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TECHNICAL COMPETENCIES NEEDED
BY INDUSTRIAL ARTS TEACHERS TO PERFORM ADEQUATELY
IN CONTEMPORARY POWER TECHNOLOGY LABORATORIES

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

David Leonard DePue, B.S., M.S.

* * * * *

The Ohio State University
1976

Reading Committee: Approved by

Dr. James Kelly Duncan
Dr. Donald G. Lux
Dr. William D. Umstattd

Advisor
The College of Education
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and energies.
VITA

July 25, 1939 .......... Born - Detroit, Michigan
1959-61 ........ Radioman, Third Class Petty Officer,
 defeated (Reserve)
1963 ........ A&P Diploma, Northrop Institute of
 Technology, California.
1963-64 ........ Aircraft Engine Inspector, Aviation
 Power Supply, Burbank, California.
1964-66 ........ Experimental Flight Line Mechanic,
 Lockheed California Company.
1966-68 ........ Flight Line Mechanic, United Air Lines,
 Los Angeles.
1971 .......... B.S., Cum Laude State University College
 at Buffalo, New York.
1971 .......... Substitute Teacher, West Seneca (N.Y.)
 Public Schools.
1972 .......... M.S., State University College at Buffalo.
1971-73 .......... Teacher, Gahanna, Ohio Public Schools.
1973-74 .......... Teaching Associate, The Ohio State University.
1974-76 .......... Assistant Professor, The University of
 Georgia.

FIELDS OF STUDY

Major Field: Industrial Technology Education, Professors Donald G. Lux
 and Willis E. Ray.

Corollary Areas: Curriculum, Professor James Kelly Duncan.

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CHAPTER I

INTRODUCTION

Orientation To The Problem

Power and energy have become very popular topics in recent years. Contemporary media continue to inform us that the days of obtaining inexpensive energy from fossil fuels are over. The significance of energy forms to an industrial nation is profound. Consider that the very level of civilization enjoyed by Americans today may be directly attributed to our ability to utilize energy sources for power.

A major reason for the strength and prosperity of this country is the increasing effort spent in technological research to improve and acquire new prime movers (power plants) (Duffy, 1972, p. 546).

Contemporary writers have attributed developments in power to advancements during major eras in the history of man.

This story of man's progress may be told in terms of his ability to gain control of his surroundings. As he gained control, he put the elements and later machines, to work for him. These machines became more and more complex as man developed devices which put greater amounts of energy under his control. (Bohn & MacDonald, 1970, p. 18).

The search by man to find ways of extending his physical capabilities is reflected in repeated attempts throughout history to harness more energy other than that of his own muscle. In these attempts to discover the useful energy forms around him, he learned how to utilize and control many of them to perform useful work. Today we term this energy utilization and control as the field of power; the rate at which work is performed. (Trudeau, 1971, p. 1).
Thus, each level of technological advance has been determined by the availability of machines and prime movers (power plants) (Duffy, 1972, p. 1).

Industrial arts is a school subject whose principle mission is to provide youth with a broad understanding of the body of knowledge of industrial technology (American Vocational Association, 1968, p. 8).

In a 1974 joint goal statement, Guidelines for Industrial Arts in Career Education, the American Industrial Arts Association (AIAA) and the American Vocational Association (AVA) spelled out the role of industrial arts education. The AIAA and AVA have reasoned that realistic and meaningful career decisions cannot be made unless programs allow a student to progress systematically and sequentially through a series of programs, elementary through secondary, which concentrate on career awareness, orientation, exploration, and prespecialization.

Power is the force that moves industry. This power has been defined as the "prime mover of technology" (Duffy, 1972, p. 1). The mission of industrial arts would include the charge that the technology of power be taught to our youth.

Power, as a school subject, began in an inauspicious manner as early as the 1930's. The topic of power was usually initiated by individual teachers who felt a need for students to understand power conversion and transmission. Since the programs were so individualized, no one curriculum emerged as an educational model.

The subject area of power has had several titles since it came into being. Among these titles are auto mechanics, small engine mechanics, power and transportation, power mechanics and others which received less recognition. These courses have been based upon analyses of the
trades involved, technical practices of various industries and several abstracts from the physical sciences. (Ecker, 1965, p. 11).

Power "technology" was one of the curriculum areas introduced in a 1947 proposal by William E. Warner and a group of his graduate students. However, nearly two decades after Warner's "A Curriculum To Reflect Technology," little substantial change had been made. Industrial arts leaders were criticizing the profession for its methods and subject matter. (Feirer, 1963) (Schmitt & Pelley, 1967).

Statement of the Problem

Currently, schools usually combine power and energy theory under a "power mechanics" heading, a vague label which often means the teaching of small engine repair. This is obviously an inadequate way of dealing with the "high technology" involved in solving global energy problems. ("Council Hopes," 1975, p. 6).

This content inadequacy has been recognized by other researchers. Dissertations by Ecker (1965), Davis (1966), and Webster (1970) cite the need for a unified program in Power Technology and for improvement in programs to prepare teachers for this subject area. These dissertations as well as others by Cameron (1963), Grannis (1970), and Cooksey (1973) have attempted to answer the question "What is the curriculum in power technology?"

Teacher education programs seem to be the obvious place to confront the problem of achieving the skill and knowledge to teach the technology of power. However, mere program improvement in teacher education may not solve the problem. Current certification practices indicate that,
upon graduation, industrial arts teachers are normally qualified to teach a variety of technical subjects. In Ohio, for example, this certification is based upon satisfactory completion of course work distributed over eight areas, including "power" mechanics. However, further delineation of the desired competencies is lacking. The resulting problem is that there can be little quantitative evaluation of teacher expertise in the area of power mechanics or power technology. A professional identification and ordering of these competencies is needed.

The purpose of this study was to identify and classify the competencies needed by the prospective industrial arts teacher of power technology. The study addressed the question, "What is the qualified industrial arts power technologist able to do?"

Significance of the Study

Although a moderate number of researchers have studied industrial arts teachers' performance, relatively few have actually listed the specific competencies needed by the pre-service teacher. Each researcher in these previous studies has recommended further study in this area. A review of these competency studies can be found in chapter II.

The need for further research in the subject matter areas is expressed by Michael F. Shugrue:

PBTE is a phenomenon which demands and deserves the attention of subject matter specialists engaged in the pre-and in-service education of teachers. These specialists can contribute to the success of PBTE in three important ways. They can strengthen the research base on which PBTE rests, they can participate in the design and conduct of programs which incorporate the best current research in subject matter fields and they can help to devise and validate the evaluative instruments and procedures essential to any performance based program. (1973, p. VI)
Power technology is an emerging subject area in industrial arts education. Dr. Warner's proposal to teach the technology which fosters our industry has enjoyed favorable reaction in the profession. While this idea has largely been accepted, no complete plan was ever developed (Towers, et al., 1966, p. 108). Further, industrial arts power technology has evolved into a program of consumer auto mechanics and small engine maintenance. It is felt that an accurate listing of the competencies needed to teach power technology would contribute greatly toward broadening the curriculum to more adequately reflect the technology of power.

While research by Allen (1963), Ecker (1965), Davis (1966), and Grannis (1970), indicates a trend for industrial arts programs to move from teaching the mechanics of power, it is felt that an identification of the competencies needed to teach power technology would speed acceptance of this new program thrust. In addition; (1) awareness of these competencies will help teacher educators to develop more uniform courses of study and to prepare more uniformly competent teachers, (2) prospective employers will know what to expect in the way of performance from industrial arts teachers and (3) educational hardware and software developers will be able to serve the power technology teacher of the future more effectively.

**Objectives of the Study**

The objectives of this study are:

1. To develop a knowledge structure for the subject "power technology" in industrial arts education.
2. To identify the technical competencies needed by the pre-service teacher to perform in contemporary power technology laboratories.
3. To secure validation of competencies from a jury of experts.
4. To determine how professional educators rank order these clusters of competencies in order of importance.

Assumptions

Basic assumptions made in developing this study are that:
1. The body of knowledge for power technology can be structured.
2. A list of technical competencies for pre-service teachers of power technology can be compiled.
3. Teachers and selected supervisors can validate the technical competencies needed to teach a specific industrial arts course.
4. The jury will be able to respond to a paired, forced-choice inventory and provide accurate responses.
5. The instrument will yield valid responses.

Delimitations

Certain delimitations made in this study are that:
1. The content of power technology is the knowledge of practice of converting energy to power and the conversion, transmission, and control of this power.
2. The population of experts from which a representative sample was taken for this study, was restricted to educators who have published on power technology in the United States in the last 10 years, to teacher educators listed in the 1974–75 Industrial
Teacher Education Directory who teach a course titled "Energy" or "Power Technology," and to charter members of the National Educational Council on Energy and Power.

3. This study identifies those competencies which could be detected by listening to and watching the pre-service teacher practicing his skills in the laboratory. Only those competencies relating to technical knowledge and/or manipulative skills are considered.

4. The codified competencies identified in this study are also delimited to those which may be identified in technical books, laboratory manuals, equipment operating instructions and other power technology resources.

Definition of Terms

For effective communication, it is necessary to agree on terminology. Terms which have common meanings or are unique to the areas of study have been identified and defined. It is hoped that the operational definitions presented here will facilitate communication of ideas in this study. Terms are listed in alphabetical order to assist the reader.

**Competency-Based Teacher Education (CBTE)** --is more concerned with consequences obtained than with the specification of objectives. **Objectives** --- are important only to the extent to which they enable the desired results or consequences to occur when the pre-service teacher candidate is teaching pupils (Kelley, 1974, p. 11).

**Competency** --the demonstrated ability to perform to a criterion at function and job levels (Dodl, 1973, p. 195).
Curriculum — the organized educational process through which the individual gains knowledge (Hauenstein, 1972, p. 1).

Enablers — are criterion-referenced statements of activity or performance that exhibit comprehension and application of content, principles, knowledges, processes, techniques, terminology, etc., under given conditions at specified levels of competence. (Hauenstein, 1973, p. 186).

Energy — the ability to do work - or the ability to produce motion, heat, and light (Bohn and MacDonald, 1970, p. 30).

Industrial Arts — an organized study of the knowledge of practice within that subcategory of the economic institution of society which is known as industry. (Towers, et al., 1966, p. 43).

A Module — includes a set of activities intended to facilitate the learner's achievement of a specific objective or set of objectives. It is a relatively self-contained unit, designed for a specific purpose, and is a part of a broader, more comprehensive instructional system. (Howsam & Houston, 1972, p. 10).

Performance-Based Teacher Education (PBTE) — is organized with primary emphasis on the teaching behaviors to be demonstrated. Assessing and evaluating teacher candidates are done on the basis of standards related to cognitive, affective, and performance objectives. (Kelley, 1974, p. 11).

Power — in its general sense, can be used interchangeably with "force" and "energy." Specifically, "Power is the rate of doing work" and "Power is the rate of energy conversion." (Stephenson, 1969, pp. 1 & 7).
Power — (The study of) concerned with introducing concepts of how man converts, transmits, controls, and applies energy to do work. (Duffy, 1972, p. vi).

Power Technology — the body of knowledge of practice of processing energy; converting, transmitting, and controlling power.

Praxiology (Technology) — the product of the organized, disciplined study of the practices of man. It has to do with all of the practices which ultimately affect individual and social behavior. (Towers, et al., 1966, p. 39).

Q-Technique — mainly a sophisticated way of rank-ordering objects (items, stimuli, etc.) and then assigning numerals to subsets of the objects for statistical purposes. It centers particularly in sorting decks of cards called Q sorts and in the correlations among responses of different individuals to the Q sorts. (Kerlinger, 1973, p. 582).

Tasks — activities or performances that exhibit a level of competency expected under given conditions. The tasks provide evidence of being able to apply enabling knowledges, attitudes, and skills in situations. (Hauenstein, 1973, p. 186).

Technical — knowledge of a special and usually practical type. (Webster, 1974, p. 1196).

Technologist — one who is concerned with the applications of science and other forms of knowledge to the needs of man in society. (Kranzberg, 1964, p. 2).
Procedures of the Study

The first step in the study was to review the research on competency based teacher education, particularly studies in the field of industrial education. This review allowed the writer to benefit from the contributions of earlier researchers and served as an orientation to the task at hand.

The second step was to review research in power technology. The purpose was to derive a structure and content for power technology.

Next, curriculum development efforts were examined to search for a context for the study of power technology. Due to the nature of this subject area and as a delimiting tactic, only curricular endeavors based on technology were studied.

The next step was to devise a knowledge structure for power technology.

The fifth step involved reviewing power technology course outlines, texts, laboratory manuals, operators' manuals and other technical literature to identify technical competencies. Hauenstein's (1973 p. 187) model was used to codify tasks and enablers needed to function in a power technology laboratory.

The sixth step was to develop an assessment instrument, a seventh step identified and selected a jury, and the last step consisted of data collection and analysis procedures. An overview of the assessment component of this study is continued on the next pages and graphically illustrated in Figure 1.
Figure 1
RESEARCH PROCEDURES FLOW CHART
Instrument Development

The assessment method considered most appropriate for this study was an evaluation of the listed competencies by a jury of experts. An instrument was developed for this purpose (see Appendix C).

Evaluation techniques considered for the assessment process were: (1) the Delphi technique, (2) a ranking system of the Likert type, and (3) Q-methodology. The Delphi technique was rejected because the jurists typically would be required to formulate and supply the competencies to be included. This would be a very time consuming task and would be asking for a great deal of effort on the part of each jurist. The ranking system was rejected because of the great length of the competencies list. The time needed by each jurist to evaluate the entire list would be extensive. The Q-methodology seemed to be the most practical and effective technique of obtaining opinions of a group of people on a large number of established items. It was decided that this method would be used in making the assessment.

The Q-methodology, utilizing forced-choice rating procedures, makes examination and statistical treatment of the data possible. Previous dissertations by Talkington (1962), Russell (1970), and Guentzler (1973) reveal the applicability of the Q-technique to this problem.

Q-technique is a set of procedures used to implement Q-methodology. It centers particularly in sorting decks of cards called Q sorts and in the correlations among responses of different individuals to the Q sorts. Q-technique is mainly a sophisticated way of rank-ordering objects (items, stimuli, etc.) and then assigning numerals to subsets of the objects for statistical purposes. (Kerlinger, 1973, p. 582).
Jury Selection

It was of considerable importance to select only those who were knowledgeable in the practices of teaching power technology to serve in an evaluative group. Such qualification was necessary due to the very technical nature of the listed competencies. Teachers and teacher educators currently teaching courses in power would likely fulfill the criterion of being knowledgeable. To overcome the problem of identifying power technology professionals and of establishing that each was an "expert," the following methods were used. First, industrial arts journals from the past 10 years were searched for authors of power technology articles. From this effort a list of names was compiled. A second list from the population of experts was identified by utilizing college level power technology instructors identified in the 13th edition of the Industrial Teacher Education Directory. Charter members of the National Educational Council on Energy and Power created a third list of experts. A random sample of personnel from these three groups produced a jury with representation from supervisors, administrators, college instructors, and public school teachers.

Data Collection and Analysis

The last step of this study was to interpret the Q-sort data collected. Data analysis showed the competencies which were judged most and least important by the jury. The data were compared, and percentages of agreement among respondents were computed. These assessment results are described and illustrated in Chapter V.

In summary, a need exists for citizens to be knowledgeable of the technology of power. Industrial arts is the school subject which seems
best suited to accomplish this goal. However, subject matter in in-
dustrial arts power courses has been largely centered on automobile
mechanics and small engine maintenance.

The current push for competency based teacher education provides
a means for a possible solution to curriculum improvement in power. A
broad set of competencies representing contemporary power technology is
needed.

This study was undertaken to develop a framework for the body of
knowledge for power technology. Once this knowledge structure was
developed, specific technological activities were identified and sub-
jected to assessment by a panel of professionals. Figure 1 graphically
presents this sequence of activities.
CHAPTER II

REVIEW OF THE LITERATURE

The literature review served to help conceptualize the problem and to examine how others have approached similar investigations. This provided a base and a direction for the thrust of this study.

The first section of this chapter, "An Overview of Curriculum Based on Technology" highlights two curriculum studies. While 30 curriculum proposals were reviewed in preparation for this study, only two were selected as having defensible knowledge structures and viable curricula for a broad based, conceptually structured course in power technology education. The two programs which were reviewed are: American Industry Project and Industrial Arts Curriculum Project.

The second section of this chapter is titled "Curriculum in Power Technology." The purpose of this section was to establish what is and what should be the content of a contemporary course in power technology.

The last section in this chapter is titled "An Overview of Research in Industrial Teacher Competencies." It establishes a base upon which to propose a list of teacher competencies. Studies examined began with that of Silvius in 1946 and ending with the project by Brooks in 1974.

To insure that all relevant literature could be considered for inclusion in this review the following computer searches were made:
(1) Xerox University Microfilms' Direct Access to Reference Information (DATRiX II) computer search of doctoral dissertations. (2) The Ohio
State University Libraries' Mechanized Information Center (MIC) computer search of all library holdings as well as the ERIC (Educational Resources Information Center) data bank. The ERIC search included: Resources in Education Index (RIE), Current Index to Journals in Education (CIJE), Pacesetters in Innovation Index, Manpower Research Index, and Abstracts of Instructional and Research Materials in Vocational-Technical Education (AIM/ARM). In addition a current awareness computer search was continued on a once per month basis to continually update the literature search from ERIC's Research In Education (RIE) and Current Index to Journals in Education (CIJE).

Additional computer searches were available through Phi Delta Kappa's School Research Information Service (SRIS) and the American Council on Industrial Arts Teacher Education (ACIATE) service Summaries of Studies in Industrial Arts, Trade and Industrial and Technical Education. These two searches were not requested. ACIATE's loose-leaf collection of abstracts and the SRIS quarterly publication were satisfactory guides for manual topic searches, due to the delimited scope of this study.

Manual searches were also made of convention proceedings of the American Industrial Arts Association, Master's Thesis in Education, Minnesota Research Coordinating Unit Publications, Review of Educational Research, National Society for the Study of Education (NSSE) Yearbooks, and lastly the ACIATE Yearbooks.
An Overview of Curricula Based on Technology

During the decade of the 60's, availability of funding by the USOE and nongovernment groups led to much research and development in curriculum development in education. The launching of Sputnik by the Russians had created a drive for curriculum improvement in science and math which soon spread into related subject areas. Industrial arts would also share in this progress. In a single decade there were more than twenty proposals developed by groups and individuals. Some were funded and some were developed independently (Cochran, 1970). These were compared and reported in a 1968 doctoral dissertation by Leslie H. Cochran, later to be offered to the profession as Innovative Programs In Industrial Education (1970).

Another relevant publication describing progress in this field is Review and Evaluation of Curriculum Development in Industrial Arts Education. Daniel L. Householder (1972) authored this contemporary study of curriculum proposals. A helpful classification scheme used by Householder includes: industry-centered approaches, technology-centered approaches, alternative strategies, and evolutionary approaches.

Other less comprehensive but informative studies which were reviewed for this chapter included those by:

1. Swanson (1965) who reviewed curriculum efforts to identify the body of knowledge from which each was derived. His four classifications were (1) common life needs related to industry or technology, (2) crafts, trades, processes, tools, machines, and products, (3) applications of mathematics and science, and (4) industry.
2. Streichler (1966) who included selected curriculum developments in his review of industrial arts research.

3. Towers, et al., (1966) when they examined selected curriculum proposals and analyzed the organization and selection of content and method in each.

4. Brown (1969) who selected eight local innovations and reported on the program features of each.

5. Industrial Arts and Vocational Education magazine (1970) which contrasted seven operating programs in roundtable fashion. Spokesmen for each program wrote in terms of (1) central purpose, (2) innovativeness, (3) and difference among the program surveyed.


7. The 24th yearbook of the American Council on Industrial Arts Teacher Education, edited by Moon (1975) which included a chapter on facilities for new programs. Experts in each of seventeen programs were asked to contribute a brief philosophy and operation of their program as a rationale for a suggested facilities design. Several respondents included suggested floor plans and equipment lists.

Selecting and Examining Curricula

A subject matter course conceptualized on the technology of power must have its content derived from a study of the knowledge of practice rather than from an analysis of occupations, tasks, industries, or scientific principles. Cochran placed the twenty innovative programs which he examined in the following classifications (1970, p. 22):
1. Integrative programs
2. Interpretation of industry programs
3. Occupational family programs
4. Technology-oriented programs

The course structure being designed in this study would fit into the technology-oriented category in which Cochran (1970, p. 74) lists the following programs:

1. The Alberta Plan
2. Industrial Arts Curriculum Project
3. Industrial Arts: A Study of Industry and Technology
4. Industrial Arts: A Study of American Industry
5. The Parma (Ohio) Approach

Householder (1972, p. 21) also lists a technology-centered classification for programs. Two which concur with the thrust of this study are Olson's *Industrial Arts as the Study of Technology*, and DeVore's "Technology as a Discipline."

Of these recent curriculum projects and proposals only two have received major funding and can be seen as being significant nationally.

**American Industry Project**

This interpretation of industry was not just another way to teach industrial arts, but a new curriculum area. According to one of the developers, Dr. E. R. Flug (1967, p. 35) the objectives which guided this curriculum project were:

1. To develop an understanding of those concepts which directly apply to industry.
2. To develop the ability to solve problems related to industry.

Two terms seem to hold the key to understanding the American Industry Project. These terms are concept and structure. Face and Flug (1965, p. 118) define a concept as "a psychological construct resulting from a variety of experiences (detached from the many situations giving
rise to it), fixed by a word or other symbol, and having functional value to the individual in his thinking and behavior." In an early report to the profession, professors Face and Flug also explain their use of the terms structure and industry.

Structure, as used here, simply refers to a unified, basic description of the several facets of industry as found in contemporary American society. Industry is conceived in this structure as consisting of several major areas, each of which is further subdivided into still smaller units. Industry, for the purpose of this project, is defined as "an institution in our culture which, through the application of knowledge and the utilization of men, money, machines, and materials, produces goods or services to meet the needs of man. (1965, p. 117).

Figure 2 has been used to graphically present this structure and attempt to categorize understandings rather than specific industries, materials, or occupations.

The structure of American Industry does not end with the 13 major concepts illustrated. A taxonomy of subconcepts and minor concepts is identified in hierarchial order. An example of this conceptual structure is illustrated in Figure 3.

Using the structure illustrated in Figure 2, three levels of courses were developed. The purpose of the first course was to establish a broad frame of reference to which a student could relate other learning. The second course placed more emphasis on the concepts themselves and less attention on inter-relationships between content areas. Level III, the last course involved the development of knowledge and problem-solving skills within an identified conceptual area or group of areas relating to the students' interests and abilities. The individual would identify a problem area, plan an approach, and utilize resources to an end. All this would be done under the direction of an advisor teacher (Flug, 1967, p. 36).
Figure 2

AMERICAN INDUSTRY STRUCTURE OF KNOWLEDGES
(Gebhart, 1968, p. 4)
AMERICAN INDUSTRY CONCEPTUAL STRUCTURE EXAMPLE
(Gebhart, 1967, p. 11)
The American Industry Project, initially funded in 1964, was developed with nearly one million dollars in public and private funds (Cochran 1970, p. 30). By 1972 an estimated 300-500 teachers per year were being trained to teach this curriculum (Sargent, 1972).

**The Industrial Arts Curriculum Project**

Charges had been made that irrelevant activities and fragmented approaches were being used to educate students about our continuously changing industrial technology. The Ohio State University and the University of Illinois in cooperation with local school districts across the nation obtained a grant from the USOE to deal with the problems of contemporary industrial technology by researching and developing a prospective school program called the Industrial Arts Curriculum Project (IACP). The first step was to develop a rationale and structure that would form a basis for a complete instructional system in industrial arts (Peter, 1969, p. 8). An advisory committee of industrial arts educators, logicians, historians, philosophers, economists, sociologists, and specialists from all phases of industry was then assembled. This committee provided much of the knowledge base for the study of industrial technology. The project staff adapted the identified practices to the junior high school industrial arts program.

The IACP project staff made the following assumptions upon which they based their rationale to guide their research:

1. Industrial arts is a study of industry. It is an essential part of the education of all students in order that they may better understand their industrial environment and made wise decisions affecting their occupational goals.
2. Man has been and remains curious about industry, its materials, processes, organization, research, and services.

3. Industry is so vast a societal institution that it is necessary, for instructional purposes, to place an emphasis on conceptualizing a fundamental structure of the field, i.e., a system of basic principles, concepts, and unifying themes.

Further assumptions were made as the study progressed:

1. For purposes of analysis, man's knowledge can be categorized and ordered logically.

2. To provide for the most effective and efficient transmission of knowledge, the educator must codify and structure disciplined bodies of knowledge.

3. The structure of a body of knowledge can be developed before the total curriculum is designed.

4. All domains of man's knowledge must be included in an effective general educational program (Towers, et al., 1966 pp. 2-3).

Having not found a defenseable body of industrial knowledge, the IACP staff set out to develop this. The following criteria were used to derive an adequate structure for instructional purposes.

1. It includes all industrial practices which affect humans and materials.

2. It has mutually exclusive subcategories.


The IACP accepted the conceptualization that man's knowledge can be classified in the formal, descriptive, prescriptive, and praxiological (technological) domains. These knowledge categories are further delineated by considering man's practices or patterns of behavior.
Formalizations of such patterns of activity have become man's institutions. Many sociologists refer to these institutions as government, religion, family, education, and the economic system. While recognizing the need to teach how man is served through his institution known as the economic system, the IACP developers saw the need to limit their area to the production of material goods which are substantially changed from their natural form. This production activity, called industry, is defined as:

that subcategory of the economic institution which substantially changes the form of materials in response to man's wants for goods. In the process, it generates knowledge of how to efficiently produce, use, and service industrial material goods. (1966, p. 40).

Figure 4 graphically describes this view of the economic institution. In the interest of developing an operationally adequate system, services are not considered as a separate entity. They are considered to be based in the knowledge of practice which is created and used in the material production continuum. For the purposes of the IACP classification the service of plowing, as in selling the service of plowing a home garden, would be studied as part of agricultural production rather than in a separate course on "servicing." Similarly, product testing would be studied as part of the respective manufacturing unit.

The IACP staff developed a rationale based on precise use of terminology. The reader may find several definitions useful at this point.

A very popular definition of industrial arts has been:

A study of the changes made in the forms of materials to increase their values and of the problems of life related to these changes (Bonser and Mossman, 1924, p. 4).
Economic Institution

provides

Economic Goods

through

Material Production

Genetic

Extractive

Industrial

Construction

Manufacturing

Other Economic Activity

Communication

Domestic

Education

Entertainment and Recreation

Finance, Insurance, and Real Estate

Health

Legal

Marketing

Transportation

Miscellaneous

Figure 4

ELEMENTS OF THE ECONOMIC INSTITUTION
(Towers, et al., 1966, p. 73)
However, in the search to identify the source from which to draw subject matter the IACP defines the scope of industry as:

That institutional element which substantially changes the form of material to satisfy man's material wants. Industry essentially includes construction and manufacturing. While agriculture and mining also are engaged in material production, they do not essentially change the form of the material produced. For this reason they may be designated "genetic" or "extractive" material production (Towers et al., 1968, p. 12).

The IACP staff equated the term "praxiology" with the term "technology" as follows:

Praxiology (technology) is the product of the organized, disciplined study of the practices of man. It has to do with all of the practices which ultimately affect individual and social behavior. Praxiological (technological) knowledge ... is not practice per se ... (it) is a distinct, developing body of knowledge (principles) which is being tested in practice and is likely to be codified (Towers et al., 1966, p. 39).

While the term praxiology has a precise meaning, the IACP writers realized that it served poorly to communicate. Technology, while widely accepted, has several meanings. However, it was decided to employ the term technology with the understanding that it would be used in the single meaning as it is equated with praxiology.

To further delineate the educational domain of studies in industrial technology the IACP staff concludes:

Industrial praxiology (technology) is that subcategory of praxiological (technological) knowledge which is derived from the study of principles of industrial practices. In such practices there are those which have to do with industrial management and those which have to do with industrial production. Practices (may effect) ... workers, materials, and consumers... Collectively the knowledge of these practices may be called industrial praxiology (technology), and, ultimately they all affect human behavior (Towers et al., 1966 pp. 42-43).
Figure 5 illustrates the domain of industrial technology (see p. 29).

Industrial technology, as previously defined, can be studied for many purposes and at many levels. Examples of these subject areas are industrial psychology, industrial engineering, as well as areas in sociology, vocational education, and others. The IACP staff further reasons that:

Knowledge of industrial practices may be studied in industrial arts for the purpose of helping pupils gain an understanding of how they affect materials and humans in industry. Understanding... includes both knowledge of practices and the ability to apply the practices themselves. Industrial arts may be studied in pre-school, school, college and university, adult, and specialized studies (Towers, et al., 1966 pp. 43-44).

All industrial technology used for the production of industrial material goods can be classified in the technologies of management, production, and personnel. At a general level this knowledge has been structured into major classes and subclasses. This ordering of "particulars" and "classes" was done by the IACP staff to provide transfer of learning potential for students.

Before presenting a listing of the IACP knowledge structure, it is necessary to point out that while this list is in a linear order, cyclical and feedback activities occur. Two instances would be in planning and controlling: while listed only once these activities must occur all through the production continuum but they still remain as components of management technology. Note also that the outline entries are gerunds which imply "action" or doing." This active, involvement connotation is the keynote of all the IACP materials.
Figure 5

MAJOR ELEMENTS IN INDUSTRIAL TECHNOLOGY
(Towers, et al., 1966, p. 167)
Setting the tone for their knowledge structure, the IACP staff states:

Management plans, organizes the inputs to the system (to implement the plan), and controls the plan and organization to produce products. Production actually produces the product while assuming selected minor management responsibilities. And throughout the system the human and how to affect his behavior remains the most critical element (Towers, et al., 1966 p. 173).

Following is a second level delineation of the industrial technology knowledge structure (Towers, et al., 1966, pp. 174-196).

I. INDUSTRIAL MANAGEMENT TECHNOLOGY

1. Planning
   1.1 Formulating
   1.2 Researching
   1.3 Designing
   1.4 Engineering

2. Organizing
   2.1 Structuring
   2.2 Supplying

3. Controlling
   3.1 Directing
   3.2 Monitoring
   3.3 Reporting
   3.4 Correcting

II. INDUSTRIAL PRODUCTION TECHNOLOGY

1. Pre-processing
   1.1 Receiving
   1.2 Unpackaging
   1.3 Handling *
   1.4 Storing *
   1.5 Protecting

2. Processing
   2.1 Separating
   2.2 Combining
   2.3 Forming

3. Post-processing
   3.1 Altering
   3.2 Installing
   3.3 Maintaining
   3.4 Repairing

* Handling and Storing practices occur throughout the production cycle.
III. INDUSTRIAL PERSONNEL TECHNOLOGY

1. Hiring
   1.1 Recruiting
   1.2 Selecting
   1.3 Inducting
2. Training
   2.1 On the job training
   2.2 Other training
3. Working
   3.1 Providing economic rewards
   3.2 Providing physical setting
   3.3 Providing social environment
4. Advancing
   4.1 Promoting
   4.2 Demoting
   4.3 Discharging
5. Retiring
   5.1 Counseling
   5.2 Pre-retirement job engineering
   5.3 Recognizing service
   5.4 Awarding retirement benefits

The preceding structure of practices in industrial technology is equally applicable to the fields of manufacturing and construction. However, at higher levels of specificity, unique management, production, and personal technologies were identified by the IACP. The relationship of these unique practices within the industrial technology was shown in figure 5 page 29.

Minor reordering and clarification of the IACP structure, relating to the post-processing section, has occurred since its inception.

Writing in the Manufacturing Education Curriculum Project (MECP) rationale and structure, W. D. Umstattd (1975 p. 132) states:

In Post-Processing, the manufacturing practices under pre-processing and processing (separating, forming, and combining) are utilized to install, maintain, repair, and alter manufactured material goods.

In addition to establishing a consistent chronology of events in the post-processing structure, the MECP elaborates on a service component.
Practices are identified for the industrial servicing of manufactured goods in company agencies, service companies, and home workshops.

**Energy and Power as a Requisite for Industry**

As the economic system strives to meet man's needs for material goods, certain inputs or resources are necessary. Resources needed for a functional economic system can be classified as human, natural, capital (tools and facilities), energy, finance, and knowledge.

As described by Towers, et al. (1966, pp. 150-153):

> These resources are processed in accordance with practices appropriate to the particular field of economic activity. The outputs of this productive system are the distributed economic goods, containing added form, place, possession, and/or time utility.... Economic value is added as resources are processed through efficient management and production practices.

Energy and its refined form, power, are critical elements of the industry upon which today's society is built. Power is even more of a controlling factor in industrial production than the availability of raw materials or production tools (Duffy, 1972, p. 546). One only needs to reflect on the energy crisis of 1974 to appreciate the impact of energy and power on our society.

The IACP staff ordered the progression of economic inputs through management and production systems to be realized as distributed economic goods (see Figure 6).

It became clear that the two major components of an industrial technology educational program would be construction technology and manufacturing technology. With the refined structure developed, the project staff organized task forces of subject matter specialists to identify elements relating to the respective structures. The results
Sub-element relationships are shown as a linear sequence with a solid line or through a feedback process with broken lines.

Figure 6

MAJOR GROUPS OF ECONOMIC PRACTICES
(Towers, et al., 1966, p. 152)
were disseminated nationally and changes were made based on feedback (Peter, 1969, p. 17). Two experimental courses were developed and field-tested on a substantial scale. Continued field tests and revision resulted in fourth editions of the accompanying software which became available in 1971.

The Industrial Arts Curriculum Project was begun in 1965 and completed as a project in 1971. Funding was through grants from the USOE with some industry support. Over 2.2 million dollars was spent on the total program (Buffer, 1971). By 1972 an estimated 3,000 teachers annually were being trained in the program at 78 colleges and universities (Buffer, 1972 p, 259).

In summary, this section of the review of the literature overviewed the two most popular industrial arts curriculum projects in current practice. Examination of the rationale and structure of these projects served to identify an appropriate and defenseable base for a supplementary development in power.

Curricula in Power Technology

A chronological review of power, with the descriptor technology, must start with Dr. W. E. Warner's 1947 proposal "A Curriculum to Reflect Technology." This proposal included six "divisions:" Author of the Power Division, John P. Lisack (1965, p. 20) saw four major subjects as illustrated in Figure 7. However, consideration of the source, generation, transmission, and utilization of power was not a new concept in industrial arts education. In an earlier Master's thesis, P. R. Bowers (1937) proposed a course of study to teach an understanding
1. SOURCES

Natural
Sun
Wind
Water
Food

Electrical
Mechanical
Chemical

Thermal
Solids
Gasses
Liquids
Atomic

2. GENERATION

Solar
Hydro
Biological
Combustion
Nuclear Fission
Electrical

3. TRANSMISSION

Hydraulic
Pneumatic
Mechanical
Electrical

4. UTILIZATION

Manufacture
Construction
Transportation
Communication

Figure 7
MAJOR FACTORS IN THE STUDY OF POWER
(Lisack, 1947, p. 20)
of power development and utilization. In another Master's thesis, Crow (1938) suggested (1) historical development and early uses of power, (2) power development and measurement, (3) power transmission methods, and (4) social and economic factors involved in the application of power (p. 154).

Authors of the three studies referred to above had placed the study of power in a central position in industrial arts education. These writers had apparently accepted Fredrick G. Bonser's philosophy (1930) of determining content through a socioeconomic analysis of industry.

Other research studies from the 1930's to the 1950's concentrated on the narrower topic of transportation forms rather than the broad field of power. Typical of these early studies were those dealing with only automobiles such as by Carney (1938), Snyder (1940), and Robertson (1940). Later researchers proposed expanding the curriculum to include aviation. Master's theses by Wooden (1946), Julian (1948), and Burns (1949) would be typical of this emphasis. The idea to include all forms of transportation began with the Prospectus for Industrial Arts. Like the Prospectus, it was done under the leadership of W. E. Warner at the Ohio State University.

Other general transportation curricula were proposed by Belton (1949), Aman (1951), and McCall (1955). These three studies contributed to the promotion of transportation education by: (1) justifying the program based on current literature of the time, (2) showing that activities could be based on procedures and processes rather than only projects, and (3) releasing survey results of narrowly conceived public programs
While Warner's new curriculum idea of 1947, including Lisack's Power Division, continued to receive favorable comments within the profession, the reactions to the curriculum plan were mixed (Towers, et al., 1966). Further research would be needed to implement any curriculum which would reflect technology.

Contemporary Power Curriculum Studies

Sanders (1959) prepared the next curriculum plan which was concerned with power. Title Power and Transportation, this Master's thesis revealed that little agreement existed among teacher educators over the content of such a program. However, the writer went on to propose a teacher education course centered on work with small engines and automobiles similar to the traditional subject matter of previous decades.

Kirkpatrick (1961) reviewed state curriculum guides and surveyed industry to suggest subject matter for power and transportation. The result was several suggestions for units of study for inclusion in a general shop course.

A new direction was proposed in a Master's thesis by Wiseman (1961). In proposing a high school power mechanics course, he distinguished between his program and the traditional auto mechanic's approach. The result was a curriculum based heavily on scientific principles and covering the broad field of power development and utilization.

Allen (1963) surveyed selected teacher educators to assist in the development of technical courses. Findings revealed that a growing interest existed for laboratory programs in power and that curriculum should evolve from various methods of developing power and its application through various mechanical devices. He concluded: (1) that content
determination is generally based on an analysis of the overall technology rather than being limited to a job or trade analysis; (2) content should be broadened in scope to include a study of all the major sources of power; and (3) that this phase of the industrial arts program tends not to lend itself to project construction (p. 126).

During the summers of 1963 and 1964, Terence J. Trudeau received state funds to operate a curriculum workshop at the State University College at Buffalo (New York). A comprehensive curriculum guide including teacher demonstrations, student laboratory activities, suggested equipment, and technical reference resulted from this project. This curriculum became part of the teacher education program and was experienced by nearly 200 prospective and practicing teachers per year. Many articles appearing in professional journals were based on this curriculum study: most notably were "the physics of power" series by Dr. Trudeau appearing in several issues of Industrial Arts and Vocational Education during 1966. Also developed as a result of the Power Technology Curriculum Workshop was the Power-lab series of experimenters designed by Professor Trudeau and marketed by Brodhead-Garrett Company (Trudeau, 1975).

In a very comprehensive dissertation, Ecker (1965) surveyed 96 teacher education institutions which offered a program in power. Based on the survey returns and his review of the literature, a teacher education course in power technology was projected. Course content, based on physical and mathematical sciences, is illustrated by the following outline of major instructional units: (1) an introduction to power; (2) power measurement; (3) power transmission; (4) internal combustion
engines; (5) external combustion engines; (6) fluid power; (7) fundamentals of electricity; (8) atomic energy; (9) solar energy; and (10) future energy sources (pp. 189-190). Ecker urged that the term power technology be adapted as a course title which reflects the applied science approach as outlined above: The proposed course would meet the needs of youth in our technical society more adequately than usual courses in auto mechanics or small engine repair.

In a 1966 dissertation Davis surveyed department heads of all industrial arts teacher education institutions to determine what should be included in a power course. Using the results of this survey and information gleaned from industrial education publications, periodicals, curriculum guides and texts, Davis (1966) suggested the following topics as a power mechanics course outline: (1) history of power development, (2) measurement, (3) external combustion converters (continuous combustion), (6) direct energy converters, (7) nuclear power, (8) transmission of power, (9) fuels and lubricants, and (10) conventional electric converters (pp. 93-94). Davis concludes by noting that while educational resources are not plentiful in the area of power technology, a definite trend can be seen as teachers move away from the traditional auto mechanics approach.

In a more recent dissertation Crannis (1970) surveyed secondary schools and industry to determine instructional content for a course in power. While attitudinal differences occurred in school and industry, a data analysis system did enable the researcher to reject six of the 114 proposed instructional topics. The following study units together with percentages of course time are suggested: (1) historical
development of power, 5.4 percent; (2) measurement of work, power, and energy, 6.7 percent; (3) steam power, 6.3 percent; (4) reciprocating action internal combustion engines, 22.1 percent; (5) internal continuous combustion engines, 12.0 percent; (6) nuclear power, 7.1 percent; (7) emerging sources of power, 6.8 percent; (8) power transmission, 12.3 percent; (9) fuels and lubricants, 7.1 percent; and (10) electricity, 14.2 percent (pp. 164-165). The researcher suggested that program modification be considered on the basis of this input from industry and schools.

Webster (1970) surveyed secondary schools and colleges in the United States to determine the status of power mechanics programs. Based on data gathered from 1036 returned questionnaires, the researcher found that: (1) power mechanics is a fairly large industrial arts curriculum area; (2) power mechanics is a growing instructional area; (3) power mechanics programs are well distributed across the country; (4) power mechanics instructors are not trained in this field; (5) power mechanics is defined as a study of energy sources and machines that convert energy into useful work; (6) power mechanics should be a part of the curriculum because of the importance of power to our culture; (7) no one organizational scheme dominates the field; and (8) the content presented at the various instructional levels differs significantly.

The following problems were identified: (1) there is a lack of appropriate software and hardware; (2) there is a confusion over objectives; (3) teacher training programs need improvement; (4) there is a lack of information about course content; (5) new types of facilities are needed; (6) national professional organizations have not provided
needed leadership; (7) and there is a general resistance toward changing from a traditional automotive mechanics program. (p. VI).

In 1971 Joseph Duffy completed a study for the Power Transmission Distributors Association which resulted in the development of a multi-level curriculum for power. Titled *Energy Processing, Conversion, Transmission, and Control*; this curriculum guide suggests programs for all levels from junior high school to technical school and college. While leaning heavily toward power transmission, the guide includes every conceivable topic suggested by the title in addition to an extensive industrial resource directory.

Guentzler (1973) suggests an industrial arts teacher education curriculum in fluid power technology as part of a power technology program. While his dissertation centers on hydraulics and pneumatics, the researcher does offer a comprehensive rationale and structure for fluid power technology and relates this body of knowledge to the complete field of industrial technology.

**Exigent Professional Literature**

For over fifteen years articles have appeared in professional journals urging adoption and expansion of courses designed to teach the technology of power. Typical of articles exhorting curricular innovation were authored by: Risher (1960); Feirer (1960); Margules (1962); Sredl (1962); Schank (1964); Pritchett (1965); Trudeau (1966); Trudeau (1968); Trudeau (1969); Risher (1969); Diehl and Kreuger (1960); Sullivan (1970); Good and Kreuger (1972); Bohn (1972); and Feirer (1974).
Perhaps the greatest indication of the importance of curriculum content in power was the recent emergence of the National Educational Council on Energy and Power (NECEP). Founded in January of 1975 by a group of concerned industrial education leaders, the NECEP supports these beliefs:

1. It is imperative for human survival to focus the attention of the educational community on the concepts, information, and future relating to energy and power including energy sources, conversion devices, conservation measures, and power applications.

2. That development of a high level of civic literacy as to energy and power is an important aspect of educational programs (1974, p. 3).

The NECEP commits itself to:

1. Foster attitudinal change and concept development in respect to energy and power at all learning levels.

2. Collect and disseminate relevant, important and reliable information.

3. Develop curricular and instructional materials to implement a comprehensive national effort.

4. Utilize the resources of science, industry, business, government, and education to assure the effective coordination of their services (1974, p. 3).

In addition the NECEP proposes the following tasks:

1. Development of guidelines for the various sectors of the educational community to organize for effective use of professional resources and provide for a continuity of effort.

2. Professional associations serve their membership by the dissemination of information.

3. Teacher educators evolve and refine methodology, techniques, and experiments to implement instruction.

4. Coordinators and developers of curricular materials within school districts and consortia select, arrange and program content materials for instruction about energy and power.
5. Teachers plan educational facilities to provide an effective climate for instruction in energy and power (1974, p. 3-4).

Encouraged by 15 years of support from the profession, a national council of education leaders have called for a representative curriculum in the technology of power. Writers, researchers, and NECEP members acknowledge that an exemplary teacher education program in power technology would effectively address the issues of greatest concern. It appears that a plan for an accountable teacher education program in power would serve the profession. The literature review in the last section of this chapter addresses the issue of contemporary teacher education curricula in industrial education.

Developing Competent Teachers

Improvement in industrial arts teacher preparation programs has been a major concern within the profession since the beginning of this century. Competencies of industrial arts teachers have been the object of professional conferences, special committees of educators, funded studies, dissertations, and publications such as bulletins, monographs, and yearbooks.

The productive Mississippi Valley Conference turned its attention to teacher preparation in the beginning of the 20th century. By 1913 this conference had made proposals to lengthen the college curriculum to four years, and suggested credit and proportionment of manual arts courses to other academic subjects (Barlow, 1967, p. 94).

The American Vocational Association (AVA) published the first of a series of influential studies in 1929. "Standards of Attainment in
"Industrial Arts Teaching" delineated what a boy should know and be able to do. This apparently popular document was published again in 1931 and reprinted in 1934.

After this period of attention to standards, the industrial arts section of the AVA concentrated on objectives. General objectives were highlighted in the 1946 publication "Improving Instruction in Industrial Arts." The 1953 publication "A Guide to Improving Instruction in Industrial Arts" introduced behavioral objectives to the profession.

Beginning in 1952 the American Council on Industrial Arts Teacher Education (ACIATE) began publishing yearbooks to promote progress in this field. Several of these yearly texts dealt directly with preparing beginning teachers. Yearbook four, *Superior Practices in Industrial Arts Teacher Education* (Hornbake and Maley, 1955) reported on areas of progress and problems in college programs. Yearbook Five, *Problems and Issues in Industrial Arts Teacher Education* (Hutchcraft, 1956) made significant recommendations. One listed change which must occur was that the student would direct more of his own program, assessing his needs and evaluating his subsequent growth. Another serious change needed would be for the subject areas in the college program, i.e.: chemistry, English, mathematics and even industrial arts, to be re-designed to meet general education objectives rather than objectives of those particular subject specialist. (p. 192).

ACIATE Yearbook 11, *Essentials of Preservice Preparation* (Lux, 1962) made recommendations for all three of the elements of the undergraduate preparation for prospective industrial arts teachers. General education should make up about half, professional education about one-sixth, and technical courses about one-third of the four-year program.
Additionally, courses in the three areas should be a part of each college year. (pp. 174-176).

Yearbook 20, Components of Teacher Education (Ray and Streichler, 1971) addressed itself to just two of the three "essentials" of industrial arts teacher education. A strong case is made to go beyond merely offering courses.

We must identify and structure the elements of our content (industrial technology) and the elements of our method (educational technology) (p. 234).

Progress in identifying and structuring the content of industrial arts subject matter was discussed earlier in this chapter. Attempts to identify and structure methods has been the goal of many studies in the teaching profession.

Early research by Silvius (1946) identified 160 general activities which the industrial arts teacher should be able to perform. Survey results determined that the "most important" of these activities had to do with running the laboratory.

Giachino (1949) asked a sample of the profession to rank-order a list of 95 success factors of industrial arts teachers. Success factors in the category of "Shop Management" were rated by a majority of the respondents as being "very important."

A study of the competencies needed by elementary teachers of industrial arts was conducted by Brown (1955). This research resulted in a list of activities of the arts and crafts type which contributed to elementary education objectives.

Newhouse (1956) also addressed the question of "What is a competent industrial arts teacher?" His research resulted in determining six roles
of the teacher and the competencies necessary to fill these roles. The specific laboratory competencies were not included as a role.

Walsh (1960) engaged a group of experts to identify competencies required to teach trade and industrial courses. In this study for the Department of Health, Education and Welfare, the participants developed a list of 107 competencies. These competencies were divided into the area of knowledge and the area of skills. The respondents in this national study rated those competencies which expressed ability "to do" as higher than knowledge or understanding "to know." However, the skill competencies were those of shop practices and not patterned after specific subject areas (pp. 43-44).

In a study to determine the characteristics of an effective industrial arts teacher, Mansfield (1959) reported that mechanical aptitude was an important factor. The author concluded that such general competencies as resourcefulness, intelligence, physical coordination, etcetera, were highly desirable.

In a survey to determine what industrial arts competencies were employed by occupational therapists in Minnesota, Jackman (1961) listed 18 findings. Of special interest are the findings that the respondents felt lacking in competencies of ordering and maintaining tools and equipment. Other skills desired were machine operation and tool conditioning (pp. 173-174).

Silvius and Ford (1965) interviewed selected individuals from industry, business, and education to establish practices and policies for preparing junior and senior high school industrial education teachers in Michigan. The conclusions made for comprehensive senior high teachers were as follows:
1. All industrial education teachers in senior high schools should have some industrial work experience, and preferably in their teaching area.

2. Industrial education teachers in special vocational high schools should have in depth industrial work experience in the area in which they teach.

3. There is a need to increase both the number and depth of the technical courses that are a part of industrial teacher preparation.

4. Additional experience in mathematics and the sciences is needed by the senior high school industrial education teacher (p. 35).

These conclusions were made relating to junior high industrial arts teachers:

1. A limited amount of supervised industrial work experience should be an integral part of the teacher's preparation for teaching industrial arts in junior high schools.

2. Persons preparing to teach at the junior high school level should have a better understanding and knowledge of other subject areas, particularly the basic sciences and their application in industrial activities (p. 22).

It was determined that a successful junior high industrial arts teacher:

1. Has an interest in children - including participation in out-of-school activities.

2. Likes to work with tools and materials.

3. Has an adequate technical background - a real command of each subject area to be taught.

4. Possesses a generalized education - has an appreciation for the humanities.

5. Has a real concern and knowledge of counseling and guidance practices (p. 22).
While no specific competencies were identified in this study, it is evident that technical ability was a major concern. Perhaps later studies would address this problem directly.

Gianini (1968) studied professional competencies of Florida's technical education instructors. However his instrument asked only that the respondents evaluate their own competencies as related to their technical training or their work experience.

Miller (1971) identified functional competencies needed by instructors to teach in contemporary industrial arts laboratories and classrooms. The most supported competencies by teacher educators were:

1. Demonstrate safe operational procedures of machines and equipment.
2. Exhibit a fair, consistently firm, friendly, tolerant and understanding attitude.
3. Stimulate and maintain interest throughout the instructional process.
4. Express interest and concern for the welfare of students.
5. Develop situations which permit students to think and work independently.
6. Exhibit poise and self control.
7. Develop and initiate an effective safety program.
8. Exhibit initiative and drive.
9. Conduct effective demonstrations.
10. Motivate students to acquire skill and knowledge.
11. Provide situations which allow students to develop creative abilities.
12. Maintain order in the classroom and laboratory (p. 49).
N. J. Popovich (1973) also concentrated on the professional element of industrial teacher competencies. The study sought to validate a list of competencies developed earlier by Cotrell (1971). These competencies were noticeably different than the same number identified by J. A. Miller (1971) and were more closely confined to industrial type teachers. Categories of these competencies were (1) planning instruction, (2) executing instruction, (3) evaluating instruction, (4) guidance, (5) management (classroom), (6) public and human relations, and (7) professional (dealing with personal and clerical functions) (Popovich, 1973, p. 78). The subsequent findings are not of concern in this review because both Cotrells' competencies and Popovichs' survey were addressed to vocational, technical and occupational educators and, in addition, the particular survey included only teachers in the region surrounding Wayne State University.

As part of a status study for competency-based industrial arts teacher education, Brooks (1974) contracted with several local teachers who were to list technical competencies needed to teach their courses. Competencies submitted in these subject areas were evaluated by a college professor responsible for each respective area. David Gierke, a teacher of power technology, submitted a list of 42 competencies for his area. Unfortunately, largely due to time constraints, the technical competencies listed for power technology in the above study were restricted to the area of internal combustion piston and rotary engines.

Dissertation by Ecker (1965) and Grannis (1970) and a masters thesis by DePue (1972), as well as much of the literature reviewed earlier in this chapter, suggest that at least ten topics are normally considered
important as content in a power technology course in the secondary school. It is apparent that a widely acceptable listing of the technical competencies needed by an industrial arts power technology teacher is not presently available to the profession.

Developing Performance Elements

Performance elements and competencies have appeared with the contemporary mood of accountability. In the words of L. L. Cunningham:

We live in an age when citizens are seemingly hungry for information about institutional effectiveness.... People are asking for visible evidence of success, and their inquiries are now appearing in accountability language. The press for accountability is real, takes many forms, and appears at many decision points within the educational system (1969, p. 285).

A generally accepted approach to accountability in education is through the use of objectives. While some writers continue to be critical of their use, most of the profession accepts objectives, even if only tacitly.

As the teacher translates the broad goals of education into what should be taught, objectives at more than one level become necessary. Hough and Duncan (1970) suggest developing three levels of objectives: course objectives, intermediate (unit or module) objectives, and daily instructional objectives. It is this last or lowest level which requires the greatest specificity. Instructional objectives describe what activity will take place on the part of the student. When stated in terms of student performance, objectives serve three primary functions:

1. They focus the teachers attention on what he should be doing in the instructional situation (classroom, seminar, discussion, etc.)
2. They focus the student's attention on what is expected of them as a result of their participation in the instructional situation.

3. They make public the criteria on which the measurement of student achievement will be based (Hough and Duncan, 1970, p. 47).

Mager (1962) defines an instructional objective as an intended outcome and being composed of the following: (1) a given, (2) a situation, and (3) a criterion or standard upon which to judge whether the objective has been met.

Much of the criticism of objectives arises from recognition of lack of control of variables when dealing with people. Ralph Tyler, often called the father of behavioral objectives, recognizes this concern.

It is not too difficult to identify the tasks or activities of a doctor, a lawyer, a teacher, or a member of any other of the well-known professions. But it is not easy to answer the question: What can or should a student learn in order to perform these professional tasks or activities (1975, p. 122)?

Tasks related to the technical performance of teachers of power technology are the concern of this study. What is normally considered the professional performance of teachers such as questioning, motivating, and responding to students is not within the thrust of this study. While "professional" competence of a teacher is a critical factor, numerous studies have been done in this direction as illustrated in Chapter II of this study.

Contributors to the American Council on Industrial Arts Teacher Education (AICIATE) 20th Yearbook sought to improve teacher preparation. The improvement of the technological components of industrial arts teacher education was their focus. One contributor offered an innovative model of a teacher education instructional system (see Figure 8).
Figure 8
OPERATIONAL MODEL FOR A TEACHER EDUCATION
INSTRUCTIONAL SYSTEM

(Buffer, 1971, p. 184)
Writing in a chapter of the Yearbook, James J. Buffer reviewed current theoretical bases of instruction and suggested a structured instructional system to improve the preparation of teachers. While not intending his system to serve as an entire model program for teacher preparation, the contributor offered his conceptualization to include the major components of any instructional program.

Figure 8 illustrates Buffer's system. Examples of inputs are various responsibilities of the classroom teacher i.e.: determining subject matter to be taught to a given child with certain capabilities and to specify terminal performance objectives for individuals and groups. The process portion would deal with selecting and implementing instructional activities such as media, materials, strategies, and techniques. Outputs would include implementing the treatments, observing behavioral changes and assessing with feedback information.

Buckingham (1973) employed Buffer's model to develop performance levels and essential knowledge for IACP "World of Construction" teachers. Adding his schema or systematic plan to the input, process, output portion of Buffer's model, Buckingham was able to organize his project. The IACP taxonomy of construction, broad and intermediate objectives, and other inputs were processed into enabler knowledges and terminal performance criteria to be rated by a jury.

Figure 9 shows Buckingham's schema. Phase "A" consists of a search for tasks (Analyzing), verification of the tasks with the IACP rational (Verifying), eliminating items (Selecting), and grouping tasks into modules (Structuring). Phase "B" consists of fitting tasks into Terminal Performance Model form and writing enablers and levels of performance. Phase "C" puts the generated items into a questionair format.
Figure 9

SCHEMA FOR THE IDENTIFICATION AND
UTILIZATION OF PRAXIOLOGICAL INPUTS
AND RELATIONSHIP TO TPC MODEL
(Buckingham, 1973, p. 117)
Lawson's Three Step Sequence

Lawson (1974) has offered a strategy for designing competency-based instruction based on contemporary concepts in instructional psychology. A three-step sequence is suggested. The three steps are illustrated in Figure 10 (p. 56) and outlined below:

1. **Goal analysis; breaking down terminal goals into enroute or enabling tasks.**

2. **Determining learner pre-instructional behavior; ascertaining, through testing, what competencies the learner possesses prior to instruction.**

3. **Formulating instructional events which include practice of performance, practice of knowledge, and presentation of knowledge, (Lawson, 1974, p. 16).**

The above listed goal analysis is to be conducted by beginning with a previously established terminal performance objective and working backward. By determining what pre-requisite capabilities the learner must possess to master the terminal objective, one or more enroute objectives can be specified. Starting with a desired student entry behavior, enroute objectives should then be carefully sequenced according to the order in which knowledge and skill competencies are to be acquired.

Criterion-referenced tests must be constructed to determine pre-instructional behavior. Test items are to be dependent upon enroute and terminal objectives. In addition, items must be in agreement with the type of learning tasks listed. Testing can be done either on the process, the learners activity, or on the product of his effort.

The testing parameters are:
PROCEDURES FOR DESIGNING COMPETENCY-BASED INSTRUCTION
(Lawson, 1974, p. 17)
1. Testing conditions; consists of specific "givens" in the testing situation to which the learner must attend.

2. Operations performed; verb classifications suggesting different observable performances exhibited by the learner.

3. Behavioral mode; the way in which the behavior is demonstrated on the part of the learner (Lawson, 1974, p. 10).

After developing and sequencing objectives and determining learner preinstructional behavior, it is necessary to formulate instructional events. The first event is for performance practicing by the student. Lawson suggests employing one or both of two approaches: (1) practicing equivalent skills as implied by the objective terminology and (2) practicing activities which are analogous but not identical to objectives. These psychomotor activities are critical to attaining any objective expressed in behavioral terms.

Practice of knowledge is the second event in Lawson's instructional phase. This cognitive activity is to be a two-way activity between the learner and his media. Typical knowledge practice activities are on machine nomenclature, describing step-by-step procedures, relating safety rules, interpreting schematic diagrams and discussing principles and concepts.

Presentation of knowledge is the third event in the instructional phase being reviewed. In this phase a presentation mode is selected on the basis of the relationship between the knowledge offered and the ultimate performance outcome. Presentation alternatives include: (1) instructor presentations, (2) various audio-visual media, (3) written material, and (4) training aids. The four purposes of
presentation are: (1) providing orientation, (2) providing organization and meaning, (3) guiding practice, and (4) simply presenting knowledge for the student to learn.

Figure 10 illustrated the relationship between the steps of (1) goal analysis, (2) determining pre-instructional behavior, and (3) formulating instructional events.

Lawson's systematic approach to promote learner attainment of pre-defined competencies relies heavily on current principles of educational psychology and instructional technology. Supported by criterion-reference testing, this three-step instructional sequence appears sound.

Hauensteins' Performance-Based Approach

A systems approach is the basis for Hauenstein's (1973) curriculum model. The input, process, output of a system is changed to purpose, process, and content for curriculum development. Processes in this plan become the competencies to be achieved. Modules or training situations are devised to arrange opportunities for the student to perform. These performances or activities which the student is to be able to do are written out as tasks. "Content" in the Hauenstein model is what enables the student to perform the tasks. This necessary content is appropriately called "enablers." The development of this educational system begins with goals which are refined into specific performance objectives. The key element in Hauenstein's module is the gerund noun. This use of "ing" words signifies a behavioral base (doing) which is all important in any attempt to focus on performance. Descriptive or data-based curricula use nouns as titles. The effect of this terminology is
apparent when you consider the expected outcomes of a course called "English" rather than one titled "speaking," "writing," or "reading."

Dr. Hauenstein has offered a system for analyzing subject matter to promote cognitive, affective, and psychomotor learning. In addition, he uses a workbook approach giving step-by-step directions on planning, engineering, and implementing a curriculum in any subject matter discipline (1972).

Following are Hauenstein's steps in condensed form (1973, pp. 186-187):

Guidelines

1. Identify a professional or technical universe (of content).
2. Identify a major purpose of human activity within that universe. In the case of industrial arts, identify a major purpose or function of industrial activity.
3. Identify the basic processes through which the purpose is achieved. Use "ing" words.
4. Arrange the processes or steps in a logical order.
5. Draw a diagram illustrating the universe, purpose or goal, and process. See Figure 11A.
6. Ask yourself, do the parts equal the whole? Do the processes, as listed, achieve the goal? Are there any major processes omitted that should be represented? Adjust the processes until there is a logical flow to reaching the goal. Use "ing" words.
7. Ask yourself, Do the singular processes or steps overlap with one another? Are the processes mutually exclusive? Adjust the terminology to reduce any overlap. Use "ing" words.
8. It is vitally important to consider the universe-process-goal relationship—at length, for once established, these concepts will determine the parameters for all else that is contained in the course. The processes will become the module titles.

Establish the Modules

Modules are the sub-universes or steps in the process. Modules contain the tasks and enablers which develop the competency to perform the singular and over-all processes. The following
are guidelines that may help you develop performance-based and criterion-referenced learning experiences.

1. State the name of the universe (one of the steps in the over-all processes) and state its purpose or goal.
2. Identify the major steps or processes through which the goal is achieved—minimum of two steps, maximum of seven or eight steps. Use "ing" words.
3. Arrange the processes in a logical order.
4. Draw a diagram illustrating the module (universe), purpose, and processes. See Figure 11B.
5. Apply the criteria of total inclusiveness to the module universe (parts to whole). Do the tasks (module processes) as listed achieve the goal? Are there any major tasks omitted that should be represented? Adjust the module tasks until there is a logical flow to reaching the goal. Use "ing" words.
6. Are the tasks mutually exclusive? There should be no overlap of function. Adjust the task terminology to reduce overlap. Use "ing" words.
7. The module tasks are the processes to achieve the module goal.

Determine Instructional Time

Determine how many instructional periods in minutes are to be allotted for the course... Designate a tentative time span for each task and module.

Develop Enablers

Analyze each task for essential knowledge, attitudes, skills, and techniques needed to be able to do the task. See Figure 11C. Write singular instructional objectives for each enabler stating the name of the act, the conditions, and level of acceptable performance.

Identify Enabler Resources

Identify what information is required... search for instructional resources... list for each enabler.

Write Task Statements

Review the task enablers and write a situation or problem which applies the knowledge contained
Figure 11

A: Model of a Universe, Its Processes (Modules) to Achieve Its Purpose or Goal

B: Model Showing Delineation of Module Universe, Goal, and Tasks

C: Model Showing Delineation of Tasks, Universe, Goal, and Enablers

in the enablers. State the task (activity),
conditions, and level of acceptable per­
formance. Repeat the process for each task.

Write Module Goal Statements

Review the tasks in a given module. Write a
statement that summarizes the tasks. Repeat
the process for each module.

Write Entry Requirements

Consider each task, the level of performance, and
the knowledge required to perform it.

Write Module Instructions

Review the tasks, enablers, and goal.
Write statements that overview the tasks and
develop the need for the module. Tell why
the module is important and how its achieve­
ment can be of benefit. Repeat the process
for each module.

Write Course Goals, Introduction, and Table of Contents

Review the modules and summarize the goals of
the modules.
Describe the outcomes of the course.
Write an introduction to the course, over­
viewing the course and its importance.
Write table of contents and title page.

Duplicate and Disseminate

Duplicate copies of the course.
Distribute copies to each student in the course.

Dr. Hauenstein's systems approach to developing performanced-based
courses has been illustrated in condensed form to show its application
in this study. Tasks, enablers, and goals would become the teacher
competencies sought in this research.

In summary, the literature review presented in this chapter
examines contemporary curriculum developments in industrial arts. The
American Industry Project and the Industrial Arts Curriculum Project
were reviewed for the purpose of selecting a referent upon which to base a rationale and structure for power technology.

The mission of the second section of this review was to report how authorities stand with regard to whether power technology is a viable and necessary subject for today's youth. This section also confirms that improvement is needed in order to adequately conceptualize and organize power technology content in curricula for students and their prospective teachers.

A third section of this chapter highlighted efforts to improve teaching in industrial arts, concluding with a view of the state of the art in this field relative to CBTE. Research is common in the professional component of an industrial arts teacher's preparation but limited in the technical part, especially in the area of power technology.

A fourth section of this chapter reviewed three approaches for developing performance elements in CBTE programs. The model proposed by A. D. Hauenstein seemed well suited for identifying technical competencies.

The goal of the next chapter is to present a rationale for, and a structure of, the body of knowledge for power technology to serve as a referent for an industrial arts curriculum component in this area. Identification will then be made of knowledge and skills essential for adequate performance of teachers in power technology laboratories.
CHAPTER III

PRESENTATION OF A RATIONALE FOR AND STRUCTURE OF POWER TECHNOLOGY

This chapter's purpose is to present a rationale for, and the structure of, the body of knowledge known as power technology. By specifying power technology in this manner, curriculum components may be selected for teaching-learning situations. The structure offered in this study suggests competencies which are needed by teachers of the area of power technology in industrial arts education.

The first section of this chapter identifies the rationale and structure of the Industrial Arts Curriculum Project from which this study was developed. Suggestions as to the place of power technology within the context of industrial technology are made in the next section.

Finally, the area of power processing technology is identified as a component of industrial technology, and developed into a taxonomy.

The Industrial Arts Curriculum Project Rationale and Structure as a Referent

The Industrial Arts Curriculum Project (IACP) was reviewed in Chapter II as a possible referent upon which to base the foundation of this study. It was felt that the IACP rationale and structure would support an extension into the area of power technology. This extension is described on the next several pages.
The IACP curriculum has proven to be defensible, popular, and successful. In his Review and Evaluation of Curriculum Development in Industrial Arts Education, D. L. Householder states:

The Industrial Arts Curriculum Project (IACP) is unique in several ways. It is the only major industrial arts curriculum effort which has been rooted in an analysis of the structure of knowledge. It is the first project to produce instructional materials and a sequence of courses correlated with a taxonometric classification of a body of knowledge. The intensive field testing and in-service teacher education which accompanied the development have been unequalled. Finally, IACP is the only program which has produced a substantial group of integrated instructional materials and made them available through a commercial publisher. In view of these attributes, IACP is considered by many to be the outstanding accomplishment of the past decade in industrial arts curriculum development (1972, p. 18).

Power as an Input to Industry

One input to the economic system is rapidly increasing in significance; potential energy. The level of civilization in America today has been credited to our ability to convert potential energy sources to power (Duffy, 1972, p. 546). This economic value which is added to energy as it is processed by industry is increasingly significant in today's energy dependent society. Moreover, society, as we know it could not exist without this energy production.

The IACP classifies the industrial process of changing potential energy to kinetic energy as a manufacturing process (Towers, et al., 1966, p. 74). Therefore the knowledge required to process this energy efficiently is subsumed within the structure of manufacturing production technology.

Adding to the above conceptualization of man's economic activities Rumble identifies a theme (1975 p. 240):
A common theme—the progression of raw materials from their origin to their use as elements of man's industrially-created environment. Assisting the progress of raw materials through a variety of processes from base substances to adequately functioning products are a number of "enabling" technologies—communications technology, power technology, and transportation technology. These are operative, to a greater or lesser degree, at each phase of the material goods continuum from the procurement of raw materials to the use by the consumer and the servicing of the product that contains the raw materials in modified form. Without the input from these "enabling" technologies, the progression from raw materials to adequately functioning products would be severely impeded, if not terminated. The fabric of the technologies affecting raw materials and the "enabling" technologies is interlaced with "facilitating" technologies—management technology and personnel technology. Management technology is concerned with planning, organizing, and controlling the operations that take place within the technologies affecting raw materials and products and the "enabling" technologies. Personnel technology deals with the hiring, training, working, advancing, and retiring of personnel both within the technologies affecting raw materials and products and within the "enabling" technologies.

Figure 12 illustrates Rumble's conceptualization of the technologies within industrial technology.

The Place of Power Technology Within Industrial Technology

Because power is classified as a manufactured product, the "facilitating" technologies in the area of management and personnel would apply to the operation of a commercial power plant. The management activities of planning, organizing, and controlling, as well as the personnel practices of hiring, training, working, advancing, and retiring are largely identical whether carried on in a nuclear power plant producing electricity or a steel plant producing I-beams. The resulting output of a commercial power plant supports the manufacture of automobiles
Figure 12

"ENABLING" TECHNOLOGIES

ENABLING AND FACILITATING TECHNOLOGIES
(Rumble, 1975, p. 240).

Diagram showing the relationship between different categories of enabling and facilitating technologies.
and the construction of bridges just as does the products of the steel plant. Figure 13 (p. 69) illustrates the relationship of power technology to the technologies of manufacturing and construction and the consumer.

While the practices needed in management and personnel can be considered identical for an electricity-producing plant as for a steel producing plant, the production processes differ at specific levels. For example, a post-processing function in manufacturing would be installing an electric motor. Of greatest concern here would be that the installation conformed to safety and operational specifications. In power post-processing technology the electrical circuit itself would be of significance. Practices of examining the forces effecting electron flow to efficiently transmit and control electrical power are what is valued in power technology.

The reader may seek further clarification on the concept of an additional set of production practices performed by personnel who may be working within a given manufacturing plant. Consider the production processing practices of manufacturing electric motors. The manufacturing technologist is concerned with efficient practices of producing motors to established standards of quality control. The power technologist is concerned with efficient practices of examining the operating parameters of the motor in question. Generalizing then, manufacturing technology concerns efficiency in motor production while power technology concerns efficiency in motor operation. The difference is in which is being manufactured; the motor or the power.

The power technologist can be, and often is, hired to work in a manufacturing plant. This work may be in a research, engineering, or
Figure 13

CONSTRUCTION, MANUFACTURING, AND POWER TECHNOLOGY RELATIONSHIPS
quality control capacity. However, such employment does not alter his practices any more than an industrial plant physician's practices are changed due to the facility in which he works. Hopefully, neither of these practitioners would be primarily concerned with the number of motors the plant assembled on a given day.

Structuring Power Technology

Much literature has been devoted to man's efforts to systematize or classify knowledge. Dictionaries include the terms classify and systematize to define science. There are many reasons for classifying (structuring) knowledge. Perhaps the most important reason is due to the rapid increase in knowledge accompanying the current information explosion. Many educators believe that structured knowledge is easier to learn because major and minor concepts can be associated and better understood. Once learned, a structure integrates new and old information to assist in organizing and remembering.

Rules for classification were exemplified by the IACP staff into the following criteria:

Properties of an adequate structure for instructional purposes:

1. It includes all industrial practices which affect humans and materials.
2. It has mutually exclusive sub-categories.
3. It is operationally adequate for instructional purposes (Towers, et al., p. 80).

To clarify; all parts of the structure must equal the whole, omitting none, there is no overlap between categories, and it meets the purpose for which it was developed.
Knowledge which is continually changing is a general problem in our society and a momentous problem in education. Technical knowledge becomes obsolete rapidly; this is a significant problem for both industry and industrial education. A knowledge structure provides a system to classify the body of knowledge of industrial technology. While specific industrial practices do change, categories and sub-categories with a structure offer needed resistance to obsolescence.

Hauenstein proposed four principles to guide in the development of a structure for the body of knowledge of industrial technology (1966, p. 53-54).

a. The structure should reflect major distinctions between practices as agreed to by experts in the field.

b. The terminology used in the structure should be consistent and the logical subdivisions further subdivided to the extent that appears necessary and useful.

c. The structure should be consistent with present understanding of the practices used to manage and change the form of materials.

d. The classification should be in relatively vertical fashion, and it should not indicate value, quality, or quantity comparisons between practices.

The IACP structure of industrial technology fulfills Hauenstein's four principles. At the most general level this structure includes the technologies of management, production, and personnel. A discussion of the relationships between concepts contained in the IACP structure is included in Chapter II.

Earlier in this chapter it was suggested that the IACP structure of management and personnel technology would also apply to the field of power technology. Industrial practices of managing by planning, organizing, and controlling; and directing personnel by hiring, training, working, advancing, and retiring are similar in plants manufacturing electricity and in plants manufacturing electric motors. It
is the production practices which differ, beyond the general level, between manufacturing technology and power technology.

Hauenstein proposed four criteria for developing an industrial production technology structure (1966, p. 50):

1. The practices must fall into one of the principle categories:
   a. worker control
   b. material handling
   c. separating
   d. forming
   e. combining
2. The practices must be representative of industry.
3. The practices must not mention tools, materials, or skills.
4. The practices must be subject to review by a panel of experts.

In addition to these criteria, Hauenstein's four principles listed on the previous page were used in the development of the power technology taxonomy.

The general manufacturing concepts of pre-processing, and post-processing lose their applicability to power technology at more specific levels. The manufacturing production practices of receiving, separating, and installing for example; are not very applicable to the operator of an electric motor. The power technologist mentioned here is converting electrical power to rotating shaft power.

Using Hauenstein's Schema

Dr. Hauenstein's complete guidelines for structuring content are described with the literature review in Chapter II. Using these guidelines and following the principles and criteria listed on the preceding pages, the sequence below produced a structure.

1. Identify a technical universe:

   The field of power technology.
2. Identify a major purpose of human activity within that universe:

Power technology is an input which enables manufacturing and construction (also communications and transportation) industries to operate.

3. Identify the basic processes through which the purpose is achieved.

Energy is processed, converted, transmitted, and controlled.

4. Arrange the processes or steps in a logical order.

Power is derived from an energy source, then transmitted and controlled to do work. The IACP production concepts of pre-processing, processing, and post-processing fit well here. For example: power is pre-processed as the energy of coal is changed to heat and, in the form of steam, spins a turbine which produces rotating shaft power. This power is processed as it is converted to electrical power in a generator. Post-processing occurs as the electricity is transmitted through wires to a manufacturing plant.

Similar logic is applied to the remaining energy sources and their respective power plants; and next to methods of converting and finally transmitting power. It became necessary, however, to include some additional descriptors to the gerund-noun taxonomy to provide clarity within and between categories.

The following structure of power technology should be delineated sufficiently to provide for curriculum development at the general education level in high schools and teacher preparation programs.
1. Processing Energy (Power Pre-Processing Technology)

1.1 Processing Energy Directly

1.1.1 Converting the Motion of Wind to Power (windmill)
1.1.2 Converting the Motion of Water, (water wheel & turbine)
1.1.3 Converting Light Energy to Electricity (solar cell)
1.1.4 Converting Chemical Energy (fuel cell)
1.1.5 Converting Heat to Electricity (thermocouple)

1.2 Processing Energy with Reaction and Impulse Engines

1.2.1 Processing Energy in Solid Fuel Rockets
1.2.2 Processing Energy in Liquid Fuel Rockets
1.2.3 Processing Nuclear Energy
1.2.4 Processing Air through Jet Turbines
1.2.5 Processing Air through Ram Jets
1.2.6 Processing Air through Resonant Jets
1.2.7 Processing Steam through Turbines

1.3 Processing Energy with Piston Engines

1.3.1 Processing Steam through Piston Engines
1.3.2 Processing Air through Rotary Piston Engines (Wankle)
1.3.3 Processing Air through Two Stroke Spark Ignition Engines
1.3.4 Processing Air through Four Stroke Spark Ignition Engines
1.3.5 Processing Air through Four Stroke Diesel Engines
1.3.6 Processing Air through Two Stroke Diesel Engines

2. Converting Power (Power Processing Technology)

2.1 Modifying Mechanical Input and Output

2.1.1 Gaining Mechanical Advantage
2.1.2 Changing Motion and Direction

2.2 Converting Fluid Power

2.2.1 Compressing Air (pneumatics)
2.2.2 Pumping Liquids (hydraulics)
2.2.3 Rotating and Actuating with Fluids

2.3 Converting Electrical Power

2.3.1 Generating Electricity
2.3.2 Rotating with Electric Motors
2.3.3 Charging Batteries
3. Transmitting and Controlling Power (Post-Processing Technology)

3.1 Rotating Shafts

3.1.1 Coupling and Supporting Shafts
3.1.2 Lubrication Components
3.1.3 Controlling and Transmitting with Gears
3.1.4 Controlling and Transmitting with Belt and Chain Drives
3.1.5 Controlling with Clutches and Brakes

3.2 Transmitting and Controlling Fluid Power

3.2.1 Conditioning and Transmitting Fluids
3.2.2 Amplifying Power
3.2.3 Controlling Flow

3.3 Transmitting and Controlling Electrical Power

3.3.1 Conducting Electricity (circuits)
3.3.2 Switching Electricity
3.3.3 Amplifying Electricity
3.3.4 Transforming, Rectifying, and Filtering Electricity
3.3.5 Regulating Electricity

The purpose of this chapter was to establish the place of power technology within manufacturing technology as it relates to the economic system. Rumble's conceptualization was used to illustrate the relationship of the technologies of management, personnel, and production. Power, as an "enabling" technology, was described as an input which makes the construction and manufacture of material goods possible. Power pre-processing, processing, and post-processing technology were delineated into a structure which will be used in the next chapter as the basis for a set of teacher competencies.
CHAPTER IV
IDENTIFYING THE COMPETENCIES OF A POWER TECHNOLOGIST
IN INDUSTRIAL ARTS EDUCATION

The purpose of this chapter is to show how the structure of power processing technology has been developed. This structure was then subdivided into competencies expressed as tasks and enablers which could be evaluated. Criteria were then added to specify the level of performance, the time allowed, and the equipment and materials needed. It is anticipated that this information will assist in the preparation and evaluation of prospective industrial arts power technology teachers.

The beginning of CBTE and the focus on competencies has been advanced by Houston and Howsam (1972, p. viii):

Whatever its more obscure antecedents, the real thrust of the competency-based movement as it applies to teacher education appears to have been generated by the USOE Elementary Models Project. Each of the ten models relatively independently arrived at an emphasis on competencies.

Necessary in preparation for a CBTE program is a list of competencies. Cooper and Weber suggest four ways by which teacher competencies can be identified:

1. from a philosophical base beginning with a set of assumptions, i.e.: nature of man, purpose of education, nature of learning and instruction. From these assumptions specify desired pupil growth or outcome. Next specify the role of the teacher. Finally specify teacher competencies needed for that role; 2. from an empirical base which would describe
significant relationships between teacher behavior and pupil gain, although such a research base does not exist; (3) from a subject matter base. Identify what the teacher must know in the discipline; (4) from a practitioner base. Derive teaching competencies from an analysis of what "effective practitioners" do (1973, pp. 17-23).

Tyler's (1950) objectives of the 50's were made popular in the 60's by Mager (1962) and others. Refinements in objective format began with Bloom's taxonomy of objectives for the cognitive domain (1956). Krathwohl, Bloom, and Masia soon produced a taxonomy for the affective domain (1964). Next, researchers developed objectives for the psychomotor area. Among these were taxonomies by Simpson (1966), Harrow (1972), and Hauenstein (1972).

Simpson's psychomotor categories were: (1) Perception, (2) Set, (3) Guided response, (4) Mechanism, (5) Complex overt response, (6) Adaptation, and (7) Origination. Harrow's major classification were: (1) Reflex movements, (2) Basic fundamental movements, (3) Perceptual abilities, (4) Physical abilities, (5) Skilled movements, and (6) Non-Discursive communication.

Hauenstein describes the relationship between performance objectives in the three domains. Using Krathwohl's affective behavior on a vertical axis and Bloom's cognitive behaviors on a horizontal line; a psychomotor vector is drawn between the two axis to show dominance (see Figure 14). A psychomotor vector can be drawn to illustrate the behavior which would result from a high cognitive but lower affective situation.

Inherent in the psychomotor functions vector is the notion that humans do not merely act but act in accordance with their intellect and emotions. Thus, by classifying an observable behavior (manipulating,
Figure 14

FUNCTIONAL RELATIONSHIP*
BETWEEN THE COGNITIVE, AFFECTIVE, AND PSYCHOMOTOR FUNCTIONS
(Hauenstein, 1972, p. 22)

*The psychomotor vector moves toward the axis with the greatest influence. A student with high cognitive but low affective development would be illustrated with a vector drawn toward the cognitive axis (see dashed line). This shortens the affective axis (1972, p. 22).
for example), the attendant cognitive (applying) and affective (valuing) abilities of an individual can be inferred. To develop desired behaviors the curriculum or course should provide experiences in which the student is allowed to operationally perceive (establish referents), imitate (repeat), manipulate (practice), perform (operate) and perfect (refine) his behavior in accordance with his cognitive and affective capability. By comparing the psychomotor performance to specified performance objectives deficiencies in cognitive and affective domains can be identified. The psychomotor vector will fluctuate toward the cognitive or affective axis in relation to the forces attributed to a learner's cognitive and affective development. (Hauenstein, 1972, p. 22).

Developing Tasks and Enablers

Inherent in the measurement of competencies or performance is the use of criterion-referenced tests. A test may reference an examinee's score to all other examinees as a group or his performance may be compared to a criterion.

The "criterion" to which an examinee's score is referenced is the delimited class of skills which the test is designed to measure... it is possible to reference an examinee's performance to a clearly described set of behaviors so that we can say with confidence, for example, whether a student does or does not possess a particular competency (Popham, 1976, p. 593).

Practice of performance implies that the student is given opportunities within the teaching sequence to practice the skill component listed as a performance objective. Popham and Baker (1970) contend that practice situations can be of two major types: (1) equivalent situations, where the same skills implied by the objective are practiced; and (2) analogous situations, where learner activity is similar, but not identical to that expressed in the objective
To encourage the use of practice of performance situations and in keeping with guidelines proposed by Hauenstein, (see Chapter II) performance objectives in this study are written as "tasks." These tasks become the criterion-referenced statements of performance (competencies) central to this study. Banathy's criteria served to guide the preparation of task statements.

Specify: 1. What the learner is expected to be able to do, by:
   a. Using verbs that denote observable action.
   b. Indicating the stimulus that is to evoke the behavior of the learner.
   c. Specifying resources (objects) to be used by the learner and persons with whom the learner should interact.

2. How well the behavior is expected to be performed by identifying:
   a. Accuracy or correctness of response.
   b. Response length, speed, rate, and so forth.

3. Under what circumstances the learner is expected to perform by specifying:
   a. Physical or situational circumstances.
   b. Psychological conditions (1968, p. 3).

As a means for minimizing content and in keeping with the focus of this study, a common delimiting tactic was employed. Each task was analyzed for essential knowledge, attitudes, skills, and techniques needed to enable the candidate to perform the task. The resulting attributes are appropriately called enablers.

The common systems concept of input-process-output was used to develop the tasks and enablers which make up the remainder of this chapter.

Inputs were course outlines, textbooks, laboratory manuals, journal articles, achievement tests, and equipment operating instructions.

The process was developed on the basis of Hauenstein's guidelines. These procedures were outlined in Chapter III as used to develop the knowledge structure of power technology (see p. 60).

Outputs were the following modules, tasks, and enablers.
Modules, Tasks, and Enablers For Power Technology

Area I. Processing Energy (Power Pre-Processing Technology)

Module 1. Processing Energy Directly

Tasks 1.1 Converting the Motion of Wind to Power (windmill)
1.2 Converting the Motion of Water (wheel & turbine)
1.3 Converting Light Energy to Electricity (solar cell)
1.4 Converting Chemical Energy (fuel cell)
1.5 Converting Heat to Electricity (thermocouple)

Module 2. Processing Energy with Reaction and Impulse Engines

Tasks 2.1 Processing Energy in Solid Fuel Rockets
2.2 Processing Energy in Liquid Fuel Rockets
2.3 Processing Nuclear Energy
2.4 Processing Air through Jet Turbines
2.5 Processing Air through Ram Jets
2.6 Processing Air through Resonant Jets
2.7 Processing Steam through Turbines

Module 3. Processing Energy with Piston Engines

Tasks 3.1 Processing Steam through Piston Engines
3.2 Processing Air through Rotary Piston Engines (Wankle)
3.3 Processing Air through Two Stroke Spark Engines
3.4 Processing Air through Four Stroke Spark Engines
3.5 Processing Air through Four Stroke Diesel Engines
3.6 Processing Air through Two Stroke Diesel Engines

Area II. Converting Power (Power Processing Technology)

Module 4. Modifying Mechanical Input and Output

Tasks 4.1 Gaining Mechanical Advantage
4.2 Changing Motion and Direction

Module 5. Converting Fluid Power

Tasks 5.1 Compressing Air (pneumatics)
5.2 Pumping Liquids (hydraulics)
5.3 Rotating and Actuating with Fluids

Module 6. Converting Electrical Power
Tasks 6.1 Generating Electricity
6.2 Rotating with Electric Motors
6.3 Charging Batteries

Area III. Transmitting and Controlling Power (Power Post-Processing)

Module 7. Rotating Shafts

Tasks 7.1 Coupling and Supporting Shafts
7.2 Lubricating Components
7.3 Controlling and Transmitting with Gears
7.4 Controlling and Transmitting with Belt and Chain Drives
7.5 Controlling with Clutches and Brakes

Module 8. Transmitting and Controlling Fluid Power

Tasks 8.1 Conditioning and Transmitting Fluids
8.2 Amplifying Power
8.3 Controlling Flow

Module 9. Transmitting and Controlling Electrical Power

Tasks 9.1 Conducting Electricity (circuits)
9.2 Switching Electricity
9.3 Amplifying Electricity
9.4 Transforming, Rectifying, and Filtering Electricity
9.5 Regulating Electricity

Knowledge Enablers

Necessary for the performance of any complex task is specific knowledge. Hauenstein's system (see Figure 11, p. 61) was used to identify essential knowledge which would "enable" performance of one or more complex tasks.

Enablers developed for the power technology competencies are considered minimum knowledge to support their respective tasks. However, the enabler statements could be expanded or condensed to meet particular situations. Enablers may also support more than one task: Knowledge enablers are listed below in singular form, but may appear with more than one task statement (see appendix D).
Enablers: A prospective teacher of power technology should possess the ability to:

1. Follow procedures outlined in a dynamometer operator's manual to: (1) safely conduct a test; (2) collect useable data and; (3) systematically record data on a procedure sheet.

2. Manipulate simple mathematical equations involving division, multiplication, factoring, and moving decimal places.

3. Calibrate a dynamometer air-flow meter including: selecting the proper air-flow nozzle, leveling the manometer, and using the air-flow meter within stated operating limitations.

4. Make dynamometer air-flow corrections for atmospheric conditions. This activity includes reading a wet and dry bulb thermometer, reading a barometer, and interpreting a correction factor on the chart provided.

5. Interpret an engine combustion efficiency meter and related charts.

6. Disassemble and reassemble a typical small engine of a specified type, including major sub-assemblies, to outline a synthesis of the following systems: fuel, lubrication, cooling, starting, ignition (if applicable), and intake exhaust.

7. Interpret typical performance data on piston engines.

8. Use basic hand tools and measuring instruments (ie: Venier-calipers, feeler-gages, and torque-wrenches) as well as any special tool recommended by a particular engine manufacturer.

9. Visualize concepts related to the conservation of energy theorem and Newtons' laws of motion.

10. Follow procedures outlined in a typical fuel cell operators manual.

11. Interpret symbolic representation of common elements and compounds relative to a specific fuel cell unit being operated.

12. Connect ammeters and voltmeters in a circuit.

13. Read meter values, interpolate to nearest whole number, and convert these to formula values when given procedures in symbolic form.
14. Follow procedures to safely fire a model rocket engine and plot a useable static thrust curve.

15. Weigh model rocket unit to the nearest grain and compute mass ratio after firing.

16. Interpret the maximum thrust and the time elapse data, from the average number of squares on a rocket test graph.

17. Apply Einstein's formula $E=MC^2$ to describe atomic fission.

18. Interpret a current Periodic Table of the Elements.

19. Follow major nuclear reactor operations through a complete cycle.

20. Express Newton's third law of action - reaction.

21. Recognize the turbine stages responsible for compression, combustion, turbine drive, and exhaust.

22. Identify the major turbine components: centrifugal-compressors, axial-flow compressors, stators, vanes, burner "cans", exhaust-nozzles, and turbine-nozzles, rotors, and stators.

23. Express the relationship between powerplant input energy, output energy, and the resulting emission rates. This information is to be used to project powerplant efficiency and desirability for an intended use.

24. Follow procedures outlined in a Steam Engine Test Unit manual to safely and properly run a test resulting in the collection of useable data recorded on a procedure sheet.

25. Follow procedures outlined in a Pulse-Jet Test Unit manual to safely and properly run a test resulting in the collection of useable data recorded on a procedure sheet.

26. Interpret vibrator tachometer and torque meter readings.

27. Recognize the major ramjet components: ignitor, flame holder, fuel nozzle (injector), and convergent-diffuser section.

28. Arrange components and operate examples of reciprocating, rotary and linear force.

29. Assemble and solve simple gear rotation direction problems.
30. Arrange components and operate examples of the six simple machines.

31. Compute work from force and distance measurements to determine simple ratios.

32. Demonstrate Pascal's Law.

33. Demonstrate Charles' Law and Boyle's Law.

34. Follow simple printed procedure for connecting fluid components, measuring diameters, computing area, and solving equations requiring cross multiplication.

35. Use Fleming's left-hand rule to determine armature magnetic field direction.

36. Recognize characteristics of common types of DC and AC motors.

37. Operate a typical electric motor dynamometer and to calculate horsepower and torque from rpm and force readings.

38. Test electrolyte with a hydrometer and correct for temperature variables.

39. Calibrate and operate a battery tester (cell voltage-load tester).

40. Interpret S A E Battery ratings and/or A A B M 20-Hour Rating Discharge charts.

41. Recognize differences between the various types of bearings, two coupling types, and several types of hubs.

42. Select and use: keys and key ways, set screws, locking rings, allen wrenches, lock ring pliers, drift punches, open end wrenches, and press fit components.

43. Operate an oil analysis kit to collect useable data on the contents of an oil sample.

44. Interpret oil industry technical information relating to viscosity, additive package, VIS index, high temp test, and cold test.

45. Interpret auto industry technical information relating to API/ASTM/SAE ratings, warranty requirements, and operating conditions and procedures.
46. Read standard air-flow measuring devices (rotameters, orific meters, pitot tubes) and convert readings to Standard Cubic Meters per minute.

47. Read standard air pressure measuring devices (Bourdon-tube or diaphragm type dial gages and liquid filled manometers) and convert readings in centimeters of liquid to atmospheres of pressure.

48. Set-up and operate shut-off valves, needle valves, check valves, and quick exhausting valves in various circuits to control flow.

49. Set up and operate air regulators and oil pressure regulating valves to manipulate system pressure.

50. Follow simple printed procedures for connecting fluid components, taking gage readings, and operating common devices.

51. Recognize symbols for electrical components and devices being used.

52. Interpret schematic diagrams of simple electrical assemblies.

53. Effectively operate a combination voltmeter, ammeter, ohmmeter (multimeter).

54. Set up a general purpose oscilloscope to compare waveforms in an experimental circuit.


56. Read voltmeters, ammeters, and to convert these force and rate values to watts.

57. Take readings of rpm and force to the nearest whole number.

58. Recognize components representing the five major types of clutches and four major types of brakes.

The objectives of this chapter were to illustrate the development of a structure for power processing technology and to expand that structure into tasks and enablers. The pre-service power technology teacher competencies listed in this chapter were expanded to include the level of the
performance expected, the time allowed for a candidate to display each, and the equipment and materials needed to demonstrate each competency. These competencies were then subjected to a jury for assessment. Appendix D contains specimen copies of the expanded competency statements.

The reader may notice that all measurement references in the enablers and the expanded task statements are metric. A teacher can no longer speak of metrics as part of the future. Even the casual observer sees metric symbols on road signs, in the market, and in the media. General Motors Corporation, for example, has metric threaded fasteners making up many of such components on its 1977 cars. Nearly every automobile manufacturers' sub-compact cars have been designed for metric components. Full metrication of this particular industry is in process.

The following chapter includes results of the assessment activities. Input was requested from professionals concerned with power and energy education. The resulting data are presented in text and table format.
CHAPTER V

ASSESSMENT OF POWER TECHNOLOGY TEACHER COMPETENCIES

A primary purpose of this study was to identify technical competencies needed by industrial arts teachers in contemporary power technology programs. With a list of competencies generated, it was then necessary to seek validation and relative importance of items.

Using criteria as outlined in Chapter I, a population was identified which consisted of teacher educators, writers, and charter members of the National Educational Council on Energy and Power. A random sample taking 50 percent of this population netted 43 prospective participants. An initial letter describing the study and asking their participation was sent to the sample group. Enclosed post cards were returned and 28 persons completed their participation (65%). This jury was made up of teachers, supervisors, and those who could fit in both classifications. Most jurists were in the supervisor or "both" groups.

A copy of the initial contact letter is in Appendix A.

The Assessment Materials

Each jurist received (1) a letter of introduction, (2) a combination instruction sheet and response form, (3) a stamped, return-addressed envelope and (4) a list of 39 competencies. The competencies included knowledge enablers, assessment criteria, and necessary equipment. Each competency was on a separate sheet making a total of 39 pages.
The instruction sheet consisted of text and sketches describing three main steps in the assessment process. Each jurist was asked to:

1. Sort the 39 task sheets into three temporary stacks as to most important, undecided, and least important;
2. Select from the three stacks of pages to make nine stacks, of specific numbers, with the first stack being most important and receding to least important in the ninth stack;
3. Take the task number from each sheet in the nine stacks and write this number in its respective position on the answer sheet.

Only the answer sheet was to be returned. Jurists were invited to retain the remainder of the materials.

As the assessment forms began to be returned, one respondent asked to be removed from the jury. The reason given was that the content and structure of the proposed course was not philosophically agreeable to him. Unfortunately the written material received by this jurist did not communicate that the study in question did not deal with curricula; but with the performance assessment of prospective teachers. Several other unsolicited comments were: "I found it difficult to assign values as all items have importance," "Let me know if I can help more in the future," "Excellent set of competencies," "The materials looked excellent."

Sample assessment materials are found in Appendices A, B, C, and D.

Data Analysis Procedures

General statistical methods and formulas are based on the rules of probability or the "law of chance." Closely related to this is the normal probability curve or normal curve of distribution. This curve is the basis for inferential statistics, which makes possible reasonably

The decision was made to normalize the ratings of the jurists in this study. In marking the standard deviations along the base line of the normal curve it was decided to use a nine-unit range. Stanines condense the range slightly, causing contractions at the tails of the curve. It was felt that this broadening of the end categories would assist the jurists in decision making at the highest and lowest values. This system is discussed by Guilford (1965, p. 528) and effectively used by Guentzler (1973). Figure 15 illustrates the distribution used in this analysis.

A primary objective of this study was to rank order teacher competencies, in clusters, in order of importance. The data provided by the jury were punched onto cards and a computer program was prepared. The Statistical Package For The Social Sciences, SPSSSH was employed to compare the data. Clustering occurred because the relative placement of the competency within a given column was not considered. Data analysis was based on the distribution of the competencies among the nine columns in which they had been placed (see Figure 15). Columns were labeled "one" through "nine" with column "nine" corresponding to the most important column.

**Assessment Results**

The first presentation of the data provides the reader with a quick overview of the assessment results. A tabular format allows a display of competencies in relative order of importance.
<table>
<thead>
<tr>
<th>Column number</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment</td>
<td>Very Strongly Agree</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Strongly Disagree</td>
<td>Very Strongly Disagree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stanines</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Percent of sample</td>
<td>4%</td>
<td>7%</td>
<td>12%</td>
<td>17%</td>
<td>20%</td>
<td>17%</td>
<td>12%</td>
<td>7%</td>
<td>4%</td>
</tr>
</tbody>
</table>

**Figure 15**

Q-SORT DISTRIBUTION CURVE
In the second part of this section each competency is examined in terms of its statistical rating received as a result of mathematical treatment. This part of the assessment section offers the reader a more detailed analysis of the data pertaining to each individual competency.

Relative Importance of Power Competencies

The fourth and last objective of this study was to determine the relative order of importance of the competencies of a prospective power technology teacher.

Ranking of competencies was determined by jurists who checked the competencies in one of nine different columns on the assessment answer sheet. Using computer processing, the mean placement of each competency was calculated. The mean rating of the competency determined its respective place on a linear scale. Next the variance was calculated. It was then manipulated to determine the level of significance of differences between competency ranking on the scale. While several competencies were ranked much higher than other stanines on a linear scale, no single competency ranked significantly higher or lower than its neighboring competency, \( t(2) = 1.0, p < .05 \).

The data are presented in Table 1 (p. 93) in linear fashion. Competencies are listed in descending order and are accompanied by their respective mean ratings. Relative ratings and any statistically significant differences can be readily observed. Also included in Table 1 is the original task structuring two digit numbers to provide for easy reference to the module, task, and enabler materials which are located in the appendices.
<table>
<thead>
<tr>
<th>Rank</th>
<th>Mean</th>
<th>Task#</th>
<th>Competencies (Tasks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.357</td>
<td>3.4</td>
<td>Processing Air through Four-Stroke Spark Ignition Engines</td>
</tr>
<tr>
<td>2</td>
<td>6.536</td>
<td>6.1</td>
<td>Generating Electricity</td>
</tr>
<tr>
<td>3</td>
<td>6.464</td>
<td>4.1</td>
<td>Gaining Mechanical Advantage</td>
</tr>
<tr>
<td>4</td>
<td>6.179</td>
<td>3.5</td>
<td>Processing Air through Four-Stroke Compression Ignition Engines</td>
</tr>
<tr>
<td>5</td>
<td>5.964</td>
<td>3.3</td>
<td>Processing Air through Two-Stroke Spark Ignition Engines</td>
</tr>
<tr>
<td>6</td>
<td>5.964</td>
<td>5.2</td>
<td>Pumping Liquids (hydraulics)</td>
</tr>
<tr>
<td>7</td>
<td>5.929</td>
<td>1.3</td>
<td>Converting Light Energy to Electricity (solar cell)</td>
</tr>
<tr>
<td>8</td>
<td>5.893</td>
<td>5.1</td>
<td>Compressing Air (pneumatics)</td>
</tr>
<tr>
<td>9</td>
<td>5.786</td>
<td>9.1</td>
<td>Conducting Electricity (circuits)</td>
</tr>
<tr>
<td>10</td>
<td>5.571</td>
<td>4.2</td>
<td>Changing Motion and Direction</td>
</tr>
<tr>
<td>11</td>
<td>5.500</td>
<td>6.2</td>
<td>Rotating with Electric Motors</td>
</tr>
<tr>
<td>12</td>
<td>5.393</td>
<td>7.3</td>
<td>Controlling and Transmitting with Gears</td>
</tr>
<tr>
<td>13</td>
<td>5.321</td>
<td>1.5</td>
<td>Converting Heat to Electricity (thermocouple)</td>
</tr>
<tr>
<td>14</td>
<td>5.286</td>
<td>2.7</td>
<td>Processing Steam through Turbines</td>
</tr>
<tr>
<td>15</td>
<td>5.250</td>
<td>3.6</td>
<td>Processing Air through Two-Stroke Compression Ignition Engines</td>
</tr>
<tr>
<td>16</td>
<td>5.179</td>
<td>1.4</td>
<td>Converting Chemical Energy (fuel cell)</td>
</tr>
<tr>
<td>17</td>
<td>5.107</td>
<td>5.3</td>
<td>Rotating and Actuating with Fluids</td>
</tr>
<tr>
<td>18</td>
<td>5.107</td>
<td>8.3</td>
<td>Controlling Flow</td>
</tr>
<tr>
<td>19</td>
<td>5.071</td>
<td>3.2</td>
<td>Processing Air through Rotary Piston Engines (Wankle)</td>
</tr>
<tr>
<td>20</td>
<td>5.036</td>
<td>1.2</td>
<td>Converting the Motion of Water (water wheel &amp; turbine)</td>
</tr>
<tr>
<td>21</td>
<td>5.000</td>
<td>9.2</td>
<td>Switching Electricity</td>
</tr>
<tr>
<td>22</td>
<td>5.000</td>
<td>7.4</td>
<td>Controlling and Transmitting with Belt and Chain Drives</td>
</tr>
<tr>
<td>23</td>
<td>4.750</td>
<td>7.5</td>
<td>Controlling with Clutches and Brakes</td>
</tr>
<tr>
<td>24</td>
<td>4.679</td>
<td>9.5</td>
<td>Regulating Electricity</td>
</tr>
<tr>
<td>25</td>
<td>4.643</td>
<td>8.2</td>
<td>Amplifying Power</td>
</tr>
<tr>
<td>26</td>
<td>4.607</td>
<td>1.1</td>
<td>Converting the Motion of Wind to Power (windmill)</td>
</tr>
<tr>
<td>27</td>
<td>4.571</td>
<td>6.3</td>
<td>Charging Batteries</td>
</tr>
<tr>
<td>28</td>
<td>4.536</td>
<td>7.1</td>
<td>Coupling and Supporting Shafts</td>
</tr>
<tr>
<td>29</td>
<td>4.500</td>
<td>2.4</td>
<td>Processing Air through Jet Turbines</td>
</tr>
<tr>
<td>30</td>
<td>4.464</td>
<td>8.1</td>
<td>Conditioning and Transmitting Fluids</td>
</tr>
<tr>
<td>31</td>
<td>4.393</td>
<td>9.3</td>
<td>Amplifying Electricity</td>
</tr>
<tr>
<td>32</td>
<td>4.393</td>
<td>3.1</td>
<td>Processing Steam through Piston Engines</td>
</tr>
<tr>
<td>33</td>
<td>4.179</td>
<td>9.4</td>
<td>Transforming, Rectifying, and Filtering Electricity</td>
</tr>
<tr>
<td>34</td>
<td>4.107</td>
<td>2.1</td>
<td>Processing Energy in Solid Fuel Rockets</td>
</tr>
<tr>
<td>35</td>
<td>4.071</td>
<td>7.2</td>
<td>Lubricating Components</td>
</tr>
<tr>
<td>36</td>
<td>4.000</td>
<td>2.3</td>
<td>Processing Nuclear Energy</td>
</tr>
<tr>
<td>37</td>
<td>3.429</td>
<td>2.2</td>
<td>Processing Energy in Liquid Fuel Rockets</td>
</tr>
<tr>
<td>38</td>
<td>2.929</td>
<td>2.6</td>
<td>Processing Air through Resonant Jets</td>
</tr>
<tr>
<td>39</td>
<td>2.893</td>
<td>2.5</td>
<td>Processing Air through Ram Jets</td>
</tr>
</tbody>
</table>

Note: The difference between competency means must be greater than 1.000 to be significant (p < .05).
Examination of the Data on Each Competency

To assist the reader who seeks a more detailed analysis, this section lists each competency along with its respective data. Table 1 (p. 93) displays competencies by rank of importance as perceived by the jury rather than task number according to the structure. The purpose of this first table is to offer the cursory reader an overview of the assessment findings and to display the relative order of each competency on a continuum.

Jurists' inputs to this study were placed in a normal distribution using stanines (see Figure 15 p. 91). Column nine on the survey answer sheet was labeled "most important" with lower importance being assigned to each other position. Value descended with each column down to position one (stanine 9) which was considered "least important."

The following tables contain numerals most of which are from 1.000 to 9.000 to correspond with the column with which the particular competency is associated. The mean value was used to rank order the list of competencies. Other measures of central tendency included are the mode and the median.

Other table values include the minimum and maximum: these indicate lowest valued (minimum) and the highest valued (maximum) group or column to which that particular competency was assigned. In addition, kurtosis and skewness are offered to describe a graphical image of the data analysis.

Measures of variability given are the variance, the standard deviation, the standard error, and the range. The standard deviation is given to indicate the importance of a specific competency relative to other competencies located on the base line of the normal curve. The
standard error is an estimate of chance fluctuation against which differences between means may be checked for significance. The variance is listed to provide the reader with a measure of the dispersion or spread of scores. The range, of course, will provide an awareness of the difference between the highest and lowest measures.

Table 2

| Competency 1. Processing air through four-stroke spark ignition engines (Task 3.4)* |
|---------------------------------------------|----------------|--------|------|----------------|----------------|
| Mean                                       | 7.357          | STD Error  | 0.357 | Median         | 8.167          |
| Mode                                       | 9.000          | STD Deviation  | 1.890 | Variance       | 3.571          |
| Kurtosis                                   | -1.109         | Skewness    | -0.651 | Range          | 5.000          |
| Minimum                                   | 4.000          | Maximum     | 9.000  | Sample         | 28             |

*Numbers in parenthesis are the task and module structure identifiers.

While this competency was clearly rated as the most important, the range and variance indicates complete agreement was not present. There were 13 jurists (46%) who had placed this item in the most important column. The remaining respondents scattered this competency into each column down to a low of number four. Four jurists (14%) rated this competency as of lesser importance.

It is apparent that educators continue to feel that skills related to automobile-type engines are needed by teacher candidates. However, it is also clear that these skills and related knowledges are not to make up a majority of an instructional program that would be representative of the broad conceptual framework of this research.
Table 3

**Competency 2. Generating electricity (Task 6.1)**

<table>
<thead>
<tr>
<th>Mean</th>
<th>6.536</th>
<th>STD Error</th>
<th>0.423</th>
<th>Median</th>
<th>7.000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode</td>
<td>8.000</td>
<td>STD Deviation</td>
<td>2.236</td>
<td>Variance</td>
<td>4.999</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.232</td>
<td>Skewness</td>
<td>-0.803</td>
<td>Range</td>
<td>8.000</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.000</td>
<td>Maximum</td>
<td>9.000</td>
<td>Sample</td>
<td>28</td>
</tr>
</tbody>
</table>

This competency received a diverse rating as indicated by the wide range. However, the three lowest columns only received one vote each for this item, for a total of 11%. The median and mode ratings reflect the emphasis placed on this competency. This high rating was probably due to the dependence our society places upon electric power.

Table 4

**Competency 3. Gaining mechanical advantage (Task 4.1)**

<table>
<thead>
<tr>
<th>Mean</th>
<th>6.464</th>
<th>STD Error</th>
<th>0.513</th>
<th>Median</th>
<th>7.000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode</td>
<td>9.000</td>
<td>STD Deviation</td>
<td>2.715</td>
<td>Variance</td>
<td>7.369</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.697</td>
<td>Skewness</td>
<td>-0.716</td>
<td>Range</td>
<td>8.000</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.000</td>
<td>Maximum</td>
<td>9.000</td>
<td>Sample</td>
<td>28</td>
</tr>
</tbody>
</table>

Ratings were received by this item in every column except the second from the lowest: three votes (11%) were placed in the lowest column. The three measures of central tendency indicate the high value placed on this competency. As reflected in the mode, 11 jurists (39%) considered this item as most important. If the placement within a given column can be considered, eight respondents (29%) assigned this item to the first level of the most important column.
Our civilization was built with combinations of levers, called tools and machines. Expertise with devices which gain force and velocity is considered an important part of a power teacher's competence.

Table 5

**Competency 4.** Processing air through four-stroke compression ignition engines (Task 3.5)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>STD Error</th>
<th>Median</th>
<th>Mode</th>
<th>STD Deviation</th>
<th>Variance</th>
<th>Kurtosis</th>
<th>Skewness</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>6.179</td>
<td>0.353</td>
<td>6.071</td>
<td>6.000</td>
<td>1.867</td>
<td>3.485</td>
<td>-1.041</td>
<td>0.082</td>
<td>6.000</td>
<td>3.000</td>
<td>9.000</td>
<td>28</td>
</tr>
</tbody>
</table>

All three measures of central tendency are in close agreement on this item. While the ratings are somewhat diverse, the unit mode of six (25%) exerts a force toward center scale. The importance of this competency is indicated by the absence of votes in the lowest two columns and the presence of five (18%) selections in the most important column.

While this competency is rated significantly below (p. 05) the top rated item, the jurists may have considered the diesel very important and as the powerplant of the immediate future. Industrial arts teacher competence in the area of diesel power is essential.

Table 6

**Competency 5.** Processing air through two-stroke spark ignition engines (Task 3.3)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>STD Error</th>
<th>Median</th>
<th>Mode</th>
<th>STD Deviation</th>
<th>Variance</th>
<th>Kurtosis</th>
<th>Skewness</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.964</td>
<td>0.435</td>
<td>5.900</td>
<td>9.000</td>
<td>2.301</td>
<td>5.295</td>
<td>-1.234</td>
<td>-0.102</td>
<td>7.000</td>
<td>2.000</td>
<td>9.000</td>
<td>28</td>
</tr>
</tbody>
</table>
The high rating received by this item reflects the engine's popularity as used on motorcycles and portable equipment. The several lower ratings may be due to jurists' awareness of higher pollutants emitted by this type of powerplant.

The mean values for competencies five and six are identical: When considering the mode and standard deviations, however, competency five has been given slightly more value. This competency also received six votes (21%) for most important. Competency six received but two votes (7%) in the top column.

The reader is reminded that competency placement on this continuum is arbitrary, as no single item is statistically significant in relation to the next item.

Table 7

<table>
<thead>
<tr>
<th>Competency 6. Pumping liquids (hydraulics) (Task 5.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Mode</td>
</tr>
<tr>
<td>Kurtosis</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
</tbody>
</table>

The increasing significance of fluid power in manufacturing, construction, and transportation is evident by the value placed on this item. Nearly identical mean, median, and mode ratings as well as kurtosis and the standard deviation place this competency securely in the upper mid-position on the scale.
Table 8

**Competency 7. Converting light energy to electricity (solar cell)**
(Task 1.3)

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.929</td>
<td>STD Error</td>
<td>0.436</td>
<td>Median</td>
</tr>
<tr>
<td>Mode</td>
<td>8.000</td>
<td>STD Deviation</td>
<td>2.308</td>
<td>Variance</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.995</td>
<td>Skewness</td>
<td>-0.455</td>
<td>Range</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.000</td>
<td>Maximum</td>
<td>9.000</td>
<td>Sample</td>
</tr>
</tbody>
</table>

Current popularity of solar energy may have influenced ratings of this item. It is interesting to note the minimum, maximum, range, and variance data: votes for this item were placed in all nine columns. The two lowest columns received one vote each (4%) while the two most important categories received nine votes (32%). The mode, column eight, received six votes (21%) while column seven earned five (18%).

Table 9

**Competency 8. Compressing air (pneumatics) (Task 5.1)**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.893</td>
<td>STD Error</td>
<td>0.339</td>
<td>Median</td>
</tr>
<tr>
<td>Mode</td>
<td>6.000</td>
<td>STD Deviation</td>
<td>1.792</td>
<td>Variance</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>0.407</td>
<td>Skewness</td>
<td>-0.496</td>
<td>Range</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.000</td>
<td>Maximum</td>
<td>9.000</td>
<td>Sample</td>
</tr>
</tbody>
</table>

This competency makes up the other half of the fluid power team: competency six relates to hydraulics skills. These two items would be expected to be close on the continuum.

The range appears broad on this item, however there was only one vote placed in the lowest and one vote placed in the third column (4%). A heavy influence on all data in Table 9 is the mode: 10 votes (36%)
were placed in column six. Kurtosis and deviation data place this item clearly in the upper mid-position on the scale.

**Table 10**

**Competency 9. Conducting Electricity (circuits) (Task 9.1)**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.786</td>
<td>STD Error</td>
<td>0.428</td>
</tr>
<tr>
<td>Mode</td>
<td>6.000</td>
<td>STD Deviation</td>
<td>2.267</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.847</td>
<td>Skewness</td>
<td>-0.383</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.000</td>
<td>Maximum</td>
<td>9.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median</td>
<td>6.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variance</td>
<td>5.138</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Range</td>
<td>8.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sample</td>
<td>28</td>
</tr>
</tbody>
</table>

Electrical circuit skills were valued by the respondents although many differed in their rating of this item. Range, variance, and kurtosis data show that jurists put this item in every possible column. The least value was one vote (4%) in the lowest column and greatest value was indicated by three votes (11%) in the most important category. Five (18%) choose column eight while six (21%) made up the mode.

**Table 11**

**Competency 10. Changing motion and direction (Task 4.2)**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.571</td>
<td>STD Error</td>
<td>0.406</td>
</tr>
<tr>
<td>Mode</td>
<td>5.000</td>
<td>STD Deviation</td>
<td>2.150</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.902</td>
<td>Skewness</td>
<td>-0.087</td>
</tr>
<tr>
<td>Minimum</td>
<td>2.000</td>
<td>Maximum</td>
<td>9.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median</td>
<td>5.357</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Variance</td>
<td>4.624</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Range</td>
<td>7.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sample</td>
<td>28</td>
</tr>
</tbody>
</table>

This is the second of a pair of competencies relating to levers and simple machines. While not placed close to its counterpart (which rated number two) this item placed well into the upper half of the scale. The mode located itself on center scale (seven votes for 25%) and
influenced the other data. There were no votes for the lowest column and three jurists (11%) choose it as a most important item.

Table 12

<table>
<thead>
<tr>
<th>Competency 11. Rotating with electric motors (Task 6.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Mode</td>
</tr>
<tr>
<td>Kurtosis</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
</tbody>
</table>

Some agreement can be seen in the data relating to operating electric motors. The variance indicates that the range data is somewhat misleading. There was but one vote placed in the second column on the low end and one jurist (4%) selected the highest column. All measures of central tendency center around the mode at 11 votes (39%).

Table 13

<table>
<thead>
<tr>
<th>Competency 12. Controlling and transmitting with gears (Task 7.3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Mode</td>
</tr>
<tr>
<td>Kurtosis</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
</tbody>
</table>

Skills related to power transmission were considered important by the respondents. All measures of central tendency place this competency in the upper half of the scale making the gear skills the highest rated of the mechanical power transmission group. A heavy influence on this competency's data was the mode: eight votes (29%) were placed in column
five, the mid-most group. Both the forth and seventh columns each had five votes (18%), with one in the lowest group and two (7%) in the most important column.

Table 14

<table>
<thead>
<tr>
<th>Competency 13. Converting heat to electricity (thermocouple) (Task 1.5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>5.321</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
<tr>
<td>1.000</td>
</tr>
</tbody>
</table>

Skills relating to this direct energy converter seem to rate unusually high. Thermocouples, while essential devices, produce the least proportional amount of electricity of any classification: The next lower rated competency deals with steam turbines, the powerplant which produces nearly all of our industrial and residential electricity.

The variance is a good indication of the scattered responses to this item with columns four through eight receiving almost identical numbers of votes. Column one received two votes (7%) and the highest value was group eight which received five votes (18%): columns four and seven also were chosen by five jurists each.

Table 15

<table>
<thead>
<tr>
<th>Competency 14. Processing steam through turbines (Task 2.7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>5.286</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
<tr>
<td>1.000</td>
</tr>
</tbody>
</table>
This competency deals with the powerplant which produces nearly all of the electricity used by homes and industry in our country. Laboratory activities were difficult to create in this area until recently, as vendors began offering working turbine models.

Central tendency data reflect considerable agreement on the location of this competency. The range datum is misleading as only one respondent chose the highest column (4%): the lowest two groups each had one vote also. The middle column received the greatest number of votes at seven (25%).

Table 16

**Competency 15. Processing air through two-stroke compression ignition engines (Task 3.6).**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>STD Error</th>
<th>Median</th>
<th>Mode</th>
<th>STD Deviation</th>
<th>Median</th>
<th>Kurtosis</th>
<th>Skewness</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.250</td>
<td>0.397</td>
<td>5.100</td>
<td>4.000</td>
<td>2.102</td>
<td>0.019</td>
<td>-0.773</td>
<td>-0.019</td>
<td>8.000</td>
<td>1.000</td>
<td>9.000</td>
<td>28</td>
</tr>
</tbody>
</table>

Diesel engines of this type are the bulk of large truck powerplants. While common on the highways, size and expense have kept them from classrooms. Jurists placed less emphasis on this powerplant because skill activities are difficult to arrange.

Three columns received more than half of the ratings on this competency. Column four, the mode, received six votes (21%) while columns five and seven earned five each (18%). One respondent (4%) chose the lowest group and two each (7%) chose columns eight and nine.
Table 17

Competency 16. Converting chemical energy (fuel cell) (1.4)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>STD Error</th>
<th>Median</th>
<th>Mode</th>
<th>STD Deviation</th>
<th>Variance</th>
<th>Kurtosis</th>
<th>Skewness</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.179</td>
<td>0.375</td>
<td>5.167</td>
<td>4.000</td>
<td>1.982</td>
<td>3.930</td>
<td>0.231</td>
<td>0.019</td>
<td>6.000</td>
<td>2.000</td>
<td>8.000</td>
<td>28</td>
</tr>
</tbody>
</table>

Direct energy converters were not popular with the jury. Fuel cells may be labeled the powerplant of the future, but the respondents did not see an urgent need to emphasize these in present power technology studies.

There were no votes in the least or greatest columns, but each other group was selected by at least three respondents. Columns two, three, five, and seven earned three votes (11%); columns six and eight earned five each (18%); and column four received six (21%). Agreement was evident that this competency was important, but how important is a more difficult question.

Table 18

Competency 17. Rotating and actuating with fluids (5.3)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>STD Error</th>
<th>Median</th>
<th>Mode</th>
<th>STD Deviation</th>
<th>Variance</th>
<th>Kurtosis</th>
<th>Skewness</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.107</td>
<td>0.283</td>
<td>5.167</td>
<td>6.000</td>
<td>1.499</td>
<td>2.247</td>
<td>-0.564</td>
<td>0.016</td>
<td>6.000</td>
<td>2.000</td>
<td>8.000</td>
<td>28</td>
</tr>
</tbody>
</table>

Fluid power skills were well accepted by the jury. There was general agreement to place these particular fluid motor and cylinder techniques soundly in the center of the scale. Note the absence of items in the lowest and highest columns. Although some variance exists, central
tendency indices and skewness indicate a well formed curve. Middle columns four, five, and six received 20 votes (72%).

Table 19

**Competency 18. Controlling flow (Task 8.3)**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>STD Error</th>
<th>Median</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.107</td>
<td>0.323</td>
<td>4.944</td>
<td>28</td>
</tr>
<tr>
<td>Mode</td>
<td>5.000</td>
<td>1.707</td>
<td>2.914</td>
<td></td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.428</td>
<td>0.415</td>
<td>Range</td>
<td>7.000</td>
</tr>
<tr>
<td>Minimum</td>
<td>2.000</td>
<td>9.000</td>
<td>Sample</td>
<td>28</td>
</tr>
</tbody>
</table>

Skills employing valves, lines, and regulators to control fluid power were valued by the respondents. Central tendency indices place this fluid power competency soundly in the center of the continuum. The mode, with nine votes (32%) was surrounded by column three (14%), column four (18%), column six and seven with 11% each for a total of 24 votes (86%) in the middle five columns.

Table 20

**Competency 19. Processing air through rotary piston engines (Task 3.2)**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>STD Error</th>
<th>Median</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.071</td>
<td>0.463</td>
<td>4.900</td>
<td>28</td>
</tr>
<tr>
<td>Mode</td>
<td>5.000</td>
<td>2.448</td>
<td>5.995</td>
<td></td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-1.196</td>
<td>0.023</td>
<td>Range</td>
<td>8.000</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.000</td>
<td>9.000</td>
<td>Sample</td>
<td>28</td>
</tr>
</tbody>
</table>

Operational skills related to the wankle-type engines received mixed evaluation by the groups. Data associated with central tendency indicate some agreement, however kurtosis, variance, and range data show
much disagreement. Each column designation was supported by at least two jurists with columns 5 and 8 receiving 5 votes each (18%).

Table 21
Competency 20. Converting the motion of water (Task 1.2)

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.036</td>
<td>STD Error</td>
<td>0.473</td>
<td>Median</td>
<td>5.100</td>
</tr>
<tr>
<td>Mode</td>
<td>5.000</td>
<td>STD Deviation</td>
<td>2.502</td>
<td>Variance</td>
<td>6.258</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-1.114</td>
<td>Skewness</td>
<td>-0.040</td>
<td>Range</td>
<td>8.000</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.000</td>
<td>Maximum</td>
<td>9.000</td>
<td>Sample</td>
<td>28</td>
</tr>
</tbody>
</table>

Abilities associated with extracting power from water wheels and turbines received very mixed ratings from the jury. All data show disagreement but a slight trend toward center scale can be detected: the mode, column five, earned five votes (18%). Columns two, four, and eight received two votes (7%) each; columns one, six, and nine received three (11%) each; and columns three and seven each earned four (14%).

Table 22
Competency 21. Switching electricity (Task 9.2).

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>5.000</td>
<td>STD Error</td>
<td>0.313</td>
<td>Median</td>
<td>5.000</td>
</tr>
<tr>
<td>Mode</td>
<td>5.000</td>
<td>STD Deviation</td>
<td>1.656</td>
<td>Variance</td>
<td>2.741</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>0.442</td>
<td>Skewness</td>
<td>-0.098</td>
<td>Range</td>
<td>8.000</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.000</td>
<td>Maximum</td>
<td>9.000</td>
<td>Sample</td>
<td>28</td>
</tr>
</tbody>
</table>

The group of electrical control skills under this competency received a solid mid-scale endorsement from the jury. The center column, with 10 votes (36%) reflects this agreement. End columns; numbers one, two, and nine received one vote each (4%); near center columns three
(two at 7%), four (five at 18%), six and seven (four at 14% each) complete the tally.

Table 23

**Competency 22. Controlling and transmitting with belt and chain drives (Task 7.4).**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>STD Error</th>
<th>Median</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competency 22</td>
<td>5.000</td>
<td>0.267</td>
<td>4.955</td>
<td>28</td>
</tr>
</tbody>
</table>

Skills needed to transmit and control shaft power through belts and chains earned a very sound center scale rating from the assessment panel. Column five, at mid-scale, was the mode with 11 votes (39%): columns closest to the ends, numbers two and eight, received one vote (4%) each; columns three and six earned three (11%) each, while column seven earned four (14%), and number four received five votes (18%).

Table 24

**Competency 23. Controlling with clutches and brakes (Task 7.5)**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>STD Error</th>
<th>Median</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competency 23</td>
<td>4.750</td>
<td>0.270</td>
<td>4.750</td>
<td>28</td>
</tr>
</tbody>
</table>

Skills associated with rotating shaft control were generally agreed to fall at slightly below mid-scale. Extreme end ratings consisted of one vote (4%) in each of the second and eighth columns. The mid-cluster of scores consisted of five votes (18%) in column three, six (21%) in
column four and eight (29%) in column five (which was the mode).
Columns six and seven earned five (18%) and two votes (7%) respectively.

Table 25

<table>
<thead>
<tr>
<th>Competency 24. Regulating electricity (Task 9.5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Mode</td>
</tr>
<tr>
<td>Kurtosis</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
</tbody>
</table>

Tasks requiring circuit voltage and current control were generally valued by the assessment panel. Heavy clustering occurred in the center three columns as they collectively earned the support of seventeen (60%) respondents. Variability was caused by two votes (7%) in each of the lowest two columns. Kurtosis and skewness were affected partly by the three votes (11%) in each of the third and the eighth columns; column seven received one vote (4%).

Table 26

<table>
<thead>
<tr>
<th>Competency 25. Amplifying power (Task 9.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Mode</td>
</tr>
<tr>
<td>Kurtosis</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
</tbody>
</table>

Tasks dealing with intensifying and manipulating fluid flow were believed to have near mid-scale importance. However, little agreement existed in the specification of this fluid power competency on a continuum. The scores clustered within columns three (21%), four (14%),
five (11%), and six (21%). Columns two and seven each received 11% and the extreme columns; one, eight, and nine, received one vote (4%) each.

Table 27

Competency 26. Converting wind to power (Task 1.1)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.607</td>
</tr>
<tr>
<td>STD Error</td>
<td>0.552</td>
</tr>
<tr>
<td>Median</td>
<td>4.500</td>
</tr>
<tr>
<td>Mode</td>
<td>1.000</td>
</tr>
<tr>
<td>STD Deviation</td>
<td>2.923</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-1.418</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.000</td>
</tr>
<tr>
<td>Maximum</td>
<td>9.000</td>
</tr>
<tr>
<td>Sample</td>
<td>28</td>
</tr>
</tbody>
</table>

The competency relating to windmill powerplant operation was given relatively low value by the jury. Seven jurists (25%) selected the lowest column, and one (4%) selected the second group. All measures of variability were affected as between two and four jurists selected each of the next columns up to and including column nine. Widespread disagreement may have been caused by the appeal of windmill devices to advocates of alternate forms of energy. Other jurists may have been influenced by relative contribution of such devices to our society's needs.

Table 28

Competency 27. Charging batteries (Task 6.3)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.571</td>
</tr>
<tr>
<td>STD Error</td>
<td>0.372</td>
</tr>
<tr>
<td>Median</td>
<td>4.667</td>
</tr>
<tr>
<td>Mode</td>
<td>4.000</td>
</tr>
<tr>
<td>STD Deviation</td>
<td>1.971</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.216</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.034</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.000</td>
</tr>
<tr>
<td>Maximum</td>
<td>9.000</td>
</tr>
<tr>
<td>Sample</td>
<td>28</td>
</tr>
</tbody>
</table>
Techniques of storing and retrieving electricity were assigned mid-scale value by the jury. Central columns four, five, and six received six votes each for a total of 64%. The competency mean was effected downward by columns one and three receiving three votes (11% each); this lower rating along with token votes (one, 4% each) in columns two, seven, eight, and nine caused great variability to be evident.

Table 29

Competency 28. Coupling and supporting shafts (Task 7.1)

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.536</td>
</tr>
<tr>
<td>STD Error</td>
<td>0.376</td>
</tr>
<tr>
<td>Median</td>
<td>4.167</td>
</tr>
<tr>
<td>Mode</td>
<td>4.000</td>
</tr>
<tr>
<td>STD Deviation</td>
<td>1.990</td>
</tr>
<tr>
<td>Variance</td>
<td>3.962</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.460</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.483</td>
</tr>
<tr>
<td>Range</td>
<td>8.000</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.000</td>
</tr>
<tr>
<td>Maximum</td>
<td>9.000</td>
</tr>
<tr>
<td>Sample</td>
<td>28</td>
</tr>
</tbody>
</table>

Skills requiring the selection of bearings and couplings to transmit shaft power were given lower mid-scale value by the respondents. The mode, column four, greatly affected the ranking of this competency with nine votes (32%). Some disagreement, shown as variability, was evident: Column three received four votes (14%), columns two, five, and six received three (11%) each. Columns one and nine received one (4%) each and columns seven and eight earned two (7%) each.

Table 30

Competency 29. Processing air through jet turbines (Task 2.4)

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.500</td>
</tr>
<tr>
<td>STD Error</td>
<td>0.435</td>
</tr>
<tr>
<td>Median</td>
<td>4.333</td>
</tr>
<tr>
<td>Mode</td>
<td>4.000</td>
</tr>
<tr>
<td>STD Deviation</td>
<td>2.301</td>
</tr>
<tr>
<td>Variance</td>
<td>5.296</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.679</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.328</td>
</tr>
<tr>
<td>Range</td>
<td>8.000</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.000</td>
</tr>
<tr>
<td>Maximum</td>
<td>9.000</td>
</tr>
<tr>
<td>Sample</td>
<td>28</td>
</tr>
</tbody>
</table>
Abilities dealing with operational cycles of jet turbines received mixed assessment from the jury. Central tendency data, however, reveals a below mid-point ranking of this competency. Clustering of scores occurred in the center columns of four and five which received six (21%) and five (18%) votes respectively. A lower value direction was caused by columns one, two, and three which received three votes (11%) each; column six also with three votes, helped stabilize this direction. Variability was largely due to columns eight and nine receiving two votes (7%) each.

Table 31

| Competency 30. Conditioning and transmitting fluids (Task 8.1) |
|-------------|---------------|------------|------------|
| Mean        | 4.464         | STD Error  | 0.413      |
| Mode        | 6.000         | STD Deviation | 2.186      |
| Kurtosis    | -0.912        | Skewness   | -0.090     |
| Minimum     | 1.000         | Maximum    | 9.000      |

Skills dealing with analyzing fluid characteristics and setting up transmission lines earned a very mixed assessment from the jury. Perhaps jury members felt that these skills were not essential to success with other fluid power competencies which were valued more highly.

Columns with the highest value; numbers seven, eight, and nine, earned four (14%) zero, and one (4%) votes respectively. Lowest value columns; one, two, and three, earned four (14%), two (7%) and three (11%) votes respectively. Column five, the mid-point, also received three votes. Columns receiving the most votes were numbers four with five votes (18%) and six with six votes (21%).
Table 32

Competency 31. Amplifying electricity (Task 9.3)

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.393</td>
</tr>
<tr>
<td>Mode</td>
<td>5.000</td>
</tr>
<tr>
<td>STD Error</td>
<td>0.403</td>
</tr>
<tr>
<td>Median</td>
<td>4.500</td>
</tr>
<tr>
<td>STD Deviation</td>
<td>2.132</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.206</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.000</td>
</tr>
<tr>
<td>Maximum</td>
<td>9.000</td>
</tr>
<tr>
<td>Sample</td>
<td>28</td>
</tr>
</tbody>
</table>

While variability exists, the above data show that there was general agreement to place this competency in the lower mid-portion of the continuum. Amplifying skills were placed in column five the mid-point, by nine jurists (32%). Columns four and two were selected by five (18%) and six (21%) each. Two jurists (7%) selected the highest column and two selected the lowest. One each (4%) selected columns three, six, seven, and eight.

Table 33

Competency 32. Processing steam through piston engines (Task 3.1)

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.393</td>
</tr>
<tr>
<td>Mode</td>
<td>4.000</td>
</tr>
<tr>
<td>STD Error</td>
<td>0.386</td>
</tr>
<tr>
<td>Median</td>
<td>4.333</td>
</tr>
<tr>
<td>STD Deviation</td>
<td>2.043</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.746</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.000</td>
</tr>
<tr>
<td>Maximum</td>
<td>8.000</td>
</tr>
<tr>
<td>Sample</td>
<td>28</td>
</tr>
</tbody>
</table>

In spite of limited application of steam piston engines today, general agreement was evident to place this related competency in the lower mid-position on the continuum. Four lower middle columns (numbers three, four, five, and six) received 19 (68%) votes. The lowest (number one) and highest (number eight) columns received three votes (11%) each. Column nine was left empty and two (7%) votes were in column two.
Table 34

**Competency 33.** Transforming, rectifying, and filtering electricity
(Task 9.4)

<table>
<thead>
<tr>
<th>Mean</th>
<th>STD Error</th>
<th>Median</th>
<th>Mode</th>
<th>STD Deviation</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.179</td>
<td>0.395</td>
<td>4.500</td>
<td>5.000</td>
<td>2.091</td>
<td>4.374</td>
</tr>
</tbody>
</table>

Kurtosis -0.206 Skewness 0.322 Range 8.000
Minimum 1.000 Maximum 9.000 Sample 28

General agreement was evident to place electrical power supply circuit skills in the lower mid-scale position on the continuum. The mid-most column (number five) received ten votes (36%). The next two lower columns received four votes each totaling 29%. Variability was due to four jurists (14%) selecting column one, the lowest, and two (7%) selecting the second column. One (4%) selected column nine, the highest, and two (7%) selected column eight.

Table 35

**Competency 34.** Processing energy in solid fuel rockets (Task 2.1)

<table>
<thead>
<tr>
<th>Mean</th>
<th>STD Error</th>
<th>Median</th>
<th>Mode</th>
<th>STD Deviation</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.107</td>
<td>0.389</td>
<td>4.500</td>
<td>2.000</td>
<td>2.061</td>
<td>4.247</td>
</tr>
</tbody>
</table>

Kurtosis -1.460 Skewness -0.067 Range 6.000
Minimum 1.000 Maximum 7.000 Sample 28

Assessment of analysis skills associated with solid fuel rocket powerplants resulted in little agreement among jurists. Central tendency data and considerable variability make ranking this competency difficult. While solid fuel rockets are widely used by the military and for some space mission applications, the powerplant makes a relatively small contribution to society's total power needs. The highest rating
given this item was four votes (14%) in column seven. The lowest columns, numbers one and two, received three (11%) and six (21%) each. Middle columns (numbers four, five, and six) received two (7%), five (18%) and five votes respectively.

Table 36

| Competency 35. Lubricating components (Task 7.2) |
|-------------------------------|-----------------|-----------------|-----------------|-----------------|
| Mean                          | 4.071           | STD Error       | 0.337           | Median          | 4.167           |
| Mode                          | 5.000           | STD Deviation   | 1.783           | Variance        | 3.180           |
| Kurtosis                      | -0.379          | Skewness        | 0.089           | Range           | 7.000           |
| Minimum                       | 1.000           | Maximum         | 8.000           | Sample          | 28              |

Oil application and analysis skills were ranked in the lower mid-position on the continuum in this assessment. Three lower center columns, numbers three, four, and five, received 68% of the votes. The lowest column received three votes (11%), and column two earned two votes (7%). Column eight was the highest selected with one vote (4%), column seven received two (7%).

Table 37

| Competency 36. Processing nuclear energy (Task 2.3) |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Mean            | 2.893           | STD Error       | 0.306           | Median          | 2.500           |
| Mode            | 2.000           | STD Deviation   | 1.618           | Variance        | 2.618           |
| Kurtosis        | -0.799          | Skewness        | 0.592           | Range           | 5.000           |
| Minimum         | 1.000           | Maximum         | 6.000           | Sample          | 28              |

Fission and fusion analysis abilities were generally not valued proportionally in this assessment. Possibly the lack of appropriate hardware for activity based learning affected these ratings. The lowest two
columns, numbers one and two, collected equal votes, totaling 12 (43%). In contrast, column nine received three votes (11%); the next highest, column seven, earned four (14%). Middle columns (number four, five and six) received four (14%), one (4%), and two (7%) votes respectively.

Table 38

Competency 37. Processing energy in liquid fuel rockets (Task 2.2)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>STD Error</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode</td>
<td>3.429</td>
<td>0.397</td>
<td>3.167</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>1.000</td>
<td>2.098</td>
<td>4.402</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.000</td>
<td>0.341</td>
<td>6.000</td>
</tr>
</tbody>
</table>

Performance analysis skills dealing with liquid fuel rockets drew mixed responses but data analysis shows a very low proportionate rating. While this powerplant contributes little to society's total power needs, it remains the workhorse of all manned space missions. In addition to the fact that the liquid fuel rocket enjoys frequent media exposure, hardware has existed to provide activity based learning.

Column one, the lowest, received seven votes (25%); column two earned five (18%) and column three earned three votes (11%). More value was implied in this competency by nine respondents (32%) when three each selected columns five, six, and seven (the highest chosen). Column four earned four votes (14%).

Table 39

Competency 38. Processing air through resonant jets (Task 2.6)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>STD Error</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode</td>
<td>2.929</td>
<td>0.391</td>
<td>2.500</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>1.000</td>
<td>2.071</td>
<td>4.291</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.605</td>
<td>1.045</td>
<td>8.000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>9.000</td>
</tr>
<tr>
<td>Sample</td>
<td>28</td>
</tr>
</tbody>
</table>
Analysis skills dealing with the pulse jet engine were given very low value in this assessment. Besides hobby applications this power-plant plays no role in contributing to our society's power needs. However, the pulse jet's operating principles are similar to those of numerous other powerplants; furthermore, the operating models are inexpensive and lend themselves well to activity based learning.

Data analysis shows some variability but central tendency figures sum up this competency's rating. Most variability was caused by one jurist (4%) who selected column nine, the highest rating. The next highest selections were column six with three votes (11%) and column five with one vote (4%). Column one, the lowest valued, had 10 votes (36%); columns two and three earned four (14%) each. The four lowest columns were selected by 82% of the jury.

Table 40

| Competency 39. Processing air through ram jets (Task 2.5) |
|-----------------|---------|---------|---------|---------|
| Mean            | 2.893   | STD Error | 0.306   | Median  | 2.500   |
| Mode            | 2.000   | STD Deviation | 1.618   | Variance | 2.618   |
| Kurtosis        | -0.799  | Skewness  | 0.592   | Range   | 5.000   |
| Minimum         | 1.000   | Maximum   | 6.000   | Sample  | 28      |

Skills dealing with analyzing ram jet performance were given a very low rating by the jury. The overall low rating seems unwarranted as the ram jet principle (called a by-pass ram jet) is used on every jet aircraft that can exceed the speed of mach 3. This engine is the simplest yet most efficient for high altitude, high speed flight.

On the negative side, the ram jet powerplant makes practically no power contribution to our society, is not available as a model, and is
poorly suited for class activities. Furthermore, the operating principle is perhaps the simplest of all powerplants and may not warrant a proportionate amount of class time.

Assessment results for the ram jet competency are made quickly upon notice that the lowest three columns were selected by 19 (68%) of the jurists. The next two columns, numbers three and four, received five (18%) and four (14%) votes. The mid-most column, number five, received two votes (7%). The highest rating received was column six, where three (11%) jurists placed this item.

In summary, this chapter described the jury selection procedure, the population parameters, and the assessment materials. Data analysis procedures were outlined and assessment results were displayed in two parts. A linear ranking of the 39 competencies was offered in Table 1: Tables 2 through 40 displayed the data analysis of each competency in order of the rank assigned as a result of the assessment.

The next chapter, the last, summarizes the procedures and results of the study. Conclusions and recommendations are made based on the findings of the study.
CHAPTER VI

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Contemporary media continue to remind us that power and energy alternatives are among the most critical issues of our time. Nearly every journal has reflected on some aspect of this problem. Kahn and Brown, writing in a World Future Society publication, elaborate on the near-term solutions to our energy dilemma (pp. 39-41):

(a) the conservation of energy . . .
(b) relatively small changes in life styles . . .
(c) the vigorous development of new sources of energy . . .

Solutions to energy problems require the support and usually the full cooperation of citizens. Public understanding and support can best be earned through education.

Efficient practices of processing energy (power technology) have been a school subject with the mission of preparing effective citizens in this regard. Contemporary curricula and competent teachers are needed to achieve the desired goal.

Typically, industrial arts teachers of power courses have been overly concerned with the automobile and its operation. Gasoline burning piston engines have been the focus of these courses to the exclusion of the entire energy-power field.
Within the preservice preparation of industrial arts power technology teachers seemed a logical place to provide direction. The competency-based approach provides an efficient method to employ and initiate change.

Purpose of the Study

The primary purpose of this study was to develop a list of technical competencies needed by teachers of industrial arts power technology courses. A secondary purpose of this study was to rank these competencies in order of importance. Efforts also were made to identify and validate the technical competencies needed by a prospective to perform to criterion when operating, testing, or demonstrating hardware in the field of power technology.

There were four specific objectives of this study, these were:

1. To develop a knowledge structure for the subject "power technology" in industrial arts education.
2. To identify the technical competencies needed by the pre-service teacher to perform in contemporary power technology laboratories.
3. To secure validation of competencies from a jury of experts.
4. To determine how professional educators rank order these clusters of competencies in order of importance.

Development of the Knowledge Structure

"Learning" and "understanding" often refer to a person's ability to perceive general relationships from particulars. Teaching-learning situations can be enhanced when the knowledge and practices taught/studied are codified or structured. Concepts (processes and actions) can be put into a logical sequence with meaningful parts/whole relationship. The
resulting hierarchy of behaviors becomes a taxonomy of that particular technology (i.e., power processing technology).

Criteria used by the IACP staff (Towers et al., 1966, p. 80) and principles outlined by Hauenstein (1966, pp. 50-54) were followed to develop a knowledge structure for the field of power technology. The following steps resulted in the taxonomy developed as part of this study:

1. Review research in power technology to seek a knowledge structure; not finding one, content was identified to be codified.
2. Examine curriculum development efforts to find a context for the study of power technology.
3. Devise a knowledge structure for power technology to fit within the framework of industrial technology.

Development of the Competencies

Identification was made of technical competencies of the type which could be detected during observation of the teacher candidate as he or she demonstrated representative power technology hardware. The systems model of input, process, output was used to guide the development of competencies.

Input: Using the power technology knowledge structure as an outline, technical information was accumulated. Typical sources were: course outlines, texts, laboratory manuals, operator's manuals and equipment performance specifications.

Process: Hauenstein's model (1973 p. 187) was used to codify knowledges and processes into tasks and enablers which were needed to function in a contemporary power technology laboratory.
Output: Tasks and enablers were specified as to what the candidate is expected to do, how well it is to be done, and under what conditions. The final product was 39 technical competencies for industrial arts power technology. These competencies were further analyzed for the knowledge and abilities needed to perform to criterion. A total of 58 supportive statements called "enablers" were identified.

Competencies and enablers can be found in Chapter IV and in Appendix D.

Assessment Process

A practical and effective method was needed to obtain opinions of a relatively large number of people on numerous items. The time necessary for jurists to complete the questionnaire was a major concern. Q-methodology uses forced-choice rating procedures to collect, examine, and statistically treat data. It was decided to use this technique to organize the assessment process of this study.

Participants in this research were a group of educators and administrators who had been randomly selected from a population of experts. Teacher educators and/or authors in the field of power technology and charter members of the National Educational Council on Energy and Power formed the population for this study. A 50% sample was taken from a population of 86, from this group of 43, 28 (65%) participated in the assessment.

Data were collected and analyzed in a nine column format which allowed value to be determined according to the stanine into which a particular competency was placed. The mean placement of each competency was calculated and used to locate each item on a linear scale.
Findings

The mean rating of each particular competency determined its place on a linear scale (see Table 1, p. 93). Several competencies were ranked much higher than others on the scale however, no single competency's position was significantly higher or lower than its neighboring competency, \( t (2) = 1.0, p < .05 \). Data analysis resulted in listing extensive enumeration with respect to each competency. These data were interpreted to make generalizations as to the value of certain competencies.

The five competencies listed under Module 1, "Processing Energy Directly," were ranked in the fourth and fifth stanines. This location places the direct energy conversion competencies in center scale in terms of value. The top item in the direct converter group is significantly below only the very highest ranking competency. Center scale location denotes considerable value. However, the current emphasis on forms of solar energy and other non-polluting converters suggests that a higher value for this module would be appropriate. Tasks 1.1 through 1.5 make up this module and include operation of solar cells, windmills, fuel cells, water wheels, and thermocouples (see p. 81 for listing).

Module 2, "Processing Energy with Reaction and Impulse Engines," contains seven competencies which, as a group, were ranked on the lowest end of the scale. Competencies in the operation of resonant jets and ram jets earned ratings which were significantly below the next module classification. Another very low ranked competency dealt with analysis of liquid fuel rockets. Competencies in nuclear energy and solid fuel rockets, while on the bottom of the scale, did rank within one stanine (in stanine four) of center scale. The competency describing
operation of jet turbines scored higher, within half a stanine from
the center. The highest ranked item within Module 2 described steam
turbine analysis. This competency was placed in stanine five, somewhat
above the mid-point on the scale. These seven competencies earned
ratings approximately in line with their exposure to the public; these
relative positions seem appropriate, although somewhat low overall. The
item which does appear to be rated low relates to nuclear energy analysis.
A possible explanation is the wording of the task statement itself:
The emergence of hardware appropriate for simulation of nuclear pro­
cessing will make activities and competencies in this technology much
more attractive.

Competencies in Module 3, "Processing Energy With Piston Engines,"
were rated above mid-scale; with one exception. The lowest item in
this group (steam piston engine analysis) earned a place in the center
of the fourth stanine. Ranking in the fifth stanine were competencies
with rotary piston and two-stroke diesel engines.

Rotary engine tasks may be over-rated: The Mazda automobile,
initially only rotary powered, now offers a conventional engine as
standard equipment. Mazda had earlier ceased to mention rotaries in
advertisements. General Motors has dropped their option on a licensing
agreement to manufacture rotary engines; losing millions on research
and development activities and previously paid royalties.

The two-stroke diesel tasks may have been somewhat under-rated as
this powerplant is dominate in highway freight transports, and becoming
increasingly popular in other industrial applications. The four-stroke
diesel competency were placed in the sixth stanine; a reflection of
the familiarity of this engine with the respondents. While this
engine is less efficient than the two-stroke version, smaller models of the four-stroke powerplant are available for classroom use. This diesel engine is now available in three automobile makes, including a volkswagen which topped the 1977 fuel economy ratings at 52 miles-per-gallon.

Ranked next to the diesel item was the competency relating to the two-stroke spark ignition engine. This engine is common on portable power equipment, but is losing popularity to "cleaner" operating powerplants. The two-stroke gasoline engine may not be able to meet the 1978 emission rates for hydrocarbons and sulfur and is presently in trouble with California standards. The four-stroke gasoline engine, while continuing to be dominant as an automobile powerplant, is the least efficient and one of the highest polluters of the internal combustion engine classification. The four-stroke engine competency was ranked significantly higher than all but the second and third placed items, and it was the only competency in the top stanine.

Technology describing the conversion of power from one form to another was generally placed above mid-scale. Module 4, Modifying Mechanical Input and Output, contained two competencies which were highly valued. The item dealing with mechanical advantage earned a number three overall rating. The other item, Changing Motion and Direction, was placed in the middle of the fifth stanine which earned it a number 10 (out of 28) rating. These two competencies describe lever and simple machine concepts and are popular in power courses.

Module 5, "Converting Fluid Power," contained three competencies which were valued in the assessment. "Pumping Liquids and Compressing Air" (hydraulics & Pneumatics) were placed in the sixth stanine, earning
scale positions of six and seven respectively. The competency describing rotating and actuating abilities was placed in the lower fifth stanine, and ranked number 17. Rotating fluid motors and operating cylinders is the primary purpose for pumping and compressing; these abilities should all have near the same value on a continuum.

Module 6, "Converting Electrical Power," lists three competencies which were placed in separate stanines. "Generating Electricity" earned a second place overall rank: an appropriate rating for this essential technology. Electric motor analysis was ranked 11th and placed in the center of the fifth stanine: somewhat low in relation to the item's importance in our lives. Secondary cell (battery) analysis was placed in the center of the fourth stanine. While seemingly low considering this relates to one of our few methods of storing energy, the competency demonstration is simple in comparison to many others in this study.

Technology of transmitting and controlling power earned places in the center (fourth and fifth) stanines. These competencies are generally less involved to demonstrate, and, they involve significant concepts to learn.

Module 7, "Rotating Shafts," contained five competencies of which gear operations ranked highest (12 of 39 total) and lubricating analysis skills scored lowest (ranked 35). Skills involving coupling shafts and providing bearing supports were ranked 28th on the continuum. Competencies specifying power transmission with belt and chain drives, and control with clutches and brakes were ranked 22nd and 23rd respectively.

Module 8, "Transmitting and Controlling Fluid Power" scored, as a unit, below the other fluid power module (Module 5). Skills called for
in the lower rated module were less stringent, perhaps causing a lower assessment. Fluid preparation characteristics were ranked 18th, power amplifying procedures ranked 25th, and fluid analysis and transmission techniques placed 30th.

Module 9, "Transmitting and Controlling Electrical Power," lists five competencies which were placed from the upper fifth stanine to the lower fourth stanine. Electrical circuit analysis was rated unusually high (9th of 39), while essential power supply operations (transforming, rectifying, and filtering) ranked very low (33rd). Amplification procedures also ranked proportionally low (31st). Skills in current and voltage regulation ranked 24th: electrical switching techniques ranked higher, at 21st. A possible explanation for the range of ranks and the two low valued electrical competencies is the tradition of teaching power and electrical technology as separate courses. Some jurists may not have been familiar with less common components of electrical technology.

In summary, the study resulted in these specific findings:

1. Competencies expressing skills close to the daily lives of average citizens (i.e., working with auto engines, electricity, and levers) were rated very high.

2. Competencies describing skills remote from the life of an average citizen (i.e., rocket and jet engine operation, and nuclear reactor processes) were valued very low.

3. A rationale for and structure of the body of knowledge known as power technology can be logically derived for industrial arts education.

4. Power pre-processing technology, power processing technology, and power post-processing technology can serve as major sub-sets of power manufacturing technology within industrial technology.
5. Processing energy and converting, transmitting, and controlling power represent the major functions within power technology and fulfill the requirements of a logical and functional structure.

6. The subject of power technology borrows heavily from the realm of "knowledge of practice." Noticeably missing and beyond the scope of this study are elements of man's other knowledge domains: "descriptive knowledge" (classifications), "prescriptive knowledge" (values), and "formal knowledge" (syntactics). Sound curricula would likely contain elements from all four of these domains.

Summarizing, a logical structure has been developed to support curriculum hardware and software innovation in power technology. Also, teacher competencies have been specified and ordered to provide for program development and assessment in teacher education and/or administrative situations.

Conclusions

The following conclusions were drawn from the findings of this study:

1. The literature reviewed in this study overwhelmingly declares that people learn better when they can relate particulars to generalities or "parts to whole." Course syllabi organized in such a manner are called structures or organized bodies of knowledge.

2. The concept of power technology as a curriculum base must be broadened and course syllabi must be developed from a comprehensive and logically derived rationale and structure.

3. The practices involved in processing energy (to change it to power); converting, transmitting, and controlling power; successfully define the scope of power technology.

4. Studies in power processing technology would logically follow the study of industrial technology. Management and personnel practices are essentially the same throughout industry and need not be repetitiously included in power technology studies.

5. Technical competencies of prospective power technology teachers can be developed and ordered.
6. Power technology competencies which deal with common life situations of average citizens are most valued by experts in the field of power technology education.

7. Power technology competencies which deal with situations more remote from average citizens are least valued by experts in the field of power technology education.

8. With the literature calling for curricula to promote more citizenship competencies in the valueing realm, industrial arts power course activities should place less emphasis on psychomotor functions and more on affective abilities.

**Recommendations**

The following recommendations are made as a result of the experience in performing this study and in consideration of the assessment results.

1. Teacher educators should consider the relative importance of the 39 competencies in the preparation of power technology teachers.

2. Teacher education program evaluation in the area of power technology should consider the relative value of the 39 competencies.

3. A feasibility study should be made to develop a competency test based on the competencies and assessment results of this study.

4. A similar study should be made resulting in another assessment of the 39 competencies but using jurists who themselves possess most of the competencies.

5. Another assessment of the 39 competencies should be made after the current accelerated development of learning hardware results in making enriched activities available in power technology classrooms.

6. Another competency assessment should be made when efficiency in energy usage becomes more popular and/or the automobile engine, as we have known it, ceases to play a major role in transportation.

7. A similar competency assessment should be made with a format to rate beginning competencies for initial entry and advanced competencies (i.e., for higher certification, masters degree, or jr. and sr. high school).
8. Another approach to structuring power technology and deriving competencies should be studied or the structure and power practices presented here re-examined. Additional research may result in a reorganized or redefined model for program and product assessment.

9. Teachers, teacher educators, and supervisors should join together through their various professional associations to aggressively push for an industrial arts education which is based on technology rather than the narrow trades, crafts, or occupation approach. Pressure should be applied to colleagues, programs, and/or institutions which continue to follow an outmoded tradition.

In summary, this study has offered a rational for and a structure of the body of knowledge known as power technology. Furthermore, a list of beginning teacher competencies was developed and the component items were listed in relative order of importance.

The writer acknowledges the changing nature of a dynamic field such as power and the changeable factors in assessing competence. This study will have served a purpose if others refine or extend the work begun here.
APPENDIX A

Specimen of Contact Letter to Prospective Assessment Jurists, Specimen of Reply Post Card, and Names of Jury Members
Dear

As a professional in industrial education I am sure you are concerned with the state of many of our power mechanics programs. The reference is to programs which fail to address contemporary technology in the field of energy and power.

As part of my doctoral dissertation directed by Professor Donald G. Lux at The Ohio State University, I have developed a list of technical lab competencies with accompanying knowledge enablers. These are minimum competencies which I believe a pre-service industrial arts teacher should have if he is to adequately teach a course in power.

It has been suggested by my advisory committee that a jury of experts be queried to determine the validity of this list of 40 competencies. A random number table was used to select 35 experts from a field of slightly over 100. The purpose of this letter is to inform you of this study and to ask you to consider taking part in the assessment. The Q sort, card sorting technique is being used and pilot trials show that it can be completed in about 20 minutes.

I would be honored to have you serve as a member of the jury to evaluate these curriculum materials for power technology. Please make your decision known to me on the enclosed card.

Thank you for any consideration which you give to this request.

Sincerely,

David L. DePue
Assistant Professor

Enclosure

DLD:rt
Please check one or more of these statements to indicate your intent.

_____ I will participate in the study.

_____ I do not wish to participate in the study.

_____ I would like a complete list of the competencies and enablers.

_____ I would like a summary of the results of this study.

Name: ___________________________
JURY MEMBERS

Dr. Willard A. Allen, Professor
Dept. of Industrial Arts & Technology
Division of Professional Studies
State University College at Oswego
Oswego, New York 13126

Dr. Ralph C. Bohn, Professor
Industrial Studies Department
School of Applied Sciences & Arts
San Jose State University
San Jose California 95192

Professor Norman D. Bourque
Industrial Arts Education Dept.
Division of Technology
Central Connecticut State College
New Britain, Connecticut 06050

Mr. Gene Bower, Supervisor
Industrial Arts Education
Detroit Public School Offices
Detroit, Michigan 48232

Dr. Robert C. Cooksey
Department of Industrial Education
Applied Science Department
Eastern Michigan University
Ypsilanti, Michigan 48197

Dr. Richard F. Doutt, Professor
Department of Industrial Arts Ed.
Osburn Hall
Millersville, State College
Millersville, Pennsylvania 17551

Dr. Joseph Duffy, Director
Division of Technology
Central Connecticut State College
New Britain, Connecticut 06050

Mr. Raymond D. Ginn, Jr.
Coordinator, Industrial Arts Ed.
Georgia Dept. of Education
313 State Office Bldg.
Atlanta, Georgia 30334

Mr. James E. Good, Supervisor
Vocational & Technical Ed.
Greece Central School District
Rochester, New York 12616

Dr. Gary E. Grannis
Department of Industrial Arts & Technology
School of Professional Studies
California State University
Fresno, California 93740

Dr. William D. Guentzler
Dept. of Industrial Studies
College of Professional Studies
San Diego State University
San Diego, California 92115

Professor Roy A. Hartman
Dept. of Industrial Arts & Technology
School of Professional Studies
California State University
Fresno, California 93740

Mr. Thomas A. Hughes, Jr.
State Supervisor
Industrial Arts Education
Virginia State Dept. of Ed.
Richmond, Virginia 23216

Professor Dennis Karwatka
Dept. of Industrial Ed. & Tech.
School of Applied Sciences & Technology
Morehead State University
Morehead, Kentucky 40351
Dr. George C. Ku  
Industrial Arts Education Dept.  
Division of Technology  
Central Connecticut State College  
New Britain, Connecticut 06050

Professor Edward O. Morical  
School of Industry & Technology  
University of Wisconsin-Stout  
Menomonie, Wisconsin 54751

Mr. John O. Murphy, Jr.  
State Supervisor for Industrial Arts  
State Department of Education  
Baton Rouge, Louisiana 70804

Dr. Lloyd D. Neher  
Department of Industrial Ed.  
School of Technology  
Purdue University  
West Lafayette, Indiana 47907

Dr. Willis P. Norton  
Industrial Arts & Technology  
College of Natural Sciences  
University of Northern Iowa  
Cedar Falls, Iowa 50613

Professor Anthony J. Palumbo  
Department of Industrial Education & Technology  
Bowling Green State University  
Bowling Green, Ohio 43403

Mr. Paul A. Reynolds  
Industrial Arts Department  
Greece Arcadia High School  
Rochester, New York 12616

Dr. Joe A. Rinck, Professor  
School of Industry & Technology  
University of Wisconsin-Stout  
Menomonie, Wisconsin 54751

Professor George Samson  
Department of Industrial Education & Technology  
Division of Professional Studies  
Glassboro State College  
Glassboro, New Jersey 08028

Mr. Anthony E. Schwallier  
Dept. of Industrial Arts Ed.  
School of Industrial Arts & Technology  
Eastern Illinois University  
Charleston, Illinois 61920

Dr. Ralph V. Steeb  
Industrial Arts Consultant  
Florida State Department of Ed.  
Tallahassee, Florida 32304

Dr. James A. Sullivan  
Chairman, Vocational Education Studies  
School of Engineering and Tech.  
Southern Illinois University  
Carbondale, Illinois 62901

Mr. Edward B. Tangman, Jr.  
Supervising Director  
Trade & Industrial Education  
Bruce Administration Bldg.  
770 Kenyon St., N.W.  
Washington, D.C. 20010

Dr. Terence Trudeau, Professor  
Industrial Arts Education  
1300 Elmwood Ave.  
State University College at Buffalo  
Buffalo, New York 14222

Professor Edgar L. Webb  
Chairman, Industrial Arts Dept.  
College of Education  
Wichita State University  
Wichita, Kansas 67208
Mr. Paul M. Wighaman
Advisor, Industrial Arts Programs
Pennsylvania Dept. of Education
P.O. Box 911
Harrisburg, Pennsylvania 17126
APPENDIX B

Cover Letter Accompanying Assessment Instrument
Dear

In appreciation of your willingness to serve on a jury of experts to evaluate power technology competencies, all printed matter has been made as concise as possible.

This competency list for power technology is designed to serve as a source from which a teacher educator (or supervisor) can select criteria to measure the performance of a preservice teacher. As a result, this work may provide some direction for power-energy courses.

Technical competencies are limited to lab activities which a technologist teacher should be able to perform. Professional competencies, concerned with classroom management, and academic knowledge competencies, dealing with subject matter, are not the focus of this study.

The behavioral oriented curriculum which you are evaluating, represents the results of an analysis of objectives of power and energy courses and is based on Dean Hauenstein's model (M/S/T Jan. '73). This curriculum is broken into three areas, seven modules (units), and 39 tasks. Each task is supported by technical knowledges which, hopefully, would enable the task to be performed. It is the relative importance of these tasks that this study is concerned with.

The Q-sort technique was chosen to enable your assessment duties to be expedited. An instruction guide, 39 task sheets, and a return envelope are enclosed. All that you are asked to return in the pre-addressed envelope is the completed answer-instruction sheet. The task sheets may be retained by you.

Thank you for your cooperation.

Sincerely,

David L. DePue
Assistant Professor
Industrial Arts

DLD:rt
APPENDIX C

Assessment Directions and Response Form
Q-SORT INSTRUCTION GUIDE

I. The goal of this activity is to end up with 9 stacks (A-I) of task pages in order from most to least important. The easiest way to start is to first make 3 temporary stacks as illustrated below.

Begin by looking through the 39 tasks and sorting them into the 3 temporary stacks according to your opinion as to "importance". There are no right or wrong answers, however your first decision is usually the best.

![Stacks](image)

Most Important  Undecided  Least Important

II. From the most important stack, select the three most important and place them in a pile on your extreme left. Sort out the next three most important tasks and place these just to the right of your first stack. Next, select the four most important, the six most important, the seven, and continue with stacks of six, four, three, and end with the three last tasks which seem least important.

<table>
<thead>
<tr>
<th>Levels of Importance</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of pages in stack</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

III. Take the task number in the upper left hand corner of each sheet and record it on the answer sheet in its relative position.

![Answer Sheet](image)

Please place this sheet in the envelope and mail
APPENDIX D

Competencies Statement Sheets
AREA I  PROCESSING ENERGY

Module 1.  PROCESSING ENERGY DIRECTLY

Task 1.1  Converting the Motion of Wind to Electricity

Given a prefashioned propellor, a small generator, a compressed air source, a millivoltmeter and a milliammeter, the candidate will be able to change the motion of air to electricity. This activity shall be accomplished within five minutes with calculations accurate to the nearest milliwatt.

1.1 Enablers: A teacher candidate should possess the ability to:

* 1.1.1 Ability to connect ammeters and voltmeters in a circuit.

* 1.1.2 Ability to manipulate simple equations involving division, multiplication, factoring, and moving decimal places.

Suggested Equipment:

Miscellaneous items available locally ie: Model airplane propellor, small permanent magnet D.C. motor, and hose with nozzel for shop air.

* Duplicate entry
AREA I PROCESSING ENERGY

Module 1. PROCESSING ENERGY DIRECTLY

Task 1.2 Converting the Motion of Water

Given the weight and head (depth) of a water source, and provided with illustrations of two or more different types of water wheels the candidate will be able to: calculate the potential and kinetic energy available (ignoring friction), calculate the maximum rpm and force each power plant has the potential to produce, calculate the potential power in watts produced by a 90% efficient generator attached to one of the above shafts. In addition identify three major design factors in developing maximum power from a water turbine. This task is to be completed within ten minutes with conclusions in agreement with published data.

1.2 Enablers: A teacher candidate should possess the ability to:

* 1.2.1 Ability to manipulate simple equations involving division, multiplication, factoring, and moving decimal places.

* 1.2.2 Ability to visualize concepts related to the conservation of energy theorem and Newtons' laws of motion.

Suggested Equipment:


* Duplicate entry
AREA I PROCESSING ENERGY

Module 1. PROCESSING ENERGY DIRECTLY

Task 1.3 Converting Sun (light energy) to Electricity. (Solar Cell)

Given a solar cell, a light source, a millivoltmeter, and ammeter, the candidate will be able to convert light energy directly to electricity and calculate the amount of watts obtained. This shall be accomplished within three minutes, and be accurate to the nearest milliwatt.

1.3 Enablers: A teacher candidate should possess the ability to:

* 1.3.1 Ability to connect ammeters and voltmeters in a circuit.

* 1.3.2 Ability to manipulate simple equations involving division, multiplication, factoring and moving decimal places.

Suggested Equipment:

3. Lamp or "Trouble Light" with 150 watt bulb.

* Duplicate entry
AREA I PROCESSING ENERGY

Module 1. PROCESSING ENERGY DIRECTLY

Task 1.4 Converting Chemical Energy (Fuel Cell)

Given a fuel cell test unit, the candidate will be able to mix the chemicals, operate the test unit, and measure the power produced. A measurable output must be produced within 30 minutes, with calculations accurate to the nearest tenth of a watt, and with no more than moderate boiling of the fuel and/or oxidant. Use of technical manual permitted.

1.4 Enablers: A teacher candidate should possess the ability to:

* 1.4.1 Ability to follow procedures outlined in operators manual.

* 1.4.2 Ability to interpret symbolic representation of common elements and compounds relative to the fuel cell unit being operated.

* 1.4.3 Ability to interpret symbols and make measurements in the metric system.

* 1.4.4 Ability to read meter values, interpolate to nearest whole number, and convert these to formula values when given procedures in symbol form.

Suggested Equipment:

* 3. Balance scale 50 grain, 3 gram. Brodhead-Garrett #300312

* Duplicate entry
AREA I PROCESSING ENERGY

Module 1. PROCESSING ENERGY DIRECTLY

Task 1.5 Converting Heat to Electricity (thermocouple)

Given a twenty centimeter length of copper and of constantan wire (or a thermocouple) a source of flame, a millivoltmeter and a milliammeter, the candidate will be able to convert heat energy directly to electricity and calculate the amount of watts obtained. This shall be accomplished within three minutes, and be accurate to the nearest milliwatt.

1.5 Enablers: A teacher candidate should possess the ability to:

* 1.5.1 Ability to connect ammeters and voltmeters in a circuit.
* 1.5.2 Ability to manipulate simple equations involving division, multiplication, factoring, and moving decimal places.

Suggested Equipment:

1. Thermo-Electric Generator Test Unit PL-3 (or suitable equivalent). Brodhead-Garrett #184670.

* Duplicate entry
AREA I PROCESSING ENERGY

Module 2. PROCESSING ENERGY WITH REACTION AND IMPULSE ENGINES

Task 2.1 Processing Energy in Solid Fuel Rockets

Given a Solid Fuel Rocket Test Unive and a procedure outline with formulas, the candidate will be able to operate the unit to mechanically plot a thrust curve on a graph. Using the graph and subsequent data compute each of the following, labeling them in their respective values; average thrust, propellant weight flow rate, specific propellant consumption, total impulse, specific impulse and exhaust velocity. This activity shall be completed within 20 minutes with calculations accurate to the nearest significant digit. Use of technical manual permitted.

2.1 Enablers: A teacher candidate should possess the ability to:

2.1.1 Ability to follow procedures to safely fire a rocket engine and result the plotting of a useable static thrust curve.

2.1.2 Ability to weigh rocket to the nearest grain and compute mass ratio after firing.

2.1.3 Ability to interpret the maximum thrust and the time elapse data, and count the average number of squares on a rocket test graph.

* 2.1.4 Ability to manipulate simple equations involving division, multiplication, factoring, and moving decimal places.

Suggested Equipment:

3. Standard model rocket engine type B8-0 with igniter wire and 12 volt battery.
* 5. Balance Scale 50 grain, 3 gram. Brodhead-Garrett #300312 (or equivalent).

* Duplicate entry
AREA I PROCESSING ENERGY

Module 2. PROCESSING ENERGY WITH REACTION AND IMPULSE ENGINES

Task 2.2 Processing Energy in Liquid Fuel Rockets

Given a Liquid Fuel Rocket Test Unit and a procedure outline with formulas, the candidate will be able to operate the unit safely, keeping the combustion temperature within the specified range and adjusting the pressure to maintain fuel and oxidizer flowmeters on the given setting. Using the data recorded on the outline during test firing calculate the propellant weight flow rate, specific propellant consumption, total impulse, specific impulse, and exhaust velocity. This activity shall be completed within 20 minutes with calculations accurate to the nearest significant digit. Use of technical manual permitted.

2.2 Enablers: A teacher candidate should possess the ability to:

* 2.2.1 Ability to follow procedures to safely and properly make a test firing resulting in the collection of useable data recorded on a procedure sheet.

* 2.2.2 Ability to manipulate simple equations involving division, multiplication, factoring, and moving decimal places.

* 2.2.3 Ability to read meter values, interpolate to nearest whole number, and convert these to formula values when given these in symbol form.

Suggested Equipment:

* 3. Hearing Protectors. Brodhead-Garrett #420346 (or equivalent).

* Duplicate entry
Module 2. PROCESSING ENERGY WITH REACTION AND IMPULSE ENGINES

Task 2.3 Processing Nuclear Energy

Hypothetical Fission Problem: Given an atom of U-235 which has been split apart by an accelerated neutron of radium, the candidate will be able to account for all mass and indicate a method of heat control.

Hypothetical Fusion Problem: Given two deuterium atoms which have been heat-fused together resulting in a change of their structure, the candidate will be able to account for all mass and project a control technique.

This task is to be completed within five minutes with conclusions in agreement with published information. Use of technical publication permitted.

2.3 Enablers: A teacher candidate should possess the ability to:

2.3.1 Apply Einstein's formula $E=mc^2$.

2.3.2 Interpret a current Periodic Table of the Elements.

2.3.3 Follow major reactor operations through a complete cycle.

Suggested Equipment:

AREA I PROCESSING ENERGY

Module 2. PROCESSING ENERGY WITH REACTION AND IMPULSE ENGINES

Task 2.4 Processing Air Through Jet Turbines

Given a cutaway model of a turbo-Jet engine, the candidate will be able to trace the working fluid through the cycles of intake, compression, power, and exhaust. This procedure shall be completed within three minutes, without error.

2.4 Enablers: A teacher candidate should possess the ability to:

2.4.1 Express Newton's third law of action - reaction.

2.4.2 Recognize the turbine stages responsible for compression, combustion, turbine drive, and exhaust.

2.4.3 Identify the major turbine components; centrifugal-compressors, axial-flow compressors, stators, vanes, burner "cans", exhaust-nozzles, and turbine-nozzles, rotors, and stators.

2.4.4 Express the relationship between input energy, output energy, and the resulting emission rates. This information is to be used to project powerplant efficiency and desirability for an intended use.

Suggested Equipment:

AREA I PROCESSING ENERGY

Module 2. PROCESSING ENERGY WITH REACTION AND IMPULSE ENGINES

Task 2.5 Processing Air Through Ram Jets

Given a diagram of a ramjet engine, the candidate will be able to illustrate the four cycles of intake, compression, power and exhaust. In addition, distinguish the ramjets advantages and disadvantages in contrast to the turbojet engine. This task is to be completed within three minutes, with responses in agreement with published information.

2.5 Enablers: A teacher candidate should possess the ability to:

* 2.5.1 Ability to express Newtons' third law of motion.

2.5.2 Ability to recognize the major ramjet components: ignitor, flame holder, fuel nozzle (injector), and convergent-diffuser section.

Suggested Equipment:

2. Teachers Manual # BK-14TM. Estes Industries; Penrose, Colorado 81240.

* Duplicate entry
AREA I PROCESSING ENERGY

Module 2. PROCESSING ENERGY WITH REACTION AND IMPULSE ENGINES

Task 2.6 Processing Air Through Resonant Jets

Given a Pulse-Jet Test Unit and a procedure outline with formulas, the candidate will be able to run through a test, read the thrust gage and airmeter, interpret the weight of fuel consumed, and record the time of test. Using the data recorded, compute the mass flow rate in slugs, the terminal exhaust velocity in feet per second, and approximate thrust horsepower. This activity shall be completed within 20 minutes with calculations accurate to the nearest significant digit. Use of technical manual permitted.

2.6 Enablers: A teacher candidate should possess the ability to:

* 2.6.1 Ability to follow procedures outlined in operators manual to safely and properly run a test resulting in the collection of useable data recorded on a procedure sheet.

* 2.6.2 Ability to read meter values, interpolate to nearest whole number, and convert these to formula values when given procedures in symbol form.

* 2.6.3 Ability to manipulate simple equations involving division, multiplication, factoring, and moving decimal places.

Suggested Equipment:

* 3. Hearing Protectors. Brodhead-Garrett #420346 (or equivalent).

* Duplicate entry
AREA I PROCESSING ENERGY

Module 2. PROCESSING ENERGY WITH REACTION AND IMPULSE ENGINES

Task 2.7 Processing Steam Through Turbines

Given a steam turbine test unit, the candidate will be able to initiate power plant operation, then manipulate turbine and dynamometer controls to vary the load. RPM and torque readings are to be taken at six or more equally spaced speeds under full throttle conditions. A graph will be filled in with data obtained expressing horsepower and torque values at the rpm intervals used. This shall be accomplished within ten minutes with torque values accurate to the nearest ounce-inch and brake horsepower correct to the nearest significant digit. Use of technical manual permitted.

2.7 Enablers: A teacher candidate should possess the ability to:

* 2.7.1 Ability to follow procedures outlined in operators manual to safely and properly run a test resulting in the collection of useable data recorded on a procedure sheet.

* 2.7.2 Ability to manipulate simple equations involving division, multiplication, factoring, and moving decimal places.

* 2.7.3 Ability to interpret vibrator tachometer and torque meter readings.

Suggested Equipment:

1. Power Lab Steam Turbine Test Unit PL-S1. Brodhead-Garrett #184691.
2. Technical Manual for PL-S1 (included with unit).

* Duplicate entry
AREA I PROCESSING ENERGY

Module 3. PROCESSING ENERGY WITH PISTON ENGINES

Task 3.2 Processing Air Through Rotary-Piston Engines (Wankle)

Given a typical small engine of this type which is properly prepared and positioned on a dynamometer and provided with a testing procedure sheet, the candidate will be able to do the following: (1) initiate engine operation and vary engine load while taking rpm and force readings over four or more equally spaced engine speeds with a full-throttle setting, (2) record inputs of fuel-flow and air-flow rate at the rpm settings selected, (3) record the emission rates for HC, NO₂, SO₂, and CO, (4) after testing; compute the engine volumetric efficiency at the lowest and highest rpm for which data was taken, (5) calculate the fuel and air consumed in equivalent joules per hour, the torque, power and output joules per hour as well as the resulting thermal efficiency, (6) fill in the graph expressing the power and torque for the rpm ranges observed, (7) be prepared to contrast this powerplant with others in terms of cost, efficiency, emissions, and general performance related to its' intended use. This activity shall be accomplished within 90 minutes, with tabulations accurate to the first significant digit. Use of technical manual permitted.

3.2 Enablers: A teacher candidate should possess the ability to:

* 3.2.1 Follow procedures outlined in an operator's manual to:
(1) safely conduct a test; (2) collect useable data and;
(3) systematically record data on a procedure sheet.

* 3.2.2 Manipulate simple equations involving division, multiplication, factoring, and moving decimal places.

* 3.2.3 Calibrate an air flow meter including: selecting the proper air-flow nozzle, leveling the manometer, and using the air-flow meter within stated operating limitations.

* 3.2.4 Make air-flow corrections for atmospheric conditions. This activity includes reading a wet and dry bulb thermometer, reading a barometer, and interpreting a correction factor on the chart provided.

* 3.2.5 Interpret a combustion efficiency meter and related charts.
Task 3.2 (continued)

* 3.2.6 Disassemble and reassemble a typical small engine of this type, including major sub-assemblies, to outline a synthesis of the following systems: fuel, lubrication, cooling, starting, ignition (if applicable), and intake-exhaust.

* 3.2.7 Use basic hand tools and measuring instruments (ie: Venier-calipers, feeler-gages, and torque-wrenches) as well as any special tool recommended by a particular engine manufacturer.

Suggested Equipment:

* 1. Go-Power Engine Analysis System DY-7DE (or equivalent).
* 2. Go-Power Model M-1100 Air-Fuel System (or equivalent).
* 4. Small engine, Brodhead-Garrett #186610 (or suitable equivalent).

* Duplicate entry
Module 3. PROCESSING ENERGY WITH PISTON ENGINES

Task 3.1 Processing Steam Through Piston Engines

Given a steam engine test unit, the candidate will be able to initiate engine operation, then manipulate engine and dynamometer controls to vary engine load. RPM and torque readings are to be taken at four or more equally spaced engine speeds under full throttle conditions. A graph will be filled in with data obtained expressing horsepower and torque values at the four rpm intervals. This shall be accomplished within ten minutes with torque values accurate to the nearest ounce-inch and brake horsepower correct to the nearest significant digit. Use of technical manual permitted.

3.1 Enablers: A teacher candidate should possess the ability to:

* 3.1.1 Ability to follow procedures outlined in operators manual to safely and properly run a test resulting in the collection of useable data recorded on a procedure sheet.

* 3.1.2 Ability to manipulate simple equations involving division, multiplication, factoring, and moving decimal places.

* 3.1.3 Ability to interpret vibrator tachometer and torque meter readings.

Suggested Equipment:

1. Power Lab Steam Engine Test Unit PL-S2. Brodhead-Garrett #184710
2. Technical Manual for PL-S2 (included with unit)
* 3. Steam Boiler Model PL-S3. Brodhead-Garrett #18473 (or equivalent)

* Duplicate entry
AREA I PROCESSING ENERGY

Module 3. PROCESSING ENERGY WITH PISTON ENGINES

Task 3.3 Processing Air Through Two-Stroke-Spark-Ignition Engines

Given a typical small engine of this type which is properly prepared and positioned on a dynamometer and provided with a testing procedure sheet, the candidate will be able to do the following: (1) initiate engine operation and vary engine load while taking rpm and force readings over four or more equally spaced engine speeds with a full-throttle setting, (2) record inputs of fuel-flow and air-flow rate at the rpm settings selected, (3) record the emission rates for HC, NO₂, SO₂, and CO, (4) after testing; compute the engine volumetric efficiency at the lowest and highest rpm for which data was taken, (5) calculate the fuel and air consumed in equivalent joules per hour, the torque, power, and output joules per hour as well as the resulting thermal efficiency, (6) fill in the graph expressing the power and torque for the rpm ranges observed, (7) be prepared to contrast this powerplant with others in terms of cost, efficiency, emissions, and general performance related to its' intended use. This activity shall be accomplished within 90 minutes, with tabulations accurate to the first significant digit. Use of technical manual permitted.

3.3 Enablers: A teacher candidate should possess the ability to:

* 3.3.1 Follow procedures outlined in an operator's manual to: (1) safely conduct a test; (2) collect useable data and; (3) systematically record data on a procedure sheet.

* 3.3.2 Manipulate simple equations involving division, multiplication, factoring, and moving decimal places.

* 3.3.3 Calibrate an air flow meter including: selecting the proper air-flow nozzle, leveling the manometer, and using the air-flow meter within stated operating limitations.

* 3.3.4 Make air-flow corrections for atmospheric conditions. This activity includes reading a wet and dry bulb thermometer, reading a barometer, and interpreting a correction factor on the chart provided.

* 3.3.5 Interpret a combustion efficiency meter and related charts.
Task 3.3 (continued)

* 3.3.6 Disassemble and reassemble a typical small engine of this type, including major sub-assemblies, to outline a synthesis of the following systems: fuel, lubrication, cooling, starting, ignition (if applicable), and intake-exhaust.

* 3.3.7 Use basic hand tools and measuring instruments (ie: Vernier-calipers, feeler gages, and torque wrenches) as well as any special tool recommended by a particular engine manufacturer.

Suggested Equipment:

* 1. Go-Power Engine Analysis System DY-7DE (or equivalent).
* 2. Go-Power Model M-1100 Air-Fuel System (or equivalent).
  4. Small engine, Brodhead-Garrett 187159 (or suitable equivalent).

* Duplicate entry
AREA I  PROCESSING ENERGY

Module 3. PROCESSING ENERGY WITH PISTON ENGINES

Task 3.4 Processing Air Through Four-Stroke-Spark-Ignition Engines

Given a typical small engine of this type which is properly prepared and positioned on a dynamometer and provided with a testing procedure sheet, the candidate will be able to do the following: (1) initiate engine operation and vary engine load while taking rpm and force readings over four or more equally spaced engine speeds with a full-throttle setting, (2) record inputs of fuel-flow and air-flow rate at the rpm settings selected, (3) record the emission rates for HC, NO₂, SO₂, and CO (4) after testing; compute the engine volumetric efficiency at the lowest and highest rpm for which data was taken, (5) calculate the fuel and air consumed in equivalent joules per hour, the torque, power and output joules per hour as well as the resulting thermal efficiency, (6) fill in the graph expressing the power and torque for the rpm ranges observed, (7) be prepared to contrast this powerplant with others in terms of cost, efficiency, emissions, and general performance related to its intended use. This activity shall be accomplished within 90 minutes, with tabulations accurate to the first significant digit. Use of technical manual permitted.

3.4 Enablers: A teacher candidate should possess the ability to:

* 3.4.1 Follow procedures outlined in an operator's manual to:
   (1) safely conduct a test; (2) collect useable data and;
   (3) systematically record data on a procedure sheet.

* 3.4.2 Manipulate simple equations involving division, multiplication, factoring, and moving decimal places.

* 3.4.3 Calibrate an air flow meter including: selecting the proper air-flow nozzle, leveling the manometer, and using the air-flow meter within stated operating limitations.

* 3.4.4 Make air-flow corrections for atmospheric conditions. This activity includes reading a wet and dry bulb thermometer, reading a barometer, and interpreting a correction factor on the chart provided.

* 3.4.5 Interpret a combustion meter and related charts.
Task 3.4 (continued)

* 3.4.6 Disassemble and reassemble a typical small engine of this type, including major sub-assemblies, to outline a synthesis of the following systems: fuel, lubrication, cooling, starting, ignition (if applicable), and intake-exhaust.

* 3.4.7 Use basic hand tools and measuring instruments (ie: Venier-calipers, feeler-gages, and torque-wrenches) as well as any special tool recommended by a particular engine manufacturer.

Suggested Equipment:

* 1. Go-Power Engine Analysis System DY-7DE (or equivalent).
* 2. Go-Power Model M-1100 Air-Fuel System (or equivalent).
* 4. Small Engine, Brodhead-Garrett 187115 (or suitable equivalent).

* Duplicate entry
AREA I  PROCESSING ENERGY

Module 3.  PROCESSING ENERGY WITH PISTON ENGINES

Task 3.5  Processing Air Through Four-Stroke-Compression-Ignition Engines

Given a typical small engine of this type which is properly prepared and positioned on a dynamometer and provided with a testing procedure sheet, the candidate will be able to do the following: (1) initiate engine operation and vary engine load while taking rpm and force readings over four or more equally spaced engine speeds with a full-throttle setting, (2) record inputs of fuel-flow and air-flow rate at the rpm settings selected, (3) record the emission rates for HC, NO₂, SO₂, and CO, (4) after testing; compute the engine volumetric efficiency at the lowest and highest rpm for which data was taken, (5) calculate the fuel and air consumed in equivalent joules per hour, the torque, power and output joules per hour as well as the resulting thermal efficiency, (6) fill in the graph expressing the power and torque for the rpm ranges observed, (7) be prepared to contrast this powerplant with others in terms of cost, efficiency, emissions, and general performance related to its' intended use. This activity shall be accomplished within 90 minutes, with tabulations accurate to the first significant digit. Use of technical manual permitted.

3.5 Enablers: A teacher candidate should possess the ability to:

* 3.5.1 Follow procedures outlined in an operator's manual to:
(1) safely conduct a test; (2) collect useable data and;
(3) systematically record data on a procedure sheet.

* 3.5.2 Manipulate simple equations involving division, multiplication, factoring, and moving decimal places.

* 3.5.3 Calibrate an air flow meter including: selecting the proper air-flow nozzle, leveling the manometer, and using the air-flow meter within stated operating limitations.

* 3.5.4 Make air-flow corrections for atmospheric conditions. This activity includes reading a wet and dry bulb thermometer, reading a barometer, and interpreting a correction factor on the chart provided.

* 3.5.5 Interpret a combustion meter and related charts.
Task 3.5 (continued)

* 3.5.6 Disassemble and reassemble a typical small engine of this type, including major sub-assemblies, to outline a synthesis of the following systems: fuel, lubrication, cooling, starting, ignition (if applicable), and intake-exhaust.

* 3.5.7 Use basic hand tools and measuring instruments (ie: Venier-calipers, feeler-gages, and torque-wrenches) as well as any special tool recommended by a particular engine manufacturer.

Suggested Equipment:

* 1. Go-Power Engine Analysis System DY-7DE (or equivalent).
* 2. Go-Power Model M-1100 Air-Fuel System (or equivalent).
* 4. Small engine, Brodhead-Garrett #186485 (or suitable equivalent).
AREA I PROCESSING ENERGY

Module 3. PROCESSING ENERGY WITH PISTON ENGINES

Task 3.6 Processing Air Through Two-Stroke-Compression-Ignition Engines

Given a manufacturers' information sheet of necessary performance data on a typical two-stroke-diesel-engine which is supercharged, the candidate will be able to do the following: (1) compute volumetric efficiency for a given rpm, (2) convert input and output energy to joules per hour, (3) calculate thermal efficiency, and (4) contrast the performance factors of power, torque, volumetric efficiency, thermal efficiency, cost, and emissions with a powerplant of similar capability. This task is to be completed within 30 minutes with calculations accurate to the nearest whole number. Conclusions shall be in agreement with current published information.

3.6 Enablers: A teacher candidate should possess the ability to:

* 3.6.1 Manipulate simple equations involving division, multiplication, factoring and moving decimal places.

* 3.6.2 Interpret typical performance data on piston engines.

Suggested Equipment:

1. Engine Performance Reports, Detroit Diesel Engine Division, General Motors Corp., Detroit, Michigan 48202.
2. Engine Performance Bulletins, Cummins Engine Co., Columbus, Ind.
Module 4. MODIFYING MECHANICAL INPUT AND OUTPUT

Task 4.1 Gaining Mechanical Advantage

Given a lever and fulcrum, a wheel and axle (demonstration model), a set of pulleys, a small inclined plane, a wedge and a large, threaded nut and bolt, the candidate will demonstrate how each can be used to increase force, speed and distance. The set of pulleys is to be used in conjunction with a measuring tape, spring scale, and assorted weights to experimentally demonstrate the gaining of mechanical advantage with pulleys. Measurements and calculations to be made are: Effort-distance, resistance-distance, resistance-force, effort-force, mechanical-advantage and force lost to friction. This task shall be completed within ten minutes with answers accurate to the nearest whole number.

4.1 Enablers: A teacher candidate should possess the ability to:

4.1.1 Arrange components and operate examples of the six simple machines.

4.1.2 Compute work from force and distance measurements to determine simple ratios.

Suggested Equipment:

* Mechanical Control Experimenter with manual by Bohn & MacDonald; McKnight Co. #7267 (or suitable equivalent).

* Duplicate entry
AREA II CONVERTING POWER

Module 4. MODIFYING MECHANICAL INPUT AND OUTPUT

Task 4.2 Changing Motion and Direction

Given a selected assortment of gears, attachments and hardware the candidate will be able to demonstrate three methods of changing motion from one of reciprocating, rotary, and linear to another, and demonstrate two methods of changing direction of rotation. This task shall be completed within five minutes, without error.

4.2 Enablers: A teacher candidate should possess the ability to:

4.2.1 Ability to arrange components and operate examples of reciprocating, rotary and linear force.

4.2.2 Ability to assemble and solve simple gear rotation direction problems.

Suggested Equipment:

* Mechanical Power Package. Brodhead-Garrett #474265 (or suitable equivalent)

* Duplicate entry
Area II: Converting Power

Module 5. Converting Fluid Power

Task 5.1 Compressing Air (pneumatics)

Given a suitable air cylinder, a pressure gage (0-30 psi), a shut-off valve, fluid line to connect these components, a steel tape measure, and five to ten pounds of weight which can be fastened onto the piston rod of the cylinder, the candidate will be able to demonstrate that decreasing the volume of a gas increases the pressure and a rise in pressure causes a temperature rise. In addition, show by calculation how the variables of force and area caused the pressure reading obtained on the gage during the demonstration. This task shall be completed in five minutes with calculations accurate to the nearest whole number.

5.1 Enablers: A teacher candidate should possess the ability to:

5.1.1 Ability to demonstrate Charles' Law and Boyle's Law.

* 5.1.2 Ability to follow simple printed procedure for connecting fluid components, measuring diameters, computing area, and solving equations requiring cross multiplication.

Suggested Equipment:

* Fluid Control Experimenter with manual, by Bohn & MacDonald. McKnight Co. #7269 (or suitable equivalent)

* Duplicate entry
Module 5. CONVERTING FLUID POWER

Task 5.2 Pumping Liquids (hydraulics)

Given two suitable hydraulic cylinders of different diameters and of the same length, a pressure gage (0–60 psi), fluid line to connect these components, a steel tape measure, a spring scale, and suitable liquid to fill the system, the candidate will be able to demonstrate basically that pressure on a liquid is exerted equally in all directions, and that liquid is shapeless and incompressable. In addition show by calculation, how variables of force and area caused the pressure reading obtained on the gage during the demonstration. This task shall be completed in five minutes with calculation accurate to the nearest whole number.

5.2 Enablers: A teacher candidate should possess the ability to:

5.2.1 Ability to demonstrate Pascals' Law.

* 5.2.2 Ability to follow simple printed procedure for connecting fluid components, measuring diameters, computing area, and solving equations requiring cross multiplication.

Suggested Equipment:

Multi-Power Lab System, Fluid Power Package with manual #MP-F. Brodhead-Garrett #474298 (or suitable equivalent).

* Duplicate entry
Module 5. CONVERTING FLUID POWER

Task 5.3 Rotating and Actuating With Fluids

Given the following selected components: A fluid motor, cylinder, pressure gage, shut off valves, fluid line to connect components to power source, a steel tape measure, several weights, and a sleeve or pulley and cord to fasten onto the motor shaft for use as a winch. The candidate will be able to demonstrate motor speeds and confirm by calculation torque values as pressure and weight variables are changed. Given the displacement of the motor calculate to flow required to maintain a given motor speed. In addition demonstrate relative speed and confirm by calculation pressure needed to lift a given weight with a cylinder. This task shall be completed in ten minutes with calculations within ten percent of readings and weight values.

5.3 Enablers: A teacher candidate should possess the ability to:

* 5.3.1 Ability to follow simple printed procedure for connecting fluid components, measuring diameters, computing area, and solving equations requiring cross multiplication.

* 5.3.2 Ability to demonstrate Pascals' Law and Boyle's Law

Suggested Equipment:

* Multi-Power Lab System, Fluid Power Package with manual #MP-F. Brodhead-Garrett #474298 (or suitable equivalent)

* Duplicate entry
AREA II CONVERTING POWER

Module 6. CONVERTING ELECTRICAL POWER

Task 6.1 Generating Electricity

Given a permanent magnet, a coil assembly, a voltmeter, ammeter and wire leads, the candidate will be able to convert motion into electricity and express the quantity in volts and amperes. This activity shall be accomplished within three minutes with readings accurate to the smallest increment on the respective meters.

6.1 Enablers: A teacher candidate should possess the ability to:

* 6.1.1 Ability to connect ammeters and voltmeters in a circuit

6.1.2 Ability to read voltmeters, ammeters, and to convert these force and rate values to watts.

Suggested Equipment:

* Mechanical Control Experimenter with manual by Bohn & MacDonald; McKnight Co. #7267 (or suitable equivalent).

* Duplicate entry
Module 6. CONVERTING ELECTRICAL POWER

Task 6.2 Rotating With Electric Motors

Given a simple DC motor, a common household motor, and an electric motor dynamometer, the candidate will, (1) determine the direction of rotation of the simple DC motor (without applying power), (2) state the type of household motor supplied with reference to current direction, windings, and started system, and (3) make a dynamic analysis of the motor to verify manufacturer's ratings with respect to amperes, watts, torque, and rpm. Responses are to be made without error while readings and calculations can be within two percent of specifications. This task is to be completed within 30 minutes with use of technical manual permitted.

6.2 Enablers: A teacher candidate should possess the ability to:

6.2.1 Use Fleming's left-hand rule.

6.2.2 Recognize characteristics of common types of DC and AC motors.

6.2.3 Operate a typical electric motor dynamometer and to calculate horsepower and torque from rpm and force readings.

Suggested Equipment:

Module 6. CONVERTING ELECTRICAL POWER

Task 6.3 Charging Batteries

Given battery specifications, a lead acid battery, a hydrometer, several standard dry cells, a battery (dry cell) voltage-load tester, and clip leads, the candidate will be able to, (1) test specific gravity, (2) determine ampere-hour rating, (3) test for actual voltage available, and (4) connect cells or batteries together to increase voltage and to increase amperage. This task shall be completed within 20 minutes, with computations and values accurate to the nearest whole number.

6.3 Enablers: A teacher candidate should possess the ability to:

6.3.1 Test electrolyte with a hydrometer and correct for temperature variables.

6.3.2 Calibrate and operate a battery tester (cell voltage-load tester).

6.3.3 Interpret S A E Battery ratings and/or A A B M 20-Hour Rating Discharge charts.

Suggested Equipment:

1. Battery (dry cell) Tester Model 585. Brodhead-Garrett #398070 (or equivalent).
2. Battery Hydrometer. Brodhead-Garrett #400756 (or equivalent).
Area III Transmitting and Controlling Power

Module 7. Rotating Shafts

Task 7.1 Coupling and Supporting Shafts

Given an assortment of power transmission components the candidate will be able to set up a flexible and a rigid coupling. Each of the shafts is to be supported with either a sleeve, an anti-friction, or a thrust bearing. A U-joint and at least two types of hubs must also be employed. These assemblies are to be completed within 20 minutes, with visible operation of set-ups as the criterion for acceptance. Use of technical manual permitted.

7.1 Enablers: A teacher candidate should possess the ability to:

7.1.1 Ability to recognize components of the three types of bearings, two coupling types, and several types of hubs.

* 7.1.2 Ability to select and use: keys and key-ways, set screws, locking rings, allen wrenches, snap-ring pliers, drift-punches, open-end wrenches, and press-fit components.

Suggested Equipment:

* 1. Mechanical Control Experimenter and manual, by Bohn & MacDonald McKnight Co. (or suitable equivalent).
* 2. Selected components locally chosen from a catalog of power transmission products (for example Morse Products, Ithaca, N.Y. 14850).
* 3. Typical hand tool set. Brodhead-Garrett #193440 or adequate other.

* Duplicate entry
AREA III TRANSMITTING AND CONTROLLING POWER

Module 7. ROTATING SHAFTS

Task 7.2 Lubricating Components

Given an oil analysis kit and samples of crankcase oil from a heavy-duty diesel engine and from a light duty gasoline engine, the candidate will be able to test and record; (1) water contents, (2) acid content, (3) oil service weight (viscosity), and (4) percentage of solid material. Using manufacturers' specifications, the candidate will then determine if proper viscosities, performance ratings, and operational procedures were followed. This task is to be completed within 30 minutes, with responses generally agreeing with published data and previous tests and conclusions. Use of technical manual permitted.

7.2 Enablers: A teacher candidate should possess the ability to:

7.2.1 Operate an oil analysis kit to collect useable data on the contents of an oil sample.

7.2.2 Interpret oil industry technical information relating to viscosity, additive package, VIS index, high temp test, and cold test.

7.2.3 Interpret auto industry technical information relating to API/ASTM/SAE ratings, warranty requirements, and operating conditions and procedures.

Suggested Equipment:

2. Oil industry information ie: Technical Bulletin #177, SOHIO, Sales Technical Div. Columbus, Ohio 43229.
3. General publications ie: Selecting & Storing Fuels & Lubricants, Catalog #102 AAVTM, 120 Engineering Center, Athens, Ga. 30602
4. Oil Analysis Kit. Available from local science supply firms or Lenger, Inc., 7 King Charles Place, P.O. Box 126, Annapolis, Maryland.
AREA III TRANSMITTING AND CONTROLLING POWER

Module 7. ROTATING SHAFTS

Task 7.3 Controlling and Transmitting with Gears

Given a selected assortment of gears and supporting hardware, the candidate will be able to set up gears to: (1) increase force by three to one; (2) increase speed by three times; (3) change the direction of rotation; and (4) set up a combination of gears to increase force and to increase speed by more than twenty to one. For each set-up calculate the output rpm, torque, and mechanical advantage from a known rpm and force input. This task is to be completed within 15 minutes with figures accurate to the nearest whole number.

7.3 Enablers: A teacher candidate should possess the ability to:

* 7.3.1 Take readings of rpm and force to the nearest whole number.

* 7.3.2 Compute work from force and distance measurements to determine simple ratios.

* 7.3.3 Assemble and solve simple gear rotation direction problems.

Suggested Equipment:

* Mechanical Control Experimenter and manual, by Bohn & MacDonald, McKnight Co. (or suitable equivalent).

* Duplicate entry
AREA III TRANSMITTING AND CONTROLLING POWER

Module 7. ROTATING SHAFTS

Task 7.4 Controlling and Transmitting with Belt and Chain Drives

Given a selected assortment of belts and pulleys and chain drives with attaching hardware, the candidate will be able to: (1) increase force by three to one; (2) increase speed by three times; (3) increase force and increase speed by more than twenty to one; (4) change direction of rotation; (5) provide for a 90 degree directional change; and (6) provide for on-off switching (belts only). For each set-up calculate the output rpm, torque, and mechanical advantage from a known rpm and force input. This task is to be completed within 15 minutes with figures accurate to the nearest whole number.

7.4 Enablers: A teacher candidate should possess the ability to:

* 7.4.1 Take readings of rpm and force to the nearest whole number.

* 7.4.2 Compute work from force and distance measurements to determine simple ratios.

* 7.4.3 Assemble and solve simple gear rotation direction problems.

Suggested Equipment:

* Mechanical Control Experimenter and manual, by Bohn & MacDonald McKnight Co. (or suitable equivalent).

* Duplicate entry
AREA III TRANSMITTING AND CONTROLLING POWER

Module 7. ROTATING SHAFTS

Task 7.5 Controlling With Clutches and Brakes

Given component examples of clutches (friction disc, positive mechanical, automatic type, over-running, electric) and brakes (band, drum, disc, and magnetic- eddy current type) the candidate will be able to set up each to function in an experimental operating system. This task is to be completed within 30 minutes with visible functioning of the components as the criterion for acceptance. Use of technical manual permitted.

7.5 Enablers: A teacher candidate should possess the ability to:

7.5.1 Recognize components representing the five major types of clutches and four major types of brakes.

* 7.5.2 Select and use key and key ways, set screws, locking rings, allen wrenches, snap-ring pliers, drift-punches, open-end wrenches, and press-fit components.

Suggested Equipment:

* 1. Mechanical Control Experimenter and manual, by Bohn & MacDonald. McKnight Co. (or suitable equivalent).

* 2. Selected components locally chosen from a catalog of power transmission products (for example: Morse Products, Ithaca, N.Y. 14850 or Horton Co. Minneapolis, Minn. 55414).

* 3. Typical hand tool set. Brodhead-Garrett #193440 or adequate other.

* Duplicate entry
AREA III TRANSMITTING AND CONTROLLING POWER

Module 8. TRANSMITTING AND CONTROLLING FLUID POWER

Task 8.1 Conditioning and Transmitting fluids

Given the suggested training Units or selected individual components, the candidate will demonstrate: friction in a line, operating resistance, viscosity changes in oil at extreme temperatures, and operating a cylinder with a vacuum. The criteria for acceptance shall be a noticeable change in the movement of the gage or medium being observed. These exhibits are to be displayed within 30 minutes, with use of technical manual permitted.

8.1 Enablers: A teacher candidate should possess the ability to:

8.1.1 Ability to read standard air-flow measuring devices (rotameters, orific meters, pitot tubes) and convert readings to Standard Cubic Feet per Minute.

8.1.2 Ability to read standard air pressure measuring devices (Bourdon-tube or diaphragm type dial gages and liquid-filled manometers) and convert readings in inches of liquid to pounds per square inch.

* 8.1.3 Ability to follow simple printed procedure for connecting fluid components, taking gage readings, and operating common devices.

Suggested Equipment:

* 3. Alternate selected individual components to set-up above circuits.

* Duplicate entry
AREA III TRANSMITTING AND CONTROLLING POWER

Module 8. TRANSMITTING AND CONTROLLING FLUID POWER

Task 8.2 Amplifying Power

Given the suggested Training Unit or selected individual components, the candidate will demonstrate: actuating a remote cylinder with a control cylinder, boosting (intensifying) cylinder movement with a second cylinder or diaphragm, and amplifying actuation with a servo valve. At each exhibit calculate the amplification factor present. The criteria for acceptance shall be visible, proportional movement of the components being examined and calculations accurate to the nearest whole number. This task shall be completed in 30 minutes, with use of technical manual permitted.

8.2 A teacher candidate should possess the ability to:

* 8.2.1 Ability to follow simple printed procedure for connecting fluid components, measuring diameters, computing area, and solving equations requiring cross-multiplication.

* 8.2.2 Ability to set up and operate air regulators and oil pressure regulating valves to manipulate system pressure.

* 8.2.3 Ability to set-up and operate: shut-off valves, needle valves, check valves, and quick exhausting valves in various circuits to control flow.

Suggested Equipment:


* 2. Vega Advanced Hydraulics Kit HK-2 for use with Vega B-3 Unit. Brodhead-Garrett #178272.

3. Alternate selected individual components to set up above circuits.

* Duplicate entry
AREA III TRANSMITTING AND CONTROLLING POWER

Module 8. TRANSMITTING AND CONTROLLING FLUID POWER

Task 8.3 Controlling Flow

Given the suggested Training Units or selected individual components, the candidate will demonstrate: controlling reverse and forward motion with one valve, effecting control with parallel lines, varying movement in one direction only and in both directions, and controlling an oil system with air. The criteria for acceptance shall be visible movement of components being examined. This task shall be completed in 30 minutes, with use of technical manual allowed.

8.3 Enablers: A teacher candidate should possess the ability to:

* 8.3.1 Ability to set-up and operate: shut-off valves, needle valves, check valves, and quick exhausting valves in various circuits to control flow.

* 8.3.2 Ability to set up and operate air regulators and oil pressure regulating valves to manipulate system pressure.

* 8.3.3 Ability to follow simple printed procedures for connecting fluid components, taking gage readings, and operating common devices.

Suggested Equipment:


3. Alternate selected individual components to set up above circuits.
AREA III TRANSMITTING AND CONTROLLING POWER

Module 9. TRANSMITTING AND CONTROLLING ELECTRICAL POWER

Task 9.1 Conducting Electricity

Given a set of connectors, several resistors, a multimeter and a power supply, the candidate will be able to: (1) set up a series circuit, (2) a parallel circuit, and (3) a combination circuit. Using the proper meters, (4) establish the voltage at the source and across each resistance, then (5) measure the resistance of each device. Next (6) calculate the current of each resistance, the total circuit current, and the total resistance of each circuit. Finally, (7) verify answers by use of meters. This task is to be completed within 20 minutes, with calculations and readings within ten percent of actual value.

9.1 Enablers: A teacher candidate should possess the ability to:

* 9.1.1 Effectively operate a combination voltmeter, ammeter, ohmmeter (multimeter).

* 9.1.2 Solve Ohms' Law problems for series, parallel, and combination circuits.

Suggested Equipment:

* 1. Electrical Control Experimenter and manual, by Bohn & MacDonald. McKnight Co.
* 2. VOM Meter (multimeter) Brodhead-Garrett #166767 (or equivalent).

* Duplicate entry
AREA III TRANSMITTING AND CONTROLLING POWER

Module 9. TRANSMITTING AND CONTROLLING ELECTRICAL POWER

Task 9.2 Switching and Regulating Electricity

Given an assortment of switches, connectors, fuses, lamps, a circuit breaker, a solinoid, a transistor, a silicon-controlled rectifier, a small DC motor, and a power supply, the candidate will be able to: demonstrate independent mechanical control of lights from three locations, control a motor from a remote location by electromagnetics, switch lights with transistors and with a silicon-controlled rectifier, protect devices from overload and regulate current to a motor with a silicon-controlled rectifier. This task is to be completed within 20 minutes, with visible operation of components and set-ups as the criterion for acceptance. Use of technical manual permitted.

9.2 Enablers: A teacher candidate should possess the ability to:

9.2.1 Ability to recognize symbols for electrical components and devices being used.

9.2.2 Ability to interpret schematic diagrams of simple electrical assemblies.

Suggested Equipment:
* 1. Electrical Control Experimenter and manual, by Bohn & MacDonald. McKnight Co.

* Duplicate entry
Module 9. TRANSMITTING AND CONTROLLING ELECTRICAL POWER

Task 9.3 Amplifying Electricity

Given an assortment of connectors, resistors, a transistor, a multimeter, and two power supplies, the candidate will assemble components to amplify voltage and amplify power. This task is to be completed within 15 minutes, with visible increases in meter reading as the criterion for acceptance. Use of technical manual permitted.

9.3 Enablers: A teacher candidate should possess the ability to:

* 9.3.1 Ability to recognize symbols for electrical components and devices being used.

* 9.3.2 Ability to interpret schematic diagrams of simple electrical assemblies.

* 9.3.3 Ability to effectively operate a combination voltmeter, ammeter, ohmmeter (multimeter).

Suggested Equipment:

* 1. Electrical Control Experimeter and manual, by Bohn & MacDonald. McKnight Co.
* 2. VOM Meter (multimeter) Brodhead-Garrett #166767 (or equivalent).

* Duplicate entry
AREA III TRANSMITTING AND CONTROLLING POWER

Module 9. TRANSMITTING AND CONTROLLING ELECTRICAL POWER

Task 9.4 Transforming, Rectifying, and Filtering Electricity

Given an AC power source, an oscilloscope, a multimeter, and selected components as; a transformer, 4 diodes, a capacitor, a choke, and a lamp or resistor, the candidate will be able to assemble components to transform, rectify, and filter electricity. This shall include: (1) stepped down voltage, (2) a one-half wave, (3) a full wave, (4) a bridge rectifier circuit, and (5) a simple choke circuit employing three components. The candidate is to (1) report voltage readings and wattage values for transformer input and output and (2) sketch the waveform of each rectifier output and of the filter output. This task is to be completed within 20 minutes with meter readings and calculations being accurate to the nearest whole number. Waveform sketches are to correspond with oscilloscope patterns of the signal being observed. Use of technical manual permitted.

9.4 Enablers: A teacher candidate should possess the ability to:

* 9.4.1 Recognize symbols for electrical components and devices being used.

* 9.4.2 Interpret schematic diagrams of simple electrical assemblies.

* 9.4.3 Effectively operate a combination voltmeter, ammeter, ohmmeter (multimeter).

* 9.4.4 Set up a general purpose oscilloscope to compare waveforms in an experimental circuit.

Suggested Equipment:

1. 3-E Experimenter #903 with manual #910. Radatron Corp.
* 2. Alternate selected individual components to set up above circuits.
* 3. VOM Meter (multimeter) Brodhead-Garrett #166767 (or equivalent).
4. General purpose Oscilloscope, Brodhead-Garrett #166884 (or equivalent).

* Duplicate entry
AREA III TRANSMITTING AND CONTROLLING POWER

Module 9. TRANSMITTING AND CONTROLLING ELECTRICAL POWER

Task 9.5 Regulating Electricity

Given a multimeter and selected power supply circuit components including a voltage regulator tube, fuses, circuit breakers, and a zener diode device, the candidate will be able to: (1) assemble components to regulate voltage and current output with two different circuits, (2) connect assembled circuits to operate a load, (4) protect against overloading and (5) vary the load to demonstrate regulation with one of the two circuits. This task is to be completed within 20 minutes with visual examination of the circuit and observation of meter deflection as the criterion for acceptance. Use of technical manual permitted.

9.5 Enablers: A teacher candidate should possess the ability to:

* 9.5.1 Effectively operate a combination voltmeter, ammeter, ohmmeter (multimeter).

* 9.5.2 Recognize symbols for electrical components and devices being used.

* 9.5.3 Interpret schematic diagrams of simple electrical assemblies.

Suggested Equipment:

DeVry circuit panel with accompanying manual #21401; available from Energy Concepts, Chicago, Illinois (or selected individual components).

* Duplicate entry
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