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COMMUNICATIONS TECHNOLOGY: A TAXONOMY

DISSERTATION

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

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1986

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This work is dedicated
to my loving wife, Moe.
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TABLE OF CONTENTS

DEDICATION...............................................iii
ACKNOWLEDGEMENTS..........................................iv
VITA........................................................v

CHAPTER PAGE

1. Introduction........................................1
   Statement of Problem........................................8
   Objectives of Study.........................................12
   Limitations of Study.......................................12
   Basic Assumptions.........................................13
   Definition of Terms.......................................13

2. Literature Review.................................16
   Curriculum Approaches to the Study of Technology..............18
   The Nature of Concepts......................................22
   Designing Conceptual Systems..............................30
   Research Relative to Communications Technology.................40

3. Methodology.......................................52
   The Delphi Technique........................................53
   Face-to-Face Expert Panels................................59
   Industry Analysis/Questionnaire.........................63
   An Extended Dissertation Committee......................65
   The Dissertation Committee................................66
   Summary of Methodology Review............................67
   Procedures................................................71
   Summary....................................................80

4. Findings..........................................80
   Version One- The Initial Draft of the Taxonomy...............92
   Version Two- The First Revision of the Taxonomy..............96
CHAPTER 1

INTRODUCTION

The profession of Industrial Arts is undergoing a dramatic self-examination resulting in a redefinition of its role in public education. There is widespread change taking place in terms of fundamental beliefs and theories about how to organize content for the study of industry and technology. Time honored traditions of organizing content by materials or trade-based analysis are being challenged. Innovators are finding it an exciting time to be a part of the profession. There exists a "window of opportunity" as technology teachers witness a society being impacted by rapid changes in technology and questioning the educational response to these rapid changes. A debate continues about what citizens need to know about technology to be intelligent participants in a society characterized by the sophisticated applications of technology (Waetjen, 1985). The "window of opportunity" refers to the potential of industrial arts/technology education to become that part of general education that teaches students about the technological systems that
Thomas Jefferson (Smith, 1976) stated "That the foundation of a democracy is an informed populace (p.92)". The informed populace to which Jefferson refers must possess a basic understanding of the systems of technology if it is to manage these systems for the betterment of humankind. Naisbit (1982), in Megatrends, suggests that our society is witnessing a subtle but important shift in the democratic process with the "proposition" movement. Citizens are being asked to make decisions relative to specific issues by voting on local and state referenda or proposition ballots. Increasingly, these referenda or proposition issues require an understanding of technology to make that "informed decision." A case-in-point is the recent proliferation of state referenda items dealing with issues related to the use, and consequences of use, of nuclear energy. Jefferson's point was that if democracies are to make intelligent decisions, they must understand the issues; in today's world that means understanding technology. If our society is to make informed decisions concerning our energy needs, it must understand the complexities of the energy issue.

Boyer, (1985) in writing High School: A Report on Secondary Education in America, takes a clear position on the importance of the study of technology:
We are quite frankly disappointed that none of the schools we visited required a study of technology. The great urgency is not "computer literacy" but "technology literacy", the need for students to see how society is being reshaped by our inventions, just as tools of earlier eras changed the course of history.

It is increasingly important for all students to explore the critical role that technology has played throughout history and develop a capacity to make judgments about its use. (p. 111)

Industrial arts/technology education then must concern itself with the development and organization of programs that teach students about the systems of technology in a conceptual manner.

The timing for industrial arts/technology education could not be more opportune as the profession has been evolving a theory of curriculum and instruction that reflects this need to teach students about the systems of technology and the organization of industry. The early work of Warner, in *A Curriculum to Reflect Technology* (Warner, 1947) done at The Ohio State University, has been followed by notable curriculum development work. The Industrial Arts Curriculum Project (IACP), also of OSU origin (Towers, Lux, Ray, 1966), produced the *World of*
Manufacturing and the World of Construction instructional systems; the University of Wisconsin-Stout (Face & Flug, 1966) produced the American Industry Project materials which provided a conceptual structure for the study of industry; the Maryland Plan, as developed at the University of Maryland (Maley, 1973), took an anthropological approach to the study of industry and technology. All of these works were an attempt to redirect the field of industrial arts education. More recently a consortium of distinguished educators produced the Jackson's Mill Industrial Arts Curriculum Theory (Snyder & Hales, 1981) a successful attempt at arriving at agreement of a common base for industrial arts curriculum theory. These materials and documents lead industrial arts/technology education away from organizing content by job and trade analysis (Bensen, 1983) and toward the organizing of curriculum around the concepts and systems of technology.

Therein lies the problem for this study. The Jackson's Mill Industrial Arts Curriculum Theory identified four human adaptive systems used by humankind to alter the environment: manufacturing, construction, communication, and transportation. The follow-up document to the Jackson's Mill Curriculum Theory was the Curriculum Implementation Project (CIP) (Wright & Sterry,
1984) funded by the Technical Foundation of America. The purpose of CIP was to carry the Jackson's Mill work a step further by producing materials to be used by classroom teachers in the implementation of courses that reflect the study of technology. The group working on the communications portion of CIP encountered a problem, met by various curriculum builders, of trying to organize the study of technologies related to communication in a conceptually meaningful, instructionally deliverable fashion. CIP ended up choosing to "cluster" technologies with similar processes rather than develop a conceptual model whereby all processes could be organized and interrelated. The problem of conceptual organization went unresolved.

DeVore (1968), a scholar of the study of technology and a leader in the industrial arts/technology education profession, helps put the problem of conceptual organization into perspective in the document, *Structure and Content Foundations for Curriculum Development*, where he states:

Are there no constants or universals upon which to build a curriculum which can provide a structure with external validity and internal flexibility and adaptability to change as humankind's knowledge increases or changes? At what level is this constant
on-going curriculum activity required? Is it necessary constantly to revise the total, or can a structure be established whereby various content levels can be adjusted to meet changing knowledge requirements.

The task then is to analyze the approach and ascertain whether a structure can be determined from which a curriculum and its content can be derived. (p.1)

While DeVore's document was first published by the American Industrial Arts Association in 1968, the problem of conceptual organization lingers as noted professional leaders call for continued research in the area. Mohamed (1984) summarized important research topics to industrial arts education in his article, "Research Problems Unique to Industrial Education: A Reaction." Mohamed summarized the writings of four leaders in the profession: Strong, DeVore, Moss and Householder. These four were able to delineate five areas of general consensus in which research efforts should be directed in industrial arts education:

1. Content derivation in a changing society, economy, technology, environment, and resources.
2. Policy issues regarding definition, objectives and philosophy of industrial educations relationships
with business, industry, and other educational delivery systems.

3. Clientele—the targeted groups and their objectives.

4. Delivery models and forms of industrial education.

5. Impact of industrial education on businesses and industries served. (p.39)

Items number one and four lend evidence to the need for studies such as this one.

Lux (1979) reinforces the idea that the profession needs to look for fresh approaches in the derivation and organization of curriculum. Lux states:

Trade and job analysis sends industrial arts teachers down the wrong road in their search for the substance of industrial technology. . . . Industrial arts teachers need to look to other forms of analysis for the core of their instruction. . . . Only when we look to other, relevant bases for identifying and organizing subject matter can we expect industrial arts to provide the industrial technological literacy students so desperately need. (p.2)

Past research and curriculum development efforts in the area of manufacturing and construction have provided the profession with conceptual models for their
implementation. While the area of transportation (Bender, 1982) appears to need further refinement and modeling before it will be accepted and implemented, work is under way. This investigator believes it is not philosophically sound to use identified concepts as content organizers in construction, manufacturing and transportation content areas and then revert to a different logic - that of "clustering" to organize the content in communications. There is a need to use the same organizational logic throughout the curriculum. This writer perceived a need by the profession to develop and validate a conceptual model for the study of communications technology.

STATEMENT OF THE PROBLEM

Our society and the societies of the world are being impacted daily by the application of communications technology. Numerous authors and futurists refer to the kind of society we are evolving into as; The Information Society, Communications Age, Third Wave, Post Industrial Society (Thebold, 1982) (Toffler, 1980) (Davis & McCormick, 1981). While the titles may differ, all refer to the reshaping of many social institutions as a direct result of communication and information technology. Just as the industrial revolution extended our ability to produce material goods, the emerging technologies of
communication will greatly extend our ability to create, transmit and store information. New technologies becoming commonplace in business, industrial, residential and educational settings demand new skills and competencies in the individuals expected to function effectively within these environments. The use of many of these systems and their technologies have become commonplace in our lives. The challenge to industrial arts/technology education is to integrate the study of these emerging technologies into its program of study.

The major question addressed in this study was: How can communication technologies and systems be conceptually modeled thus providing a framework for study? This conceptual model, with concepts and subconcepts, would be a valid organizer even if specific technological products and processes change daily. Concepts should stand the "test of time" while specific technologies will continue to change at an unprecedented pace. Indeed, the ability of students to think and organize technical content in a conceptual fashion leads to the ability to adapt to a changing technological environment. This ability to adapt to changing technical means will grow in importance as an occupational requirement as well as a requirement for informed citizenship.

Accumulated knowledge doubles at a rate of once
every five years, with this growth rate expected to advance at an even increased pace (Bensen, 1985). This fact illuminates the idea that the period of time that specific technical knowledge is valid is shrinking. What was the state of the art today may be technological history within months. While techniques, procedures and machine-specific skills may also change as a result of technological advancement, a well defined conceptual model should endure as a logical organizational scheme for a content area. The problem was to develop and validate a conceptual model for the organization and study of communication technology.

It was not the intent of this study to start from scratch, but rather to accept the work of the Jackson's Mill project in respect to the area of communications. It was accepted that communications is one of four human adaptive systems and thus appropriate content for technology education. The following major concepts of communications, as listed in Jackson's Mill, are accepted: encoding, transmitting, receiving, storing, retrieving, decoding, and feedback. While professional debate continues as to the nature of our discipline it appears that most are willing to accept the area of communications as an important area of study. The need then was to identify, organize, and define second- and third- level
subconcepts to the communications concepts identified in Jackson's Mill.

It was also important to distinguish this work from the area of science as it was not meant to be an investigation of scientific concepts or phenomena. While science might investigate the characteristics of electrical, acoustic and visual phenomena for the purpose of their description, the study of communication technology would center itself on how humankind applies tools, techniques and processes to manipulate these phenomena for the purpose of creating, moving and storing information. The focus being on the technical means used to communicate.

Of similar importance is the need to distinguish this work from human communication skills and abilities. The ability to read is the ability to decode the printed word and derive meaning. It makes use of acquired mental skills and abilities and as such would not be considered a technical communications act. The human brain has the ability to encode, store and decode information and as such represents an extremely sophisticated process. This study in no way pretends to deal with this mental/human communications process. However, should this encoded message be stored on microfilm/fiche and retrieved using a fiche/film reader then the act is making use of a
technical communication system. This system is a tool, designed by people, to create a more efficient system for the exchange of ideas. The focus of this model is on the technical aspects of communication systems and not on the mental/human communication skills.

OBJECTIVES OF THE STUDY

The primary objectives of this investigation are:
A. To identify the subconcepts of communications. Accepting the major concepts of communications identified in Jackson's Mill: encoding, transmitting, receiving, storing, retrieving, decoding and feedback.
B. To validate the identified subconcepts for technical accuracy and interrelatedness.

LIMITATIONS OF THE STUDY

The major limitations of the study were in the process and procedures used to establish the initial conceptual model and definitions as well as the identification of a process appropriate for the model's validation. Both of these issues are addressed under procedures in Chapter 3.

This study looked solely at the organization of concepts used in communication systems. This study did
not deal with the relationship to other identified systems nor deal with the social/cultural implications of communications technology.

**BASIC ASSUMPTIONS**

The basic assumptions of this study were:

A. That through research of current approaches to the organization of communications technology, review of business and industrial research and inquiry into other disciplines approaches to the area, a conceptual model was derived.

B. That an appropriate process was structured to review all materials for their technical accuracy and conceptual structure.

**DEFINITION OF TERMS**

**Technology**: The "know-how" or creative processes that may use tools, resources, and systems to solve problems thus enhancing control over the natural and man-made environment and altering the human condition (Gebheart, et. al, 1982).

**Industry**: That section of the societal institution that utilizes resources to produce goods, services and information to meet the needs and wants of society (Snyder & Hales, 1980).
Technology Education: A comprehensive educational program concerned with technology, its evolution, utilization and significance; with industry, its organization, personnel, systems, techniques, resources, and products; and their social/cultural impact (Starkweather, 1984).

Communication: The transfer of meaningful information from one location to another (Cannon & Luecke, 1984).

Information: A physical pattern that has been assigned a commonly understood meaning (Cannon & Luecke, 1984).

Communication Technology: The application of technical processes to the act of communication. The way that humans use tools, processes and systems to encode, transmit, receive, store, retrieve and decode information.

Concept: A psychological abstraction resulting from a variety of experiences fixed by a word or other symbol having functional value to the individual in his/her thinking and behavior (Face & Flug, 1965).

Cluster: A number of things of the same sort gathered together or growing together (Guralink, 1968).

Industrial arts: A general education subject matter area concerned with the interpreting of industry. Bonser's classic definition implies it is the study of
converting raw materials into finished products to meet man's needs (Bonser, 1925)
CHAPTER 2

REVIEW OF LITERATURE

This review of literature has two specific objectives. The need is to review current thoughts, theories and practices relative to the use of concepts as a tool in curriculum building. The primary focus being on the need for and use of concepts to delineate curriculum in technology related subject matter. Furthermore investigation is needed into the procedures used in the development of conceptual models. A second objective is to review past research relative, in part or whole, to the area of communications technology.

Educators in general and technology educators in particular have struggled with identifying appropriate methods in the selection and organization of curriculum. Our heritage as industrial educators saw content drawn from the trades. School programs were focused on emulating the skills and crafts of the trade-specific craftsman. This manual arts era gave way, somewhat, to the industrial arts or industrial education movement. The major difference was that content was organized to teach
students about industry as a social institution which organized people, materials and tools for the production of goods to meet the needs and wants of society (Towers, Lux, Ray, 1966). The most recent survey of our field, conducted by Dugger (1982) and the staff of Virginia Polytechnic Institute and State University suggests that much of the profession remains closer to the manual training era than the technology education era. The industrial arts, industrial education movement saw a wealth of research and subsequent innovative programs in the 1960's and 1970's: The Ohio State University, Industrial Arts Curriculum Project (Towers, Lux, Ray, 1966); University of Wisconsin-Stout, American Industry Project (Face & Flug, 1966); Indiana State University, Orchestrated Systems (Yoho, 1972); University of Maryland, Maryland Plan (Maley, 1973); and the University of Wisconsin-Platteville, Industrialogy (Kirby, 1970), to mention a few.

The most recent movement, and perhaps the most dynamic, is the technology education thrust. The fundamental philosophical difference is the inclusion of a conceptual study of technology as well as a study of industry.
CURRICULUM APPROACHES TO THE STUDY OF TECHNOLOGY

The technology educator has a wealth of options open as he/she begins the process of content selection for the study of technology. A brief review of these options is needed to put the conceptual approach into perspective relative to other curriculum design possibilities.

The behavioral approach has seen much use in the profession as it relies heavily on the use of task analysis as a method of identifying content (Bensen, 1983). The behavioral approach has focused on the behaviors of "work" while it can be used in identifying other behaviors. Job and trade analysis has evolved into a very precise research method while it continues to be problematic as it focuses on "what is" rather than "what should be" or "what will be."

The Engineering Concepts Curriculum Project (Laid, 1972) and the Man-Made World (ECCP, 1967) curricula were two products of the engineering field's approach to curriculum design. Content could be organized around engineering fields such as mechanical, electrical, civil, industrial, chemical, aerospace, etc. While this approach draws industrial education closer to science education and possibly enhances our overall image in education, it has been endorsed by few technology educators.
The transactional analysis approach was used as the process in the Texas Industrial Arts Curriculum Project (Piersen, 1974) and incorporated an analysis of the transactions that take place between people and the phenomenal technological world. The transactional analysis approach is a very broad, comprehensive approach to content selection.

The Maryland Plan (Maley, 1973) was the first to encourage the use of the societal problems approach, a diverse, dynamic, student centered approach to the study of technology. In this approach students identify problems relative to technology in areas such as production, transportation, communication, energy, automation, etc. and then go about using a research and development process for a student generated solution to the problem. The actual technological content covered is identified by the student in the selection of the problem. The societal problems approach sees greater emphasis placed on the process rather than the product, as "how" to solve a problem becomes as important as the actual solution. The Maryland Plan requires a creative, flexible, student centered teacher.

The processes of technology approach has its basis on a set of universal processes used by a technologist in any technological endeavor. The focus is on the skills and
competencies used by people in the solution of technological problems (Halfin, 1973). Using a Delphi study, the following processes were identified by Halfin:

1. Defining the problem
2. Observing
3. Analyzing
4. Visualizing
5. Computing
6. Communicating
7. Measuring
8. Predicting
9. Questioning and hypothesizing
10. Interpreting data
11. Constructing models
12. Experimenting
13. Testing
14. Designing
15. Creating
16. Modeling
17. Managing

The process of technology approach is similar to the societal problems approach used in the Maryland Plan except the process of technology would encourage the student to study each of the identified processes in an orderly fashion rather than letting the processes emerge
from a problem situation.

The systems approach (Snyder & Hales, 1981) is one that is gaining popularity in the profession as it focuses on a common model for looking at any technological system. By studying the input, process, and output model, one can view any technological process in a fashion close to that which is used in the "real world." The systems approach makes use of four identified subconcepts, these being, construction, communication, manufacturing and transportation.

The last curriculum design approach to be discussed relative to content selection in technology education is the conceptual approach. Bensen (1981), states, "A well conceived study of technology from its conceptual perspective will lead to a very comprehensive program and one which is holistic and internally consistent" (p. 22).

The conceptual approach views the study of technology as a set of interrelated concepts which takes the form of a taxonomy or model with several identified levels of subconcepts. Many curriculum designers view concepts as being stable over time and as a tool to organize content in times of rapid technological change. Conceptual models also cause the designer to view the entire process and maintain consistency in the coverage of each concept. The conceptual approach builds in a "check and balance" to
ensure appropriate breadth and consistent depth. The conceptual approach has been successfully used as the foundation of secondary program design in technology education (Hendricks, 1981).

Perhaps DeVore (1966), Chairman of the Program for the Study of Technology at West Virginia University, best summarizes this discussion of methods of structuring curriculum in his statement:

There are numerous ways to approach the design of an education system which incorporates the study of technology as one of the central themes. All approaches require some form of conceptual structure that organizes the components into a meaningful system showing relationships. (p.19)

Having discussed several approaches to content derivation and organization for technology education, thus adding perspective, the need exists to focus solely on the conceptual approach of curriculum design.

THE NATURE OF CONCEPTS

In reviewing the writings of many educators, both technology educators and others not specifically interested in technology education, it becomes clear that there are as many definitions of a concept as there are authors on the subject. There is a need to analyze
current thoughts on the nature of concepts prior to focusing on their use in the study of technology.

A review of several definitions of a concept will aid in the development of a working definition of a concept for this study. Face and Flug (1966), as directors of the American Industry Project, developed a definition of a concept that was then used in the creation of what was believed to be the concepts common to all industries. Their definition stated: "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, having functional value to the individual in his/her thinking and behavior" (p. 65). Hauenstein (1973) defined a concept using the following terms, "A concept is an idea or thought that forms a mental image in your mind as well as in the minds of others" (p. 25).

Gagne and Briggs (1974), using the following definition viewed a concept as a tool with which to categorize knowledge, "A concept is a capability that makes it possible for an individual to identify a stimulus as a member of a class having some characteristics in common, even though such stimuli may differ from each other markedly" (p. 40).

Spitzer (1977) viewed concepts in a similar fashion in his definition, "Concepts are very similar groups of things
that we give common names. They are our way of managing different things the same by treating them as part of the same category" (p. 23).

Henry and Brown (1974) proposed a yet simpler definition of a concept:

A concept is a set of strategies in inventing a web of reactions. A concept must be seen to move in two directions: (1) from one or a number of instances an interpretation begins to grow; (2) at a certain point the interpretation begins to congeal permitting succeeding instances to be more critically examined. In the process some instances become better exemplars than others of the proposed category (p. 45).

While there are subtle differences in all of these definitions, there is a common thread of thought present. One common idea is that the concept is a unique mental image held by an individual. This mental image allows the individual to identify events and various stimuli as having some common root or base that links it logically to a larger category. Categories then are collections of events or occurrences that can be rationalized as being related.

All authors seem to agree that concepts are a useful tool for structuring thought and understanding meaningful interrelations and patterns. A criterion for an
individual who has an understanding of a concept is the ability to distinguish the differences between concepts and to apply a conceptual logic to the categorization of a new previously unexperienced event or phenomena.

Henry and Brown (1974), in *An Inquiry into the Nature of Concept Development Within the On-Going Classroom Situation*, have identified criterion for how students develop concepts, these being:

1. A concept is best learned through the progressive development of meaning rather than as a product or finished definition.
2. The strategy of concept development is best acquired by exploration (heuristics) rather than by step-by-step directions (algorithmics).
3. A concept is best developed as it serves to harmonize more and more cases and discriminates among these cases. A concept is not a storing up of many cases (p.22).

Henry and Brown's (1974) work stresses the importance of conceptualization as an ongoing process that must be integrated into a students' educational experiences thus nurturing the ability to form meaningful concepts. Their second statement has powerful implications on how teachers organize and present information to students in technology education. They ascertain that concepts are best formed
by exploration (heuristics) rather than by step-by-step (algorithmics) methods should impact the instructional methods used by all teachers concerned about teaching concepts in laboratory settings. Their ideas make it apparent that if one is concerned with the development of conceptualization skills in students, changes need to be made in not only how content is organized, but in our basic assumptions about how to teach.

Sarapin (1981) suggests the knowledge of concepts can be a powerful tool to the technology teacher. He discusses a process approach to the development of concepts and states:

The process of concept analysis can be described as a classification method for organizing phenomena having rules for defining relevant categories, including sets of positive instances or exemplars with attributes and a name (p.10).

The key elements to this concept analysis strategy, stated by Sarapin, are defined by Martorella (1972):

A. Rules: Are the definitions or formulas specifying the attributes of a concept.

B. Attributes: Are those characteristics which are the identifying features of a concept, and enable one to distinguish between exemplars and nonexemplars.

C. Exemplars: May be regarded as positive instances
of the concept: Nonexemplars as negative examples.

D. Names: Are the symbols commonly used by a culture to identify or label a concept. (p.11)

The task then is to apply a concept analysis model to identify concepts from the universe of communication technology. This conceptual model then becomes the basis for course construction and instructional material development. Sarapin (1981) goes on to suggest an eight step process to be used to delineate the concept universe of a technological cluster.

1. Conceptualize the scientific principles related to industry and technology.
2. Formulate concept rules for classification purposes.
3. List identified concepts in random order.
4. Examine attributes and exemplars to find clusters of interrelated concepts.
5. Identify higher-order (superordinate) concepts to form mutually exclusive categories.
6. Establish subordinate (lower-order) concept classifications that are totally incumbent within the higher-order concepts.
7. Write concept hierarchy in outline form.
8. Evaluate and revise concept hierarchy in view of curriculum development needs. (p.12)
While Sarapin presents a logical and useful procedure for the identification of a concept model, statement number one indicates the need to conceptualize the "scientific principles" related to industry and technology. The investigator feels it is the task of science to conceptualize scientific principles and the task of those who study technology to conceptualize "technological principles."

Henry and Brown (1974) present ten questions to be used in the evaluation of a conceptual model and its subsequent use with students. The model development process must be kept in the context of its utilitarian goal; that of providing students with a way of organizing tools, procedures and theories related to the use of technology in the act of communicating. While this work's focus is on instructional design and the teaching of concepts it does impact the methods used to develop a conceptual model.

Gray (1980), in Conceptual Attainment is Technology: Development of an Instructional Strategy, states the need for students to develop concepts relative to the study of technology as follows:

We in technology education today are in need of an instructional approach that will orient both the qualitative and quantitative powers of our students toward the task of conceptualization.... Technology
here is accepted as an intellectual discipline. As such it is possible to identify basic assumptions and key concepts that make up its structure and the processes that perform its function (p. 21).

Gray (1980) goes on to identify ten criteria that he believes must be considered in the development of concept models for the study of technology. As in Henry and Brown's work, Gray's focus is more on instructional strategies and criteria for the teaching of concepts than on rules for the creation of models. While the focus of this dissertation is to develop a model for the teaching of communication technology, there is a need to be sensitive to instructional design ideas relative to the teaching of a conceptual model. To develop a conceptual model for communication technology that would be impossible to deliver in the classroom would be of questionable value.

In concluding this section, the investigator found virtually universal consensus on one issue: That concepts are best taught and retained when encountered in a dynamic activity-orientated setting. Perhaps Spitzer (1979) puts it best in stating simply, "We must make certain that the words and other concepts the child learns are backed up by experiences" (p.128).
DESIGNING CONCEPTUAL SYSTEMS

There has been, and remains, concern on behalf of technology educators for building concept learning into our programs of study. Industrial education has a rich history of innovative curriculum projects. While many of the projects have not impacted public school practice as much as many would like, they are, nonetheless, a source of pride for many in the profession. While they have been listed previously in this chapter, there is a need to review past curriculum activities in industrial education that have been specifically concerned with concept learning approaches to curriculum design. The focus of this review is not concerned with what these projects produced, nor their impact on the field, but focuses on how they were produced. What was the logic and rationale used in the development of these innovative curriculums and how might their developmental schemes be applied to the investigator's concern for a conceptual model for communications technology? In particular, a review of the Industrial Arts Curriculum Project, the American Industry Project and DeVore's study of technology materials will be made.

One of the major purposes of the Industrial Arts Curriculum Project (IACP), originated in the 1960's, was to conceptualize a structure of industry as a basis for
content in industrial arts (Towers, Lux, Ray, 1966). The project members felt that to achieve this goal the initial task was to investigate the nature of humankind's knowledge to establish a need for the study of humankind's total practices (Praxiology). Maccia (1965), as cited in the IACP materials, discussed praxiology in her writings, stating:

Formal theory is speculation with respect to structures...Event theory is speculation with respect to occurrences...Valuational theory is speculation as to worthwhileness...Praxiological theory is speculation about appropriate means to attain what is taken to be valuable (pp. 4-5).

From these theories the IACP staff proposed four domains of humankind's knowledge. The identified domains being:

A. Descriptive knowledge
B. Prescriptive knowledge
C. Praxiological knowledge
D. Formal knowledge (p. 85)

The project equated descriptive knowledge with the sciences, prescriptive knowledge with the fine arts and humanities, praxiological knowledge being the knowledge of practice, and formal knowledge as the tools used to order all knowledge.

The task of structuring praxiological knowledge was
indeed a challenge as Towers, Lux and Ray (1966) stated in *A Rationale and Structure for Industrial Arts Subject Matter:*

Into what division might this knowledge be categorized logically? Attempts to classify or categorize this vast body of accumulated knowledge and recorded knowledge are difficult, since there is controversy as to the nature of knowledge and since knowledge is always in a state of development (p. 4).

The writers further state several basic assumptions prior to beginning the task of structuring industrial praxiological knowledge related to industrial arts:

1. For purpose of analysis, humankind'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 humankind's knowledge must be included in an effective general education program.

(p. 3)

From this base, the project identified a set of criteria to be used in the development of a structure for the study of praxiology. The identified criteria could be used
effectively in the development of any conceptual structure. The criteria were developed "to serve in deriving an adequate structure for instructional purposes." The identified were stated as follows:

1. It includes all industrial practices which affect humans and materials.
2. It has mutually exclusive categories.
3. It is operationally adequate for instructional purposes. (p. 78)

Using these criteria the IACP project staff went on to develop the taxonomies of industrial practices which resulted in the *World of Manufacturing* (Lux & Ray, 1971) and *World of Construction* (Lux & Ray, 1971). These materials enriched the profession providing many public school teachers with the structure and activities to teach students about industrial practice.

The value of modeling or structuring praxiological knowledge was stated to suggest that when the body of praxiological knowledge is conceptualized into a meaningful structure for pedagogical purposes, it could serve many educational programs meeting special needs at various educational levels.

DeVore (1966) has spoken of the need for a comprehensive study of technology for many years. His booklet, *Structure and Content Foundations for Curriculum*
Development, was first published in 1968 by the American Industrial Arts Association. DeVore suggests that one reason for confusion and lack of clarity in direction is that industrial arts educators have failed to establish the area as a discipline or to think of it as such. DeVore continues to explain that one characteristic of a discipline is a sound theoretical framework which the field of technology education needs to delineate. DeVore states:

The body of knowledge of a discipline consists of key ideas, principles and concepts unique to the field and evidencing the essence of the discipline. The basic concepts range in difficulty from elemental to complex. Understanding the basic concepts provides a means to comprehend a vast knowledge field and serves as a foundation from which to increase knowledge and simplify learning (p. 4).

Once a theoretical base is defined, curriculum can be logically deduced from it. DeVore (1966) states the advantage of curriculum design based on a theoretical base as follows:

A curriculum based on organized knowledge field is better learned and retained than knowledge which is specific and isolated. The discipline structure provides meaningful relations required for efficient
learning. In addition, knowledge in a discipline is cumulative, utilizing a hierarchy of concepts applicable to numerous situations in an individual's learning experience, thereby providing a greater efficiency and permanence of learning through continual reinforcement of the basic ideas, principles and concepts (p. 5).

DeVore's ideas come together in the creation of taxonomies which serve as models from which to derive curriculum guides. The process and procedures used in the act of classifying or ordering knowledge are often more enlightening than attempts to define it (Machlup, 1962). As in the Industrial Arts Curriculum Project, there is a need to establish the criteria to used in the establishing of models or taxonomies. DeVore (1966) identifies eight such selection criteria:

1. Mutually exclusive groups. Categories or clusters are established wherein each larger unit is a combination of subgroups. The groups or categories are established in a hierarchical order.

2. Each category is identified by a word or phrase which delimits the category but is non-transient and permits additions to the structure as discoveries of new knowledge warrant.

3. There is a relatively small number of mutually
exclusive groups or categories.

4. The distinction between groups or categories is established by a universal concept inherent in the knowledge area itself.

5. Taxonomies are not limited to local or national knowledge but are international in scope. The mutually exclusive categories are of the external world and not simply categories of the contents of first-person knowledge.

6. Taxonomies are logically developed and internally consistent. There is evidence of external stability and internal flexibility and adaptability to evolving new knowledge within the discipline.

7. Taxonomies have structure because there are internal relations existing between the elements. The structure is dependent upon this interrelationship.

8. The structure of taxonomies varies from external logical and homogeneous classifications of elements to vague, ambiguous, heterogeneous and difficult-to-define relationships of the elements. (p. 9)

The selection material outlined in the IACP materials along with DeVore's extensive listing or criteria provide a well defined process for the identification of concepts.
for the study of a technological universe. The criteria selection in *Structure and Content Foundations for Curriculum Development,* parallels strategies used in the sciences for the development of taxonomies. The document further stresses that the purpose of a taxonomy is not to limit the field of knowledge but rather to ascertain its totality, identify component elements and interrelationships. DeVore suggests six specific functions that taxonomies would address in the area of technology:

1. Eliminate confusion and simplify the task of curriculum planning by providing a perspective of the relationships between elements and the structure, and by ordering the knowledge area into specific categories, thereby assuring a balanced allocation of content.

2. Facilitate communication among membership of the field of knowledge, together with others, such as administrators, curriculum specialists and scholars in other fields.

3. Simplify understanding and economize intellectual effort by treating large numbers of different things as though they were identical with respect to the aspects by which the categories are defined.
4. Provide a base for long term research and inquiry into the nature of the discipline area by ordering the area of knowledge in such a way as to reveal significant relationships between the elements of the structure.

5. Provide a base for developing valid evaluation instruments by identifying elements of content to be evaluated.

6. Aid in identifying difficulty levels of content areas for establishing instructional sequences at different levels of learning. (p. 8)

DeVore's work has done much to provide a system for creating taxonomies and promote the study of technology.

American Industry (Face & Flug, 1966), as developed at the University of Wisconsin-Stout, was a project funded by the Ford Foundation and the U.S. Office of Education. American Industry was the first of a series of innovative curriculum projects of the 1960's whose focus was on the development of a conceptual model for the study of industry. The project identified, initially, two major goals:

1. Provide a reorientation for industrial arts as organized around a comprehensive study of industry.
2. The identification of the major concepts of industry.
The study made an extensive review of current thought on concepts and concept formation. An initial conceptual model was identified through a literature review, industrial consultation, graduate student research and work with practicing teachers.

The project did not identify a selection criteria for concepts and subconcepts and was criticized by some for that. However, the intent was to produce a model that would identify concepts that are a part of any industry, making it a very broad based model in scope. Some saw this breadth as a problem; but this investigator, having taught the American Industry Program in public schools, found it to be a workable, solid model. The concepts as identified by the project were:

1. Communication
2. Transportation
3. Finance
4. Property
5. Research
6. Procurement
7. Relationships
8. Marketing
9. Management
10. Production
11. Materials
12. Energy
13. Processes.

Based on this review it can be concluded that the profession of industrial arts education has been concerned and continues to believe that subject matter organization by conceptual models is of value. A variety of processes have been used to identify concepts and structure models relative to industry and industrial practice. The need then is to review works that have dealt with the conceptual organization of communication technology.

RESEARCH RELATIVE TO COMMUNICATIONS TECHNOLOGY

Several major curriculum works address the area of communications in a broad sense. The first must be Warner's work which included a "Communications Division" in *A Curriculum to Reflect Technology*. Warner's proposal saw the introduction of a communications division which was conceptually organized. An outline of the section follows.

A CURRICULUM TO REFLECT TECHNOLOGY
THE COMMUNICATIONS DIVISION

<table>
<thead>
<tr>
<th>COMPOSITION &amp; DUPLICATION</th>
<th>TRANSMISSION &amp; RECEPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphic Arts-Sound, Recording</td>
<td>Mechanical-Electrical</td>
</tr>
<tr>
<td>Drawing, sketching, Drafting, Blueprinting</td>
<td>Telegraphy, Telephone</td>
</tr>
<tr>
<td>Letterpress</td>
<td>Radio</td>
</tr>
</tbody>
</table>
Photography
Intalagliography
Planography
Duplicating
Sound Recording
Teletype
Facsimile
Television
Multi-Channel Methods
Radar

INTERPRETATION
Visual, Sounds & Codes
Historical
Signal flags
Lights
Sound devices

The American Industry Project (Face & Flug) included in its list of 13 concepts that of communications. The area of communications was a part of both the level 1 and level 2 instructional materials. The level 1 materials saw the following conceptual outline identified:

AMERICAN INDUSTRY LEVEL 1
COMMUNICATIONS CONCEPT

A. Source
B. Vehicle
C. System
D. Receiver
E. Feedback
F. Interference

In the American Industry materials, communication was viewed, as all 13 concepts were, as a conceptual part of all industries. It was not used as a tool to identify communication technology nor the communication industry.

William E. Huss (1967), a professor at the State
University College, Oswego, made a presentation at the AIAA conference entitled "Communications Technology" in which he argued that the process of communications technology may be conceived as the design of a complex system through the process of coordinating all elements that make up the system and taking into account their interactions as well as their individual characteristics. Huss' proposal stated:

This proposal searches for channels of communication that connect various disciplines as a means of developing a sense of structure. It pulls courses apart into concepts and components and then attempts to reconstruct them into a new, single discipline.

The design of a complex system such as the proposed curriculum by the process of coordinating all elements that make up the system as well as their individual characteristics is known as systems engineering (p. 137).

Huss' work was a proposal to structure communications technology, and was a well stated one at that. It was only a proposal through. It did not contain a specific example of what this new structure for communications might be nor how it would be created. Huss' ideas, presented in 1967, demonstrated a need that has yet to be fulfilled in
the investigator's opinion.

Halfin's dissertation, *Technology-A Process Approach* identified communicating as one of the processes of technology. Communicating was defined as, "The process of conveying information (or ideas) from one source (sender) to another through a media using various modes."

It is interesting to note that communicating was also identified as a process of science in Livermore's (1964) *Science-A Process Approach*. Halfin's work in identifying technological processes was based on Livermore's earlier work in identifying scientific processes.

Within recent years the most notable work to include communication was the *Jackson's Mill Industrial Arts Curriculum Theory*. The authors of this document defined communication as, "a technical adaptive system designed by people to efficiently utilize resources to transfer information to extend human potential."

The work went on to identify the following concepts of communication.

**JACKSONS MILL COMMUNICATION CONCEPTS**

A. Encoding
B. Transmitting
C. Recieving
D. Storing
The Jackson's Mill project, being the most recent work to identify communications as an integral part and being widely accepted by the profession, is being accepted here as having identified appropriate concepts for the study of communication.

The Jackson's Mill Industrial Arts Curriculum Theory warrants a more detailed review. As stated, chapter one of this dissertation was premised upon the communication concepts as identified in the Jackson's Mill document. For years educators have found value in classifying and structuring content areas for study. The Jacksons Mill Industrial Arts Curriculum Theory identified four domains of knowledge. These four were the sciences, humanities, technologies and formal knowledge. It was argued in Jackson's Mill that these four domains of knowledge provide the cognitive base for human adaptation in the natural environment. Formal knowledge was identified as language, linguistics, mathematics and logic and as such provided both form and structure to the other three identified domains.

The Jackson's Mill group went on to describe three "human adaptive systems." These adaptive systems, used by people, can be studied to understand how people, society and
technology have evolved. The three systems are technological, sociological and idealogical. Technological systems pertain to the technical system used to manipulate the man-made world and natural environment to meet man's needs and wants. Sociological systems pertain to how we organize our societies into some structure. Idealogical systems deal with the beliefs and values of individuals within the society. Human adaptive systems interact with the domains of knowledge with each contributing to the other.

The concept of a system was further discussed in the context of a "universal systems model." This universal systems model consists of input, processes and outputs. The input portion of the model identified all of the needed resources to accomplish the goals of the system. The processes portion of the model dealt with the practices used to transform the input resources into some desired output. The output of the system pertained both end products or outcomes of the system. Inputs, as identified in Jackson's Mill, included people, knowledge, materials, energy, capital and finance. Processes of construction, manufacturing, transportation and communications were defined as part of the systems model, while outputs might include constructed structures, manufactured products, transported people and/or goods and communicated information. It was through this logical sequence of ideas that the Jackson's Mill Industrial
Arts Curriculum Theory identified communication as a human adaptive system and thereby warranted study. The project went on to identify first order subconcepts for communication as previously discussed.

Curriculum development in communication technology continues to struggle in terms of a clear organizational outline. This is evidenced by the lack of research conducted in the area. Nonetheless the area holds great potential for technology education as a key component to technological literacy which must deal with communication technology. Few researchers have attempted to deal with the great breadth encountered in the communications field. The most notable work has been done in the area of graphic arts with several studies found that dealt with the conceptual organization of graphic communications subject matter. While several of these studies suggested they were studies of the communications industry, they all focused on the graphic arts portion of the industry and not the communications industry as a whole. Several of these works suggested they were studies of visual communications or graphic communications but only in a very narrow sense of the term. Visual communication must include television and other formats of dynamic visual imaging. Graphic communications must include computer generated graphics both of the static and dynamic type. These studies did present a conceptual model for a part of communication
technology but failed to address the entire area. They will be valuable as they relate to a wholistic approach.

Bentley (1984) worked to develop a set of cognitive organizers for the area of graphic communications. This work appears to be the most recent attempt at such an organization for graphics and, as such, will be of value as it identifies concepts that may be useful in a model of communications technology. Karsnitz (1976), while focusing on the status of program offerings in graphic arts relative to a validated body of knowledge, also produced materials that may be of value in the derivation of a communications technology model.

Other works in the area of electronics were found that dealt with the electronic communications area again with the intent of building conceptual models for the study of electronics. These studies will be valuable as electronic communications ideas must be a part of any communications technology model and will then lend important information for the derivation of the model.

The most valuable and extensive work in the area of electronics is that of Inaba (1970) who identifies communication technology as a part of his study of electronics. Inaba does an excellent job of identifying the interrelatedness of electronics to communication technology. His work was the only recent dissertation found that spent considerable time defining the whole of communications
technology before concentrating on electronics technology. Inaba notes the lack of extensive work in the area of structuring a model for communications technology. He believes communications technology involves the transferring of ideas, knowledge, information, feelings, gestures, etc. through a process of communications which essentially consists of encoding, transmitting, receiving, decoding, and feedback. Communications technology is taken to mean the knowledge of the communicating devices used in the process of communications. Inaba notes that this notion is misleading because communications technology includes more than just the "hardware" of communications, but rather the term applies broadly to the total communications technology process. This is an important point. Any model of communications must address discrete devices used in communicating but it must also deal with the systems of which these devices are a part. We continue to see great diversity in system configurations using numerous communicating devices. We must understand the processes, devices and the systems they create.

Another recent dissertation dealing with communications was that of Richter (1980) who created and validated a test for technological literacy in the area of communications. This work is of interest not because of the test but in terms of how Richter identified the body knowledge of communications
from which to construct test items. Richter chose not to use a content domain for communications identified by the industrial arts profession, perhaps acknowledging the lack of such a structured content model. Kranzberg's (1967) *Technology in Western Civilization* was used with Richter selecting the portions of that document that deal with communications. While this is an interesting work, one wonders if the constructed test is a test of technological literacy in communications or a test dealing with the history of communications as Kranzberg's work is a historical document.

Two textbooks done by industrial arts/technology educators are worth noting. Hauenstien and Bachmeyer (1974) developed the text *The World of Communications-Visual Media* in which the authors suggest the study of communications in a comprehensive fashion. The authors suggest identifying a conceptual model of communications as follows.

<table>
<thead>
<tr>
<th>Encoding</th>
<th>Transmitting</th>
<th>Recieving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percieving</td>
<td>Gesturing</td>
<td>Seeing</td>
</tr>
<tr>
<td>Comprehending</td>
<td>Touching</td>
<td>Reading</td>
</tr>
<tr>
<td>Symbolizing</td>
<td>Speaking</td>
<td>Hearing</td>
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<tr>
<td>Organizing</td>
<td>Writing</td>
<td>Feeling</td>
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<tr>
<td>Valuing</td>
<td>Drawing</td>
<td>Smelling</td>
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<td></td>
<td></td>
<td>Tasting</td>
</tr>
<tr>
<td>Storing</td>
<td>Retrieving</td>
<td>Decoding</td>
</tr>
<tr>
<td>Classifying</td>
<td>Recalling</td>
<td>Perceiving</td>
</tr>
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<td>Memorizing</td>
<td>Restating</td>
<td>Interpreting</td>
</tr>
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<td></td>
<td></td>
<td>Synthesizing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Responding</td>
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</tbody>
</table>

While the text was an early attempt at defining
communications as a content area, it is problematic as the identified subconcepts are human communication practices and not technical communication acts. While the text goes on to discuss technical aspects of the communication process, the conceptual model is not used as a fundamental organizational structure. The author of this text and its model seem unable to devise boundaries for communications technology.

A more recent text by DuVall, Maughan and Berger (1981) titled *Getting The Message: The Technology of Communication* also discussed the concepts of communications identifying the same major concepts as Jackson's Mill. The authors chose to cluster related communications practices identifying chapter titles of: Technology-Based Visual Systems, Technology-Based Electrical Telecommunication Systems, Technology-Based Acoustical Systems and Technology-Based Electronic Telecommunication Systems. The authors also include chapters on Human Communication & Perception and Major Systems in Which Communication Occurs which deal with human and animal communication systems among others. While the technical portion of the text is interesting, the overall outline includes content more appropriately taught by other disciplines as it is not a part of the technical process of communication.

This review illustrates that many have been concerned with structuring the area of communications technology but
few have attempted to do it in a conceptual form. The cited works will be of value as they have sought to conceptualize pieces of the whole and thus can be integrated into the whole. There is a need to develop a model that is conceptually interrelated, broad in its coverage and technically accurate.
CHAPTER 3

METHODOLOGY

Industrial education as a profession has always been concerned with relevant curriculum development and the subsequent validation of that curriculum. This dissertation continues the pursuit of knowledge important to curriculum developers by designing and validating a conceptual model in the area of communications technology.

The task of creating and validating program content was an easier task when the primary content base for the profession was the trades. The manual training teacher could look to the specific tradesman and validate content via comparison of the tradesman's tools, techniques and processes with those used in the school shop setting. As our content base shifted to that of industry and our programs began to simulate the activities and practices of the social institution called industry our validation tools relied on having industrialists review content. Both the American Industry Project and the Industrial Arts Curriculum Project made extensive use of industrialists for content review and validation. As our content base
again makes a shift, this time to reflect technology as our dominant content base, curriculum builders must use a variety of tools to design and validate programs for the study of technology.

Prior to describing the methodology used by the investigator in the creation and validation of a conceptual model for communication technology, a review must be made of the tools and practices used by recent curriculum designers. The methods of validating curriculum to be included in this review are as follows:

A. The Delphi technique
B. Face-to-face expert panels
C. Industry analysis/questionnaire
D. An extended dissertation committee
E. The dissertation committee

THE DELPHI TECHNIQUE

The Delphi technique has a varied history as a tool used by technology educators for curricular decision making. The Delphi is a research method which incorporates the employment of a group of experts (Judd, 1972). The Delphi is characterized by anonymity of responses, multiple interactions, and convergence of the distribution of answers while preserving intact a distribution that may still remain wide. As a research
tool, the Delphi technique is most often associated with an expert panel and predictions of possible future events (Dybas, 1980).

The Delphi was first developed by the Rand corporation (Judd, 1972) and while the technique was not designed specifically for educational research, it has been used by numerous educators for a wide range of purposes. The technique, which has been called the systematic use of expertise, normally incorporates four carefully designed interrogations. Pfeiffer (1968) outlined the technique as follows:

1. The first questionnaire may call for a list of opinions involving experienced judgment, a list of predictions or recommended activities.

2. On the second round, each expert receives a copy of the first and is asked to rate or evaluate each item by some criterion such as importance, probability of success, and so on.

3. The third questionnaire includes the list and the ratings, indicates the consensus if any, and in effect, asks the expert to revise his/her opinion or else specify reasons for remaining outside the consensus.

4. The fourth questionnaire includes the lists, ratings, the consensus, and minority opinions. The
questionnaire asks each expert to agree to the consensus or state reasons for remaining outside the consensus group. (p. 68)

While the Delphi technique is being used in a much broader range of settings than initially designed, it appears to be most appropriate under the following conditions (Turoff & Pill, 1971):

1. The respondent group has very little time to devote to the effort because of other commitments.
2. Disagreement may exist among the experts to the extent that a refereed communication is desired.
3. Questions to be answered by intuitive judgments supersede questions to be answered by concrete measurements.
4. There is no way of immediately confirming the results.
5. The questions are subject to many interpretations and thus cannot be found through traditional methods of research.
6. The desirability of overlooking some facet of a question can be minimized by a diversity of group opinions.
7. A cross fertilization of opinion is desired which may lead to innovations and breakthroughs.
8. The expertise of the group is more desirable than
the opinions of one expert.

9. It is necessary to minimize the psychological aspects of face-to-face confrontation. (p. 57-71)

These criterion which identify appropriate situations for use of the Delphi suggest that there are situations where curriculum development activities may be enhanced by its use. Turoff and Pill (1971) suggest that one advantage of the Delphi is that it minimizes the psychological impact of face-to-face confrontation. However, Turoff and Pill emphasize the negative or conceivably negative impact of a panel of experts meeting face-to-face. What they fail to realize is that one disadvantage or shortcoming of the Delphi may be the use of a panel of experts without ever allowing them to meet and discuss the issue at hand.

The investigator was concerned with the use of the Delphi by technology educators to validate conceptual models or other curricular strategies. A brief review of dissertations that used the Delphi related to technology education follows. This review focuses solely on the use of the Delphi in terms of a research tool; those dissertations which relate to communications models have been reviewed in greater detail in the chapter two.

Halfin (1973) used three rounds of the Delphi in his study "Technology: A Process Approach" with an expert panel of twenty-eight members. Halfin's study has been
the basis for the process approach to curriculum organization mentioned earlier. Through scholarly research, Halfin identified the processes universal to all technologists and then modified them and validated them through the Delphi process. Halfin chose not to rely on the expert panel to create the initial list of processes, but rather created the list from his research. Halfin's work demonstrates that taking an investigator developed model to a panel of experts for validation is a workable approach resulting in a valid model.

Sterry (1976) in "A System to Manage Resource Information Appropriate to Industrial Education" structured a model or system for the classification of contemporary resource materials in industrial education. The structure was designed and then modified through three rounds of the Delphi. Sterry's work also demonstrates the usefulness of an investigator creating an initial model and then taking it to a panel of experts for review.

The Delphi technique was also employed by Lawrence (1980) in his work "Applications of the Delphi Technique in Determining Automotive Technologist Curriculum Content." Lawrence used three rounds of the Delphi to establish an initial list of competencies and gain consensus on the accuracy of the identified competencies. While Halfin's and Sterry's work used the Delphi for
rather broad-based curricular activities, Lawrence demonstrates the Delphi's usefulness for determining more specialized, narrowly focused technical concepts.

Dybas (1980) used the Delphi to identify curriculum concepts for the creation of electronics programs in "A Delphi Approach to Industrial Arts Teacher Education Electronics Curriculum Identification" while Griscom (1981) used an identical technique for the identification of concepts of data communications. Both of these dissertations used the Delphi process to establish, as well as validate, curricular concepts. Dybas and Griscom made use of experts, through the Delphi, to validate subconcepts of the area of communications technology. Dybas' and Griscom's work demonstrates the usefulness of the Delphi for curriculum development in the area of communications.

Two other uses of the Delphi in areas related to technology education are of interest. Hales (1972) used the Delphi process to identify and validate a set of concepts that characterized the idea of "technological literacy" in secondary students. Bindocci (1983) used the Delphi to identify content areas for the study of technology in her work, "Identification of Technology Content for Science and Technology Centers."

The Delphi appears to be a valuable method of using
the collective expertise of people in the know. The Delphi has demonstrated usefulness both in broad-based curriculum development activities and detailed technical content validation. The investigator feels that the modification of the Delphi process to include face-to-face meetings is an appropriate alternative for curriculum development.

FACE-TO-FACE EXPERT PANELS

Any time a group meets, there is the potential for a synergistic output from the identified experts. Indeed, the product of the collective efforts of an expert panel, meeting face-to-face, may be greater than the total output of the individual members.

The Jackson's Mill Industrial Arts Curriculum Theory may be a good example of the synergy that emerges from the meeting of an expert panel (Bensen, 1985). The Jackson's Mill document is clearly one of the more significant documents impacting the profession today. A consensus was forged at Jackson's Mill which provides the basis for much of the technology education movement. If the Jackson's Mill document proves to be as important and respected a document as many in the profession feel it will be in charting a new course for the profession, then the process of arriving at the document warrants investigation and
review. For this reason, the investigator met on several occasions and discussed both the processes used, as well as the product, with Dr. M. James Bensen, a Jackson's Mill Project participant.

Central to the Jackson's Mill project was the process of identifying the participants. A key ingredient to any project which intends to use a panel of experts is the identification of the panel who are indeed considered the experts. While this may appear an easy task, in reality it may be a difficult one. The Jackson's Mill project was started by Dr. James Hales and Dr. James Snyder who received endorsement from the then American Industrial Arts Association and subsequent funding from the Technical Foundation of America. Hales and Snyder identified a person who they believed was an acknowledged leader and curriculum designer in the profession and asked him to identify two other people he believed to be the best curriculum thinkers in the profession. No one seems to know the identity of this first individual.

The two originally identified curriculum theorists where then sent the same kind of request. This process of asking a person to name two others who are, in their estimation, the best curriculum thinkers in the profession continued until the process began to produce the same names over and over. This list of twenty-one constituted
the panel of experts which met and produced the *Jackson's Mill Industrial Arts Curriculum Theory*. Hales and Snyder had not determined how large or small the group would be prior to beginning the identification process nor were they concerned with geographical locations as they had project funding to support travel and lodging.

The initial meeting of the Jackson's Mill participants saw a group of recognized experts begin to design a statement of philosophy and curriculum structure to which all could agree. The group attempted to arrive at a consensus opinion through debate and discussion as one large group. After this initial meeting tasks were identified and subgroups formed. After each subgroup studied their assigned task, coming to an intellectually defendable position, the subgroups work was reported back to the entire group. The large group then worked until consensus was reached on the subgroup's report. In this fashion the concepts for the communications section of Jackson's Mill were identified and validated by the group. Bensen (1985) recalls little disagreement taking place relative to the communications concepts identified. Jackson's Mill serves as a good illustration of the benefits of repeated face-to-face meetings by a recognized panel of experts. Jackson's Mill made effective use of an expert panel which benefitted from face-to-face
interactions. The process of having an expert panel meet, discuss, debate and interact with a model seems of utmost importance if the expert panel is to be used to its maximum potential. The face-to-face interaction of people and ideas is critical.

Hauenstien (1966) also used a process of face-to-face meetings with a panel of experts to validate a taxonomy for the area of construction. Hauenstien identified several principles upon which he relied for structuring the process in the development of his model. In terms of validation, the key principle was that the taxonomy must reflect major distinctions between construction practices as agreed to by architects, contractors and engineers. Hauenstien, while receiving funding as a part of the Industrial Arts Curriculum Project, held two face-to-face meetings with experts from various facets of the construction industry to validate his taxonomy of construction concepts. Hauenstien arrived at the original draft by scholarly study and the review of previous works in the area of construction education as well as making use of data derived from a questionnaire sent to people in the construction trades. The taxonomy of construction concepts identified by Hauenstien was an integral part of the World of Construction materials developed by IACP. The World of Construction remains a vital instructional
resource, in part, because of its solid foundation on a taxonomy of construction practices. Hauenstien's work is an excellent example of the benefits to be derived from designing instructional systems on sound taxonomies of technical areas. Hauenstein's work emphasizes the value of two procedures. First, using a face-to-face meeting to validate a taxonomy, second, seeking technical reviews from people with technical backgrounds. Hauenstein made effective use of architects, engineers and contractors in validating his construction taxonomy. Hauenstein did not ask technical experts to make curriculum development decisions, but rather used technical people to validate a taxonomy which would then serve as a valuable tool in the curriculum development process.

While several researchers asked the expert panel to actually identify the concepts for a taxonomy, the most successful conceptual models demonstrate the research of the investigator in building the initial model as a central element. Taking a proposed model which has been initially developed as a result of a substantial amount of research seems a more logical and fruitful approach to building a taxonomy than asking a group of experts to design the initial taxonomy. In the interest of making wise use of the time actually spent in face-to-face meetings, it suggests the value of asking the expert panel
to react to a model rather than to create one from scratch. The work of Halfin, Hauenstien and others makes this point.

INDUSTRY ANALYSIS/QUESTIONNAIRE

Other researchers have used various methods to solicit information from knowledgeable people for the purpose of curriculum development. Berry (1967) used a questionnaire/check sheet containing a validated list of related factors and processes for the manufacturing industries to derive specific course content for industrial arts. Berry's work focused on using an industry analysis approach to identify common factors or processes of the manufacturing industries of New England and further identify a priority listing of these processes and factors. Those functions which were indicated by better than seventy-three per cent of the respondents were considered valid for determining curricular components.

Another approach to validating curriculum was that of Pickle (1983) who was concerned with the identification of a high technology curriculum for industrial technology and technology education. Pickle designed and used two questionnaires. The first questionnaire was sent to a group of high technology industries and participants who were asked to identify courses valuable for their
respective occupations. A second questionnaire was sent to departments and programs of industrial technology to determine current course offerings relative to high technology occupations. Pickle's attempt was to compare industry needs, as identified through the questionnaire, with current collegiate offerings. His hope was to impact offerings in industrial and technology education programs.

AN EXTENDED DISSERTATION COMMITTEE

Several researchers have used an extended dissertation committee involving educators at various institutions to review and evaluate content and activities for technology education. Squire's (1981) work in the area of a service enterprise unit of instruction exemplified this strategy for curriculum design and validation. Squire used a number of university educators, including Umstattd of OSU and Sterry of Stout to review the proposed content for a unit in the area of service. Squire tested the activities for this service unit via a field test of the instructional unit with experienced classroom teachers who evaluated and criticized the activities as well as made recommendations for improvement. Having served as an evaluating classroom teacher for Squire's work, the investigator viewed the process as a valuable one for curriculum design and review. This
reaction is based on the observation that Squire asked the right people the right questions. He asked university educators to validate the content for his proposed unit and then asked practicing teachers if the activities were effective in teaching the content. Squire asked different groups different questions to validate his materials. Using the input from both groups, he produced a valuable set of instructional materials.

THE DISSERTATION COMMITTEE

The use of the dissertation committee as a review and validation agent has also been a strategy for curriculum development and validation. The work of Delmar Olson is most notable. Olson (1950), in his dissertation "Technology and Industrial Arts", recommended that the subject matter for industrial arts should be developed around the technology in use in industry. William E. Warner served as chairman on Delmar Olson's dissertation committee. Olson's dissertation was highly regarded in the profession and led to other work by Olson that pointed new directions for the profession of industrial arts. The process used by Olson and his committee resulted in a valuable contribution to the profession. Delmar Olson's work and process suggest that the combination of a skilled, hardworking doctoral candidate and a demanding
advisor can indeed be a powerful combination. The perseverance of the researcher and the intellectual challenge as issued by the dissertation advisor may indeed be the key elements to meaningful research which will impact the profession.

A more recent work, also reviewed by the dissertation committee, was that of Inaba (1970). Inaba's work was an excellent conceptualization of first order concepts of communication technology similar to those of the Jackson's Mill document. While Inaba did not go beyond the identification of first order concepts in all identified areas, he did develop indepth materials in the area of electronic communication systems. Inaba makes no reference to the use of any evaluation strategy other than the review of his work by his dissertation committee. The body of knowledge of communications is well reviewed by Inaba and the unit of instruction developed around electronic communication is of high quality and would make a valuable contribution to any technology education program. Inaba's methods resulted in a well designed set of curriculum materials.

SUMMARY OF METHODOLOGY REVIEW

It becomes apparent that as a profession we have employed a number of different strategies for the purpose
of designing and validating curriculum models and content. A number of these strategies seem appropriate as they resulted in curricular materials that are valuable to the profession. It is apparent that a number of possible "right ways" have been developed.

A number of other conclusions can be derived. The profession of industrial arts has a long history of making use of the opinions of experts to validate curriculum. Both formal and rather informal designs have been used in this systematic use of expertise. The use of a panel of experts has been employed both in a face-to-face interaction mode and a paper/pencil mode with no verbal or written interaction between expert panel participants. Both face-to-face and paper/pencil strategies have advantages and disadvantages. Our history of curriculum development demonstrates that technology educators do indeed have access to knowledgeable individuals who can help determine and validate content.

Clearly, the Delphi technique is less costly and easier for a researcher to manage. However, one can easily see that there is no potential for a synergistic experience in this mode of expert panel review. Face-to-face meetings while complicated by expense and meeting arrangements allow for the interaction of the expert panel with the potential outcome greater than the
individual participant's review and reaction in isolation. Both approaches to the use of experts are only as valuable as the experts are qualified. Asking the right people the right questions is the key. The panel selection process may be a formal process such as recognized leaders being asked to identify other recognized experts as in Jackson's Mill or an outside review panel making the expert panel selection as used in Dybas's work. Another approach would be the selection of a panel with the approval of the dissertation committee. Whatever the process, the important outcome is asking the right people the right questions and using their responses appropriately thereby benefiting from their expertise in validating developed materials.

The investigator believes that this review of methodology suggests several techniques which must be incorporated into the procedures which follow. It seems appropriate that an investigator developed model be taken to the expert panel for review rather than ask the panel to expend the time required to develop a model of communications technology. Several researchers used this approach of developing the model or taxonomy to which the panel would be asked to respond.

The Jackson's Mill process, Hauenstien's work and others demonstrates the value of a face-to-face meeting of
the identified experts. The negative aspects of asking a group to meet and interact around a model appear minor when compared to the possible output from such a meeting. The disadvantage of such a meeting is working within a geographic boundary where all experts can get together easily or working around a convention at which many of the experts will be in attendance. While this is a complication of the process, it is one that can be effectively dealt with. A good share of the professions finest curriculum work appears to be the result of getting good minds together to discuss, develop and interact with contemporary curriculum ideas.

The work of Squire, Hauenstein, Berry and Pickle reinforces the concept of asking the right group of experts the right questions. Asking technical people to make judgment as to the accuracy of a technical model and asking curriculum people to make judgments about curriculum concepts appears logical. Individuals with expertise in the development of taxonomies can make evaluations about the process and logic used in the taxonomies development without being technical experts in the area. Technical specialists may struggle with the identification and organization of a concept model but can determine the accuracy of the technical concept as used. Several researchers have used expert panels for the
identification of broadbased materials, as in the case of Halfin, while others such as Lawrence, used experts to validate narrow technical concepts. This dissertation attempted to do both, identify a broadbased concept model of communications technology as well as identify specific, narrowly focused subconcepts of the major concepts. This dissertation molded together the procedures used in isolation by numerous researchers and curriculum developers in an attempt at accomplishing several tasks in one work.

PROCEDURES

Having reviewed the strategies and methods used by a number of researchers in a variety of settings what follows is a detailed plan of the procedures used in this project. The process used for the design and validation of a conceptual model for the organization of communication technology involved nine specific steps. The purpose of each step and the processes used will be described and detailed. For the model of communications technology to be valid and useful, it must be both conceptually sound and technically accurate. The investigator believed that an appropriate approach was to make use of two specific groups of people; one group who posses expertise in conceptual model development and a
second group who are technical experts in various areas of communications technology. These two groups of experts will ensure both the overall design of the taxonomy and that specific concepts identified are valid. While some individuals may possess both identified characteristics—the ability to conceptualize and specific technical expertise—the investigator believes that an insufficient number of these people are available. Furthermore, separating the development and review of the technical details from the development of the overall model is more logical and workable. With this as an introduction, a description of each of the nine steps for the creation and validation of a conceptual model in communications technology follows:

**Step 1** Create the initial version of the model of communications technology.

**Step 2** Submit the initial model to an expert panel review focusing on the conceptual soundness of the model.

**Step 3** Revise the model based on input from the review done in Step 2.

**Step 4** Conduct a series of interviews with technical specialists with the focus being on the technical accuracy of the proposed concepts.

**Step 5** Revise the model based on input from
the technical specialist group.

**Step 6** Validate the revised model by submitting it to both of the identified groups and obtaining their written feedback.

**Step 7** Revise the model based on input from the written feedback obtained in Step 6.

**Step 8** Conduct a final face-to-face review of the model with those members of the initial concept group and other selected technology educators who are in attendance at the ITEA conference in Kansas City.

**Step 9** Revise model as appropriate based on the review conducted in Step 8.

The following is a further discussion of each of the identified steps including the objective, anticipated results and procedures used.

**Step 1**

The objective of Step 1 was to review the concepts of communication as identified in the Jackson's Mill project to verify the process used to identify the concepts and their usefulness of further development. A further purpose was to identify an initial set of subconcepts for each of the identified Jackson's Mill concepts.

The procedures for accomplishing this objective was a careful review of the Jackson's Mill Industrial Arts
Curriculum Theory including repeated, indepth discussion with participants of the project as well as a review of all written project materials as archived by Dr. M. James Bensen.

For the objective of identifying the subconcepts to the Jackson's Mill communications concepts, a careful review of existing taxonomies relative to communications technology was undertaken as well as a review of numerous technical books, journals, reports, etc. This material review was coupled with continued participation by the researcher in a wide range of communications related seminars and conferences both nationally and in the midwest.

The result of Step 1 was a conceptual model of major concepts and subconcepts that demonstrates a systematic, scholarly review of the communications technology field. The model was detailed enough as to be ready for review by a panel of experts.

Step 2

The objective of Step 2 was to have the initial model reviewed with a focus on its conceptual soundness. This would then serve as the first step in the validation process.

To accomplish this objective, an expert panel was identified and reviewed by the dissertation committee
chairman. The criteria identified for the selection of the expert panel were as follows:

1. The panel member should possess demonstrated abilities in the development and validation of conceptual taxonomies.
2. The panel member should possess an understanding of the nature of concepts and their value in curriculum development activities.
3. The panel member should possess an understanding of the changes taking place in industrial arts either as a result of their involvement in the profession or as a result of the investigator's introductory materials.
4. The panel member should possess an understanding of instructional design principles.
5. The panel member should have a working knowledge of new communication and information technologies.
6. The panel member must be able to attend a meeting in Columbus with little or no travel reimbursement provided by the investigator.

These criteria are listed in no particular order. Various panel members possessed strengths in all of the listed criteria while others had demonstrated strengths in some of the areas. It would be difficult to identify an expert
panel with strengths in all of the above listed areas. One of the shortcomings of face-to-face meetings of expert panel members is the need to limit the panel to a geographic area which will allow for the meeting to take place with little or no expenses. However, the investigator believes that this limitation does not impact this study in a dramatic fashion because of the nature of The Ohio State University. One reason the investigator chose to attend The Ohio State University was because of the concentration of highly regarded individuals who make up the faculty. The investigator believes that the nature of the institution lends itself to this use of a face-to-face expert panel review.

This process was followed by making arrangements for the identified panel to participate in a face-to-face meeting at The Ohio State University. A detailed procedure for conducting this first meeting was developed and submitted to the dissertation committee chair prior to conducting the meeting.

The result of Step 2 was a model that the panel believed to be conceptually sound at a minimum of first and second level major concepts. Major strengths and weaknesses of the model were identified as a result of this meeting. The researcher also inquired about strategies for eliminating weaknesses in the model and the
process from the panel.

**Step 3**

The objective of Step 3 was to use the review conducted in Step 2 to revise the original model.

**Step 4**

The objective of Step 4 was to submit the model in revised form to a group of technical specialists for review. This group of technical specialists included people with technical knowledge concentrated in an area. This group included, but was not be limited to, specialists in: computer hardware and software, video tape and disc, radio and TV, telecommunications, graphics, electronic communications, etc. Two specialists were identified in each of the following communication areas:

1. Voice communications systems
2. Data communications systems
3. Video communications systems
4. Graphic reproduction
5. Computing as it relates to communications

The investigator selected these individuals based on demonstrated technical expertise as evidenced by degrees, current position held, previous work experience or a combination of all three. Because of the investigator's knowledge of communication specialists in Wisconsin, the extensive number of people available, and the cost of
conducting interviews outside the state, the technical 
specialists were selected from within the state. A list 
of the selected individuals and the reasons for their 
individual selection were submitted and approved by the 
dissertation advisor prior to their interview.

This group was interviewed on an individual basis with 
the prime focus being on the technical accuracy of the 
identified concepts and subconcepts. The interview 
process asked the specialist to only react to those 
concepts and subconcepts which they felt technically 
competent to analyze. This restriction was in realization 
that the breadth of the model would prohibit most 
individuals from being comfortable and confident 
responding to it in its entirety. The investigator 
required that each concept and subconcept be reviewed by 
at least three specialists.

**Step 5**

The objective of Step 5 was to revise the model based 
on the input of the technical specialists as collected in 
Step 4.

**Step 6**

The next step in the validation process was to submit 
the revised model to the OSU expert panel and the 
technical specialists. The objective was to validate that 
the comments, criticisms and recommendations of the
individuals involved in the first phase of the validation were accurately incorporated into the revised model. Each participant was asked to re-evaluate the model, or as much of it as they felt comfortable with, to determine if the modifications made were logical and accurate.

**Step 7**

The objective of Step 7 was a second revision of the model based on the input received as a result of Step 6. This revision focused on second and third level concept refinements.

**Step 8**

The objective of Step 8 was a final review by a group of technology educators. This group consisted of those original expert panel participants who attended the 1986 ITEA Conference at Kansas City and other selected technology educators as approved by the dissertation committee chair prior to the conference. This final review would be for the purpose of again reviewing the developed model and determining the value of the model to curriculum development efforts in the profession.

**Step 9**

The objective of Step 9 was the final revision of the model based on input gained from the face-to-face meeting held in Kansas City.
SUMMARY

The investigator believes that following the process identified resulted in a conceptually valid model for the study of communications technology. The developed model is technically accurate as a direct result of the interaction of technical specialists and conceptually sound as a result of the review by educators.

The investigator believes the process of face-to-face meetings, interviews, and paper/pencil reviews was a reasonable process of validating a model in light of the resources typically available to a doctoral candidate. The process employed made use of the strengths of several validation processes and bypassed many of the problems inherent to some of the reviewed processes. The process was a hybrid. The process was an attempt at taking procedures used by other researchers in different settings and combining them for the purpose of developing major concepts and subconcepts for communications that were accurate and logical. While the Delphi is a series of rounds expected to get convergence of ideas around a topic that is fixed, this work used a series of interrogations with the model or topic changing based on received input. While the Delphi is used primarily without face-to-face
meeting this work incorporated both face-to-face and written evaluations. The process made use of two separate groups of experts, asking each to deal with a specific portion of the model where a traditional Delphi would use one expert panel. This dissertation procedure shares with the traditional Delphi the purpose of making maximum use of the collective expertise of a group of people in the know.

It is believed that the end product is a valuable contribution to the profession and a tool to further organize content relative to communications technology.
CHAPTER 4

FINDINGS

It was the intent of this research to develop and validate a taxonomy of the concepts for the area of communications technology. The development and subsequent validation process was a hybrid, making use of a variety of strategies to accomplish the end. In order for the reader to fully understand the completed taxonomy and assess the value of it, a review of the validation procedures is presented. This review of the process is followed by an analysis of each step and an evaluation of its usefulness to the research project.

After reviewing the process of development and validation of the taxonomy a step-by-step evolution of the taxonomy is presented to illustrate the actual modifications made to the taxonomy as a direct result of each validation step. The final version of the taxonomy appears in Appendices E for reference in this discussion. Prior versions of the model appear in the appendices and their review may be helpful in understanding the progression of development.
The conclusion of this chapter contains the beliefs of the investigator regarding the overall validity and usefulness of the taxonomy. In following the progression of ideas as presented, an understanding of the procedures used and the product of this research can be obtained.

The proposed development and validation process incorporated nine steps. After the initial version of the model was created in step one, it was submitted to a panel of experts for review in a face-to-face meeting held at The Ohio State University. This first expert panel consisted of individuals from the technology education profession as well as the educational technology area. The identified task for this initial group was to review the taxonomy for its conceptual soundness and, furthermore, to analyze the rules of logic as applied by the investigator and used in the initial development. Step three was to use the written reviews and other information gathered from this first meeting to complete the first revision of the taxonomy. After completing the revision required in step three, a series of individual interviews took place between the investigator and technical experts as identified in business, industrial and educational settings. The focus of this review dealt less with the conceptual soundness or the rules of logic but rather with the technical accuracy and overall
comprehensiveness of the taxonomy.

In completing the technical specialists interviews, a revision of the taxonomy was warranted. This revision was then sent back to the technical specialists interviewed in the previous step and the expert panel that met at The Ohio State University. Both of these groups were asked to perform a paper and pencil review of the taxonomy as individuals and return their responses to the researcher. After receiving this written evaluation from all individuals involved, the taxonomy was revised to reflect the input. This revised version of the taxonomy was then mailed to a group of technology educators who had responded to an earlier inquiry and had agreed to participate in an informal group meeting to take place at the International Technology Education Association meeting held in Kansas City. The Kansas City group consisted of members of the original Ohio State meeting group as well as other selected technology educators who either had a history of being curriculum innovators and/or had specific experience in developing curriculum or teaching in the area of communications technology. The input gained from the Kansas City experience was then incorporated into the final revision of the model. This is an overview of each of the steps involved in the development and validation of the taxonomy. Only minor changes were made from the
proposed procedures.

For the most part this validation process served its identified purpose. The validation process saw a number of different evaluation strategies incorporated into one process. As such, some discussion of the usefulness of each step seems appropriate.

The development of the initial version of the taxonomy, identified as step one, was the pulling together of technical study done over the past several years in the area of communications technology as well as researching numerous new technical areas. This research included study in a wide range of disciplines; technology education, educational technology, communications systems engineering, communications science, library science and computer science to mention a few. The breadth of the Jackson's Mill communications concepts forced research and study to be undertaken in a very broad range of disciplines related to communications technology. If the taxonomy was to be wholistic, it must address the numerous and varied facets of communications as addressed by a number of disciplines.

Upon collecting quite a quantity of technical information in the communications technology area, the perplexing task began-that of applying several accepted rules of logic in categorizing and ordering the technical
processes of communications in a conceptually sound fashion. This task was the most intellectually challenging of this research. The diverse technologies of communications have been organized by others making use of a number of organizational logics. To identify one rule or single principle and get all levels of the taxonomy to adhere to this principle was indeed a difficult task.

The final version of the taxonomy does not violate the rule of the single principle at the first, second and, in most cases, third level of concepts. In all honesty, there remains some difficulty in a number of concept areas at the more detailed technical levels of the taxonomy. The investigator believes this to be a minor problem in relationship to the overall conceptual soundness of the taxonomy. In addition to developing taxonomies for each conceptual area of communications, as identified in Jackson's Mill, each concept was also defined and the definition validated during the process. Developing acceptable definitions for each concept proved to be a less difficult task than developing taxonomies for each concept.

The first validation procedure- the convening of a meeting at The Ohio State University of curriculum experts for the purpose of reviewing the concepts identified as the process used was very useful. Individuals were
selected who were available and familiar with my work or who had reason to frequent OSU at some regular intervals. While identifying individuals with the expertise to evaluate my materials was not a major problem, getting all of these identified individuals together on one day did prove problematic. In spite of this difficulty, the investigator continues to believe that getting a group of recognized experts together to meet face-to-face and interact around a given problem is a very useful strategy. The problem comes into play when one realizes the intense schedules most of these experts maintain. Match the busy schedules of the individual experts with the inability of the investigator to finance taking these individuals out of their day to day schedules and the problem mushrooms. The ideal scenario would be to isolate the expert panel away from their day to day tasks in a setting whereby they could focus solely on the identified problem. The financial resources needed to do that are beyond those available for most dissertations. Outside funding for such a project may indeed have been solicited had the problem been identified at an earlier stage. The first validation meeting took place at The Ohio State University on January 24, 1986 and was an extremely valuable step for the investigator and the project. While this first validation meeting did not follow the structured agenda,
as identified by the investigator, the result in terms of direction and feedback was excellent. To have tried to force the meeting to follow the format, as originally designed, may have caused the stifling of creative ideas and insightful questions that ensued. While the meeting process was altered, the desired end result was accomplished. It is believed that the interactions of the individuals in a group setting was an important ingredient to the overall success of the meeting. The involvement of individuals outside of the technology education field was also quite valuable. If the taxonomy is to communicate a new set of processes by which teachers might organize content, it must do so in such a way as to not assume any perceived understanding of communication technology as defined by technology educators. If the taxonomy can communicate to non-technical educators, clearly and concisely, then it should communicate a new strategy for organization to those within the technology education profession who have a fixed perception of what communications technology is.

The process of conducting individual interviews with technical experts, while time consuming, was extremely valuable. As well as providing a comprehensive review of the existing concepts contained in the taxonomy, the technical specialists raised numerous questions about
technical communications concepts not currently addressed in the taxonomy. The technical specialists also identified numerous sources of technical information that would have gone untouched without an industrialist's insight into information sources within their technical field. There is no better way to validate detailed technical concepts than to interact on a one-to-one basis with an individual who works with the technology on a constant basis. It is a continued belief that the important idea is to ask the right people the right set of questions, and the first two groups used in the validation process were asked just that.

Making use of the information gained during the technical specialists interviews, as well as further study and research as guided by the questions and comments made during the process, provided for another version of the taxonomy. This version of the taxonomy was then mailed back to the technical specialist involved as well as the original OSU expert panel. All were asked to make comments and suggestions for further modifications. While the input received using this paper and pencil step of the validation process was not that dramatic, in terms of suggested changes and modifications, it was used to further modify the taxonomy in preparation of the Kansas City meeting. This step in the process was to ensure that
the comments and suggestions made by both groups involved thus far were integrated into the model in an acceptable fashion.

The Kansas City meeting presented the taxonomy to several members of the original OSU meeting and a number of selected curriculum innovators. While a number of "great minds" were collected for the Kansas City meeting, the meeting was less successful than hoped. A number of issues were raised that caused the need for further clarification and modification of the taxonomy. These modifications were at the fourth and fifth order of concepts in the taxonomy. No major questions surfaced during the meeting in regards to first, second and third order concepts. While the meeting served to identify a few holes for specific, albeit remote, technical concepts, it did not focus on the larger issue of the impact the taxonomy might have on the profession. The meeting called together a number of individuals who again had very busy schedules at a time of day, five-thirty, that had seen them already put in a full day of meetings, presentations, etc. This may have been a factor. There were a number of individuals, Dr. Post and Dr. DeVore to mention two, who could not meet during he time identified. The investigator met with these participants on an individual basis to review the taxonomy. These individual meetings
went quite well and resulted in a variety of notes to modify and further investigate areas important to the taxonomy. While the group meeting left the investigator feeling less than comfortable, the individual meetings went well making the Kansas City conference a valuable overall step in the validation process. In looking back at the Kansas City meeting, it occurred to the researcher that another interpretation of the meeting might also be valid. The fact that no questions were raised relative to the higher order concepts might imply the endorsement of these concepts by the group.

Overall, the validation process went as expected. Several steps were obviously of greater value than others although this was anticipated. The diversity of the people involved and the quantity of time spent with them and in the library made for a workable validation process. Using different groups of people and asking them to provide different input worked well when this input was compiled. Several of the meetings took on a less structured format than anticipated and also went longer than planned. This validation process resulted in a taxonomy of communications technology that is conceptually sound and technically accurate.

Having now reviewed and evaluated the process used for the creation and validation of the taxonomy, an
evolution of the taxonomy itself will be presented. A summary of changes made as well as reasons for these changes will be reviewed.

**VERSION ONE- THE INITIAL DRAFT OF THE TAXONOMY**

Version one of the taxonomy consisted of a definition of the major concepts of communications as identified by the Jackson's Mill Industrial Arts Curriculum Theory. In addition, first, second, and third order subconcepts were identified for each major concept. Encoding was defined to include all technical processes that prepared or modified information into an acceptable format for transmission or storage. Specifying and composing were the first order subconcepts that had a more people-oriented focus. These two subconcepts identified processes performed by people to information before it was encoded for later use. The third of the first order subconcepts was converting. Converting was identified as those processes that transduced energy from one form to another. Much of the converting concept dealt with getting the information into an electrical format for transmission or storage. Examples of such devices include microphones, which convert an acoustical waveform into an electrical signal or a television camera which converts reflected light energy into an electrical format. These
examples are but two of many that would demonstrate the concept of converting.

The fact that concepts such as specifying and composing, which identified people-oriented tasks, were included in the same area as converting, appeared problematic for some. Converting subconcepts tended to be more related to the technical characteristics of devices rather than the acts of people. The guiding rule of logic in the development process was that the taxonomy would identify processes of communication systems. These identified processes might be tasks performed by people relative to communication systems or processes of devices used within communication systems. This mixture of people related tasks and characteristics of devices arose as a problem primarily in the encoding section. While not identified as a major obstacle or failure in logical progression, it was frequently discussed.

The transmitting concept dealt with those processes that moved information, now in a properly encoded format, from one location to another. It included first order subconcepts of modulating, amplifying, multiplexing, duplexing, propagating, frequency allocating and switching. While numerous concepts in this section saw revision, there were also a number of concepts added as a result of the validation process. Transmitting processes
might find use in microwave or satellite systems or much simpler atmospheric systems such as AM and FM radio. Further subconcepts would include physical carriers such as coaxial cable, fiber optics or twisted pair cable.

The receiving concept runs parallel to the transmitting concept as it deals with processes of accepting incoming signals, amplifying, demodulating and demultiplexing the signal. Added to these concepts were subconcepts dealing with collecting the signal from its atmospheric propagation or connecting physical carriers through which signals passed. Receiving processes might look at capturing electromagnetic signals propagated through the atmosphere and cover such devices as satellite receiving antenna or microwave horns. Or, in physical carriers how the carrier i.e., coaxial cable or fiber optic, is connected to the receiving/decoding device.

The concept of retrieving stayed rather constant throughout the validation process. Based heavily on library science and research on information retrieval systems, it included subconcepts of abstracting, indexing, accessing, processing and controlling. Retrieving was the concept that dealt with recalling information from a stored condition. One or more retrieval processes might find use when recalling information from magnetic computer media or an optical storage media or audible stereo
records.

Storing, as a conceptual ingredient to many communications systems, was concerned with recording and filing information for use at a later time. As such, it included the technical processes by which information was recorded, including subconcepts of separating, coating, conditioning and forming. The storing process would include such devices as video disc, magnetic storage media, film based systems as well as conventional printing processes.

The area of decoding paralleled the encoding concept to some extent. Decoding was defined to include those processes which converted, recorded or modified information into an acceptable format for use. As such, it saw numerous processes that, once again, converted energy from one form to another. One example might be a simple speaker, which converts an electrical signal back into an acoustical waveform so as to be heard by a person. Version one of the taxonomy saw only one subconcept identified— that being converting.

The final concept presented in version one was feedback. Feedback was defined to include those processes which sent information back to the point of origin to help determine if what was sent was received correctly. Feedback processes were identified as either open looping
or closed looping systems. Feedback caused some problem as it consisted of subconcepts which were first order concepts. The idea being that some encoding, transmitting, decoding processes were used to move appropriate information back to the head end of a communication system.

The first version of the model was presented at The Ohio State University on January 24, 1986 to an expert panel consisting of Dr. John Belland, OSU; Dr. Keith Blankenbaker, OSU; Dr. Paul Post, OSU; Dr. Mike Scott, OSU; Dr. Marge Cambre, OSU; Dr. Donald Lux, OSU; Dr. Bill Umstattd, OSU and Dr. Paul DeVore, West Virginia University. The formal portion of the meeting took place in the morning with informal dialogue continuing most of the afternoon.

VERSION TWO—THE FIRST REVISION OF THE TAXONOMY

Version two of the taxonomy was created based on the input received at the January 24 meeting at Ohio State. While the meeting forced a closer look at the rules of logic guiding the development of the taxonomy, it did not result in a major revision in terms of technical content. This was expected since the major purpose of the meeting was to review the method and logic behind the development process. A feeling that what was being developed was not
a model but rather a taxonomy resulted in a change in the terminology used to describe the project.

Version two of the encoding concept saw a further breakout of the converting concept based on the type of energy conversion taking place. The transmitting concept saw the addition of two subconcepts. Two new areas were added. Frequency selecting attempted to better describe the process of choosing the appropriate frequency for the type of message transmission. A second addition was that of signal conditioning. Signal conditioning included those processes that caused a change in the form or format of the transmitted message while in process. Such concepts included analog-to-digital conditioning, serial-to-parallel and light-to-electrical conditioning.

The decoding concept also saw modifications of first order subconcepts. While a single concept was identified in the first version, this was modified to show three first-order subconcepts in version two. It was identified that several of the subconcepts under the area of converting did make use of an energy form as a part of the decoding process but no energy was actually being converted. Two new first order subconcepts were added: projecting and reflecting. Projecting was identified as the process of passing light through a material; thereby, causing the image stored on the substrate to be projected
onto another surface. Examples of projecting as a decoding process would include 35mm slides, 16mm and various other formats of motion picture projection as well as overhead transparencies. Reflecting was added as a first order concept to the decoding area. Reflecting would include those processes where light is caused to be shown upon or reflected upon the surface of a material and, by doing so, decodes the image. An example of the process of reflecting would consist of reflecting laser light off the surface of a piece of holographic film or plate allowing one to view the three dimensional image stored on it. A single subconcept was identified for reflecting.

The first two revisions saw a number of changes made at the first and second order of subconcepts. This was expected. Subsequent evaluations began to focus on more detailed technical concepts and less on first- and second-order concepts. Version two of the taxonomy was then submitted to the technical specialists identified for greater indepth evaluation of the technical concepts.

**VERSION THREE - THE SECOND REVISION OF THE TAXONOMY**

Upon completing the technical specialist interviews, version three of the taxonomy was created. As expected, the technical specialist's interviews yielded the greatest
number of recommended alterations to the technical concepts. The technical specialist interviews also produced numerous recommendations to research new areas as well as identifying new sources of technical information. Numerous journals and technical manuals were identified that would have otherwise remained untouched had not these discussions taken place with industry insiders.

The converting concept saw several changes. While version two identified types of microphones, version three took this classification of specific devices out. The converting acoustical energy concept was modified with the subconcepts being transducing and controlling directionality. Transducing identified those used to convert acoustical energy into electrical signals. These transducing processes might be found in any number of specific devices. The second category added was controlling directionality to identify those processes that determine which acoustical waves are allowed to strike the transducer and which are prohibited from doing so. The converting concept also saw the addition of the category of converting heat energy to include those processes of sensing heat energy and converting this to an electrical signal. While heat sensing devices may not be common encoding devices, they do find application in the feedback loop of some communication systems.
The transmitting subconcept was modified in the amplifying concept and the additions made to the signal conditioning concept. The frequency selecting concept also added a new subconcept. The amplifying concept was broken down into three subconcepts. These subconcepts are frequency filtering, signal regenerating and signal adding. The amplifying concept then deals with sorting out which frequencies to amplify and which not to amplify in the frequency filtering process. Signal regenerating and signal adding deal with the processes of increasing signal power so as to continue to move the signal through the channel. Signal conditioning saw the addition of the subconcept of protocol converting. This concept was added to include the processes of changing the form the encoded message takes as it moves from one communication system to another. As communication systems move towards greater levels of integration, the need to change one systems protocol to that of another becomes of increasing importance.

In version two of the transmitting concept, the frequency selecting subconcept dealt only with the electromagnetic frequency spectrum. Version three then added the frequencies of light as a new optical subconcept was created. The optical category was further divided into infrared, visible and ultraviolet frequency ranges.
The receiving concept in version three was modified so that the amplifying subconcept followed the same logic as used in the transmitting concept. Other than this modification, the receiving concept went unchanged.

The storing concept was modified in reaction to one technical specialists questioning about where the idea of instant or Polaroid photography fit in. Investigation into the instant photography resulted in the addition of two subconcepts, these being: multi-step darkroom processing and single step ambient processing. Both of these subconcepts were introduced into the developing concept which is a subconcept to latent image processing. Multi-step darkroom processing covers conventional print processing as done in most darkrooms. Single step ambient processing deals with the instant photography process where development takes place within the individual film packet. A further minor modification was made to the conditioning concept with the addition of another head positioning process called longitudinal scanning.

The decoding concept was modified along the same logical path as encoding with the substitution of transducing for vibrating. Transducing then dealt with processes of converting electrical waveforms back to acoustical waves.
VERSION FOUR- THE THIRD REVISION OF THE TAXONOMY

Version four was completed based on input obtained from a through-the-mail, paper and pencil review, conducted with the technical specialists and the original OSU expert panel. This rework of the taxonomy included a major revision of the first order subconcept of designing under the encoding concept. A question from Dr. Lux asked if designing was not designing regardless of the technological system. If this was true, then another evaluation of the Industrial Arts Curriculum Project instructional materials was in order. Having done this, it was decided that several of the basic principles identified in the IACP materials were appropriate to a designing concept in a taxonomy for communication technology. The version three designing subconcept of specifying was changed into two second-order subconcepts of formulating and evaluating. The subconcepts of specifying were then further modified under these two new second order subconcepts. A further second order subconcept was added and called researching. The researching subconcept was gleaned from the IACP materials relative to researching. Upon completing this revision of the designing concept, it was quite similar, in part, to the designing concept in the Industrial Arts Curriculum Project and a major improvement.
Other modifications made to the encoding subconcept included the addition of a subconcept of selecting emulsions to converting a latent chemical image area. While other concepts in this area dealt with the processing of latent images, this new concept filled a void in the area of selecting the right emulsion for the specific application.

While no concepts were actually modified in the transmitting concept, the order in which the concepts were presented was changed. To better reflect a logical sequencing of concepts, the frequency selecting concept was placed immediately before the propagating concept.

The storing concept saw further modification in the area dealing with instant photography. The concept of single-step ambient processing was removed from the separating concept and placed in the conditioning concept under the subconcept of developing. This was done to better reflect the process used in instant photography as compared to conventional photographic methods.

The revisions made in version four of the taxonomy were less dramatic than those made in previous versions. The function of the through-the-mail, paper and pencil review was to ensure that the comments and recommendations from the technical specialists and the original OSU panel were adequately incorporated into the taxonomy. Receiving
relatively few dramatic proposed changes led the investigator to believe that the changes made in previous validation steps had been integrated into the taxonomy in a meaningful manner. This version was then mailed to those educators who had already agreed to participate in the informal review of the taxonomy during the International Technology Education Association Conference in Kansas City.

VERSION FIVE- THE FINAL REVISION OF THE TAXONOMY

In Kansas City a review was conducted at the scheduled group session as well as individual discussions with others who had previously been involved but could not attend the group meeting. As a result a final version of the taxonomy was created. Version five makes use of a different numbering plan to better reflect the style used in organizing and presenting a taxonomy. The encoding concept saw the reordering of concepts to place the composing concept before the evaluating concept to reflect a more logical sequence. The first order concepts of converting were modified to include in the title the nature of the energy conversion taking place. This change makes sense particularly in presenting the taxonomy to non-technical individuals.

The transmitting concept was modified in the addition
of the quadraplexing subconcept to the duplexing concept. No other significant changes took place in the transmitting, receiving, retrieving, storing or feedback concepts. The decoding concept was modified so that the converting concepts mirrored the changes made to the converting concepts in the encoding concept.

Another issue raised several times, by various individuals, throughout the validation process, merits further discussion. The issue raised is the validity of the feedback concept. While no one argued that feedback was not an integral component of many communication systems there was repeated questioning about the identified subconcepts. This problem with the subconcepts led the researcher to question the feedback concept itself. The subconcepts for feedback were found in other areas of the taxonomy and as such violated the rule of logic dealing with mutual exclusivity. Feedback systems are not developed making use of unique technical concepts but rather by utilizing processes and devices found in the concept areas of encoding, transmitting and receiving.

Feedback was a concern as the researcher did not feel that the concept could be deleted during the series of five evaluation measures as this dissertation began by accepting the work of the Jackson's Mill Industrial Arts Curriculum Theory. The introduction and statement of
the problem are premised upon accepting the Jacksons Mill concepts for communication. However, in completing this taxonomy, after the conclusion of all validation measures, it is the judgement of the researcher that feedback is not a first order concept of communications and therefore should not be treated as such. Feedback should be dealt with as system which configures other processes for the specific purpose of monitoring the functionality of a communications system. The final draft of the taxonomy omits the feedback concept.

Modifications made in version five were minor in comparison to other revisions and dealt with more detailed technical concepts rather than first order concepts.

CONCLUSIONS

It is the feeling of the investigator that the overall revision process resulted in a technically accurate, conceptually oriented, useful taxonomy of the processes of communications technology. The first order subconcepts have remained rather stable throughout the validation process while numerous changes have taken place at more detailed levels of the taxonomy. While it is believed that the first- and second- order concepts are quite stable and accurately reflect the major processes used in communication systems, the third and fourth order
concepts could see further revision as the technology changes. New technological developments should find a conceptually understandable position at the third and fourth order of the taxonomy.

While the taxonomy is one of communication processes and not one of all communication devices, a common strategy used by evaluators has been to run various devices or systems through the taxonomy to see if they fit in. This has been a useful strategy and one that further emphasizes the stability and validity of the first and second order concepts. Any taxonomy of a technology should allow new technological developments and devices to be integrated into the taxonomy if it is to remain a useful tool in the curriculum process. It is believed that this taxonomy does that.

It must also be remembered that any taxonomy of a system of technology is dynamic. It must change in time to reflect advances and innovations in the technology. It is believed that at this point in time that this taxonomy is comprehensive, technically accurate and therefore useful. Perhaps the writing of Professor Willis Ray best summarizes the usefulness and dynamic nature of a taxonomy in stating:

It must never be forgotten that all classification systems are man-made. Because they
are conceived by man, they are, in a measure, arbitrary. The technology of industry is changing rapidly; hence the elements may change and their mutual relationships will vary over time (p. 231).
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This final chapter will first summarize the intent of the study, then identify major conclusions and finally suggest recommendations for further study. In doing so one can get a perspective on the intent and results of this dissertation.

SUMMARY

There is a continuing need to organize the discipline of technology into a meaningful structure for study. As the profession of Technology Education comes to grips with the difficult task of teaching all students about technology, the need for curriculum development grows. We live in a society characterized by the sophisticated application of technology. The general population in this technological society has little understanding of the technological systems that surround it. Technology education is emerging into the content area that provides all students with a fundamental understanding of industry and technology.

Numerous curriculum problems are evident as the
profession begins the implementation of programs that serve a general education need to understand man's technical means. The profession must address these problems and generate solutions that are both intellectually defendable and instructionally practical. If humankind is to manage the affairs of technology in such a way as to use our technical means to improve the human condition, then it must provide its youth with instructional programs that foster technological literacy.

Curriculum development will be a constant activity if the profession is to stay abreast of technical fields that see their knowledge base double every five years. This doubling of the content base is taking place in an increasingly shorter time frame. The critical issue becomes how to design instructional systems that can deal with this rapidly changing technology.

One potential solution is to identify major concepts of technological systems and structure content based on concepts that are relatively stable. To identify these concepts, ensure their technical validity and design instructional systems that teach them is not an easy task. However, teaching concept-based programs may moderate the process of infusing new technologies into existing programs. Well defined, concept-based programs, will allow new devices and processes to be integrated into an
existing structure with greater ease. While the specific devices used in technical systems may change daily, the technical concepts these devices make use of will change less rapidly. An example is the technical concept of modulation, identified as a first order concept in the transmitting area. People have manipulated an electrical signal so that the signal carries information since the invention of the telegraph. Modern pulse code modulation schemes, while manipulating an electrical signal in a different fashion, is still just a new subset of modulation. If a student understood the broader concept of modulation, he or she could more easily understand new methods of modulating carrier signals to carry information. New technical practices can be easily integrated into a comprehensive conceptual taxonomy.

This dissertation chose to address the area of communications technology. It tried to add to the body of existing knowledge a taxonomy of concepts that was wholistic and technically accurate. No such taxonomy for communications technology was found during the review of literature.

The emerging technologies of communication will redefine much of the world as we know it. Daily developments will change the way people function in a growing number of settings. Being literate in the
technologies of communication will be of increasing importance. This knowledge requirement is important in both a general education and career sense.

This dissertation began by accepting the work of the Jackson's Mill Industrial Arts Curriculum Theory. While Jackson's Mill is not the final solution in structuring the discipline of technology, it is a step towards consensus the likes of which the profession had not seen. Jackson's Mill identified human adaptive systems in the areas of transportation, construction, manufacturing and communication. The communication area saw further development as major concepts of encoding, transmitting, receiving, storing, retrieving, decoding and feedback were identified. While taxonomies existed in the other human adaptive systems identified by Jackson's Mill, no such defined taxonomy existed in communications. It was the identified task of this research to build on the Jacksons' Mill foundation by identifying subconcepts for each major communications concept.

Having identified the purpose and the desired outcome of this research, a method for accomplishing the task was researched and designed. The development and validation process was a varied one making use of several evaluation strategies to produce a taxonomy that was accurate.

The initial taxonomy was designed by the investigator
and then submitted to various individuals and groups for evaluation and recommended modifications. These groups consisted of educators within the profession who were widely respected for their curriculum building skills as well as individuals outside the profession who were considered technical experts in their respective communications field. Care was taken in the selection of the technical experts to ensure coverage of the diverse content of the proposed taxonomy. This evaluation strategy drew upon a number of methods used by curriculum designers in previous studies. The taxonomy was modified five times. Each modification was a direct result of input gained from an evaluation procedure. Typically, each evaluation procedure was followed by further technical research in the library.

CONCLUSIONS

In reviewing the process, it was believed that asking different people different questions and then integrating their responses into the taxonomy development process was workable. While the input varied from step to step, the process proved to be a worthwhile procedure in insuring the conceptual soundness and technical accuracy of the taxonomy. Professions that are intellectually healthy will continue to devise new research strategies to respond
to new needs within their respective discipline. The process achieved the desired result and thus must be considered effective.

The product of this research is a taxonomy of concepts of communication technology. Its development caused the investigator to inquire into numerous technical fields in the attempt of identifying those concepts and subconcepts that were appropriate to communications technology. This was both a challenging and rewarding task. The taxonomy consists of major subconcepts for each of the communications concepts identified in the Jackson's Mill project. Each of the identified first order subconcepts is further detailed. It is believed that these concepts and subconcepts make up the major process of communications technology. It was the goal to identify the technical processes of communications technology but not to classify all communications devices. This distinction was not always easy to achieve.

The investigator continues to believe that accepting the Jackson's Mill work was a wise decision. However, the investigator feels that the first order concept of feedback, identified in Jackson's Mill, is inappropriate. Feedback, as used in Jackson's Mill, violates several rules of logic used by the researcher to further define the taxonomy. Feedback systems, which find use in many
technological systems, make use of other communications concepts in monitoring and reporting on the functionality of a technological system. The second order concepts, identified for feedback, are first order concepts found elsewhere in the taxonomy. Feedback systems, while important, simply make use of other communications concepts and devices to encode, transmit and receive information on some systematic basis.

The first order concepts are thought to be quite stable while less stability can be assumed for the more detailed levels of the taxonomy. This taxonomy represents an addition to the content domain of communications and, as such, may prove to be an important tool for those who choose to design instructional systems in the communications technology field.

The taxonomy is just a taxonomy. It is not a curriculum guide; it is not a course outline; it does not contain all of the content one might determine appropriate for the study of communication technology. The taxonomy is the detailing of the technical processes of communications technology and, as such, should be a tool used in the development process for instructional programs in communications. Other curriculum elements must be addressed in designing instructional systems for communications.
No instructional system would be complete without looking at regulatory issues in the communications industry or the social, cultural implications of the technology including impacts, ethics and possible future developments in the technology. While the taxonomy defines the technical concepts, other issues must be addressed if a meaningful instructional system is to be developed. It would be unacceptable and inappropriate to produce students who only understood the technical dimensions of a technological system.

RECOMMENDATIONS

If one accepts the conclusion that the process utilized in this research was appropriate, and therefore useful, then the researcher would recommend its application in other technical areas. As a profession, we must carefully define our content base. Integrating a variety of validation strategies into one process may be a useful tool in the content base definition. A broader recommendation, in regards to process, is that as a profession we must design and develop new research tools to validate the technical and non-technical concepts we propose to teach. Not to do so risks teaching outdated, inaccurate or inappropriate content to students.

The first step in the intelligent use of a taxonomy
of a technical field, such as the one developed here, would be to determine which concepts should be taught at what level of education. Clearly it would be inappropriate to attempt to deliver third- fourth- or fifth-order technical concepts to a junior high school student. It becomes important to match the readiness of the student, his or her past experiences and the desired outcome of the course with the appropriate depth of technical concepts presented. One would expect different levels of conceptual understanding from a junior high school student where the goal is developing technological literacy than from a college student preparing to enter the communications industry as a technologist or manager. It is the task of the technology educator to make educationally sound judgments about what content should be presented at what level.

If this taxonomy is to impact the profession, then there are a number of other research and development activities that must take place. As stated, it would be important to begin identifying what level of technical content is appropriate for what level of education. It would also be important to structure the other elements necessary for a comprehensive communications technology course. What are the regulatory issues and how have we regulated communication services in the past? What are
the impacts of the tremendous number of communication and information technologies becoming commonplace? What are possible scenarios for the future? What technical developments are likely to occur? What are the skills and abilities that all of us need to be informed citizens in the information age? What are the skills and abilities that will be needed by those who hope to find employment in the communications field? These are but a few of the issues that must be resolved if meaningful instruction in communications technology is to take place.

No one dissertation can change an entire profession and it would be naive to think any different of this one. Those individuals and projects that have significantly altered the course of the profession have seen the sustained involvement, research, and application of research over a period of time. It is believed that this work has made a contribution to the profession by defining the processes of communications technology in a meaningful conceptual fashion. It is believed that this work could be the basis for further developmental activity and, if that were to happen, this could have a significant impact on the profession.
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COMMUNICATIONS TECHNOLOGY: A CONCEPTUAL MODEL

AN INTRODUCTION

Our society and the societies of the world are being impacted daily by the application of communications technology. Numerous authors and futurists refer to the kind of society we are evolving into as; The Information Society, Communications Age, Third Wave, Post Industrial Society (Thebold, 1982) (Toffler, 1980) (Davis & McCormick, 1981). While the titles may differ, all refer to the reshaping of many social institutions as a result of communication technology. Just as the industrial revolution extended our ability to produce material goods the emerging technologies of communication will greatly extend our ability to create, transmit and store information. New technologies becoming commonplace in business, industrial, residential and educational settings demand new skills and competencies in the individuals expected to function effectively within these environments. The use of many of these systems and their technologies have become commonplace in our lives. The
challenge to industrial arts/technology education is to integrate the study of these emerging technologies into its program of study.

Industrial education as a profession has always been concerned with relevant curriculum development and the subsequent validation of that curriculum. This dissertation continues the pursuit of knowledge important to curriculum developers by designing and validating a conceptual model in the area of communications technology.

Communications was one of four human adaptive systems defined in the *Jackson's Mill Industrial Arts Curriculum Theory*, the other three being construction, transportation and manufacturing. The *Jackson's Mill Industrial Arts Curriculum Theory* is clearly one of the more significant documents impacting the industrial arts/technology education profession today. A consensus was forged at Jackson's Mill which provides the basis for much of the technology education movement. The challenge facing the profession today is to interpret the Jackson's Mill work and integrate its systems into classrooms and laboratories throughout the country. Indeed, the profession is responding to this challenge. Taxonomies have been developed, some prior to the Jackson's Mill work, in the areas of manufacturing, construction and transportation. Instructional materials for these
taxonomies are developed or being developed in various settings around the country. In communications technology no comprehensive taxonomy exists and developed curriculum materials reflect the clustering of similar processes rather than the organization of content around validated concepts. This problem, in the investigators opinion, has been apparent in numerous curriculum documents including the recently completed Curriculum Implementation Project.

It is the intent of this study to build upon the foundation established by the Jackson's Mill work. It is accepted that communications is one of four human adaptive systems and thus appropriate content for technology education. The major concepts of communications, as listed in Jackson's Mill are accepted. These concepts being: encoding, transmitting, receiving, storing, retrieving, decoding and feedback. The need then is to identify, organize and define second and third level subconcepts to the communications concepts identified in Jackson's Mill. The task of this study is to organize the processes of communications into a conceptual model thus providing a framework for study.
A MODEL OF THE CONCEPTS
OF
COMMUNICATIONS TECHNOLOGY

DEVELOPED BY
ROBERT W. HENDRICKS
ENCODING: THE TECHNICAL PROCESSES WHICH RECODE OR MODIFY INFORMATION INTO A DESIRED FORMAT OR PATTERN FOR A SPECIFIC METHOD OF TRANSMISSION OR STORAGE.

A. SPECIFYING
1. DETERMINING OBJECTIVE OF COMMUNICATION
2. ANALYZING AUDIENCE/RECIIVER CHARACTERISTICS
3. CHOOSING THE APPROPRIATE TECHNOLOGY

B. COMPOSING
1. SCRIPTING
2. FLOWCHARTING
3. STORYBOARDING
4. ASSEMBLING GRAPHIC IMAGE
5. PROGRAMMING

C. CONVERTING
1. ACOUSTIC-TO-ELECTRICAL
   A. VIBRATING
      1. VIBRATING DIAPHRAMS
      2. VIBRATING RIBBONS
   B. GENERATING ELECTRICAL SIGNALS
      1. SENSING
      2. PRODUCING
   C. AMPLIFYING
      1. SELECTING
      2. INCREASING

2. LIGHT-TO-ELECTRICAL
   A. ILLUMINATING
      1. SPOTLIGHTING
      2. FLOODLIGHTING
      3. BACKLIGHTING
   B. FOCUSING
      1. VIEWFINDING
      2. DIRECT LENS ALIGNING
      3. INDIRECT LENS ALIGNING
   C. ELECTRICAL EMITTING
      1. EMITTING PHODIODES
      2. EMITTING PHOTOMULTIPLIERS
   D. PHOTOSENSING
      1. QUANTIFYING
      2. RECOGNIZING
   E. SCANNING
      1. MECHANICAL
      2. ELECTRONIC
   F. SYNCHRONIZING
      1. COLOR BURST SIGNALING
3. **LIGHT-TO-CHEMICAL**
   A. **ILLUMINATING**
      1. SPOTLIGHTING
      2. FLOODLIGHTING
      3. BACKLIGHTING
   B. **FOCUSING**
      1. VIEWFINDING
      2. DIRECT LENS ALIGNING
      3. INDIRECT LENS ALIGNING
   C. **EXPOSING**
      1. CONTROLLING QUANTITY
      2. CONTROLLING DURATION
   D. **SCALING**
      1. ENLARGING
      2. REDUCING

4. **MECHANICAL-TO-ELECTRICAL**
   A. VIBRATING
   B. POSITIONING
   C. DEPRESSING
   D. ROTATING

5. **ELECTRICAL-TO-LIGHT**
   A. SAMPLING
   B. QUANTIFYING
   C. DIGITIZING
   D. LIGHT EMITTING
      1. LASERS
      2. LIGHT EMITTING DIODES
TRANSMITTING: THE TECHNICAL PROCESSES OF CONVEYING INFORMATION FROM ONE LOCATION TO ANOTHER

A. MODULATING
   1. PULSE CODING
   2. PULSE DURATION VARYING
   3. FREQUENCY VARYING
   4. AMPLITUDE VARYING
   5. ENCRYPTING

B. AMPLIFYING
   1. FREQUENCY FILTERING
      A. LOW PASSING
      B. BAND PASSING
      C. HIGH PASSING
   2. SIGNAL INCREASING
      A. COLLECTING
      B. PROCESSING
      C. EMITTING

C. MULTIPLEXING
   1. TIME DIVIDING
   2. FREQUENCY DIVIDING

D. DUPLEXING
   1. SIMPLEXING
   2. HALF DUPLEXING
   3. FULL DUPLEXING

E. PROPAGATING
   1. ATMOSPHERIC CHANNELING
      A. DIRECT WAVE RADIATING
      B. GROUND WAVE RADIATING
      C. SKY WAVE RADIATING
      D. RADIATION PATTERNING
      E. POSITIONING
   2. PHYSICAL CHANNELING
      A. WAVE GUIDING
      B. LIGHT GUIDING FIBER OPTIC
         1. MULTIMODE INDEXING
         2. SINGLE MODE INDEXING
         3. MULTIMODE GRADED INDEXING
      C. ELECTRICAL SIGNAL GUIDING
         1. TWISTED PAIR CABLE
         2. COAXIAL CABLE
            A. BROADBAND
            B. BASEBAND
F. FREQUENCY ALLOCATING
1. LOW FREQUENCY
2. MEDIUM FREQUENCY
3. HIGH FREQUENCY
4. VERY HIGH FREQUENCY
5. ULTRA HIGH FREQUENCY
6. SUPER HIGH FREQUENCY

G. SWITCHING
1. SENSING ACCESS REQUEST
2. DETERMINING DESTINATION
3. SELECTING PATH
4. ESTABLISHING CONNECTION
5. DISCONNECTING CIRCUIT
RECEIVING: THE TECHNICAL PROCESSES OF RECOGNIZING AND ACCEPTING INFORMATION THAT HAS BEEN TRANSMITTED.

A. COLLECTING
   1. DETECTING
      A. MEASURING RADIATION PATTERN
      B. DETERMINING EFFECTIVE AREA
      C. POSITIONING
      D. CONCENTRATING
   2. SELECTING
      A. SEPARATING
      B. TUNING

B. CONNECTING
   1. SPLICING
   2. SOLDERING
   3. COUPLING
   4. BONDING

C. AMPLIFYING
   1. FREQUENCY FILTERING
      A. LOW PASSING
      B. BAND PASSING
      C. HIGH PASSING
   2. SIGNAL INCREASING
      A. COLLECTING
      B. PROCESSING
      C. EMITTING

D. DEMODULATING
   1. PULSE CODING
   2. PULSE DURATION VARYING
   3. FREQUENCY VARYING
   4. AMPLITUDE VARYING

E. DEMULTIPLEXING
   1. TIME DIVIDING
   2. FREQUENCY DIVIDING
STORING: THE TECHNICAL PROCESSES OF RECORDING AND FILING INFORMATION FOR USE AT A LATER TIME

A. SEPARATING
   1. LATENT IMAGE PROCESSING
      A. DEVELOPING
      B. FIXING
      C. DRYING
      D. MOUNTING
      E. RE-EXPOSING
      F. SCALING
   2. PUNCHING
      A. FORMATING
      B. LOCATING
      C. SHEARING
      D. REMOVING
   3. MACHINING
      A. FORMATING
      B. ELECTROMECHANICAL TRANSDUCING
      C. REMOVING

B. COATING
   1. FIXED RAISED SURFACE PRINTING
   2. ADDRESSABLE RAISED SURFACE PRINTING
   3. PLANE SURFACE PRINTING
   4. SUNKEN SURFACE PRINTING
   5. THROUGH-THE-SURFACE PRINTING
   6. SPRAYING THE SURFACE
   7. MAGNETIC DEPOSITING ON THE SURFACE

C. CONDITIONING
   1. MAGNETIZING
      A. POSITIONING SUBSTRATE
      B. DEMAGNETIZING
      C. CREATING A FRINGING FIELD
      D. HEAD POSITIONING
         1. TRACKING
         2. QUADRAPLEXING
         3. HELICAL SCANNING
   2. HEATING
      A. POSITIONING SUBSTRATE
      B. CONTROLLING HEAT SOURCE

D. FORMING
   1. POSITIONING SUBSTRATE
   2. APPLYING HEAT AND/OR PRESSURE
RETRIEVING: THE TECHNICAL PROCESSES OF RECALLING INFORMATION FROM A STORED CONDITION.

A. ABSTRACTING
   1. ASSESSING ITEM CONTENT
   2. SUMMARIZING ITEM CONTENT

B. INDEXING
   1. DETERMINING SEARCH VOCABULARY
      A. CONTROLLING VOCABULARY
      B. NON-CONTROLLING VOCABULARY
   2. CODING ITEM

C. ACCESSING
   1. LOCATING
   2. RECALLING

D. PROCESSING
   1. MANUAL
   2. ELECTRONIC

E. CONTROLLING
   1. IDENTIFYING USER
   2. DETERMINING USER RETRIEVAL PRIVILEGES
DECODING: THE TECHNICAL PROCESSES WHICH CONVERTRecorded
or modified information into an acceptable format for use.

A. CONVERTING
   1. ELECTRICAL-TO-ACOUSTIC
      A. ACOUSTIC BAFFLING
         1. ENCLOSING
         2. SUSPENDING
      B. VIBRATING
         1. ELECTROMAGNETIZING
         2. PIEZO-ELECTRIC STRESSING
         3. ELECTROSTATIC DEFLECTING
      C. ACOUSTIC WAVE GENERATING
         1. DIAPHRAMS
         2. CONES

   2. ELECTRICAL-TO-LIGHT
      A. PICTURE ELEMENT LOCATING
         1. SCANNING
         2. ADDRESSING
      B. LIGHT EMITTING
         1. FLOURESCING
         2. ELECTROLUMINESING
         3. GAS DISCHARGING
      C. LIGHT REFLECTING
         1. LIQUID CRYSTAL REFLECTING
         2. LIQUID CRYSTAL ABSORBING

   3. CHEMICAL-TO-LIGHT
      A. PROJECTING
         1. INCOHERENT LIGHTING
         2. COHERENT LIGHTING
         3. TRANSPORTING SUBSTRATE
      B. REFLECTING
         1. INCOHERENT LIGHTING
         2. COHERENT LIGHTING
      C. SCALING
         1. ENLARGING
         2. REDUCING
      D. FOCUSING
         1. VIEWFINDING
         2. LENS ALIGNING

   4. ELECTRICAL-TO-MECHANICAL
      A. STRIKING
      B. CONTROLLING
      C. POSITIONING
5. **LIGHT-TO-ELECTRICAL**
   A. LIGHT SENSING
   B. RECONSTRUCTING
   C. AMPLIFYING
FEEDBACK: THE TECHNICAL PROCESSES WHICH USE A COMMUNICATION SYSTEM TO TRANSMIT INFORMATION BACK TO THE POINT OF ORIGIN.

A. OPEN LOOPING
   1. ENCODING
   2. TRANSMITTING
   3. RECEIVING

B. CLOSED LOOPING
   1. MONITORING
   2. ENCODING
   3. TRANSMITTING
   4. RECEIVING
   5. MODIFYING
PROCEDURE FOR THE OSU EXPERT PANEL MEETING

A. BEFORE THE MEETING

Before the meeting each participant will be sent the following materials:

1. A brief introduction to the study identifying its purpose and intended outcomes.
2. A description of the validation procedures to be used.
3. The model of communications technology as developed to date.
4. The validation instrument to be used in this first round.
5. An agenda of the meeting.
6. A list of participants for the OSU meeting.

Each participant is asked to carefully read all of the materials paying particular attention to the concept model. The intended outcome of this first validation step is to review the concepts and their definitions and further review the first order subconcepts for each area. It is hoped that you will begin to complete the validation instrument identifying areas of agreement as well as areas in need of further development while reserving final judgement until each concept, definition and first order subconcepts are presented and reviewed.

B. DURING THE MEETING

The agenda for this first meeting is as follows:

8:30 to 8:45 An introduction to my work and the reasons for pursuing the development of a conceptual model for communications technology.

8:45 to 9:00 Review of the model development and validation process.

9:00 to 10:30 Review each major concept, definition and first order subconcepts of the model. Following questions and answers, each participant would complete the validation instrument.
**10:30 to 11:00** Ask for overall reactions to the model, the development process and the validation process. Identify major concerns of panel.

**C. AFTER THE MEETING**

After the meeting the investigator will tabulate the data from the validation instrument and present percentages of consensus in the form of accept, reject or modify comments made by the participants. A revision of the model will follow.
SUMMARY OF VALIDATION PROCEDURES

The process to be used for the design and validation of a conceptual model for the organization of communication technology involved nine steps. The purpose of each step and the processes used will be described. For the model of communications technology to be valid and useful it must be both conceptually sound and technically accurate. The investigator believes that an appropriate approach is to make use of two specific groups of people: one group who possesses expertise in conceptual model development and a second group who are technical specialists in various areas of communications technology. These two groups of experts will ensure that both the overall design of the taxonomy and the specific concepts identified are valid. While some individuals may possess both identified characteristics, the ability to conceptualize and specific technical expertise, the investigator believes that an insufficient number of these people are available. Furthermore, separating the development and review of the technical details from the development of the overall model is more logical and workable. With this as an introduction, a description of each of the nine steps for the creation and validation of a conceptual model in communications technology follows.
Step 1. Create the initial version of the model of communications technology.

Step 2. Submit the initial model to an expert panel review focusing on the conceptual soundness of the model.

Step 3. Revise the model based on input from the review done in Step 2.

Step 4. Conduct a series of interviews with technical specialists with the focus being on the technical accuracy of the proposed concepts.

Step 5. Revise the model based on input from the technical specialist group.

Step 6. Validate the revised model by submitting it to both of the identified groups and obtaining their written feedback.

Step 7. Revise the model based on input from the written feedback obtained in Step 6.

Step 8. Conduct a final face-to-face review of the model with those members of the initial concept group and other selected technology educators who are in attendance at the ITEA conference in Kansas City.

Step 9. Revise model as appropriate based on the review conducted in Step 8.

I believe that following this procedure will result in a useful conceptual model for the organization of the processes used in communication systems and, in doing so, make a contribution to the profession.
OSU EXPERT PANEL PARTICIPANTS

1. Dr. John Belland  
   Department of Educational Theory & Practice  
   The Ohio State University

2. Dr. Marge Cambre  
   Department of Educational Theory & Practice  
   The Ohio State University

3. Dr. Paul DeVore  
   Technology Education Program  
   West Virginia University

4. Dr. Keith Blankenbaker  
   Department of Industrial Technology Education  
   The Ohio State University

5. Dr. Donald Lux  
   Professor Emeritus  
   Department of Industrial Technology Education  
   The Ohio State University

6. Dr. Mike Scott  
   Department of Industrial Technology Education  
   The Ohio State University

7. Dr. Bill Umstattd  
   Department of Industrial Technology Education  
   The Ohio State University

8. Dr. Paul Post  
   Department of Industrial Technology Education  
   The Ohio State University
APPENDIX B

A TAXONOMY OF THE CONCEPTS

OF

COMMUNICATIONS TECHNOLOGY

DEVELOPED BY

ROBERT W. HENDRICKS

142
ENCODING: THE TECHNICAL PROCESSES WHICH RECODE OR MODIFY INFORMATION INTO A DESIRED FORMAT OR PATTERN FOR A SPECIFIC METHOD OF TRANSMISSION OR STORAGE.

A. DESIGNING
   1. SPECIFYING
      A. DETERMINING OBJECTIVE OF COMMUNICATION
      B. ANALYZING AUDIENCE/RECIIVER CHARACTERISTICS
      C. CHOOSING THE APPROPRIATE TECHNOLOGY

2. COMPOSING
   A. SCRIPTING
   B. FLOWCHARTING
   C. STORYBOARDING
   D. ASSEMBLING GRAPHIC IMAGE
   E. PROGRAMMING

B. CONVERTING ACOUSTICAL ENERGY
   1. TO AN ELECTRICAL SIGNAL
      A. VIBRATING
         1. CARBON MICROPHONE
         2. CRYSTAL MICROPHONE
         3. DYNAMIC MICROPHONE
         4. RIBBON MICROPHONE
         5. CONDENSER MICROPHONE
      B. GENERATING ELECTRICAL SIGNALS
         1. SENSING
         2. PRODUCING/MODULATING

C. CONVERTING LIGHT ENERGY
   1. TO AN ELECTRICAL SIGNAL
      A. ILLUMINATING
         1. SPOTLIGHTING
         2. FLOODLIGHTING
         3. BACKLIGHTING
      B. FOCUSING
         1. VIEWFINDING
         2. DIRECT LENS ALIGNING
         3. INDIRECT LENS ALIGNING
      C. ELECTRICAL EMITTING
         1. EMITTING PHODIODES
         2. EMITTING PHOTOMULTIPLIERS
      D. PHOTOSENSING
         1. QUANTIFYING
         2. RECOGNIZING
      E. SCANNING
1. MECHANICAL
2. ELECTRONIC

F. SYNCHRONIZING
   1. COLOR BURST SIGNALING

2. TO A LATENT CHEMICAL IMAGE
A. ILLUMINATING
   1. SPOTLIGHTING
   2. FLOODLIGHTING
   3. BACKLIGHTING

B. FOCUSING
   1. VIEWFINDING
   2. DIRECT LENS ALIGNING
   3. INDIRECT LENS ALIGNING

C. EXPOSING
   1. CONTROLLING QUANTITY
   2. CONTROLLING DURATION

D. SCALING
   1. ENLARGING
   2. REDUCING

D. CONVERTING MECHANICAL ENERGY
1. TO ELECTRICAL ENERGY
   A. VIBRATING
   B. POSITIONING
   C. DEPRESSING
   D. ROTATING
TRANSMITTING : THE TECHNICAL PROCESSES OF CONVEYING INFORMATION FROM ONE LOCATION TO ANOTHER

A. MODULATING
1. PULSE CODING
2. PULSE DURATION VARYING
3. FREQUENCY VARYING
4. AMPLITUDE VARYING
5. PHASE VARYING
6. ENCRYPTING

B. AMPLIFYING
1. FREQUENCY FILTERING
   A. LOW PASSING
   B. BAND PASSING
   C. HIGH PASSING

2. SIGNAL INCREASING
   A. SUMMING AMPLIFIERS
   B. INTEGRATING AMPLIFIERS
   C. OSCILLATING AMPLIFIERS

C. MULTIPLEXING
1. TIME DIVIDING
2. FREQUENCY DIVIDING

D. DUPLEXING
1. SIMPLEXING
2. HALF DUPLEXING
3. FULL DUPLEXING

E. PROPAGATING
1. ATMOSPHERIC CHANNELING
   A. DIRECT WAVE RADIATING
   B. GROUND WAVE RADIATING
   C. SKY WAVE RADIATING
   D. RADIATION PATTERNING
   E. POSITIONING

2. PHYSICAL CHANNELING
   A. WAVE GUIDING
   B. LIGHT GUIDING FIBER OPTIC
      1. MULTIMODE INDEXING
      2. SINGLE MODE INDEXING
      3. MULTIMODE GRADED INDEXING
   C. ELECTRICAL SIGNAL GUIDING
      1. TWISTED PAIR CABLE
      2. COAXIAL CABLE
         A. BROADBAND
B. BASEBAND

F. SIGNAL CONDITIONING

1. ELECTRICAL-TO-LIGHT CONVERTING
   A. SAMPLING
   B. QUANTIFYING
   C. DIGITIZING
   D. LIGHT EMITTING
      1. LASERS
      2. LIGHT EMITTING DIODES

2. LIGHT-TO-ELECTRICAL CONVERTING
   A. LIGHT SENSING
   B. RECONSTRUCTING

3. ANALOG-TO-DIGITAL
   A. SAMPLING
   B. QUANTIFYING
   C. DIGITIZING

4. DIGITAL-TO-ANALOG
   A. RECEIVING INPUT CODE
   B. STEPPED VOLTAGE OUTPUT
   C. AMPLIFYING
   D. FILTERING

5. SERIAL-TO-PARALLEL
   A. SAMPLING
   B. SHIFT REGISTERING

6. PARALLEL-TO-SERIAL
   A. SAMPLING
   B. SHIFT REGISTERING

G. FREQUENCY SELECTING

1. LOW FREQUENCY
2. MEDIUM FREQUENCY
3. HIGH FREQUENCY
4. VERY HIGH FREQUENCY
5. ULTRA HIGH FREQUENCY
6. SUPER HIGH FREQUENCY

H. SWITCHING

1. SENSING ACCESS REQUEST
2. DETERMINING DESTINATION
3. SELECTING PATH
4. ESTABLISHING CONNECTION
5. DISCONNECTING CIRCUIT
RECEIVING: THE TECHNICAL PROCESSES OF RECOGNIZING AND ACCEPTING INFORMATION THAT HAS BEEN TRANSMITTED.

A. COLLECTING
   1. DETECTING
      A. MEASURING RADIATION PATTERN
      B. DETERMINING EFFECTIVE AREA
      C. POSITIONING
      D. CONCENTRATING
   2. SELECTING
      A. SEPARATING
      B. TUNING

B. CONNECTING
   1. SPLICING
   2. SOLDERING
   3. COUPLING
   4. BONDING

C. AMPLIFYING
   1. FREQUENCY FILTERING
      A. LOW PASSING
      B. BAND PASSING
      C. HIGH PASSING
   2. SIGNAL INCREASING
      A. SUMMING AMPLIFIERS
      B. INTEGRATING AMPLIFIERS
      C. OSCILLATING AMPLIFIERS

D. DEMODULATING
   1. PULSE CODING
   2. PULSE DURATION VARYING
   3. FREQUENCY VARYING
   4. AMPLITUDE VARYING
   5. PHASE VARYING
   6. DECRYPTING

E. DEMULTIPLEXING
   1. TIME DIVIDING
   2. FREQUENCY DIVIDING
STORING: THE TECHNICAL PROCESSES OF RECORDING AND FILING INFORMATION FOR USE AT A LATER TIME

A. SEPARATING
   1. LATENT IMAGE PROCESSING
      A. DEVELOPING
      B. FIXING
      C. DRYING
      D. MOUNTING
      E. RE-EXPOSING
      F. SCALING

   2. PUNCHING
      A. FORMATING
      B. LOCATING
      C. SHEARING
      D. REMOVING

   3. MACHINING
      A. FORMATING
      B. ELECTROMECHANICAL TRANSDUCING
      C. REMOVING

B. COATING
   1. FIXED RAISED SURFACE PRINTING
   2. ADDRESSABLE RAISED SURFACE PRINTING
   3. PLANE SURFACE PRINTING
   4. SUNKEN SURFACE PRINTING
   5. THROUGH-THE-SURFACE PRINTING
   6. SPRAYING THE SURFACE
   7. ELECTROSTATIC DEPOSITING ON THE SURFACE

C. CONDITIONING
   1. MAGNETIZING
      A. POSITIONING SUBSTRATE
      B. DEMAGNETIZING
      C. CREATING A FRINGING FIELD
      D. HEAD POSITIONING
         1. TRACKING
         2. QUADRAPLEXING
         3. HELICAL SCANNING

   2. HEATING
      A. POSITIONING SUBSTRATE
      B. CONTROLLING HEAT SOURCE

D. FORMING
   1. POSITIONING SUBSTRATE
   2. APPLYING HEAT AND/OR PRESSURE
RETRIEVING: THE TECHNICAL PROCESSES OF RECALLING INFORMATION FROM A STORED CONDITION.

A. ABSTRACTING
   1. ASSESSING ITEM CONTENT
   2. SUMMARIZING ITEM CONTENT

B. INDEXING
   1. DETERMINING SEARCH VOCABULARY
      A. CONTROLLING VOCABULARY
      B. NON-CONTROLLING VOCABULARY
   2. CODING ITEM

C. ACCESSING
   1. LOCATING
   2. RECALLING

E. CONTROLLING
   1. IDENTIFYING USER
   2. DETERMINING USER RETRIEVAL PRIVILEGES
DECODING: THE TECHNICAL PROCESSES WHICH CONVERT RECORDED OR MODIFIED INFORMATION INTO AN ACCEPTABLE FORMAT FOR USE.

A. CONVERTING ELECTRICAL ENERGY
   1. TO ACOUSTICAL ENERGY
      A. ACOUSTIC BAFFLING
         1. ENCLOSING
         2. SUSPENDING
      B. VIBRATING
         1. ELECTROMAGNETIZING
         2. PIEZO-ELECTRIC STRESSING
         3. ELECTROSTATIC DEFLECTING
      C. ACOUSTIC WAVE GENERATING
         1. DIAPHRAMS
         2. CONES

   2. TO LIGHT ENERGY
      A. PICTURE ELEMENT LOCATING
         1. SCANNING
         2. ADDRESSING
      B. LIGHT EMITTING
         1. FLUORESCING
         2. ELECTROLUMINESING
         3. GAS DISCHARGING
      C. LIGHT REFLECTING
         1. LIQUID CRYSTAL REFLECTING
         2. LIQUID CRYSTAL ABSORBING

   3. TO MECHANICAL ENERGY
      A. STRIKING
      B. CONTROLLING
      C. POSITIONING

B. PROJECTING
   1. ILLUMINATING
      A. INCOHERENT LIGHTING
      B. COHERENT LIGHTING
      C. TRANSPORTING SUBSTRATE
   2. SCALING
      A. ENLARGING
      B. REDUCING
   3. FOCUSING
      A. VIEWFINDING
      B. LENS ALIGNING

C. REFLECTING
   1. ILLUMINATING
      A. INCOHERENT LIGHTING
      B. COHERENT LIGHTING
FEEDBACK: THE TECHNICAL PROCESSES WHICH USE A COMMUNICATION SYSTEM TO TRANSMIT INFORMATION BACK TO THE POINT OF ORIGIN.

A. OPEN LOOPING
1. ENCODING
2. TRANSMITTING
3. RECEIVING

B. CLOSED LOOPING
1. MONITORING
2. ENCODING
3. TRANSMITTING
4. RECEIVING
5. MODIFYING
PROPOSED TECHNICAL SPECIALISTS

A. VOICE COMMUNICATIONS

1. Pete Morgan  
   Technical Consultant  
   AT&T  
   Pete has expertise in voice systems as well as data networks and systems. Pete spent a number of years at UW-Stevens Point prior to joining AT&T giving him an educational background as well. Pete prepared the spec's for the PBX and Data networks aquired by UW-SP.

2. Dr. Harry Herbert  
   Director of Instructional Technology Services  
   Chairman- Telecommunications Coordinating Team  
   UW-Stout  
   Dr. Herbert has a long and varied career with a solid background in a number of technical areas. He currently is managing the decisionmaking process as to a new phone system for our campus. Dr. Herbert's broad background would be of great value in reviewing various parts of my model.

B. DATA COMMUNICATIONS

1. Dave Rasmussen  
   Industrial Trainer  
   Allen-Bradley Co.  
   Dave deals with programmable controllers and the manufacturing shop floor communications as used in automated manufacturing settings. Dave also has a very broad general computing background having authored and marketed several pieces of software.

2. Andy Bear  
   Instructor  
   UW-Stout  
   Andy has strengths in computing hardware and software. He has engineered several local area networks on campus as well as designing the computer system for Hobar Publications. Andy has also written numerous pieces of software marketed through Hobar Publications which was started by his father. Having taught graphic arts for several years Andy would also valuable in reviewing the graphics component of the model.
C. VIDEO COMMUNICATIONS

1. Dave Kaun
   Engineering Manager
   Tele-Production Center
   Channel 28

   Dave, as an engineer, manages all broadcast quality
   program production for Channel 28. Dave has a very solid
   technical background in the video field as well as other
   areas of communication related to this study. Dave has
   designed several of the on-campus phone systems as
   well as a video distribution network.

2. John Lauson
   Audio/Video Coordinator
   Instructional Technology Services
   Teleproduction Center Channel 28

   John coordinates audio and video services both on
   campus and for Channel 28. Having taught for several
   years at the vocational school level John also brings a
   solid electronics background to the study.

D. GRAPHIC REPRODUCTION

1. Bob Biddick
   Communications Technology Instructor
   Rice Lake High School

   After working in the printing industry for several
   years Bob has returned to teaching at Rice Lake. Bob
   still does commercial graphic design work. Bob
   understands how graphics fits into a study of
   communications technology. Bob also has a sound computing
   background.

2. Dale Hansen
   Graphic Arts/Communications Instructor
   Appleton Senior High School

   Dale spent numerous years running a family owned
   printing business before choosing to teach. Along with a
   good background in graphics Dale has expertise in
   electronics.

E. COMPUTING

1. Mike Jensen
   Electronic Communication Instructor
   Rice Lake High School
Mike teaches several advanced communications courses at Rice Lake including electronic communications, video production and computer aided design. Mike’s background includes being vocationally certified in electronics.

2. Dan Massopust
   Engineer
   Cray Research
   Dan has a strong electronics background and has been interested in what students are taught about computing. Dan would work well in terms of seeing how computing is an integral part of communication systems.
APPENDIX C

A TAXONOMY OF THE CONCEPTS OF COMMUNICATIONS TECHNOLOGY

DEVELOPED BY ROBERT W. HENDRICKS
ENCODING: THE TECHNICAL PROCESSES WHICH RECODE OR MODIFY INFORMATION INTO A DESIRED FORMAT OR PATTERN FOR A SPECIFIC METHOD OF TRANSMISSION OR STORAGE.

A. DESIGNING
   1. SPECIFYING
      A. DETERMINING OBJECTIVE OF COMMUNICATION
      B. ANALYZING AUDIENCE/RECIPIENT CHARACTERISTICS
      C. ANALYZING ECONOMIC VARIABLES
      D. CHOOSING THE APPROPRIATE TECHNOLOGY

2. COMPOSING
   A. SCRIPTING
   B. FLOWCHARTING
   C. STORYBOARDING
   D. ASSEMBLING GRAPHIC IMAGE
   E. PROGRAMMING

B. CONVERTING ACOUSTICAL ENERGY
   1. TO AN ELECTRICAL SIGNAL
      A. TRANSUDUCING
         1. DYNAMIC TRANSUDUCING
         2. MAGNETIC TRANSUDUCING
         3. ELECTROSTATIC TRANSUDUCING
         4. PIEZOELECTRIC TRANSUDUCING
         5. ELECTRORESTRICTIVE TRANSUDUCING
         6. CARBON TRANSUDUCING
      B. CONTROLLING DIRECTIONALITY
         1. UNIDIRECTIONAL INPUT
         2. BI-DIRECTIONAL INPUT

C. CONVERTING LIGHT ENERGY
   1. TO AN ELECTRICAL SIGNAL
      A. ILLUMINATING
         1. SPOTLIGHTING
         2. FLOODLIGHTING
         3. BACKLIGHTING
      B. FOCUSING
         1. VIEWFINDING
         2. DIRECT LENS ALIGNING
         3. INDIRECT LENS ALIGNING
      C. ELECTRICAL EMITTING
         1. Emitting photodiodes
         2. Emitting photomultipliers
      D. PHOTOSENSING
         1. QUANTIFYING
2. RECOGNIZING
E. SCANNING
   1. MECHANICAL
   2. ELECTRONIC
F. SYNCHRONIZING
   1. COLOR BURST SIGNALING
   2. RANDOM INTERLACING

2. TO A LATENT CHEMICAL IMAGE
A. ILLUMINATING
   1. SPOTLIGHTING
   2. FLOODLIGHTING
   3. BACKLIGHTING
B. FOCUSING
   1. VIEWFINDING
   2. DIRECT LENS ALIGNING
   3. INDIRECT LENS ALIGNING
C. EXPOSING
   1. CONTROLLING QUANTITY
   2. CONTROLLING DURATION
D. SCALING
   1. ENLARGING
   2. REDUCING

D. CONVERTING MECHANICAL ENERGY
   1. TO ELECTRICAL ENERGY
      A. VIBRATING
      B. POSITIONING
      C. DEPRESSING
      D. ROTATING

E. CONVERTING HEAT ENERGY
   1. TO ELECTRICAL ENERGY
      A. THERMOCOUPLE SENSING
      B. THERMISTOR SENSING
      C. RESISTIVE TEMPERATURE SENSING
TRANSMITTING: THE TECHNICAL PROCESSES OF CONVEYING INFORMATION FROM ONE LOCATION TO ANOTHER

A. MODULATING
1. PULSE CODING
2. PULSE DURATION VARYING
3. FREQUENCY VARYING
4. AMPLITUDE VARYING
5. PHASE VARYING
6. ENCRYPTING

B. AMPLIFYING
1. FREQUENCY FILTERING
   A. LOW PASSING
   B. BAND PASSING
   C. HIGH PASSING
2. SIGNAL REGENERATING
   A. OSCILLATING AMPLIFIERS
3. SIGNAL ADDING
   A. SUMMING AMPLIFIERS
   B. INTEGRATING AMPLIFIERS

C. MULTIPLEXING
1. TIME DIVIDING
2. FREQUENCY DIVIDING

D. DUPLEXING
1. SIMPLEXING
2. HALF DUPLEXING
3. FULL DUPLEXING

E. PROPAGATING
1. ATMOSPHERIC CHANNELING
   A. DIRECT WAVE RADIATING
   B. GROUND WAVE RADIATING
   C. SKY WAVE RADIATING
   D. RADIATION PATTERNING
   E. POSITIONING
2. PHYSICAL CHANNELING
   A. LIGHT GUIDING FIBER OPTIC
      1. MULTIMODE INDEXING
      2. SINGLE MODE INDEXING
      3. MULTIMODE GRADED INDEXING
   B. ELECTRICAL SIGNAL GUIDING
      1. TWISTED PAIR CABLE
2. COAXIAL CABLE
   A. BROADBAND
   B. BASEBAND

3. WAVE GUIDING

F. SIGNAL CONDITIONING

1. ELECTRICAL-TO-LIGHT CONVERTING
   A. SAMPLING
   B. QUANTIFYING
   C. DIGITIZING
   D. LIGHT EMITTING
      1. LASERS
      2. LIGHT EMITTING DIODES

2. LIGHT-TO-ELECTRICAL CONVERTING
   A. LIGHT SENSING
      1. PHOTODIODES
      2. PHOTOTRANSISTORS
   B. RECONSTRUCTING

3. ANALOG-TO-DIGITAL CONVERTING
   A. SAMPLING
   B. QUANTIFYING
   C. DIGITIZING

4. DIGITAL-TO-ANALOG CONVERTING
   A. RECEIVING INPUT CODE
   B. STEPPED VOLTAGE OUTPUT
   C. AMPLIFYING
   D. FILTERING

5. SERIAL-TO-PARALLEL CONVERTING
   A. SAMPLING
   B. SHIFT REGISTERING

6. PARALLEL-TO-SERIAL CONVERTING
   A. SAMPLING
   B. SHIFT REGISTERING

7. ESTABLISHING PROTOCOL
   A. IDENTIFYING CHARACTER SET
   B. DETERMINING MESSAGE TIMING
   C. IDENTIFYING ERRORS
   D. ERROR CORRECTING

G. FREQUENCY SELECTING
   A. ELECTRICAL
      1. VERY LOW FREQUENCY
      2. LOW FREQUENCY
      3. MEDIUM FREQUENCY
4. HIGH FREQUENCY
5. VERY HIGH FREQUENCY
6. ULTRA HIGH FREQUENCY
7. SUPER HIGH FREQUENCY

B. OPTICAL
1. INFRARED
2. VISABLE
3. ULTRAVIOLET

H. SWITCING
1. SENSING ACCESS REQUEST
2. DETERMINING DESTINATION
3. SELECTING PATH
4. ESTABLISHING CONNECTION
5. DISCONNECTING CIRCUIT
RECEIVING: THE TECHNICAL PROCESSES OF RECOGNIZING AND ACCEPTING INFORMATION THAT HAS BEEN TRANSMITTED.

A. COLLECTING
   1. DETECTING
      A. MEASURING RADIATION PATTERN
      B. DETERMINING EFFECTIVE AREA
      C. POSITIONING
      D. CONCENTRATING
   2. SELECTING
      A. SEPARATING
      B. TUNING
      C. RECOGNIZING

B. CONNECTING
   1. SPLICING
   2. SOLDERING
   3. COUPLING
   4. BONDING

C. AMPLIFYING
   1. FREQUENCY FILTERING
      A. LOW PASSING
      B. BAND PASSING
      C. HIGH PASSING
   2. SIGNAL REGENERATING
      A. OSCILLATING AMPLIFIERS
   3. SIGNAL ADDING
      A. SUMMING AMPLIFIERS
      B. INTEGRATING AMPLIFIERS

D. DEMODULATING
   1. PULSE CODING
   2. PULSE DURATION VARYING
   3. FREQUENCY VARYING
   4. AMPLITUDE VARYING
   5. PHASE VARYING
   6. DECRYPTING

E. DEMULTIPLEXING
   1. TIME DIVIDING
   2. FREQUENCY DIVIDING
STORING: THE TECHNICAL PROCESSES OF RECORDING AND FILING INFORMATION FOR USE AT A LATER TIME

A. SEPARATING
   1. LATENT IMAGE PROCESSING
      A. DEVELOPING
         1. MULTI-STEP DARKROOM PROCESSING
         2. SINGLE-STEP AMBIENT PROCESSING
      B. FIXING
      C. DRYING
      D. MOUNTING
      E. EXPOSING
      F. SCALING
      G. FILTERING

2. PUNCHING
   A. FORMATING
   B. LOCATING
   C. SHEARING
   D. REMOVING

3. MACHINING
   A. FORMATING
   B. ELECTROMECHANICAL TRANSUDUCING
   C. REMOVING

B. COATING
   1. FIXED RAISED SURFACE PRINTING
   2. ADDRESSABLE RAISED SURFACE PRINTING
   3. PLANE SURFACE PRINTING
   4. SUNKEN SURFACE PRINTING
   5. THROUGH-THE-SURFACE PRINTING
   6. SPRAYING THE SURFACE
   7. ELECTROSTATIC DEPOSITING ON THE SURFACE

C. CONDITIONING
   1. MAGNETIZING
      A. POSITIONING SUBSTRATE
      B. DEMAGNETIZING
      C. CREATING A FRINGING FIELD
      D. HEAD POSITIONING
         1. TRACKING
         2. TRANSVERSE SCANNING
         3. HELICAL SCANNING
         4. LONGITUDINAL SCANNING
   2. HEATING
      A. POSITIONING SUBSTRATE
      B. CONTROLLING HEAT SOURCE
D. FORMING
   1. POSITIONING SUBSTRATE
   2. APPLYING HEAT AND/OR PRESSURE
RETRIEVING: THE TECHNICAL PROCESSES OF RECALLING INFORMATION FROM A STORED CONDITION.

A. ABSTRACTING
   1. ASSESSING ITEM CONTENT
   2. SUMMARIZING ITEM CONTENT

B. INDEXING
   1. DETERMINING SEARCH VOCABULARY
      A. CONTROLLING VOCABULARY
      B. NON-CONTROLLING VOCABULARY
   2. CODING ITEM

C. ACCESSING
   1. LOCATING
   2. RECALLING

E. CONTROLLING
   1. IDENTIFYING USER
   2. DETERMINING USER RETRIEVAL PRIVILEGES
DECODING: THE TECHNICAL PROCESSES WHICH CONVERT-recorded
OR MODIFIED INFORMATION INTO AN ACCEPTABLE FORMAT FOR USE.

A. CONVERTING ELECTRICAL ENERGY
   1. TO ACOUSTICAL ENERGY
      A. ACOUSTIC BAFFLING
         1. ENCLOSING
         2. SUSPENDING
      B. TRANSDUCING
         1. ELECTROMAGNETIZING
         2. PIEZO-ELECTRIC STRESSING
         3. ELECTROSTATIC DEFLECTING
      C. ACOUSTIC WAVE GENERATING
         1. DIAPHRAMS
         2. CONES

2. TO LIGHT ENERGY
   A. PICTURE ELEMENT LOCATING
      1. SCANNING
      2. ADDRESSING
   B. LIGHT EMITTING
      1. FLOURESCING
      2. ELECTROLUMINESING
      3. GAS DISCHARGING
   C. LIGHT REFLECTING
      1. LIQUID CRYSTAL REFLECTING
      2. LIQUID CRYSTAL ABSORBING

3. TO MECHANICAL ENERGY
   A. STRIKING
   B. CONTROLLING
   C. POSITIONING
   D. VIBRATING

B. PROJECTING
   1. ILLUMINATING
      A. INCOHERENT LIGHTING
      B. COHERENT LIGHTING
      C. TRANSPORTING SUBSTRATE
   2. SCALING
      A. ENLARGING
      B. REDUCING
   3. FOCUSING
      A. VIEWFINDING
      B. LENS ALIGNING
C. REFLECTING
   1. ILLUMINATING
      A. INCOHERENT LIGHTING
      B. COHERENT LIGHTING
FEEDBACK: THE TECHNICAL PROCESSES WHICH USE A COMMUNICATION SYSTEM TO TRANSMIT INFORMATION BACK TO THE POINT OF ORIGIN.

A. OPEN LOOPING
   1. ENCODING
   2. TRANSMITTING
   3. RECEIVING
   4. DECODING

B. CLOSED LOOPING
   1. MONITORING
   2. ENCODING
   3. TRANSMITTING
   4. RECEIVING
   5. DECODING
   6. MODIFYING
COMMUNICATIONS TECHNOLOGY: A TAXONOMY

AN INTRODUCTION

Our society and the societies of the world are being impacted daily by the application of communications technology. Numerous authors and futurists refer to the kind of society we are evolving into as; The Information Society, Communications Age, Third Wave, Post Industrial Society (Thebold, 1982) (Toffler, 1980) (Davis & McCormick, 1981). While the titles may differ, all refer to the reshaping of many social institutions as a result of communication technology. Just as the industrial revolution extended our ability to produce material goods, the emerging technologies of communication will greatly extend our ability to create, transmit and store information. New technologies becoming commonplace in business, industrial, residential and educational settings are demanding new skills and competencies in the individuals expected to function effectively within these environments. The use of many of these systems and their
technologies have become commonplace in our lives. The challenge to technology education is to integrate the study of these emerging technologies into its program of study.

Technology education as a profession has always been concerned with relevant curriculum development and the subsequent validation of that curriculum. This dissertation continues the pursuit of knowledge important to curriculum developers by designing and validating a taxonomy in the area of communications technology.

Communications was one of four human adaptive systems defined in the Jackson's Mill Industrial Arts Curriculum Theory, the other three being, construction, transportation and manufacturing. The Jackson's Mill Industrial Arts Curriculum Theory is clearly one of the more significant documents impacting the technology education profession today. A consensus was forged at Jackson's Mill which provides the basis for much of the technology education movement. The challenge facing the profession today is to interpret the Jackson's Mill work and integrate its systems into classrooms and laboratories throughout the country. Indeed, the profession is responding to this challenge. Taxonomies have been developed, some prior to the Jackson's Mill work, in the areas of manufacturing, construction and transportation.
Instructional materials for these taxonomies are developed or being developed in various settings around the country. In communications technology no comprehensive taxonomy exists and developed curriculum materials reflect the clustering of similar processes rather than the organization of content around validated concepts. This problem, in the investigators opinion, has been apparent in numerous curriculum documents including the recently completed *Curriculum Implementation Project*.

It is the intent of this study to build upon the foundation established by the Jackson's Mill work. It is accepted that communications is one of four human adaptive systems and thus appropriate content for technology education. The major concepts of communications, as listed in Jackson's Mill are accepted. These concepts being: encoding, transmitting, receiving, storing, retrieving, decoding and feedback. The need then is to identify, organize and define second and third level subconcepts to the communications concepts identified in Jackson's Mill. The task of this study is to organize the processes of communications into a taxonomy thus providing a framework for study. The taxonomy is a systematic detailing of the technical processes of communications technology. While the combining of these technical processes results in a wide variety of communication
devices, this taxonomy is not intended to be a categorization of communication devices. However, the operational significance of the taxonomy is exhibited when a specific device is traced through it.

It is important to distinguish this work from the area of science and the area of human communication skills and abilities. This work is not intended to be an investigation of scientific concepts or phenomenon. While science might investigate the characteristics of electrical, acoustic and visual phenomenon for the purpose of their description, the study of communication technology would center itself on how people apply tools, techniques and processes to manipulate these phenomenon for the purpose of creating, moving and storing information. Of similar importance is to distinguish this work from human communication skills and abilities. The ability to read is the ability to decode the printed word and derive meaning. It makes use of acquired mental skills and abilities and as such would not apply the technologies of communication. The human brain has the ability to encode, store and decode information and as such represents an extremely sophisticated process. This study in no way pretends to deal with this mental/human communications process. However, if this printed word is stored magnetically, reproduced, or transmitted in a
digital format then the technologies of communications come into play. The focus of this taxonomy is on the technologies used by people to enhance communications.
A TAXONOMY OF THE CONCEPTS
OF
COMMUNICATIONS TECHNOLOGY

DEVELOPED BY
ROBERT W. HENDRICKS
ENCODING: THE TECHNICAL PROCESSES WHICH RECODE OR MODIFY INFORMATION INTO A DESIRED FORMAT OR PATTERN FOR A SPECIFIC METHOD OF TRANSMISSION OR STORAGE.

A. DESIGNING
   1. FORMULATING
      A. DETERMINING OBJECTIVE OF COMMUNICATION
      B. ANALYZING AUDIENCE/RECIEVER CHARACTERISTICS

2. RESEARCHING
   A. LOCATING DATA
   B. RETRIEVING DATA
   C. DESCRIBING DATA
   D. EVALUATING DATA
   E. FORECASTING

3. EVALUATING
   A. ANALYZING ECONOMIC VARIABLES
   B. ANALYZING TECHNICAL VARIABLES
   C. CHOOSING THE APPROPRIATE TECHNOLOGY

4. COMPOSING
   A. SCRIPTING
   B. FLOWCHARTING
   C. STORYBOARDING
   D. ASSEMBLING GRAPHIC IMAGES
   E. PROGRAMMING

B. CONVERTING ACOUSTICAL ENERGY
   1. TO AN ELECTRICAL SIGNAL
      A. TRANSDUCING
         1. DYNAMIC TRANSDUCING
         2. MAGNETIC TRANSDUCING
         3. ELECTROSTATIC TRANSDUCING
         4. PEIZOELECTRIC TRANSDUCING
         5. ELECTRORESTRICTIVE TRANSDUCING
         6. CARBON TRANSDUCING
      B. CONTROLLING DIRECTIONALITY
         1. UNIDIRECTIONAL INPUT
         2. BI-DIRECTIONAL INPUT

C. CONVERTING LIGHT ENERGY
   1. TO AN ELECTRICAL SIGNAL
      A. ILLUMINATING
         1. SPOTLIGHTING
         2. FLOODLIGHTING
3. BACKLIGHTING

B. FOCUSING
   1. VIEWFINDING
   2. DIRECT LENS ALIGNING
   3. INDIRECT LENS ALIGNING

C. ELECTRICAL EMITTING
   1. EMITTING PHOTODIODES
   2. EMITTING PHOTOMULTIPLIERS

D. PHOTOSENSING
   1. QUANTIFYING
   2. RECOGNIZING

E. SCANNING
   1. MECHANICAL
   2. ELECTRONIC

F. SYNCHRONIZING
   1. COLOR BURST SIGNALING
   2. RANDOM INTERLACING

2. TO A LATENT CHEMICAL IMAGE

A. ILLUMINATING
   1. SPOTLIGHTING
   2. FLOODLIGHTING
   3. BACKLIGHTING

B. FOCUSING
   1. VIEWFINDING
   2. DIRECT LENS ALIGNING
   3. INDIRECT LENS ALIGNING

C. EXPOSING
   1. CONTROLLING QUANTITY
   2. CONTROLLING DURATION

D. SCALING
   1. ENLARGING
   2. REDUCING

E. SELECTING EMULSION

D. CONVERTING MECHANICAL ENERGY
   1. TO ELECTRICAL ENERGY
      A. VIBRATING
      B. POSITIONING
      C. DEPRESSING
      D. ROTATING

E. CONVERTING HEAT ENERGY
   1. TO ELECTRICAL ENERGY
      A. THERMOCOUPE SENSING
      B. THERMISTOR SENSING
      C. RESISTIVE TEMPERATURE SENSING
TRANSMITTING: THE TECHNICAL PROCESSES OF CONVEYING INFORMATION FROM ONE LOCATION TO ANOTHER

A. MODULATING
1. PULSE CODING
2. PULSE DURATION VARYING
3. FREQUENCY VARYING
4. AMPLITUDE VARYING
5. PHASE VARYING
6. ENCRYPTING

B. AMPLIFYING
1. FREQUENCY FILTERING
   A. LOW PASSING
   B. BAND PASSING
   C. HIGH PASSING
2. SIGNAL REGENERATING
   A. OSCILLATING AMPLIFIERS
3. SIGNAL ADDING
   A. SUMMING AMPLIFIERS
   B. INTEGRATING AMPLIFIERS

C. MULTIPLEXING
1. TIME DIVIDING
2. FREQUENCY DIVIDING

D. DUPLEXING
1. SIMPLEXING
2. HALF DUPLEXING
3. FULL DUPLEXING

E. FREQUENCY SELECTING
A. ELECTRICAL
   1. VERY LOW FREQUENCY
   2. LOW FREQUENCY
   3. MEDIUM FREQUENCY
   4. HIGH FREQUENCY
   5. VERY HIGH FREQUENCY
   6. ULTRA HIGH FREQUENCY
   7. SUPER HIGH FREQUENCY
B. OPTICAL
   1. INFRARED
   2. VISABLE
   3. ULTRAVIOLET
F. PROPAGATING

1. ATMOSPHERIC CHANNELING
   A. DIRECT WAVE RADIATING
   B. GROUND WAVE RADIATING
   C. SKY WAVE RADIATING
   D. RADIATION PATTERNING
   E. POSITIONING

2. PHYSICAL CHANNELING
   A. LIGHT GUIDING FIBER OPTIC
      1. MULIMODE INDEXING
      2. SINGLE MODE INDEXING
      3. MULTIMODE GRADED INDEXING
   B. ELECTRICAL SIGNAL GUIDING
      1. TWISTED PAIR CABLE
      2. COAXIAL CABLE
         A. BROADBAND
         B. BASEBAND
      3. WAVE GUIDING

G. SIGNAL CONDITIONING

1. ELECTRICAL-TO-LIGHT CONVERTING
   A. SAMPLING
   B. QUANTIFYING
   C. DIGITIZING
   D. LIGHT EMITTING
      1. LASERS
      2. LIGHT EMITTING DIODES

2. LIGHT-TO-ELECTRICAL CONVERTING
   A. LIGHT SENSING
      1. PHOTODIODES
      2. PHOTOTRANSISTORS
   B. RECONSTRUCTING

3. ANALOG-TO-DIGITAL CONVERTING
   A. SAMPLING
   B. QUANTIFYING
   C. DIGITIZING

4. DIGITAL-TO-ANALOG CONVERTING
   A. RECEIVING INPUT CODE
   B. STEPPED VOLTAGE OUTPUT
   C. AMPLIFYING
   D. FILTERING

5. SERIAL-TO-PARALLEL CONVERTING
   A. SAMPLING
   B. SHIFT REGISTERING
6. PARALLEL-TO-Serial CONVERTING
   A. SAMPLING
   B. SHIFT REGISTERING

7. ESTABLISHING PROTOCOL
   A. IDENTIFYING CHARACTER SET
   B. DETERMINING MESSAGE TIMING
   C. IDENTIFYING ERRORS
   D. ERROR CORRECTING

H. SWITCHING
1. SENSING ACCESS REQUEST
2. DETERMINING DESTINATION
3. SELECTING PATH
4. ESTABLISHING CONNECTION
5. DISCONNECTING CIRCUIT
RECEIVING: THE TECHNICAL PROCESSES OF RECOGNIZING AND ACCEPTING INFORMATION THAT HAS BEEN TRANSMITTED.

A. COLLECTING
   1. DETECTING
      A. MEASURING RADIATION PATTERN
      B. DETERMINING EFFECTIVE AREA
      C. POSITIONING
      D. CONCENTRATING
   2. SELECTING
      A. SEPARATING
      B. TUNING
      C. RECOGNIZING

B. CONNECTING
   1. SPlicing
   2. SOLDERING
   3. COUPLING
   4. BONDING

C. AMPLIFYING
   1. FREQUENCY FILTERING
      A. LOW PASSING
      B. BAND PASSING
      C. HIGH PASSING
   2. SIGNAL REGENERATING
      A. OSCILLATING AMPLIFIERS
   3. SIGNAL ADDING
      A. SUMMING AMPLIFIERS
      B. INTEGRATING AMPLIFIERS

D. DEMODULATING
   1. PULSE CODING
   2. PULSE DURATION VARYING
   3. FREQUENCY VARYING
   4. AMPLITUDE VARYING
   5. PHASE VARYING
   6. DECRYPTING

E. DEMULTIPLEXING
   1. TIME DIVIDING
   2. FREQUENCY DIVIDING
STORING: THE TECHNICAL PROCESSES OF RECORDING AND FILING INFORMATION FOR USE AT A LATER TIME

A. SEPARATING
   1. LATENT IMAGE PROCESSING
      A. DEVELOPING
         1. MULTI-STEP DARKROOM PROCESSING
      B. FIXING
      C. DRYING
      D. MOUNTING
      E. EXPOSING
      F. SCALING
      G. FILTERING
   2. PUNCHING
      A. FORMATING
      B. LOCATING
      C. SHEARING
   3. MACHINING
      A. FORMATING
      B. ELECTROMECHANICAL TRANSDUCING

B. COATING
   1. FIXED RAISED SURFACE PRINTING
   2. ADDRESSABLE RAISED SURFACE PRINTING
   3. PLANE SURFACE PRINTING
   4. SUNKEN SURFACE PRINTING
   5. THROUGH-THE-SURFACE PRINTING
   6. SPRAYING THE SURFACE
   7. ELECTROSTATIC DEPOSITING ON THE SURFACE

C. CONDITIONING
   1. MAGNETIZING
      A. POSITIONING SUBSTRATE
      B. DEMAGNETIZING
      C. CREATING A FRINGING FIELD
      D. HEAD POSITIONING
         1. TRACKING
         2. TRANSVERSE SCANNING
         3. HELICAL SCANNING
         4. LONGITUDINAL SCANNING
   2. HEATING
      A. POSITIONING SUBSTRATE
      B. CONTROLLING HEAT SOURCE
   3. DEVELOPING
      A. SINGLE-STEP AMBIENT PROCESSING
D. FORMING

1. POSITIONING SUBSTRATE
2. APPLYING HEAT AND/OR PRESSURE
RETRIEVING: THE TECHNICAL PROCESSES OF RECALLING INFORMATION FROM A STORED CONDITION.

A. ABSTRACTING
   1. ASSESSING ITEM CONTENT
   2. SUMMARIZING ITEM CONTENT

B. INDEXING
   1. DETERMINING SEARCH VOCABULARY
      A. CONTROLLING VOCABULARY
      B. NON-CONTROLLING VOCABULARY
   2. CODING ITEM

C. ACCESSING
   1. LOCATING
   2. RECALLING

E. CONTROLLING
   1. IDENTIFYING USER
   2. DETERMINING USER RETRIEVAL PRIVILEGES
DECODING: THE TECHNICAL PROCESSES WHICH CONVERT Recorded OR MODIFIED INFORMATION INTO AN ACCEPTABLE FORMAT FOR USE.

A. CONVERTING ELECTRICAL ENERGY
   1. TO ACOUSTICAL ENERGY
      A. ACOUSTIC BAFFLING
         1. ENCLOSING
         2. SUSPENDING
      B. TRANSDUCING
         1. ELECTROMAGNETIZING
         2. PIEZO-ELECTRIC STRESSING
         3. ELECTROSTATIC DEFLECTING
      C. ACOUSTIC WAVE GENERATING
         1. DIAPHRAMS
         2. CONES
   2. TO LIGHT ENERGY
      A. PICTURE ELEMENT LOCATING
         1. SCANNING
         2. ADDRESSING
      B. LIGHT EMITTING
         1. FLOURESCING
         2. ELECTROLUMINESING
         3. GAS DISCHARGING
      C. LIGHT REFLECTING
         1. LIQUID CRYSTAL REFLECTING
         2. LIQUID CRYSTAL ABSORBING
   3. TO MECHANICAL ENERGY
      A. STRIKING
      B. CONTROLLING
      C. POSITIONING
      D. VIBRATING

B. PROJECTING
   1. ILLUMINATING
      A. INCOHERENT LIGHTING
      B. COHERENT LIGHTING
      C. TRANSPORTING SUBSTRATE
   2. SCALING
      A. ENLARGING
      B. REDUCING
   3. FOCUSING
      A. VIEWFINDING
      B. LENS ALIGNING
C. REFLECTING
   1. ILLUMINATING
      A. INCOHERENT LIGHTING
      B. COHERENT LIGHTING
FEEDBACK: THE TECHNICAL PROCESSES WHICH USE A COMMUNICATION SYSTEM TO TRANSMIT INFORMATION BACK TO THE POINT OF ORIGIN.

A. OPEN LOOPING
   1. ENCODING
   2. TRANSMITTING
   3. RECEIVING
   4. DECODING

B. CLOSED LOOPING
   1. MONITORING
   2. ENCODING
   3. TRANSMITTING
   4. RECEIVING
   5. DECODING
   6. MODIFYING
APPENDIX E

A TAXONOMY OF THE CONCEPTS
OF
COMMUNICATIONS TECHNOLOGY

DEVELOPED BY
ROBERT W. HENDRICKS
1. Encoding: The technical processes which recode or modify information into a desired format or pattern for a specific method of transmission or storage.

1.1 Designing

1.1.1 Formulating
1.1.1.1 Determining objective of communication
1.1.1.2 Analyzing audience/receiver characteristics

1.1.2 Researching
1.1.2.1 Locating data
1.1.2.2 Retrieving data
1.1.2.3 Describing data
1.1.2.4 Evaluating data
1.1.2.5 Forecasting

1.1.3 Composing
1.1.3.1 Scripting
1.1.3.2 Flowcharting
1.1.3.3 Storyboarding
1.1.3.4 Assembling graphic images
1.1.3.5 Programming

1.1.4 Evaluating
1.1.4.1 Analyzing economic variables
1.1.4.2 Analyzing technical variables
1.1.4.3 Analyzing aesthetic variables
1.1.4.4 Choosing the appropriate technology

1.2 Converting acoustical to electrical energy

1.2.1 Transducing
1.2.1.1 Dynamic transducing
1.2.1.2 Magnetic transducing
1.2.1.3 Electrostatic transducing
1.2.1.4 Piezoelectric transducing
1.2.1.5 Electrorestrictive transducing
1.2.1.6 Carbon transducing

1.2.2 Controlling directionality
1.2.2.1 Unidirectional input
1.2.2.2 Bi-directional input
1.3 CONVERTING LIGHT TO ELECTRICAL ENERGY

1.3.1 ILLUMINATING
   1.3.1.1 SPOTLIGHTING
   1.3.1.2 FLOODLIGHTING
   1.3.1.3 BACKLIGHTING

1.3.2 FOCUSING
   1.3.2.1 VIEWFINDING
   1.3.2.2 DIRECT LENS ALIGNING
   1.3.2.3 INDIRECT LENS ALIGNING

1.3.3 ELECTRICAL EMITTING
   1.3.3.1 PHOTODETECTING
   1.3.3.2 PHOTOCONDUCTING
   1.3.3.3 PHOTOMULTIPLYING

1.3.4 PHOTOSENSING
   1.3.4.1 QUANTIFYING
   1.3.4.2 RECOGNIZING

1.3.5 SCANNING
   1.3.5.1 MECHANICAL
   1.3.5.2 ELECTRONIC

1.3.6 SYNCHRONIZING
   1.3.6.1 COLOR BURST SIGNALING
   1.3.6.2 RANDOM INTERLACING

1.4 CONVERTING LIGHT TO A LATENT CHEMICAL IMAGE

1.4.1 ILLUMINATING
   1.4.1.1 SPOTLIGHTING
   1.4.1.2 FLOODLIGHTING
   1.4.1.3 BACKLIGHTING

1.4.2 FOCUSING
   1.4.2.1 VIEWFINDING
   1.4.2.2 DIRECT LENS ALIGNING
   1.4.2.3 INDIRECT LENS ALIGNING

1.4.3 EXPOSING
   1.4.3.1 CONTROLLING QUANTITY
   1.4.3.2 CONTROLLING DURATION

1.4.4 SCALING
   1.4.4.1 ENLARGING
   1.4.4.2 REDUCING

1.4.5 SELECTING EMULSION
   1.4.5.1 SILVER BASED
1.4.5.2 NON-SILVER BASED

1.5 CONVERTING MECHANICAL TO ELECTRICAL ENERGY
1.5.1 VIBRATING
1.5.2 POSITIONING
1.5.3 DEPRESSING
1.5.4 ROTATING

1.6 CONVERTING HEAT TO ELECTRICAL ENERGY
1.6.1 THERMOCOUPLE SENSING
1.6.2 THERMISTOR SENSING
1.6.3 RESISTIVE TEMPERATURE SENSING
TRANSMITTING: THE TECHNICAL PROCESSES OF CONVEYING INFORMATION FROM ONE LOCATION TO ANOTHER.

2.1 MODULATING
2.1.1 PULSE CODING
2.1.2 PULSE DURATION VARYING
2.1.3 FREQUENCY VARYING
2.1.4 AMPLITUDE VARYING
2.1.5 PHASE VARYING
2.1.6 ENCRYPTING

2.2 AMPLIFYING
2.2.1 FREQUENCY FILTERING
  2.2.1.1 LOW PASSING
  2.2.1.2 BAND PASSING
  2.2.1.3 HIGH PASSING

2.2.2 CARRIER SIGNAL GENERATING
  2.2.2.1 OSCILLATING AMPLIFIERS

2.2.3 SIGNAL ADDING
  2.2.3.1 SUMMING AMPLIFIERS
  2.2.3.2 INTEGRATING AMPLIFIERS

2.3 MULTIPLEXING
2.3.1 TIME DIVIDING
2.3.2 FREQUENCY DIVIDING

2.4 DUPLEXING
2.4.1 SIMPLEXING
2.4.2 HALF DUPLEXING
2.4.3 FULL DUPLEXING
2.4.4 QUADRAPLEXING

2.5 FREQUENCY SELECTING
2.5.1 ELECTRICAL
  2.5.1.1 VERY LOW FREQUENCY
  2.5.1.2 LOW FREQUENCY
  2.5.1.3 MEDIUM FREQUENCY
  2.5.1.4 HIGH FREQUENCY
  2.5.1.5 VERY HIGH FREQUENCY
  2.5.1.6 ULTRA HIGH FREQUENCY
  2.5.1.7 SUPER HIGH FREQUENCY

2.5.2 OPTICAL
  2.5.2.1 INFRARED
  2.5.2.2 VISABLE
  2.5.2.3 ULTRAVIOLET
2.6 PROPAGATING

2.6.1 ATMOSPHERIC CHANNELING
   2.6.1.1 DIRECT WAVE RADIATING
   2.6.1.2 GROUND WAVE RADIATING
   2.6.1.3 SKY WAVE RADIATING
   2.6.1.4 RADIATION PATTERNING
   2.6.1.5 POSITIONING

2.6.2 PHYSICAL CHANNELING
   2.6.2.1 LIGHT GUIDING FIBER OPTIC
      2.6.2.1.1 MULTIMODE INDEXING
      2.6.2.1.2 SINGLE MODE INDEXING
      2.6.2.1.3 MULTIMODE GRADED INDEXING
   2.6.2.2 ELECTRICAL SIGNAL GUIDING
      2.6.2.2.1 TWISTED PAIR CABLE
      2.6.2.2.2 COAXIAL CABLE
      2.6.2.2.2.1 BROADBAND
      2.6.2.2.2.2 BASEBAND
      2.6.2.2.3 PARALLEL RIBBON CABLE
      2.6.2.2.4 WAVE GUIDING

2.7 SIGNAL CONDITIONING

2.7.1 ELECTRICAL-TO-LIGHT CONVERTING
   2.7.1.1 SAMPLING
   2.7.1.2 QUANTIFYING
   2.7.1.3 DIGITIZING
   2.7.1.3.1 LASING
   2.7.1.3.2 DIODE EMITTING

2.7.2 LIGHT-TO-ELECTRICAL CONVERTING
   2.7.2.1 LIGHT SENSING
      2.7.2.1.1 PHOTODIODES
      2.7.2.1.2 PHOTOTRANSISTORS
   2.7.2.2 RECONSTRUCTING

2.7.3 ANALOG-TO-DIGITAL CONVERTING
   2.7.3.1 SAMPLING
   2.7.3.2 QUANTIFYING
   2.7.3.3 DIGITIZING

2.7.4 DIGITAL-TO-ANALOG CONVERTING
   2.7.4.1 RECEIVING INPUT CODE
   2.7.4.2 STEPPED VOLTAGE OUTPUT
   2.7.4.3 AMPLIFYING
   2.7.4.4 FILTERING
2.7.5 SERIAL-TO-PARALLEL CONVERTING
  2.7.5.1 SAMPLING
  2.7.5.2 SHIFT REGISTERING
  2.7.5.3 OUTPUTING

2.7.6 PARALLEL-TO-SERIAL CONVERTING
  2.7.6.1 SAMPLING
  2.7.6.2 SHIFT REGISTERING
  2.7.6.3 OUTPUTING

2.7.7 ESTABLISHING PROTOCOL
  2.7.7.1 IDENTIFYING CHARACTER SET
  2.7.7.2 DETERMINING MESSAGE TIMING
  2.7.7.3 IDENTIFYING ERRORS
  2.7.7.4 ERROR CORRECTING

2.8 SWITCHING
  2.8.1 SENSING ACCESS REQUEST
  2.8.2 DETERMINING DESTINATION
  2.8.3 SELECTING PATH
  2.8.4 ESTABLISHING CONNECTION
  2.8.5 DISCONNECTING CIRCUIT
3. RECEIVING: THE TECHNICAL PROCESSES OF RECOGNIZING AND ACCEPTING INFORMATION THAT HAS BEEN TRANSMITTED.

3.1 COLLECTING
3.1.1 DETECTING
   3.1.1.1 MEASURING RADIATION PATTERN
   3.1.1.2 DETERMINING EFFECTIVE AREA
   3.1.1.3 POSITIONING
   3.1.1.4 CONCENTRATING

3.1.2 SELECTING
   3.1.2.1 SEPARATING
   3.1.2.2 TUNING
   3.1.2.3 RECOGNIZING

3.2 CONNECTING
   3.2.1 SPLICING
   3.2.2 SOLDERING
   3.3.3 COUPLING
   3.3.4 BONDING

3.3 AMPLIFYING
   3.3.1 FREQUENCY FILTERING
      3.3.1.1 LOW PASSING
      3.3.1.2 BAND PASSING
      3.3.1.3 HIGH PASSING

   3.3.2 SIGNAL REGENERATING
      3.3.2.1 OSCILLATING AMPLIFIERS

   3.3.3 SIGNAL ADDING
      3.3.3.1 SUMMING AMPLIFIERS
      3.3.3.2 INTEGRATING AMPLIFIERS

3.4 DEMODULATING
   3.4.1 PULSE CODING
   3.4.2 PULSE DURATION VARYING
   3.4.3 FREQUENCY VARYING
   3.4.4 AMPLITUDE VARYING
   3.4.5 PHASE VARYING
   3.4.6 DECRYPTING

3.5 DEMULTIPLEXING
   3.5.1 TIME DIVIDING
   3.5.2 FREQUENCY DIVIDING
4. STORING: THE TECHNICAL PROCESSES OF RECORDING AND FILING INFORMATION FOR USE AT A LATER TIME.

4.1 SEPARATING

4.1.1 LATENT IMAGE PROCESSING

4.1.1.1 DEVELOPING

4.1.1.1.1 MULTI-STEP DARKROOM PROCESSING

4.1.1.2 FIXING
4.1.1.3 DRYING
4.1.1.4 MOUNTING
4.1.1.5 EXPOSING
4.1.1.6 SCALING
4.1.1.7 FILTERING

4.1.2 PUNCHING

4.1.2.1 FORMATING
4.1.2.2 LOCATING
4.1.2.3 SHEARING

4.1.3 MACHINING

4.1.3.1 FORMATING
4.1.3.2 ELECTROMECHANICAL TRANSDUCING

4.3 COATING

4.3.1 FIXED RAISED SURFACE PRINTING
4.3.2 ADDRESSABLE RAISED SURFACE PRINTING
4.3.3 PLANE SURFACE PRINTING
4.3.4 SUNKEN SURFACE PRINTING
4.3.5. THROUGH-THE-SURFACE PRINTING
4.3.6 SPRAYING THE SURFACE
4.3.7 ELECTROSTATIC DEPOSITING ON THE SURFACE

4.4 CONDITIONING

4.4.1 MAGNETIZING

4.4.1.1 POSITIONING SUBSTRATE
4.4.1.2 DEMAGNETIZING
4.4.1.3 CREATING A FRINGING FIELD
4.4.1.4 HEAD POSITIONING

4.4.1.4.1 TRACKING
4.4.1.4.2 TRANSVERSE SCANNING
4.4.1.4.3 HELICAL SCANNING
4.4.1.4.4 LONGITUDINAL SCANNING

4.4.2 HEATING

4.4.2.1 POSITIONING SUBSTRATE
4.4.2.2 CONTROLLING HEAT SOURCE
4.4.3 DEVELOPING
  4.4.3.1 SINGLE-STEP AMBIENT PROCESSING

4.5 FORMING
  4.5.1 POSITIONING SUBSTRATE
  4.5.2 APPLYING HEAT AND/OR PRESSURE
5. RETRIEVING: THE TECHNICAL PROCESSES OF RECALLING INFORMATION FROM A STORED CONDITION.

5.1 ABSTRACTING
   5.1.1 ASSESSING ITEM CONTENT
   5.1.2 SUMMARIZING ITEM CONTENT

5.2 INDEXING
   5.2.1 DETERMINING SEARCH VOCABULARY
       5.2.1.1 CONTROLLING VOCABULARY
       5.2.1.2 NON-CONTROLLING VOCABULARY
   5.2.2 CODING ITEM

5.3 ACCESSING
   5.3.1 LOCATING
   5.3.2 RECALLING

5.4 CONTROLLING
   5.4.1 IDENTIFYING USER
   5.4.2 DETERMINING USER RETRIEVAL PRIVILEGES
6. DECODING: THE TECHNICAL PROCESSES WHICH CONVERT RECORDED OR MODIFIED INFORMATION INTO AN ACCEPTABLE FORMAT FOR USE.

6.1 CONVERTING ELECTRICAL TO ACOUSTICAL ENERGY
   6.1.1 ACOUSTIC BAFFLING
      6.1.1.1 ENCLOSING
      6.1.1.2 SUSPENDING
   6.1.2 TRANSDUCING
      6.1.2.1 ELECTROMAGNETIZING
      6.1.2.2 PIEZO-ELECTRIC STRESSING
      6.1.2.3 ELECTROSTATIC DEFLECTING
   6.1.3 ACOUSTIC WAVE GENERATING
      6.1.3.1 DIAPHRAMS
      6.1.3.2 CONES

6.2 CONVERTING ELECTRICAL TO LIGHT ENERGY
   6.2.1 PICTURE ELEMENT LOCATING
      6.2.1.1 SCANNING
      6.2.1.2 ADDRESSING
   6.2.2 LIGHT EMITTING
      6.2.2.1 FLOURESCING
      6.2.2.2 ELECTROLUMINESING
      6.2.2.3 GAS DISCHARGING
   6.2.3 LIGHT REFLECTING
      6.2.3.1 LIQUID CRYSTAL REFLECTING
      6.2.3.2 LIQUID CRYSTAL ABSORBING

6.3 CONVERTING ELECTRICAL TO MECHANICAL ENERGY
   6.3.1 STRIKING
   6.3.2 CONTROLLING
   6.3.3 POSITIONING
   6.3.4 VIBRATING

6.4 PROJECTING
   6.4.1 ILLUMINATING
      6.4.1.1 INCOHERENT LIGHTING
      6.4.1.2 COHERENT LIGHTING
      6.4.1.3 TRANSPORTING SUBSTRATE
   6.4.2 SCALING
      6.4.2.1 ENLARGING
      6.4.2.2 REDUCING
   6.4.3 FOCUSING
6.4.3.1 VIEWFINDING
6.4.3.2 LENS ALIGNING

6.5 REFLECTING
6.5.1 ILLUMINATING
   6.5.1.1 INCOHERENT LIGHTING
   6.5.1.2 COHERENT LIGHTING