AN OCCUPATIONAL ANALYSIS OF ELECTROMECHANICAL TECHNICIAN OCCUPATIONS WITH IMPLICATIONS FOR CURRICULUM DEVELOPMENT

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CHAPTER I

INTRODUCTION

As man journeys into space, demands have been made on his support systems to operate in environments much different than those that exist on earth. Environmental conditions of high vacuum, extreme temperature change, extreme accelerations, and high velocities have been factors in creating a need for systems engineering. Skills and knowledge that were previously considered highly specialized are now being combined into new technical occupations (Roney, 1969, p. 201). This systems approach has caused sweeping changes to take place in American industry, and in post-high school educational institutions which supply an ever-increasing proportion of industry's technical manpower (Dugger, 1968, p. 1). One of the specific changes of this technological development is the creation of thousands of jobs at the technician level which require the completion of two years of post secondary technician education prior to employment (Venn, 1964, pp. 17-19).

To provide this two year post-high school education, many communities have established new junior or community colleges. It has been estimated that 50 new community colleges will be created each year in the foreseeable future (Reynolds 1969, p. vi). For these new two-year instituions being created, the development of curriculums to meet the technical needs of American industry is a problem of upmost importance. As for the two-year training institutions, already in existence, the changing industrial manpower requirements make it necessary to initiate new and to improve old curricula. One of the new technical curricula being developed is electromechanical technology. This program utilizes concepts which cross the fields of electricity, mechanics, fluids, acoustics, thermodynamics, and optics.

Statement of the Problem

To develop educational objectives for an occupational curriculum, it is necessary to know what tasks are performed in the occupation and the frequency of performing these tasks (Mager and Beach, 1967, p. 2). In the emerging field of electromechanical technology, little research has been done to determine the specific skills and knowledge needed in the occupation.

Purpose of the Study

The primary purpose of this study was to conduct an occupational analysis of electromechanical technician occupations in order to determine the frequency of performing selected tasks and the area of activity in which these tasks are performed. A secondary purpose of this study was to analyze and organize this occupational analysis data in preparation for writing educational objectives for an electromechanical technician education program.

Background for the Study

After the field study (Roney, 1966) was completed, the Technical Education Research Center of Cambridge, Massachusetts, funded a demonstration program for the development of an electromechanical technology curriculum at Oklahoma State University (see Appendix I for summary of field study). The purpose of this demonstration program was to develop a curriculum and the accompanying instructional material for a two-year electromechanical technology education program (see Appendix J for summary of demonstration program).

Along with this electromechanical technology program, the Bureau of Educational Personnel Development funded a graduate fellowship program to train teachers to implement this technical education program in appropriate institutional media throughout the United States (see Appendix K for summary of fellowship program). The final phase of this graduate fellowship program entailed the development of an occupational analysis questionnaire for analyzing the electromechanical technician occupation. For the final master's report, each of thirteen participants (fellows) administered this questionnaire to a selected number of electromechanical technicians and their supervisors. This questionnaire was designed to determine the frequency with which selected tasks were performed and the area of activity in which these tasks were performed, in a selected number of organizations employing electromechanical technicians. The geographical area and type of industrial establishments covered in each of the thirteen separate reports was usually limited to the area to which each graduate fellow was going to establish an electromechanical technology program upon graduation.

Need for the Study

To develop educational objectives, as one element in the process of curriculum development, the occupational analysis is needed to help identify the tasks performed and the frequency of performing these tasks. In order to use the data mentioned in the preceding section for an occupational analysis, it was deemed necessary to select additional industrial establishments so that the study would be more representative of those identified in the field study. The Education Professional Development Bureau, acting on a specific proposal, approved this increased scope of activity. Funding was subsequently made available and the project was set in motion.

Assumptions of the Study

The design of the study was based upon two assumptions:

(1) the tasks performed by electromechanical technicians in June 1970 were no different from the tasks performed in March 1971, and

(2) the electromechanical technicians and their supervisors completed the questionnaires to the best of their ability.

Constraints of the Study

One major constraint of this study was that it was not a random sample of the electromechanical technicians or even industrial establishments employing electromechanical technicians. This occupation was so new that the Standard Industrial Classification did not specifically identify industrial activities that require electromechanical technicians. After consultation with manpower economists and educators performing manpower research, it was decided that it would not be feasible to try to determine the population of industrial establishments that employ electromechanical technicians. Therefore, the subjects for this study were selected on criteria other than randomness. These criteria are further delineated in Chapter III.

Definitions of Terms

Engineering Technician - An engineering technician is one whose education and experience qualify him to work in the field of engineering technology. He differs from a craftsman in his knowledge of scientific and engineering theory and methods, and from an engineer in his more specialized background and in his use of technical skills in support of engineering activities (ASEE, 1962).

Electromechanical Technician - An electromechanical technician is an engineering technician whose education and experience qualify him to work in the combined fields of electrical and mechanical technologies. He differs from the specialized technician in his cross-disciplinary knowledge of scientific and engineering theory and methods.

Engineering Technology - Engineering technology is that part of engineering which requires the application of scientific and engineering knowledge and methods combined with technical skills in support of engineering activities; it lies in the occupational area between the craftsman and the engineer (ASEE, 1962).

Engineering Technology Curriculum - An engineering technology curriculum is a planned sequence of college-level courses, usually leading to the associate degree, designed to prepare students to work in the field of engineering technology.

(a) The term college-level in the definition of a technology curriculum indicates the attitude with which the education is approached, the rigor, and the degree of achievement demanded, and not solely or even necessarily that the credits are transferable to baccalaureate programs.

(b) There are many specific branches of engineering technology in which curricula are offered. Commonly encountered are such curriculum titles as mechanical technology, electronic technology, chemical technology, and civil technology.

Electromechanical Technology - Electromechanical Technology is an engineering technology which is based on the technical concepts of two or more specialized technologies. Primarily, electromechanical technology emphasizes concepts involved in electrical and/or mechanical systems, but these concepts are applied to other areas such as magnetics, optics, acoustics, and thermodynamics.

Electromechanical Technology Curriculum - Electromechanical technology curriculum is a careful integration of mathematics, communications, physics, and cross-disciplinary technical studies. Instead of traditional discrete units of mechanics, electricity, heat, sound, and light a system of unified concepts is utilized. The basic concepts of energy conversion and mass transfer are introduced in generalizable forms, applicable to mechanical, electrical, pneumatics, hydraulics, and thermal systems. These are termed as unified concepts.

Cross-Disciplinary - Two or more technical disciplines combined to make one curriculum or occupation.

Third Generation - Curriculum or occupation in which the basic scientific principles or concepts are utilized rather than the specialized techniques and knowledge appropriate for a single specialty.

Concept - A concept is a mental image of a thing formed by generalization from particulars.

Unified Concepts - A concept that can be applied to two or more fields of study.

Occupation - The term "occupation" is used interchangeably with the term "job". A job is thought of more in terms of a piece of work. Yet, they both are defined as a specific duty - "the principle business of one's life."

Task - A task is a related set of actions required for the completion of a job objective.

Occupational Analysis - The procedure for determining (1) what tasks and knowledges constitute a job or cluster of jobs, (2) how those tasks and knowledges are to be performed at present and in the foreseeable future, and (3) what behaviors are required of the worker in a domain appropriate to relevant constraints. All of the above inputs are determined from various levels of manpower in the work environment and the appropriate professional educators.

CHAPTER II

REVIEW OF THE LITERATURE

The primary purpose of this study was to conduct an occupational analysis of electromechanical technician occupations in order to determine the frequency of performing selected tasks and the area of activity in which these tasks are performed. A secondary purpose of this study was to analyze and organize the data in preparation for writing educational objectives for an electromechanical technician education program.

An effort was made, in this review of the literature, to develop the relationship between occupational analyses and the writing of educational objectives. To do this, the literature was divided into these major areas: occupational analysis, curriculum development, and emerging technologies.

Occupational Analysis

The concept of the task analysis was implemented during World War I when it was necessary to train a large number of workers for a special skill in a short period of time. Since that time, the task analysis has been expanded to job or occupational analysis. In reviewing the literature it was found that the terms task, job, and occupational analyses were often used synonymously. Therefore, in this study, occupational analysis was used except in quotations from other sources.

Since World War I, occupational analyses have been used in many of the fields of vocational education. In an occupational analysis of the agricultural supply business, Brinkley (1965) surveyed 90 employees in 65 businesses in Kentucky. Each employee completed a questionnaire covering 251 tasks. Each task was checked as being very helpful, helpful, or of little value. The results were used as a basis for establishing four pilot programs in off-farm agricultural occupations.

Dillon (1965) did a study of certain abilities needed in licensed nurseries and licensed ornamental horticulture businesses. Each task was to be checked in two areas: (1) need knowledge (No, Yes), (2) ability to perform (a, b, c, d).

a. None (I do not perform this activity in my job).

b. I perform this activity with supervision.

c. I perform this activity without supervision.

d. I perform this activity without supervision so well that my performance may be used to instruct others.

Dillon concluded different curriculums should be developed for each program.

Another occupational analysis in agriculture was done by Long (1968). The objective of this study was to obtain up-to-date facts about clusters of tasks performed by Washington state farm operators engaged primarily in producing grain, livestock, dairy commodities, poultry, forest products, horticulture commodities, and general farming commodities. The questionnaire listed 132 tasks to be answered yes or no, if they had been performed in the last two years. The 132 tasks were divided among 18 groups, such as soil structures, farm power, plant pests, etc. The results of this study showed that tasks classified as management, marketing, animal care, and plant production were performed by a large percentage of most categories of farm operators.

Rahmlow and Kiehn (1967) conducted an occupational analysis of the child care occupation in the state of Washington. Their questionnaire was similar to Long's.

An occupational analysis of home related occupations was conducted by Shipley (1967). The tasks listed in this questionnaire were checked in one of three ways: I never do this task; I sometimes do this task; I always do this task. The data was analyzed as to the number of each response in each of the three related occupations.

Curriculum Development

The development of a curriculum, whether it be a new one or the improvement of an existing one, is a complex and time consuming task for any instructor. In the early stages of curriculum development the philosophy of the institution and the overall institutional objectives must be considered to establish boundaries for the curriculum (Emch, 1958, pp. 41-57). Along with the institutional philosophy and objectives, the students to be served and the prospective employers must be considered before establishing a curricula that will start at the present level of the students and progress toward the needs of the employers.

The major problems in curriculum development arise after the initial examination of the institutional philosophy and objectives. Five problems that arise are: What courses should be included in the curriculum? What should be the content of specific courses? What should be the specific course objectives? What should be the arrangement of the individual courses? What should be the arrangement of each course outline? In attempting a solution of these problems several approaches may be used. One would be to choose a curriculum already developed by some other institution. Another would be to review the curricula from several institutions and then select the parts of each that best suits the philosophy and objectives of the institution. A third method would be to use the advise of experts in the occupation to establish the curriculum.

Probably the most effective way is a combination of these, along with an analysis of the knowledges and skills needed for effective performance (Dept. Heath, Education, and Welfare, 1962, p. 16).

The use of and need for educational objectives in curriculum development has been discussed by many writers. Bloom and others (1956) discussed a taxonomy of educational objectives in which objectives are first classified into three domains: cognitive, affective, and psychomotor. They stated that "Curriculum builders should find the taxonomy helps them to specify objectives so that it becomes easier to plan learning experiences and prepare evaluation devices" (Bloom, 1956, p. 2). The commonly used sources in arriving at educational objectives are such things as the students' present level of development, their needs, and their interests. Other sources for objectives are conditions and problems of contemporary life, activities that the individuals are expected to perform, and problems they are expected to encounter.

Tyler (1949, pp. 391-407) contended that the problems of curriculum development and instruction are usually considered in relation to four major types of questions.

1. What educational purposes or objectives should the school or course seek to attain?

2. What learning experiences can be provided that are likely to bring about the attainment of these purposes?

3. How can these learning experiences be effectively organized to help provide continuity and sequence for the learner and help him in integrating what might otherwise appear as isolated learning experiences?

4. How can the effectiveness of learning experiences be evaluated by the use of tests and other systematic evidence-gathering procedures?

In another publication, Basic Principles of Curriculum and Instruction, Tyler (1949) discussed two common arguments for using job analysis for curriculum development and improvement. The first of these arguments was that because contemporary life is so complex and because life is continually changing, it is necessary to focus educational efforts on the critical aspects of life that are important today. The job analysis will help eliminate wasting time on objectives that were important fifty years ago but no longer have significance. The job analysis will also help identify objectives that are now important but are not included in the curriculum. The second argument for using the job analysis stems from findings relating to transfer of training. Tyler said that as long as educators believed that it was possible for a student to train his mind in general and then transfer this training to a specific situation, there was less need for an analysis of contemporary life. He further stressed that studies of transfer of training indicate that the student is most likely to apply his learning if it has been related to real-life situations.

Tyler also gave three criticisms of the job analysis of contemporary life. First, the identification of a contemporary activity does not in itself indicate that it is desirable. Second, in the changing world, contemporary activities might change, leaving the person unprepared for the future. Third, some of the critical problems of contemporary life and some of the activities engaged in by adults might not be interesting nor a concern to the student. To assume that these activities should become educational objectives neglects the importance of considering student interests and needs as a basis for deriving objectives.

In order to work out a plan for organizing a curruculum, it is necessary to identify the elements of that curriculum which serve as the organizing threads. From these threads the educational objectives are obtained. These objectives should be selected according to their relative importance and frequency of use. There is much less likelihood of the student forgetting material that is important and frequently used. The three criteria to be used in selecting these learning experiences are continuity, sequence, and integration.

Mager (1967) said that the object of vocational instruction is to send a student away capable of performing satisfactorily on the job and capable of increasing his skills through further practice. To achieve this first goal, it is necessary to know what the jobs consist of, what is needed to perform each task, and how frequently each task is performed. To achieve the second goal, it is necessary to teach the student to be able to identify perfect and imperfect performance of the tasks.

To prepare a course to accomplish these goals, it is necessary first to make a general job description. From this general outline, a finer list of the tasks is composed (task analysis). From this list, the course objectives are drawn and the criterion examination is made. To accomplish this task analysis, it is necessary to talk to the men on the job to determine what the job is and to the supervisor to determine what it ought to be.

In developing the task analysis, the first step is to determine the frequency of performance of the task. The frequency is very useful in deciding how deeply to go into a subject, how much practice to provide, and how to sequence the course. The second step is to list the tasks in terms of what the person does when performing the task. The final step is to list the learning difficulty of each task.

Mager stated in conclusion:

> There are probably as many techniques for performing a task analysis as there are people doing it. The only large error you can make is not to use any task analysis technique at all.

Evans (1966, pp. 3-19) presented a paper at the University of Wisconsin in which he stated:

> Most of this paper concentrates on the relationship of occupational data for curriculum planning for education which is occupationally related. The principle reason for this limitation is that we know a little more about curriculum planning than about setting goals. Nevertheless, it should be remembered that occupational data can and should be useful in specifying society's goals for all of education and for determining the clientele of the school.

He went on to say that there are two major types of occupational data required, supply and demand. Evans contended that more or less accurate information is available on the number of people employed and unemployed, but little data is available on the abilities, interests, and achievement levels needed in different fields. He further contended that in occupational education one needs to have a considerable amount of data about skills as they relate to occupations. He concluded his paper by saying:

> In the absence of data or in the absence of the use of data, certain types of occupational education are remarkably resistant to change, in spite of rapidly changing occupational requirements.

In discussion after Evans' paper, Meade (1966, pp. 25-29) said that one does not have an efficient system of getting what little information he does have about occupations to the people who determine educational programs in the schools. He contended that, "You only have to visit schools and hear teachers stumble their way through a description of the jobs that exist outside the school sometimes just across the street."

Weibrod (1966, pp. 33-40), in discussing Evans' paper, said that one needs definitions of occupations in terms of "skill mixes and skill clusters".

Smith and Lipsett (1956, pp. 138-139) wrote that in constructing curriculum based on an occupational analysis, the next step is to allocate each task to some course of instruction. They suggested that a simple but practical technique is to list the courses which seem to represent the major areas of content. In this outline of courses, the tasks are placed where they are deemed most appropriate. They claimed the following advantages for this method of approach:

1. Facilitates the elimination of duplication and superfluous material.

2. Tends to provide greater incentive by virtue of its showing relationship between activities and content.

3. Assists in providing stabilized and validated courses even though instructors may change.

4. Aids in providing content prepared for a specific vocational objective in contrast to general content.

One of the recommendations on technical curricula reported from a conference of the American Association of the Advancement of Science (1968), p. 18) was:

> Technical educators and the employers of technicians should be fully aware of the rapidity of change in technical occupations and their corresponding educational requirements. Technical education curricula should be under continuous cooperative study by institutions and employers, and, to the extent possible, the need for change should be anticipated rather than accommodated. The scientific community can make important contributions by helping to foresee the direction of change in science and technology that will affect technical education, and by helping to plan educational programs that will take account of these trends.

The U. S. Office of Education (1962, pp. 16-19) recommended that the first step in curriculum construction, based on job analysis, be the preparation of composite lists of knowledges and skills needed for effective performance of the occupations. From this list of knowledges and skills, subject matter areas are selected and divided into groups to become courses. The next step in the curriculum construction is to determine the educational objectives of each course from the list of knowledges and skills associated with that course.

Brandon and Evans (1965), pp. 263-279) suggested three basic research tools for program-planning in vocational education. They were:

a. community occupational surveys,

b. local advisory committees with representative from both management and labor,

c. occupational analysis.

One major change in the three basic research tools suggested by these authors was to expand the surveys from the community level to the national level, enlarge the geographical area for advisory committees, and expand the occupational analysis to occupational clusters.

The electronics technology curriculum has been systematically developed over several years and has a generally accepted outline (Electronic Technology, 1967). A similar curriculum has also been developed for mechanical technology (Mechanical Technology, 1962).

These curriculums were developed for the U. S. Office of Education by experts that had been working in the respective curriculums for several years.

Emerging Technologies

With the development of scientific knowledge and the application of this knowledge, it has become necessary for some technicians to become knowledgeable in more than one field of technology. The field study, (Roney, 1966) which was conducted in two parts, identified some occupational and educational needs of the emerging electromechanical technician. From an in-plant study, along with a mailed questionnaire to determine the future need for electromechanical technicians, it was determined that by 1970 there would be an additional need of 20,329 electromechanical technicians.

It was found, by Robertson (1970, p. 83), that only about 198 electromechanical technicians would be graduated in 1970. These graduates would come from 21 schools with electromechanical technology programs. His survey indicated that only about five percent of the junior colleges offered this program. He further concluded that many educational administrators did not differentiate between electronics technology and electromechanical technology.

An occupational analysis of an emerging occupation, the bio-medical equipment technician, was completed by the Technical Education Research Center (TERC, 1970). Their occupational analysis questionnaire listed 19 tasks to be indicated on a scale of zero to six as to the frequency of performance. The questionnaire also listed 36 pieces of equipment. To the equipment list the interviewee responded yes or no if the technician ever worked with the equipment, did preventive maintenance and/or calibration on the equipment, install equipment for operation or use, or carried out major or minor repair on equipment. Also on the equipment lists were five levels of entry performance expected of the technicians.

Although the tasks were responded to as to frequency of performance, they were reported as to whether the task was performed by the technicians. In listing the 19 tasks in the order of the percent of respondents who performed them, a difference of less than ten percent was considered not significant.

In reporting on the equipment used by the technicians, the percent of respondances in each category was listed. The conclusion was:

> Although the percentage of BMET's who perform calibration and preventive maintenance are slightly lower than the percentages of BMET's who carry out major and minor repairs, the difference is too small to be significant. This suggests that BMET educational programs should be designed to give the students skills and knowledge relevant to all four functions: calibration, preventive maintenance, troubleshooting and repair.

The Technical Education Research Center of Cambridge, Massachusetts, is also in the process of completing an occupational analysis of the electro-optical technician.

Summary

From the review of literature, several major elements of the occupational analysis are indicated as important for curriculum development and the writing of educational objectives. The first of these is the tasks performed and the frequency of performing these tasks. A second element of the occupational analysis is to determine what the person does when performing the task. A third element is to expand the occupational analysis to occupational clusters. A fourth element of the occupational analysis is to determine both what the person does and what his supervisor expects him to be able to do.

These major elements were generally agreed upon, by the various writers, as being necessary in the occupational analysis. The writers also generally agreed that the occupational analysis is a useful tool in curriculum development and the writing of educational objectives. One major omission in the literature is the specific method of transferring the occupational analysis data to educational objectives.

Research Questions to be Answered

The research questions to be answered in this study were derived from the review of literature and are concerned with both the frequency of use and area of activity of task performance by the electromechanical technician. Also of concern were the selected unified concepts used in instructing the electromechanical technician education program at Oklahoma State University.

The following research questions will be viewed from what the technician does and from what the supervisors expect the technician to be able to do upon entry.

RQ_1. Which of the selected technical tasks are most frequently performed by the electromechanical technicians, as viewed by the technicians and as viewed by the supervisors?

RQ_2. Which of the selected communication tasks are most frequently performed by the electromechanical technician, as viewed by the technicians and as viewed by the supervisors?

RQ_3. Which of the selected mathematical tasks are most frequently performed by the electromechanical technician, as viewed by the technicians and as viewed by the supervisors?

RQ_4. Which of the selected shop tools are most frequently used by the electromechanical technician, as viewed by the technicians and as viewed by the supervisors?

RQ_5. Which of the selected test instruments are most frequently used by the electromechanical technician, as viewed by the technicians and as viewed by the supervisors?

RQ_6. What is the order of selected activities of performing the selected tasks, as viewed by the technicians and as viewed by the supervisors?

RQ_7. Which of the selected unified concepts are most frequently used by the electromechanical technician, as viewed by the technicians and as viewed by the supervisors?

RQ_8. Is there a difference in the task performance of electromechanical technicians with an increase in years of experience?

RQ_9. Is there a difference in the task performance of electromechanical technician when viewed from different major emphasis of work, e.g., research and design, production, maintenance, and other?

RQ_{10}. Can educational objectives be written from the results of the selected occupational analysis questionnaire?

CHAPTER III

METHODOLOGY

The purpose of this chapter is to describe the design of the study and the methods used in collecting and analyzing the data. In order to achieve this purpose the chapter is divided into the following sections:

(1) sampling procedures,

(2) instrumentation,

(3) data collection, and

(4) analysis of data.

Sampling Procedures

The data utilized in this study were obtained from the industrial establishments reported in the 13 master's degree reports referred to in Chapter I, and the 15 additional establishments, subsequently selected (see Appendix F for list of the industrial establishments). The selection of industrial establishments, for each of the 13 reports, was made either from a list of establishments in the field study (Roney, 1966) or establishments that would be potential employers of the graduating electromechanical technician from programs the graduate fellow expected to start upon completion of the fellowship program.

The selection of the industrial establishments contacted by each graduate fellow was based on several criteria. Each student had a list of the industrial establishments reported in the field study.

From this list, the fellows selected those that they would contact. The fellows that were already employed also selected industrial establishments from that geographical area. Other industrial establishments were selected because they were conveniently located for the fellows to visit.

The additional industrial establishments were selected from those reported in the field study on the basis of geographical location and types of industrial establishments necessary to make this study representative of those reported in the field study. This method of selection led to the selection of 15 additional industrial establishments from the field study. These 15 establishments were contacted and interviews were arranged. From these 15 establishments, usable data were collected from 11. The data from one of the establishments could not be gathered because of a misunderstanding between the contact personnel, the management representative, and the interviewer on the interview time schedule. Two of the other establishments from which no data were collected agreed with the contact personnel to the interviews, but in discussions between the interviewer and the management representative it was determined that they did not employ electromechanical technicians. The other establishment from which no data were collected also agreed to the interviews, but the work schedule at the appointed time made it impossible to collect data from the supervisors or technicians. Therefore, the usable data included in this study were obtained from 57 industrial establishments, 66 supervisors of electromechanical technicians, and 137 electromechanical technicians.

Instrumentation

The questionnaire used in this study was developed through the joint effort of 13 graduate students at Oklahoma State University. These students had backgrounds in various technical fields, academic education, teaching experience, and industrial experience. The instrument was developed after working with the electromechanical technician demonstration curriculum for a year and while enrolled in a course of occupational analysis at Oklahoma State University. Because no standard occupational analysis questionnaire was available for electromechanical technology, it was necessary to utilize various personnel with different backgrounds in technology to develop the occupational analysis questionnaire. This was accomplished by each of the graduate fellows listing tasks in the field in which he had had the most experience. These tasks were then reviewed and compiled into a preliminary questionnaire by the graduate fellows. The preliminary questionnaire was reviewed by Drs. Maurice W. Roney and Paul V. Braden and then revised by the graduate fellows. This revised questionnaire was pre-tested in two industrial establishments in May 1970; the final revisions were then made.

In developing the questionnaire, many considerations and decisions were made pertaining to the number of items listed and the fields to be covered. One of these decisions was the different fields to cover in the questionnaire. It was finally decided by the graduate fellows to put the major emphasis on the six fields of electricity-electronics, mechanical, fluid, thermal, acoustical, and optical principles. These six fields were stressed in the electromechanical demonstration program. It was decided to include a few general tasks in the fields of nuclear and chemical principles. The next decision was to determine how many tasks were to be included in each field. One consideration taken into account was the length of time necessary for the interviewee to complete the questionnaire. After studying other questionnaires and on advice from Drs. Maurice W. Roney and Paul V. Braden, it was decided by the graduate fellows to design the questionnaire so that it might be completed in 45 to 60 minutes. Therefore, the tasks selected for each field needed to be limited and made general. Other related fields included in the questionnaire were mathematics and communication. It was also decided to include the use of some major shop tools and test equipment. Because of the limited number of items listed in each area, space was left for the interviewees to add other tasks, tools, and equipment.

The questionnaire listed 91 tasks in eight fields of technology. For each task a frequency of daily, weekly, monthly, seldom, or not applicable was to be indicated by the interviewee. Also a primary activity of instructing, modifying, analyzing, troubleshooting, installing, testing, constructing, calibrating, repairing, servicing, or operating was to be indicated by the interviewee for each task. The questionnaire categorized each of these tasks into one of the 11 unified concepts used in teaching the electromechanical technology demonstration program or into a category for tasks applying to all concepts.

The instrument also listed 19 tasks in mathematics. The frequency of use of these tasks was rated as daily, weekly, monthly, seldom, or never. The level of proficiency of these tasks was rated as do not need, need general understanding, familiarity with terms but not necessarily competent, need working knowledge.

The questionnaire listed 11 tasks in communication with a frequency of use the same as for mathematics. Also listed in the questionnaire were eight shop tools and 36 general test instruments used in different fields of technology. For each of these shop tools and test instrument a frequency of use, the same as for the 91 tasks, was to be indicated. For each category space was left for the interviewee to add necessary tasks or equipment not otherwise covered (see Appendix D and E for the questionnaire used).

A separate information sheet was provided for each supervisor and technician to be completed at the time of the interview. (See Appendix C and E.) A letter of introduction with a general information questionnaire was to be completed by the management personnel. The information gathered from the management personnel was used in setting up the interviews, follow-up work, and special comments by the representative pertaining to electromechanical technicians (see Appendix A and B).

Data Collection

Each industrial establishment was contacted to determine if they did employ electromechanical technicians and to arrange interviews. The interviewees, both supervisors and technicians, were selected by management personnel on basis of being classified as, or working as, electromechanical supervisors or technicians. The technicians were instructed to complete the questionnaire as it pertained to their present job. The supervisors were instructed to complete the questionnaire as to what they expect the electromechanical technicians to be able to do upon entry. A researcher was available while the interviewee was completing the questionnaire to answer any questions and to make sure the questionnaire was completed correctly.

The typical procedure for conducting the interview was (1) to contact the management representative, (2) interview the supervisors of electromechanical technicians, and (3) interview the electromechanical technician.

Several methods were used to make the initial contacts with the management representative. They were: (1) mailed letters, (2) telephone calls by interviewer, (3) personal contacts by interviewer, and (4) telephone calls to selected representative from an industrial establishment. The fourth method proved to be the most effective and efficient method to arrange the interviews and was used in contacting the additional 15 establishments.

Analysis of Data

To analyze the data in preparation for answering the research questions, the first step was to tabulate it by frequency of task performance. To answer research questions one through five, which pertains to the frequency of use, the tasks, tools, or test instruments were ranked according to the number of respondents indicating a frequency of use.

To answer research question six, which pertains to the area of activities of performing the tasks, the percent of responses for each area of activity was listed for each task.

To answer research question seven, which pertains to the frequency of use of the unified concepts, the unified concepts were ranked according to the number of respondents indicating a frequency of use. As there was a different number of tasks relating to each unified concept, an equivalent number, for ranking purpose, was established by dividing the total number of responses for each unified concept by the number of tasks relating to that unified concept.

To answer research question eight, which pertains to the differences of task performance with an increase in years of experience, the data from the technicians were divided into four groups according to years of experience as an electromechanical technician. The four groups were zero to two years, three to five years, six to ten years, and more than ten years of experience. All fraction of years of experience were rounded off to the nearest whole number year. The data were then analyzed to determine changes or trends.

To answer research question nine, which pertains to the differences of task performance according to major emphasis of work, the data from the technicians were separated into groups according to major emphasis of work, e.g., research and design, production, sales, maintenance, and other. The data were then analyzed to determine similarities and differences.

To answer research question ten, which pertains to the writing of educational objectives from the results of the occupational analysis, subjective evaluations of the data and information obtained during the oral interviews were used.

To organize the data technical tasks were ranked in descending order according to the number of respondents indicating a frequency of use. The percentage of respondents for each area of activity was calculated for each task. The communication tasks, mathematics tasks, test equipment, and shop tools were also ranked in descending order according to the number of respondents indicating a frequency of use.

The responses of the supervisors were compared to those of the technicians. To make this comparison, a Spearman rank coefficient of correlation r_s was used. This coefficient was calculated by using the following equations (Siefel, 1956):

$$r_s = 1 - \frac{6\sum d^2}{N^3 - N}$$

r_s = the Spearman rank coefficient of correlation

d = the difference in rank of the items

$$d_i = x_i - y_i$$

N = the number of items being correlated.

If a significant number of ties occurred, then the coefficient was calculated by using the following equations.

$$r_x = \frac{\sum x^2 + \sum y^2 - \sum d^2}{2\sqrt{\sum x^2 \sum y^2}}$$

where $$\sum x^2 = \frac{N^3 - N}{12} - \sum t_x$$

and $$\sum y^2 = \frac{N^3 - N}{12} - \sum t_y$$

where $$t = \frac{t^3 - t}{12}$$

t = the number of observations tied at a given rank.

CHAPTER IV

PRESENTATION AND ANALYSIS OF THE DATA

The presentation of data in this chapter is organized around three major divisions of the research questions. These major divisions are supervisors' and technicians' data, technicians' data by years of experience, and technicians' data by major emphasis of work.

Supervisors' and Technicians' Data

The information presented in this section includes the usable data from 66 supervisors of electromechanical technicians and 137 electromechanical technicians from 57 industrial establishments. To rank the electromechanical tasks in Tables I, II, and III, the total number of interviewees indicating a frequency of use of daily, weekly, monthly or seldom was computed and then the tasks were ranked from the largest to smallest total.

To compare the ranking of tasks by the supervisors to that of the technicians, a Spearman rank coefficient of correlation r_s was calculated. This coefficient was .93 when the rankings of the electromechanical tasks by the supervisors was compared to the ranking by the technicians. The technicians tended to rank the mechanical and optical tasks higher on frequency of use while the supervisors ranked the fluid and thermal tasks higher. This is shown by a difference of 10 or more in the rank of three mechanical tasks gear ratios for maximum power transfer, gear

TABLE I

RANK ORDER OF ELECTROMECHANICAL TASKS BY FREQUENCY OF USE

Number of Respondents Indicating Each Frequency of Use

66 Supervisors					137 Technicians				
Task*	Daily	Weekly	Monthly	Seldom	Task*	Daily	Weekly	Monthly	Seldom
Potential differences in circuit	48	6	7	2	Current flow by use of instruments	53	33	16	15
Current flow by use of instruments	42	12	6	3	Potential differences in circuit	72	24	6	14
Inductance and/or capacitance	23	14	8	13	Circuit losses	33	17	16	36
Circuit losses	28	9	11	9	Thermocouples	23	25	26	27
Specifications of electronic components	14	21	15	7	Precision measuring instruments and precision tolerances	44	23	16	15
Integrated circuits	28	10	9	7	Inductance and/or capacitance	24	24	21	31
Thermocouples	15	16	14	9	Specifications of electronic components	33	22	18	27
X_C and/or X_L	19	9	6	19	Integrated circuits	26	23	14	33
Precision measuring instruments and precision tolerances	29	8	5	9	The gain of an amplifier	18	24	24	26
Rise and fall times	23	11	4	12	Thermal control devices	18	21	24	25
The gain of an amplifier	14	15	6	15	Pulse and logic circuits	34	17	14	22
Thermal control devices	15	9	10	16	Rise and fall times	22	21	15	27
Pulse and logic circuits	26	7	9	7	The effect of feedback loop components in electronic circuits	11	14	18	42
The effect of feedback loop components in electronic circuits	11	10	14	12	Bias networks	12	25	15	30
Bias networks	7	17	8	14	X_C and/or X_L	12	14	15	40
Heat sink and radiator capacities	8	7	8	22	Gear trains and linkage	12	24	24	18
Specifications and characteristics of fastening devices such as adhesives, bolts, rivets, screws and welds	11	11	7	16	Speed control mechanisms	16	16	18	27
Speed control mechanisms	13	10	9	12	Specifications and characteristics of fastening devices such as adhesives, bolts, rivets, screws and welds	22	12	12	29
Piezoelectric devices	6	4	5	28	Photosensitive devices	8	17	20	27
Antifriction devices and lubricants	13	8	11	11	Heat sink and radiator capacities	7	10	12	41
Micro electronic components, circuits, and packaging	15	4	13	11	Power converters and energy storage cell	10	11	19	30
Photosensitive devices	13	12	6	12	Mechanical indexing or sequenching devices	15	15	11	29
Power converters and energy storage cell	7	11	6	18	Micro electronic components, circuits, and packaging	24	10	11	24
Pressure drops in a system	11	12	10	8	Characteristics of materials such as, hardness, temperature characteristics, etc.	17	14	12	26
Rate of flow	15	11	7	8	Rate of flow	11	19	14	24
System losses due to pressure drops	10	11	10	10	Fluid regulators, sensors, switches and valves	11	16	15	26
Gear trains and linkages	13	8	11	9	Component values for tuned circuits	7	12	17	30
Thermal capacity and thermal resistance	8	5	10	18	Light intensity	8	18	18	21
Component values for tuned circuits	8	7	7	19	System power requirements dealing with pumps, compressors, etc.	21	10	12	20
Fluid regulators, sensors, switches and valves	13	8	7	12	Antifriction devices and lubricants	14	14	16	19
Mechanical servos	11	6	7	18	Power transmission systems such as belts, chains and drive shafts	12	19	15	17
Dew point or humidity	8	6	7	18	Thermal capacity and thermal resistance	8	12	17	26
Power transmission systems such as belts, chains and drive shafts	17	4	6	11	Pressure drops in a system	12	17	13	20
Mechanical indexing or sequenching devices	9	9	8	12	Stress and/or strain caused by static forces	9	14	10	27
Heat flow rates for temperature differential	8	4	5	20	Photo emittive devices	6	9	21	24
Power requirements of mechanical systems	6	4	6	21	Lens systems	11	16	15	17
Characteristics of materials such as, hardness, temperature characteristics, etc.	8	8	7	14	Piezoelectric devices	5	11	13	28

*Tasks as derived from instrument, prefaced by "do you work with or determine."

TABLE I (Continued)

Task	Daily	Weekly	Monthly	Seldom	Task	Daily	Weekly	Monthly	Seldom
Vibratory systems of analysis	4	5	14	13	Power requirements of mechanical systems	8	10	12	28
Fluid measuring devices	8	4	5	19	Gear ratios for maximum power transfer	4	7	10	37
Stress and/or strain caused by static forces	7	5	4	19	Mechanical servos	9	9	17	23
Heat losses	6	6	6	17	Transmission and delay lines	10	3	12	32
Transmission and delay lines	6	6	5	18	Vibratory systems or analysis	4	4	14	34
Light intensity	10	5	13	7	Rotational or translational rates	9	11	13	22
Specifications and characteristics of fittings, pipes and hoses	9	7	5	13	System losses due to pressure drops	3	10	17	24
Photo emittive devices	9	8	4	13	System response time	7	11	10	26
Transducers such as microphones and speakers	6	6	7	15	Bearing loadings and specifications	7	10	12	24
Rotational or translational rates	7	4	7	15	Industrial control and high power switching circuits	12	10	11	19
System power requirements dealing with pumps, compressors, etc.	12	7	9	5	Fluid measuring devices	10	8	13	20
Lens systems	8	6	13	6	Optical filters and polarizers	5	10	7	28
Industrial control and high power switching circuits	14	4	5	10	Specifications and characteristics of fittings, pipes and hoses	9	9	10	22
Thermal chambers	6	6	15	6	Spring constants and/or inertial values	4	6	10	29
System response time	7	7	7	11	Laminates plastics and ceramics	9	11	9	18
Gear ratios for maximum power transfer	3	5	4	19	Thermal chambers	10	13	9	15
Fluidic devices such as oscillators, sensors, switches, etc.	6	7	10	8	Coefficient of friction	4	8	8	26
Fluids servo devices	9	6	6	10	Heat losses	5	9	10	22
Coefficient of friction	4	2	7	17	Stresses and strains by dynamic force	6	11	11	18
Spring constants and/or inertial values	5	4	6	15	Fluidic devices such as oscillators, sensors, switches, etc.	7	8	8	22
Specific heat	6	5	2	17	Heat flow rates for temperature differential	10	7	5	22
Or adjust hydraulic servo systems to meet performance specifications	5	3	7	15	Transducers such as microphones and speakers	4	7	7	26
Laminates plastics and ceramics	6	7	5	12	Dew point of humidity	11	7	9	16
Fluid capacitance	6	3	9	11	Sound intensities	4	3	12	23
Stresses and strains by dynamic force	2	5	7	14	Specific heat	6	7	6	22
Bearing loadings and specifications	6	2	9	10	Sound frequencies	7	5	8	18
Thermal system efficiency	3	3	7	14	Light frequency	6	5	11	14
Sound intensities	3	3	5	16	Refrigeration and/or airconditioning systems	3	2	4	27
"k" factors	5	2	6	13	Thermal system efficiency	3	10	7	15
Sound frequencies	5	3	6	12	Fluid servo devices	3	4	8	20
Modulation percentage	4	7	5	10	Ultransonic	5	5	5	19
Refrigeration and/or airconditioning systems	7	4	6	9	Luminescent materials	2	2	8	26
Maximum power transfer in a system	3	5	5	12	Maximum power transfer in a system	2	3	9	19
Ultrasonic devices	6	10	4	5	Fluid characteristics or specifications	6	4	4	19
Fluid characteristics or specifications	7	2	7	8	Fluid capacitance	6	3	8	15
Optical filters and polarizers	5	5	8	5	Resonant conditions	5	2	8	15
Fluid actuator parameters	6	2	7	8	Or adjust hydraulic servo systems to meet performance specifications	1	5	7	17
Frequencies above 500 megahertz	4	6	0	12	Modulation percentage	2	4	6	17
Resonant conditions	5	2	3	12	"k" factors	3	2	4	19
Luminescent materials	4	5	6	6	Diffraction gratings	4	3	7	13
Light frequency	5	2	4	9	Frequencies above 500 megahertz	2	2	2	18
Antenna field strength	3	1	3	13	Cryogenic systems	4	4	4	11
Laser devices	2	3	5	9	Fluid actuator parameters	4	1	5	13
Sound absorption coefficients	1	2	3	11	Antenna field strength	0	2	3	16
Diffraction gratings	6	0	2	8	Laser devices	1	2	2	12
Cryogenic systems	3	2	3	7	Sound absorption coefficient	2	0	1	12
Velocity of sound in various media	0	4	1	5	Velocity of sound in various media	1	1	0	13

trains and linkages, and bearing loadings and specifications and the six optical tasks light intensity, lens systems, light frequency, optical filters and polarizers, photo emittive devices, luminescent material. The five fluid tasks and three thermal tasks ranked higher by the supervisors are system losses due to pressure drop fluid capacitance, fluid servo devices, adjust hydraulic servo systems to meet performance specifications, fluid measuring devices, heat flow rates for temperature differential, heat losses, dew point or humidity. Of the 21 selected electrical-electronic tasks listed in the instrument, the supervisors ranked 14 in the upper quartile and the technicians ranked 13 in the upper quartile. The supervisors ranked five of the nine optical tasks and six of the seven acoustical tasks in the lower quartile. The technicians ranked four optical and five acoustical tasks in the lower quartile.

The information presented in Tables II, III, and IV pertain to the area of activity of task performance by the supervisors and technicians. The tasks are ranked according to the frequency of use as they were in Table I. The numbers in each row indicate the percent of respondents indicating that activity for the task. (Note: These percentages might not equal 100 percent because of rounding off.) Table II is the information from the supervisor's questionnaires and Table III is the information from the technician's questionnaires. The information in Table IV is the percent of respondents for each area of activity as indicated by the supervisors and technicians.

The activities most often indicated by the supervisors and technicians were Analyzing, Troubleshooting, and Testing. Construction was the next highest for both supervisors and technicians. None of the

TABLE II

AREA OF ACTIVITY OF TASK PERFORMANCE: 66 SUPERVISORS

Task*	Percent of Respondents Indicating Each Area of Activity										
	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
Potential differences in circuit	6.3	4.8	15.9	42.9	1.6	19.0	3.2	3.2		1.6	1.6
Current flow by use of instruments	3.2	4.8	17.5	39.7		23.8	3.2	4.8		1.6	1.6
Inductance and/or capacitance	3.4	1.7	15.5	37.9		24.4	6.9	5.2	1.7	3.4	1.7
Circuit losses	3.5	1.8	31.6	40.4		17.5	1.8			3.5	
Specifications of electronic components		14.0	15.8	17.5		22.8	19.3		5.3	1.8	3.5
Integrated circuits	7.4		13.0	29.6	3.7	24.1	13.0		1.9	3.7	3.7
Thermocouples	3.7		7.4	29.6	7.4	33.3	5.6	5.6	1.9		5.6
X_C and/or X_L	3.8	1.9	32.1	26.4		22.6	5.7	3.8		1.9	1.9
Precision measuring instruments and precision tolerances	3.9	5.9	11.8	25.5	7.8	15.7	11.8	5.9	3.9	3.9	3.9
Rise and fall times	4.0	4.0	28.0	32.0		22.0	6.0	2.0			2.0
The gain of an amplifier	2.0	6.0	24.0	30.0		26.0			4.0	6.0	2.0
Thermal control devices	4.0	2.0	6.0	32.0	8.0	26.0	6.0	4.0	4.0		8.0
Pulse and logic circuits		6.1	16.3	32.7	2.0	22.4	14.3			4.1	2.0
The effect of feedback loop components in electronic circuits			23.4	40.4		23.4	2.1	2.1	2.1	2.1	
Bias networks	4.3	8.7	15.2	37.0		21.7	10.9		2.2		
Heat sink and radiator capacities	2.2	8.9	26.7	17.8	13.3	15.6	6.7	2.2	4.4		2.2
Specifications and characteristics of fastening devices such as adhesives, bolts, rivets, screws and welds	4.4	11.1	11.1	8.9	13.3	17.8	22.2		8.9		2.2
Speed control mechanisms	2.3	9.1	9.1	36.4	4.5	22.7	9.1	2.3			4.5
Piezoelectric devices	2.3	4.7	11.6	20.9	4.7	27.9	11.6	2.3		7.0	7.0
Antifriction devices and lubricants	2.3	2.3	14.0	25.6	2.3	14.0	11.6		4.7	23.3	
Micro electronic components, circuits, and packaging		7.0	18.6	27.9	9.3	18.6	9.3			4.7	4.7
Photosensitive devices	4.7	2.3	20.9	34.9	2.3	16.3	4.7	2.3		7.0	4.7
Power converters and energy storage cell	2.1	7.1	9.5	35.7		26.2	7.1	2.4		9.5	
Pressure drops in a system	4.9	2.4	12.2	34.1	2.4	24.4	4.9	2.4	2.4	7.3	2.4
Rate of flow	4.9	2.4	19.5	26.8	2.4	29.3	2.4	2.4		7.3	7.4
System losses due to pressure drops	2.4	2.4	14.6	39.0	4.9	19.5	2.4	2.4	4.9	4.9	2.4
Gear trains and linkages	2.4	4.9	14.6	29.3	7.3	12.2	12.2	2.4	9.8	2.4	2.4
Thermal capacity and thermal resistance		2.4	19.5	26.8	2.4	31.7	7.3	2.4			7.3
Component values for tuned circuits	4.9	2.4	24.4	26.8	2.4	19.5	7.3	2.4	4.9	2.4	2.4
Fluid regulators, sensors, switches and valves	5.0	10.0	5.0	35.0	2.5	17.5	7.5		2.5	7.5	7.5
Mechanical servos	2.6	10.3	2.6	28.2	5.1	25.6	10.3		7.7	2.6	5.1
Dew point or humidity	2.6		15.4	17.9	7.7	38.5		7.7			10.3
Power transmission systems such as belts, chains and drive shafts	5.3	5.3	2.6	39.5	7.9	7.9	10.5		15.8	2.6	2.6
Mechanical indexing or sequenching devices		7.9	13.2	31.6	7.9	15.8	10.5		10.5		2.6
Heat flow rates for temperature differential			27.0	21.6		24.3	5.4	5.4	2.7		13.5
Power requirements of mechanical systems	2.7	8.1	18.9	16.2	5.4	16.2	13.5		8.1	5.4	5.4
Characteristics of materials such as hardness, temperature characteristics, etc.	2.7	5.4	21.6	16.2	5.4	32.4	5.4			2.7	8.1
Vibratory systems cr analysis	2.8	5.6	16.7	27.8		36.1	5.6				5.6
Fluid measuring devices	5.6	2.8	8.3	27.8	5.6	30.6	5.6	5.6	5.6	2.8	
Stress and/or strain caused by static forces	2.9	5.7	14.3	25.7		28.6	11.4		5.7		5.7
Heat losses	2.9	2.9	28.6	20.0	2.9	22.9	2.9	2.9		5.7	8.6
Transmission and delay lines	5.7		5.7	37.1	5.7	31.4	5.7	5.7		2.9	
Light intensity	5.7		25.7	25.7	2.9	23.9	5.7	5.7	2.9		2.9

*Tasks as derived from instrument, prefaced by "do you work with or determine."

TABLE II (Continued)

Task	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
Specifications and characteristics of fittings, pipes and hoses	2.9	11.8	5.9	11.8	14.7	11.8	14.7		17.6	5.9	2.9
Photo emittive devices	2.9	2.9	17.6	38.2	5.9	14.7	2.9	2.9	2.9	5.9	2.9
Transducers such as microphones and speakers	5.9		17.6	17.6	5.9	26.5	2.9	5.9	5.9	5.9	5.9
Rotational or translational rates		6.1	6.1	18.2		27.3	18.2	3.0	12.1		9.1
System power requirements dealing with pumps, compressors, etc.	3.1	3.1	12.5	21.9	6.3	25.0		9.4	6.3	3.1	9.4
Lens systems	3.0		15.2	27.3	9.1	15.2	9.1	12.1	3.0	3.0	3.0
Industrial control and high power switching circuits	3.0	9.1	9.1	39.4	6.1	15.2	9.1		6.1		3.0
Thermal chambers	3.0	3.0	6.1	18.2		42.4	9.1	6.1	3.0	3.0	6.1
System response time	3.1	3.1	15.6	34.4		37.5	3.1	3.1			
Gear ratios for maximum power transfer		22.6	12.9	6.5	3.2	16.1	9.7		16.1	9.7	3.2
Fluidic devices such as oscillators, sensors, switches, etc.	3.2	9.7	9.7	29.8	6.5	25.8	6.5	3.2	3.2	3.2	
Fluids servo devices		6.5	9.7	35.5	6.5	19.4	3.2	6.5		6.5	6.5
Coefficient of friction	3.3	3.3	10.0	20.0		30.0	13.3		13.3		6.7
Spring constants and/or inertial values		3.3	20.0	16.7		23.3	16.7	6.7	10.0	3.3	
Specific heat	3.3	10.0	23.3	16.7	3.3	26.7				10.0	6.7
Or adjust hydraulic servo systems to meet performance specifications	6.7	10.0		36.7	6.7	23.3		6.7	3.3	6.7	
Laminates plastics and ceramics	3.3	6.7	16.7	10.0	3.3	16.7	23.3		13.3	6.7	
Fluid capacitance		3.4	10.3	31.0	3.4	31.0	13.8	3.4		3.4	
Stresses and strains by dynamic force	7.1	3.6	14.3	25.0		28.6	10.7	3.6	7.1		
Bearing loadings and specifications	3.7	11.1	14.8	18.5	3.7	29.6	7.4		7.4		3.7
Thermal system efficiency	3.7	7.4	33.3	14.8		25.9			3.7		11.1
Sound intensities	7.4	3.7	18.5	18.5	7.4	29.6	3.7	7.4		3.7	
"k" factors	3.8		42.3	15.4	3.8	11.5			3.8	7.7	11.5
Sound frequencies	3.8		26.9	15.4	3.8	34.6	3.8	3.8		7.7	
Modulation percentage	3.8		15.4	23.1		42.3		7.7		3.8	3.8
Refrigeration and/or airconditioning systems	3.8		11.5	26.9	7.7	23.1	7.7		3.8	7.7	7.7
Maximum power transfer in a system		4.0	24.0	24.0	4.0	24.0	8.0	8.0		4.0	
Ultrasonic devices	8.0		12.0	28.0		20.0	8.0	4.0	4.0	4.0	12.0
Fluid characteristics of specifications		12.5	29.2	16.7	4.2	20.8	4.2			4.2	8.3
Optical filters and polarizers		8.7	21.7	8.7	17.4	34.8	4.3				4.3
Fluid actuator parameters	4.3	8.7	17.4	26.1	4.3	17.4	4.3		4.3	8.7	4.3
Frequencies above 500 megahertz	9.1	4.5	13.6	13.6		36.4	9.1	4.5	4.5		4.5
Resonant conditions	4.5		27.3	27.3	4.5	22.7	4.5	4.5	4.5		
Luminescent materials	4.8	4.8	23.8	19.0	14.3	19.0	4.8	4.8			4.8
Light frequency	4.0		45.0	10.0		20.0	5.0	10.0			5.0
Antenna field strength	5.0	5.0	20.0	15.0	10.0	30.0		10.0		5.0	
Laser devices			21.1	15.8	10.5	26.3	10.5	10.5			5.3
Sound absorption coefficients	6.3		31.3	25.0	18.8	6.3	6.3			6.3	
Diffraction gratings	6.3		18.8	18.8	6.3	12.5	6.3	6.3	6.3	6.3	12.5
Cryogenic systems		6.7	6.7	26.7		20.0	6.7			13.3	20.0
Velocity of sound in various media	10.0		40.0	40.0			10.0				

TABLE III

AREA OF ACTIVITY OF TASK PERFORMANCE: 137 TECHNICIANS

	Percent of Respondents Indicating Each Area of Activity										
Task*	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
Current flow by use of instruments	0.8	3.4	11.9	32.2	1.7	32.2	3.4	5.1	4.2	0.8	4.2
Potential differences in circuit	0.9	3.4	13.8	43.1	0.9	25.0	1.7	3.4	5.2		2.6
Circuit losses	1.0	2.0	20.6	33.3	1.0	26.5	4.9	3.9	2.9	1.0	2.9
Thermocouples	3.0		10.9	20.8	12.9	35.6	3.0	5.9	3.0		5.0
Precision measuring instruments and precision tolerances	2.0	2.0	16.8	13.9	1.0	26.7	11.9	12.9	7.9	1.0	4.0
Inductance and/or capacitance	1.0	6.0	20.0	19.0		27.0	11.0	8.0	4.0	4.0	
Specifications of electronic components	1.0	6.0	21.0	13.0	2.0	25.0	18.0	4.0	8.0	2.0	
Integrated circuits	2.1	2.1	17.7	30.2	3.1	21.9	12.5	1.0	6.3	1.0	3.1
The gain of an amplifier	1.1	4.3	17.4	18.5		31.5	5.4	10.9	3.3	3.3	4.3
Thermal control devices	1.1		11.4	25.0	6.8	30.7	4.5	5.7	8.0	2.3	4.5
Pulse and logic circuits	3.4	3.4	17.2	29.9	1.1	27.6	6.9	1.1	4.6	1.1	3.4
Rise and fall times		3.5	22.4	21.2		38.8	4.7	4.7	3.5		1.2
The effect of feedback loop components in electronic circuits	1.2	1.2	20.0	28.2		24.7	11.8	3.5	5.9	3.5	
Bias networks		1.2	14.6	24.4		30.5	18.3	3.7	3.7		
X_C and/or X_L	1.2	3.7	37.0	16.0		24.7	8.6	2.5	4.9	1.2	
Gear trains and linkages	1.3	2.6	11.7	26.0	7.8	19.5	10.4	3.9	10.4	1.3	5.2
Speed control mechanisms	1.3	3.9	11.7	27.3	9.1	22.1	7.8	3.9	6.5	2.6	3.9
Specifications and characteristics of fastening devices such as adhesives, bolts, rivets, screws and welds	1.3	5.3	16.0	5.3	13.3	13.3	30.7	1.3	9.3	2.7	1.3
Photosensitive devices	2.8	1.4	15.3	22.2	5.6	23.6	11.1	8.3	2.8	2.8	4.2
Heat sink and radiator capacities		4.3	20.0	15.7	7.1	25.7	20.0			2.9	4.3
Power converters and energy storage cell		1.4	10.0	22.9	4.3	30.0	11.4	4.3	5.7	8.6	1.4
Mechanical indexing or sequenching devices	4.3	1.4	8.6	34.3	11.4	15.7	11.4	1.4	7.1	2.9	1.4
Micro electronic components, circuits, and packaging	2.9	2.9	17.4	26.1	1.4	24.6	17.4		1.4	2.9	2.9
Characteristics of materials such as, hardness, temperature characteristics, etc.	1.4	2.9	23.2	5.8	4.3	30.4	18.8	1.4	7.2	2.9	1.4
Rate of flow		1.5	11.8	26.5	4.4	32.4	5.9	8.8	5.9	1.5	1.5
Fluid regulators, sensors, switches and valves			5.9	36.8	7.4	23.5	5.9	2.9	8.8	2.9	5.9
Component values for tuned circuits		10.6	22.7	15.2		22.7	12.1	9.1	4.5	1.5	1.5
Light intensity			23.1	23.1	4.6	26.2	7.7	6.2	3.1	1.5	4.6
System power requirements dealing with pumps, compressors, etc.			9.5	30.2	6.3	34.9	3.2	4.8	3.2	3.2	4.8
Antifriction devices and lubricants	1.6		6.3	15.9	6.3	17.5	12.7	1.6	7.9	27.0	3.2
Power transmission systems such as belts, chains and drive shafts	1.6		6.3	27.0	6.3	14.3	14.3	3.2	19.0	3.2	4.8
Thermal capacity and thermal resistance			19.0	23.8	1.6	39.7	7.9	4.8		1.6	1.6
Pressure drops in a system	1.6	1.6	14.5	32.3	1.6	29.0	4.8	4.8	3.2	3.2	3.2
Stress and/or strain caused by static forces	1.7		21.7	25.0	5.0	25.0	10.0	3.3	1.7	3.3	3.3
Photo emittive devices	1.7	1.7	16.7	23.3	5.0	26.7	10.0	6.7	1.7	3.3	3.3
Lens systems			16.9	18.6	6.8	30.5	10.2	1.7	6.8	3.4	5.1
Piezoelectric devices			17.5	19.3	1.8	24.6	12.3	12.3	7.0	3.5	1.8
Power requirements of mechanical systems	1.7	1.7	19.0	13.8	10.3	24.1	13.8		6.9	3.4	5.2
Gear ratios for maximum power transfer	1.7	3.4	12.1	22.4	13.8	13.8	19.0	1.7	5.2	6.9	8.9
Mechanical servos	1.7		12.1	25.9	6.9	27.6	1.7	1.7	10.3	5.2	6.9
Transmission and delay lines	3.5		17.5	12.3		40.4	12.3	5.3	5.3	3.5	
Vibratory systems or analysis	1.8		17.9	23.2	5.4	33.9	5.4	5.4	1.8	3.6	1.8
Rotational or translational rates	1.8		20.0	18.2	3.6	30.9	10.9	7.3	1.8		5.5

*Tasks as derived from instrument, prefaced by "do you work with or determine."

TABLE III (Continued)

Task	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
System losses due to pressure drops		1.9	9.3	31.5	3.7	35.2	5.6	3.7	3.7	1.9	3.7
System response time		3.7	13.0	29.6	1.9	31.5	3.7	7.4	1.9	1.9	5.6
Bearing loadings and specifications	1.9		15.1	11.3	13.2	24.5	15.1		7.5	9.4	1.9
Industrial control and high power switching circuits	3.8		15.4	36.5	1.9	15.4	11.5	1.9	7.7	1.9	3.8
Fluid measuring devices			2.0	30.0	6.0	24.0	4.0	2.0	14.0	6.0	12.0
Optical filters and polarizers		2.0	18.0	16.0	10.0	24.0	8.0		6.0	2.0	14.0
Specifications and characteristics of fittings, pipes and hoses	2.0	4.0	10.0	14.0	14.0	16.0	26.0	2.0	8.0		4.0
Spring constants and/or inertial values			10.2	20.4	6.1	26.5	24.5	6.1	4.1	2.0	
Laminates plastics and ceramics	2.1	2.1	23.4	4.3	4.3	21.8	29.8	2.1	4.3	4.3	2.1
Thermal chambers			10.6	14.9	4.3	48.9	6.4		2.1		12.8
Coefficient of friction	2.2		19.6	23.9	4.3	26.1	17.4	4.3		2.2	
Heat losses	2.2		26.1	17.4	4.3	37.0	8.7		2.2		2.2
Stresses and strains by dynamic force			20.0	11.1	2.2	26.7	15.6	6.7	6.7	2.2	
Fluidic devices such as oscillators, sensors, switches, etc.		2.2	8.9	26.7	6.7	28.9	8.9	6.7	4.4	2.2	4.4
Heat flow rates for temperature differential			20.5	15.9	4.5	31.8	9.1	9.1	2.3	2.3	4.5
Transducers such as microphones and speakers			18.2	22.7	6.8	29.5	9.1	2.3	6.8		4.5
Dew point or humidity			25.6	11.6	7.0	37.2	9.3	4.7	2.3		2.3
Sound intensities		2.4	26.2	19.0	2.4	23.8	11.9		4.8	2.4	7.1
Specific heat			19.5	17.1	4.9	36.6	12.2	4.9		4.9	
Sound frequencies		2.6	26.3	15.8	2.6	26.3	10.5		5.3	2.6	7.9
Light frequency			33.3	25.0	2.8	30.6	2.8				5.6
Refrigeration and/or airconditioning systems			11.1	11.1	8.3	25.0	11.1				14.8
Thermal system efficiency			25.7	11.4		42.9	11.4	2.9			5.7
Fluid servo devices			8.6	17.1	2.9	28.6	8.6	5.7	11.4	11.4	5.7
Ultransonic devices			14.7	17.6	5.9	26.5	8.8		8.8		17.6
Luminescent materials	2.9		26.5	5.9	5.9	17.6	20.6	5.9		8.8	5.9
Maximum power transfer in a system			12.1	18.2	6.1	42.4	9.1	3.0	6.1		3.0
Fluid characteristics or specifications			24.2	15.2	6.1	36.4	6.1	3.0		6.1	3.0
Fluid capacitance			15.6	15.6	6.3	25.0	9.4	15.6		9.4	3.1
Resonant conditions			26.7	10.0	3.3	36.7	6.7	10.0	3.3		3.3
Or adjust hydraulic servo systems to meet performance specifications			3.3	26.7	3.3	13.3	6.7	16.7	10.0	10.0	10.0
Modulation percentage		3.4	31.0	20.7		10.3		20.7	3.4	3.4	6.9
"k" factors			32.1	17.9		32.1	7.1	3.6	7.1		
Diffraction gratings			22.2	22.2	7.4	22.2	11.1				14.8
Frequencies above 500 megahertz			29.2	8.3	4.2	29.2	20.8	4.2	4.2		
Cryogenic systems			4.3	17.4	8.7	43.5					26.1
Fluid actuator parameters			8.7	30.4	13.0	21.7	8.7		4.3	4.3	8.7
Antenna field strength		4.8	23.8	19.0		33.3	4.3	9.5			4.8
Laser devices			11.8	11.8	5.9	41.2	5.9	5.9	5.9		11.8
Sound absorption coefficient			33.3	20.0	6.7	13.3	20.0				6.7
Velocity of sound in various media			33.3	6.7	13.3	33.3					13.3

remaining activities were indicated as primary activities by more than 5.1 percent of the responding supervisors or technicians.

TABLE IV

PERCENT OF RESPONDENTS FOR EACH AREA OF ACTIVITY

Area of Activities	Percent of Supervisors Responding	Percent of Technicians Responding
Instructing	3.1	1.0
Modifying	4.9	1.8
Analyzing	16.8	16.8
Troubleshooting	26.9	21.8
Installing	4.0	4.5
Testing	23.3	27.4
Constructing	7.4	10.3
Calibrating	2.8	4.4
Repairing	3.4	5.1
Servicing	3.5	2.8
Operating	3.8	3.9

The eleven selected communication tasks are ranked according to the number of respondents indicating a frequency of use. The ranking of the communication tasks for supervisors and technicians are shown in Table V. The coefficient of correlation between the ranking of these tasks by

TABLE V

COMMUNICATION TASKS FREQUENCY OF USE

Number of Respondents Indicating a Frequency of Use And Rank of Tasks

Task	66 Supervisors	Rank	137 Technicians	Rank	28 Technicians 0-2 Years	Rank	43 Technicians 3-5 Years	Rank	31 Technicians 6-10 Years	Rank	35 Technicians Over 10 Years	Rank	48 Technicians R & D	Rank	28 Technicians Production	Rank	52 Technicians Maintenance	Rank	9 Technicians Others	Rank
Read engineering drawings and/or schematics	64	1.5	125	1.5	24	1.0	37	1.0	30	2.5	34	1.0	47	2.5	23	2.0	46	1.0	9	1.5
Read specifications	64	1.5	125	1.5	22	2.5	30	5.0	31	1.0	32	2.0	47	2.5	24	1.0	45	2.0	9	1.5
Present findings orally	60	3.5	112	3.0	20	4.0	34	2.0	30	2.5	30	3.0	45	4.0	20	3.0	39	3.0	8	3.5
Prepare graphs and charts	60	3.5	104	4.0	16	5.0	33	3.0	29	4.0	26	4.0	48	1.0	17	6.5	31	5.0	8	3.5
Prepare evaluation reports	59	5.0	93	6.0	15	6.0	29	6.0	27	5.0	22	5.0	44	5.5	18	5.0	25	6.5	6	5.5
Participate in training and teaching activities (formal and informal)	57	6.0	97	5.0	22	2.5	31	4.0	23	8.0	21	6.0	39	7.5	19	4.0	33	4.0	6	5.5
Fill in evaluation sheets	53	7.0	83	7.5	14	7.0	25	8.0	24	6.5	20	7.5	39	7.5	17	6.5	22	8.0	5	7.0
Prepare specifications	49	8.0	83	7.5	13	8.0	26	7.0	24	6.5	20	7.5	44	5.5	10	9.0	25	6.5	4	8.0
Participate in engineering management and customer planning sessions	46	9.5	48	9.0	6	10.0	16	9.5	15	10.0	11	9.0	21	10.0	10	9.0	14	10.0	3	9.5
Participate in engineering management and customer evaluation sessions	46	9.5	46	10.0	4	11.0	16	9.5	16	9.0	10	10.0	22	9.0	10	9.0	11	11.0	3	9.5
Computer programming	28	11.0	40	11.0	11	9.0	14	11.0	9	11.0	6	11.0	18	11.0	4	11.0	16	9.0	2	11.0

TABLE VI

MATHEMATICS TASK FREQUENCY OF USE

Number of Respondents Indicating a Frequency of Use And Rank of Tasks

Task	66 Supervisors	Rank	137 Technicians	Rank	28 Technicians 0-2 Years	Rank	43 Technicians 3-5 Years	Rank	31 Technicians 6-10 Years	Rank	35 Technicians Over 10 Years	Rank	48 Technicians R & D	Rank	28 Technicians Production	Rank	52 Technicians Maintenance	Rank	9 Technicians Others	Rank
Basic Arithmetic	64	1.0	134	1.0	25	1.0	43	1.0	31	1.0	35	1.0	48	1.0	26	1.0	51	1.0	9	1.0
Graphs	60	2.0	109	3.0	19	3.0	36	2.0	30	2.5	24	2.0	47	2.0	19	3.0	36	2.0	7	2.5
Linear equation with one unknown	59	3.0	111	2.0	21	2.0	35	3.0	30	2.5	23	3.0	46	3.0	21	2.0	35	3.0	7	2.5
Linear equation with two or more unknowns	52	4.0	93	4.0	17	5.0	30	4.0	25	4.5	21	4.0	43	4.0	•17	4.0	28	4.5	5	5.0
Decibels	50	5.0	76	8.5	15	6.5	27	7.5	21	8.5	13	9.5	35	9.0	14	5.5	23	9.0	4	9.0
Vectors	49	6.5	83	7.0	15	6.5	28	5.5	21	8.5	19	5.5	40	6.5	12	7.5	26	6.0	5	5.0
Solution of right triangles	49	6.5	84	5.5	14	8.0	28	5.5	23	6.0	19	5.5	40	6.5	14	5.5	25	7.5	5	5.0
Exponents & radicals	48	8.0	84	5.5	18	5.0	27	7.5	25	4.5	14	8.0	41	5.0	11	9.0	28	4.5	4	9.0
Logarithms	46	9.0	76	8.5	12	11.0	24	10.0	22	7.0	18	7.0	38	8.0	12	7.5	22	10.0	4	9.0
Quadratic equations	44	10.5	64	10.5	12	11.0	24	10.0	17	11.0	11	14.0	34	10.0	6	13.5	21	11.5	3	12.0
Binary Arithmetic	44	10.5	58	12.0	12	11.0	19	15.0	14	14.5	13	9.5	25	17.0	8	10.5	25	7.5	0	18.0
Determinants	42	12.0	56	14.0	12	11.0	24	10.0	12	17.0	8	15.5	28	14.5	6	13.5	20	13.0	2	14.5
Complex numbers (J-operator)	40	13.5	55	15.0	9	16.5	21	14.0	13	16.0	12	12.0	29	13.0	6	13.5	16	16.5	4	9.0
Solution of oblique triangles	40	13.5	64	10.5	11	14.5	22	12.5	19	10.0	12	12.0	31	11.0	8	10.5	21	11.5	4	9.0
Analytic Geometry	38	15.0	57	13.0	12	11.0	22	12.5	16	12.0	7	17.5	30	12.0	6	13.5	19	14.0	2	14.5
Booleon Algebra	37	16.0	47	17.0	11	14.5	16	17.5	8	18.5	12	12.0	24	18.0	5	16.0	18	15.0	0	18.0
Differentiation	35	17.0	46	18.0	3	18.0	17	16.0	14	14.5	7	17.5	28	14.5	3	18.5	13	18.0	2	14.5
Integration	34	18.0	48	16.0	9	16.5	16	17.5	15	13.0	8	15.5	26	16.0	4	17.0	16	16.5	2	14.5
Basic differential equa.	31	19.0	39	19.0	7	19.0	15	19.0	8	18.5	5	19.0	20	19.0	3	18.5	12	19.0	0	18.0

the supervisors and technicians was .98. The difference in rank of any one of the communication tasks, as ranked by the supervisors and technicians, was never larger than one.

In Table VI the 19 selected mathematic tasks are ranked according to the number of respondents indicating a frequency of use. The coefficient of correlation between the ranking by supervisors and technicians was .96. The largest difference in the ranking of the mathematical tasks was 3.5. The supervisors ranked the task, decibels, fifth while it was ranked between eighth and ninth by the technicians. The task, determinants, was ranked twelfth by the supervisors and fourteenth by the technicians. Four tasks ranked higher by the technicians were exponents and radicals, solution of oblique triangles, analytic geometry, and integration. These four tasks had a difference in rank of at least two.

In Table VII the eight selected shop tools are ranked according to the respondents indicating a frequency of use. The coefficient of correlation between the ranking for supervisors and technicians was .92. The difference in ranking of the shop tools was never greater than two. The drill press was ranked first and abrasive power tools second by both supervisors and technicians. Four shop tools ranked higher by supervisors were power saws, lathe, milling machine, and arc welder. Two shop tools ranked higher by technicians were sheet metal tools and gas welder.

In Table VIII the 36 selected test equipment items were ranked according to the number of respondents indicating a frequency of use. The coefficient of correlation between the ranking for the supervisors and technicians was .94. The largest difference in the ranking of the test equipment was 10.5. The supervisors ranked the item, pulse

TABLE VII

SHOP TOOLS FREQUENCY OF USE

Items	Number of Respondents Indicating a Frequency of Use and Rank of Items																			
	66 Supervisors	Rank	137 Technicians	Rank	28 Technicians 0-2 Years	Rank	43 Technicians 3-5 Years	Rank	31 Technicians 6-10 Years	Rank	35 Technicians Over 10 Years	Rank	48 Technicians R & D	Rank	28 Technicians Production	Rank	52 Technicians Maintenance	Rank	9 Technicians Others	Rank
Drill Press	52	1.0	111	1.0	20	1.0	34	1.0	23	1.0	34	1.0	42	1.0	17	1.0	44	1.0	8	1.0
Abrasive power tools	46	2.0	89	2.0	14	3.0	25	3.0	20	2.0	30	2.0	23	5.5	13	2.5	35	2.0	4	3.0
Power saws	41	3.0	79	4.0	8	4.5	26	2.0	18	4.5	27	3.0	32	3.5	13	2.5	30	3.0	4	3.0
Lathe	38	4.5	59	5.0	4	8.0	21	4.0	18	4.5	16	5.5	32	3.5	7	6.5	19	6.0	2	5.5
Sheet metal tools	38	4.5	81	3.0	16	2.0	20	5.0	19	3.0	26	4.0	38	2.0	11	4.0	28	4.0	4	3.0
Milling machine	29	6.0	40	7.0	6	6.0	16	6.0	8	8.0	10	8.0	4	7.0	4	8.0	14	7.0	1	7.0
Arc welder	27	7.5	39	8.0	5	7.0	12	8.0	10	7.0	12	7.0	3	8.0	8	5.0	13	8.0	0	8.0
Gas welder	27	7.5	53	6.0	8	4.5	15	7.0	14	6.0	16	5.5	23	5.5	7	6.5	21	5.0	2	5.5

TABLE VIII

TEST EQUIPMENT FREQUENCY OF USE

Number of Respondents Indicating a Frequency of Use and Rank of Tasks

Items	66 Supervisors	Rank	137 Technicians	Rank	28 Technicians 0-2 Years	Rank	43 Technicians 3-5 Years	Rank	31 Technicians 6-10 Years	Rank	35 Technicians Over 10 Years	Rank	48 Technicians R & D	Rank	28 Technicians Production	Rank	52 Technicians Maintenance	Rank	9 Technicians Others	Rank
VOM-VTVM-TVM	60	1.0	127	1.0	25	1.0	38	1.0	31	1.0	33	1.0	46	2.0	24	1.0	48	1.0	9	2.0
Oscilloscope	59	2.0	112	2.5	20	3.0	35	2.0	30	2.0	27	6.0	45	5.0	22	2.0	36	3.5	9	2.0
Pressure Gages	55	4.0	90	12.0	18	5.0	17	16.5	24	8.5	22	13.0	32	16.5	18	5.5	34	6.5	6	13.0
Thermocouple instruments	55	4.0	99	6.5	17	7.0	29	10.0	24	8.5	29	3.0	42	8.0	14	13.5	37	2.0	6	13.0
Impedance Bridge	55	4.0	98	8.5	17	7.0	32	7.5	23	13.5	26	7.5	40	11.0	14	13.5	31	9.5	8	5.5
Regulated Power supplies	54	7.0	112	2.5	21	2.0	34	4.0	28	3.5	29	3.0	46	2.0	21	3.0	36	3.5	9	2.0
Plotters and Recorders	54	7.0	99	6.5	16	10.5	32	7.5	23	13.5	28	5.0	43	7.0	14	13.5	34	6.5	8	5.5
Thermometer	44	7.0	98	8.5	17	7.0	28	12.0	24	8.5	29	3.0	41	9.0	16	10.0	34	6.5	7	9.0
Slide rule	53	9.0	105	4.0	19	4.0	33	6.0	28	3.5	25	9.0	46	2.0	17	7.5	34	6.5	8	5.5
Micrometer	52	10.0	101	5.0	16	10.5	34	4.0	25	6.0	26	7.5	45	5.0	18	5.5	31	9.5	7	9.0
Signal Gen.	51	11.0	96	11.0	16	10.5	30	9.0	27	5.0	23	11.5	40	11.0	20	4.0	29	12.0	7	9.0
Pulse Gen.	49	12.5	86	13.0	13	14.0	28	12.0	22	17.0	23	11.5	40	11.0	16	10.0	25	16.5	5	19.0
Desk Calculator	49	12.5	71	17.0	12	15.5	21	20.0	20	18.0	18	16.5	33	15.0	8	21.0	25	16.5	5	19.0
Vernier Caliper	48	14.0	97	10.0	16	10.5	34	4.0	23	13.5	24	10.0	45	5.0	17	7.5	27	14.0	8	5.5
Freq. Meter	47	15.5	81	14.0	12	15.5	27	14.5	23	13.5	19	14.5	34	14.0	14	13.5	28	13.0	5	19.0
Tachometer	47	15.5	70	18.5	11	17.0	28	12.0	17	19.5	14	20.5	31	18.0	8	21.0	26	15.0	5	19.0
Pyrometers	44	17.0	66	20.0	10	18.5	21	20.0	17	19.5	18	16.5	29	19.5	8	21.0	24	18.0	5	19.0
Flow Meters	43	18.5	76	15.5	15	13.0	21	20.0	24	8.5	16	18.0	27	23.0	13	16.0	30	11.0	6	13.0
Strobelight	43	18.5	76	15.5	7	23.0	27	14.5	23	13.5	19	14.5	38	13.0	9	18.5	23	19.0	6	13.0
Torque Meter	39	20.0	70	18.5	9	20.0	26	16.5	23	13.5	12	24.5	32	16.5	16	10.0	17	21.5	5	19.0
Strain gages	38	21.0	54	22.0	7	23.0	17	22.0	16	21.5	14	20.5	28	21.5	6	24.5	14	24.5	6	13.0
Curve Tracer	37	22.5	62	21.0	10	18.5	22	18.0	16	21.5	14	20.5	29	19.5	12	17.0	17	21.5	4	23.0
Light meter	37	22.5	43	25.0	5	29.0	13	27.5	13	25.5	12	24.5	20	26.5	3	32.0	18	20.0	2	28.5
SWR Meter	36	24.0	47	23.0	6	26.0	15	23.5	13	25.5	13	23.0	20	26.5	9	18.5	16	23.0	2	28.5
Hydrometers	35	25.0	46	24.0	6	26.0	15	23.5	11	28.5	14	20.5	23	25.0	7	23.0	14	24.5	2	28.5
Hardness Tester	32	26.0	32	32.0	5	29.0	9	35.0	10	31.0	8	30.5	19	28.5	2	34.5	10	30.0	1	32.5
Force Gages	31	27.0	42	26.5	5	29.0	14	25.5	15	23.0	8	30.5	26	24.0	4	29.0	9	34.0	3	24.5
Spectrometer	29	28.5	33	30.0	4	31.5	10	32.5	10	31.0	9	27.5	16	32.5	3	32.0	12	26.5	2	28.5
Tension Tester	29	28.5	34	28.0	8	21.0	10	32.5	8	34.0	8	30.5	19	28.5	6	24.5	9	34.0	0	35.0
Compression Tester	28	30.5	30	33.5	7	23.0	11	31.0	5	36.0	7	34.0	16	32.5	4	29.0	10	30.0	0	35.0
Accelerometers	28	30.5	42	26.5	4	31.5	14	25.5	14	24.0	10	26.0	28	21.5	1	36.0	8	36.0	5	19.0
Viscosity Meters	27	32.0	28	36.0	6	26.0	9	35.0	8	34.0	5	36.0	12	36.0	4	29.0	12	26.5	0	35.0
Noise Gen.	26	33.0	33	30.0	2	34.0	12	29.5	10	31.0	9	27.5	16	32.5	5	26.5	10	30.0	2	28.5
Wave Analyzer	25	34.5	33	30.0	2	34.0	13	27.5	11	28.5	7	34.0	16	32.5	5	26.5	10	30.0	2	28.5
Sound intensity meter	25	34.5	29	35.0	1	36.0	9	35.0	12	27.0	7	34.0	14	35.0	3	32.0	9	34.0	3	24.5
Spectrum Analyzer	24	36.0	30	33.5	2	34.0	12	29.5	8	34.0	8	30.5	17	30.0	2	34.5	10	30.0	1	32.5

generators, between second and third and the technicians ranked it thirteenth. One item, pressure gauges, had a difference in rank of seven. The supervisors ranked this item fifth and the technicians twelfth. Several items had a difference in rank of six or less.

In Table IX the eleven unified concepts, used in instructing the electromechanical demonstration program, and one category containing tasks not included in one of the unified concepts are ranked as to the number of respondents indicating a frequency of use. Since each unified concept had a different number of tasks, the total number of responses was divided by the number of tasks included in the unified concept. The unified concepts were then ranked according to this number. The coefficient of correlation between the ranking for supervisors and technicians was .94. The largest difference in ranking of these unified concepts was 2.

On this percentage the tasks included in the unified concept differential forces was ranked first and the tasks in the concept feedback and stability was ranked second from the supervisor's data. From the technician's data the concept feedback and stability was ranked first and differential forces was ranked second.

The largest differences in rank of the unified concepts was for the concepts time constants, amplification, and the tasks - all concepts. The unified concepts waves was ranked eleventh and fields was ranked twelfth from both the supervisor's and technician's data.

TABLE IX

RANK OF UNIFIED CONCEPTS

Unified Concept	Rank by Supervisors	Rank by Technicians
Differential forces	1	2
Flow rates	3	4
Real opposition	7	7
Energy storage	4	5
Impedance	10	9
Time constants	5	3
Resonance	9	10
Amplification	6	8
Feedback and Stability	2	1
Waves	11	11
Fields	12	12
Tasks - All concepts	8	6

In Table X the nuclear and chemistry tasks are listed along with the frequency of use as indicated by the supervisors and technicians. No coefficient of correlation was calculated for these rankings since there were only three nuclear and four chemistry tasks. The nuclear tasks were ranked the same by the supervisors and technicians. In the chemistry tasks the supervisors ranked chemical etching, plating or anodizing first and chemical compounds or solutions second while the technicians ranked them in reverse order.

TABLE X

NUCLEAR AND CHEMISTRY TASKS FREQUENCY OF USE

Number of Respondents Indicating Each Frequency of Use									
66 Supervisors Task	Daily	Weekly	Monthly	Seldom	137 Technicians Task	Daily	Weekly	Monthly	Seldom
Radiation measuring devices	6	2	5	10	Radiation measuring devices	7	2	7	9
Radioactive elements or isotopes	4	0	2	10	Radioactive elements or isotopes	5	5	4	6
Fusionable or fission-able material	0	1	0	4	Fusionable or fission-able material	1	2	1	5
Chemical etching, plating or anodizing	7	3	5	8	Chemical compounds of solutions	4	9	15	11
Chemical compounds or solutions	5	2	5	8	Chemical etching, plating or anodizing	7	8	7	17
Ph factors	4	2	5	9	Ph factors	1	5	5	18
Separation of compounds	5	2	0	2	Separation of compounds	0	3	4	6

Technicians' Data by Years of Experience

The information presented in this section includes the usable data from 137 electromechanical technicians. The data were separated into four categories according to years of experience as an electromechanical technician. Any fraction of a year of experience was rounded off to the nearest whole year. These categories were: (1) 0 to 2 years, (2) 3 to 5 years, (3) 6 to 10 years, and (4) over 10 years of experience. The four categories consisted of 28, 43, 31, and 35 technicians, respectively.

The electromechanical tasks were ranked according to the number of respondents indicating a frequency of use. The number of respondents for each task is recorded in Tables XI through XIV under the heading of technicians responding. The percent of responses for each area of activity is also shown in Tables XI through XIV. To compare the rank of the electromechanical tasks by the four categories, a Spearman rank coefficient of correlation was computed for each possible pairing. These coefficients are as follows:

0-2 vs. 3-5	.82
0-2 vs. 6-10	.81
0-2 vs. over 10	.80
3-5 vs. 6-10	.85
3-5 vs. over 10	.87
6-10 vs. over 10	.81

Table XV shows the percent of respondents for each of the four categories indicating each of the selected primary activities. Trouble-shooting, testing, constructing, and analyzing were indicated as primary activities by 75.2 percent of the technicians with 0 to 2 years of

TABLE XI

AREA OF ACTIVITY OF TASK PERFORMANCE: 28 TECHNICIANS 0 THROUGH 2 YEARS OF EXPERIENCE

Task*	Technicians Responding	Percent of Respondents Indicating Each Area of Activity: Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
Potential differences in circuit	21			4.8	76.2	4.8	4.8		9.5			
Current flow by use of instruments	21			4.8	52.4	4.8	19.0		9.5	4.8		4.8
Thermocouples	20			5.0	40.0	10.0	30.0		5.0	5.0		5.0
Circuit losses	19			5.3	47.4		31.6	5.3		5.3	5.3	
Integrated circuits	19			10.5	31.6		26.3	15.8		10.5		
Specifications of electronic components	19			10.5	15.8		26.3	26.3		15.8	5.3	
Bias networks	18				27.8		33.3	16.7	5.6	16.7		
Inductance and/or capacitance	18		5.6		27.8		27.8	16.7	5.6	5.6	11.1	
Pulse and logic circuits	17		5.9		35.3		41.2	5.9		5.9		5.9
Rise and fall times	17			5.9	35.3		41.2	5.9	5.9			5.9
Specifications and characteristics of fastening devices such as adhesives, bolts, rivets, screws and welds	17		17.6	5.9		11.8	11.8	35.3		11.8	5.9	
Pressure drops in a system	16			18.8	31.3		43.8	6.3				
Rate of flow	16			12.5	31.3	6.3	31.3	6.3	12.5			
Power converters and energy storage cell	16		6.3		37.5	6.3	18.8	12.5	6.3	6.3	6.3	
The gain of an amplifier	16				18.8		50.0	6.3	18.8	6.3		
Micro electronic components, circuits, and packaging	16			12.5	31.3		25.0	18.8		6.3		6.3
System power requirements dealing with pumps, compressors, etc.	15				60.0	13.3	26.7					
Fluid measuring devices	15				40.0	6.7	33.3	6.7		6.7	6.7	
System losses due to pressure drops	15				40.0	6.7	40.0	6.7	6.7			
Gear trains and linkages	15		6.7		26.7	20.0	13.3	6.7	6.7	6.7	13.3	6.7
Speed control mechanisms	15		6.7		46.7		13.3	13.3		13.3		
Precision measuring instruments and precision tolerances	15			6.7	20.0		33.3	6.7	20.0	13.3		
Fluid regulators, sensors, switches and valves	15				53.3	6.7	33.3			6.7		
Thermal control devices	15				33.3	6.7	26.7	6.7	6.7	20.0		
Characteristics of materials such as, hardness, temperature characteristics, etc.	14		7.1	14.3	14.3	7.1	21.4	21.4		14.3		
Photosensitive devices	14			7.1	28.6		7.1	21.4	14.3	7.1	7.1	7.1
Stress and/or strain caused by static forces	13			38.5	38.5	7.7	15.4					
Heat sink and radiator capacities	13		7.7	7.7	38.5	15.4	15.4	7.7			7.7	
Specifications and characteristics of fittings, pipes and hoses	13		15.4	7.7	15.4	30.8	15.4	15.4				
Rotational or translational rates	12			8.3	16.7		33.3	16.7	16.7			8.3
The effect of feedback loop components in electronic circuits	12				25.0		33.3	8.3	16.7	16.7		
Photo emittive devices	12			16.7	25.0		16.7	16.7	8.3	8.3	8.3	
Power requirements of mechanical systems	11				9.1	18.2	27.3	18.2		18.2	9.1	
Mechanical indexing or sequenching devices	11				36.4	18.2	18.2	9.1		9.1	9.1	
System response time	11		9.1	9.1	27.3		36.4		18.2			
Thermal capacity and thermal resistance	11			18.2	27.3		45.5				9.1	
Component values for tuned circuits	11		18.2		18.2		27.3	9.1	18.2	9.1		
Light intensity	11			9.1	36.4		27.3	9.1	9.1			9.1
X_C and/or X_L	10			30.0	20.0		30.0	20.0				
Transmission and delay lines	10			10.0			30.0	10.0	30.0	10.0	10.0	
Power transmission systems such as belts, chains and drive shafts	10				30.0		10.0	10.0		30.0	10.0	10.0
Antifriction devices and lubricants	9				44.4			22.2			33.3	

*Tasks as derived from instrument, prefaced by "do you work with or determine."

TABLE XI (Continued)

Task	Technicians Responding	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
Spring constants and/or inertial values	9				11.1	11.1	22.2	22.2	22.2	11.1		
Fluidic devices such as oscillators, sensors, switches, etc.	9		11.1		33.3	11.1	33.3	11.1				
Lens systems	9				44.4		33.3	11.1		11.1		
Laminates plastics and ceramics	9		11.1	33.3	11.1			22.2		11.1	11.1	
Heat losses	8			50.0	25.0		25.0					
Specific heat	8			25.0	25.0	12.5	25.0		12.5			
Thermal system efficiency	8			37.5	12.5		50.0					
Vibratory systems or analysis	8				37.5		25.0	12.5	12.5	12.5		
Mechanical servos	8				37.5		25.0			25.0	12.5	
Optical filters and polarizers	8				50.0		12.5	12.5		12.5		12.5
Industrial control and high power switching circuits	8			12.5	37.5			25.0	12.5		12.5	
Dew point or humidity	8			25.0	12.5		37.5		12.5	12.5		
Piezoelectric devices	7			14.3	14.3		28.6	28.6		14.3		
Coefficient of friction	7			14.3	28.6		14.3	14.3	14.3		14.3	
Bearing loadings and specifications	7				14.3	14.3	14.3	28.6		14.3	14.3	
"k" factors	7			57.1	14.3		14.3		14.3			
Gear ratios for maximum power transfer	7					14.3	14.3	28.6	14.3	14.3	14.3	
Maximum power transfer in a system	7			28.6			42.9		14.3	14.3		
Thermal chambers	7				42.9		57.1					
Stresses and strains by dynamic force	6			16.7	33.3		16.7			16.7	16.7	
Or adjust hydraulic servo systems to meet performance specifications	6				16.7		16.7		33.3	33.3		
Ultrasonic devices	6			16.7	50.0			16.7				16.7
Fluid characteristics or specifications	6			16.7	16.7	16.7	16.7		16.7		16.7	
Transducers such as microphones and speakers	6			16.7	66.7				16.7			
Heat flow rates for temperature differential	5			40.0	20.0		40.0					
Fluid capacitance	5			20.0		20.0	40.0		20.0			
Fluid servo devices	5						20.0	20.0	20.0	20.0	20.0	
Sound intensities	5			20.0	80.0							
Frequencies above 500 megahertz	4			25.0	25.0			50.0				
Resonant conditions	4			25.0	25.0		25.0		25.0			
Diffraction gratings	4				75.0			25.0				
Light frequency	4			25.0	50.0		25.0					
Sound frequencies	4			25.0	75.0							
Fluid actuator parameters	4				50.0	25.0	25.0					
Refrigeration and/or airconditioning systems	4			25.0			25.0				50.0	
Luminescent materials	4				25.0			25.0	25.0			25.0
Cryogenic systems	3				66.7	33.3						
Sound absorption coefficients	1			100.0								
Velocity of sound in various media	1			100.0								
Laser devices	1							100.0				
Antenna field strength	0											
Modulation percentage	0											

TABLE XII

AREA OF ACTIVITY OF TASK PERFORMANCE: 43 TECHNICIANS 3 THROUGH 5 YEARS OF EXPERIENCE

Task*	Technicians Responding	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
	Percent of Respondents Indicating Each Area of Activity											
Current flow by use of instruments	38			15.8	23.7		34.2	5.3	5.3	5.3	2.6	7.9
Potential differences in circuit	36		2.8	16.7	36.1		27.8	2.8		8.3		5.6
X_C and/or X_L	36		3.8	46.2	11.5		23.1	7.1		3.8	3.8	
Precision measuring instruments and precision tolerances	33		3.0	24.2	6.1		27.3	15.2	15.2	9.1		
Integrated circuits	32	3.1		18.8	34.4		18.8	12.5		6.3	3.1	3.1
Specifications of electronic components	31		6.5	22.6	16.1	6.5	22.6	12.9		9.7	3.2	
Circuit losses	31			25.8	19.4	3.2	32.3	6.5	3.2	3.2		6.5
Inductance and/or capacitance	30		10.0	26.7	6.7		23.3	10.0	13.3	6.7	3.3	
Rise and fall times	30			40.0	6.7		40.0	3.3	3.3	6.7		
The gain of an amplifier	29	3.4	6.9	20.7	17.2		27.6	3.4	6.9		3.4	10.3
Thermocouples	29	3.4		17.2	17.2	10.3	34.5	3.4		3.4		10.3
Thermal control devices	28			14.3	21.4		25.0	7.1	7.1	7.1	7.1	10.7
Pulse and logic circuits	28	7.1		21.4	35.7	3.6	17.9	3.6		3.6	3.6	3.6
The effect of feedback loop components in electronic circuits	26			23.1	23.1		23.1	19.2	3.8	3.8	3.8	
Bias networks	26			26.9	15.4		23.1	19.2	7.7	7.7		
Power requirements of mechanical systems	25			20.0	12.0	12.0	24.0	20.0		4.0	4.0	4.0
Light intensity	24			25.0	25.0	4.2	25.0	8.3		8.3		4.0
Micro electronic components, circuits, and packaging	24	4.2		20.8	29.2	4.2	20.8	16.7			4.2	
Gear trains and linkages	24			20.8	20.8	4.2	16.7	12.5	4.2	12.5		8.3
Power transmission systems such as belts, chains and drive shafts	24	4.2		4.2	16.7	4.2	25.0	16.7	4.2	12.5	4.2	8.3
Component values for tuned circuits	23		8.7	21.7		8.7	13.0	13.0	13.0	4.3	4.3	4.3
Speed control mechanisms	23		4.3	13.0	21.7	8.7		8.7		8.7	4.3	4.3
Specifications and characteristics of fastening devices such as adhesives, bolts, rivets, screws and welds	23		4.3	17.4		17.4	8.7	43.5	4.3	4.3		
Photosensitive devices	22	4.5	4.5	13.6	18.2	4.5	36.4	9.1		4.5		4.5
Characteristics of materials such as, hardness, temperature characteristics, etc.	21		4.8	19.0	4.8	4.8	33.3	19.0	4.8	4.8		4.8
Heat sink and radiator capacities	21		4.8	14.3	4.8	4.8	33.3	28.6			4.8	4.8
Mechanical indexing or sequenching devices	21	5.3		5.3	36.8	5.3	15.8	10.5		10.5	5.3	5.3
Antifriction devices and lubricants	21	4.8		4.8	4.8	4.8	28.6	14.3	4.8	9.5	19.0	4.8
Lens systems	20			25.0	10.0	5.0	35.0	15.0		10.0		
Optical filters and polarizers	20		5.0	20.0	15.0	10.0	30.0	5.0		5.0		10.0
Rate of flow	20			10.0	25.0	5.0	25.0	5.0	5.0	15.0	5.0	5.0
Power converters and energy storage cell	20			10.0	20.0	5.0	35.0	15.0	5.0	10.0		
Gear ratios for maximum power transfer	20			15.0	25.0	10.0	20.0	15.0		10.0	5.0	
Stresses and strains by dynamic force	20			15.8	5.3		36.8	15.8	5.3	10.5		10.5
Piezoelectric devices	19			21.1	10.5		26.3	5.3	21.1	10.5		5.3
Fluid regulators, sensors, switches and valves	18			5.6	44.4	11.1	16.7	5.6	5.6	11.1		
Photo emittive devices	18	5.6	5.6	16.7	22.2		27.8	11.1				11.1
Stress and/or strain caused by static forces	18			16.7	16.7	5.6	27.8	16.7	5.6		5.6	5.6
Pressure drops in a system	18	5.6		11.1	38.9		16.7			11.1	5.6	11.1
Bearing loadings and specifications	18	5.6		5.6	16.7	5.6	33.3	22.2		5.6	5.6	
Thermal capacity and thermal resistance	18			27.8	22.2		27.8	16.7	5.6			
Vibratory systems or analysis	17			29.4	23.5	5.9	17.6	5.9	5.9		5.9	5.9

*Tasks as derived from instrument, prefaced by "do you work with or determine."

TABLE XII (Continued)

Task	Technicians Responding	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
Mechanical servos	17			5.9	23.5	5.9	29.4	5.9		11.8	5.9	11.8
Industrial control and high power switching circuits	17			17.6	35.3		17.6	5.9		17.6		5.9
Rotational or translational rates	17			23.5	17.6	5.9	23.5	11.8	11.8			5.9
System power requirements dealing with pumps, compressors, etc.	17			11.8	17.6	5.9	35.3		5.9	5.9	11.8	5.9
System response time	17		5.9	17.6	29.4		41.2			5.9		
Light frequency	16			31.3	31.3		31.3					6.3
Thermal chambers	16			6.3	12.5	6.3	37.5	6.3		6.3		25.0
Fluid measuring devices	16				18.8		25.0	6.3		12.5	12.5	25.0
Heat flow rates for temperature differential	16			12.5	12.5	6.3	31.3	12.5	18.8	6.3		
Coefficient of friction	16			6.3	18.8		43.8	31.3				
Heat losses	16			31.3	18.8		37.5	6.3		6.3		
Transmission and delay lines	16	6.3		25.0	6.3		5.0	12.5				
Dew point or humidity	15			33.3	13.3	6.7	26.7	6.7	6.7			6.7
Transducers such as microphones and speakers	15			26.7	33.3	6.7	20.0	6.7		6.7		
Fluidic devices such as oscillators, sensors, switches, etc.	15			6.7	26.7		20.0	13.3	13.3	6.7	6.7	6.7
Fluid servo devices	14				21.4		28.6	7.1	7.1	14.3	14.3	7.1
Spring constants and/or inertial values	14				21.4		35.7	35.7	7.1			
Specific heat	14			28.6			35.7	14.3	7.1		14.3	
Sound frequencies	13			53.8	15.4		15.4			7.7		7.7
Sound intensities	13			53.8	15.4		7.7	7.7		7.7		7.7
Laminates plastics and ceramics	13	7.7		15.4		7.7	23.1	30.8	7.7	7.7		
Specifications and characteristics of fittings, pipes and hoses	13			15.4	7.7	7.7		53.8	7.7	7.7		
Luminescent materials	13			23.1	7.7		23.1	30.8			15.4	
System losses due to pressure drops	13			7.7	30.8		30.8	7.7		15.4		7.7
Maximum power transfer in a system	13				23.1	7.7	46.2	15.4		7.7		
Or adjust hydraulic servo systems to meet performance specifications	12				33.3		8.3	16.7	25.0		16.7	
Thermal system efficiency	12			25.0	8.3		41.7	8.3				16.7
Modulation percentage	11		9.1	27.3	18.2		9.1		36.4			
Fluid capacitance	11			18.2	18.2		18.2	18.2	9.1		18.2	
Resonant conditions	10			40.0	10.0		30.0		10.0	10.0		
Diffraction gratings	10			20.0	10.0		40.0	10.0				20.0
Fluid characteristics or specifications	10			40.0	10.0		40.0				10.0	
Refrigeration and/or airconditioning systems	10			10.0	20.0	10.0	10.0	10.0		10.0	10.0	20.0
Ultrasonic devices	9			33.3			22.2			22.2		22.2
Cryogenic systems	9				11.1		55.6					33.3
Fluid actuator parameters	9			11.1	22.2		33.3			11.1	11.1	11.1
Laser devices	7			14.3	14.3		42.9		14.3	14.3		
"k" factors	7			14.3	28.6		42.9			14.3		
Antenna field strength	6			16.7	33.3		33.3		16.7			
Sound absorption coefficients	6			50.0			16.7	33.3				
Frequencies above 500 megahertz	5			60.0			20.0		20.0			
Velocity of sound in various media	4			75.0		25.0						

TABLE XIII

AREA OF ACTIVITY OF TASK PERFORMANCE: 31 TECHNICIANS 6 THROUGH 10 YEARS OF EXPERIENCE

		Percent of Respondents Indicating Each Area of Activity										
Task*	Technicians Responding	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
Potential differences in circuit	27		3.7	14.8	44.4		29.6	3.7	3.7			
Circuit losses	26		3.8	15.4	53.8		23.1	3.8				
Inductance and/or capacitance	26			15.4	26.9		34.6	11.5	11.5			
Current flow by use of instruments	25		3.8	11.5	30.8	3.8	38.5	7.7	3.8			
The gain of an amplifier	24		8.3	12.5	25.0		25.0	12.5	8.3		8.3	
Integrated circuits	24		4.2	20.8	33.3	4.2	33.3	4.2				
Specifications of electronic components	24		8.3	33.3	8.3		29.2	16.7	4.2			
Precision measuring instruments and precision tolerances	24	4.2	4.2	16.7	12.5	4.2	25.0	12.5	12.5			8.3
Thermocouples	23	4.3		4.3	17.4	17.4	34.8	8.7	13.0			
The effect of feedback loop components in electronic circuits	23	4.3	4.3	21.7	39.1		12.7	4.3			4.3	
X_C and/or X_L	22			31.8	27.3		22.7	4.5	9.1	4.5		
Mechanical indexing or sequenching devices	22	4.5		18.2	31.8	13.6	13.6	13.6		4.5		
Pulse and logic circuits	21		4.8	14.3	28.6		42.9	4.8		4.8		
Gear trains and linkages	21	4.8		14.3	23.8	4.8	28.6	14.3		4.8		
Rise and fall times	20		5.0	5.0	40.0		45.0	5.0				
Characteristics of materials such as, hardness, temperature characteristics, etc.	20	5.0		30.0	5.0		40.0	15.0			5.0	
Photosensitive devices	20	5.0		10.0	20.0	15.0	30.0	15.0	5.0			
Vibratory systems or analysis	19	5.3		15.8	21.1	5.3	42.1	5.3			5.3	
Speed control mechanisms	19	5.3		21.1	21.1	10.5	26.3	5.3	5.3	5.3		
Stress and/or strain caused by static forces	18	5.6		16.7	27.8	5.6	27.8	11.1				5.6
Rotational or translational rates	18	5.6		22.2	16.7	5.6	33.3	11.1		5.6		
Rate of flow	18			11.1	22.2	5.6	44.4	5.6	11.1			
Bias networks	18			5.6	33.3		38.9	22.2				
Heat sink and radiator capacities	18			16.7	16.7	11.1	27.8	16.7				11.1
Gear ratios for maximum power transfer	18	5.6	5.6	11.1	22.2	11.1	11.1	27.8			5.6	
Component values for tuned circuits	18		16.7	27.8	11.1		27.8	11.1	5.6			
Specifications and characteristics of fastening devices such as adhesives, bolts, rivets, screws and welds	18	5.6		16.7	11.1	5.6	27.8	16.7		5.6	5.6	5.6
System power requirements dealing with pumps compressors, etc.	17			5.9	23.5	5.9	52.9	5.9	5.9			
Antifriction devices and lubricants	17			5.9	11.8	11.8	23.5	17.6		11.8	17.6	
Fluid regulators, sensors, switches and valves	17			11.8	35.3	5.9	23.5	17.6	5.9			
Thermal control devices	17			5.9	23.5	17.6	41.2	5.9		5.9		
Power converters and energy storage cell	16			18.8	18.8		18.8	18.8	6.3		18.8	
Transmission and delay lines	16			25.0	18.8		31.3	12.5		6.3	6.3	
System response time	16			12.5	25.0	6.3	31.3	12.5	12.5			
Thermal capacity and thermal resistance	16			12.5	31.3		43.8	6.3	6.3			
Mechanical servos	16	6.3		12.5	25.0	12.5	37.5			6.3		
Light intensity	16			18.8	18.8	12.5	37.5	12.5				
Laminates plastics and ceramics	16			18.8	6.3	6.3	25.0	37.5			6.3	
Pressure drops in a system	15			13.3	20.0	6.7	33.3	6.7	13.3		6.7	
Bearing loadings and specifications	15			20.0	13.3	13.3	26.7	13.3		6.7	6.7	
Lens systems	15			13.3	20.0	13.3	26.7	13.3			6.7	6.7
Micro electronic components, circuits, and packaging	15		6.7	13.3	20.0		33.3	20.0				6.7
Photo emittive devices	15			13.3	20.0	20.0	33.3	6.7	6.7			

*Tasks as derived from instrument, prefaced by "do you work with or determine."

TABLE XIII (Continued)

Task	Technicians Responding	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
Piezoelectric devices	14			21.4	35.7	7.1	7.1	7.1	7.1	7.1	7.1	
System losses due to pressure drops	14			7.1	21.4	7.1	42.9	7.1	7.1		7.1	
Spring constants and/or inertial values	14			14.3	21.4	14.3	21.4	21.4		7.1		
Specifications and characteristics of fittings, pipes and hoses	14	7.1		7.1	28.6	7.1	28.6	14.3				7.1
Coefficient of friction	13	7.7		15.4	30.8	15.4	23.1	7.7				
Power transmission systems such as belts, chains and drive shafts	13			15.4	30.8	7.7	7.7	23.1	7.7	7.7		
Fluidic devices such as oscillators, sensors, switches, etc.	13			15.4	23.1	7.7	38.5	7.7	7.7			
Ultrasonic devices	13			7.7	15.4	15.4	23.1	15.4		7.7		15.4
Thermal chambers	13			5.4	7.7	7.7	61.5	7.7				
Power requirements of mechanical systems	12			25.0	16.7	8.3	25.0	8.3		8.3		8.3
Stresses and strains by dynamic force	12			25.0	16.7	8.3	8.3	16.7	8.3			16.7
Optical filters and polarizers	12			25.0	8.3	16.7	8.3	16.7		8.3		16.7
Sound frequencies	12			16.7	8.3	8.3	33.3	25.0			8.3	
Sound intensities	12			16.7	8.3	8.3	33.3	25.0			8.3	
Industrial control and high power switching circuits	12			8.3	41.7	8.3	8.3	25.0				8.3
Transducers such as microphones and speakers	12			25.0	8.3	8.3	41.7	16.7				
Fluid characteristics or specifications	11			9.1	18.2	9.1	54.5	9.1				
Heat losses	10				10.0	20.0	60.0	10.0				
Fluid capacitance	10			20.0	20.0	10.0	20.0	10.0	20.0			
Refrigeration and/or airconditioning systems	10			20.0	20.0	20.0	20.0				10.0	10.0
Frequencies above 500 megahertz	9			11.1	11.1	11.1	44.4	11.1		11.1		
Light frequency	9			44.4		11.1	33.3	11.1				
Modulation percentage	9			44.4	33.3				11.1		11.1	
Luminescent materials	9	11.1		33.3		22.2	11.1	22.2				
Heat flow rates for temperature differential	8			12.5	12.5	12.5	50.0	12.5				
Specific heat	8				25.0	12.5	50.0	12.5				
Maximum power transfer in a system	8			12.5	25.0	12.5	37.5	12.5				
Diffraction gratings	8			25.0	12.5	25.0	12.5	12.5				12.5
Antenna field strength	8		12.5	37.5	25.0		25.0					
Fluid measuring devices	7				14.3	14.3	42.9		14.3	14.3		
Resonant conditions	7			28.6	14.3	14.3	28.6	14.3				
Fluid servo devices	7			28.6	14.3	14.3	42.9					
Laser devices	7			14.3	14.3	14.3	42.9					14.3
Cryogenic systems	7			14.3	14.3	14.3	42.9					14.3
Dew point or humidity	7			28.6	14.3	28.6	28.6					
Thermal system efficiency	6				16.7		50.0	16.7	16.7			
Velocity of sound in various media	6			16.7	16.7	16.7	33.3					16.7
Fluid actuator parameters	6				33.3	33.3	16.7	16.7				
Or adjust hydraulic servo systems to meet performance specifications	5			20.0	20.0	20.0	40.0					
"k" factors	4				25.0		50.0			25.0		
Sound absorption coefficients	4				25.0	25.0	25.0	25.0				

TABLE XIV

AREA OF ACTIVITY OF TASK PERFORMANCE: 35 TECHNICIANS OVER 10 YEARS OF EXPERIENCE

	Percent of Respondents Indicating Each Area of Activity											
Task*	Technicians Responding	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
Current flow by use of instruments	33	3.0	9.1	12.1	30.3		33.3		3.0	6.1		3.0
Potential differences in circuit	32	3.1	6.3	15.6	28.1		31.3		3.1	9.4		3.1
Thermocouples	29	3.4		13.8	13.8	13.8	41.4		6.9	3.4		3.4
Precision measuring instruments and precision tolerances	29	3.4		13.8	20.7		24.1	10.3	6.9	10.3	3.4	6.9
Thermal control devices	28	3.6		17.9	25.0	7.1	32.1		7.1	3.6		3.6
Circuit losses	26	3.8	3.8	30.8	19.2		19.2	3.8	11.5	3.8		3.8
Specifications of electronic components	26	3.8	7.7	15.4	11.5		23.1	19.2	11.5	7.7		
Inductance and/or capacitance	25	3.8	7.7	30.8	19.2		23.1	7.7		3.8	3.8	
The effect of feedback loop components in electronic circuits	24			25.0	25.0		25.0	12.5		8.3	4.2	
X_C and/or X_L	23	4.3	8.7	34.8	8.7		26.1	8.7		8.7		
The gain of an amplifier	23			30.4	13.0		30.4		13.0	8.7		4.3
Pulse and logic circuits	21	4.8	4.8	28.6	19.0		14.3	14.3	4.8	4.8		4.8
Integrated circuits	21	4.8	4.8	19.0	19.0	4.8	9.5	19.0	4.8	9.5		4.8
Bias networks	20		5.0	20.0	25.0		30.0	15.0		5.0		
Speed control mechanisms	20		5.0	10.0	25.0	15.0	20.0	5.0	10.0			10.0
Heat sink and radiator capacities	18		5.6	38.9	11.1		22.2	22.2				
Power converters and energy storage cell	18			11.1	16.7	5.6	44.4			5.6	11.1	5.6
Gear trains and linkages	18		5.9	5.9	35.3	5.9	17.6	5.9	5.9	11.8		5.9
Rise and fall times	18		11.1	27.8	11.1		27.8	5.6	11.1	5.6		
Mechanical indexing or sequenching devices	18	5.6	5.6	5.6	33.3	11.1	16.7	11.1	5.6	5.6		
Thermal capacity and thermal resistance	18			16.7	16.7	5.6	44.4	5.6	5.6			5.6
Fluid regulators, sensors, switches and valves	18			5.6	16.7	5.6	22.2			16.7	11.1	22.2
Piezoelectric devices	17			11.8	17.6		35.3	17.6	11.8		5.9	
Mechanical servos	17			23.5	23.5	5.9	17.6		5.9	5.9	5.9	11.8
Specifications and characteristics of fastening devices such as adhesives, bolts, rivets, screws and welds	17			23.5	11.8	17.6	5.9	23.5		17.6		
Antifriction devices and lubricants	16			12.5	18.8	6.3	6.3			6.3	43.8	6.3
Power transmission systems such as belts, chains and drive shafts	16			6.3	37.5	12.5	6.3	6.3		31.3		
Photosensitive devices	16			31.3	25.0		12.5		18.8		6.3	6.3
Heat flow rates for temperature differential	15			26.7	20.0		20.0	6.7	6.7		6.7	13.3
Transmission and delay lines	15	6.7		6.7	20.0		46.7	13.3		6.7		
Lens systems	15			20.0	13.3	6.7	26.7		6.7	6.7	6.7	13.3
Industrial control and high power switching circuits	15	13.3		20.0	33.3		26.7			6.7		
Photo emittive devices	15			20.0	26.7		26.7	6.7	13.3		6.7	
Rate of flow	14		7.1	14.3	28.6		28.6	7.1	7.1	7.1		
System power requirements dealing with pumps, compressors, etc.	14			21.4	21.4		21.4	7.1	7.1	7.1		14.3
Component values for tuned circuits	14			35.7	7.1		35.7	14.3		7.1		
Light intensity	14			35.7	14.3		14.3		21.4		7.1	7.1
Micro electronic components, circuits, and packaging	14	7.1	7.1	21.4	21.4		21.4	14.3			7.1	
Characteristics of materials such as, hardness, temperature characteristics, etc.	14			28.6		7.1	21.4	21.4		14.3	7.1	
Pressure drops in a system	13		7.7	15.4	38.5		23.1	7.7	7.7			
Fluid measuring devices	13			8.3	41.7	8.3				25.0		16.7
Bearing loadings and specifications	13			30.8		23.0	15.4			7.7	15.4	7.7
Gear ratios for maximum power transfer	13		7.7	15.4	30.8	23.1	7.7	7.7			7.7	
Dew point or humidity	13			15.4	7.7		53.8	23.1				

*Tasks as derived from instrument, prefaced by "do you work with or determine."

TABLE XIV (Continued)

Task	Technicians Responding	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
System losses due to pressure drops	12		8.3	25.0	33.3		25.0					8.3
Heat losses	12	8.3		25.0	16.7		25.0	16.7				8.3
Spring constants and/or inertial values	12			25.0	25.0		25.0	16.7			8.3	
Vibratory systems or analysis	12			16.7	16.7	8.3	50.0		8.3			
Sound intensities	12		8.3	8.3	8.3		41.7	8.3		8.3		16.7
Refrigeration and/or airconditioning systems	12						41.7	25.0	8.3	16.7	8.3	
Stress and/or strain caused by static forces	11			18.2	18.2		27.3	9.1	9.1	9.1	9.1	
Specific heat	11			18.2	27.3		36.4	18.2				
Thermal chambers	11			18.2	9.1		45.5	9.1				18.2
Transducers such as microphones and speakers	11				9.1		45.5	9.1		18.2		18.2
Coefficient of friction	10			50.0	20.0		10.0	10.0	10.0			
Power requirements of mechanical systems	10	10.0	10.0	30.0	20.0		20.0					10.0
"k" factors	10			40.0	10.0		30.0	20.0				
System response time	10			10.0	40.0		10.0				10.0	30.0
Specifications and characteristics of fittings, pipes and hoses	10			10.0		10.0	20.0	20.0		30.0		10.0
Optical filters and polarizers	10			20.0		10.0	40.0				10.0	20.0
Thermal system efficiency	9			33.3	11.1		33.3	22.2				
Resonant conditions	9			11.1			55.6	11.1	11.1			11.1
Fluid servo devices	9			11.1	22.2		22.2	11.1		11.1	11.1	11.1
Sound frequencies	9		11.1				44.4	11.1		11.1		22.2
Modulation percentage	9			22.2	11.1		22.2		11.1	11.1		22.2
Laminates plastics and ceramics	9			33.3			33.3	22.1				11.1
Rotational or translational rates	8			25.0	25.0		37.5					12.5
Stresses and strains by dynamic force	8			25.0			37.5	25.0	12.5			
Fluidic devices such as oscillators, sensors, switches, etc.	8			12.5	25.0	12.5	25.0			12.5		12.5
Luminescent materials	8			37.5			25.0		12.5		12.5	12.5
Or adjust hydraulic servo systems to meet performance specifications	7				28.6					14.3	14.3	42.9
Light frequency	7			28.6	28.6		28.6					14.3
Antenna field strength	7			14.3			42.9	14.3	14.3			14.3
Fluid capacitance	6				16.7		33.3		16.7		16.7	16.7
Frequencies above 500 megahertz	6			33.3			33.3	33.3				
Ultrasonic devices	6				16.7		66.7					16.7
Fluid characteristics or specifications	6			33.3	16.7		16.7	16.7				16.7
Maximum power transfer in a system	5			20.0	20.0		40.0					20.0
Diffraction gratings	5			40.0	20.0		20.0					20.0
Sound absorption coefficients	4			25.0	50.0							25.0
Velocity of sound in vauious media	4						75.0					25.0
Cryogenic systems	4						50.0					50.0
Fluid actuator parameters	4			25.0	25.0			25.0				25.0
Laser devices	2						50.0					50.0

experience. Testing, analyzing, troubleshooting, and constructing indicated as primary activities by 76.1 percent of the technicians with 3 to 5 years of experience. Testing, troubleshooting, analyzing, and constructing were indicated as primary activities by 80.6 percent of the technicians with 6 to 10 years of experience. Testing, analyzing, and troubleshooting were indicated as primary activities by 65.0 percent of the technicians with over 10 years of experience.

TABLE XV

PRIMARY ACTIVITIES OF PERFORMING ELECTROMECHANICAL TASKS BY YEARS OF EXPERIENCE

	Percent of Respondents for Each Area of Activity			
Activities	0 to 2 Years Percent	3 to 5 Years Percent	6 to 10 Years Percent	Over 10 Years Percent
Instructing	0.0	1.0	1.4	1.5
Modifying	2.0	1.4	1.5	2.5
Analyzing	9.0	19.4	16.3	19.7
Troubleshooting	31.3	18.6	22.3	18.6
Installing	4.5	3.2	7.6	3.2
Testing	24.7	26.8	30.7	26.7
Constructing	10.2	11.3	11.3	8.1
Calibrating	6.2	4.2	3.3	4.5
Repairing	6.9	6.1	1.8	5.8
Servicing	3.6	3.0	2.0	3.0
Operating	1.5	4.9	1.9	6.4

Table VI shows the ranking of the selected mathematical tasks by the number of respondents indicating a frequency of use. To compare the rank of the mathematical tasks by the four categories, a Spearman rank coefficient of correlation was computed for each possible pairing. These coefficients are as follows:

0 to 2	vs. 3 to 5	.94
0 to 2	vs. 6 to 10	.87
0 to 2	vs. over 10	.86
3 to 5	vs. 6 to 10	.90
3 to 5	vs. over 10	.86
6 to 10	vs. over 10	.85

The mathematical tasks that increased in rank with increased years of experience were logarithms, solution of oblique triangles, complex numbers, and integration. The mathematical tasks that decreased in rank with increased years of experience were exponents and radicals, determinants, analytic geometry, decibels and quadratic equations.

Table V shows the ranking of the selected communication tasks by the number of respondents indicating a frequency of use.

To compare the rank of the communications tasks by the four categories, a Spearman rank coefficient of correlation was computed for each possible pairing. These coefficients are as follows:

0 to 2	vs. 3 to 5	.88
0 to 2	vs. 6 to 10	.77
0 to 2	vs. over 10	.90
3 to 5	vs. 6 to 10	.82
3 to 5	vs. over 10	.92
6 to 10	vs. over 10	.94

Tasks that increased in rank with increased years of work experience were read specifications and present findings orally. Tasks that decrease in rank with increased years of experience were participate in training and teaching activities and computer programming.

Table VII shows the ranking of the selected shop tools by the number of respondents indicating a frequency of use.

To compare the rank of the shop tools by the four categories, a Spearman rank coefficient of correlation was computed for each possible pairing. These coefficients are as follows:

0 to 2 vs. 3 to 5	.54
0 to 2 vs. 6 to 10	.75
0 to 2 vs. over 10	.73
3 to 5 vs. 6 to 10	.84
3 to 5 vs. over 10	.88
6 to 10 vs. over 10	.95

Items that increased in rank with increased years of experience were lathe and abrasive power tools. Items that decreased in rank with increased years of experience were milling machine, gas welder, and sheet metal tools.

Table VIII shows the ranking of the selected test equipment by the number of respondents indicating a frequency of use. To compare the rank of the test equipment by the four categories, a Spearman rank coefficient of correlation was computed for each possible pairing. These coefficients are as follows.

0 to 2 vs. 3 to 5	.88
0 to 2 vs. 6 to 10	.88
0 to 2 vs. over 10	.89

3 to 5	vs.	6 to 10		.92
3 to 5	vs.	over 10		.92
6 to 10	vs.	over 10		.89

In comparing the ranking of each item of test equipment, few trends could be established. Items compression tester, tension tester, and viscosity meters did decrease in rank with increased years of experience. Item strobelight increased in rank with increased years of experience.

Technicians' Data by Major Emphasis of Work

The information included in this section includes the usable data from 137 electromechanical technicians. The data were separated into categories according to major emphasis of work, as indicated by the technicians on the coversheet of their questionnaire. These categories were research and design, production, sales, maintenance, and other. The five categories consisted of 48, 28, 0, 52, and 9 technicians, respectively. Of the nine technicians included in the category, other, six specified testing and one each specified environmental evaluation, field service, and instrumentation service.

Tables XVI through XIX show the ranking of the selected electromechanical tasks by the number of respondents indicating a frequency of use. The percent of responses for each area of activity are also shown in these tables. The ranking of the tasks for each category was compared with each of the other categories. The Spearman rank coefficients of correlation are as follows:

R & D	vs.	Prod	.74
R & D	vs.	Main	.75
R & D	vs.	Other	.64

Prod	vs.	Main	.82
Prod	vs.	Other	.72
Main	vs.	Other	.67

In ranking the 84 selected tasks, 16 Electrical-electronic, 7 Mechanical, 4 Fluid, 3 Thermal, 2 Optical, and 0 Acoustical tasks were ranked in the upper quartile by at least one of the four selected categories.

Table XX shows the percent of respondents for each of the four categories indicating each of the selected primary activities, analyzing, testing, and constructing were indicated as primary activities by 70.7 percent of the research and design technicians. Testing and troubleshooting were indicated as primary activities by 73.3 percent of the production technicians. Troubleshooting, testing, analyzing, and repairing were indicated as primary activities by 77.9 percent of the maintenance technicians. Testing was indicated as the primary activity by 58.1 percent of the technicians in the category others.

Table VI shows the ranking of the selected mathematical tasks by the number of respondents indicating a frequency of use. To compare the rank of the mathematical tasks by the four categories, a Spearman rank coefficient of correlation was computed for each possible pairing. These coefficients are as follows:

R & D	vs.	Prod	.89
R & D	vs.	Main	.87
R & D	vs.	Other	.95
Prod	vs.	Main	.93
Prod	vs.	Other	.88
Main	vs.	Other	.79

TABLE XVI

AREA OF ACTIVITY OF TASK PERFORMANCE: 48 TECHNICIANS RESEARCH AND DESIGN

	Percent of Respondents Indicating Each Area of Activity											
Task*	Technicians Responding	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
Thermocouples	42	2.4		23.8	2.4	11.9	35.7	7.1	4.8			11.9
Potential differences in circuit	41			29.3	17.7	2.4	34.1	4.9		4.9		7.3
Current flow by use of instruments	40		2.4	26.8	14.6	4.9	29.3	7.3		4.9		9.8
Heat sink and radiator capacities	38			28.9	2.6	7.9	23.7	31.6				5.3
Inductance and/or capacitance	38	2.6	13.2	34.2	5.3		15.8	23.7		2.6	2.6	
Integrated circuits	38	5.3	2.6	31.6	10.5	2.6	15.8	23.7		5.3		2.6
Specifications of electronic components	38	2.6	2.6	34.2	7.9	2.6	15.8	34.2				
Circiut losses	37			40.5	8.1		21.6	10.8	8.1	2.7		8.1
The gain of an amplifier	37	2.7	5.4	35.1	2.7		21.6	10.8	10.8	2.7		8.1
The effect of feedback loop components in electronic circuits	37	2.7	2.7	29.7	16.2		13.5	24.3	5.4	2.7	2.7	
Rise and fall times	35		5.7	34.3	5.7		31.4	11.7	5.7	5.7		
Specifications and characteristics of fastening devices such as adhesives, bolts, rivets, screws and welds	35	2.9	2.9	28.6	5.7	11.4	5.7	42.9				
Thermal control devices	35			25.7	5.7	5.7	31.4	11.4	2.9	2.9	2.9	11.4
X_C and/or X_L	34	2.9	2.0	50.0	2.9		17.6	17.6		2.9	2.9	
Bias networks	32		3.1	31.3	6.3		25.0	31.3	3.1			
Mechanical indexing or sequenching devices	32	6.3	3.1	12.5	15.6	12.5	12.5	21.9	3.1	6.3	3.1	3.1
Precision measuring instruments and precision tolerances	32	2.4		28.6	4.8	2.4	19.0	21.4	11.9	2.4		7.1
Characteristics of materials such as, hardness, temperature characteristics, etc.	32	3.1		34.4	3.1	6.3	31.3	18.8				3.1
Antifriction devices and lubricants	31			12.9	9.7	12.9	19.4	22.6	•	3.2	12.9	6.5
Speed control mechanisms	31	3.2	3.2	22.6	6.5	16.1	19.4	16.1	3.2		3.2	6.5
Light intensity	31			38.7	3.2	6.5	22.6	12.9	3.2	3.2	3.2	6.5
Pulse and logic circuits	30	6.7	6.7	33.3	10.0	3.3	16.7	16.7		3.3		3.3
Component values for tuned circuits	30		6.7	33.3	6.7		16.7	26.7		3.3	3.3	3.3
Piezoelectric devices	29			27.6	10.3		27.6	20.7	6.9		3.4	3.4
Gear trains and linkages	29	3.4		17.2	13.8	10.3	17.2	24.1	3.4			10.3
Stresses and strains by dynamic force	29			27.6	6.9	3.4	27.6	20.7		3.4		10.3
Thermal capacity and thermal resistance	29			34.5	10.3		34.5	13.8	3.4			3.4
Lens systems	29			27.6		6.9	31.0	17.2		3.4	3.4	10.3
Laminates plastics and ceramics	29			34.5	3.4	6.9	17.2	37.9				
Photosensitive devices	29	6.9	3.4	27.6		6.9	24.1	20.7	3.4			6.9
Power converters and energy storage cell	28		3.6	17.9	10.7		28.6	28.6		3.6	3.6	3.6
Micro electronic components, circuits, and packaging	28	3.6		32.1	10.7	3.6	14.3	35.7				
Coefficient of friction	27	3.7		25.9	7.4	7.4	29.6	25.9				
Gear ratios for maximum power transfer	27	3.7		18.5	18.5	18.5	7.4	25.9		3.7	3.7	
Vibratory systems or analysis	27	3.7		29.6	11.1	7.4	29.6	11.1			3.7	3.7
Optical filters and polarizers	27		3.7	29.6		7.4	25.9	7.4		3.7	3.7	18.5
Stress and/or strain caused by static forces	26	3.8		26.9	3.8	7.7	26.9	23.1	3.8			3.8
Bearing loadings and specifications	26			23.1	7.7	15.4	15.4	26.9		3.8	3.8	3.8
Power requirements of mechanical systems	26			23.1	3.8	11.5	15.4	30.8			3.8	11.5
Spring constants and/or inertial values	26			19.2	7.7	7.7	23.1	38.5	3.8			
Power transmission systems such as belts, chains and drive shafts	26			11.5	15.4	11.5	19.2	26.9		3.8	3.8	7.7.
Thermal chambers	26			19.2	3.8	3.8	46.2	11.5				15.4
Photo emittive devices	26	3.8	3.8	26.9		7.7	23.1	23.1	8.3			7.7

*Tasks as derived from instrument, prefaced by "do you work with or determine."

TABLE XVI (Continued)

Task	Technicians Responding	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
Rotational or translational rates	25	4.0		36.0	8.0	4.0	16.0	20.0	4.0			8.0
Rate of flow	24			20.8	20.8	4.2	25.0	16.7		4.2	4.2	4.2
Heat losses	24			29.2		4.2	41.7	16.7		4.2		4.2
Transmission and delay lines	24	8.3		25.0	4.2		33.3	25.0		4.2		
System response time	24		4.2	25.0	20.8	4.2	33.3	4.2				8.3
Mechanical servos	24	4.2		20.8	12.5	16.7	25.0	4.2		4.2		12.5
Dew point or humidity	24			33.3		8.3	37.5	16.7				4.2
Heat flow rates for temperature differential	23			34.8		8.7	26.1	17.4	8.7			4.3
Pressure drops in a system	21			19.0	23.8	4.8	23.8	14.3			4.8	9.5
Luminescent materials	21			28.6		9.5	9.5	28.6	4.8		14.3	4.8
Thermal system efficiency	20			30.0	5.0		35.0	20.0				10.0
Light frequency	20			50.0		5.0	3.0	5.0				10.0
Sound intensities	20			25.0		5.0	25.0	25.0		10.0		10.0
Industrial control and high power switching circuits	20			20.0	30.0		20.0	25.0				5.0
Transducers such as microphones and speakers	20			25.0		5.0	35.0	20.0		10.0		5.0
System power requirements dealing with pumps, compressors, etc.	19			21.1	5.3	10.5	31.6	10.5	5.3		5.3	10.5
Fluid measuring devices	19			5.3	15.8	10.5	21.1	10.5		5.3	10.5	21.1
Specific heat	19			31.6	5.3		36.8	26.3				
Sound frequencies	19			26.3		5.3	26.3	21.1		10.5		10.5
System losses due to pressure drops	18			22.2	16.7	5.6	27.8	16.7				11.1
Fluid regulators, sensors, switches and valves	18			14.3	28.6	9.5	9.5	19.0	4.8			14.3
Refrigeration and/or airconditioning systems	18			16.7	5.6	5.6	33.3	16.7	5.6		5.6	11.1
Maximum power transfer in a system	17			11.8	23.5	11.8	29.4	17.6				5.9
Fluid servo devices	17			11.8	17.6	5.9	29.4	17.6	5.9		5.9	5.9
Specifications and characteristics of fittings, pipes and hoses	17	5.9		11.8	11.8	5.9	5.9	52.9				5.9
Fluidic devices such as oscillators, sensors, switches, etc.	16			25.0	12.5	6.3	25.0	18.8				12.5
Diffraction gratings	16			25.0		12.5	25.0	12.5				25.0
Ultrasonic devices	16			6.3	6.3	6.3	31.3	6.3		18.8		25.0
"k" factors	15			40.0	6.7		33.3	13.3		6.7		
Resonant conditions	15			40.0		6.7	26.7	13.3		6.7		6.7
Modulation percentage	15		6.7	33.3	20.0		13.3		20.0			6.7
Frequencies above 500 megahertz	14			35.7		7.1	14.3	35.7	7.1			
Fluid characteristics or specifications	14			42.9	7.1	7.1	21.4	14.3				7.1
Cryogenic systems	13			7.7	7.7	7.7	38.5					38.5
Fluid actuator parameters	13			15.4	23.1	15.4	15.4				7.7	7.7
Or adjust hydraulic servo systems to meet performance specifications	12				25.0	8.3	16.7	16.7	25.0			8.3
Laser devices	12			16.7		8.3	41.7	8.3		8.3		16.7
Antenna field strength	12			33.3	16.7		33.3	8.3	8.3			
Fluid capacitance	11			27.3	9.1	9.1	18.2	27.3				9.1
Sound absorption coefficients	10			30.0	10.0	10.0	10.0	30.0				10.0
Velocity of sound in vauious media	10			20.0		20.0	40.0					20.0

TABLE XVII

AREA OF ACTIVITY OF TASK PERFORMANCE: 28 TECHNICIANS PRODUCTION

Percent of Respondents Indicating Each Area of Activity

Task*	Technicians Responding	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
Potential differences in circuit	23			4.3	65.2		21.7		8.7			
Current flow by use of instruments	22				40.9		59.1					
Inductance and/or capacitance	22			9.1	31.8		40.9		13.6	4.5		
Circuit losses	21			4.8	47.6		42.9			4.8		
Specifications of electronic components	21		4.8	9.5	19.0	4.8	42.9	9.5	4.8	4.8		
Integrated circuits	18			5.6	33.3		38.9		5.6	11.1		5.6
The gain of an amplifier	18			5.6	33.3		50.0		11.1			
Rise and fall times	18				27.8		72.2					
Pulse and logic circuits	17			5.9	23.5		58.8		5.9			5.9
Thermocouples	16				18.8	12.5	56.3		12.5			
Specifications and characteristics of fastening devices such as adhesives, bolts, rivets, screws and welds	16			6.3	6.3	18.8	31.3	18.8		12.5		6.3
Precision measuring instruments and precision tolerances	16			12.5	18.8		37.5	12.5	12.5			6.3
Component values for tuned circuits	15			6.7	40.0		40.0		13.3			
Pressure drops in a system	14			14.3	21.4		50.0		14.3			
X_C and/or X_L	14		7.1	28.6	21.4		35.7		7.1			
The effect of feedback loop components in electronic circuits	14			7.1	50.0		35.7			7.1		
Micro electronic components, circuits, and packaging	14		7.1		28.6		50.0	7.1				7.1
Heat sink and radiator capacities	13		7.7	7.7	30.8	7.7	30.8	7.7			7.7	
Bias networks	13				30.8		53.8			15.4		
System power requirements dealing with pumps, compressors, etc.	13				23.1	7.7	69.2					
Rate of flow	12			8.3	8.3		58.3		25.0			
Fluid regulators, sensors, switches and valves	12				33.3		50.0		8.3	8.3		
Specifications and characteristics of fittings, pipes and hoses	12				8.3	33.3	50.3	8.3				
Thermal control devices	12				25.0	8.3	58.3			8.3		
Power converters and energy storage cell	11			9.1	18.2		63.9		9.1			
Characteristics of materials such as, hardness, temperature characteristics, etc.	11		9.1	27.3			45.5	9.1			9.1	
Photosensitive devices	11				18.2	9.1	36.4	9.1	9.1		9.1	9.1
Gear trains and linkages	11			9.1	27.3	9.1	36.4		9.1			9.1
System losses due to pressure drops	11				18.2	9.1	54.5		18.2			
Stress and/or strain caused by static forces	10				30.0	10.0	50.0					10.0
Rotational or translational rates	10				10.0		70.0		10.0			10.0
Power requirements of mechanical systems	10			10.0	10.0		60.0			20.0		
Transmission and delay lines	10				10.0		70.0		10.0	10.0		
Power transmission systems such as belts, chains and drive shafts	10	10.0			20.0		40.0	10.0	10.0			10.0
Speed control mechanisms	10				30.0		50.0		20.0			
Light intensity	9				11.1		66.7	11.1				11.1
Thermal chambers	9					11.1	77.8					11.1
Antifriction devices and lubricants	9	11.1			11.1		44.4	11.1		11.1	11.1	
Fluid measuring devices	8				28.6		57.1		14.3			
Heat losses	8			12.5	25.0		62.5					
Gear ratios for maximum power transfer	8			12.5	12.5		37.5	25.0	12.5			
Mechanical indexing or sequenching devices	8				37.5	12.5	37.5	12.5				
Vibratory systems or analysis	8				12.5		75.0				12.5	

*Tasks as derived from instrument, prefaced by "do you work with or determine."

TABLE XVII (Continued)

Task	Technicians Responding	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
Photo emittive devices	8				25.0		62.5				12.5	
Thermal capacity and thermal resistance	7						71.4		14.3		14.3	
Heat flow rates for temperature differential	7			14.3			85.7					
Mechanical servos	7			14.3	28.6		57.1					
Lens systems	7					14.3	71.4	14.3				
Fluid characteristics or specifications	7			14.3			71.4				14.3	
Specific heat	7			14.3			85.7					
Bearing loadings and specifications	6	16.7			16.7		50.0	16.7				
Fluid capacitance	6					50.0		50.0				
Fluidic devices such as oscillators, sensors, switches, etc.	6				33.3		33.3	16.7	16.7			
Thermal system efficiency	6			16.7			66.7		16.7			
System response time	6				33.3		33.3		33.3			
Dew point or humidity	5				20.0		60.0		20.0			
Industrial control and high power switching circuits	5				40.0		40.0	20.0				
Spring constants and/or inertial values	5				20.0		40.0	20.0	20.0			
"k" factors	4			25.0	25.0		50.0					
Stresses and strains by dynamic force	4				25.0		25.0	25.0				25.0
Maximum power transfer in a system	4						75.0		25.0			
laminates plastics and ceramics	4	25.0					50.0				25.0	
Luminescent materials	4			25.0			50.0	25.0				
Ultrasonic devices	4				25.0	25.0	25.0				25.0	
Sound intensities	4				25.0		50.0				25.0	
Sound frequencies	4				25.0		50.0				25.0	
Fluid servo devices	4				25.0		25.0		25.0	25.0		
Or adjust hydraulic servo systems to meet performance specifications	3				33.3				33.3	33.3		
Refrigeration and/or airconditioning systems	3				33.3		33.3				33.3	
Transducers such as microphones and speakers	3				33.3		66.7					
Optical filters and polarizers	3				33.3	33.3	33.3					
Light frequency	3			33.3	33.3		33.3					
Antenna field strength	2			50.0			50.0					
Modulation percentage	2			50.0					50.0			
Diffraction gratings	2			50.0				50.0				
Resonant conditions	2						100.0					
Coefficient of friction	2						100.0					
Piezoelectric devices	1					100.0						
Sound absorption coefficients	1						100.0					
Frequencies above 500 megahertz	1						100.0					
Cryogenic systems	1						100.0					
Fluid actuator parameters	1						100.0					
Laser devices	0											
Velocity of sound in various media	0											

TABLE XVIII

AREA OF ACTIVITY OF TASK PERFORMANCE: 52 TECHNICIANS MAINTENACE

Percent of Respondents Indicating Each Area of Activity

Task*	Technicians Responding	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
Current flow by use of instruments	46		6.5	6.5	45.7		17.4	2.2	10.9	6.5	2.2	2.2
Potential differences in circuit	43		9.3	7.0	62.8		11.6		2.3	7.0		
Circuit losses	37		5.4	13.5	51.4	2.7	16.2	2.7	2.7	2.7	2.7	
Thermal control devices	37			2.7	45.9	8.1	18.9		10.8	13.5		
Thermocouples	35			2.9	48.6	14.3	20.0		5.7	8.6		
Pulse and logic circuits	35	2.9	2.9	11.4	51.4		17.1			8.6	2.9	2.9
Gear trains and linkages	35		5.9	5.9	38.2	5.9	11.8	2.9	2.9	23.5	2.9	
Integrated circuits	35		2.9	11.4	54.3	2.9	11.4	5.7		5.7	2.9	2.9
Specifications of electronic components	35		11.4	14.3	14.3		20.0	5.7	8.6	20.0	5.7	
Precision measuring instruments and precision tolerances	35	2.9	5.7	5.7	25.7		22.9	2.9	11.4	20.0	2.9	
Inductance and/or capacitance	34		2.9	14.3	25.7		25.7	5.7	11.4	5.7	8.6	
Speed control mechanisms	34		5.9	5.9	47.1	5.9	11.8	2.9		14.7	2.9	2.9
Bias networks	31			6.5	45.2		22.6	9.7	6.5	9.7		
The gain of an amplifier	31		6.5	6.5	32.3		22.6	3.2	12.9	6.5	9.7	
The effect of feedback loop components in electronic circuits	30			13.3	36.7		30.0		3.3	10.0	6.7	
Fluid regulators, sensors, switches and valves	30			3.3	50.0	6.7	16.7			16.7	6.7	
Photosensitive devices	29			6.9	48.3	3.4	17.2	3.4	13.8	3.4	3.4	
X_C and/or X_L	28		3.6	32.1	25.0		21.4	3.6	3.6	10.7		
Power converters and energy storage cell	28			3.6	39.3	7.1	17.9		7.1	10.7	14.3	
Rate of flow	27			7.4	44.4	3.7	22.2		11.1	11.1		
System power requirements dealing with pumps, compressors, etc.	27			3.7	55.6	3.7	18.5		7.4	7.4	3.7	
Mechanical indexing or sequenching devices	27			7.4	59.3	11.1	7.4			11.1	3.7	
Power transmission systems such as belts, chains and drive shafts	26			3.8	42.3	3.8		3.8		42.3	3.8	
Rise and fall times	26		3.8	23.1	42.3		15.4		7.7	3.8		3.8
Industrial control and high power switching circuits	25	8.0		12.0	44.0	4.0	4.0		4.0	16.0	4.0	4.0
Mechanical servos	24			4.2	41.7		16.7		4.2	20.8	8.3	4.2
Photo emittive devices	24			8.3	50.0	4.2	16.7		12.5	4.2	4.2	
Pressure drops in a system	23			13.0	52.2		17.4		4.3	8.7	4.3	
Micro electronic components, circuits, and packaging	23	4.3	4.3	13.0	47.8		8.7	4.3		4.3	8.7	4.3
Characteristics of materials such as, hardness, temperature characteristics, etc.	23		4.3	8.7	13.0	4.3	17.4	21.7	4.3	21.7	4.3	
Specifications and characteristics of fastening devices such as adhesives, bolts, rivets, screws and welds	23		13.0	4.3	4.3	13.0	8.7	21.7	4.3	21.7	8.7	
Piezoelectric devices	22			9.1	36.4		13.6	4.5	13.6	18.2	4.5	
Fluid measuring devices	22				45.5	4.5	13.6			27.3	4.5	4.5
Gear ratios for maximum power transfer	22		9.1	4.5	31.8	13.6	9.1	9.1		9.1	13.6	
Thermal capacity and thermal resistance	22			4.5	54.5	4.5	31.8		4.5			
Antifriction devices and lubricants	21				28.6		4.8		4.8	9.5	52.4	
Power requirements of mechanical systems	21	4.8	4.8	14.3	28.6	14.3	19.0			9.5	4.8	
System losses due to pressure drops	21			4.8	57.1		23.8			9.5	4.8	
Fluidic devices such as oscillators, sensors, switches, etc.	21		4.8		38.1	9.5	28.6		4.8	9.5	4.8	
System response time	21		4.8	4.8	42.9		19.0	4.8	9.5	4.8	4.8	4.8
Light intensity	21			14.3	57.1	4.8	9.5		14.3			
Stress and/or strain caused by static forces	20			25.0	50.0		10.0		5.0	5.0	5.0	

*Tasks as derived from instrument, prefaced by "do you work with or determine."

TABLE XVIII (Continued)

Task	Technicians Responding	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
Transmission and delay lines	20			20.0	25.0		25.0	5.0	10.0	5.0	10.0	
Lens systems	20			10.0	50.0	5.0	15.0		5.0	10.0	5.0	
Bearing loadings and specifications	19			10.5	15.8	15.8	21.1			15.8	21.1	
Vibratory systems or analysis	19			10.5	47.4		21.1		15.8	5.3		
Transducers such as microphones and speakers	19			15.8	47.4	5.3	15.8		5.3	5.3		5.3
Rotational or translational rates	18			11.1	38.9	5.6	22.2	5.6	11.1	5.6		
Specifications and characteristics of fittings, pipes and hoses	18		11.1	11.1	22.2	11.1	5.6	5.6	5.6	22.2		5.6
Spring constants and/or inertial values	17				41.2	5.9	23.5	5.9	5.9	11.8	5.9	
Component values for tuned circuits	17		23.5	23.5	5.9		11.8		23.5	11.8		
Optical filters and polarizers	17				41.2	5.9	23.5	5.9		11.8		11.8
Sound intensities	16		6.3	31.3	43.8		12.5					6.3
Heat sink and radiator capacities	15		13.3	13.3	40.0	6.7	13.3				6.7	6.7
Coefficient of friction	14			14.3	64.3		7.1		7.1		7.1	
Fluid capacitance	14			14.3	28.6	7.1	14.3		14.3		21.4	
Laminates plastics and ceramics	14		7.1	7.1	7.1		21.4	21.4	7.1	14.3	7.1	7.1
Specific heat	13			7.7	46.2	15.4	7.7		15.4		7.7	
Or adjust hydraulic servo systems to meet performance specifications	13			7.7	30.8		7.7		7.7	15.4	23.1	7.7
Sound frequencies	13		7.7	30.8	38.5		15.4					7.7
Maximum power transfer in a system	12			16.7	16.7		50.0			16.7		
Fluid servo devices	12			8.3	16.7		16.7			25.0	25.0	8.3
Ultrasonic devices	12			33.3	41.7		8.3	8.3				8.3
Refrigeration and/or airconditioning systems	12			8.3	16.7	8.3	16.7			25.0	25.0	
Heat flow rates for temperature differential	11				54.5				18.2	9.1	9.1	9.1
Heat losses	11			27.3	54.5	9.1	9.1					
Stresses and strains by dynamic force	11			9.1	18.2		27.3		18.2	18.2	9.1	
Resonant conditions	11			18.2	27.3		27.3		27.3			
Light frequency	11			9.1	63.6		27.3					
Modulation percentage	11			27.3	27.3		9.1		18.2	9.1	9.1	
Dew point or humidity	11			18.2	36.4	9.1	18.2		9.1	9.1		
Fluid characteristics or specifications	9				33.3	11.1	33.3		11.1		11.1	
Frequencies above 500 megahertz	8			25.0	25.0		37.5			12.5		
Diffraction gratings	8			12.5	62.5		25.0					
Thermal chambers	8				75.0		12.5					12.5
Luminescent materials	8	12.5		12.5	25.0		25.0		12.5			12.5
"k" factors	7			28.6	28.6		14.3		14.3	14.3		
Thermal system efficiency	7			28.6	42.9		28.6					
Cryogenic systems	7				42.9	14.3	28.6					14.3
Fluid actuator parameters	7				57.1	14.3	14.3			14.3		
Laser devices	5				40.0		40.0		20.0			
Velocity of sound in vauious media	5			60.0	20.0		20.0					
Antenna field strength	5		20.0		40.0		20.0		20.0			
Sound absorption coefficients	4			50.0	50.0							

TABLE XIX

AREA OF ACTIVITY OF TASK PERFORMANCE:
9 TECHNICIANS OTHERS

		Percent of Respondints Indicating Each Area of Activity										
Task*	Technicians Responding	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
Potential differences in circuit	9	11.1			11.1		55.6		11.1	11.1		
Current flow by use of instruments	9	11.1			22.2		55.6		11.1			
Thermocouples	8	25.0				12.5	62.5					
Precision measuring instruments and precision tolerances	8			12.5			62.5		25.0			
Circuit losses	7	14.3			28.6		57.1					
Bias networks	6						50.0	33.3		16.7		
Rise and fall times	6			16.7			83.3					
The gain of an amplifier	6						83.3					16.7
Specifications of electronic components	6			16.7	16.7		50.0	16.7				
Piezoelectric devices	5						60.0		40.0			
Rate of flow	5		20.0			20.0	60.0					
Inductance and/or capacitance	5				20.0		60.0		20.0			
X_C and/or X_L	5				40.0		60.0					
Pulse and logic circuits	5				20.0		60.0	20.0				
Thermal capacity and thermal	5			20.0			60.0	20.0				
Integrated circuits	5						80.0	20.0				
Fluid regulators, sensors, switches and valves	5					20.0	60.0					20.0
Component values for tuned circuits	4		25.0		25.0		50.0					
Stress and/or strain caused by statec forces	4			25.0	25.0		25.0				25.0	
Pressure drops in a system	4	25.0	25.0				50.0					
System power requirements dealing with pumps, compressors, etc.	4			25.0			50.0					25.0
System losses due to pressure drops	4		25.0				75.0					
Heat sink and radiator capacities	4						75.0	25.0				
The effect of feedback loop components in electronic circuits	4			25.0			50.0	25.0				
Light intensity	4				25.0		50.0			25.0		
Micro electronic components, circuits, and packaging	4						100.0					
Thermal control devices	4	25.0					50.0				25.0	
Thermal chambers	4						75.0			25.0		
Heat flow rates for temperature differential	3				33.3		66.7					
Coefficient of friction	3						33.3	33.3	33.3			
Heat losses	3	33.3		33.3			33.3					
Power converters and energy storage cell	3					33.3	33.3				33.3	
Transmission and delay lines	3						100.0					
Gear trains and linkages	3			33.3			66.7					
Mechanical indexing or sequenching devices	3	33.3					66.7					
System response time	3						100.0					
Mechanical servos	3						66.7				33.3	
Lens systems	3				33.3		33.3			33.3		
Optical filters and polarizers	3			33.3	33.3	33.3						
Characteristics of materials such as, hardness, temperature characteristics, etc.	3						66.7	33.3				
Specifications and characteristics of fittings, pipes and hoses	3			33.3				66.7				
Fluid characteristics or specifications	3			33.3	33.3		33.3					
Dew point or humidity	3			33.3			66.7					
Refrigeration and/or airconditioning systems	3					33.3		33.3				33.3

*Tasks as derived from instrument, prefaced by "do you work with or determine."

TABLE XIX (Continued)

Task	Technicians Responding	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
Photosensitive devices	3			33.3			33.3			33.3		
Rotational or translational rates	2						100.0					
Fluid measuring devices	2						50.0					50.0
Antifriction devices and lubricants	2									50.0	50.0	
Bearing loadings and specifications	2						100.0					
"k" factors	2				50.0		50.0					
Specific heat	2						50.0				50.0	
Stresses and strains by dynamic force	2								100.0			
Fluidic devices such as oscillators, sensors, switches, etc.	2						50.0		50.0			
Thermal system efficiency	2						100.0					
Vibratory systems or analysis	2					50.0	50.0					
Resonant conditions	2						100.0					
Fluid servo devices	2						100.0					
Or adjust hydraulic servo systems to meet performance specifications	2						50.0					50.0
Speed control mechanisms	2						100.0					
Light frequency	2				50.0		50.0					
Sound frequencies	2			50.0			50.0					
Sound intensities	2			50.0			50.0					
Ultrasonic devices	2						100.0					
Antenna field strength	2						50.0					50.0
Industrial control and high power switching circuits	2			50.0			50.0					
Cryogenic systems	2						100.0					
Fluid actuator parameters	2						50.0					50.0
Photo emittive devices	2			50.0			50.0					
Transducers such as microphones and speakers	2					50.0	50.0					
Power requirements of mechanical systems	1			100.0								
Spring constants and/or inertial values	1						100.0					
Fluid capacitance	1						100.0					
Frequencies above 500 megahertz	1						100.C					
Gear ratios for maximum power transfer	1						100.0					
Power transmission systems such as belts, chains and drive shafts	1								100.0			
Diffraction gratings	1				100.0							
Modulation percentage	1											100.0
Specifications and characteristics of fastening devices such as adhesives, bolts, rivets, screws and welds	1						100.0					
Luminescent materials	1			100.0								
Sound absorption coefficients	0											
Maximum power transfer in a system	0											
Laser devices	0											
Velocity of sound in various media	0											
Laminates plastics and ceramics	0											

TABLE XX

PRIMARY ACTIVITIES OF PERFORMING ELECTROMECHANICAL TASKS BY MAJOR WORK EMPHASIS

Activities	Percent of Respondents for Each Area of Activity			
	R & D Percent	Production Percent	Maintenance Percent	Others Percent
Instructing	1.4	0.5	0.4	3.5
Modifying	1.3	0.7	2.8	1.6
Analyzing	27.1	5.6	10.3	7.8
Troubleshooting	8.2	23.2	40.3	8.1
Installing	5.9	3.2	3.7	3.1
Testing	24.0	50.1	17.1	58.1
Constructing	19.6	3.8	2.5	5.0
Calibrating	2.2	6.7	6.1	4.3
Repairing	2.1	2.5	10.2	2.7
Servicing	1.5	1.6	5.1	2.3
Operating	6.5	1.9	1.5	3.5

A few differences occurred in the ranking of the mathematical tasks by the technicians in the four categories. The technicians in production ranked task decibels higher than the other three groups did while ranking task graphs lower than the other three groups did. Production and others ranked task exponents and radicals ninth while the other two groups ranked it fifth. The task complex numbers was ranked higher by those technicians in the group others than by the other three groups.

The task binary arithmetic was ranked higher by the technicians in the maintenance group than the other three groups.

Table V shows the ranking of the selected communication tasks by the number of respondents indicating a frequency of use. To compare the rank of the communication tasks by the four categories, a Spearman rank coefficient of correlation was computed for each possible pairing. The coefficients are as follows:

R & D	vs.	Prod	.86
R & D	vs.	Main	.81
R & D	vs.	Other	.91
Prod	vs.	Main	.89
Prod	vs.	Other	.93
Main	vs.	Other	.92

In the communication tasks the major difference in rank occurred for the task prepare graphs and charts. The technicians in research and design ranked it first, those in others ranked it third, those in maintenance fifth and those in production sixth. The task prepare specifications was ranked higher by the technicians in the categories research and design, and maintenance than by the other two groups. The task participate in training and teaching activities was ranked lower by the research and design technicians than by the other three groups.

Table VII shows the ranking of the selected shop tools by the number of respondents indicating a frequency of use. To compare the rank of the shop tools by the four categories, a Spearman rank coefficient of correlation was computed for each possible pairing. These coefficients are as follows:

R & D	vs.	Prod	.65
R & D	vs.	Main	.72
R & D	vs.	Other	.67
Prod	vs.	Main	.84
Prod	vs.	Other	.96
Main	vs.	Other	.87

The shop tool lathe was ranked higher by the technicians in research and design than by the technicians in the other three groups. While the shop tool abrasive power tool was ranked lower by the technicians in research and design than by the technicians in the other three groups. The shop tool arc welder was ranked higher by the technicians in production and others than by those in the other two groups.

Table VIII shows the ranking of the selected test equipment by the number of respondents indicating a frequency of use. To compare the rank of the test equipment by the four categories, a Spearman rank coefficient of correlation was computed for each possible pairing. These coefficients are as follows:

R & D	vs.	Prod	.87
R & D	vs.	Main	.86
R & D	vs.	Other	.91
Prod	vs.	Main	.87
Prod	vs.	Other	.82
Main	vs.	Other	.84

Ten of the test equipment items had a difference in rank of at least ten. The largest difference in rank occurred for the item accelerometers. This item was ranked nineteenth by the technicians in the group others, twenty-second by research and design, and thirty-sixth by the other two groups. Other items showing a difference of ten or more are thermocouple instruments, torque meter, pressure gauges, strain gauges, flow meters, force gauges, SWR meter, tension tester, and sound intensity meter.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The primary purpose of this study was to conduct an occupational analysis of electromechanical technician occupations in order to determine the frequency of performing selected tasks and the area of activity in which these tasks are performed. A secondary purpose of this study was to analyze and organize occupational analysis data in preparation for writing educational objectives for an electromechanical technician education program.

Summary

The occupational analysis was developed and conducted in the following manner:

(1) An occupational analysis instrument was developed through the joint effort of thirteen graduate students at Oklahoma State University (see Appendixes A through E for instrument).

(2) Each of the thirteen graduate students did an occupational analysis of selected industries (see Selected Bibliography for these reports).

(3) Fifteen additional industrial establishments were selected from those reported in the field study (Roney, 1966). The selection was based on geographical

location and types of industrial establishments necessary to make this study representative of those reported in the field study.

(4) In each industrial establishment, management representatives, supervisors of electromechanical technicians, and electromechanical technicians were interviewed. The supervisors and technicians also completed an occupational analysis questionnaire.

The information presented in this study includes the usable data from 66 supervisors of electromechanical technicians and 137 electromechanical technicians from 57 industrial establishments. The management representatives were given a chance to write comments about any aspects of the electromechanical technician. These are reported in Appendix G.

The information from the occupational analysis was analyzed in the following manner:

(1) Ten research questions were developed (see pages 19 and 20).

(2) The data from the supervisors was compared to the data from the technicians.

(3) The technician's data were divided into four categories according to years of experience and then the data were compared.

(4) The technician's data were divided into five categories according to major emphasis of work and then the data were compared.

Conclusions

This occupational analysis of the electromechanical technician's occupation was conducted to determine the frequency of task performance and the area of activity in which these tasks were performed. The information was organized and analyzed in preparation for writing educational objectives. The conclusions in this section were drawn in regards to the research questions to be answered.

> R_Q1. Which of the selected technical tasks are most frequently performed by the electromechanical technicians, as viewed by the technicians and as viewed by the supervisors?

The electromechanical tasks were ranked by frequency of use as indicated by the supervisors and technicians. The Spearman rank coefficient of correlation was .93. The technicians tended to rank the mechanical and optical tasks higher while the supervisors tended to rank the fluid and thermal tasks higher.

> R_Q2. Which of the selected communication tasks are most frequently performed by the electromechanical technician, as viewed by the technicians and as viewed by the supervisors?

The communication tasks were ranked by frequency of use as indicated by the supervisors and technicians. The Spearman rank coefficient of correlation was .98. The largest difference in the rank of communication task was one. The supervisors ranked, prepare evaluation reports, fifth, and participate in training and teaching activities, sixth, while the technicians ranked these two tasks sixth and fifth, respectively.

R_Q3. Which of the selected mathematical tasks are most frequently performed by the electromechanical technician, as viewed by the technicians and as viewed by the supervisors?

The mathematical tasks were ranked by frequency of use as indicated by the supervisors and technicians. The Spearman rank coefficient of correlation was .96. Only two of the mathematical tasks had a difference in rank of three. The task (decibels) was ranked higher by the supervisors than the technicians while the task solution of oblique triangle was ranked higher by the technicians than the supervisors.

R_Q4. Which of the selected shop tools are most frequently used by the electromechanical technician, as viewed by the technicians and as viewed by the supervisors?

The shop tools were ranked by frequency of use as indicated by the supervisors and technicians. The Spearman rank coefficient of correlation was .92. The largest difference in rank of any shop tool was two. This occurred for the tools gas welder and sheet metal tools. In both cases, the technicians ranked these higher than the supervisors.

R_Q5. Which of the selected test instruments are most frequently used by the electromechanical technicians, as viewed by the technicians and as viewed by the supervisors?

The test equipment items were ranked by frequency of use as indicated by the supervisors and technicians. The Spearman rank coefficient of correlation was .94. One item, pulse generators, has a difference in rank of 10. This item was ranked higher by the supervisors than the technicians. The item pressure gauges had a difference in rank of seven. The supervisors ranked this item higher than the technicians. Several other items had a difference in rank of six.

R_Q6. What is the order of selected activities of performing the selected tasks, as viewed by the technicians and as viewed by the supervisors?

In Tables II and III, the percent of responses for each area of activity on each electromechanical task is listed. In Table IV, the percent of responses for each area of activity is listed. Testing, troubleshooting, and analyzing were the activities most often indicated by both the supervisors and technicians as primary area of activity.

R_Q7. Which of the selected unified concepts are most frequently used by the electromechanical technician, as viewed by the technicians and as viewed by the supervisors?

The selected unified concepts were listed with the ranking by the supervisors and technicians. The Spearman rank coefficient of correlation was .94. The largest difference in the ranking was two. This occurred for unified concepts time constants, amplification, and for tasks-all concepts.

R_Q8. Is there a difference in the task performance of electromechanical technicians with an increase in years of experience?

The data from the 137 electromechanical technicians were divided into four categories of years of experience. These were 0 to 2, 3 to 5, 6 to 10, and over 10 years of experience. There were some tasks that showed an increase or decrease in rank with years of experience, but no general trend could be established from the analysis of the data.

This indicates that either there are few differences in the tasks performed by electromechanical technicians with increasing years of experience or that the questionnaire was not sensitive enough for this type of analysis.

Troubleshooting and testing were two major areas of activity for all four categories. Constructing increased from 10.2 percent for the category 0 to 2 years to 11.3 percent for the next two categories, then decreased to 8.1 percent in category over 10 years experience. Instructing showed a slight increase with years experience while analyzing showed a large increase. Calibrating and repairing showed a slight decrease in percent. Modifying, installing, and servicing showed little change with years of experience. Operating was higher in categories 3 to 5 and over 10 years of experience than the other two categories.

R_Q9. Is there a difference in the task performance of electromechanical technicians when viewed from different major emphasis of work, e.g., research and design, production, maintenance, and others?

The data from the 137 electromechanical technicians were divided into four categories of major emphasis of work. These categories were research and design, production, maintenance, and others. When comparing the ranking of the electromechanical task in the four categories, the Spearman Rank coefficient of correlation was highest for production versus maintenance and lowest for research and design versus others. The ranking of the other tasks, tools, and test equipment showed a high correlation between all groups. Some differences did occur in the primary activities. The technicians in research and design indicated analyzing, testing, and construction as their primary activities. The technicians in production indicated testing and troubleshooting as primary activities. The technicians in maintenance indicated troubleshooting, testing, analyzing, and repairing as their primary activities. The technicians in the category, others, indicated testing as their primary area of activity.

R_Q10. Can educational objectives be written from the results of the selected occupational analysis questionnaire?

In the Review of the Literature, the need for educational objectives and the need for an occupational analysis in order to write these objectives was documented. The specific process of moving from the occupational analysis to the objectives could not be found in the literature.

After conducting this occupational analysis and analyzing the data, there are several areas that should be considered carefully before writing educational objectives.

During the interviews, the management representatives, supervisors, and technicians indicated the need for the educational system to teach the tasks performed by the technicians in industry. In most cases, they agreed that the occupational analysis was one method of identifying these tasks. It was also pointed out by the supervisors and technicians that their tasks were often different from time to time so the answers given on the questionnaire had to be general and could only be an estimate.

From an analysis of the ranking of the tasks by the supervisors and technicians, it is possible to get some indication of the selected tasks to place emphasis on when writing educational objectives. The coefficient of correlation of the ranking of the tasks, tools, and test equipment was between .92 and .98.

The information presented in Table IV indicates that the overall objectives of an electromechanical technology education program should be directed toward testing, troubleshooting, and analyzing. The areas of activity for each specific task are listed in Tables II and III.

When the technician's data were separated by major emphasis of work, differences occurred in the ranking of the tasks, tools, and test equipment between the four categories. Differences also occurred in the area of activities of performing these tasks.

Conclusions From Personal Interviews

From the interviews with the supervisors and technicians, it was concluded that three areas of engineering technology had not been covered in the questionnaire. These areas were high vacuum, magnetism, and magnetic fields. These areas were usually suggested by the supervisors and technicians in research and design.

Recommendations for Writing Educational Objectives

In writing educational objectives from this occupational analysis, several factors should be considered. One of the factors is the scope of the education program. If the program is for training a technician for a certain type of industry then the data reported in that major emphasis of work should be used. If the placement of the graduates of the training program will be in various industries, the combined data of the supervisors and technicians should be used for writing the educational objectives.

The emphasis on activities in performing tasks will also depend on the expected placement of the graduates. The activities most frequently indicated as primary were testing, troubleshooting, analyzing, and constructing. The primary activity also varied with the individual tasks. Several supervisors and technicians pointed out that in some cases some of the other activities needed to be performed in order to reach the primary activity. These factors should be considered when developing educational objectives from this occupational analysis.

In the related areas of communication and mathematics, there was a high correlation between the ranking of the tasks by the supervisors and technicians. But again some differences occurred when the data were separated into the various groups. In the selected mathematic tasks, most of the algebra and trigonometry tasks were ranked higher than the analytic geometry, calculus, differential equation, and Booleon algebra tasks.

In developing the educational objectives for an electromechanical technology education program, some of the objectives should pertain to pertain to the operation of shop tools. The shop tools were ranked various ways depending on the grouping category but from the overall count at least 40 percent of the supervisors and technicians indicated a frequency of use for each selected shop tool. The ranking of the selected test equipment also varied with the various grouping categories. The test equipment pertaining to the audio and optical fields were generally ranked lower than the other test equipment. The slide rule and desk calculator were indicated as items frequently used and should, therefore, be included in the electromechanical technology education program.

Recommendations for Further Research

(1) It is recommended that further study be conducted to determine if there is a difference in task performance, of the electromechanical technician, with increase in years of experience.

(2) It is recommended that further study be conducted to determine the tasks performed by the electromechanical technicians in the areas of high vacuum, magnetism, and magnetic fields.

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APPENDIX A

LETTER OF INTRODUCTION

To be returned to interviewer or Dr. Paul V. Braden, 406 Classroom Bldg. Oklahoma State University, Stillwater, Oklahoma 74074.

OKLAHOMA STATE UNIVERSITY • STILLWATER

74074

School of Occupational and Adult Education and
Department of Technical Education
406 Classroom Building
372-6211 - Ext. 6287

TO: Employers of Technicians who work with both Electrical and Mechanical Devices (Electromechanical Technicians)

FROM: Dr. Paul V. Braden, Director, Electro-Mechanical Fellowship Project, Oklahoma State University,

and

Mr. Howard R. Shelton and L. Paul Robertson, Sandia Laboratories, Representing the National Advisory Committee for Electromechanical Technology

SUBJECT: Identification of the Tasks performed by Electromechanical Technicians.

The name of your company has been identified as one that employs persons who might be classified as electromechanical technicians. As the name implies, this is a person working with electrical, mechanical, and electromechanical devices such as servomechanisms, motor controls, gear trains, and/or automated equipment. Electromechanical technicians also may work in other fields such as hydraulics, pneumatics, or thermodynamics.

In conjunction with the National Advisory Committee on Electromechanical Technology, we are conducting an occupational analysis to aid in better defining the job of an electromechanical technician. This representative from OSU would like to visit selected supervisor(s) and electromechanical technicians for the above purpose.

The information from this study will be used to help initiate a new type of technical training program at junior colleges, technical institutes, area vocational-technical schools and other relevant institutions. The outcome should be a supply of technicians who are better trained to work in cross-disciplinary fields thus helping you find more qualified employees.

A report showing the results of approximately 70 visitations to establishments across the nation will be made available to you as well as the findings from your specific organization.

Interview # ___________

Interviewer ______________________

To be returned to interviewer or Dr. Paul V. Braden, 406 Classroom Bldg., Oklahoma State University.

APPENDIX B

MANAGEMENT REPRESENTATIVE QUESTIONNAIRE

TO BE COMPLETED IN INTERVIEW WITH
MANAGEMENT REPRESENTATIVE

The following information is needed to assist in further planning for electromechanical technician training programs in the United States. In general, the kind of programs under consideration are offered at the post-high school level, two years in length with conceptual and practical exposure in the electrical, mechanical, fluid, and thermodynamic fields.

____
Name of Management Representative

____
Title

____
Name of Establishment

____
If this establishment is a part of a larger organization please specify but report only for this establishment.

____
Street and Number   City

____
Telephone Number and Extension of Representative

Responses to these questions refer only to this establishment - Responses will not be identified by individuals or establishments without specific permission in any published materials or reports.

What is the approximate number of personnel that are presently employed in this establishment?

____
Number of Employees

What is the major activity of your establishment (or division):

_____ Manufacturing

_____ Construction

_____ Mining

_____ Public Utilities

_____ Trade (wholesale or retail)

_____ Finance-Insurance-Real Estate

_____ Service

_____ Government

_____ Other (please specify) ____________________________

Are there any comments you would care to make concerning the recruitment, in-service training, promotion, etc., of electromechanical technicians, in your establishment.

____

____

____

____

Who is the direct supervisor(s) of your electromechanical technicians?

Name	Department	Time
Name	Department	Time
Name	Department	Time
Name	Department	Time

What time would you arrange an appointment with the supervisor(s)?

____

THANK YOU!!

APPENDIX C

SUPERVISOR'S QUESTIONNAIRE

TO BE COMPLETED BY SUPERVISOR OF
ELECTROMECHANICAL TECHNICIAN

Name ____

Title ____

Department ____

Telephone Number and Extension ______________________________

Years of Experience: _____ As Supervisor

_____ As Technician

_____ As Electromechanical Technician

How many technicians do you have that work with both electrical and mechanical devices? ____________ Number of Technicians

Could we look at some of your job descriptions?

Which of the following represents the primary activity of these electromechanical technicians?

__ Research and Design ______ How Many

__ Sales ______ How Many

__ Production ______ How Many

__ Maintenance ______ How Many

__ Other ____________________ (Please Specify)

Are there any comments you would like to make about electromechanical technicians in the areas of recruitment, in-service training, promotion, etc.?

____

____

APPENDIX D

SUPERVISOR'S INSTRUMENT COVER SHEET

TO BE COMPLETED BY SUPERVISOR OF EM TECHNICIAN(S). PLEASE COMPLETE THIS FORM IN TERMS OF WHAT YOU EXPECT THE EM TECHNICIAN TO BE ABLE TO DO UPON ENTRY.

NAME OF SUPERVISOR ____________________

DO YOU WORK WITH OR DETERMINE - -	Frequency Of Use					Check the Primary Activity Within Which You Perform This Task										
TASKS INVOLVING ELECTRICAL-ELECTRONIC PRINCIPLES	Daily	Weekly	Monthly	Seldom	Not Applicable	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
1. Potential differences in circuit [1]																
2. Current flow by use of instruments [2]																
3. Circuit losses [3]																
4. Inductance and/or capacitance [4]																
5. X_C and/or X_L [4]																
6. Transmission and delay lines [5]																
7. Rise and fall times [6]																
8. Component values for tuned circuits [7]																
9. The gain of an amplifier [8]																
10. The effect of feedback loop components in electronic circuits [9]																
11. Antenna field strength [11]																
12. Modulation percentage																
13. Integrated circuits																
14. Pulse and logic circuits [5]																

APPENDIX E

TECHNICIAN'S QUESTIONNAIRE AND INSTRUMENT

If found please return to Interviewer or Dr. Paul V. Braden, 406 Classroom Building, Oklahoma State University, Stillwater, Oklahoma, 74074.

TO BE COMPLETED BY THE
ELECTROMECHANICAL TECHNICIAN

Name ______________________________

Name of Establishment ______________________________

Education: (Circle last year completed)

(a) 7 8 9 10 11 12

College or Post-High School

1 2 3 4

(b) Type of School ______________________________
(Please Specify)

(c) Major Field of Study ______________________________
(Please Specify)

Years of Experience:

_____ As Technician
Years

_____ As Electromechanical Technician
Years

Which of the following represents your primary activity:

☐ Research and Design ☐ Production

☐ Sales ☐ Maintenance

☐ Other ______________________________
(Please Specify)

Percent of time spent in following fields (total should add to 100 percent).

Electrical/Electronics 10 20 30 40 50 60 70 80 90 100

Mechanical 10 20 30 40 50 60 70 80 90 100

Fluids (hyd/Pneum) 10 20 30 40 50 60 70 80 90 100

Thermal 10 20 30 40 50 60 70 80 90 100

Optical or Acoustical 10 20 30 40 50 60 70 80 90 100

Percent of time spent in following activities (total should add to 100 percen

Analyzing	10	20	30	40	50	60	70	80	90	100
Instructing	10	20	30	40	50	60	70	80	90	100
Modifying	10	20	30	40	50	60	70	80	90	100
Troubleshooting	10	20	30	40	50	60	70	80	90	100
Installing	10	20	30	40	50	60	70	80	90	100
Testing	10	20	30	40	50	60	70	80	90	100
Constructing	10	20	30	40	50	60	70	80	90	100
Calibrating	10	20	30	40	50	60	70	80	90	100
Repairing	10	20	30	40	50	60	70	80	90	100
Servicing	10	20	30	40	50	60	70	80	90	100
Operating	10	20	30	40	50	60	70	80	90	100

Areas in which you feel a need for additional education. Please rank the following 1 (one) through N (any appropriate number) with 1 (one) representing the most critical area of need.

______ Electrical/Electronics

______ Mechanical

______ Fluids (hyd/Pneum)

______ Optics

______ Acoustics

______ Communications

______ Other ______________________________
(Please Specify)

TO BE COMPLETED BY THE EM TECHNICIAN. PLEASE COMPLETE THIS FORM IN TERMS OF WHAT YOU ACTUALLY DO.

NAME OF TECHNICIAN ____________________

DO YOU WORK WITH OR DETERMINE - - TASKS INVOLVING ELECTRICAL-ELECTRONIC PRINCIPLES	Frequency of Use					Check the Primary Activity Within Which You Perform This Task										
	Daily	Weekly	Monthly	Seldom	Not Applicable	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
1. Potential differences in circuit [1]																
2. Current flow by use of instruments [2]																
3. Circuit losses [3]																
4. Inductance and/or capacitance [4]																
5. X_C and/or X_L [4]																
6. Transmission and delay lines [5]																
7. Rise and fall times [6]																
8. Component values for tuned circuits [7]																
9. The gain of an amplifier [8]																
10. The effect of feedback loop components in electronic circuits [9]																
11. Antenna field strength [11]																
12. Modulation percentage																
13. Integrated circuits																
14. Pulse and logic circuits [5]																

DO YOU WORK WITH OR DETERMINE - -	Frequency of Use					Check the Primary Activity Within Which You Perform This Task										
TASKS INVOLVING ELECTRICAL-ELECTRONIC PRINCIPLES (CONTINUED)	Daily	Weekly	Monthly	Seldom	Not Applicable	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
15. Specifications of electronic components																
16. Bias networks [3]																
17. Power converters and energy storage cell [4]																
18. Industrial control and high power switching circuits																
19. Frequencies above 500 megahertz [5]																
20. Micro electronic components, circuits, and packaging																
21. Piezoelectric devices [1]																
22. Other																
23. Other																

DO YOU WORK OR DETERMINE - - TASKS INVOLVING MECHANICAL PRINCIPLES	Frequency of Use					Check the Primary Activity Within Which You Perform This Task										
	Daily	Weekly	Monthly	Seldom	Not Applicable	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
1. Stress and/or strain caused by static forces [1]																
2. Rotational or translational rates [2]																
3. Coefficient of friction [3]																
4. Spring constants and/or inertial values [4]																
5. Gear ratios for maximum power transfer [5]																
6. Mechanical indexing or sequenching devices [6]																
7. Vibratory systems or analysis [7]																
8. Mechanical servos [8]																
9. Speed control mechanisms [9]																
10. Gear trains and linkages [5]																
11. Precision measuring instruments and precision tolerances																
12. Characteristics of materials such as, hardness, temperature characteristics, etc.																

DO YOU WORK OR DETERMINE - -	Frequency of Use					Check the Primary Activity Within Which You Perform This Task										
TASKS INVOLVING MECHANICAL PRINCIPLES (CONTINUED)	Daily	Weekly	Monthly	Seldom	Not Applicable	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
13. Laminates plastics and ceramics																
14. Stresses and strains by dynamic force [5]																
15. Power transmission systems such as belts, chains and drive shafts [5]																
16. Antifriction devices and lubricants[3																
17. Bearing loadings and specifications[3																
18. Power requirements of mechanical systems [3]																
19. Specifications and characteristics of fastening devices such as adhesives, bolts, rivets, screws and welds																
20. Other																
21. Other																

DO YOU WORK OR DETERMINE - -	Frequency of Use					Check the Primary Activity Within Which You Perform This Task										
TASKS INVOLVING FLUID PRINCIPLES	Daily	Weekly	Monthly	Seldom	Not Applicable	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
1. Pressure drops in a system [1]																
2. Rate of flow [2]																
3. System losses due to pressure drops [3																
4. Fluid capacitance (fluid reservoirs pressurization required to accelerate a fluid in a pipe or passage) of a fluid system [4]																
5. Maximum power transfer in a system [5																
6. System response time [6]																
7. Fluidic devices such as oscillators, sensors, switches, etc. [5]																
8. Fluid servo devices [8]																
9. Or adjust hydraulic servo systems to meet performance specifications [8]																
10. System power requirements dealing with pumps, compressors, etc. [2]																
11. Cryogenic systems																

DO YOU WORK OR DETERMINE - -	Frequency of Use					Check the Primary Activity Within Which You Perform This Task										
TASKS INVOLVING FLUID PRINCIPLES (CONTINUED)	Daily	Weekly	Monthly	Seldom	Not Applicable	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
12. Fluid actuator parameters																
13. Fluid regulators, sensors, switches and valves																
14. Specifications and characteristics of fittings, pipes and hoses																
15. Fluid measuring devices [2]																
16. Fluid characteristics or specifications																
17. Other																
18. Other																

DO YOU WORK OR DETERMINE - -

TASKS INVOLVING THERMAL PRINCIPLES	Frequency of Use					Check the Primary Activity Within Which You Perform This Task										
	Daily	Weekly	Monthly	Seldom	Not Applicable	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
1. Thermocouples [1]																
2. Thermal capacity and thermal resistance [6]																
3. Thermal control devices																
4. Heat flow rates for temperature differential [2]																
5. Heat sink and radiator capacities [3]																
6. Specific heat [4]																
7. Thermal system efficiency [5]																
8. Thermal chambers																
9. Heat losses [3]																
10. "k" factors [3]																
11. Dew point or humidity																
12. Refrigeration and/or airconditioning systems																
13. Other																
14. Other																

DO YOU WORK OR DETERMINE- -	Frequency of Use					Check the Primary Activity Within Which You Perform This Task										
TASKS INVOLVING ACOUSTICAL PRINCIPLES	Daily	Weekly	Monthly	Seldom	Not Applicable	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
1. Sound frequencies [10]																
2. Sound intensities [10]																
3. Transducers such as microphones and speakers																
4. Sound absorption coefficients [3]																
5. Resonant conditions [7]																
6. Ultrasonic devices [10]																
7. Velocity of sound in various media[10																
8. Other																
9. Other																

DO YOU WORK OR DETERMINE - - TASKS INVOLVING OPTICAL PRINCIPLES	Frequency of use					Check the Primary Activity Within Which You Perform This Task										
	Daily	Weekly	Monthly	Seldom	Not Applicable	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
1. Light intensity [10]																
2. Lens systems [10]																
3. Diffraction gratings [10]																
4. Light frequency [10]																
5. Optical filters and polarizers [10]																
6. Laser devices [10]																
7. Photosensitive devices																
8. Photo emittive devices																
9. Luminescent materials																
10. Other																
11. Other																

DO YOU WORK OR DETERMINE - -	Frequency of Use					Check the Primary Activity Within Which You Perform This Task										
TASKS INVOLVING NUCLEAR RADIATION PRINCIPLES	Daily	Weekly	Monthly	Seldom	Not Applicable	Instructing	Modifying	Analyzing	Troubleshooting	Installing	Testing	Constructing	Calibrating	Repairing	Servicing	Operating
1. Radiation measuring devices																
2. Radioactive elements or isotopes																
3. Fusionable or fissionable material																
4. Other																
5. Other																
TASKS INVOLVING CHEMISTRY PRINCIPLES																
1. Ph factors																
2. Separation of compounds																
3. Chemical compounds or solutions																
4. Chemical etching, plating or anodizing																
5. Other																
6. Other																

COMMUNICATIONS

DO YOU - -	Frequency of Activity				
	Daily	Weekly	Monthly	Seldom	Never
1. Prepare graphs and charts					
2. Prepare evaluation reports					
3. Fill in evaluation sheets					
4. Prepare specifications					
5. Participate in engineering management and customer planning sessions					
6. Participate in engineering management and customer evaluation sessions					
7. Read specifications					
8. Read engineering drawings and/or schematics					
9. Present findings orally					
10. Participate in training and teaching activities (formal and informal)					
11. Computer programming					
12. Other					
13. Other					

MATHEMATICS

DO YOU USE	Frequency of Use: Daily	Weekly	Monthly	Seldom	Never	Level of Proficiency: Do not need	Need general understanding, familiar with terms, but not necessarily competent	Need working knowledge
1. Basic Arithmetic								
2. Algebra A. linear equation with one unknown								
B. linear equation with two or more unknowns								
C. Determinants								
D. Exponents & radicals								
E. Quadratic equations								
F. Complex numbers (J-operator)								
G. Logarithms								
H. Graphs								
I. Vectors								
J. Decibels								
3. Trigonometry A. Solution of right triangles								
B. Solution of oblique triangles								
4. Analytic Geometry								
5. Calculus A. Differentiation								
B. Integration								
C. Basic differential equa.								
D. Booleon Algebra								
E. Binary Arithmetic								

SHOP TOOLS

DO YOU OPERATE - -	Frequency of Use				
	Daily	Weekly	Monthly	Seldom	Not Applicable
1. Drill Press					
2. Lathe					
3. Milling machine					
4. Gas welder					
5. Arc welder					
6. Sheet metal tools					
7. Power saws					
8. Abrasive power tools					
9. Other					
10. Other					

INSTRUMENT LIST

		Frequency of Use				
Code Number	Electrical	Daily	Weekly	Monthly	Seldom	Not Applicable
1.01	VOM-VTVM-TVM					
1.02	Oscilloscope					
1.03	Impedance Bridge					
1.04	SWR Meter					
1.05	Pulse Gen.					
1.06	Signal Gen.					
1.07	Curve Tracer					
1.08	Regulated power supplies					
1.09	Freq. Meter					
1.10	Plotters and Recorders					
1.11	Other					
	Mechanical					
2.01	Torque Meter					
2.02	Tachometer					
2.03	Strobelight					
2.04	Micrometer					
2.05	Vernier Caliper					
2.06	Strain gages					
2.07	Hardness Tester					
2.08	Compression Tester					
2.09	Tension Tester					
2.10	Force Gages					
2.11	Accelerometers					
2.12	Other					

		Frequency of Use				
Code Number	Fluid	Daily	Weekly	Monthly	Seldom	Not Applicable
3.01	Pressure Gages					
3.02	Flow Meters					
3.03	Viscosity Meters					
3.04	Hydrometers					
3.05	Other					
	Thermal					
4.01	Thermocouple instruments					
4.02	Thermometer					
4.03	Pyrometers					
4.04	Other					
	Optical					
5.01	Spectrometer					
5.02	Light meter					
5.03	Other					
	Audio					
6.01	Noise Gen.					
6.02	Wave Analyzer					
6.03	Sound intensity meter					
6.04	Spectrum Analyzer					
6.05	Desk Calculator					
6.06	Slide rule					
6.07	Other					

APPENDIX F

REPORTING ESTABLISHMENTS

Establishment	Location
Stanford Research Institute	Menlo Park, California
Royco Instrument Inc.	Menlo Park, California
EMP Electronics Inc.	Phoenix, Arizona
Ball Brothers Res. Corp.	Boulder, Colorado
The Quaker Oats Co.	Sherman, Texas
Anderson, Clayton and Co.	Sherman, Texas
Eastman Kodak Co.	Rochester, New York
Xerox Corporation	Rochester, New York
Packard Instrument Co. Inc.	Downer Grove, Illinois
US Naval Ordnance Laboratory	White Oak, Maryland
Motorola Inc.	Schiller Park, Illinois
Timken Roller Bearing Co.	Canton, Ohio
Atlantic Richfield Co.	Philadelphia, Pa.
Tele-Dynamics Div.	Ft. Washington, Pa.
Honeywell Inc.	Green Wood Acre, Maryland
Monsanto	St. Louis, Missouri
Sandia Laboratories	Albuquerque, New Mexico
Continental Oil Company	Ponca City, Oklahoma
Public Service Company of Oklahoma	Tulsa, Oklahoma
Telex Computer Products	Tulsa, Oklahoma
Nelson Electrical Company	Tulsa, Oklahoma
Lockheed Electrical Company	Houston, Texas
Texas Instruments	Stafford, Texas
International Business Machines	Houston, Texas
Honeywell Incorporated	St. Petersburg, Florida
General Electric Company	St. Petersburg, Florida

Establishment	Location
Sperry Rand Company	St. Petersburg, Florida
Congoleum Industries Inc.	Wilburton, Oklahoma
Getty Oil Company	Bakersfield, California
Bell & Howell (CEC)	Pasadena, California
U. S. Borax & Chemical Corporation	Boron, California
California State Dept. of Water Resources	Bakersfield, California
Standard Oil Company of California	Taft, California
Argonne National Laboratories	Argonne, Illinois
General Mills, Inc.	West Chicago, Illinois
Bell Telephone Laboratories	Naperville, Illinois
International Harvester	F. Wayne, Indiana
North American Rockwell, Tulsa Lab.	Tulsa, Oklahoma
McDonald-Douglas Aircraft Company	Tulsa, Oklahoma
Century Electronics and Instruments, Inc.	Tulsa, Oklahoma
Dorsett Electronics	Tulsa, Oklahoma
Dalton Precisions Inc.	Cushing, Oklahoma
Barlett-Collins Company	Sapulpa, Oklahoma
Midland Coop., Inc.	Cushing, Oklahoma
U. S. Tufted Carpets, Inc.	Bristow, Oklahoma
Electronic System Eng. Company	Cushing, Oklahoma
Radio Specialty Mfg. Company	Portland, Oregon
Bonnville Power Administration	Vancouver, Washington
United Medical Laboratories	Portland, Oregon
Standard Controls Inc.	Seattle, Washington
Southtown Electric Contractor	St. Louis, Missouri

Southwestern Bell Telephone	St. Louis, Missouri
McDonnell-Douglas	St. Louis, Missouri
McHenry Metal Products Co., Inc.	St. Louis, Missouri
Bell Refinery	Ardmore, Oklahoma
Slaughter Company	Ardmore, Oklahoma
Stromberg-Carlston	Ardmore, Oklahoma
Whites Machines & Supply Company	Cashion, Oklahoma
Aero Space Controls	Wichita, Kansas
Beech Aircraft Corp.	Wichita, Kansas
Recognition Equipment Inc.	Dallas, Texas
Texas Instruments	Dallas, Texas

APPENDIX G

ADDITIONAL COMMENTS BY MANAGEMENT

REPRESENTATIVES

These selected comments were made by management representatives about recruitment and training of electromechanical technicians.

From a large oil establishment:

> Most of the electromechanical work is done in the field by electricians, who have come up thru the ranks with the service training. Nearly all of them have had no education beyond high school and essentially no formal training in their work. When they encounter unfamiliar or unusual problems they can call on either of the technicians (questionnaire attached) or engineers for specialized assistance. Because of the large area extent of our operations line it is not practical to have a specialized technician in each area.
>
> As our operations became more sophisticated in design, we expect to have more in service training of some kind to improve their performance in installing, operating, and maintaining such equipment.
>
> Our primary use of technicians at present is as engineering assistants and draftsmen in a design function rather than as maintenance use. They would also be available for assistance for troubleshooting equipment after it is placed in operation.
>
> In our operations we would prefer that the education of technicians would be slanted toward the use and application of electromechanical devices rather than design of specific items of equipment.

From production establishments:

> Since most production equipment in large manufacturing units are rapidly automating with computer control a good background in computer logic, computer theory, and programming will be a big help in addition to the mechanical work.
>
> Recruitment is from electric-electronic or instrument background with in service training in the department.
>
> Presently recruit by promotion from field ranks.

From manufacturing establishments:

> From a labor relation standpoint, this subject is very touchy.
>
> Need industry-education coop. programs and summer work programs.
>
> 1. Military training seems pretty good.
> 2. More in upper portion of classes go on to become engineers.

3. Pound the fundamentals of physics home.

From research and development establishments:

We have all varieties of training and background -- sort of catch as catch can.

We select technicians from the top ten percent of ECPD approved programs and then train them in electromechanical.

Should have a good and complete background in math.

Should have capability of understanding and working with times - stepping switches - sample servos - meters - etc -

From small establishments:

We feel there is a great need for such training. We certainly could use these people in our work.

We feel there is a need for such a person.

Our company would be very responsive towards a training program of this type. We would be interested in hiring this type of personnel if we had the opening.

We do not currently have a classification of EM tech. Our more experienced tech's get the EM experience more or less because they're interested.

APPENDIX H

ADDITIONAL TASKS AND EQUIPMENT LISTED BY

SUPERVISORS AND TECHNICIANS

ELECTROMECHANICAL TASKS

- Electromechanical Relays
- Bridge Circuits
- Solid State Lamps
- Motors and Solenoids
- Error Detection Devices
- Servo Amplifiers
- Digital Circuits
- Capillary Systems
- Optical Density
- X-Ray Testing
- Chemical Gases

SHOP TOOLS

- Hand Tools
- Shear
- Brake
- Spot Welder
- Hydraulic Test Stand
- Environmental Chambers

TEST EQUIPMENT

- Digital CNTR
- Digital VM
- Computers
- Vibtometer
- Distortion Meters
- Partial Pressure Analyzer
- Laser
- Collimator

APPENDIX I

SUMMARY OF FIELD STUDY

ELECTROMECHANICAL TECHNOLOGY

A Field Study of Electromechanical

Technician Occupations

Part I

Summary and Conclusions

The field study for electromechanical technician occupation was conducted in two stages. In the first phase of the study, personal interviews were conducted in 26 industrial organizations selected by size and by principal activity and distributed geographically throughout the United States.

Twenty-two of the 26 organizations included in this phase of the study indicated an expanding need for technicians capable of working with electromechanical systems and devices. At the time the study was conducted, these 22 firms employed electronics technicians or mechanical technicians and provided on-the-job training in electronics or mechanics correspondent to individual needs. All of the 22 saw a pressing need for pre-employment training of technical personnel for these occupations. The kind of pre-employment training desired was described as follows:

1. The training should put emphasis on electrical and mechanical principles rather than on specific applications of these principles.
2. Communication skills are extremely important in the work of electromechanical technicians and should be given special attention in the training program.

3. A study of the interrelationship of electrical and mechanical elements of systems and devices should be central in the specialized technical courses of the instructional program. Whenever possible, electrical and mechanical principles should be studied together, and not as separate entities.
4. Principles of electrical and mechanical physics are basic tools in the work of electromechanical technicians and all technical instruction should develop analytical skills for which these tools are fundamental. In addition, there is an increasing need for the technician to work with new applications of other physical sciences such as: optical equipment, thermal energy devices, hydraulic and pneumatic controls, and a wide variety of measuring instruments.

The second phase of the study utilized a very brief questionnaire designed to obtain a broad sample of the quantitative need for electromechanical technicians. Ninety-three industrial organizations responded to the request for information. Their total need for trained electromechanical technicians (new hires) was estimated to be 20, 329 by 1970, a number 25% greater during this period than their combined hires of electronic technicians and mechanical technicians.

The use of a personal interview technique in this study made it mandatory to select an individual with special qualifications. The principal consultant on this project was especially well-qualified, having had recent experience in engineering and technical institute teaching, curriculum design in two-year technology programs, and field work in a national study of instrumentation education programs.

In general, the study succeeded in its major objectives of identifying occupational and educational needs in the new and emerging occupation of electromechanical technology. The information obtained has been used to prepare a basic curriculum plan for a two-year, post-high school program in electromechanical technology. This curriculum plan, with recommendations for developing instructional materials and laboratory facilities, will be prepared and submitted as a separate report to the U. S. Office of Education.

The results of the study indicate a clear and pressing need for experimentation and innovation in the development of technical education for new and emerging occupations. The evidence points to a specific need for new training programs in electromechanical technology and suggests that similar combinations of technological skills may be required in other emerging occupations.

Experimentation and innovation is indicated because of the need for an interdisciplinary training approach that apparently does not now exist or, if it exists, has not been documented. While the field study did not include educational institutions and programs, and hence did not provide conclusive evidence as to the educational process involved, there was a general feeling that more is needed in the training of electromechanical specialist than a simple combination of existing courses in electrical technology and mechanical technology.

The procedures used in the field study were somewhat unconventional, in that a great deal of the information obtain required subjective value judgments on the part of the principal consultant. This procedure appears to be justifiable when no taxonomy exists for the kind of rigidly structured survey instruments that might normally be used.

The controls in this case rested with the Panel of Consultants who, in a sense, served as a jury of experts. As educational programs for this emerging occupation are developed, more sophisticated analyses will be required to better identify specific job functions.

ELECTROMECHANICAL TECHNOLOGY

A Post-High School Technical Curriculum

Part II

Conclusions

1. The increased complexity and the closely interrelated character of electromechanical systems makes it desirable that technicians be equally capable and proficient in each of the technical areas. Their educational program must integrate the two technologies so that they become mutually supporting elements having a common objective.

2. It appears feasible to teach electromechanical principles within the time limits of a two-year program by using a correlated teaching system in which each subject reinforces other subjects in the curriculum. Such an instructional technique will require extensive development. The amount of material which should be included in an electromechanical curriculum cannot be presented within the desired time interval of two years if conventional methods are used.

3. With the educational background, provided by the proposed program, the graduate technician should be prepared to

learn the highly specialized techniques peculiar to a particular job, and is prepared for continued study and growth in the electromechanical field.

4. It is impossible to express this curriculum in conventional terms, using familiar names for courses, when there is to be integration of subject material.

5. Suitable text materials and laboratory experiments for interrelated teaching are not presently available. The development of these materials will be an important element in the development of the instructional program.

6. In order to obtain the desired merging of the electrical-electronic and mechanical technologies it will be necessary to develop new laboratory approaches which make use of modern electromechanical systems and devices. These will be used not only in the electromechanical phases of the program, but also in support of the physics, the electronic, and the mechanical courses.

7. Administrative officials in any institution where this program is to be offered will need to make provisions for a high degree of staff planning and coordination in order to maintain the proper relationship of program material.

8. Each faculty member in an interrelated program will have to be reasonably competent, in more than one discipline, and must display a willingness to cross over into related disciplines for purposes of integration.

9. The success of the proposed electromechanical program will depend to a large measure on a continuous developmental

program involving teacher training, preparation of instructional materials, and the development of laboratory facilities.

10. An active advisory committee is most important in developing and evaluating a curriculum in this emerging field of employment.

11. While the remarks about the study have been directly concerned with the electromechanical technology, they should not be viewed in such a restricted sense. The principles seem to be applicable to some extent to all technologies, in fact, it would appear that the principles can be applied at all levels of education.

Recommendations

The conclusions reached in this study of the emerging occupations in electromechanical technology support the need for a new kind of instructional program. The proposed curriculum reflects the unique requirements of these occupations and is presented as a framework for experimentation and innovation. With these two basic premises as guidelines, the following recommendations are made:

Recommendation No. 1 -

New programs of electromechanical technology should be placed and implemented as soon as possible.

Recommendation No. 2 -

The major effort in developing new programs for electromechanical technicians should be devoted to two-year associate degree level curriculums.

Recommendation No. 3 -

Schools with existing programs of electronic and mechanical technology should not expect to develop electromechanical technology programs by assembling existing courses and utilizing existing instructional staff without further training.

Recommendation No. 4 -

An extensive research project should be planned and carried out to further develop and document the instructional plan proposed for the curriculum in electromechanical technology.

Recommendation No. 5 -

Research studies should be made in other emerging occupational fields which require new combinations of technical skills.

APPENDIX J

SUMMARY OF ELECTROMECHANICAL

DEMONSTRATION PROGRAM

EMT DEMONSTRATION PROGRAM

[1]Preparing technical graduates who are immediately useful employees requires the use of "hands-on" industrial equipment wherever possible in the program. At the same time the program must emphasize knowledge and thought processes instead of special techniques or procedures if the student's education is to have a sufficiently broad base. To help a student go on to advanced studies in his field, the technical educator must teach a group of technical principles soundly based in mathematics and science skills. The nature of the two-year program further requires a non-traditional approach in the scheduling of mathematics and science courses. Rather than preceding the introduction of the technical specialty - the usual academic procedure - these courses must parallel the technical subject matter and must contain selected concepts which are immediately applicable in the technical courses.

Background of the EMT Curriculum

The electromechanical curriculum is the result of a systematic and thorough research and development project involving four major steps: occupational analysis, development of the tentative curriculum, testing, and development and circulation of EMT materials.

Occupational Analysis

The research staff of Oklahoma State University's School of Industrial Education organized and initiated a two-phase field study during 1965-66 to determine how extensive the need for electromechanical

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[1]*EMT Program Compendium* (New York, 1971), pp 2-5.

technicians was, and to identify the skills and knowledge that industry deemed essential in this emerging occupational category. A panel of consultants was selected from a broad geographic area. New York, California, Texas, and Ontario, Canada were some of the areas providing members. They represented such divergent industrial activities as manufacturing, research, distribution, and service. This panel advised and assisted the Oklahoma State University group in planning and conducting the survey, and was largely responsible both for the depth and significance achieved in the investigation and for the objectivity and validity of the conclusions drawn from the findings. (See Appendix I.)

Development of the Tentative Curriculum

Using the field study information, the research group formulated a set of basic guidelines to describe the pre-employment training needed for EMT technicians:

1. The training should put emphasis on electrical and mechanical principles rather than on specific applications of these principles.

2. Communication skills are extremely important in the work of electromechanical technicians and should be given special attention in the training program.

3. A study of the interrelationship of electrical and mechanical elements of systems and devices should be central in the specialized technical courses of the instructional program. Whenever possible, electrical and mechanical principles should be studied together, not as separate entities.

4. Principles of electrical and mechanical physics are basic tools in the work of electromechanical technicians and all technical

instruction should develop analytical skills for which these tools are fundamental. In addition, there is an increasing need for the technician to work with new applications of other physical sciences such as: optical equipment, thermal energy devices, hydraulic and pneumatic controls, and a wide variety of measuring instruments.

It soon became apparent to the curriculum planners that the need for multiple coordination among courses in an EMT curriculum dictated radical changes in the basic organization of such foundation courses as physics and even in some of the established instructional methods of higher education.

The answer use was a curriculum built upon a series of unified concepts, concepts which are common both to electrical and mechanical technology. Such concepts must be used in concurrent courses for mutual support and learning reinforcement through theory introduction, application, and repetition of application in electrical, mechanical, and electromechanical laboratories. The unified concepts which the group formulated are the following:

1. Differential Forces
2. Flow Rates
3. Real Opposition (resistance)
4. Energy Storage
5. Time Constants
6. Impedances
7. Resonances
8. Waves and Fields
9. Amplification
10. Feedback and Stability

Curriculum Testing

The third phase of the electromechanical project, testing of the curriculum and development materials under classroom conditions, began at Oklahoma State University in September 1968, with the enrollment of the first EMT class. Twenty-seven students consituted the class, 17 of whom graduated with EMT associate degrees in 1970. A second group of 28 students enrolled in the OSU program in September 1969. Further testing was conducted at Milwaukee Technical Community College, where the first class was enrolled in the fall of 1969, and a second in the fall of 1970. The Texas State Technical Institute, Waco, Texas initiated its first EMT curriculum in the fall of 1970. All of these classes were conducted under the provisions of a grant from the U. S. Office of Education, under the direction of the Technical Education Research Center. A number of other institutions also began using the curriculum and materials in the fall of 1970.

Textbooks providing the integration of subject matter required in the EMT curriculum were not available when the first class started at Oklahoma State University. In fact, the staff found that not even terminology was "available" at times - conventional terms and familiar course names failed to describe the integrated courses the staff was designing and teaching. Therefore, during the months before the beginning of the first class, and after it got underway, staff members were preparing curriculum materials, primarily in the form of laboratory texts. These texts typically included a discussion of technical principles, an experimental procedure, data tables, analysis guides, and homework problems. These materials, of course, underwent a vast amount of revision during 1968-69, when Oklahoma State University EMT staff began to discover through class exposure what would and would not work in an integrated curriculum. At times, revisions literally occurred on a day-to-day basis, but a smoothly functioning program gradually took shape. The fact that such changes could be made without resulting in the total disruption of the program perhaps best illustrates one of the greatest assets of the EMT curriculum: both in its embryonic stages and as a tested and proven product, it has a unique capacity for flexibility and adaptation.

Circulation of Materials

By July 1970, the EMT staff at Oklahoma State University had received and filled requests for materials and information from 17 junior colleges, 88 colleges and universities, 125 technical institutions, and 44 other groups ranging from high school boards of education to large industrial concerns. The Technical Education Research Center met with representatives from 13 commercial publishing firms in May 1970, and invited them to submit proposals to publish the EMT class and laboratory materials for distribution beginning fall 1972. Various members of the staff have presented the program at numerous professional meetings throughout the United States and articles discussing its concepts and progress have appeared in several professional publications. The dissemination function, of course, is just beginning; its role will become more important as EMT materials become available in quantity.

APPENDIX K

SUMMARY OF ELECTROMECHANICAL

FELLOWSHIP PROGRAM

DEVELOPMENT AND EVALUATION OF A TEACHER EDUCATION PROGRAM IN ELECTROMECHANICAL TECHNOLOGY

The project entitled, "The Development and Evaluation of a Teacher Education Program in Electromechanical Technology," was approved by the newly created EPDA Bureau and initiated in the spring of 1969. The 15 program participants began their program involvement June 1, 1969, and terminated on July 31, 1970. An extension was granted before submitting this final report in order to facilitate rather elaborate evaluation procedures designed into the project. This extension was granted until June 30, 1971, and provided the opportunity to complete the participant follow-up and evaluation of selected participant attitudes along with other evaluation criteria.

The problem which was stated in the initial project proposal and subsequently funded was: The rapid development of Electromechanical Technology (EMT) has created an increasingly serious need for thousands of broadly trained electromechanical technicians and the professional staff to design and implement these educational programs.

The Technical Education Master's degree program at Oklahoma State University was well established in the field at the inception of this fellowship experience. The fellowship program was further strengthened with additional activities related to the national two-year post high school Electromechanical Technology demonstration program emphasizing electromechanical concepts and experiences, i.e., the electromechanical technician demonstration project, still in operation at Oklahoma State University (see Appendix J). This project was fully utilized as a learning resource in the Teacher Fellowship program.

Generally, participants in the Teacher Fellowship program proceeded through the following sequence of activities:

1. The program was initiated by a two-months summer session emphasizing (1) the organization and structure of technician education and (2) a work project in the national electromechanical technician demonstration program.
2. The fall semester concentrated on technical education program planning and the strengthening of each participant's technical background in electronics and/or mechanical technology.
3. The spring semester was devoted to curriculum development in technical education and course work in statistics, research, and technology. A developmental project in the electromechanical technician program served as the master's degree report. This occupational analysis project is described in detail later in this report.
4. The 1970 summer session was devoted to a full-time experience in selected industries that employed electromechanical technicians. An occupational analysis was conducted on-the-job relating to electromechanical technician tasks.

Program Time Schedule

(1) Summer Industrial Experience 1970 - June 1 to July 31

(2) Spring Semester 1970 - January 27 to May 24

(3) Fall Semester 1969 - September 8 to January 24

(4) Summer 1969 - June 1 to July 31.

VITA

Eric William Skouby

Candidate for the Degree of

Doctor of Education

Thesis: AN OCCUPATIONAL ANALYSIS OF ELECTROMECHANICAL TECHNICIAN OCCUPATIONS WITH IMPLICATIONS FOR CURRICULUM DEVELOPMENT

Major Field: Higher Education

Biographical:

Personal Data: Born in Bland, Missouri, June 11, 1934, the son of Mr. and Mrs. Charles I. Skouby.

Education: Graduated from Pulaski High School, Pulaski, Iowa, in May, 1952; attended Missouri School of Mines and Metallurgy from 1955 to 1957; received the Bachlor of Science in Education degree from Central Missouri State College in 1959, with a major in Physics and a minor in Mathematics; received the Master of Arts degree from Central Missouri State College in 1963, with a major in Mathematics. Additional graduate study at University of Missouri, 1965; completed requirements for the Master of Science degree at Oklahoma State University in May 1971, as an Education Council for Professional Development Fellow; completed requirements for the Doctor of Education degree from Oklahoma State University, July, 1972.

Professional Experience: Teacher, Leavenworth High School, 1959-60; teacher, Knob Noster High School, 1960-61; graduate assistant, Central Missouri State College, 1961-62; chairman, Department of Mathematics, Linn Technical College, 1962-69; Director of Technical Education and instructor at Northern Oklahoma College, 1971-present.

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