical enrollment reduces the figure to 4,590 or only 4.23 per cent of the total high school enrollment.

The majority of the technicians acquired some job skills or knowledges at a post high school, technical institute, junior college, college or university. Of the 221 technicians, 183, or 83 per cent were in this category. Technicians were almost equal in selecting the type of institution to attend. Geographic location of the institution was a governing criteria in determining the institution attended.

TABLE VI

TYPE OF POST HIGH SCHOOL INSTITUTIONS WHERE TECHNICIANS ACQUIRED JOB KNOWLEDGES AND SKILLS

Institution	Number	Per Cent
Technical Institute	57	31.15
Junior College	56	30.60
University	54	29.51
College	16	8.74
	183	100.00

As revealed in Table VII, the 183 technicians had taken courses in a variety of technical fields. Many of the 183 technicians indicated dual areas of study. Closely tied in with the wide-range of interests of the technicians was their remarks concerning their freedom to "pick and choose" from an institutions offerings without being bound by formal program restrictions. This did not apply to those following a two or four year program.

Technicians were asked to indicate courses and/or activities which were of greatest value to them on the job. As might be expected, areas of

TABLE VII

TECHNICIANS MAJOR AREA OF STUDY

Area	Number
Electronic Technology	74
Engineering	66
Drafting Technology	27
Mathematical Science	24
Mechanical Technology	21
Business and Management	18
Drafting Trades	9
Machine Trades	8
Liberal Arts	7
Electrical Trades	6
Agriculture	5
Building Trades	4
Civil Technology	4
Data Processing	4
Art	3
General	3
Printing Trades	3
Air Frame and Power Mechanics	2
Engineer Mechanic	2
Industrial Arts	2
Physical Science	2
Appliance Repairs	1
Biological Science	1
Foreign Trade	1
Home Economics	1
Technical Writing	1
Does Not Apply	38

specialization exerted considerable influence in their reactions. Because of special and isolated spheres of influence, a great many individual courses and activities were noted. As shown in Table VIII, mathematics was listed a total of 106 times. Algebra was noted 13 times, Trigonometry 10 times, and Calculus 6 times. Together these total 135. In addition, mathematics oriented physical sciences were named 47 times; Physics was listed 32 times and Chemistry 15 times.

From the preceding data, it seems reasonable to assume that mathematics and the physical sciences form the nucleus of courses which are considered to be of greatest value to technicians on the job. It is of some note that Drafting and English were subjects other than mathematics and the physical sciences which were frequently mentioned.

Technicians were asked to indicate courses or activities which were of lowest value to them on the job. Social Sciences, History and Humanities were most frequently mentioned as having little value on the job. As revealed by Tables VIII and IX, a certain amount of spill-over was noted by the technicians, that is certain courses appeared on both lists.

Technicians were asked to indicate both courses and activities which were of greatest and least value to them on the job. None of the technicians listed "activities" as such.

Of the 221 technicians included in this study, 54, or 24 per cent were presently enrolled in courses to upgrade their technical backgrounds. Sixteen of these were actively pursuing various degree programs on a part-time basis. Aside from these 16, the single largest group of technicians were enrolled in electricity-electronics courses. As indicated in Table X, the courses covered a wide variety of subjects.

TABLE VIII

JUNIOR COLLEGE OR UNIVERSITY COURSES OR ACTIVITIES WHICH HAVE PROVEN TO BE OF GREATEST VALUE ON THE JOB

Course or Activity		Number
Mathematics		106
Drafting		45
Physics		32
English		25
Basic Electronics		23
Chemistry		15
Algebra		13
Circuit Analysis		10
Trigonometry		10
None of specific value		10
	Sub-Total	292
Miscellaneous (less than 10)		93
	Total	385

Those technicians who were actively engaged in pursuing a degree program were generally quite verbal in describing their goals. Without question these technicians were expressing their awareness of the premium and prestige which industry places on the baccalaureate degree.

TABLE IX

JUNIOR COLLEGE OR UNIVERSITY COURSES OR ACTIVITIES WHICH HAVE PROVEN TO BE OF LEAST VALUE ON THE JOB

Course or Activity		Number
Social Sciences		18
History		16
Humanities		9
Chemistry		6
Foreign Languages		6
Art		4
All Courses		4
Drafting		4
Economics		4
English		4
	Sub-Total	75
Miscellaneous (less than 4)		41
	Total	116

In view of the fact that the majority of the interviews were conducted during the summer months, the numbers of technicians currently enrolled in all upgrading courses may be considered quite high. Since intentions are difficult if not impossible to measure, no formal record was obtained of those intending to enroll in the fall. From observations, however, the figure is likely to be greater during the academic year than for those involved during the summer.

TABLE X

PROGRAMS OR COURSES IN WHICH TECHNICIANS WERE CURRENTLY ENROLLED

Program or Course		Number
Degree Program		16
Electronic Engineering	7	
Civil Engineering	5	
English	1	
Industrial Engineering	1	
Teaching (technical)	1	
Physics	1	
Electricity-Electronics		12
Correspondence (unspecified)		10
Mathematics		8
Miscellaneous		8
		54

Technicians were asked to indicate education or training they had acquired other than junior college or university preparation. As might be expected, a wide variety of education, preparation and training was reported. Military schooling and training led the list with 114 or the 221 technicians, or 52 per cent have been involved in this kind of preparation.

TABLE XI

EDUCATION AND TRAINING OF TECHNICIANS
OTHER THAN JUNIOR COLLEGE OR UNIVERSITY

Type of Preparation		Number
Military Schools		114
Formal on the Job Training		104
In-plant Training		85
Correspondence Courses		81
Vocational Schools		37
Private Institutions		33
Apprenticeship		27
Other		24
	Total	505

As revealed in Table XI, private industry is much involved in training employees. Of the 221 technicians in this study, 189, or 86 per cent indicated that they had received some formal on the job training or in-plant training. From Table XI, it is obvious that some technicians received more than one kind of preparation.

It seems reasonable to assume that most successful technicians will have one or more of these kinds of experiences in their background.

Technicians were asked to provide information concerning employers policies concerning payment of tuition for technicians to attend upgrading courses, and whether employers permitted technicians time off to attend such classes. As shown by Table XII, the majority of the companies were willing to pay for technicians tuition while attending upgrading classes, but were largely unwilling to grant time off for employers to attend classes.

TABLE XII

EMPLOYERS POLICIES CONCERNING PAYMENT OF TUITION FOR UPGRADING COURSES AND/OR TIME-OFF FOR CLASS ATTENDANCE

	Technicians Companies who Pay Tuition	Technicians Companies who Grant Time Off
Yes	181	81
No	35	139
Unknown	5	1
	221	221

Table XII is not a record of 221 companies, but the report of 221 technicians employed by the 17 participating companies. From Table XII, it seems reasonable to assume that Arizona industrial concerns are quite willing to pay technicians tuition while they attend upgrading courses.

Since it would have been beyond the scope of this study to seek out specific high school records of the technicians included in this study -- and since it also seemed appropriate to have some indication of their ability to achieve -- technicians were asked to indicate their rank in their high school graduating class. Insofar as these answers are valid, and insofar as rank in high school graduating class is an indication of ability to achieve, Table XIII represents the range of ability to achieve of the technicians included in this study.

As revealed by Table XIII, the majority of the technicians were in the upper half of their graduating class. Eighty per cent, or 177, were in this category. Only one technician did not know where he ranked within a quartile.

It seems reasonable to assume that ability to achieve is a prime requisite for successful technicians. Very few technicians indicated they were in the lower half of their graduating classes.

Technicians were asked whether the high schools from which they graduated offered vocational-technical education which could have prepared them for their present technical jobs, and further, whether they enrolled in such courses or programs.

As indicated by Table XIV, only 73, or 33.03 per cent of the technicians attended high schools where vocational-technical programs were available, (These are exclusive of industrial arts programs taught for general education purposes.), while 55, or 24.89 per cent of the 221 technicians had actually enrolled in vocational-technical courses. A total of 55, or 75.34 per cent of the 73 technicians who had vocational-technical courses available to them had enrolled in them.

From Table V, it will be noted that only 31, or 14.03 per cent of the technicians included in this study indicated that they enrolled in

TABLE XIII

RANK IN HIGH SCHOOL GRADUATING CLASS
(ABILITY TO ACHIEVE)

Rank	Number	Per Cent
76 - 100	99	44.80
51 - 75	78	35.29
26 - 50	28	12.67
0 - 25	2	0.91
GED	2	0.91
Did not graduate	11	4.97
Unknown	1	0.45
	221	100.00

vocational-technical programs. Twenty four other technicians had enrolled in such courses without having vocational-technical education listed as a program of studies.

Table XV shows that electricity-electronics and drafting-design programs were most often taken by the technicians in this study.

As might be expected, the 55 tec... ...ians had, in some instances, enrolled in more than one vocational-technical area.

Technicians were asked to indicate the size of the community they lived in when they attended high school. Table XVI reveals that the

TABLE XIV

HIGH SCHOOLS OFFERING VOCATIONAL-TECHNICAL EDUCATION AND TECHNICIANS ENROLLING IN THEM

	High School with Vocational-Technical Courses in their Technical Area		Technicians who enrolled in High School Vocational-Technical Programs or Courses	
	Number	Per Cent	Number	Per Cent
Yes	73	33.03	55	24.89
No	146	66.06	164	74.20
Unknown or does not apply	2	0.91	2	0.91
	221	100.00	221	100.00

majority of the technicians included in this study came from small communities of 10,000 or less. It is possible that smaller communities are not in a strong position to offer high quality, multiple-area vocational education. This may well account for some of the data revealed in Tables XIV and XV.

Technicians were asked to indicate the age at which they decided to work in the general area in which they were employed. Table XVII is a record of these data.

As shown by Table XVII, the majority of the technicians decided to enter their present technical field between the ages of 16 and 25. A total of 157, or 71.04 per cent were in this category. These ages coincide with early high school years through the years when youth and young men are seeking initial jobs and moving within their organizations.

TABLE XV

HIGH SCHOOL VOCATIONAL-TECHNICAL PROGRAMS AND COURSES ENROLLED IN BY TECHNICIANS

Programs/Courses	Number
Electricity-Electronics	23
Drafting-Design	14
General Industrial	10
Machine Shop	8
Carpentry-cabinet making	4
Auto mechanics	3
Miscellaneous (less than 13)	11
	73

Technicians were asked to list previous occupations or jobs they had held which enabled them to qualify for their present technical job. Fifty nine, or 26.69 per cent of the 221 technicians did not answer this question. It seems reasonable to assume that these 59 either had no previous work experience, the work experience they had was totally unrelated to their present assignment, or they had begun work directly out of an educational institution. As shown in Table XVIII, experience in the broad field of electricity-electronics led the list of previous occupations or jobs which helped technicians qualify for the present position held.

TABLE XVI

SIZE OF COMMUNITY

Size	Number
A. 0 - 10,000	77
B. 10,000 - 20,000	31
C. 20,000 - 30,000	7
D. 30,000 - 40,000	11
E. 40,000 - 50,000	3
F. 50,000 - 60,000	11
G. 60,000 - 70,000	8
H. 70,000 - 80,000	3
I. 80,000 - 90,000	1
J. 90,000 - 100,000	3
K. 100,000 and over	66
	221

The technicians were asked to indicate the length of the previous work experience which enabled them to qualify for their present position. Data included in Table XIX indicated that the majority of technicians had from one to four years experience in the process of preparing for the present position. In view of the ages of the technicians reported in

TABLE XVII

AGE OF TECHNICIANS WHEN DECISION MADE TO ENTER PRESENT TECHNICAL FIELD

Age	Number	Per Cent
15 or under	24	10.86
16 to 20	85	38.46
21 to 25	72	32.58
26 to 30	24	10.86
Over 30	16	7.24
	221	100.00

TABLE XVIII

PREVIOUS OCCUPATIONS OR JOBS WHICH HELPED TECHNICIANS QUALIFY FOR PRESENT POSITIONS

Occupations	Number
Electricity-Electronics	83
Drafting and Design	33
Electronics Technicians	29
Military (General)	28
General Industrial Experience	7
None	59
Miscellaneous	147

N (Technicians) = 162 N (Experience) = 327

Table I, and the near average of two such work experiences revealed in Table XVIII, these relatively brief work experiences seems accurate.

Technicians were asked how long they had been with their present employer. From Table XX, it is apparent that the majority have been with their present employer from one to nine years. A total of 142, or 64.25 per cent of the technicians were in this category.

From Table XXI, it is obvious that many technicians viewed their jobs in a very broad sense. The 221 technicians listed 496 activities descriptive of their work. Research and development was most frequently indicated, followed by Testing. Only one technician indicated "Sales" as a part of his activities.

Technicians were asked to describe the most important things they were required to know in order to do their jobs. Data presented in Table XXII have been grouped for tabulating convenience. The sequence of criteria previously noted is once again present: Electricity-electronics, mathematics and drafting.

After the technicians had given an indication of the most important things they were required to know in order to do their jobs, they were asked where they had acquired the knowledge. An amazing 207, or 93.67 per cent of the 221 technicians indicated that on the job training as the place (and way) they acquired the knowledge necessary to do their job.

As shown in Table XXIII, the 221 technicians listed 469 specific sources where they acquired their technical knowledge, or slightly over two

TABLE XIX

LENGTH OF SIGNIFICANT QUALIFYING
WORK EXPERIENCES FOR PRESENT POSITION

Length of Time (Years)	Number
Less than 1 year	17
1	43
2	41
3	34
4	37
5	19
6	16
7	10
8	12
9	5
10	9
Over 10	21
	266

TABLE XX

LENGTH OF TIME WITH CURRENT EMPLOYER

Number of Years	Number	Per Cent
Less than 1	20	9.04
1 to 3	55	24.89
4 to 6	33	14.93
7 to 9	54	24.43
10 to 12	26	11.76
13 to 15	17	7.69
16 to 18	8	3.62
19 to 21	6	2.70
Over 21	2	0.94
	221	100.00

sources per technician. After on the job training, non-military schools, institutions and the like were the next most frequently mentioned sources.

After technicians had indicated what they were required to know in order to do their job, and where they had obtained the knowledge, they were asked to list the most important things they were required to do on their jobs. Once again, mathematics, electricity-electronics and drafting led the list--in these cases the application of the concepts to their jobs was indicated.

TABLE XXI

ACTIVITIES WHICH BEST DESCRIBE TECHNICIANS ACTIVITIES ON THE JOB

Activities	Number
A. Research, design or development	144
B. Production or operation	60
C. Installation or maintenance	71
D. Inspection or control	54
E. Sales	1
F. Supervision	46
G. Testing	118
H. Other	2
	496

TABLE XXII

MOST IMPORTANT ITEMS TECHNICIANS ARE REQUIRED TO KNOW IN ORDER TO DO THEIR JOBS

Job Knowledge	Number
Electricity and Electronics	167
Mathematics and Mathematics Principles	112
Drafting, sketching, reading prints	79
Mechanical knowledge (know your way around)	63
Testing and test equipment	59
Technical report writing and English	37
Tools	23
Materials	20
Business principles and practices	19
Physics	17
Computer and Data Processing	13
Shop Procedures	13
Getting along with others	11
Chemistry	10
Company policies	7
How to analyze a problem plus organization	7
Instrumentation	6
Miscellaneous	113
Total:	776

TABLE XXIII

WHERE TECHNICIANS OBTAINED TECHNICAL KNOWLEDGE NEEDED TO DO THEIR JOBS

Source	Number
On-the-Job Training	207
Schools	167
Military Schools	59
Correspondence	8
Self-taught	8
In-plant Training	5
Hobbies	4
Miscellaneous	7
	469

As shown in Table XXIV, the job skills of the technicians were quite varied. The variety of skills largely represent the different types of technicians included in this study.

The 221 technicians listed a total of 721 specific "doing" items which they considered to be of greatest importance to their jobs. Generally, each technician listed three such skill requirements.

Technicians were also asked <u>where</u> they had acquired the skills they had listed as being of primary importance on their jobs. Once again, a majority listed "on the job training" as one of these sources. Table XXV is a complete record of the technicians responses to this question. As revealed in Table XXVI, 213, or 96.38 per cent of the technicians included in this study listed "on the job training" as one of the most important sources for acquiring job skills. Public schools including secondary, vocational-technical institutes, junior colleges and college-universities were the next most frequently mentioned sources.

It seems reasonable to conclude that any well-developed technician educational program should include provision for experiences that are needed on the job.

From Table XXV, it also seems reasonable to conclude that schools, both public and military, are planning for technicians to acquire useful skills.

The technicians were asked to indicate what characteristics a successful technician should have. From Table XXVI, it can be noted that technicians list "the ability to get along with others" as one of their most outstanding traits. A total of 205, or 92.76 per cent of the 221 listed this characteristic. From these data, it seems reasonable to assume that schools which prepare technical people for employment should seek ways and means of making their students aware of personal social traits necessary to be successful on the job. This is all the more imperative when one considers that the single reason more workers lose their job is their inability to get along with others.

TABLE XXIV

MOST IMPORTANT SKILLS TECHNICIANS REQUIRED
TO HAVE IN ORDER TO DO THEIR JOBS

Item	Number
Application or use of:	
Principles of Electricity-Electronics	158
Principles of Drafting, design and layout	88
Principles of Mathematics	79
Test Equipment	42
Writing a Technical Report: English	37
Mechanical Ability	23
Tools	21
Computers, including computer maintanance	20
Maintanance of Equipment	15
Material Evaluation	14
Operate automatic Machines	14
Machine Shop Equipment	13
Test specifications; check products	13
Business procedures	10
Instructing New Men	8
Surveying Skills	8
Calibration of Instruments	7
Accurate Measuring	7
Business Machines	5
Miscellaneous (less than 5)	139
	721

TABLE XXV

WHERE TECHNICIANS ACQUIRED IMPORTANT JOB SKILLS

Source	Number
On-the-job Training	213
Schools, public	163
Military schools	58
Correspondence courses	8
In-plant schooling	8
Private schools	6
Self-taught	5
Miscellaneous	8
	469

Technicians were asked to indicate whether they belonged to professional organizations connected with their work. An overwhelming majority, 187, or 84.62 per cent, of the technicians answered no to this question. Thirty four belonged to various organizations, typically associated with their area of specialty.

Technicians were asked whether they were registered, certified or licensed in relation to their work. Of the 221, 148 or 66.97 per cent were not. As shown in Table XXVII, of the remaining 73 with some sort of

TABLE XXVI

PERSONAL-SOCIAL TRAITS NEEDED
BY SUCCESSFUL TECHNICIANS

Characteristic or Trait	Number
Ability to get along with others	205
Patience	73
Pride in job, dedication	66
Ability to follow through on a job	57
Ability to express oneself, orally and verbally	43
Have Initiative	29
Good Personality	15
Neatness and accuracy	15
Willingness to continue to learn	12
Be Inquisitive	11
Ability to concentrate	10
Ability to take constructive criticism	9
Adaptable	7
Even tempered	7
Awareness of Public Relations	6
Ability to plan and organize work	6
Honesty and Integrity	5
Ability to work with minimum supervision	4
Emotionally stable	4
Perserverance	4
Sense of Humor	4
Miscellaneous (less than 4)	27
	627

registration and the like, 58 or 79.45 per cent had various classes of F.C.C. communications licenses. The remaining 15 were quite varied, ranging from one registered with an engineering technicians association to one with a state welding certificate.

TABLE XXVII

REGISTRATION, CERTIFICATION, OR LICENSES HELD BY TECHNICIANS

Classification	Number	Per Cent
None	148	66.97
F.C.C. (all classes)	58	26.24
Miscellaneous	15	6.79
	221	100.00

From the preceding data, it seems reasonable to assume that technicians typically are not required to either belong to a professional organization or be registered, certified or licensed as a condition of their employment.

Technicians were asked whether hobbies had made an contribution to success on their present job. A total of 95, or 42.99 per cent of the technicians indicated that hobbies did not contribute to any success on their jobs.

As revealed in Table XXVIII, a total of 91 hobbies in the broad field of electricity-electronics were noted. These hobbies ranged from ham radio to high fidelity and stereo sets. As might be anticipated, most hobbies listed involved "hardware" and "active participation" on the part of the technicians.

From Table XXVIII, it is obvious that 126 technicians listed 268 hobbies as lending contributions to success on their jobs. These figures would lend credence to the belief that these technicians have wide ranging interests. A total of 95, or 43.00 per cent of the technicians said their hobbies did not help them on the job.

There is little evidence that hobbies contribute to success on the job of technicians in general. It is reasonable to assume that electronics technicians involve work skills on their hobbies, or they will use hobby skills on their jobs.

TABLE XXVIII

HOBBIES WHICH CONTRIBUTED TO SUCCESS ON THE JOB FOR THE TECHNICIANS

Hobby Area	Number
No contribution	95
Electricity-electronics	91
Photography	11
Art	9
Model Building	8
Radio-controlled models	4
Miscellaneous (less than 4)	50
	268

Technicians were asked to list all their full-time work experience. Summer employment while going to school, or part-time jobs were not considered. The work experience of the technicians ranged from farming to electrical engineering. The 221 technicians listed 811 full-time jobs, or an average of 3.67 jobs per person. As shown in Table XXIX, more technicians had two or three full-time jobs than any other. A total of 107, or 48.41 per cent were in this category.

The length of time, in years, of the full-time jobs is of considerable interest. As revealed in Table XXX, there is a considerable amount of job changing on the part of technicians. A total of 600, or 73.98 per cent of 811 reported full-time jobs were of four years duration or less. From the employment pattern indicated in the information forms, technicians generally tend to remain on their jobs after the fourth year, and once they have been on the job ten years, they apparently tend to remain.

Some technicians are union members. During labor cutbacks, layoff is by seniority with company, not total time in occupation or capability. This may be a contributing factor in job-changing statistics.

No effort was made in this study to determine the number of job separations which were voluntary and which were involuntary. This could well be a study which should be made in relationship to the presence or absence of vocational-technical education.

Technicians were asked to describe the education or training that an individual should have if he were to prepare for the technicians present

TABLE XXIX

FULL-TIME JOBS HELD BY TECHNICIANS

Number of Jobs	Number of Technicians	Total Jobs
1	14	14
2	52	104
3	55	165
4	39	156
5	29	145
6	9	54
7	11	77
8	12	96
	221	811

job. Technicians answers were largely related to their own specialty area. Some technicians not only indicated courses and subject matter, but also length of time for each. For purposes of this study, as shown in Table XXXI, answers were grouped when considered appropriate.

The 221 technicians recommended a total of 750 courses or programs. One of the most significant aspects of this table is the number of technicians who recommended both four and two year degree programs. Precisely 100, or 45.25 per cent of the technicians indicated that a four year degree

TABLE XXX

TIME-LENGTH OF TECHNICIANS JOBS

Time (Years)	Number	Per Cent (of 811)
Less than 1 year	105	12.94
1 - 2	314	38.72
3 - 4	181	22.32
5 - 6	52	6.41
7 - 8	56	6.91
9 - 10	25	3.08
Over 10	78	9.62
	811	100.00

TABLE XXXI

TECHNICIANS RECOMMENDATIONS
FOR BEST JOB PREPARATION

Preparation	Number
Mathematics (courses)	133
Technical Schools	125
Junior College (two years)	82
B.A. Degree	51
Engineering Degree	49
Physics (courses)	40
Vocational-trade Schools	33
Drafting and design (courses)	32
Electricity-electronics (courses)	32
On the job Training	28
Technical Report Writing and Business English	27
Chemistry (courses)	23
Business Courses	11
Apprenticeship	10
Science	9
Surveying	8
Miscellaneous (less than 8)	57
	750

An additional 82, or 37.10 per cent, indicated that a junior college associate degree was the best preparation for their job.

Mathematics courses (all kinds) once again led the list of characteristics indicated by technicians in this case as the best preparation for their jobs.

Technicians were asked to indicate what they expected to be doing ten years from now. One hundred thirty one of the 221 technicians, or

59.27 per cent, said they intended to remain in their present area of specialization. Of these 131, 80 indicated that they also expected to be in supervision. A total of 43, or 19.46 per cent of the technicians expected to obtain an engineering degree. As indicated in Table XXXII, a few technicians feld that they would remain at the same occupational level.

As a final part of the research, technicians were given a deck of 99 cards with a wide variety of technical activity or information (from Schill and Arnold) recorded on them.[2] Each technician first sorted the 99 cards into three groups. These three groups were defined as follows:

1. directly related to what the technician does on the job.
2. somewhat related to what the technician does on the job.
3. not related to what the technician does on the job.

After these data were noted, the technicians were then asked to put in rank order only the cards sorted into Group 1, those directly related to their jobs. From the cards in Group 1, technicians chose the three most important, the five next most important, the eight next most important, and so on. Table XXXIII is a record of the technicians preliminary sort -- cards placed in either of groups one or two.

From Table XXXIII, only three cards were selected by over one-half the technicians as "directly related" to their work. These were cards 12, 17 and

[2]See Appendix C for a complete list of the cards.

TABLE XXXII

OCCUPATIONAL EXPECTATIONS IN TEN YEARS

Occupational Expectation	Number	Per Cent
Same thing	51	23.07
Same area, supervisory	80	36.20
Complete engineering degree	43	19.46
Office work (as opposed to field)	9	4.07
Be in technical business for himself	8	3.62
Teacher, vocational	8	3.62
Miscellaneous	22	9.96
	221	100.00

and 65 with 113, or 51.13 per cent, 138, or 62.44 per cent and 125, or 56.56 per cent respectively: These cards contain the following data:

Card No. 12 --- Coulomb's Law and the basic concepts of electrostatics, direct and alternating current theory, magnetism, electro-magetism, Ampere s Law, oscillator circuits, and L'c and R'c circuits.

Card No. 17 --- Use of simple test equipment. Theory and application of commercial test equipment, trouble analysis, and test and alignment methods and practices.

Card No. 65 --- Preparation of block diagrams, schematics, and layouts using standard conventions.

TABLE XXXIII

CARDS SELECTED BY TECHNICIANS: GROUPS ONE AND TWO

Card No.	Group 1 Related	Group 2 Somewhat Related	Card No.	Group 1 Related	Group 2 Somewhat Related	Card No.	Group 1 Related	Group 2 Somewhat Related
1	70	94	34	17	71	67	66	78
2	1	3	35	37	45	68	29	73
3	67	103	36	13	54	69	42	77
4	29	46	37	30	38	70	25	51
5	2	4	38	45	66	71	82	46
6	16	45	39	4	16	72	48	49
7	11	42	40	8	24	73	39	52
8	89	38	41	22	67	74	1	2
9	0	4	42	27	54	75	50	77
10	0	5	43	6	14	76	30	53
11	4	15	44	44	71	77	78	71
12	113	34	45	6	17	78	0	4
13	1	1	46	19	95	79	58	67
14	0	5	47	63	59	80	27	71
15	0	4	48	26	49	81	6	50
16	0	6	49	15	81	82	10	36
17	138	40	50	8	59	83	6	31
18	82	44	51	101	90	84	16	73
19	5	17	52	71	110	85	9	32
20	3	28	53	38	91	86	4	22
21	10	31	54	12	60	87	0	1
22	10	41	55	5	42	88	2	13
23	20	72	56	32	90	89	23	75
24	11	49	57	102	29	90	17	53
25	7	38	58	27	85	91	8	40
26	18	79	59	16	78	92	15	39
27	14	85	60	27	73	93	30	78
28	24	75	61	55	68	94	4	36
29	25	45	62	0	4	95	13	57
30	42	72	63	44	44	96	1	7
31	9	60	64	22	41	97	1	14
32	8	29	65	125	53	98	83	68
33	22	43	66	64	80	99	12	36

As might be expected, these cards also formed one of a partnership with cards from group 2, "somewhat related" selected by the technicians in large numbers. When these two groups are combined, cards 1,3, 12, 17, 51, 52, 53, 65, 67, and 77 yield high numerical and percentage factors. Table XXXIV is a record of these numbers and percentages.

These cards contain the following data:

Card No. 1 ---Technical and scientific oral and written communication including business forms, reports, emphasizing the different types of business letters. Techniques of collecting and presenting scientific data. Informal reports and formal reports; special types of technical papers.

Card No. 3 ---Numerical control, data processing, interpretation of engineering drawings, depiction of data by manuscript, minimum dimensions and use of formulae, left data, translation, programming, and quality control.

Card No. 51 --Trigonometric functions and fundamental formulae. Logarithms and solutions of triangles, identities and equations. Trigonometry from ratios, right triangles, and identities, through vectors and graphs of trigonometric functions.

Card No. 53 --Metric system and square root; geometry from plane figures to geometric solids; algebra from operations with signed numbers through algebraic expressions, equations, special products, factoring and fractional equations and simultaneous equations.

Card No. 65 --Preparation of block diagrams, schematics, and layouts using standard conventions.

Card No. 67 --- Projection and graphic representation: use of instruments, lettering, applied geometry, dimensioning, sections, conventions (e.g., welding, pipe, electronic), auxiliary views, screw threads, cams, gears, theory of perspective, preparation of working and assembly drawings.

Card No. 77 --- The use of measuring equipment in a system to measure or control the system; such as thermocouples, strain gauges, pressure transducers and various current or voltage pickups. Accuracy inherent in alternate methods of measurement. Methods of transcribing or indicating measured values, or of using measured quantities to control the system.

It seems reasonable to assume that these cards represent key subject matter areas for technicians in general. It also seems reasonable to assume that cards such as 9, 10, 13 and 62 and the like represent areas of no concern to technicians in general.

After technicians had identified cards which were directly related and somewhat related to their work, they were asked to put the cards from the directly related group in rank order. This rank order involved identifying the three most important cards, the next five most important, the next eight most important; twelve and fourteen. Because of the small numbers involved, twelve and fourteen rank-orders are not included in this report.

Table XXXV is a record of these rank-orders as selected by the 221 technicians. Data presented in Table XXXV must be interpreted in the light of material presented in Tables XXXIII and XXXIV. For example,

TABLE XXXIV

CARDS FROM GROUPS ONE AND TWO WITH
HIGH NUMERICAL AND PERCENTAGE FACTORS

Card	Number Selected (Groups 1 and 2)	Percentage (of 221)
1	164	74.21
3	170	76.92
12	147	66.52
17	178	80.54
51	191	86.43
52	181	81.90
53	189	85.52
65	178	80.54
67	145	65.61
77	149	67.42

TABLE XXXV

RANK ORDER OF CARDS CONSIDERED TO BE OF MOST IMPORTANT BY TECHNICIANS

Card No.	3 Most Important	5 Most Important	8 Most Important	Total	Card No.	3 Most Important	5 Most Important	8 Most Important	Total	Card No.	3 Most Important	5 Most Important	8 Most Important	Total
1	21	18	20	59	34	0	2	9	11	67	25	18	19	62
2	0	0	0	0	35	13	10	7	30	68	5	5	13	23
3	10	20	30	60	36	1	1	4	6	69	10	10	17	37
4	2	3	13	18	37	7	12	6	25	70	2	5	11	18
5	1	0	0	1	38	8	14	15	39	71	27	41	9	77
6	0	1	8	9	39	0	1	0	1	72	10	23	11	44
7	1	4	1	6	40	3	1	1	5	73	6	19	9	34
8	22	50	14	86	41	2	10	8	20	74	1	0	0	1
9	0	0	0	0	42	10	5	8	23	75	4	18	21	43
10	0	0	0	0	43	0	2	2	4	76	0	10	15	25
11	1	1	0	2	44	13	7	13	43	77	15	25	28	68
12	37	47	20	104	45	0	1	1	2	78	0	0	0	0
13	0	0	0	0	46	0	6	9	15	79	15	18	13	46
14	0	0	0	0	47	13	22	20	55	80	8	7	10	25
15	0	0	0	0	48	2	4	9	15	81	0	2	0	2
16	0	0	0	0	49	0	2	7	9	82	3	0	3	6
17	78	34	18	130	50	0	0	3	3	83	0	2	2	4
18	21	49	10	80	51	27	29	33	89	84	2	4	4	10
19	0	2	0	2	52	5	25	35	65	85	0	4	1	5
20	0	1	0	1	53	12	33	42	87	86	1	2	1	4
21	2	0	4	6	54	0	3	1	4	87	0	0	0	0
22	0	5	1	6	55	0	0	0	0	88	0	0	0	0
23	1	7	7	15	56	1	8	15	24	89	2	6	8	16
24	0	4	2	6	57	69	19	9	97	90	5	1	2	8
25	0	1	4	5	58	0	7	13	20	91	0	0	3	3
26	2	6	4	12	59	0	1	7	8	92	0	5	5	10
27	1	2	8	11	60	0	3	16	19	93	2	4	12	18
28	3	5	8	16	61	13	24	11	48	94	0	0	1	1
29	16	3	1	20	62	0	2	0	2	95	2	3	3	8
30	15	9	8	32	63	9	17	11	37	96	0	0	0	0
31	2	1	4	7	64	1	7	8	16	97	1	0	0	1
32	0	0	5	5	65	22	68	30	120	98	18	27	29	74
33	2	3	11	16	66	12	24	16	52	99	3	3	4	10

from Table XXXIII, card number 8 was selected by 89 of the 221 technicians as being directly related to their jobs. From Table XXXV it is noted that 86 of the 89 had placed card number 8 in the three reported categories. Further inspection reveals that the majority -- 50 -- of the 89 technicians placed this card in the five most important group.

After the reader has found specific areas of technical knowledge and/or skills from Appendix C in which he is primarily interested, attention should be directed to those cards included in Table XXXIV as they relate to data presented in Table XXXV. Table XXXVI is a record of these data.

In addition to those cards which had previously been identified as having a high numerical and per cent factor (Table XXXIV) the following cards appear to have a high selection factor insofar as numbers of technicians who included them in the directly-related to job category <u>and</u> "most important" insofar as rank order is concerned.

Card 57, selected by 131 technicians; ranked within the 3, 5, and 8 most important by 97, or 74.05 per cent of the 131 technicians. Card 65, selected by 178 technicians; ranked within the 3, 5, and 8 most important by 120, or 67.42 per cent of the 178 technicians. Card 71, selected by 128 technicians; ranked within the 3, 5 and 8 most important by 77, or 60.16 per cent of the 128 technicians. Card 98, selected by 151 of the technicians; ranked within the 3, 5 and 8 most important by 74, or 49.01 per cent of the technicians.

TABLE XXXVI

RANK ORDER OF CARDS INCLUDED IN TABLE XXXIV SELECTED AS DIRECTLY RELATED TO TECHNICIANS JOBS--NUMBERS AND PERCENTAGES

	No. of Tech. who considered card to be most important	No. of Tech. who ranked card in top 3, 5, or 8	Per Cent
1	70	59	84.29
3	67	60	89.55
12	113	104	92.04
17	138	130	94.20
51	101	89	88.11
52	71	65	91.55
53	98	87	88.78
65	125	120	96.00
67	66	52	78.79
77	78	68	87.18

These cards contain the following data:

Card No. 57 --- Vacuum tube and transistor theory. AC parameters, resonance, transformers coupling, filters, bandpass, and complex wave forms. Tuned and untuned circuits, and vacuum tube power supplies.

Card No. 65 --- Preparation of block diagrams, schematics, and layouts using standard conventions.

Card No. 71 --- Electronic circuit theory of video amplifiers, tuned amplifiers, and basic feedback oscillators. Nonlinear amplifiers, modulators and demodulators. Noise in electon devices. Relaxation phenomena and Wave-form generation.

Card No. 98 --- Environmental testing of components, parts, and products for assessment of performance in actual application.

A simple rank-order of the ten top cards selected by the technicians as being directly related to their jobs is shown in Table XXXVII.

From the preceding data, it is reasonable to assume that technicians have reinforced the importance of drafting and design, electricity-electronics and mathematics to the successful technicians. Of some considerable importance, technicians revealed one area of activity not previously reported, namely the use of test equipment and the testing of components. It is possible that the technicians had previously taken this area for granted.

TABLE XXXVII

TEN MOST FREQUENTLY SELECTED CARDS, DIRECTLY RELATED

Card No.	Number	Per Cent
17	138	62.44
65	125	56.56
12	113	51.13
57	102	46.15
51	101	45.70
53	98	44.34
8	89	40.27
98	83	37.56
18	82	37.10
71	82	37.10

Part II, The Managers

Managers and supervisors with direct responsibility for the technicians within their organization were asked a series of questions to establish a rational for answers to questions concerning their technical people.

Managers were asked to indicate the number of full-time jobs they had had since leaving high school.

TABLE XXXVIII

FULL-TIME JOBS HELD BY MANAGERS SINCE GRADUATION FROM HIGH SCHOOL

No. of Jobs	No. of Managers	Per Cent
1	7	4.93
2	25	17.61
3	25	17.61
4	31	21.83
5	20	14.08
6	8	5.63
7	9	6.34
Miscellaneous (8 or more)	13	9.15
Unknown (no answer)	4	2.82
	142	100.00

As shown in Table XXXVIII, 101, or 71.13 per cent of the managers had held between two to five full-time jobs since high school graduation. It seems reasonable to assume that managers acquire job knowleuges and skills with various organizations rather than with one organization.

Managers were asked whether they had ever worked in a technical capacity similar to the work being done by the technical people for whom they were responsible. A total of 108, or 76.06 per cent of the 142 managers indicated that they had such technical experience.

Managers were asked whether they had ever completed a technician training program. A total of 75, or 52.82 per cent of the managers said they had not completed such a program.

From the preceding data, it is reasonable to assume that managers of technicians will generally have worked as a technician during a part of his work experience, and further, the chances are about even that he would not have completed a technician training program. The inference is obvious; about half the managers received on-the-job technical training.

From Table XI, it will be recalled that only seven, or 4.93 per cent of the managers had not completed high school. A total of 55, or 38.73 per cent of the managers had completed a minimum of 12 grades (high school graduation). In addition to these 55, an additional 80 or, 56.34 per cent had continued their formal education by completing two or four years of degree programs.

Only one of the managers had completed a graduate program of studies. It seems reasonable to assume that the graduate degree is not considered essential to managerial employment in the industries cooperating in the study.

Fifty nine or 41.55 per cent of the managers felt that their educational background was adequate for their present job; by constrast, 57, or 40.14 per cent, felt that their educational background was inadequate for their present position.

Managers were also asked to indicate the strengths of their formal education. Fifty two, or 36.62 per cent felt that mathematics courses were strong features. English and the sciences were also mentioned as strong areas.

Managers were less definitive in describing weaknesses in their educational programs. The most frequent criticism of programs was "no practical application,"; 19, or 13.38 per cent of the managers were in this category. The lack of Technical Report Writing or sound English programs was also mentioned by 19 managers. Ten, or 7.04 per cent of the managers indicated that humanities courses represented weaknesses in their backgrounds.

From the preceding data, it seems reasonable to assume that managers included in this study are knowledgable about their work, by reason of their education, background and experience. It also seems reasonable to assume that these managers are qualified to express knowledgeable opinions and to indicate sound judgments concerning their technicians.

Table XXXIX reveals the strengths of technicians in general as identified by those supervising them. It is reasonable to assume that aside from a technical competancy in their areas of endeavor, technicians should posses those attitudes and characteristics which any successful worker should have.

TABLE XXXIX

STRENGTHS OF SUCCESSFUL TECHNICIANS
IN THE JUDGMENT OF THEIR MANAGERS

Strength or Characteristic	Number
Understanding of electricity-electronics	57
Interest and desire to do well in work	56
Application of technical know-how	36
General mechanical ability	36
Sound mathematics background	32
Ability to get along with people	24
Intelligence	24
Drafting ability and skills	18
Common sense	15
Command of English and Technical Report Writing	12
Sense of responsibility	12
Leadership ability	11
Dependability	10
Ability to work independently	8
Command of basic sciences	7
Positive attitude	7
Aggressive	6
Imagination	4
Miscellaneous (three or less)	80

TABLE XL

WHERE MANAGERS OBTAIN TECHNICIANS

Source	Number
Companies similar to their own	72
Promote within	54
Discharged military personnel	48
Engineering School Drop-outs	26
In-state junior colleges	21
Out of state junior college	11
Technical institutes	10
High school graduates	4
Miscellaneous (three or less)	23

Almost without exception, managers indicated that technicians who were not successful did not possess the qualitites listed as strengths in Table XXXIX.

Managers were asked where they obtained the majority of the individuals to be hired as technicians. As shown in Table XL, half of the respondants indicated that they looked to companies similar to their own for their technicians.

Managers indicated that that the second most important source of technicians was promotion within their organization.

Only 30 managers indicated that they generally went to specific educational insitutions to seek technicians. These 30 named 50 specific institutions. Nineteen universities or colleges, seventeen private technical institutions, thirteen junior colleges and one vocational-technical high school were specified. Arizona State University at Tempe was named 14 times, Phoenix College, seven, De Vry Technical Institute in Chicago was listed six times.

When asked why they went to these institutions for technicians, managers were quite specific in their answers. Twenty of the 30 said that the graduates simply met their needs. In other words, previous technicians had been successful, so they kept seeking successive graduates.

Numbers of technicians that supervisors, managers or engineers generally supervised varied greatly. As revealed in Table XLI, a cluster of 68 managers indicated that their people supervised between one and four technicians.

In the main, those who indicated ten and over did so because of the varying demands of projects under way.

Managers were asked to estimate -- based on their personal professional judgment -- the numbers of technicians to be needed <u>by the industry</u> with which their organization was a part, between the years 1967 and 1970 and between 1975 and 1985. As indicated in Table XLII, their responses reveal a strong belief that technicians will be needed at a slightly higher rate as presently employed or at a much higher rate than presently employed between 1967 and 1970.

TABLE XLI

NUMBERS OF TECHNICIANS SUPERVISORS RESPONSIBLE FOR

Number of Technicians	Frequency	Per Cent
1 -- 2	32	22.53
3 -- 4	36	25.35
5 -- 6	27	19.02
7 -- 8	16	11.27
9 -- 10	24	16.90
Miscellaneous (over 10)	7	4.93
	142	100.00

As shown in Table XLIII, managers believed that a dramatic increase in number of technicians would be needed between 1975 and 1985. Only six believed they would be using about the same number of technicians as they do today.

From the preceding data, it seems reasonable to assume that institutions which train technicians will have substantial demands placed on their programs through 1985.

One of the basic tenets of our educational system should be of "present preparation for some future value."

Managers were asked to describe the probable need for individuals with various amounts of preparation. As revealed in Table XLIV, managers

TABLE XLII

NEED FOR TECHNICIANS BETWEEN 1967 - 1970

Need	Frequency	Per Cent
A. Many more than presently employed	56	39.44
B. Somewhat more than presently employed	77	54.22
C. About the same as presently employed	7	4.93
D. Somewhat less than presently employed	2	1.41
E. Much less than presently employed	0	0.00
	142	100.00

TABLE XLIII

NEED FOR TECHNICIANS BETWEEN 1975 - 1985

Need	Frequency	Per Cent
A. Many more than presently employed	88	61.97
B. Somewhat more than presently employed	48	33.80
C. About the same presently employed	6	4.23
D. Somewhat less than presently employed	0	0.00
E. Much less than presently employed	0	0.00
	142	100.00

TABLE XLIV

ESTIMATED DEMAND FOR PERSONS WITH VARIED PREPARATION

Preparation	High	Medium Demand	Low
A. High School graduate (only)	7	40	95
B. Two year technician	75	61	6
C. Four year technology	85	40	17
D. Four year engineer (professional)	99	25	18

indicated that the greater the preparation, the higher the demand.

While managers felt that the future demand for two year technicians would be either "high" or "medium"; they also indicated that four year baccalaureate graduates would be in the greatest demand.

In an effort to further define the best preparation for those who will ultimately do technical work, managers were asked to describe -- on the basis of what technicians are required to know and do -- the kind of preparation they would recommend for an individual to not only enter upon but also make progress in a technical occupation.

As shown in Table XLV, 96, or 67.61 per cent of the managers listed a sound two-year technical program as their most frequent choice.

The wide range of recommendations for technicians training and their ultimate use within a company is revealed in these data. Some organizations use technicians at the professional and/or semi-professional levels, which require a four-year (engineering) baccalaureate degree, while still others use technicians at sub-professional levels.

Once again, mathematics and drafting and design courses were high on the list of desired criteria.

One area of academic endeavor which has typically not been included in many two-year technical courses is business administration. While this area has never been high on any of the previous criteria, it has been mentioned with sufficient frequency to merit some specific inclusion in technical programs.

Managers were asked to react to two related but dis-similar educational-industry cooperative preparation programs for preparing technicians. The first cooperative program involved an extended two year technical program.

TABLE XLV

BEST PREPARATION FOR ENTERING UPON AND MAKING PROGRESS IN A TECHNICAL OCCUPATION

Preparation	Frequency	Per Cent
Two year technical program	96	67.61
Mathematics courses	51	35.92
Four year engineering degree	36	25.35
Basic Sciences	30	21.13
Drafting and design courses	25	17.61
English and technical report writing	24	16.90
Business Courses	23	16.19
On-the-job training	15	10.56
Surveying courses	7	4.93
Vocational-technical high school graduate	7	4.93
Materials testing	6	4.23
Miscellaneous (less than four)	35	------

The technicians-trainees would spend one and one-half years in the educational academic-laboratory situation. The technicians would then spend six months in on-the-job internship at a cooperating industrial corporation.

At the completion of the six months on-the-job training, the interns would be evaluated by their immediate supervisors. A final semester of academic-laboratory preparation would follow in order to build up the weakest portions of the individuals backgrounds as revealed by the evaluation. For purposes of this report, this internship program will be termed Internship One.

Managers revealed strong agreement in saying that this was a sound concept and approach to preparing technicians in the future. As revealed in Table XLVI, only seven managers felt that this was not a sound approach.

TABLE XLVI

MANAGERS REACTION TO INTERNSHIP ONE

Reaction	Frequency	Per Cent
This is a sound approach and should be initiated.	77	54.23
This is a sound concept although problems appear.	58	40.85
This is not a sound concept.	7	4.92
	142	100.00

The 58 managers who indicated that this was a sound concept, although some problems appeared, listed a total of 91 such problems. The majority of these problems involved varying recommended time-lengths for the on-the-job internship.

The seven managers who felt that this was not a good preparation for technicians listed eleven problem areas which might preclude its use in their ogranizations. The majority of these factors involved economics and bugetary considerations.

Managers were asked whether they would recommend that their company participate in such a training program. A total of 131, or 92.25 per cent, indicated that they would recommend the program to their company. Only eleven managers indicated they would not recommend such a program to their companies.

The second internship program would take the student four years to complete a two year program. For purposes of this study, this concept is termed Internship Two. It involves pairs of interns. While one intern would be spending six months at the educational institution, his counterpart intern would be spending six months in on-the-job training. At the conclusion of the six months time period the two would change places. All other features of Internship One would remain intact.

A total of 117, or 82.39 per cent, of the managers reported that this was a sound approach to technician preparation. Fifty eight said this was a good concept without reservations, while 59 said this was a good concept although some problems appeared.

Forty managers felt that Internship Two was better than Internship One. An almost equal number, 43, believed that Internship One was the better of the two.

The 59 managers who indicated this was a good concept (but that problems appeared) listed 77 such problems. Again these problems centered around time-length of the various phases of the total programs.

Seventeen managers felt this was not a sound concept. These 17 listed 23 obstacles to the program, most of which dealt with various administrative problems.

A total of 103 managers said they would recommend this technicians preparation program to their companies; 39 indicated they would not.

From the preceding data it seems reasonable to assume that Internship One is generally preferred by managers over Internship Two. It also seems reasonable to assume that there are strong points and weak points involved in both types of preparation.

Managers were asked what orientation a newly hired technician was given by their organization. As indicated by Table XLVII, a wide variety of techniques were employed.

The most common technique was placing the new man with an experienced man. Only nine managers said they did not have some form of orientation.

After managers had completed the structured questions, they were given an opportunity to make any final comments or to clarify any point related to the general area of technical education. No new concepts of ideas not already included in this report were presented.

Managers were asked to complete the card-sort portion of the research -- just as the technicians had done. Table XLVIII is a record of the cards selected by the managers. The groups are the same as described for Table XXXIII.

As will be noted, only four cards were placed in the "Directly Related" group with a frequency of over 71 or 50 per cent; these cards were 17, 51, 53, and 65.

These cards involved the following contents:

Card No. 17---- Use of simple test equipment. Theory and application of commercial test equipment, trouble analysis, and test and alignment methods and practices.

Card No. 51---- Trigonometric functions and fundamental formulae. Logarithms and solution to triangles, identities and equations. Trigonometry from ratios, right triangles, and identities, through vectors and graphs of trigonometric functions.

Card No. 53---- Metric system and square root; geometry from plane figures to geometric solids; algebra from operations with signed numbers through algebraic expressions, equations, special products, factoring and fractional equations and simultaneous equations.

Card No. 65---- Preparation of block diagrams, schematics, and layouts using standard conventions.

None of the cards were selected by 50 per cent of the managers in the "Somewhat Related" group.

When the "Directly Related" and "Somewhat Related" selections are combined, card 1, 3, 17, 51, 52, and 53 stand out over others in frequency.

TABLE XLVII

ORIENTATION OR POLISHING GIVEN TO
NEWLY HIRED TECHNICIANS

Techniques	Frequency
Put new man with experienced technician	68
Formal procedure: company policies, plant visitations, safety, security, personnel procedures	51
Informal procedure: gradual increase in responsibility	25
Locate weak points, literature on company to read	16
Close supervision, answer questions	14
None	9
On-the-job training	8
Section or branch chief responsible for new man's development	7
Miscellaneous (two or less)	28
	226

Managers were also asked to identify the first three most important cards, the five next most important and the next eight most important cards from those they had selected for their "Directly Related" groups. Table XLIX is a record of these choices.

It will be noted that only cards 17, 51 and 65 were ranked within the 3, 5 and 8 most important by over 50 per cent of the managers. Other high-frequency selections -- but not by at least 50 per cent of the managers were 1, 8, 12, 52, 53, and 57. These cards contain the following data:

Card No. 1 --- Technical and scientific oral and written communication including business forms, reports, emphasizing the different types of business letters. Techniques of collecting and presenting scientific data. Informal reports and formal reports; special types of technical papers.

Card No. 8 --- Analysis and design of basic electronic circuits involving vacuum-tube and semi-conductor devices. Graphical characteristics and co-efficients. Linear equivalent circuits. Elementary feedback analysis.

Card No. 12 --- Coulomb's Law and the basic concepts of electrostatics, direct and alternating current theory, magnetism, electromagnetism, Ampere's Lay, oscillator circuits, and L/c and R/c circuits.

Card No. 52 --- Algebraic graphing, exponents, powers, roots, radicals, imaginary and complex numbers through ratio proportions, variations, and logarithms.

Card No. 53 --- Metric system and square root; geometry from plane figures to geometric solids; algebra from operations with signed numbers through algebraic expressions, equations, special products, factoring and factional equations and simultaneous equations.

Card No. 57 --- Vacuum tube and transistor theory. AC parameters, resonance, transformers coupling, filters, bandpass, and complex wave forms. Tuned and untuned circuits, and vacuum tube power supplies.

It seems reasonable to assume that cards 1, 3, 8, 12, 17, 51, 52, 53 and 57 represent areas of considerable interest to technicians from the managers point of view. With these data in mind, an inspection of Table XXXIV reveals a striking agreement between cards selected as important to technicians jobs by both technicians and managers.

Managers and technicians demonstrated a remarkable degree of uniformity in numbers of cards placed with the "Directly Related" and "Somewhat Related" groups. A somewhat flattened normal curve of distribution appears within both groups. (See Table L).

TABLE XLVIII

CARDS SELECTED BY MANAGERS: GROUPS ONE AND TWO

Card No.	Group 1 Related	Group 2 Somewhat Related	Card No.	Group 1 Related	Group 2 Somewhat Related	Card No.	Group 1 Related	Group 2 Somewhat Related
1	64	59	34	23	51	67	48	61
2	0	3	35	12	35	68	23	57
3	54	64	36	9	41	69	26	51
4	13	34	37	14	27	70	8	37
5	0	3	38	31	49	71	54	15
6	9	27	39	3	11	72	24	32
7	9	26	40	6	11	73	26	38
8	58	19	41	28	55	74	2	4
9	0	1	42	22	42	75	25	46
10	0	0	43	4	16	76	15	39
11	2	10	44	31	44	77	57	38
12	60	35	45	2	19	78	0	2
13	0	0	46	18	58	79	44	47
14	0	2	47	44	48	80	20	43
15	0	2	48	20	42	81	5	24
16	2	2	49	8	41	82	9	22
17	86	29	50	10	30	83	6	24
18	48	24	51	79	40	84	10	57
19	2	12	52	59	46	85	3	19
20	6	24	53	77	43	86	2	10
21	6	17	54	7	38	87	0	0
22	13	25	55	4	26	88	1	14
23	30	51	56	19	51	89	12	64
24	14	27	57	57	16	90	8	26
25	12	35	58	22	44	91	3	31
26	26	39	59	16	46	92	10	24
27	15	44	60	16	46	93	16	48
28	27	51	61	33	50	94	1	19
29	34	31	62	0	0	95	12	40
30	33	54	63	19	40	96	0	2
31	11	37	64	12	37	97	3	12
32	0	21	65	82	27	98	39	38
33	14	41	66	45	61	99	5	16

RANK ORDER OF CARDS CONSIDERED TO BE OF MOST IMPORTANCE BY MANAGERS

Card No.	3 Most Important	5 Most Important	8 Most Important	Total	Card No.	3 Most Important	5 Most Important	8 Most Important	Total	Card No.	3 Most Important	5 Most Important	8 Most Important	Total
1	26	21	13	60	34	0	5	11	16	67	12	15	11	38
2	0	0	0	0	35	2	3	5	10	68	8	5	8	21
3	5	19	20	44	36	0	2	3	5	69	2	9	10	21
4	2	1	6	9	37	1	3	6	10	70	0	3	5	8
5	0	0	0	0	38	4	9	12	25	71	12	25	11	48
6	0	1	4	5	39	0	1	1	2	72	6	3	10	19
7	2	1	5	8	40	3	1	0	4	73	5	8	8	21
8	18	24	13	55	41	7	13	6	26	74	1	0	0	1
9	0	0	0	0	42	4	7	8	19	75	2	8	11	21
10	0	0	0	0	43	0	1	3	4	76	0	4	5	9
11	0	1	1	2	44	6	13	10	29	77	10	23	18	51
12	28	12	15	55	45	0	1	1	2	78	0	0	0	0
13	0	0	0	0	46	1	2	8	11	79	5	15	15	35
14	0	0	0	0	47	9	20	11	40	80	2	5	7	14
15	0	0	0	0	48	0	5	9	14	81	0	0	1	1
16	1	0	0	1	49	0	0	2	2	82	3	1	2	6
17	42	21	19	82	50	0	3	2	5	83	2	2	0	4
18	8	31	10	49	51	26	30	17	73	84	1	0	5	6
19	0	1	0	1	52	4	27	22	53	85	0	1	1	2
20	2	2	1	5	53	17	22	30	69	86	0	2	1	3
21	2	2	2	6	54	1	1	2	4	87	0	0	0	0
22	0	5	5	10	55	0	0	2	2	88	0	1	0	1
23	7	6	13	26	56	0	4	8	12	89	2	3	5	10
24	0	3	7	10	57	32	18	2	52	90	2	0	2	4
25	0	5	4	9	58	2	5	9	16	91	2	0	0	2
26	3	6	10	19	59	0	0	5	5	92	2	4	2	8
27	1	5	4	10	60	2	4	5	11	93	1	4	6	11
28	9	7	10	26	61	2	12	9	23	94	0	0	1	1
29	16	7	7	30	62	0	0	0	0	95	1	4	4	9
30	10	6	15	31	63	3	3	7	13	96	0	0	0	0
31	2	2	5	9	64	0	3	5	8	97	1	1	0	2
32	0	0	0	0	65	16	36	23	75	98	4	14	14	32
33	0	4	6	10	66	11	11	16	38	99	1	1	2	4

TABLE L

NUMBERS OF CARDS PLACED IN DIRECTLY RELATED AND SOMEWHAT RELATED GROUPS BY TECHNICIANS AND MANAGERS

DIRECTLY RELATED			SOMEWHAT RELATED		
Number Selected	Technicians	Managers	Number Selected	Technicians	Managers
1	4	0	1	0	1
2	5	3	2	0	0
3	9	4	3	1	0
4	7	7	4	0	1
5	11	6	5	3	1
6	12	2	6	2	1
7	10	9	7	2	1
8	14	2	8	3	2
9	12	9	9	5	4
10	15	8	10	9	7
11	10	11	11	4	3
12	12	9	12	7	6
13	14	9	13	7	0
14	13	7	14	10	4
15	13	6	15	10	6
16	7	5	16	14	7
17	6	4	17	8	1
18	7	6	18	6	6
19	6	3	19	11	4
20	3	5	20	11	12
21	1	3	21	11	7
22	2	2	22	9	4
23	3	3	23	7	5
24	4	3	24	5	6
25	1	4	25	7	7
26	0	2	26	13	3
27	2	1	27	7	6
28	1	2	28	2	5
29	7	0	29	4	6
30	1	1	30	1	5
31	1	1	31	5	1
32	2	0	32	1	2
33	1	2	33	2	3
34	0	1	34	3	3

SUMMARY, CONCLUSIONS AND IMPLICATIONS

Summary

Insofar as the preceding data are representative of technicians and managers throughout Arizona, and insofar as the data are reliable and valid, the following summary, conclusions, and implications seem warranted.

Successful technicians tend to be workers who have had sufficient work-experience (and educational preparation including formal, informal, military and so on) to have been on the job for a number of years. None could be considered recent high school graduates.

Successful technicians will generally have completed high school, generally have completed a two year junior college program or a four year baccalaureate degree program.

Occupations of technicians fathers were widely varied. The majority of technicians mothers were listed as (non-wage-earning) housewives.

While in high school, technicians had generally enrolled in either the general academic or the college preparatory programs of studies. Only 31, or 14.03 per cent of the 221 technicians had followed a secondary school vocational-technical program.

After employment, the need for vocational-technical upgrading becomes readily apparent, and they enroll in institutions geographically near their residence or place of employment.

Technicians major areas of study -- after high school -- were quite varied.

Technicians generally believe that mathematics, drafting, the physical sciences, English, and electronics courses are of greatest value to them on the job. Social sciences are generally felt to be of least value to them on the job. (By a strange anomaly, technicians felt that "Ability to get along with others on the job" was highly important.)

Technicians are generally aware of the prestige and premium which industry places on the four year baccalaureate degree.

Technicians seek technical upgrading in a wide variety of educational institutions.

Arizona industries are likely to pay technicians costs for upgrading courses.

Successful technicians are generally found in the upper half of their high school graduating class.

Many technicians attended high schools where vocational-technical programs did not exist. When these programs were available, these technicians tended to enroll in both individual vocational courses or for the complete programs.

Technicians generally came from small (10,000 or less) communities.

Technicians generally decided to enter the occupation between the ages of 16 and 25.

Technicians generally had one or two previous full-time -- yet relatively short -- work experiences which helped them qualify for their present technical work. These technicians generally had been with their current employer between one and nine years.

Technicians tend to view their jobs in a very broad sense. Research, design or development and testing were their most frequently mentioned activities.

Technical knowledges which technicians were required to have in order to do their jobs involved principles of electricity-electronics, mathematics and drafting and design. Technicians generally acquired these knowledges on the job. These same three areas of endeavor led the list of technical skills which technicians were required to have in order to do their job; again on-the-job training led the list when sources of these skills were indicated.

Successful technicians list those traits and characteristics commonly associated with people in general as desireable for their field. In other words, successful technicians are no different from others from a personal-social point of view.

Technicians typically do not belong to professional organizations. Generally they do not carry registration, certification, or a license as a job requirement.

Technicians generally believed that their hobbies did not contribute to their success on the job.

These technicians had typically held between three and four full time jobs -- including their present position. Technicians generally tend to remain with their employer after having remained at least four years.

Technicians generally believed that a two year or four year formal degree program was the best preparation a person could get in order to do their jobs. Mathematics courses and programs, however, once again led the list.

The greatest numbers of technicians expected to be in supervisory capacity in their same technical area after ten years.

From a deck of 99 cards, with descriptive technical data on each card, fifty per cent of the technicians chose only a few cards as being directly related to their work. In selecting the most important cards from the "Directly Related" group, technicians chose cards which dealt with the use of simple test equipment, drafting and design, electricity-electronics, and mathematics.

Managers of technicians generally relect a wide range of previous work experience. Moreover, a high percentage of these, indicated that much of this work experience was in technical areas. Generally fifty per cent of the managers had completed some form of technician training program.

Managers indicated that strengths of technicians are strengths of workers in general. Conversely, weaknesses of technicians were weaknesses of workers in general.

Technicians are generally obtained from companies similar to their own, or they are promoted from within the organization. At the time of this writing, there does not appear to be a significant number of technicians sought from educational institutions within Arizona.

Managers reported a wide number of technicians for which their supervisors were responsible. Managers expressed a firm belief that the numbers of technicians that will be needed by industry in the future will continue to increase.

Managers indicated that the more education technicians could get, the greater the demand for their services. This concept extended to the four year baccalaureate degree. The most common recommendation that managers made was to enroll in a two year technical program.

Managers believe that an internship program for preparing technicians would be of high value. Newly-hired technicians are typically placed with experienced technicians to orient them on the job.

Managers and technicians tend to agree on information, skills, and knowledges which are important to the work of the technicians.

Conclusions

Unless additional technical programs can be initiated in the secondary schools of Arizona, institutions of higher education should plan to expand adult and evening technical programs.

Mathematics, drafting, and physical science programs are important to technicians. Technicians generally do not relate what they learn in social studies classes to what they do as individuals in contact with others. These courses and programs should relate to people-type problems.

Educational institutions should investigate the role that they should play in coordinating on the job training for technicians.

Managers and technicians agree that the greater the educational preparation, the better the technician. The value of the four year baccalaureate degree should not be underestimated.

Implications

General education programs -- because of their science, mathematics, and English offerings appear to be of considerable value to future technicians. All students should be made aware of where they will find jobs and how they will use the knowledges gained in their classes.

Mathematics (up to but not including calculus), drafting and design, electricity and electronics, the physical sciences, English and Technical Report Writing and the use of simple test equipment appear to be "core" areas for various Arizona Industries using technicians.

It seems reasonable to assume that technicians were less than satisfied with courses in social sciences and the humanities. This response appears to by typical of "hardware" oriented individuals. Why this is so is another matter. It is possible that this is an area for future research. The point of view of the technology student and the point of view of those who are professionally involved in these courses could well be points of departure.

Secondary school administrators, counselors and teachers should be aware of the low demand for individuals with a high school diploma only. These factors become more significant for those youth who are contemplating dropping out of secondary schools.

From the preceding data it seems reasonable to assume that industrial managers who use technicians, and personnel from educational institutions which prepare technicians, should endeavor to initiate an on the job preparation program at the earliest possible time. This position is strengthened by the technicians reporting the value of on-the-job training (See Table XI).

It seems reasonable to assume that technicians were willing to move to another organization whenever the situation might seem appropriate.

Recommendations for Further Study

In the course of conducting, writing and evaluating this research project, the following subjects--while not a part of the present effort--seem to lend themselves to further study:

1. Why do "hardware" oriented technicians verbalize the importance of getting along with others, yet deprecate the importance of social studies in their backgrounds? How do we make future technicians aware of this expectation?

2. If vocational-technical programs were more numerous, would greater numbers of high ability students enroll in them?

3. In view of the narrow age-range where young men elect to enter a technical field, what would be the most effective recruiting procedures to use in attracting those of high ability?

4. What provision for on-the-job training for future technicians should be implemented?

5. If vocational-technical education is effective, graduates with this background should compare favorably with those who lack this background. Comparisons between involuntary job separations, and promotions, should be informative.

6. What provisions can be made for informing secondary school administrators, counselors and students of the low demand for individuals with only a high school diploma?

7. What courses from the field of business administration should be included in a two year technical program?

8. In view of the acknowledged premium placed on the four year engineering degree by industrial personnel, what type engineering curricula should be created by Arizona institutions contemplating such programs?

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APPENDIX A

C O N F I D E N T I A L

IDENTIFICATION OF SUCCESSFUL TECHNICIANS

(Management)

1. a. Company Name ______________________________

   b. Company Address ______________________________

   c. City ______________________________

2. a. Name ______________________________ B. Age ________

   c. First position with this company ______________________________

   d. Date of initial employment ______________________________

   e. Present Position with this company ______________________________

3. Management Level (s):

   3 = 3 level
   2 = 2 level
   1 = 1 level
   0 = technician level

JOB HISTORY

4. a. Title or description of first full time job: ______________________________

   b. Employed from ______________________ to ______________________
   (Date) (Date)

   c. Company Name ______________________________

5. Total number of full-time jobs since leaving high school ______________
   (Include active duty with the armed forces)

6. Have you ever worked as a technician similar to those employed by your company?

   a. Yes

   b. No

7. Did you complete a technician training program?

a. Yes   b. If yes, describe: ______________________
(Descriptive Title)   (Length)

c. No

EDUCATION

8. High School Diploma?

1 = none
2 = regular
3 = G.E.D.
4 = other

9. Junior College Graduate?

a. Yes   b. If yes, major field of study: ______________

c. No   ______________________________

10. College Graduate?

a. Yes   b. If yes, major field of study: ______________

c. No   ______________________________

11. Comments on adequacy of formal education for your present position:

Strength: ______________________________

____

Weakness: ______________________________

____

THE TECHNICIAN

12. What are the strengths of successful technicians employed by your company?

a. ______________________________

b. ______________________________

c. ______________________________

13. What are the weaknesses of the less successful technicians employed by your company?

a. ______________________________

b. ______________________________

c. ______________________________

14. Where do you obtain the majority of those to be hired as technicians?

a. Other companies similar to ours
b. Discharged military personnel
c. In-state junior colleges
d. Out-of-state junior colleges
e. Engineering school drop-outs
f. Other ______________ (specify).
g. Other ______________ (specify)

15. a. Is there an institution, or institutions, that you generally go to in order to hire technicians?

a. Yes

b. No

b. If yes, what are their names and locations?

____

____

____

c. Why do you hire their product?

16. How many technicians do each of your engineers or supervisors typically supervise?

a. 1 - 2
b. 3 - 4
c. 5 - 6
d. 7 - 8
e. 9 - 10
f. Other ______________ (specify)

17. Based on your experience and background, how many technicians will be needed by the industry which your company represents in the immediate future (1967 - 1970)?

a. Many more than presently employed
b. Somewhat more than presently employed
c. About the same as presently employed
d. Somewhat less than presently employed
e. Much less than presently employed

18. Based on your experience and background, how many technicians will be needed by the industry which your company represents projecting ahead to 1975 to 1985?

a. Many more than presently employed
b. Somewhat more than presently employed
c. About the same as presently employed
d. Somewhat less than presently employed
e. Much less than presently employed

19. What will be, in your estimation, the probably future demand for employees in industry with the following preparation:

a. High school graduate	High	Medium	Low
b. Two-year technician	High	Medium	Low
c. Four-year technology (Non-professional)	High	Medium	Low
d. Four-year engineer (professional)	High	Medium	Low

20. Considering the job knowledges and skills which your technicians are required to know, what is the best education they should attempt to obtain not only for an entry job, but also for a person to progress on the job?

____

____

____

21. A. What do you think about an extended two-year technical program which would permit the technician-trainee to follow this general schedule?

1. One and one-half ($1\frac{1}{2}$) years of academic-laboratory preparation.
2. Six months internship on the job.
3. Evaluation of intern by his immediate supervisors.
4. One final semester of academic-laboratory preparation to build up the weakest portion (s) of the individual's background as revealed by the evaluation.

REACTION

B. 1. This is a sound approach and should be initiated.

2. This is a sound concept although these problems appear:

(a) ______________________________

(b) ______________________________

(c) ______________________________

3. This is not a good concept. The following obstacles appear to be too great

(a) ______________________________

(b) ______________________________

(c) ______________________________

C. a. I would recommend to our company officials that we participate in such a program.

b. I would not recommend to our company officials that we participate in such a program.

22. A. What do you think about an extended two year technical program where the university and industry would agree to have trainees and students alternate between the two?

1. While student A was attending the university for a semester of technical education, his partner, student B, would be receiving valuable work experience.

2. This alternating system would continue until the academic requirements of the two year technical program would be completed.

REACTION

B. 1. This is a sound approach and should be initiated.

2. This is a sound concept although these problems appear:

(a) ______________________________

(b) ______________________________

(c) ______________________________

C. a. I would recommend to our company officials that we participate in such a program.

b. I would not recommend to our company officials that we participate in such a program.

24. What orientation or "polishing" do you typically give newly hired technicians?

25. Final Comments: (areas not covered, etc.)

APPENDIX B

C O N F I D E N T I A L

IDENTIFICATION OF SUCCESSFUL TECHNICIANS

Company I. D. ____________________

1. Name ______________________________ Job Title ________________

2. Age ______________

3. Highest grade level in school completed ________________________

4. Occupation of Father ______________________________________

5. Occupation of Mother ______________________________________

6. The type of high school curriculum which you followed can best be described as:

   a. College preparatory
   b. Vocational-technical
   c. General

7. Did you acquire any of your present job knowledge or skills at a post-high school technical institute, junior college, college, or university? (underline those that apply)

   a. Yes   c. If yes, describe ____________________

   b. No   ______________________________

8. What was your major area of study?

   X = does not apply
   0 = none
   1 = mathematical science
   2 = physical science
   3 = biological science
   4 = business & management
   5 = general
   6 = building trades
   7 = electrical trades
   8 = machine trades
   9 = printing trades
   10 = art
   11 = home economics
   12 = agriculture
   13 = engineering
   14 = engineer mechanic
   15 = air frame & power mechanics
   16 = drafting trades
   17 = appliance repairs
   18 = liberal arts
   19 = data processing
   20 = technical writing
   21 = civil technology
   22 = medical technology
   23 = drafting technology
   24 = mechanical technology
   25 = electronics technology
   26 = other ______________ (specify)

9. Did you complete the regular(two year) program of studies?
(four year)

a. Does not apply

b. Yes

c. No

d. If no, how long did you attend?
(0) Less than one semester
(1) One semester
(2) Two semesters
(3) Three semesters
(4) Four semesters
(5) Five semesters
(6) Six semesters
(7) Seven semesters

10. What specific junior college or university courses did you take which have proven to be of highest value to you in your present position? (What did you actually do or learn, not a course title).

1. ______

2. ______

3. ______

11. What specific junior college or university courses did you take which have proven to be of lowest value to you in your present position? (What did you actually do or learn, not a course title.)

1. ______

2. ______

3. ______

12. Are you presently enrolled in a technical course to upgrade your technical background?

a. Yes

b. If yes, describe: ______

c. No

13. Additional training acquired:	Kind of and Length of Additional Training Time
a. Formal apprenticeship	______
b. Military schools	______
c. Private institutions	______
d. Area vocational schools	______
e. Correspondence	______
f. Formal on the job training	______
g. Courses offered by inplant training	______
h. Junior college	______
i. College - University	______
j. Other ______ (specify)	______

14. Does your employer have a policy of paying tuition expenses for you while attending technical upgrading courses?

a. Yes

b. No

15. Do they provide time off for such courses? (including compensatory time)

a. Yes

b. No

16. Where did you rank in your high school graduating class? (In terms of percentile)

a. Did not graduate
b. 0 - 25 (lowest 25%)
c. 26 - 50
d. 51 - 75
e. 76 - 100 (highest 75%)

17. Did the high school (s) which you attended offer Vocational-technical education which could have prepared you for your present position?

a. Yes

b. No

c. Don't know

18. If such training was available, did you take advantage of it?

a. Does not apply

b. Yes   d. If yes, describe: ____________________

c. No   __________ ____________________

19. The size of the community where you lived when you attended high school was?

POPULATION

a. 0 - 10,000
b. 10,000 - 20,000
c. 20,000 - 30,000
d. 30,000 - 40,000
e. 40,000 - 50,000
f. 50,000 - 60,000
g. 60,000 - 70,000
h. 70,000 - 80,000
i. 80,000 - 90,000
j. 90,000 - 100,000
k. Over 100,000, specify ________

20. At what age did you decide to work in your present technical occupation?

a. 15 or under
b. 16 to 20
c. 21 to 25
d. 26 to 30
e. Over 30, specify ______

21. If any previous occupations or job enabled you to qualify for your present postion, specify job titles and length of time on each.

______

______

______

22. How long have you been employed by this firm?

a. Less than 1 year
b. 1 to 3 years
c. 4 to 6 years
d. 7 to 10 years
e. Over 10 years, specify ______

23. Which of the following best describes the activities you perform on the job? (Circle the letter of all that apply)

a. Research, design or development
b. Production or operation
c. Installation or maintenance
d. Inspection or control
e. Sales
f. Supervision
g. Testing
h. Other (describe) ______

24. What are the most important things you are required to know in order to do your job?

a. ______

b. ______

c. ______

25. Where did you acquire these knowledges? (Describe in as much detail as possible)

a. ______

b. ______

c. ______

26. What are the most important things you are required to do in order to do your job? (skills, competencies, etc.)

a. ______________________________

b. ______________________________

c. ______________________________

27. Where did you acquire these skills? (Describe in as much detail as possible)

a. ______________________________

b. ______________________________

c. ______________________________

28. What personal-social traits or characteristics do you believe a person needs in order to be successful as a technician?

____

____

____

____

29. In what professional organizations connected with your work, do you hold membership? ______________________________

____

____

30. What registration, certification, or license do you hold? ______________

____

____

31. Do (did) any of your hobbies contribute to success on your present job? Please describe: ______________________________

____

____

32. Work experience: (Start with current employment and work back)

a. 1. Company ____________________

2. Position ____________________

3. Employed from ____________________ to present

4. Compensation $____________________(week) (month) (year)

5. Companies main product or service ____________________

b. 1. Company ____________________

2. Position ____________________

3. Employed from ____________________ to ____________________

4. Compensation $____________________ (week) (month) (year)

5. Companies main product or service ____________________

c. 1. Company ____________________

2. Position ____________________

3. Employed from ____________________ to ____________________

4. Compensation $____________________ (week) (month) (year)

5. Companies main product or service ____________________

d. 1. Company ____________________

2. Position ____________________

3. Employed from ____________________ to ____________________

4. Compensation $____________________ (week) (month) (year)

5. Companies main product or service ____________________

e. 1. Company ____________________

2. Position ____________________

3. Employed from ____________________ to ____________________

4. Compensation $____________________ (week) (month) (year)

5. Companies main product or service ____________________

f. 1. Company ______________________________

2. Position ______________________________

3. Employed from ______________ to ______________

4. Compensation $______________ (week) (month) (year)

5. Companies main product or service ______________

g. 1. Company ______________________________

2. Position ______________________________

3. Employed from ______________ to ______________

4. Compensation $______________ (week) (month) (year)

5. Companies main product or sarvice ______________

h. 1. Company ______________________________

2. Postion ______________________________

3. Employed from ______________ to ______________

4. Compensation $______________ (week) (month) (year)

5. Companies main product or service ______________

i. Comments on job history: ______________________________

____

____

33. What type of education or training do you feel would be the best preparation for a persen planning to work in the <u>same</u> job you are now performing? How many year of what type of <u>formal education</u>? How many years of what type of <u>training</u>?

34. What do you expect to be doing 10 years from now?

APPENDIX C

Card Sort

1. Technical and scientific oral and written communication including business forms, reports, emphasizing the different types of business letters. Techniques of collecting and presenting scientific data. Informal reports and formal reports; special types of technical papers.

2. Fundamental physical and chemical principles governing food preservation by freezing, canning, drying, concentration, salting, smoking, fermenting, carbonating.

3. Numerical control, data processing, interpretation of engineering drawings, depiction of data by manuscript, minimum dimensions and use of formulae, left data, translation, programming, and quality control.

4. Thermosetting and thermoplastic materials. Films, enamel, paints, lacquers, alkyds, phenolics.

5. The biology of the common bacteria and microorganisms. Laboratory work in the techniques of sterilization, disinfection; isolation and maintenance of pure cultures; staining and identification.

6. Lab procedure to identify and protect against radiation and electrical hazard including medical and nursing methods.

7. Relationships between the structure and the physical and chemical properties of ceramic materials, including clays, refractories, and cement.

8. Analysis and design of basic electronic circuits involving vacuum-tube and semiconductor devices. Graphical characteristics and coefficiants. Linear equivalent circuits. Elementary feedback analysis.

9. The chemistry of food: carbohydrates, protein, fats, minerals, vitamins, and food pigments. Basic nutritional needs.

10. Mendelism, the chromosomal theory, the physic-chemical nature of the gene, cytoplasmic inheritance and environmental influences; emphasis on human inheritance, problems of genetic counseling, and eugenics; experiments with fruit flies, protozoa, and plants.

11. The constellations, solar system, structure of the universe, determination of time, and calendars. Use of astronomical instruments for data collection.

12. Coulomb's Law and the basic concepts of electrostatics, direct and alternating current theory, magnetism, electro-magnetism, Ampere's Law, oscillator circuits, and L/c and R/c circuits.

14. Microbial life with emphasis on morphology, culture and the biochemical activities of bacteria, viruses and fungi; pathogenic microorganisms, human protozoan and helminth parasities; antiseptics, disinfectants, sterilization, infection and resistance, diagnostic tests and immunizations.

15. Laboratory techniques in use for identification of parasites. Thick film for malaria, concentration techniques for ova and cysts, wet and stained preparations for intestinal parasites, especially of the common pathological forms.

16. General and economic entomology; taxonomy of the principal order in insects; life histories, habits, recognition, and control of some of the principal insect pests.

17. Use of simple test equipment. Theory and application of commercial test equipment, trouble analysis, and test and alignment methods and practices.

18. Principles of pulse and timing circuits, including multivibrators, limiters, clippers, blocking oscillators, and counting circuits. Quantitative analysis of differentiating and integrating circuits.

19. Mineralogy including physical properties, blowpipe and chemical methods; the orgin occurrence and association of minerals; basic crystallography, and the identification of minerals by means of physical and chemical properties.

20. Identification and classification of minerals and rocks with particular emphasis on well cuttings, field mapping, subsurface mapping and well correlation. Historical geology, geophysical methods, and electric log interpretation. Rotary drilling equipment, prime movers circulation systems derricks and masts, bits, lubrication, drilling technique, and mud control and drilling problems.

21. Theromodynamic aspects of gas turbine and turbo-jet engine design. Perfect and real gas relationships and their application to problems of flow through compressors and turbines. Modern gas turbine cycles and their application to power plant, industrial, and aircraft installations.

22. Engine cycles, performance, characteristics, analysis of problems, theory of internal combustion engines. Fuel systems on internal combustion engines and the functions of the parts.

23. Organization and methods involved in establishment and conduct of training programs for company employees.

24. Analysis of organizational structure of business.

25. Development of the labor movement and the main forces underlying the labor problem. Government regulation of labor relationships, approach of workers to labor problems; the development of the National Labor Relations Acts, the Wagner Act, the Taft-Hartley Act; management-labor relations.

26. Practical application of basic psychology in planning, conducting and evaluating conferences and interviews. Emphasis on employee selection, classification, training, evaluation, working conditions, counseling, group attitudes in the occupational situation as they affect motivation, status and morale.

27. Time study and the science of management; process charts, operation analysis, motion economy and job design; time study preparation, observation, calculation and adjustment; ration delay study, formula development and construction of tables, curves and multivariable charts.

28. Maintaining labor force and control so that the objectives and purposes of the company are attained as effectively and economically as possible. Methods and procedures related to the efficient utilization of resources in production; specialization of process and labor; product and process analysis, production planning and control; materials procurement and control; methods improvement; time study and wage determination; selection of layout, etc.

29. The underlying principles of plane surveying; surveying instruments and their use; adjustment of the level and transit; calculation; introduction to mapping and optical tooling.

30. Basic principles underlying human behavior and its control; perception, learning, motivation, emotion, intelligence, personality and adjustment.

31. Automotive fuels, fuel requirements, fuel ratings, fuel tanks, lines, fittings, pumps, carburetors, fuel injectors, superchargers, governors, guages, manifolds, and exhaust systems; automotive batteries, generators, alternators, rectifiers, current regulators, cranking motors, ignition systems, lighting systems, signaling devices, wiring, power windows, and convertible top electrical apparatus.

32. Elementary techniques and practices of manipulation and fabrication of simple laboratory apparatus of heat resistant glass. Bending, cutting, grinding, pulling, and joining glass.

33. Tension and compression within the elastic range. Hooke's Law working assembly, and thermal stresses. Mohr's circle, bending moment and shear diagrams. Deflection of transversely loaded beams. Theory of columns. Combined loadings. Laboratory tests.

34. Composition and resolution of forces, equilibrium conditions, Newton's laws of motion, uniformly accelerated motion, projectile motion, concept

of work, power and energy, elasticity, rotational motion, and simple harmonic motion.

35. Metal forming including machining, chemical milling, spinning, electrical forming, and explosive forming.

36. Kinematics of a particle, kinetics of rigid bodies, moments in inertia of masses, rotation of rigid bodies, any plane motion of rigid bodies, impulse, momentum, impact, properties of solids and liquids, and introduction to vector analysis.

37. Metal forming including casting, die casting, forging, extruding and the accompanying pattern and tool construction.

38. Applied statics and strength of materials, dealing with forces, stresses, and the design of simple machines and structures. Applications of the characteristics of modern engineering materials to structures.

39. The physical and chemical fundamentals of glasses. The roles of constituents in relation to the formation, structure and properties of glasses. Basic concepts in the glassy state.

40. Fundamentals of propulsion. Thermodynamic cycles and basic characteristics of ram jets, turbo jets, turbo props, pulse jets and rockets; analysis of propulsion systems.

41. Functions and manipulation of the basic business machines, with emphasis on the various duplicating processes and dictaphone machines. Some working knowledge of the comptometer, the 10-key, and other calculators and adding machines.

42. Cost accounting, job-lot process cost. Accounting methods for material, labor and factory overhead, and preparation of financial statements from cost data.

43. Tax laws as they affect business and accounting procedures; preparation of personal, partnership, and corporate income tax returns computation of capital stock, excess profits, estate, gift and excise taxes.

44. (PERT) Selection and sequencing of specific identifiable events necessary to successful completion of a project. Estimates of time, evaluation procedures, information channels, and the use of data processing techniques to permit periodic summaries of projects.

45. Techniques in presenting market data, evaluating market potential, and selecting locations for wholesale, retail, and service establishments.

46. A branch of mathematics dealing chiefly with the rate of change of functions with respect to their variables--differential calculus.

47. Graphical solution of problems involving points, lines, planes, revolutions, intersections, angles, tangent planes, and developments. Plus problems involving contoured and warped surfaces.

48. Cartesian and polar coordinates, straight lines, conics, reduction of general quadratics to type forms, locus problems, parametric equations.

49. Differential equations; line integrals; vector analysis gradient, divergence and curl; solutions of the equations. Partial differential equations and boundary value problems, wave equation, heat conduction, complex variable theory, and conformal mapping. Couchy integral theorem residue theorem.

50. Separation of variables, homogeneous functions, exact equations, integrating factors, linear equations of the first order first degree, Bernoulli's equations, coefficients linear in the two variables, series integration, orthogonal trajectories, hyperbolic functions and applications.

51. Trigonometric functions and fundamental formulae. Logarithms and solution of triangles, identities and equations. Trigonometry from ratios, right triangles, and identities, through vectors and graphs of trigonometric functions.

52. Algebraic graphing, exponents, powers, roots, radicals, imaginary and complex numbers through ratio proportions, variations, and logarithms.

53. Metric system and square root; geometry from plane figures to geometric solids; algebra from operations with signed numbers through algebraic expressions, equations, special products, factoring, and fractional equations and simultaneous equations.

54. Permutations, combinations and probabilities, infinite series, determinants; inequalities, and mathematical induction.

55. Laplace transforms, Gamma, Gessel and legendre functions; Fourier series and orthogonal functions; multiple, line and surface integrals; vector field theory, theorems of Gauss, Green, and Stokes.

56. Linear, radical, and quadratic equations; simultaneous solutions of second-degree equations; binomial theorems, deMoiver's theorem, rational and irrational roots of polynomial equations of any degree; complex numbers, cubic numbers, cubic and quadratic equations, theorems on roots, isolation, limits, and approximation of real roots.

57. Vacuum tube and transistor theory. AC parameters, resonance, transformers coupling, filters, bandpass, and complex wave forms. Tuned and untuned circuits, and vacuum tube power supplies.

58. Elementary logic, mathematical induction, permutations, combinations probability, the theory of matrices and matrix transformations, theory of vector spaces, and the concept of set.

59. Integration as the converse of differentiation, integrals as the limit of a sum, reduction of type forms; applications to geometry and mechanics

60. Analytic geometry, extremal problems limits, continuity, derivatives, antiderivatives, and the calculation or are by approximation methods and by use of antiderivative functions.

61. Sketching forms from observation; emphasizing volumes, perspective, composition, and measurements.

62. Preparation of zoological and botanical materials for microscopic examination; including principal techniques and histochemical preparations.

63. Machine elements and calculations in determining the size and shape of various machine parts. Factors which influence the selection of materials to be used. Prototypes.

64. Basic illustrating techniques; color concepts, organization of space, and aesthetic judgment.

65. Preparation of block diagrams, schematics and layouts using standard conventions.

66. ASA standards, use of handbooks, graphical treatment of empirical data, conversion charts and nomograms, graphical differentiation and integration, tolerance and limit dimensioning.

67. Projection and graphic representation: use of instruments, lettering, applied geometry, dimensioning, sections, conventions (E.G., welding, pipe, electronic) auxiliary views, screw threads, cams, gears, theory of perspective, preparation of working and assembly drawings.

68. Programming of electronic digital computers for applications in business and industry. Data processing, characteristics of computers, and computer programming or coding. Machine organization, problem formulation, automatic programming, numerical analysis, machine language programming, and applications of computers.

69. The organization and basic operation of a digital computer. Programming, number systems, and Boolean Algebra. Analysis, design, and utilization of principle computer circuits such as logic gates, flip-flops, and memory networks. Design of binary counters and application of Boolean Algebra to perform binary arithmetic.

70. Ferrous and non-ferrous metal heat treating, macrostructure, composition, physical and chemical testing. Metallography, metallurgical examinations, inspection procedures, and corrosion testing.

71. Electronic circuit theory of video amplifiers, tuned amplifiers, and basic feedback oscillators. Nonlinear amplifiers, modulators and demodulators. Noise inelectron devices. Relaxation phenomena and Wave-form generation.

72. Pattern drafting and layout; tool operations as related to processes of manufacturing sheet and plate products.

73. Metal fabrication including oxyacetylene welding and cutting; electric arc welding, heliarc and shield arc welding; friction and vacuum welding, and cold fasteners.

74. Plants morphology, physiology, genetic, inheritance, identification, classification, and environmental relationships.

75. The use of synchros and servomechanisms, synchro generators, motors, differentials and control transformers. Control circuitry for error detection, anti-hunt systems, servo amplifiers, thyratron motor control, the Ward Leonard control systems, the amplidyne, and AC servomotors. Industrial application of electronic controls including photoelectric devices.

76. Feedback problem in linear systems. Techniques such as: transfer and weighting functions; block diagrams, signal flow graphs, time-domain analysis, root locus technique and frequency-domain analysis.

77. The use of measuring equipment in a system to measure or control the system; such as thermocouples, strain gauges, pressure transducers and various current or voltage pickups. Accuracy inherent in alternate methods of measurement. Methods of transcribing or indicating measured values, or of using measured quantities to control the system.

78. The growth and development of dairying. (A) Principles and practices in the production of milk; basic feeding, management, and disease control practices. (B) Basic principles of dairy industry practices; common dairy tests; general survey of all important branches of the industry.

79. The calibration and use of typical industrial and laboratory instruments and their actual use in the analysis of equipment representative of various fields. Calorimetric, spectrophotometric, spectrographic, electrolytic, and potentiometric methods.

80. The basic laws and theories of elements, compounds, and the structure and behavior.

81. The principles, equipment, operation, and flow of chemical processes. Production of the common acids, bases, salts, gases, and cryogenic liquids.

82. Basic photography with emphasis on graphic arts procedures and applications in the preparation of negatives for offset lithography, basic photographic materials and supplies, developer reaction, color sensitive materials and supplies; and filters and halftone screens.

83. Chemical testing of industrial materials and products; preparation of solutions and reagents; and investigation of gravimetric, volumetric, and gasometric methods. Chromatographic, spectrophotometric, spectrographic, potentiometric, and conductimetric, and microscopic procedures.

84. The fundamental laws governing the behavior of gases, liquids and solutions. Chemical equilibrium in homogeneous and heterogeneous systems. Electrolysis, conductance, transference. EMF's of cells with and without transport. First law of thermodynamics with application to thermochemistry. Application of thermodynamics. Chemical kinetics including photochemistry and chain reactions Quantum theory and infared and Roman spectra.

85. Carbon compounds; their structures, properties and nomenclature; types of reactions of important functional groups. Laboratory techniques, preparations, and qualitative analysis.

86. The physical chemistry of polymerization, basic kinetics and mechanisms of condensation and addition of polymerizations. The measurement of the physical properties of high polymer systems including molecular weight, solution properties, and polymer structure.

87. Technique of venepuncture. Practice in the common biochemical medical tests (blood sugar, non-protein nitrogen, proteinometry, etc.) and the uncommon tests (e.g., sodium, potassium, phosphatases, etc.). Liver and kidney function tests, simple toxicological tests, pregnancy tests.

88. The problems and effects of industrial wastes discharge upon a sewerages collection system and treatment plants to which it is tributary. Industrial wastes ordinances and representative control problems.

89. Mechanics of fluids, temperature scales, thermal expansion, methods and laws of heat transfer, calorimetry, properties of gasses, fusion and vaporization, and an introduction to thermodynamics; wave motion and sound.

90. Atoms, singles crystals and polycrystalline materials. Properties of the metallic state; nature of alloys; making of alloys; phase equilibrium diagrams; micro-constituents of alloys; mechanical and thermal treatment; survey of non-ferrous and ferrous metallurgy.

91. Equations of state, the first and second laws of thermodynamics, reversible and irreversible processes, isothermal and adiabatic processes, Carnot processes, absolute temperature scale, entropy, free energy, Gibbs potential, equilibrium, Nerst's heat theorem, specific heats of solids.

92. The properties of fluid and vapors including use of vapor tables and charts: flow of fluids in nozzels; combustion calculations; vapor cycles and steam power applications; mixtures of vapor and gases.

93. The principles and practice of heat transfer by conduction, radiation, free and forced convection, vapor condensation, and boiling liquids. Unsteady-state heat transfer.

94. Fission, neutron diffusion, neutron meoderation, bare homogeneous thermal reaction, Reactor Theory, special relativity, x-rays, nuclear structure, natural and artificial transmutation, and radioactivity.

95. The nature and propagation of light, photometry, diffraction and interference, dispersion, spectra and color, polarized light, radiant energy, electrolysis, photoelectric effect and quantum of light, Bohr's theory, spectra of atoms.

96. Bacteria, yeasts, and molds; physiology, morphology, and systematic relationships; the significance of bacteria, yeasts and molds in general sanitation, agriculture, home economics and communicable diseases.

97. Elementary aspects of organic unit processes including nitration, sulfonation, halogenation, hydrogenation, oxidation, and alkylation.

98. Environmental testing of components, parts, and products for assessment of performance in actual application.

99. Preparations of specimens for testing by processes such as slicing, polishing, electropolishing, etching, dyeing, and impregnating.

APPENDIX D

COMPANIES PARTICIPATING IN THE RESEARCH

AiResearch Manufacturing Company
AMECO, Inc.
Arizona Public Service Company
Dickson Electronics
Dynamic Systems Electronics Company
Emerson Electric Company
Goodyear Aerospace
State of Arizona Highway Department
  a. Phoenix
  b. Flagstaff
  c. Kingman
Hughes Aircraft Company
Kennecott Copper Corp., Ray Mines Division
Motorola Aerospace Center
Motorola Semi Conductor Division
Phoenix, City of, Communications Division
Salt River Project
Sperry-Phoenix
Unidynamics (Pilot Study)
U. S. Geological Survey, Phoenix