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THE DEVELOPMENT OF A FRAMEWORK FOR AND A MODEL
TEACHING-LEARNING SYSTEM IN ELECTRONICS
TECHNOLOGY FOR THE ELEMENTARY SCHOOL

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

By
Lawrence Akio Inaba, B.Ed., M.Ed.

* * * * *

The Ohio State University
1970

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CHAPTER I

INTRODUCTION

Man has always lived with and become accustomed to change. He has been able to add to his technical knowledge and change his way of life. For centuries, the required changes in periods of history were gradual and often hardly noticeable. However, within recent years, technological knowledge has exploded at such an increasing rate that our society has not been able to keep up with and adjust to the expansion of information. The tremendous growth of technical knowledge raises the question of why man needs so much more knowledge than his ancestors had.

Ways (1968) suggested that the answer lies in radical change as a way of life. Most members of a stable society absorbed almost unconsciously all they needed to know about life around them, while a small group of men consciously shared a fixed body of knowledge. Hence, only a small part of a stable society's total effort needed to be devoted to binding one man to another, or connecting one aspect of life to another. However, this is not the case in our present society. Knirk and Childs (1968) noted that all parts of society are in motion and that most men are in
motion—changing jobs, changing residence, changing acquaintances, buying things they never bought before, confronting problems and seizing opportunities their fathers never heard of.

Ways (1968) also contended that in a radically changing society the connective tissue, the organized effort required to stay in touch, is enormous and every year will require a larger proportion of the total work. This effort is needed to accommodate change intelligently, to establish order in the midst of flux.

The entire framework of society has changed as a result of man's creative technological endeavors. A new era has followed man's implementation of his innovations in industrialization, automation, and cybernation. If man is to function effectively today and tomorrow in our changing society, then the phenomenon of technology must be understood and applied intelligently to new conditions as they arise. Hence, attention must be directed to today's children who as adults will participate in a constantly changing technological society exemplified by increasing abstraction and symbolism. They must be educated to the utmost of their abilities if they are to participate knowledgeably, not as manipulators of technique, but as functioning, intelligent citizens in a changing society.

Within the total scope of recent technological
advancements, it should be apparent that most of the giant strides in technology are the results of the use of electronics. Through electronics technology, electronic developments have produced profound changes in our way of life; indeed, we live in an "Electronic Age." No matter where we look, the evidence of the influence of electronics is all around us. Nevertheless, most people in our society know very little about electronics. They are constantly awed by the new electronic inventions and creations that appear in the commercial world. People use electronic devices daily without having any knowledge or understanding of what is happening, because most of our adult population are illiterate in the field of electronics.

The fear and marvel of electronics are indirectly being perpetuated by the schools, because knowledge about electronics is not taught to most school children. Only a small percentage receive a smattering of electronics in courses such as physics, general science, or through electronics courses in industrial arts or vocational-industrial education.

To blame the teachers and the schools for this condition is fruitless, because the schools need people with the proper training and background to teach such courses. Currently, most teachers do not attempt to teach electronic concepts, because their background in the field is inadequate. Atkin (1961) found that experimental work
in teaching elementary school classes showed that teachers whose own preparation in a field is impoverished do not feel capable of handling the subject content. Hence, this condition will be perpetuated for as long as nothing is done to remedy this situation. Goodlad (1966) stated that many subjects representing exciting advances in human knowledge are left out of the school curriculum, and will remain untaught unless a deliberate effort is made to include them.

Today, there is a great demand for more and better education for students from all age, ethnic, and socio-economic groups. The principle of "education for all" should apply to electronics since it is surely one of the dynamic forces that may control the destiny of man. The opportunity to learn electronic concepts is presently offered to only a small segment of the total student population of the nation. Hence, it discriminates against the less able students and against the greatest consumers of electronic developments in the home, the women. This latter segment of student population should not be ignored or forgotten, for they will comprise half of the general adult population of the future.

Not much can be done to present the concepts of electronics to the general adult population. Hence, the obvious and logical thing to do is to start at the beginning, in the elementary school where most of the general
population of students could be exposed to some of the
concepts of electronics. In a self-contained classroom
everyone can receive the same kind of education, whether
they be boy or girl, bright or dull.

The concepts of electronics may readily be taught in
the elementary school and may be of most worth to an in­
dividual. This was recognized by Dr. Morris Shamos (1969),
Director of the Conceptually Oriented Program in Elementary
Science (COPES), who believed that teaching in the elemen­
tary school is unique because long after a child has
forgotten facts, he will retain concepts. Atkin (1961)
also believed that carefully selected content, organized
around basic concepts, provides the necessary beginning
point for teaching. The concepts will then become the
tools for the students to use in understanding the field.

There is a limit to the number of disciplines that
can be taught within the time available; there simply is
no room in the curriculum for ten more subjects. It is
also recognized that elementary school teachers are usually
prepared as generalists rather than as specialists in a
subject field. With these facts in mind, this study will
develop, through a conceptual approach, a model instruc­
tional packaged system in electronics technology, to help
inadequately prepared teachers to present a needed subject,
by either supplementing organized units in social studies,
science, language arts, or by introducing it as a subject
matter in itself.

Purpose of the Study

The general student population in the elementary schools is not taught technology, and more specifically, electronics technology, because most elementary school teachers lack confidence in teaching electronic concepts due to their inadequate background in the subject area. Hence, in order to give elementary school teachers confidence in at least initiating or teaching some concepts of electronics technology, the purpose of this study will be twofold: (1) to develop a rationale and a structure of knowledge that may be the basis for an instructional system in electronics technology within a broader framework of technology, and (2) to design and develop an instructional packaged system in electronics technology that may be used as a model to encourage the development of other packaged systems.

Some questions that this study will attempt to answer are:

1. What are the elements in a broad study of the technology of man?

2. What are the elements of the technology of the economic system that produces all of the goods and services of mankind?

3. What is the nature of the field of communications technology?
4. What are the elements of electronics technology?

5. What are the relationships between principles of physical science and electronics technology?

6. What broad concepts in electronics technology should be taught in the elementary school?

7. What should be the content for a sequential unit in electronics technology for grades one through six?

8. How can relevant subsuming concepts facilitate the learning of unfamiliar but meaningful verbal material?

9. How should a unit in electronics technology be designed for development into an instructional packaged system?

Assumptions

Certain basic assumptions were made at the outset of this study. These assumptions are:

1. Electronics technology can be identified within the context of industrial technology, and within the broader framework of technology.

2. The body of knowledge for electronics technology can be ordered, structured, and codified for instructional purposes.

3. A general concept of electronics technology can be taught at the elementary school level.

4. Elementary school teachers in general feel inadequate to teach electronic concepts.

5. Elementary school teachers, if given an 
adequately packaged instructional system, will initiate or introduce concepts of electronics technology to their classes with more confidence.

6. The cognitive structure is hierarchically organized, and the introduction of relevant subsuming concepts called organizers, promotes discriminability of concepts and subconcepts.

Definition of Terms

In any attempt to communicate in the written word, there is the ever present problem of being misunderstood. Therefore, to lessen the terminological problem, the following words or terms are defined as they will be used in this study.

Packaged system consists of materials developed through an instructional systems approach into an integrated package.

Concept is a psychological construct resulting from a variety of experiences, fixed by a word or idea, and having functional value to the individual in his thinking and behavior (Flug, 1967, p. 34).

Electricity is the study of electrical phenomena and their application to provide power and energy.

Electronics is the study of electrical phenomena and their application to carry intelligence.

Electronics technology is that part of the total field of electronics which is mainly concerned with the
study of the application of the operational principles within industrial technology, which relate to the research and development, production, and utilization of electronic devices.

Communication is essentially a transmitting of thought, information, feelings, and ideas from man to man, or man to machine, or machine to machine.

Communications technology basically 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, from man to man, man to machine, machine to man, or machine to machine.

Industrial technology is that subcategory of technological knowledge which is derived from the study of industrial practices (Towers, Lux, and Ray, 1966, p. 85).

Industry is that subcategory of the economic institution which substantially changes the form of materials in response to man's wants for material goods (Towers, Lux, and Ray, 1966, p. 85).

Technology is the science of efficient action (Towers, Lux, and Ray, 1966).

Elementary school includes grades one through six. Sequential units are units of study built on a hierarchy of knowledge according to the difficulty or grade level.
Paradigm is a model or pattern.

Limitations of the Study

Although sequential units for grades one through six will be identified, this study will be limited to the design and development of the instructional packaged system on electronics technology for the sixth grade. This study will not include any field testing of the constructed material of the instructional system. It was believed more reasonable to develop completely the instructional system for one grade level than to develop only a part of the instructional system for field testing purposes.

It was also decided at the outset that elementary school students should not be burdened with detailed technology or urged to acquire technical skills. Instead, they should be acquainted with broad concepts of electronics technology—the governing concepts of electronics. Therefore, the instructional units will be limited to and directed toward that end.

Summary

This chapter has described the problem, stated the purpose of the study, listed some questions to be answered, made specific assumptions, defined key terms, and identified the limitations of the study.

The following chapter will present a general review of literature related to curriculum development, to
provide the necessary background information and direction needed for decision-making in developing the instructional system for this study.
CHAPTER II

REVIEW OF LITERATURE

This chapter will focus on the relevant literature which must be considered before learning experiences are selected, organized, and developed into the instructional unit on electronics technology. The works cited in this chapter reflect the general literature in curriculum development from which insight and direction were gained in preparing the instructional system. More specific reviews of literature are presented in other chapters where appropriate.

The Curriculum Development Process

In any curriculum development process certain basic guidelines and procedures should be followed in order to gain a working knowledge of the areas under consideration. Taba (1962) outlined seven steps which furnish an orderly way of thinking about curriculum development. Her plan was chosen as a model and a guideline from which to review the pertinent literature concerning curriculum development. Her plan included the following steps (Taba, 1962):

Step 1: Diagnosis of needs
Step 2: Formulation of objectives
Step 3: Selection of content
Step 4: Organization of content
Step 5: Selection of learning experiences
Step 6: Organization of learning experiences
Step 7: Determination of what to evaluate and of the ways and means of doing it (p. 12).

The review of literature in this chapter primarily focuses on Step 2 through Step 6, because the diagnosis of needs which Taba (1962, p. 346) describes as the general analysis of problems, conditions, and difficulties was discussed in the introduction and Chapter IV of this study, and Step 7 will be discussed in Chapter IV. Although the search for relevant literature was exhaustive, the materials cited in this review are selective.

Formulation of Objectives

The importance of formulating instructional objectives as a factor affecting the selection of learning activities is recognized by Gagné (1965a):

For the person who wishes to study the process of education, to analyze it, to perform research upon it for the purpose of understanding and improving it, statements of educational objectives as human performances are an absolutely essential starting point. For one thing, they help to keep in sharp focus the fact that learning of the individual student is the central purpose of education. . . . In addition, objective statements of performance provide the empirically observable foundations to which all speculations, hypotheses, and innovative hunches about educational improvement must be referred. The number of differences of opinion about educational procedures which can be rather simply resolved if both parties agree to base their arguments on performance objectives is surprising, even startling (p. 10).

Robert Mager (1962) reaffirmed the above statement when he stated that:
Once an instructor or programmer decides he will teach his students something, several kinds of activity are necessary on his part if he is to succeed. He must first decide upon the goals he intends to reach at the end of his course or program. He must then select procedures, content, and methods which are relevant to the objectives, cause the student to interact with appropriate subject matter in accordance with principles of learning, and finally measure or evaluate the student's performance according to the objectives or goals originally selected (p. 1).

Eisner (1967) also recognized the importance of educational objectives in basing educational programs:

Educational objectives . . . need to be clearly specified for at least three reasons: first, because they provide the goals toward which the curriculum is aimed; second, because once clearly stated they facilitate the selection and organization of content; third, because when specified in both behavioral and content terms they make it possible to evaluate the outcomes of the curriculum (p. 250).

Gerhard (1967, p. 92) categorized six major classifications of educational objectives:

1. Knowledge - concepts, generalizations, principles, relationships, and facts.
2. Tool skills - those skills essential in further acquiring and applying knowledge.
4. Socially-effective behaviors - the development and use of social capabilities such as assuming leadership and interacting harmoniously with others.
5. Positive attitudes toward and interest in content areas.
6. Thinking behaviors - deduction, induction, convergent thinking, divergent thinking, etc.
Perhaps the formulation of instructional objectives is most extensively classified in the works of Bloom (1956); Krathwohl, Bloom, and Masia (1966); and Simpson (1966). Bloom's work (1956, pp. 201-207) was concerned mainly with the cognitive domain. He identified and classified six major groups with 23 subgroups. The six behavior groups in the cognitive domain are: (1) knowledge, (2) comprehension, (3) application, (4) analysis, (5) synthesis, and (6) evaluation. Knowledge simply involves recall of a pattern, structure, or setting. Comprehension refers to understanding or appreciation. Application refers to the use of abstractions in particular and concrete situations. Analysis relates to the breakdown of a communication into its constituent elements or parts in order to clarify the hierarchy of ideas, and to make explicit relations between ideas. Synthesis refers to the putting together of elements and parts so as to form a whole. Evaluation involves judgments about the value of the material and methods for given purposes.

Krathwohl, Bloom, and Masia (1966, pp. 25-30) collaborated to taxonomize the affective domain into five groups containing 13 subgroups. The five main groups of the affective domain were identified as: (1) receiving, (2) responding, (3) valuing, (4) organization, and (5) characterization by a value complex. Receiving refers
to the awareness of the existence of certain phenomena and stimuli; responding refers to the involvement in a subject, phenomenon, or activity so that the learner will gain satisfaction from working with it or engaging in it; valuing refers to the internalizing of a set of specified values; organization refers to the building of a value system; and characterization by a value complex refers to acting consistently in accordance with internalized values.

Simpson (1966, pp. 25-30) worked on the psychomotor domain and taxonomized the groups in the following categories: (1) perception, (2) set, (3) guided response, (4) mechanism, and (5) complex overt response. Perception refers to the process of becoming aware of objects, qualities, or relations by way of the sense organs; set refers to the preparation and adjustment of a practical kind of action or experience; guided response refers to an overt behavioral act by an individual under the guidance of an instructor; mechanism refers to a habitual way of responding; and complex overt response refers to a high level of development at which the individual can perform a motor act that is considered complex, because of the movement pattern required.

Not all writers share the same views or are in favor of accepting objectives stated in behavioral terms. Dyer (1967) pointed out that:

The trouble is that in spite of all the hard thinking and earnest talk about educational
goals, and how to define them, the goals produced have been essentially nonfunctional — and I mean even when they have come clothed in the so-called "behavioral terms" we so much admire (p. 2).

Eisner (1967, pp. 253-260) also listed the following limitations:

1. The dynamic and complex process of instruction yields outcomes far too numerous to be specified in behavioral and content terms in advance.

2. Curriculum theory which views educational objectives as standards by which to measure educational achievement overlooks those modes of achievement incapable of measurement, e.g., mode of curiosity, inventiveness, and insight.

3. Educational objectives need not precede the selection and organization of content. The means through which imaginative curriculums can be built is as open-ended as the means through which scientific and artistic inventions occur. Curriculum theory needs to allow for a variety of processes to be employed in the construction of curriculums.

In the final analysis, Mager (1962) best summarized the main points in the formulation of instructional objectives. He contended that unless a program of studies is based on a statement of objectives which denotes measurable attributes that can be observed in the student who has completed the program, it will be difficult, if not impossible, to determine whether the program of studies is worthwhile. Mager (1962) insisted that "When clearly defined goals are lacking, it is impossible to evaluate a course or program efficiently, and there is no sound basis for selecting appropriate materials, content, or instructional materials" (p. 3).
The Selection of Content and Learning Experiences

The third and fifth steps of Taba's model (1962, p. 12) involve the selection of content and learning experiences. The criteria for content selection were established by Denemark (1963) who suggested the following nine criteria for content selection:

1. Content is accurate and up to date.
2. Content facilitates understanding of major principles and generalizations.
3. Content contributes to understanding the structure and methods of inquiry of a field.
4. Content contributes to the skills and habits basic to independent and disciplined thinking.
5. Content contributes to the development of an essential morality regarding the evaluation and use of knowledge.
6. Content has meaning and purpose for the learners.
7. Content provides both a measure of success and challenge.
8. Content contributes to balanced growth.
9. Content leads to appropriate action (pp. 19-21).

Towers, Lux, and Ray (1966) suggested several guidelines which affect the selection of learning activities:

1. There should be a concern with major concepts and principles, rather than facts.
2. There should be an emphasis on the methods used by a discipline to treat data in its domain.
3. There should be a balance in the focus on structure and methods and a concern for their interaction.
4. The scope of the learning activities should be largely restricted to the domain with which the discipline deals.
5. The degree to which interrelationships with other fields that treat the same domain are studied should be determined by the degree to which the study of these other fields illuminate the major discipline (pp. 245-246).

Foshay (1962) contended that the two important factors that influence the selection of learning
experience should be (1) a concern with major concepts and (2) a focus on the method of acquisition of these concepts. Bruner (1963) also believed that a subject becomes more understandable if fundamental principles are learned, because facts are easily forgotten, but principles stand the test of time.

Tischler (1968a) contended that there are two basic methods of teaching and learning—the conceptual method and the comprehensive method. The conceptual approach provides high motivation, broad coverage, few details, and short duration topics. Concepts build upon the learner's previous experience and should present the "big picture." The topics of a course are arranged from complex to simple. The comprehensive method, on the other hand, is narrow in scope, deals with detailed information, and arranges course information from simple to complex. Tischler also found, in his training programs, that when teaching from simple to complex only, students are easily confused and the dropout numbers are large.

The emphasis of the above studies indicates a priority on structure that enhances transfer, or on concepts to replace facts that are learned within an adequate context.

A major factor or condition affecting the selection of learning activities is the nature of learning. The
question of how human beings learn has always been a problem, and it continues to be a problem especially in the field of education. Since the early twentieth century, psychologists have studied this problem and have conducted many experiments to determine the process of learning. Thus, many theories of learning have evolved, but no one theory has completely satisfied the scholars.

Basically, learning theories fall into two major categories. One is the behaviorist or connectionist group which interprets man's behavior as connections between stimuli and responses. The emphasis is on the learner and his responses. The second group of theories is known as the organismic, gestalt, field, or cognitive theories. The common element of these theories is that they assume that cognitive processes are the fundamental characteristics of human behavior. The focus is more on the "how" of learning than on the "what." Human action is seen as marked by a quality of intelligence and the ability to create relationships (Kemp, 1968, p. 12).

Recent learning theories have been mainly extensions of various field theories. Usually, contemporary educational psychologists have worked extensively in meaningful learning (Dawson, 1965, p. 28). Since these theories are most relevant and applicable to this study, they will be reviewed here.

Lewin's field theory contended that learning is not
primarily memorization and retention, but is based on need, tension systems, perception, and is a natural development. The learner's need is more significant than habit (Thompson, Gardner, and DiVesta, 1959).

Wimer (1961) found that meaningfulness was positively related to the rate of learning. Noble (1963) found meaningfulness and familiarity to be independent concepts. He reported that a word could be familiar but not meaningful without being familiar. Bode (1940) stated that the mind is set to receive stimuli which influence the receiver's cognitive structure if the stimuli are meaningful in relation to the learner's background experience.

Hill (1963) stated that most writers agree that the organization of the materials presented to learners is the most significant variable in learning. He further suggests that teachers use whatever devices needed to make tasks become more meaningful. However, meaningfulness can be confused with student understanding. A feeling of understanding is not always needed. Bugelski (1964) also felt that understanding tends only to contribute to a feeling of satisfaction about what has been learned.

Hull (1943) remarked that learning is continuous and cumulative and occurs even when it is not observable. Such continuity builds readiness for further learning, and with enough attention, almost any student can learn.

Hilgard (1956), describing the Gestalt theory,
stated that learning is insightful rather than trial and error. Perception is based on organization, is founded on similarity, proximity, closure, and adds to past experience to provide insight.

Boring, Langfeld, and Weld (1948) contended that perception is always in response to some change or difference in the environment, and is based on what the individual desires to sift out.

The development of insight by learners is a much sought goal of educators. Although it seems that insights just occur or do not occur, Bugelski (1964) felt that positive steps could be taken to set the proper setting for insight. He claimed that teachers should lead students to perceive relationships by almost any technique available. Hence, learners should expect to reach a desired goal.

Recently, a new theory has been advanced by Ausubel (1963)—the subsumption theory. This theory assumes that relevant subsuming concepts called organizers, when introduced prior to the presentation of meaningful verbal material, will increase learning and retention. The subsumption theory of learning suggests that cognitive manipulation through the use of subsuming concepts may facilitate learning.

According to Ausubel (1963), new material as it enters the cognitive structure interacts with and is
subsumed under a relevant and inclusive conceptual system. If the material is subsumable, it becomes meaningful to the learner and makes possible the perception of insightful relationships. Subsumption follows perception, and there are three phases during meaningful reception, learning, and retention: "(1) Potentially meaningful material must be perceived before it can be learned and retained; (2) the perceived potentially meaningful information is subsumed by a relevant and appropriately inclusive conceptual system; and (3) the reproduction of the retained information" (p. 50).

Ausubel (1963) further believed that abstract material can be retained longer than factual material, because of the superiority of meaningful over rote learning. Abstractions are correlative rather than derivative and can be incorporated into the cognitive structure as suborganizers.

Ausubel and Fitzgerald (1961, p. 266) stated that advance organizers have two distinct functions: (1) When new material is unfamiliar in the sense that the cognitive structure is void of general concepts, the purpose of the organizer is to provide ideational anchorage or scaffolding. (2) The second function is that when new material is related to previously learned concepts already established in the cognitive structure, the organizer provides anchorage as well as increases the discriminability of
the learning passage from conflicting ideas in the learner's cognitive structure. Furthermore, Fitzgerald (1962) in his study also found that organizers could facilitate retention better than initial learning.

The studies reviewed above indicate a strong stress on meaningfulness, relevancy, and insight in the selection, organization, and development of content material. Ausubel's studies (1961, 1963), in particular, have given strong direction in the conceptualization of the instructional system for this study.

Organization of Content and Learning Experiences

Steps 4 and 6 of Taba's model are concerned with the organization of content and learning experiences. Taba (1962, pp. 292-309) pointed out the following seven areas of concern: (1) establishing sequence, (2) providing for cumulative learning, (3) providing for integration, (4) unifying through establishing relationships, (5) combining the logical and psychological requirements, (6) determining the focus, and (7) providing variety in modes of learning.

Hanna, et al. (1966), also commenting on the subject, stated that: "Organization of the learning experiences is a critical phase of curriculum development. Experimental evidence supports the hypothesis that learning proceeds more rapidly and is retained longer when the
subject matter possesses meaning, structure, and organization" (p. 70). Blair (1955) found a number of experimental studies supporting the above statement.

Throughout the entire curriculum development process, the curriculum developer must determine what will or will not be a product of this process. Herrick (1962) pointed out the following:

We cannot escape the value decision in curriculum planning and development as to the initial and basic orientation of the curriculum structure we are creating. . . .

Value referents should be considered in making important curriculum choices. . . .

The choice or decision areas of the learning-teaching curriculum become important focal points for relating and developing the necessary components of any thoughtful, constructive curriculum planning (pp. 62-66).

Herrick also believed that all decisions will involve emotion, intellect, and value.

The NEA Project on Instruction (1963) recommended that the content of the curriculum should be progressive in the organization of knowledge and should also help the learner to see the interrelationships among the data from the various subject fields to illuminate the problem in the major field of study.

Tyler (1950) identified five operating principles for the organization and selection of learning experiences:

1. To attain a given objective a student must
have experiences which give him an opportunity to practice the kind of behavior implied by the objective.

2. The learning experiences must be such that the student obtains satisfactions from carrying on the kind of behavior implied by the objectives.

3. The reactions desired in the experience must be within the range of possibility for the students involved.

4. There are many particular experiences that can be used to attain the educational objectives.

5. The same learning experience will usually bring about several outcomes (p. 42).

Maturation and interest also have implications for the organization of content and learning. Hanna, et al. (1966) stated that mastery of a concept is not conceived at any particular grade level, but when the curriculum is organized to provide repeated study of the concepts in subsequent grades in new contexts, the opportunity for children to acquire new meanings and associations is enhanced.

Horn (1937), stressing the importance of interest said that:

Interests arise out of values; that is, out of a sense of pertinence to fundamental needs. It is not the purpose of the school to interest the child in the sense of entertaining him, but to utilize and develop interest in those things that are most universally significant in life outside the school. Students in school where this more fundamental view is taken . . . develop a more critical sense of values and superior power to evaluate. Their interests become intelligent (p. 134).

Investigating children's contributions in free discussion periods in grades two, four, and six, Baker (1942) found that children's interests focused on the
local environment and their real and vicarious experiences whenever they appeared in the curriculum.

The above studies indicate that interests result from experiences. Hence, the schools have a responsibility to plan sequential series of experiences out of which new interests emerge. Hanna, et al. (1966) further added that interests are learned and can be strengthened or redirected in the degree to which they serve the needs of the individual and the society. The organization of the school curriculum can cultivate the present interests of children and stimulate in them wholly new purposes.

Another important factor to consider in organizing the learning activities concerns the use of instructional media. Hence, an awareness of some of the problems of designing and developing an instructional system can be gained from studying research results on the effectiveness of various media on different types of learners (Phillips, 1966).

Learner characteristics are usually evidenced by daily classroom practices. Suppes (1964) asserted that the present concept of individual differences is unrealistic and that any improvement in the learning of subject matter could best be achieved through research concentrated upon individual differences. These differences imply that each student will proceed at his own pace, but only teachers utilizing technological methods can achieve this
individual pacing.

Traweek (1964) found that effective teaching methods varied according to differences in students' personalities. He showed that students exhibiting such personality traits as withdrawal, anxiety, and insecurity were able to achieve at a much higher level when taught by programmed instruction methods than when taught by the more traditional classroom methods.

Resource characteristics (Logan, 1963) indicate that in any learning situation, the student learns what to do and how rapidly to do it. The rate at which any medium is introduced tends to affect the learning of those exposed to it.

Cartier (1963) and Pressey (1963) challenged the application of behavioristic psychology to problems of human learning. Cartier emphasized the use of perceptual psychology, clinical psychology, linguistics, communication theory, feedback, advertising research, and the social psychology of small groups to help change the instructional process. Pressey, on the other hand, emphasized the use of narrative types of instructional materials as prime sources of information. Krumboltz (1964) examined the various types of responses required in programmed instruction and found that students who were not required to make a response did as well as students who were required to make responses. He also
found that students learned better when they made non-trivial responses.

Otto (1964), commenting on the cross-media approach to learning and teaching, raised serious questions concerning the validity of the concept. He found that verbal and pictorial stimuli elicit different responses in learners. This raises the question of whether the presentations made verbally and pictorially will tend to interfere with rather than reinforce each other. Travers (1964) and Van Mondfrans and Travers (1965) indicated that multimedia presentations may not be as effective as single-channel presentations. Travers (1964) also questioned the concept that realistic representations were better than simplified representations, because simplified representations contain fewer distracting details and enable the learner to concentrate on the important details in a given learning situation.

Teacher characteristics is another problem area that must be investigated. McNeil (1964) found that a group of boys learned to read as well as a group of girls when taught by programmed materials. However, the same group of boys did not achieve as well as the same girls when taught by a teacher in a normal classroom situation. This indicated the inhibiting effect of the teacher upon the achievement of the boys. It also indicated that the unconscious human bias of teachers is minimized by the use
of various instructional media.

In the area of instructional methodology, Hayman and Johnson (1963) studied the effects of two types of repetition—exact and varied—on learning by television instruction. The study found that exact repetition significantly increased learning, but varied repetition, when applied skillfully, proved to be even more effective than exact repetition.

Fischer (1964) investigated the effects of the different methods used by teachers to give oral directions to students prior to reading an article. It was found that reading after specific directions were given was superior to reading after general directions. This indicated the effect of set upon learning.

In summarizing the studies dealing with the organization and selection of content, it is evident that a carefully organized sequence of electronics technology concepts with established goals and objectives would do much to enhance and upgrade the development of a program in electronics technology for the elementary schools.

Summary

The review of literature presented in this chapter included a general review of the curriculum development process. Taba's seven steps (1962) in curriculum development served as guidelines from which to review the literature logically. An analysis and examination of the
theoretical viewpoints and research studies concerning the formulation of objectives, the selection of content and learning experiences were covered in this chapter. The diagnosis of needs and evaluation are discussed in other chapters. This review, then, served the purpose of providing the necessary background information needed to plan and conceptualize the instructional system for this study.

The following chapter will present an attempt to identify the context of electronics technology within the broader framework of industrial technology and communications technology, and to place these, in turn, within the still-broader framework of technology. After electronics technology has been identified adequately in its proper context, the body of knowledge for electronics technology will then be structured for instructional purposes.

The following questions will be used as guidelines to discuss and structure the contents of the chapter logically:

1. What is the context of technology?
2. What is industrial technology?
3. What is communications technology?
4. What is the interface between industrial technology and communications technology?
5. What is the relationship between electricity and electronics?
6. What is the relationship of electronics technology and the physical sciences?

7. What is the context of electronics technology?

8. What is the body of knowledge for electronics technology?
CHAPTER III

THE RATIONALE AND STRUCTURE FOR AN INSTRUCTIONAL SYSTEM IN ELECTRONICS TECHNOLOGY

Electronics technology plays a major role in our society today, and will play a bigger role in the years to come. Today electronics technology is the heart of our modern communications system, and of mechanized industry; it is an indispensable part of our everyday life. Many different kinds of workers are needed to fill jobs available in the production, distribution, sales, maintenance of consumer products, and in a variety of office and administrative positions.

The various kinds of occupations created by the ever-expanding electronics industry demand special training and education. There is also a great need to educate the general public to better understand the tremendous impact and influence of electronics upon the lives of every man, woman, and child in our society. Hence, it becomes imperative that the schools of our nation take an active part in educating the masses in some concepts of electronics technology.

Before anyone can begin to understand and conceptualize the field of electronics technology, he must first
see its relationship within the broader context of industrial technology and communications, and both within the still broader context of technology. Only by understanding the whole and the relationships of its parts can we begin to conceptualize, structure, and codify a viable content for a field of study in electronics technology.

Properly conceived, then, a program of electronics technology should provide opportunities for students to study all facets of the field of electronics technology and to explore their interrelationships. Students should also have the opportunity to experience and see the unity or wholeness of the contemporary field of electronics technology, and should develop an understanding of this phase of our society with all its implications. The structure of instructional materials in the field of electronics technology should thus reflect the structure of technology itself and its related associations.

Every discipline has a structure which has been created by the practitioners of the discipline who pursued certain methodologies directed to the attainment of certain objectives. Therefore, the objectives and methods are related to the teaching-learning process. This notion is of primary importance in developing individuals who will be capable of functioning in an age of constant change, because the body of knowledge of a discipline provides a base for structuring the learning environment and aids in
the selection of educational objectives and teaching methodology. The body of knowledge also enhances the relevance of the learning experience since it is based on the actual goals of the disciplines. The development of research design, bent on identifying the discipline base (technology), provides a valid means to identify stable yet flexible structures, content based on reality, valid measurable objectives, methodology, and procedures. All of these can be identified from the bodies of knowledge in the technologies (DeVore, 1969, pp. 78-80).

Since the total technological foundation upon which electronics technology is based is itself in a continually changing state, the field of electronics technology then by its very nature must be in a continual state of transition. The advent of new and rapidly advancing technological processes has made much of the traditional content in electronics technology education obsolete with respect to contemporary industrial scenes. Therefore, a more up-to-date subject content of the total field should be found and emphasized.

The increasing developments in science and technology have caused a renewed interest in learning designed to produce general understanding of the structure of a subject field and of how facts and concepts within the field are related in meaningful ways. The true utility of facts lies in their relatedness, rather than in their mere
existence. Memorizing facts without associating them to realistic situations is no longer an accepted practice. Current educational theory emphasizes the understanding of fundamental principles and ideas. Therefore, a study of technology should be directed toward knowledge of concepts, rather than toward information about modern technology, because acquiring information may involve only the psychological processes of remembering, whereas acquiring knowledge involves the more complex processes of relating and judging (AVA, 1968).

Technology, the Base

Some basic assumptions are fundamental to the study of technology. First, it is assumed that all institutions exist to serve man, as does the institution of education. Second, the central concern of education in a democratic society is man. Third, we live in a society dominated by technology, a society in a continual state of change. Fourth, our concern in a highly complex technological society, dependent upon the intelligent functioning of all citizens, must be the development of intelligent self-functioning individuals in a world of fluid possibilities (Hilton, 1966, p. 145).

DeVore (1969, p. 77) contended that attention must also be focused on: (1) the establishment of a discipline base together with the identification of its knowledge
structure and established facts, principles, and concepts as a basis for providing the student with the means of functioning in the present; and (2) the identification of the processes of the discipline to provide the student with the basis for performing effectively in and adapting to the future.

Very few studies have been undertaken to identify and define the context of technology. Towers, Lux, and Ray (1966) concluded from their investigation of technology that "... prominent systems for classifying technology and a review of the vast literature on or related to the subject do not provide an adequate structure of praxiology (technology). ... This conclusion further verifies the generally accepted rule that classification systems reflect the purposes for which they were developed" (p. 97).

In order to conceptualize an adequate structure of technology for instructional purposes, the following criteria need to be applied to a classification schema:

1. It includes all practices which affect humans and materials.
2. It has mutually exclusive categories.

During the past several years, scholars and curriculum developers in industrial arts education have attempted to examine and identify the context of technology, in
order to structure and codify the content material for industrial arts education. A brief review of some of the major studies is presented as background material for comparison and justification of choice.

Historically, William Warner, in 1947, presented his Curriculum to Reflect Technology at the American Industrial Arts Association Convention in Columbus, Ohio. This was one of the first attempts to recognize technology as an area of study. He identified six content areas as subject matter resources that would reflect technology. These were Power, Transportation, Communication, Manufacture, Construction, and Management (Warner, et al., 1965).

Delmar Olson (1963) in his dissertation, Industrial Arts and Technology, refined Warner's ideas and added "Research" and "Services" to the original list. Neither Olson nor Warner made any claim for a comprehensive coverage of all of technology; they merely conceptualized industry to reflect technology as an area of study.

DeVore (1964, p. 80) took the position that technology is an intellectual discipline. He stated that "... using [the] basic division of man's technical endeavors as a structure, it is possible to study the discipline of technology and meet the challenge of the future." He then suggested seven areas of study: (1) Construction, (2) Communication, (3) Manufacture, (4) Research, (5) Transportation, (6) Management, and
(7) Services.

DeVore's structure does not include all the knowledge of man's practices. Technology should be considered as a broad spectrum of study made up of several interrelated disciplines.

Yoho (1965), in his attempt to structure the content for industrial arts education, used a systems approach to study the total functioning society. He stated: "Manufacturing industries, service industries, construction industries, and communication industries encompass the unique responsibility areas for the general industrial arts program and should be the basis for organization and selection of instructional content..." (p. 86). His reason for emphasizing some areas such as communication and for excluding others is unclear, and fails to meet the criterion of total inclusiveness.

If one applies the criteria for structuring technology, as given previously, it can be seen that the major studies cited above do not meet all of the requirements of defining adequately the context of technology. Hence, those studies are inadequate for curriculum purposes. Through research of all available literature on this subject, it was found that the only study that has met all the criteria given for logically structuring the context of technology was the study done by the Industrial Arts Curriculum Project. Therefore, this study will
accept their premises.

The Industrial Arts Curriculum Project (IACP), conceptualized in 1965, undertook the task of developing a viable curriculum for industrial arts education. One aspect of IACP research led to an investigation of the totality of man's knowledge. From Maccia's study (1965), it was concluded that man's knowledge may be conceptualized and ordered into four domains or classes: (1) formal knowledge, (2) descriptive knowledge, (3) prescriptive knowledge, and (4) praxiological knowledge. Praxiology, defined as the science of efficient action by Kotarbinski (1965), was then equated with technology. The principal researchers of the curriculum project then investigated all the various classifications and studies of technology, to be certain that their study achieved mutual exclusiveness as well as total inclusiveness. Thus, their research led them to investigate the following areas:

1. Histories of technology
2. Occupational classifications
3. Product classifications
4. Establishment classifications
5. Patent office classifications
6. Technological museums
7. Reference works
8. Industrial arts curriculum theorists
9. Institutions of higher education.
As previously stated, an examination of the extensive literature in the subject area did not provide an adequate structure of knowledge. Technology should be broadly conceived. It should not be narrowly interpreted as techniques related to mechanical devices or mechanical processes, although this is a common misconception today. It was in the broadest sense of the word that technology was conceived as a major domain of man's knowledge by the authors of the Industrial Arts Curriculum Project. Technology was explained as the ordered knowledge of efficient action, practice, method, or procedure. To be efficient is to be skillful; so technology is concerned with the organized knowledge of skillful action. Man has many different kinds of technologies (Towers, Lux, and Ray, 1966).

Man's practices have evolved as man himself has developed. As society changed, the basic institutions of the family and religion were unable to accommodate all of man's practices, and patterns relating to economic activity became formalized outside of the family. A system of government or political action and a formalized pattern of education have become more significant throughout the development of man (Towers, Lux, and Ray, 1966).

Cuber (1951, p. 433) indicated a general agreement among sociologists that the five fundamental societal institutions of man are: (1) familial, (2) religious,
(3) economic, (4) political, and (5) educational. These divisions are not precise; there are no sharp lines of demarcation and the functions overlap. To show more clearly the interrelationships between man's technological knowledge and the other domains of his knowledge, Figure 1 presents graphically a structure of technology that will be accepted as adequate by this study.

**Figure 1.** The Relationship of Technology to Man's Knowledge and to the Basic Societal Institutions. (Source: Towers, Lux, and Ray, 1966, p. 79.)
Essentially, as depicted in Figure 1, the technology of man's five basic institutions can be identified as: (1) educational technology, (2) religious technology, (3) familial technology, (4) political technology, and (5) economic technology.

The Elements of Economic Technology

Technology is the knowledge of practice in all of man's societal institutions. While religion, government, and the economic system each has its own function to fulfill, each interrelates with each other and with other societal institutions. For analytical purposes, it may be desirable to focus on the primary role of a societal institution, not forgetting that these roles are intricately interlaced to form the total cultural fabric (Towers, Lux, and Ray, 1966, p. 148).

This study accepts the premise that industrial technology and communications technology are subelements within the economic institution. But recognizing this premise does not necessarily overlook or minimize the tangential influence of communications and industrial technology on the other major societal functions.

Since this study has accepted the premises for the structure of technology as conceived in the Industrial Arts Curriculum Project, it seemed logical to accept also the IACP premises for the structuring of the economic institution. The research done in the IACP conceptualiza-
tion of the elements within the economic institution was exhaustive. Towers, Lux, and Ray (1966) in conceptualizing the paradigm of the economic institution (Figure 2), concluded that it is applicable to all the subelements of the economic institution, and that it includes the complete sequence. Because the paradigm applies generally to the economic institution of society, it is possible to trace the activities of any specific economic establishment, or any group of establishments, through the sequence (Towers, Lux, and Ray, 1966, p. 153).

The explanation of the paradigm (Figure 2), as given by the authors, is as follows:

The cycle commences with an act of initiation in which a human want or need is identified or anticipated. Resources—consisting of energy, natural, human, finance, capital (tools and facilities), and knowledge—are selected as inputs to the productive system. These resources are processed in accordance with practices appropriate to the particular field of economic activity. The outputs of this productive system are the distributed economic goods, containing added form, place, possession, and/or time utility. To complete the continuum, these distributed goods are the means by which human wants are satisfied. While the orientation of this total process is linear ... recirculation or feedback is represented in the diagram by the broken lines connecting the major stages (Towers, Lux, and Ray, 1966, pp. 150-153).

In order to visualize clearly the interface between industrial technology and communications technology within the economic institution, Figure 3 is presented as a breakdown of the elements of the economic institution. Figure 3 shows that communications technology and
Figure 2. A Paradigm of the Economic Institution. (Source: Towers, Lux, and Ray, 1966, p. 151.)
Figure 3. Elements of the Economic Institution. (Source: Towers, Lux, and Ray, 1966, p. 73.)
industrial technology are subelements within the framework of the economic institution. Although they are major fields of study in themselves, they also are interrelated with all the other elements within the framework of the economic institution as well as the other major societal institution.

Industrial Technology as an Element of the Economic Institution

"Industry" was identified and defined, for purposes of the Industrial Arts Curriculum Project, as:
"... that subcategory of the economic institution which substantially changes the form of materials in response to man's wants for material goods" (Towers, Lux, and Ray, 1966, p. 85). Industry essentially includes construction and manufacturing. The compound term "industrial technology" was defined for IACP purposes as: "... that subcategory of technological knowledge which is derived from the study of industrial practices" (Towers, Lux, and Ray, 1966, p. 85). For a more detailed description of industrial technology, the reader may consult Towers, Lux, and Ray, 1966, pp. 64-232.

Communications Technology as an Element of the Economic Institution

The functions of communications are vital to all of man's basic institutions. However, this study was mainly concerned with the field of electronics technology and
with the electronic products used in the process of communications. Therefore the investigation focused on communications technology as a subelement of the economic institution. This approach is justified because the electronic products used in the process of communication are essentially extensions of man's actions, and are created and utilized mainly for economic purposes.

Lasswell, in his treatise on communication, stated that "... technology has made significant impress on the economy of communication. Today's use of machines, in all lines of production, is a commonplace in the communication industry no less than in other lines of enterprise. Machines that transmit symbols represent a generous investment of capital" (Smith, Lasswell, and Casey, 1946, p. 8). Stating that man's tools are essentially extensions of man himself, McLuhan (1967, p. 8) claimed that societies have always been shaped more by the nature of the media by which men communicate than by the content of the communication.

De Fuer (1966), in his analysis of the mass communication media within the social system, diagrammed a flowchart of a production subsystem in communications, as it functions through the economic process. (See Figure 4.) Hence, a study of the structure of communications technology with its relationship to the functions of electronics technology would be most appropriately
Production Subsystem
The role systems of all groups which in any way create or produce media content including television shows, magazine articles, etc. Depending upon the medium such roles are included as: writers, actors, directors, publishers, etc.

Distribution Subsystems
National and Regional Distributors
The role systems of those who distribute content to local outlets. Includes broadcasting networks, newspaper syndicates, etc.

Local Distributors
The role systems of groups that actually present media content to the public. Includes local newspapers, local theaters, radio and television stations, etc.

Advertising Agencies
Market Research and Rating Services

Taste-Differentiated Audience of Consumers

Figure 4. Flowchart of a Production Subsystem in Communications as it Functions through the Economic Process. (Source: De Fleur, 1966, p. 132)
conceived under the structure of the economic institution.

Identifying the Structure of Communications Technology

"Communications technology" is a compound term often misused and misunderstood by people who relate "technology" only to machines or devices. Hence, "communications technology" is taken to mean knowledge of the communicating devices used in the process of communications. This notion is misleading because communications technology includes knowledge of much more than just the "hardware" of communications. The term applies broadly to the total communications process.

The nature of electronics technology also demands consideration. Can electronics technology be identified adequately within the context of communications technology? Thus far, this relationship cannot be identified adequately or logically because the existence of industrial technology vis-à-vis communications technology has not been established by anyone. Since electronics technology is mainly concerned with industrial products, it would seem reasonable to examine the relationship of industrial technology to communications technology.

To clarify the misconception of communications technology and to conceptualize electronics technology clearly through the interface between communications technology and industrial technology, the total context
of communications technology must be examined, identified, and structured in its proper perspective. In order to accomplish this task, some pertinent questions must be answered: What is communications technology? What is its historical background? How have writers on the subject defined its context? What is an adequate structure of communications technology? What is the interface between communications technology and industrial technology, and where does electronics technology fit in the total scheme?

What is Communications Technology?

If human communications ran perfectly and smoothly, there would be no need to understand the mechanism of communications. But because man's daily communications are frequently faulty, it is best to review the process to determine shortcomings. This cannot be done until man understands the whole process of communications (Fabun, 1965, p. 59).

Developments which change or accelerate the transfer of ideas are possibly the mightiest forces in the dynamics of social change. One such development has been the inventions which have enhanced the movement of ideas by substituting for face-to-face personal communications.

The history of communications has been the breakdown of the isolation of man in response to a need for living
in a world outside. To meet the needs of an infant race of human beings expanding from families into tribes and from tribes into nation, more involved forms of communications developed. The urge to communicate with others was second only to the natural instinct for self-preservation. Communications was a way to combine the effect of individual minds and emotions in order to establish regularity.

The history of communications is also a story of human interrelationship, modified through the ages by changing conceptions of time and space. The purpose of communication since prehistoric days has been to transmit messages between men, so that the influence of one mind may be felt by another. However, with changes in technology, communication has grown from a simple interchange of signs or sounds between individuals face to face, to a vast and complicated network of technological advancements through which the messages of whole nations pass to every corner of the earth with the speed of light (Woodbury, 1931).

One of the major purposes of this study was to conceptualize the basis for content in electronics technology. In order to accomplish this goal, it was necessary to identify and examine the total context of communications technology, to observe its relationships, and to define and identify the context of electronics.
Communications Technology Defined - Communication is a broad term which has a wide variety of usage in all of man's institutions. Berlo (1960) stated that "communication does not consist of the transmission of meaning. Meanings are not transmittable, not transferable. Only messages are transmittable, and meanings are not in the message, they are in the message users" (p. 175).

A review of literature on the definition of communication as given by various sources reveals some of the different interpretations of communication:

Communication requires a message and a means of giving it to someone. Communication also makes it possible for people to share their knowledge, add to it, and pass it on to the next generation. The word "communicate" comes from the Latin communicare which means to share or make common. The chief means of communicating are the brain and the senses of seeing and hearing. Communication is accomplished by speech, gesture, looks, pictures, written and printed language, and many other ways (The New Book of Knowledge, Vol. 3, 1966, p. 429).

The Encyclopedia Britannica defines communication as:

... making common or sharing of something between two or among several persons or group of people. This definition stresses the interaction that distinguishes communication from other messages, and stresses the effects of the
message. . . . The relations between the pur-
pose and interactive functions of communica-
tion have been classified by analogies with
automation (Encyclopedia Britannica, Vol. 6,
1968, p. 203).

Communication is further defined as follows:

Communication, the transfer of information from
person to person, creature to creature, or point
to point (Collier's Encyclopedia, Vol. 7, 1968,
p. 73).

Communication is the exchange of thoughts,
feelings, opinions, and information (The American

The Encyclopedia International defines the "process"
of communication. It states:

The communication process, whether simply face
to face or via a complex organization, has
three basic elements: the sender, the message,
and the receiver. In communication between
two people, one of them (the sender) speaks,
writes, shows pictures, or gestures to the
other (the receiver), who may be listening,
reading, or watching. The receiver may respond
at anytime by reversing the process and feed-
back questions, amplification, dissent, or
assent (Encyclopedia International, Vol. 5,
1968, p. 91).

It also states:

The sender of a message to a mass audience may
be an individual, such as a writer, an enter-
tainer, a commentator, or a reporter. The
sender may also be a group of individuals, such
as a school, club, or business or government
enterprise, or any of the multitude of trade
and special interest associations (Encyclopedia

The above definitions of communication, and defini-
tions from the other sources gained through the review
of literature, agree that communication is essentially a
transmitting or transfer of thought, information,
feelings, and ideas from man to man, or man to machine, 
or machine to man, or machine to machine.

In order to better understand the context of communications technology, the evolution of the field should also be studied. Hence, a brief historical description is presented as condensed from the various sources listed in the bibliography.

The Evolution of Communications

In the earliest days of human evolution, man communicated by some form of speech or by drawing pictures. Although tedious, drawing was useful because man could convey his message to his family and friends and also store information for his descendants. Communication was also basic to religion, because man interpreted the variations of nature as symbols of or messages from the gods. Drums or other musical instruments were often used to communicate with the deities.

As man became more civilized, different forms of communication developed. Simple tribal communities evolved into nations which contributed to the growth of communication. The Phoenicians developed the first alphabet and forced it on other countries with whom they traded. The speed of communication also increased with the training of swift runners to carry messages over great distances. The Egyptians learned to write letters
on papyrus; the Babylonians carved messages on clay tablets, and the Romans used horses to increase the speed of messages. However, it was war that really enhanced communication by developing techniques of signaling with sound and light.

In short, the history of communication was the development of efficient methods to communicate. Starting from simple pictorial drawings, it progressed to the development of the alphabet, to more efficient ways to carry messages, to the swifter messengers of sound and light, and eventually to the scientific discovery of electricity. It was from this point in time that the field of electronics technology was born, and destined to affect the lives of man as he had never imagined possible.

Essentially, the roots of the modern methods of communication go back to about the fifteenth century with the invention of Gutenberg's printing press which made the written word available to everyone and created the printing and publishing industry. To keep up with demands, a paper industry developed, and other industries appeared to supply the needs of still other technologies such as photography, journalism, and duplicating. This evolution eventually led to the graphic arts industry, which encompasses a broader domain than merely the printing arts.
The other lineage of the modern means of communicating began in the early sixteenth century with the experiments of Gilbert in electricity. Although there were many other contributions to the eventual use of electricity, the invention of the telegraph and the telephone really opened a new world of communications to man. At first, the time between inventions and discovery in electrical principles and application was measured in decades; today it is measured in months or weeks, and behind it all are better communications and the need for still better communications between men.

From this brief summary of historical descriptions of the evolution of communications technology, it is evident that historians describe only the means of communication used by man. History does not present an adequate structure from which to view the total context of communications technology. However, history does establish the lineage of the two basic processes which man uses to facilitate communication: (1) graphics technology and (2) electronics technology. The term "graphics technology" includes all the graphic functions of communicating, and is used here because it encompasses a much broader field of study than the traditional printing industry. Graphics technology emphasizes the process of understanding and being understood through the sensory organs of sight. It includes printing and
publishing, all facets of photography, graphic design, advertising, the graphic aspects of motion picture, cartography, engineering graphics, and other fields related to visual techniques and processes. The lineage of graphics technology includes the evolution and development of such elements as printing, photography, and journalism.

The lineage of electronics technology represents the evolution and development of electrical and electronic products that are used to facilitate communication, such as the telephone, telegraph, and other electronic devices that emphasize the sensory organs of hearing. Although these two divisions are separate fields of study, there are many interrelationships, especially today, because most of the machines used in graphics technology are powered by electronic devices.

Review of Literature of the Content of Communications

An important source of careful thought in the ordering, categorizing, and structuring of communications technology should be the encyclopedias. A review of the various encyclopedias revealed the following subheadings or articles under the heading of communication:


<table>
<thead>
<tr>
<th>Bells</th>
<th>Printing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication satellite</td>
<td>Radio</td>
</tr>
<tr>
<td>Drums</td>
<td>Signals</td>
</tr>
</tbody>
</table>
Gestures  Signs
Guns  Smoke
Light signals  Speech
Mass communication  Telegraph
Phonograph and tape recorder  Telephone
Photography  Television
Postal service  Writing


Communication by electronics - radio, television
Communication by signs - fire and smoke
Communication by sound - drum, signals, talk
Communication by telegraphy
Communication by telephone
Communication by written symbols - alphabet, printing


Communication by electrical and electronic devices
Communication by sight
Communication by sound
Space communication

The encyclopedia cited above also suggested that the reader examine the following additional related subjects:

**Electronics**
- Books, talking
- Business machine
- Maser
- Microphone

**Sight**
- Advertising
- Book
- Composition
- Cryptography
- Dance
- Deafness
- Drama
- Drawing
- Encyclopedia
- Essay
- Graph

**Audio-visual instruction**

**Morse code**  Radio station
**Motion picture**  Telegraph
**Phonograph**  Telephone
**Radio**  Television

**Paper**  Photoengraving
**Journalism**  Photography
**Letter writing**  Poetry
**Library**  Post office
**Literature**  Railroad
**Magazine**  Reading
**Manuscript**  Sculpture
**Newsaper**  Shorthand
**Novel**  Signaling
**Painting**  Spelling
**Type**
Sound
Bell
Blindness
Drum
Listening
Siren
Speech
Storytelling


Communication by paper and printing - writing, block printing, printing press, typewriter
Communication by sound - voice, drum, whistle
Message carriers - messengers, modern postal system, private letter service
Telegraph - semaphore, Morse, cables
Telephone and radio telephone


Suggested related articles:

Advertising
Alphabet
Automation
Book
Communication
satellite
Composition
Computer
Encyclopedia
Freedom of speech

Journalism
Language
Motion picture
Newspaper
Photography
Printing
Propaganda
Radio
Telephone
Television

In summarizing the review of encyclopedias cited above, there is a noticeable pattern which indicates that the topics or articles listed could naturally be categorized under the headings of sight or sound. But here again, only the means of communication which basically concern industrial products are noticeable. As stated previously, this does not present an adequate structure of the total domain of communication, because the total field does not represent a mere description of the various devices used to communicate. The devices used in the communicating process are industrial products, and the interface between
communication theory and these industrial products is not clarified by writers on the subject.

Investigation was also made of the literary field for information concerning communications. The content of the materials examined was basically similar to that cited in the review of the encyclopedias. However, some exceptions revealed a more adequate approach to the study of the field. Gerbracht's suggestions (1965) for a division of communications were interesting. He stated that "the process of 'communication' isn't realized until thoughts, words, and pictures have been composed, duplicated, transmitted, received, and finally interpreted correctly by the recipient" (p. 11). He also suggested that the interdependence of the means is necessary to the transfer of information. Hence, he listed the processes of graphics technology, and stipulated the processes of electronics technology as the "means" for the process of communication. They were listed as follows:

<table>
<thead>
<tr>
<th>Composition and Duplication</th>
<th>Transmission and Reception</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphic Arts-sound recording</td>
<td>Mechanical-</td>
</tr>
<tr>
<td>Drawing, Sketching</td>
<td>Electrical</td>
</tr>
<tr>
<td>Drafting, Blueprinting</td>
<td>Telegraphy</td>
</tr>
<tr>
<td>Letterpress</td>
<td>Telephone</td>
</tr>
<tr>
<td>Photography</td>
<td>Radio</td>
</tr>
<tr>
<td>Intagliography</td>
<td>Teletype</td>
</tr>
<tr>
<td>Planography</td>
<td>Facsimile</td>
</tr>
<tr>
<td>Duplicating</td>
<td>Television</td>
</tr>
<tr>
<td>Sound Recording</td>
<td>Multi-Channel Methods</td>
</tr>
<tr>
<td></td>
<td>Radar</td>
</tr>
</tbody>
</table>
DeVore (1967) contended that curriculum designs now being studied indicate that specific interrelationships exist between the study of transportation technology and communication technology, together with certain sciences. His conception of the domain of communication is as follows:

**Communication**

Communication Electronics
- Radio (Navigation and Commercial)
- Radar
- Communication Graphics (Photography)
- Information Systems (Computers)

Huss (1967) described the process of communications technology as being the design of a complex and interrelated system through the process of coordinating all the elements that make up the system, and taking into account their interactions and individual characteristics. In this context, communications technology becomes a way of learning about technology with graphic-photo-optical-electronic sensors for the control and communication of knowledge. He further stated that:

Communication technology is a study of the means by which man has been able to communicate and record information, knowledge, and understanding about the universe. It provides concepts and principles about the devices and procedures used in the communication industries to expand man's ability to assimilate, share, and use knowledge. It is an area concerned with devices to measure more accurately and control more closely the material and information-handling systems of technology and culture.

Communications, then, is a study of how men and machines inform each other and hence, involves
information processing. In the case of machines, it also involves control.

This conceptual approach to course content and method must be involved in all instruction in technical communications (Huss, 1967, p. 137).

The above approaches to identifying the context of communications technology are still inadequate for the purpose of this study, because the interface between the industrial products used in the process of communication, and the communication process itself is not identified. Communicating devices used in the process of communication involve the operational and servicing aspect of industrial technology. Therefore, a study of these communicating devices is a part of the study of industry because industry provides the body of knowledge used by the individuals or organizations who operate and service industrial material goods (Staff of IACP, 1969, p. 15).

Communication Theories

Communication theorists tend to view the scope of communications from the standpoint of a behavioral scientist or semanticist. They have conceptualized various models from which to view the total context of communications. One of the simplest of these models was devised by Schramm (1963), and defines communication as involving all the signs and symbols by which men try to transfer meanings and values to one another. (See Figure 5.)
In the above model, Schramm concluded that each communicator is both an encoder and decoder, and can therefore transmit or receive messages. Each can also modify his messages from the observed reactions of the other. Schramm saw two basic types of communications: (1) mass communication and (2) interpersonal communication. Interpersonal communication is basically communication between man and man; mass communication is basically communication between man and machine, machine and man, or machine and machine (Schramm, 1963, pp. 3-22).

Another basic model of communications was visualized by Lasswell who equated his model to individual areas of a scientific study in communications. (See Figure 6.)

Another communications model was conceived by Shannon and Weaver whose diagram is basic to all talk about communication and applies to any communication line, whether the symbols sent over it are words, letters, dots and dashes, music, pictures, or non-sense phrases (Shannon
Figure 6. The Lasswell Model. (Source: Lasswell, 1960, pp. 17-18.)

and Weaver, 1949, p. 5). The basic elements of the Shannon-Weaver model are described as follows:

Information source - the source initiating the message.

Transmitter - the thing that changes the message into a signal.

Channel - the medium by which signals are transmitted.

Noise - any interference that affects the signal.

Receiver - the thing that receives the signal and changes it into the message.

Destination - the user of the message.

Figure 7. The Shannon-Weaver Model. (Source: Shannon and Weaver, 1949, p. 5.)
Another of the most popular and widely used models in communications was conceptualized by Berlo. His model is simple and can be adapted to many areas of research.

![Diagram: The Berlo Model]

Figure 8. The Berlo Model. (Source: Berlo, 1960, p. 72.)

According to Berlo's model (1960), the source and the receiver both rely on communications skills, attitudes, knowledge, a social system of governing components, and a cultural background of experiences. If these factors are comparable in content, then communication will occur. If there are differences, then adjustments must be made before communication can take place.

The message which is transmitted is composed of five
subparts. All messages have content which must be structured into elements. The content is then treated in a special way (or ways) in conjunction with the intended purpose, by an encoding process, and transmitted through a channel to a receiver.

The channels of communication are the senses. The more sensory inputs that can be involved within the channel when transmitting a message, the clearer the reception of the signal. The channels are also divided into natural and artificial. The natural channels rely on the direct use of one or more of the five senses, while the artificial channels utilize devices such as radios, televisions, newspapers, movies, etc.

The feedback applies to the behavior response of the receiver as a result of receiving the message (Berlo, 1960, pp. 65-75).

Although these communications models represent structures of the context of communications technology, the relationship between these theoretical models and the utilization of industrial products to enhance the process of communications is still not clear. What is the interface between industry and communications? Are there any electronic communications concepts as such? These questions need to be answered in order to visualize fully the context and structure of communications technology.
These other sources were reviewed for a classification schema for communications:

The Standard Industrial Classification Manual
Occupational Classifications
Product Classifications
Smithsonian Institution (Classification of Exhibits)
Museum of Science and Industry (Classification of Exhibits)
Organization of Higher Education

But the sources cited above revealed virtually no classification schema under communications. The few subheadings that were listed were usually found to be too narrow to cover the broad field of communications. Communication, in most cases, was conceived of as dealing mainly with or relating to electrical and electronic devices.

The examination of the various classifications and structures of communications, as cited in the review of literature thus far, warrants a conclusion that the context is not conceived adequately to provide a logical structure for the field of communications technology. It is evident from the review of literature that the writers who deal with the subject view communications from two different approaches. On the one hand, some communication theorists use a theoretical and behavioral approach in explaining the context of communications. They visualize the context of communications as it relates to the science of communicating. On the other hand, some writers tend to
view communication as it relates to the machines or devices used in the process of communicating. Hence, the term "communications" becomes nebulous in meaning as well as in context.

According to most of the literature, one aspect of communications deals primarily with the theoretical process of communications which essentially includes encoding, transmitting, receiving, and decoding, while the other aspect of communications concerns the industrial products used in the process of communicating such as the telephone, teletype, television, etc. The interface between the two is not clear, and seems to be a "grey area" not fully understood by many people. This situation exists because the relationship between the two areas has not been adequately distinguished by the writers on the subject. As a result, the term "communications" is being used recklessly to label many industrial fields such as graphic arts communications, satellite communications, visual communications, and many others. This labeling is misleading because an examination of the content, as shown in the review of literature, reveals that the material covered is primarily focused on the industrial products used for the purpose of communicating, and does not involve the concepts of communications as such. And this situation will continue until a more adequate context of communications is conceptualized and structured.
At present, this writer could not find any written material to adequately classify and structure the elements of communications technology.

An Adequate Structure of Communications Technology

Communications technology basically 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. Direct or natural communication between man and man usually involves dynamic interaction, primarily through speaking or gesturing, and through man's five sensory receptors: (1) seeing, (2) hearing, (3) tasting, (4) touching, and (5) smelling. However, when communication involves the utilization of industrial products from which to communicate, such as described by Schramm (1963, pp. 3-22) as a situation between man and machine, machine and man, or machine and machine, a distinction must be made between the domain of communications technology and that of industrial technology. It must be made clear that the products (constructed and manufactured goods) used in the process of communication are extensions of man's actions, and are conceived, developed, and produced through the processes of industrial technology.

Industry provides the body of knowledge used by
those individuals or organizations who are engaged in operating or servicing industrial goods. For instance, when industry provides a television set, it also provides the theory of practice for its efficient installation, use, alteration, maintenance, and repair by consumers, operators, and servicemen. Industry produces this knowledge; for this reason, it is a part of the study of industry (Staff of IACP, 1969, p. 15). Therefore, the industrial products (electronic and graphic devices) used to facilitate communications should be studied within the context of industrial technology, because they represent either manufactured or constructed products. This is not to say that there are no relationships between the two areas. Industrial technology is an extension of man's actions and is therefore directly related to all of man's actions, including communicating. Thus, it provides the interface between the theoretical approach to communicating and the industrial products facilitating the communication process. Figure 9 shows graphically an adequate structure of the context of communications technology for the purpose of this study.

Structuring Electronics Technology

Now that the relationships of communications technology, industrial technology, and the products used in the communications process have been identified within the broader framework of technology (Figure 9), the
COMMUNICATIONS TECHNOLOGY
the transfer of
Ideas
Knowledge
Information
Feelings, etc.
through a
PROCESS OF COMMUNICATION
which essentially involves Feedback (Directed System)

Encoding — Transmitting — Receiving — Decoding

Man to man

Speaking
Hearing

Gesturing
Seeing

Symbolizing
Testing

Communication
Touching
Smelling

Extension of man's actions
(man to machine, machine to man, machine to machine)
through
Industrial Material Goods
produced by

INDUSTRIAL TECHNOLOGY

Construction Technology

Management Functions
Production Functions
Personal Functions
yield

Manufactured Material Goods

Manufacturing Technology

Management Functions
Production Functions
Personal Functions
yield

Manufactured Material Goods

Communicating
Graphically
Communicating
Electronically

Printing plant
Cinema

Microwave tower
Radar network

Radio set
Television set

Newspapers
Books

Figure 9. Relationships of Communications Technology, Industrial Technology, and the Products of Industry Used in the Communications Process.
problem of structuring the context of electronics technology can now be brought into focus. This section is an attempt to identify, structure, and codify the major operational concepts of electronics technology for instructional purposes. In order to adequately conceptualize the context of electronics technology, certain questions need to be answered: What is the relationship of electricity to electronics? What is electronics technology? What is the relationship between the physical sciences and electronics technology? What are the major concepts of electronics technology?

The Relationship of Electricity to Electronics

To understand the field of electronics technology, the relationship of electricity to electronics must be defined and clearly understood. This is deemed necessary to fully understand the context of electronics technology as it is used by this study. To most people, the meanings of the terms "electricity" and "electronics" are vague because the present definitions are vague. And the definitions are vague because the context of each of these fields of studies is not clearly identified. Perhaps this is rightly so, because the basic theories and principles of electricity are still in a theoretical stage.

What is Electricity? - The following definitions were taken from various sources that a person may well
Electricity is a form of energy generated by friction, induction, or chemical charge, and having magnetic, chemical, and radiant effects; it is a property of the basic particles of all matter consisting of protons and electrons which attract each other (Webster, 1966, p. 466).

Current electricity is electrons in motion. Static electricity is electrons at rest (Crispin, 1964, p. 143).

Positive and/or negative charges at rest or in motion; it is a property of the basic particles of all materials consisting of electrons and protons; a form of energy generated by heat, light friction, chemistry, or induction which has chemical, magnetic, and radiant effects (Gerrish's Technical Dictionary, 1968, p. 126).

Electricity comprise those physical phenomena involving electric charges and their effects when at rest and when in motion. Electricity is manifested as a force of attraction, independent of gravitational and short range nuclear attraction when two oppositely charged bodies are brought close to one another (McGraw-Hill Encyclopedia of Science and Technology, Vol. 4, 1966, p. 452).

It can be seen from the above definitions that the term "electricity" is not clearly defined, but perhaps it can be clarified by defining electronics.

What is Electronics? - Electronics had its origin with the invention of the incandescent lamp by Thomas Edison in 1883. He discovered that a weak electric current would flow across a partial vacuum, between a heated filament and a cold metallic electrode. The first practical use of the Edison effect was made by J. A. Fleming in 1897. He utilized the unidirectional property of the electron-
carried current to form a detector of wireless signals. The Fleming valve was the prototype of the modern diode tube. A tremendous step forward in the utilization of electron motion was made in the triode, invented by Lee DeForest in 1906. He introduced a third electrode (grid) into the two-element Fleming valve. The triode is an amplifier. Modern pentodes and multiunit tubes are modifications of DeForest's triode and are used for special purposes. But for many years the electron tube was not widely used. The present billion-dollar electronics industry actually began with the advent of broadcasting in 1922 (McGraw-Hill Encyclopedia of Science and Technology, 1966, p. 524).

The term "electronics" is defined as follows:

The science of the practical application of the theory of electrons in such devices as radio-tubes, photoelectric cells, etc. (Crispin, 1964, p. 145).

A major subdivision of electrical science that deals with the principles governing emission of electrons from various solid and liquid materials, and the subsequent control of freed electrons to perform desired functions, e.g. amplification, counting, modulation, oscillation, rectification, switching. Electronics today cannot be considered as wholly an applied science. The entire field can best be described in terms of its applications (radar; radio; television) and its technology (electron tube; transistor) (Newman, 1963, p. 375).

The branch of science and technology relating to the conduction of electricity through gases or in vacuum. Electronics is generally considered to be the study and application of electron motion, including the means for producing it, the laws governing it, and the means for controlling it
for useful purposes. By this definition, electronics embraces a broad field of intellectual and industrial effort without clear boundaries. More narrowly, electronics is concerned with the design, manufacture, and application of electron tubes (McGraw-Hill Encyclopedia of Science and Technology, 1966, p. 524).

A branch of the science of electricity. Most of electronics consists of the science of using tubes, transistors, and other electronic devices to control small electric signals (The World Book Encyclopedia, 1970, p. 161).

A broad term covering the scientific and engineering applications of devices which are based upon a flow of electrons through a vacuum, gas, or solid. The subject also includes investigation of the physical phenomena upon which the operation of such devices depends (Encyclopedia Americana, 1969, p. 207).

That field of science and engineering that deals with electron devices and their utilization. An electron device in turn, may be considered as one in which conduction of electricity takes place through a vacuum, a gas, or a semiconductor (Collier's Encyclopedia, 1968, p. 1).

The branch of science and engineering concerned with the theory, design, and use of devices utilizing electron emission or absorption, such as electron tubes, cathode ray tubes, photoelectric cells, transistors, and the circuits in which these devices are used. Electronics is best described in terms of its application (Encyclopedia Britannica, 1968, p. 246).

From the above definitions, electronics is typically defined as the application of electron flow through vacuum tubes, semiconductors, and other electronic devices used to control electrical signals. But the definitions from the major reference sources cited do not distinguish clearly the relationship between electricity and electronics.
Perhaps the relationship between electricity and electronics is best summarized by the definition given by Mileaf (1967). He stated that: "All electronic devices use electricity, but all devices that use electricity are not electronic devices" (p. 1). If this statement is true, then, what makes the difference? Mileaf contended that the answer lies in the concept of intelligence. He defined electricity as the study of how electrical phenomena are used to provide electrical energy; and electronics as the study of how electricity is used to carry intelligence. Hence, any device that uses electricity to tell, show, or otherwise inform is electronics. He further added that in the study of electronics, the power delivered is still a consideration, but it is no longer the most important characteristic. The signal becomes more important, because it carries the intelligence. (For convenience, currents or voltage that carry intelligence are often referred to as signals.) Thus an electric iron is an electrical device, because electricity is used to provide energy in the form of heat, by its element. Similarly, electricity provides the power to turn the washing machine as well as to control relays. Intelligence varies widely, from the simple doorbell which tells you that someone is calling, to complex radar systems which locate and track fast moving distant targets (Mileaf, 1967, p. 1). These definitions of electricity and
electronics are unusual, but they are logical, and they describe the relationship between electricity and electronics in more precise boundaries. Therefore they should be more easily identified and understood by the layman. For the purpose of this study, Mileaf's definition of electricity and electronics was adopted to identify and structure the context of electronics technology. Hence, the study of electricity was defined as the study of electrical phenomena and their application to provide power and energy. The study of electronics was defined as the study of electrical phenomena and their application to carry intelligence.

What is Electronics Technology?

The term "electronics technology" is often used quite freely in magazine articles and textbooks concerned with electronics. However, an exhaustive search for references that defined the compound term proved to be almost fruitless. Because very few writers have attempted to define the compound term, it has acquired various meanings, each according to the interpretation of the writer.

The term "electronics technology" can be interpreted to mean "the study of the techniques of electronics," because "technology" essentially means "the study of techniques," or as used in this study, "the science of efficient action or practice." Other clues to defining
the term were obtained from the definition of **electrical technology** which was interpreted as "the science covering the practical applications of electricity" (Crispin, 1964, p. 286), and from the definition of the **technology of electronics**, which stated that "the many jobs performed by electronic tubes depend upon three basic functions: rectification (in diodes), and amplification and oscillation (in multi-element tubes). The various ways in which these functions are performed by the tubes and the accessory circuitry constitute the electronic art and science" (p. 525). These definitions, as presented thus far, do not adequately interpret the compound term because of their broadness, but they did provide a direction. After much deliberation, the compound term was defined, for the purpose of this study, as follows: **electronics technology**—the study of the application of the **operational principles**, within **industrial technology**, which relate to the research and development, production, and utilization of electronic devices.

At this point, a clear distinction must be made between the terms "electronics" and "electronics technology." The term "electronics" as defined, refers to the total field of electronics which includes the theoretical as well as the applied uses of electronics. The term "electronics technology" refers to that part of the total field of electronics which is concerned with
the processes of electronics, and does not include the theoretical aspects of the electrical phenomena. It mainly involves the industrial production of electronic devices and the operational concepts of electronics. This point must be well understood to visualize adequately the context of electronics technology as defined in this study. Figure 10 shows the adequate structure of electronics technology.

The Relationship of the Physical Sciences to Electronics Technology

Physical scientists deal mainly with natural phenomena. They observe nature and organize the observations into laws and theories. One distinct part of the study of the physical sciences concerns the laws and theories governing electricity (defined as the study of how electrical phenomena are used to provide electrical power and energy). Electronics, on the other hand, was defined as the study of how electricity is used to carry intelligence. From the above statements it can be concluded that electronics is a part of the total field of electricity which is a part of the physical sciences.

A study of electricity would basically cover two areas: (1) the theoretical aspects governing electrical phenomena and (2) the application of electrical phenomena to provide energy and power. It is clear that the physical science concepts are a vital and necessary part
Figure 10. Relationships of Industrial Technology, Communications Technology, Electronics Technology, and Physical Science.
of the field of electronics, along with its application in carrying intelligence. **Electronics technology, on the other hand, is that part of the total field of electronics which is mainly concerned with the study of the application of the operational principles, within industrial technology, which relate to the research and development, production, and utilization of electronic devices.** Since this study is concerned with electronics technology and not with the total field of electronics, it will be delimited to that end.

The proposed instructional system will not attempt to teach the technical aspects of electronics. It will be focused mainly on the broad operational concepts of electronics technology. Therefore, it will not be concerned with the basic laws and theories of electricity, nor with its application to produce power and energy. The study of the principles governing electrical phenomena is vital to every phase of the study of electricity/electronics when learning technical knowledge, but technical knowledge is usually presented in hierarchical order; hence a study of electricity is usually a prerequisite to the study of electronics. Unlike studying for technical knowledge, the study of broad concepts (at the first level) does not necessitate the knowledge of technical data because such data are not vital to the understanding of those concepts. It is with this premise that the
proposed instructional system will be designed for instructional purposes. The relationship between the physical sciences and electronics technology is diagramed in Figure 11.

Identification of the Major Operational Concepts of Electronics Technology

The conceptual approach used by this study focuses on the universal features of the field of electronics technology. Teachers have long been aware of the educational advantages of focusing on generalizable concepts rather than on many specific and/or irrelevant facts, but the questions are: Which concepts? and How should they be taught?

Before proceeding to establish the structure of the body of knowledge which has been identified as electronics technology, it should be noted that this is a single body of knowledge on how to efficiently apply electronic operational concepts in the production and utilization of electronic devices. However, it should also be noted that this is a generalized structure of electronics technology, and that at the more specialized level the sub-elements could be substructured and studied for specific purposes. This classification system, then, could assist curriculum planners in selecting or sampling any level of generality or specificity.

Structure implies the ordering of bits and pieces
Figure 11. The Relationship Between Physical Science and Electronics Technology
into meaningful wholes, and suggests ordering of specifics and relating them to generalizations. This ordering provides transfer of learning potential by carefully delineating the "elements" within the "context." By conceptualizing themes that organize and unify, curriculum workers will more adequately structure knowledge (Towers, Lux, and Ray, 1966, p. 169).

To identify the major operational concepts of electronics technology, the nature of electronics technology was first defined and identified. Then, a search of all available written literature (see Appendix A) on the subject of electronics was conducted. The contents of each written work were examined and classified according to the major units of study each writer considered essential in the study of electronics. These major units of study were then reviewed, combined, refined, and categorized under five major concepts which are believed to be totally inclusive of all electronic operational principles involved in the study of electronics technology. In other words, every item of content in the study of electronics technology can be identified under one of the five identified concepts. These major concepts are also believed to be mutually exclusive categories. The five major concepts which form the basic structural framework of electronics technology were identified as follows:

1. Conducting electrical phenomena
2. Converting waveforms
3. Oscillating
4. Amplifying
5. Switching

Each of these five major concepts can be further refined to derive more specific subconcepts until the smallest concept or unit is identified. However, because this study is concerned mainly with identifying and using the major concepts for instructional purposes, the smaller subconcepts were not refined into their smallest units. The following pages present a classification schema for the ordering of the content for electronics technology. The list is not intended to be exhaustive or completely descriptive because of its magnitude at the lower levels of specificity.

A Classification Schema of Electronics Technology Concepts

1.0 Conducting
   1.1 Conveying electrical phenomena
   1.2 Radiating electrical phenomena
   1.3 Wiring

2.0 Converting waveforms
   2.1 Rectifying
   2.2 Filtering
   2.3 Mixing
   2.4 Transducing
2.5 Clipping

3.0 Oscillating
   3.1 Resonating circuits
   3.2 Relaxing circuits

4.0 Amplifying
   4.1 Strengthening frequencies
   4.2 Combining stages
   4.3 Regenerating

5.0 Switching
   5.1 Gating circuits
   5.2 Counting circuits
   5.3 Multivibrating circuits

6.0 Manufacturing and Constructing*
   6.1 Managing
   6.2 Producing
   6.3 Utilizing personnel

*These are the major concepts of Industrial Technology as developed by the Industrial Arts Curriculum Project.

In the generalized classification schema presented above, it should be noted that the first five major concepts are the identified operational concepts of electronics technology. The sixth concept was added because the classification schema also represents the content structure for the instructional system on electronics technology. Since all electronic devices are the products
of a managed production system which is a major concept of industrial technology, they should be considered a part of the study of electronics technology.

The generalized model presented thus far represents the broad base for a program of instruction in the elementary school. However, an instructional program could focus on any one or any combination of concepts according to student needs. Therefore, higher levels of specificity may be added to the structure on all or on selected dimensions. It would then be possible to study only the generalized structure or a more specialized structure of electronics technology. The following pages present a sample of a higher level of specificity for the ordering of content on electronics technology.

1.0 Conducting

1.1 Conveying electrical phenomena

1.1.1 Conducting through vacuum tubes

1.1.1.1 Diodes
1.1.1.2 Triodes
1.1.1.3 Tetrodes
1.1.1.4 Pentodes
1.1.1.5 Multiunit tubes
1.1.1.6 Cathode ray tubes
1.1.1.7 Photo tubes

1.1.2 Conducting through semiconductors
1.1.2.1 Diodes
1.1.2.2 Transistors
  1.1.2.2.1 NPN
  1.1.2.2.2 PNP
  1.1.2.2.3 FET
1.2 Radiating
  1.2.1 Electromagnetic radiation
    1.2.1.1 R.F. waves
      1.2.1.1.1 Carrier waves
        1.2.1.1.1.1 Very High Frequency (VHF)
        1.2.1.1.1.2 Ultra High Frequency (UHF)
    1.2.1.1.2 Damped waves
    1.2.1.1.3 Modulated waves
      1.2.1.1.3.1 Amplitude Modulation (A.M.)
      1.2.1.1.3.2 Frequency Modulation (F.M.)
      1.2.1.1.3.3 Sideband modulation
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      1.2.1.1.3.5 Complex modulation (multiplexing)
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    1.2.1.3 Heat waves
    1.2.1.4 Television signals
    1.2.1.5 Navigational signals
      1.2.1.5.1 Radar
      1.2.1.5.2 Sonar
  1.2.2 Antennas
1.3 Wiring
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2.1 Rectifying

2.1.1 Changing A.C. to D.C.

2.1.1.1 Half wave rectifying

2.1.1.2 Full wave rectifying

2.1.2 Demodulating

2.1.2.1 A.M. detecting

2.1.2.2 F.M. detecting

2.1.2.2.1 Grid leak detecting

2.1.2.2.2 Plate detecting

2.1.2.2.3 Regenerative detecting

2.1.2.2.4 Ratio detecting

2.2 Filtering

2.2.1 Filtering through capacitance

2.2.2 Filtering through inductance

2.2.3 Filtering through combinations

2.2.3.1 R.C. filters

2.2.3.2 R.L. filters

2.2.3.3 R.C.L. filters

2.3 Mixing

2.4 Transducing

2.5 Clipping

3.0 Oscillating

3.1 Resonating circuits

3.1.1 Sinusoidal circuits

3.1.1.1 Hartley oscillators
3.1.1.2 Armstrong oscillators
3.1.1.3 Colpitts oscillators
3.1.1.4 Crystal oscillators
3.1.1.5 R.C. oscillators
3.1.1.6 Power oscillators
3.1.2 Non Sinusoidal circuits
  3.1.2.1 Sawtooth generator
  3.1.2.2 Blocking oscillators
3.2 Relaxing circuits

4.0 Amplifying
4.1 Strengthening frequencies
  4.1.1 A.F. amplification
  4.1.2 R.F. amplification
  4.1.3 I.F. amplification
  4.1.4 Video amplification
  4.1.5 Power amplification
    4.1.5.1 Push-pull
    4.1.5.2 Inverting
4.2 Combining stages
  4.2.1 Impedance coupled amplifier
  4.2.2 Direct coupled amplifier
  4.2.3 Transformer coupled amplifier
  4.2.4 Grounded grid amplifier
4.3 Regenerating

5.0 Switching
5.1 Gating circuits
5.1.1 AND gates
5.1.2 OR gates
5.1.3 NAND gates
5.1.4 NOR gates
5.2 Counting circuits
5.3 Multivibrating circuits
  5.3.1 Astable circuits
  5.3.2 Monostable circuits
  5.3.3 Bistable circuits
6.0 Manufacturing and Constructing*
  6.1 Managing
    6.1.1 Planning
    6.1.2 Organizing
    6.1.3 Controlling
  6.2 Producing
    6.2.1 Pre-processing
    6.2.2 Processing
    6.2.3 Post-processing
  6.3 Utilizing personnel
    6.3.1 Hiring
    6.3.2 Training
    6.3.3 Working
    6.3.4 Advancing
    6.3.5 Retiring

*These are the major concepts of Industrial Technology as developed by the Industrial Arts Curriculum Project.
The classification schemas presented in this section should not be construed as the ultimate structure for the body of knowledge from which to select electronics technology subject matter. The quality of the conceptual construct as presented is subject to review, refinement, and modification. The final evolution of this structure will depend greatly on additional investigations and experimentation.

A Method of Selecting and Ordering Content for Electronics Technology

To further help the teacher or a curriculum developer, a system of classification was developed for further ordering and selecting content for instructional purposes. This system could be used to analyze and develop curriculum materials according to the needs of the class. An example of its use has been developed and included here to show the process.

A Classification System for Ordering Content for Electronics Technology

1. Grade Level
   (First grade)

2. Environmental Study
   (Home)

3. Concept
   (Amplifying)
From the above classification system evolved the development of a matrix to further analyze the ordering of content for electronics technology. The analysis model for the classification of content in electronics technology is presented in Figure 12. From the first order matrix presented, an example of a single cell in the analysis model is also shown for classification.

Summary

A generalized model of electronics technology has been presented in this chapter. Electronics technology was first identified within the broader framework of industrial technology and communications technology, and these in turn were placed within the still-broader framework of technology.

Technology was first identified as the knowledge or science of efficient actions of man within the five basic institutions of the family, government, religion, education, and the economic system. Within the economic institution, industrial technology and communications technology were further identified and analyzed. Industrial technology was identified as "... that subcategory
Figure 12. A Model of a Systems Analysis for Classification of Content in Electronics Technology.
of technological knowledge which is derived from the study of industrial practices" (Towers, Lux, and Ray, 1966, p. 85). Communications technology was defined as the transferring of ideas, knowledge, information, feelings, gestures, etc. through a process of communication which essentially consists of encoding, transmitting, receiving, decoding, feedback, from man to man, man to machine, machine to man, or machine to machine. The interface between industrial technology and communications technology was also discussed, along with their relationship to electronics technology, and was graphically presented in Figure 9 (see p. 72). Electronics technology was then defined as that part of the total field of electronics which is mainly concerned with the application of the operational principles within industrial technology, which relate to the research, development, production, and utilization of electronic devices. After the context of electronics technology was adequately defined, the body of knowledge for electronics technology was then identified, structured, and codified for instructional purposes. The reader should note again that the structured body of knowledge as presented in this chapter should not be construed as the ultimate structure from which electronics technology subject matter is to be selected.

Now that the instructional content of electronics technology has been adequately structured, the major
considerations and strategies for designing the instructional system on electronics technology for the elementary schools will be discussed in Chapter IV.
CHAPTER IV

DESIGNING AN INSTRUCTIONAL SYSTEM
IN ELECTRONICS TECHNOLOGY

Human variability demands that alternative approaches be considered in designing the instructional system for this study. The sound selection of alternatives also demands that all available and viable alternatives be diagnosed before decisions are made. Goodlad (1968, p. 65) contended that the creation of alternatives is an educational function which requires actions outside the jurisdiction of individual teachers, because curriculum development is a difficult and complex process. Because curriculum development is a complex process, a researcher can greatly benefit from the work of those who have gone through the process of curriculum development.

Usually, contemporary curriculum improvement projects follow common developmental patterns of: (1) identifying and structuring the body of knowledge that will serve as course content, (2) stating behavioral objectives, (3) building the prototype, and (4) building measuring instruments to see whether appropriate learnings were mastered. If the guidelines are not made explicit, it would be difficult for someone who is trying to develop a
new project to determine what procedures were followed in making decisions at the various stages of program development. These guidelines can also help curriculum developers to learn from the success or failure of the prior work of others (Towers, Lux, and Ray, 1966, p. 234). Hence, before the prototype of the instructional system in electronics technology can be developed, attention must first be focused on the many factors that must be considered before the final decisions are made for the construction of the instructional system.

The research, development, diffusion, and adoption model proposed by Clark and Guba (Guba, 1965, p. 10) was used to provide the needed overall guideline for this study. Many other research and development models have been conceptualized in the past, but the Clark and Guba model was chosen because it best fits the purpose of this study. The basic stages of the Clark and Guba model are: (1) Research, (2) Development, (3) Diffusion, and (4) Adoption (see Figure 13).

Although the Clark and Guba model (Guba, 1965) furnished the general plan for the development of the instructional system, the adoption and diffusion stages are not discussed in this chapter. These two stages will be carried out when proper funding can be obtained to carry on the program to its fruition. However, both stages were considered in the general planning.
<table>
<thead>
<tr>
<th>Process</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research</td>
<td>To advance knowledge, i.e. to depict, correlate, conceptualize, and test.</td>
</tr>
<tr>
<td>Development</td>
<td>To formulate a new solution to an operating problem.</td>
</tr>
<tr>
<td>Design</td>
<td>To draft a plan for constructing the innovation.</td>
</tr>
<tr>
<td>Construction</td>
<td>To build the components.</td>
</tr>
<tr>
<td>Assembly</td>
<td>To integrate the components into an operating system.</td>
</tr>
<tr>
<td>Diffusion</td>
<td>Dissemination To create widespread awareness of the invention among practitioners.</td>
</tr>
<tr>
<td>Demonstration</td>
<td>To afford an opportunity to examine and assess operating qualities of the invention.</td>
</tr>
<tr>
<td>Adoption</td>
<td>Training To train local personnel to manage, service, and utilize the innovation.</td>
</tr>
<tr>
<td>Trial</td>
<td>To build familiarity with the invention and provide a basis for assessing the quality, value, fit, and utility of the invention in a particular institution.</td>
</tr>
<tr>
<td>Installation</td>
<td>To fit the characteristics of the invention to the characteristics of the adopting institution.</td>
</tr>
<tr>
<td>Institutionalization</td>
<td>To assimilate the invention as an integral and accepted component of the system.</td>
</tr>
</tbody>
</table>

Figure 13. A Process Chart Depicting the Role of Evaluation in the Change Process. (Source: Stufflebeam, 1968, p. 38 (revised).)
In designing the instructional system on electronics technology for the elementary schools, the salient factors of curriculum development brought out through the review of literature in Chapter II were carefully considered, along with some other notable suggestions which are discussed in the following paragraphs.

Wiman (1969, pp. 146-153) suggested that two approaches can be used in the development of instructional material for sequential courses. One way is to develop a subject from the beginning to some finite stage, called the vertical system analysis and development. The other way is to develop all the basic subjects from the beginning to a finite level, known as the horizontal analysis and development. He also contended that program development involved two major stages: (1) the behavioral analysis of the course content, and (2) the synthesis of learner behaviors. In the first stage, learner behaviors and objectives are specified so that the nature of the behavior can be discovered, measured, modified, and identified. The second stage begins after all the objectives have been defined, tests constructed and tried out, and objectives sequenced.

Glaser (1966, pp. 216-217) recommended four steps in the designing of an instructional system: (1) analysis of the subject matter domain, (2) study of the characteristics of learners, (3) construction of teaching procedures and materials, and (4) evaluation of learner performance.
against established criteria.

After considering the suggestions presented thus far, the following factors were deemed necessary and appropriate in the development of the instructional system for this study: (1) some considerations for formulating objectives, (2) some considerations for selecting learning experiences, (3) some considerations for organizing the learning experiences, and (4) considerations for measurement and evaluation. A systems flowchart of the procedural steps is shown in Figure 14.

Some Considerations for Formulating Objectives

A major step in most curriculum development theories is the formulation of educational objectives or goals for the proposed program. Hence, the first problem was to determine the educational objectives of the instructional system in behavioral terms from the fundamental assumption that electronics technology is much more than a complex collection of principles, laws, and theories, and that elementary school children can benefit from acquiring the basic concepts of electronics technology that are essential to a child's total knowledge of the real world.

A major issue concerning the selection of objectives must first be considered. Should the educational objectives be determined by the curriculum developer at the project level, or should they be determined by the schools who use the developed product?
Figure 14. A Systems Flowchart for Developing the Instructional System.
Many curriculum planners believe that unless the teachers of the subject are involved in the process of determining the program objectives, they will not be committed to the program, and will merely go through the paces. The counter argument is that if an instructional system explicitly tells the students what to do and if the program prescribes the methods to follow to gain stated overall objectives, teachers will do a good job because they will be freed from other responsibilities and demands on their time. These questions are difficult ones with which to contend (Towers, Lux, and Ray, 1966, p. 247). However, because it was noted previously in the introduction of this study that most elementary school teachers feel inadequate to teach electronics due to their lack of training in this area, it was decided that determining the objectives for this instructional system at the project level would be of more help to teachers. But this is not to say that the situation should remain static. Once the program becomes established, teachers should be flexible enough to gradually establish new objectives to meet the needs of the students.

In formulating objectives, Gagné (1965b, pp. 20-21) sees the process of determining the nature of the desired behavior change as task analysis having three implications for the selection of learning activities. These are:

1. that in terms of the learning process, different
conditions of learning which should determine instructional methodology are required for different levels of performance, (2) the sequence of learning activities should be determined by the level of performance specified, and (3) a diagnostic assessment of student progress toward attaining certain behaviors can be carried on and the results of this assessment fed back into the instructional process. He further contended that task analysis should be continued until it can be safely assumed that the learner is operating at the desired level. Some evidence indicates that determining the level at which the learner is operating through the use of task analysis offers more insight into the ability of the learner to operate at higher levels than do some forms of achievement testing (Gagné, 1965b, pp. 355-365).

Determining specific daily objectives through the use of task analysis should result in a very logical structure of objectives. Task analysis should provide information as to the type of prerequisite learning activities that students must be able to do or must have experienced before they are given more complex problems or learning activities that require a great deal of independent thinking. The subordinate activities that make up higher order activities must be planned (Towers, Lux, and Ray, 1966, p. 250).

After considering the issues presented above concerning the formulation of objectives, this researcher has
taken the position that the instructional objectives should be determined at the project level, rather than at the local school level, and that task analysis should be used to determine the instructional objectives, because it was deemed necessary to determine the objectives in terms of observable behavior which students will be able to perform as a result of instruction. A general framework for the writing of objectives was developed for the Industrial Arts Curriculum Project and was used by the staff members as guidelines in the writing of their objectives. Since this was a logical and well-developed method to determine well-stated objectives, it was also used for the formulation of objectives for this instructional system. The framework is a series of questions used to screen or check objectives as they were written for the prototype.

1. **Terminology** - Are objectives written in terms of student behavior that can be observed and measured? Are specific rather than vague verbs used to describe behavior? Have conditions under which behavior will be observed been specified?

2. **Internal Consistency** - Is a consistent general-to-specific pattern being followed? Are lower objectives subordinate to higher objectives?

3. **Criterion Level** - Has the level of acceptable performance been specified? Have the conditions under which mastery will be demonstrated been stated?

4. **Behavioral Consistency** - Are behaviors in simple or subordinate objectives consistent with behaviors in complex objectives? Are they consistent with course objectives? With school objectives?

5. **Measurement Potential** - Can the behaviors
that have been described be observed and measured? Can valid test items be constructed?

6. Accommodation of Individual Differences - Are objectives sufficiently varied to allow for the real individual differences encountered in students of this age group? (Towers, Lux, and Ray, 1966, p. 252).

Some Considerations for Selecting Learning Experiences

An even more difficult problem than formulating objectives was deciding how best to accomplish the behavioral objectives once they were determined. Many theories for the selection and organization of learning experiences were analyzed and discussed in the chapter on the review of literature, from which the basis for the decisions on the selection and organization of content for this instructional system was established.

Among the changes taking place in the learning experiences provided by the schools across the nation, changes in the prevailing notion of the nature of learning experiences are particularly significant. At the beginning of the century the term "learning experiences" was not used. "Exercises," "assignments," "examples," and "problems" most commonly designated the learning tasks set for the pupil to do outside the class session, while the term "recitation" referred to the oral responses expected of the pupil in class. However, during the last ten to twenty years, curriculum guides began to mention such conditions as motivation, opportunity for practice,
and the like. Today, many courses of study are pointing out the need to consider these conditions in the selecting of learning experiences for a particular class group (Tyler, 1957, pp. 100-102).

The basic purpose of an educational system is to manage learning so that it will function most efficiently. Kemp (1968) contended that the essential input in this system is the student, and that the output is the student's changed behavior. The objective of this management is to insure that the greatest positive changes in student behavior occur in the shortest period of time. Kemp (1968) also suggested four concerns which educators should be aware of when selecting learning experiences:

1. Students differ greatly in their ability to perceive and learn, and in their individual requirements for learning. Some learn easily and rapidly from printed or oral presentations, with a minimum of more direct experiences. Others require experiences that are more concrete, including the use of visual media. Most students require a combination of various avenues to learning.

2. Many cultural factors affect learning. Students need a whole range of experiences involving real things, visual representations, and abstract symbols.

3. New ways to organize subject content encourages greater participation in the learning activity through discovery and inquiry methods.

4. That instructional programs themselves need to be reorganized in terms of efficient and flexible use of space, time, personnel, and resources (p. 5).

In addition to the statements made above, this study has strongly considered Ausubel's works (1961, 1963).
Schuh, Taylor, Powell, and Hast, in conjunction with the Columbus City School District, have devised a language oriented resource guide which has applications of Ausubel's subsumption theory. According to Schuh, et al. (1969, pp. 1-5), research has shown that a person's potential to learn is closely related to his ability to understand and associate words. As a means of encoding and decoding experiences, language is the primary instrument in the thinking process; conceptual development and communication both depend heavily on the development of language. However, because unorganized bits of knowledge have low retention capabilities, other measures are needed to facilitate the organizing and restructuring of meanings in order to increase the number of concepts that are used in the thinking and decision making process. Schuh, et al. (1969) further contended that concept development is directly related to vocabulary extension, for words are the residue of experience, and cannot be broadened except through the broadening of one's understanding. Words usually move through four stages: (1) wholly unknown; (2) heard of but not known; (3) known in specific settings, but not in general; and finally (4) known in both general and concrete settings. New concepts depend on new experiences. Conceptual development relates to the extending of meaningful vocabulary, which is then filed for use in the thinking process.
The direct teaching of vocabulary, especially when it is individualized and related to meaningful substance, has definite and often immediate results. That training in vocabulary produces results has been supported by a number of experiments in which direct teaching of vocabulary was found to be superior to incidental teaching or to wide reading without teaching vocabulary.

In one experiment, 60 fourth-grade children were grouped into control and experimental groups equated for mental age, I.Q., and initial knowledge of 100 selected words. In the experimental classes the teacher taught specifically 65 of the 100 words, taught another 15 incidentally but without emphasis, and did not teach the remaining 20. After two months, the original test was repeated. The two experimental groups had gained 31 per cent over the control group on the words specifically taught, 25 per cent on those incidentally taught, and only one per cent on those not discussed at all. In other words, vocabulary will not grow without training, but with direct training it will grow rapidly (Gray, 1938, pp. 29-34).

In two other experiments by Newburn (1934, pp. 9-30) and Phillips (1938, pp. 19-23), it was found that the direct teaching of 100 vocabulary terms to sixth-grade elementary students increased not only the pupils' vocabulary, but their comprehension of history as well. Hastings (1932, p. 178) also found, through a study in
geometry, that there was a significant improvement in mathematical vocabulary. Even more conspicuous was the narrowing of the range of scores. The chief effect showed at the lower end of the distribution where it was needed most.

Schuh, et al. (1969) listed five criteria for an operational framework for learning that will organize a growing reservoir of relevant meanings and experiences:

1. The content structure must engage the children in the examination of the social realities of living through inquiry and observation.
2. The content structure should invite related understandings rather than the fragmentation of subject matter.
3. The structure must be flexible enough to realistically accommodate the cultural and individual diversity that exist in the population.
4. The content must be adaptable to a wide range of understanding and experiences for transfer to new situations.
5. The content structure must be self vitalizing. It must have the means for changing to new ideas and information (p. 5).

The schools have a major responsibility to teach the child about his expanding world, and to prepare him to deal with an unknown future by helping him to realistically understand and cope with his present day living. Fish (1964, p. 370) contended that as the child experiences his environment and then evaluates his experiences, the environment serves as a point of reference—a measuring stick. Gradually and systematically the child formulates a body of generalized truths against which he assesses himself and his actions. However, as the child, a complex
energy system with an ever changing, ever expanding base of experience, interacts with his environment, which is similarly a complex, ever changing energy system, his previously formulated truths often develop apparent discontinuities. When new ideas conflict with present beliefs the child directs his energies to explaining and clarifying apparent discontinuities and modifies and extends his concepts.

In selecting and organizing the content for this instructional system, the broad major concepts of electronics technology that were identified and structured in the previous chapter will be the overarching content of the instructional system. Each of the major concepts is also a unit of study within the total field of electronics technology and may be used to strengthen an existing subject content area, or the unit may be introduced as an integral part of the general curriculum in any elementary school. Subconcepts can also be structured as units to reinforce particular areas for specific purposes.

The value of utilizing units of study is well recognized by educators, especially in the elementary schools, where the selection of units is based on the framework of established school curriculum guides. According to McPhie (1963), units should be chosen on the basis of their logical cohesiveness and their ability to stand alone as subject matter entities. The unit as a basis for instruc-
tion and learning originated from the necessity to break up the total world of human experiences into practical subdivisions for facilitating classroom procedures. Teaching on a day-to-day basis rather than from within the framework of a unit is the equivalent of breaking the large goal into areas that are too small to be challenging and that are not easily related to the larger task.

In designing and organizing the instructional system for this study, each of the identified major concepts of electronics technology was organized around a framework of key electronic technical terms or devices. These technical terms or electronic devices serve as the "organizers" which strengthen and amplify the concept being taught. Schuh, et al. (1969, pp. 2-3) contended that the child is more psychobiologically involved in the learning process when the content of the activities is familiar and related to the child's own experiences. This makes the need to understand real and necessary for the child. They also believed that overlearning and reinforcement assist language growth. After a child has successfully used a new word, it is important that he be given an opportunity to repeat it a number of times in different settings, because planned repetition tends to reduce forgetting. Thus, teaching the major electronics technology concepts through actual electronic devices such as the radio, television, laser, etc. which are real and current in the
child's natural environment, should help to strengthen the concept and make it relevant to the child. Showing the child how "amplification," for example, applies in real electronic devices such as radio, television, and laser, will also help the child, not only to know what the term amplification means, but also to understand the application of the concept in actual electronic devices found in his home, community, and total environment. Transferring the application of this concept to other electronic devices yet to be invented will probably become easier for the child, thereby preparing him to understand today's technological world as well as tomorrow's.

Some Considerations for Organizing the Learning Experiences

Having made the decisions about the selection of learning experiences, the organization of the developmental aspects can now be considered. Here, the methods or techniques of presenting the materials must be identified. This problem has several dimensions which include the teacher variable, the nature of the learner, and the media used for instruction. Glaser (1968, pp. 5-6) stated that these tasks require the construction of teaching procedures and of the materials that are to be employed in the educational process. As part of this process, the instructional designer must account for motivational effects and for the ability of humans to generalize by providing conditions
which will result in the maintenance and extension of the competence being taught.

The first test of a scheme of curricular organization lies in the relationship between the organizing center (topic, problems, questions) being used to involve the student, and the central concepts (elements, compound, model) and methods (observation, generalization, communication) that the student is to learn. Thus, the student needs a few carefully chosen facts to chew on, but the nutritive element lies within, like the vitamins in natural food (Goodlad, 1964, pp. 96-97).

Tyler (1950, pp. 364-374) stated that the purpose of organizing learning experiences is to minimize the large number of learning experiences usually required to develop complex behavior patterns. He further contended that three criteria are commonly considered necessary for a well-organized curriculum, namely, continuity, sequence, and integration. Continuity refers to the repetition of the desired behavior through the use of varied learning experiences. Sequence refers to the gradation of the learning as each experience builds on previous experience in order to attain broader and deeper understanding. Integration refers to the practice of relating what the student is learning in one field to what he is learning in other fields.

In an investigation of teaching methods, Paul Burns
(1966) compiled a review of several research studies done in the field of elementary school science which dealt with instructional methods and procedures. He summarized the studies in the form of trends and conclusions. He decided that: (1) Most studies favor organization around cores of subject matter, supplementing instruction by means of demonstration, discussion, drawing, and experiments. Data from several studies would appear to strengthen the case for a greater laboratory approach at the elementary level; (2) As yet, there seems to be no final experimental evidence to indicate the value of integration of science with other elementary school subjects; and (3) Research seems to indicate that multi-sensory devices are helpful in developing interest and factual knowledge of science. An additional value is their help to elementary school teachers who may lack the subject matter background in the field of science.

In addition to the above considerations for the organization of learning experiences, three other variables must be considered: (1) the characteristics of the teacher, (2) the nature of the learner, and (3) the use of instructional media. Each will be discussed in the following pages.

Teacher Characteristics

Teacher characteristics constitute some of the most significant stimuli in the elementary school classroom,
and they also constitute a very broad area of investigation. Ryans (1963, pp. 434-435) listed more than seventy-five variables that have been examined with some degree of sophistication during the past five years. But to account for all of the variables would be an insurmountable task. Hence, Towers, Lux, and Ray (1966, pp. 275-276) listed several alternatives that could be taken: (1) determine what the typical teacher is like, and build learning activities that are commensurate with his capabilities; (2) build the learning activities and then allow only those teachers who measure up to certain standards to use the prepared instructional system; (3) build the best instructional system possible and not worry about teachers who are incapable of using it; (4) keep in mind what the teachers are like, build the instructional system, and then train the teachers to handle the system with emphasis on those teacher characteristics that have the most effect on the teacher behavior that can be improved; and finally, (5) recognize that teaching is an art, and that it is the right of the individual to decide for himself what and how he is going to teach.

The fourth choice seems to be the most tenable for the purpose of this study since the learning activities for this instructional system are based on a structured body of knowledge. Another important reason for choosing the fourth alternative is that American elementary school
teachers are predominantly women. Their attitude toward teaching electronics technology will determine to a considerable extent their effectiveness in teaching the subject. The beliefs which underlie and are expressed in their behavior will be reflected in how and what the pupils learn.

Electronics is closely related to science, and an analogy from that field may be used to describe the problem. Mallinson (1956, pp. 369-371) stated that few women teachers are interested in taking science courses. The majority of studies in science point to the discouraging fact that most elementary school teachers have had little or no training in science, and that the training they have had is of little value in teaching elementary school children. As a result of their lack of training, they are reluctant to teach science. Hence, in the teaching of electronics technology at the elementary school level, the same kinds of problems would be encountered. The woman teacher who really understands the part that electronics plays in her daily activities and those of her pupils is well prepared for the teaching of this subject; but such teachers are rare.

Keeping in mind the basic characteristics of teachers, as well as the problems cited above, this instructional system will be developed to help teachers who lack training in electronics technology, by giving them a
packaged system and the training needed to utilize and implement the program in its proper perspective. Towers, Lux, and Ray (1966, p. 277) suggested that before teachers can guide learning activities concerning the structured body of knowledge, they must first be taught what it is. This involves building comprehensive teacher guides that deal with the various concepts involved, and also communicate the structure. If funds are available, in-service training programs could also be started.

The Nature of the Learner

The discussion on how children learn was reviewed in Chapter II. It has been recognized that human variability exists, and that because of these differences it is almost impossible to describe the typical elementary school child. Nevertheless, the schools have the responsibility of recognizing and working with the differences. This notion points to several questions that should be answered in the development of the instructional system: For whom will the instructional system be developed? At what age level can it be introduced? How will it account for individual differences?

According to Towers, Lux, and Ray (1966, p. 254), traditionally, schools have reacted to individual differences by varying their curriculum and by trying to determine the age at which it is best to introduce certain types of instruction. This reaction, the concept of
readiness, is now being re-examined. One of the most influential factors that has caused this re-examination has been the concept of the spiral curriculum. The spiral curriculum is the notion that anything can be taught to children at anytime, providing it is taught on the student's level. Today, subjects formerly taught in colleges are being introduced in the elementary schools. Taba (1962, pp. 296-297) also stated that the problem of a spiraling curriculum is to provide for a progressively demanding performance. It basically has more complex materials to deal with; greater depth and breadth of ideas to understand, relate, and apply; and greater sophistication of attitude and sensitivities which may involve short or long term sequences, depending on the course. Such a cumulative spiral provides continual reinforcement by the repeated use of what has been learned, either through practice or through use in new contexts, such as a continuity between learning and applying ideas and skills.

Hanna, et al. (1966, pp. 49-69) contended that there should be no conflict between child development considerations and the prescribing of learning experiences concerned with fostering described behavior, because if growth in subject matter areas is expected, then appropriate learning experiences must be organized and provided for children. Consequently, the biggest task of the school is to provide experiences that match the capacities of
children with the expectancies of the culture as expressed in the curriculum. The school also has the responsibility to insure gradual development of understanding so that children are not suddenly plunged into teaching-learning experiences at a specific time in the middle grades. Many studies in child growth and development show that the developmental patterns of children vary. As a result, each part of the curriculum should provide flexibility of requirements and should be sufficiently broad to match a variety of combinations of abilities. Grade levels cannot be construed as definite stages of educational achievement; therefore, teaching-learning experiences must be adapted to fit a range of maturity levels. Studies signify that children at all grade levels are able to reason and deal with abstract concepts.

This study has taken the position that this instructional system will be designed to enhance the learning opportunities of all boys and girls in the elementary schools. To accomplish this, program content and the developmental patterns of children will not be viewed in horizontal grade level stages, but rather, as expanding spirals of conceptual development regardless of age placements. Schuh, et al. (1969, p. 1) stated that such an approach will tend to free teaching from unrealistic assumptions and expectations regarding what subject must be covered, when, and how. The diverse nature of these
learning activities will enable teachers to be more selective; they will be less likely to teach all elementary school children as though they had the same cultural and individual backgrounds, interests, and potentialities. This will allow the interaction of nature and nurture in ways that will stimulate and enhance the functioning capacity.

In concluding this section, the following statement made by Cronbach (1964) serves as a useful summary:

Readiness is created, cumulatively, by a proper combination of content and method. . . . The main point for us to notice is that what pupils can understand at any age depends upon how you explain it—upon that, and upon what their background has been. It is this that justifies my initial remark that no question about readiness can be given a general answer (p. 29).

Instructional Media

For a number of years, educators have pondered the effectiveness and uses of the various media in educational programs. Many researchers have tried to determine which medium or a combination of media is best for teaching a particular subject content. But their investigations have generally not yielded consistent findings. Sometimes, motion pictures have been found to be more advantageous than lectures, and sometimes not. Furthermore, the answers obtained do not seem to be more consistent with any one kind of subject matter than with another. Therefore, dependable answers to the question of matching particular
subject matter with particular media are unlikely to be obtained except in highly specialized instances (Wiman, 1969, p. 111).

In Chapter II, various research in instructional media was cited to provide direction for this instructional system. The various studies suggest that the use of a variety of instructional media, used for different purposes, would be the most effective way to utilize instructional media. Hence, this study will use a varied media approach in the selection of media for specific subject content. The use of slides and transparencies will be provided for in specific lessons, and motion pictures and filmstrips will be listed and recommended wherever their use is appropriate.

Considerations for Measurement and Evaluation

A curriculum is essentially a plan for helping students to learn, and evaluation essentially refers to the criterion of the effectiveness of learning. Evaluation is commonly described as a process which begins with the formulation of objectives, involves decisions about the ways of obtaining evidence on the attainment of these objectives, interpreting the evidence, and assessing the strengths and weaknesses in the achievement of the students. Evaluation ends in decisions about the change and improvements needed in curriculum and teaching. This
definition places evaluation in the activities that enhance the educational process. These activities can be listed in four steps: (1) identifying educational objectives, (2) determining the experiences students must have to attain these objectives, (3) knowing the pupils well enough to design appropriate experiences, and (4) evaluating the degree to which pupils attain these objectives (Tyler, 1951, p. 48).

Taba (1962, pp. 314-326) stated that evaluation can serve many functions in the development of curriculum. One of the most often used functions of evaluation is to validate the hypothesis on which curriculum is based, because in a sense all curriculum plans are only hypotheses which need to be tested. She further contended that decisions about the methods used for gathering data for evaluation should be made only after the objectives are classified. But not all behaviors related with one general objective can be evaluated by the same technique. Therefore, a variety of methods and techniques must be used to evaluate different behaviors. These techniques are available to curriculum developers. They range from objective tests to informal procedures such as checklists, observations, records, and teacher-made exercises. These devices must be consistent with the purpose for which they are used. They must be free from subjective elements, and they must represent an adequate sample of behavior to give
valid information.

Evaluation is very important in the development of materials used in any learning situation as well as for any significant improvement in learning. However, Stewart (1969, p. 164) suggested that in order to conserve time, energy, and money, one unit that represents a good sample of the skills and knowledge to be learned from the entire course should be selected and developed first. Once the media and instructional method have been determined, developed, and tested, the balance of the course can be developed with a minimum of restructuring. The most difficult task in evaluation is to define what is to be evaluated; consequently, meaningful evaluation should be based on specific objectives measuring the achievement of course content.

It should be noted from the above references that evaluation ought not be viewed as a final process, but rather as a continuing process which aids in the improvement of the various stages of curriculum development. It should also be noted that feedback loops are vital in the evaluation process, because through the feedback process evaluation affects the selection of the learning activities as well as the final learning outcome.

As a necessary guideline, Taba (1962, pp. 316-323) suggested the use of six criteria for a program of evaluation. They are as follows:
1. Evaluation must be consistent with the objectives of the curriculum.

2. Evaluation should also be comprehensive in scope as are the objectives of the school.

3. The results of evaluation must be sufficiently diagnostic to distinguish various levels of performance or mastery attained, and describe the strengths and weaknesses in the process as well as the product of performance.

4. Validity, or the capacity of the evidence to describe what it was designed to describe, is even more important in improving curriculum and teaching than dependability and objectivity.

5. Objectives need to be broken into their component units for an analytical differentiation of the specific behavior they entail, and specific devices used to secure evidence on these specific behaviors.

6. Evaluation should be a continuous process and an integral part of curriculum development and of instruction.

Adding to Taba's guidelines, Towers, Lux, and Ray (1966) identified three major phases of an evaluation program. They are: "(1) measurement of behavior change or goal attainment, (2) evaluation of the effectiveness of instructional procedures, and (3) evaluation of the appropriateness of objectives" (p. 301). In the measurement of behavior change, the information obtained can be used by the learner, the teacher, and the project developer who can judge the effectiveness of the methods and procedures used to achieve the desired objectives. Revisions are then made accordingly in the instructional system (see Figure 15). The second phase, the evaluation of the effectiveness of instructional procedures,
Figure 15. Evaluation Loop and Use of Measurement Data. (Source: Towers, Lux, and Ray, 1966, p. 304.)
evaluates the appropriateness of the activity for a specific objective (see Figure 16). The final phase, the evaluation of the appropriateness of objectives, evaluates whether the objectives were appropriate in terms of the degree of difficulty, were sound in terms of their relation to higher level objectives, and were measurable (see Figure 17).

After the question of what should be evaluated has been answered, Goodlad (1964) suggested these different ways of evaluating a new program:

1. Observation of whether or not the students for whom the material is intended appear to be progressing successfully.
2. Casual and systematic questioning of teachers and students involved in the programs.
3. Periodic examination of students by tests designed to cover the new material.
4. Comparative testing of students in "new" and "old" programs with traditional and specifically designed tests (p. 60).

The major purpose of evaluation is to judge the success of the instructional system, and also to provide specific information that will allow the curriculum developer to make necessary changes in the objectives, instruction, and activities to strengthen the total instructional program. Since the evaluation procedures used in the Industrial Arts Curriculum Project have proven to be effective, this study will adopt the three models (Figures 15, 16, and 17) for the evaluation and refinement of this instructional system.
Figure 16. Evaluation of Procedures. (Source: Towers, Lux, and Ray, 1966, p. 306.)
Figure 17. Evaluation of Appropriateness of Objectives.  
(Source: Towers, Lux, and Ray, 1966, p. 308.)
Summary

In designing the instructional system for this study, it was deemed necessary to consider the alternative approaches and inherent problems involved in (1) formulating objectives, (2) selecting learning experiences, (3) organizing learning experiences, and (4) developing evaluation and measurement procedures. Through this approach, the following decisions were made for each step in the curriculum development process:

1. Formulating objectives - The instructional objectives were to be determined at the project level, and task analysis was to be used to determine the instructional objectives.

2. Selecting learning experiences - The major concepts of electronics technology were to be selected and organized around a framework of key electronic devices and technical terms used as "organizers," to amplify the concept being taught.

3. Organizing learning experiences - Since most elementary school teachers lack adequate training in electronics technology, the instructional system was to be developed to include a complete package. The instructional system also was to be designed to enhance the learning opportunity of all students in the elementary school by utilizing the concept of the spiral curriculum. A varied media approach was to be utilized in presenting
the lessons in electronics technology.

4. Evaluation and measurement - The major purpose of evaluation would be to judge the success of the instructional program and to provide specific information that would allow the curriculum developer to work necessary changes in the instructional objectives and activities, to strengthen the total instructional program.

Now that the strategies for developing the instructional system on electronics technology have been identified, Chapter V will discuss the invention, design, and construction of a prototype of the instructional system on electronics technology.
CHAPTER V

THE DEVELOPMENT OF A SOLUTION FOR AN INSTRUCTIONAL SYSTEM IN ELECTRONICS TECHNOLOGY FOR THE ELEMENTARY SCHOOL

This chapter describes the development of the prototype of an instructional system on electronics technology for the elementary school. The primary purpose of the instructional system is to provide the elementary schools with a means of improving the preparation of the children for effective living and participation in a changing technological society. The instructional system was also devised to help elementary school teachers present the subject in an effective manner. It will help the students to develop an understanding of electronics technology which will enhance their future employability, productivity, knowledge, and behavior patterns, all of which are affected because of the dominance of electronics in American society.

It should be emphasized that although the instructional system is carefully structured, it is not a self-study course. The teacher must actively guide and stimulate discussions by providing real experiences based on the real world. Imaginative teachers should adapt the materials to meet the special needs of their own students.
Because the instructional system was highly structured it was important to plan the specific events that would lead to the attainment of the objectives. Gagné (1965a) insisted that the conditions for learning be purposefully planned. He listed the following advantages of detailed planning of activities:

1. The selection of proper learning conditions may be made as an unhurried choice, rather than in "spur of the moment" decisions.
2. A "quality control" of the choice of learning conditions is ensured and maintained. Quality does not suffer from variations in teachers' skills.
3. Predesign makes possible pretesting. Whether or not a set of learning conditions has been correctly chosen and designed can be determined by trying it out on students and revising if necessary.
4. Predesign of learning conditions greatly reduces the necessity for the teacher to use valuable time in extemporaneous design, and thus makes it possible for proper emphasis to be restored to the teacher functions of managing instruction, motivating, generalizing, and assessing (p. 253).

In the development of the prototype of the instructional system, the instructional process that will be used involves: (1) textbook reading, (2) classroom presentations (the various means and methods), (3) student classroom activity, and (4) review and evaluation. To carry out these activities, the instructional system will provide a textbook, a teacher's guide, and a student workbook.

Construction of the Textbook

The main task of any textbook is to present the concepts to be learned in a way that the children will be able
to understand and retain much of what they read. Hence, the ideas must be presented in relation to topics that can be understood by the learner. Towers, Lux, and Ray (1966, p. 295) stated that the development of a textbook can be compared to the widening circle around a rock dropped in water. It is also necessary to present the facts that are fundamental to the understanding of the concept. Therefore, in organizing the content for each unit of study in electronics technology, it was necessary to include the following information: (1) the definition of the concept, (2) the identification of the subelements involved in the concept, (3) some applications of the concepts in industrial products, and (4) the relationship of the concept to other fields of study.

Another important aspect of the textbook construction involved the readability level of the material presented. Since the instructional system was primarily written for the sixth-grade level, the Dale-Chall readability formula was applied to the reading material to verify the class level for which it was intended. The material written in the textbook was verified for the sixth-grade level.

Each concept introduced in the textbook represents a unit of study in electronics technology. The units or concepts were not considered to be sequential, and they do not necessarily build on each other. Although the body of knowledge for electronics technology was structured in a logical sequence of study, the structure is flexible
enough that a specific unit could be meaningfully taught by itself. (See Appendix C for the prototype of the textbook.)

Construction of the Teacher's Guide

One of the assumptions made by this study is that elementary school teachers are dubious about teaching electronics because they are ill prepared to teach the subject. Hence, in order to help the teachers, a teacher's guide was included in the instructional system. The teacher's guide includes a step-by-step procedure of how each lesson should be presented, and although this approach seems highly structured, there is much flexibility as to how the lesson could be presented. Teachers who use the instructional system should add to the lessons by injecting information from their own experiences and knowledge that they consider relevant and meaningful to the students. The structured lessons are merely one suggested way of presenting the subject.

The structured approach was chosen to give teachers confidence in presenting the lessons. But it was hoped that once teachers had gone through the system and gained confidence in handling the subject, they will modify and reorganize the lessons to meet the needs of their class. The structure or format for the teacher's guide was presented in the following sequence: (1) stating the behavioral objectives, (2) listing supplies and equipment
needed, (3) explaining the overview, and (4) suggesting instructional procedures.

Behavioral Objectives

For each lesson, behavioral objectives are presented. They are written so that the teachers may see measurable results; hence, for a particular lesson, each student should be able to accomplish whatever goals are set for that day.

Supplies and Equipment

This section is included to help the teacher plan ahead and prepare for the lesson by obtaining the necessary supplies and equipment needed to carry on that lesson.

Overview

The overview is included to help the teacher explain what the lesson will cover and how it relates to the total unit. This will help the teacher as well as the students to see the total scope of the lesson in a more logical and meaningful manner.

Instructional Procedures

The instructional procedures provide the teacher with a step-by-step procedural account of how to present the lesson in a logical sequence. This section provides instructions for both the teacher and the students.

Another section included in the teacher's guide,
wherever applicable, consists of discussion questions that may be used to see whether the objectives for the lessons have been met. The questions as well as the answers are provided so that the teacher can more easily direct the discussion into meaningful learning sessions. Through this method, student feedback can be obtained. But these questions are provided merely as guidelines for a fruitful discussion. It is also highly recommended that teachers formulate their own questions.

Finally, if problems or questions are included in the student workbook, the answers are listed in the teacher's guide. Hence, the teacher's guide includes everything needed in order to teach the subject; therefore, it should allow any teacher to use the system. (See Appendix B for the prototype of the teacher's guide.)

Construction of the Student Workbook

As a part of the instructional system, a student workbook was provided as a learning device to help the students become more independent by giving them the directions for conducting their laboratory experiments and the other activities in their workbooks. Hence, the workbook allows the student to be independent of the teacher. However, the teacher is needed to guide the class, and also to act as a resource person, because there are values in direct instruction as well as in allowing students to learn things by themselves.
The workbook activities were also designed to allow for group participation. Learning to work together, to share ideas, and to make group decisions have as much value in the education of children as any other activity. Through these activities it is hoped that the child will realize the importance of cooperation, and will contribute his share to a common purpose.

In constructing the workbook, the structure of the activities was planned according to the general structure presented in Figure 18. Hence, for each concept the activities include: (1) an activity in vocabulary learning, (2) a student experiment session, and (3) an evaluation session. (See Appendix D for the prototype of the student workbook.)

The Teaching Strategy

The selected means for the classroom presentations for each unit of study in the instructional system involve a lecture-discussion session, a vocabulary learning session, a student activity session, an oral reading session, and an evaluation session. The general format for presenting a unit of study is shown in the flowchart presented in Figure 18.

Each session represented by a block in the diagram (see Figure 18), is a teaching lesson that could be carried on during one time block within a day, or during several time blocks, covering several days. The length of time for
Figure 18. A Format for Presenting A Unit of Study.
each lesson would depend upon class interest, the teacher's ability and experience, and the time allotted for the schedule of events in each school. The following sections will discuss each session.

Lecture-Discussion Session

Lectures - The lecture session (teacher presentation) will be conducted with the use of transparencies and will focus on electronic devices which are the preorganizers of the concept being taught, and are introduced to amplify the concept. The devices will be chosen from the environment under study for a particular grade level, so that they will be meaningful and relevant to the children in understanding the concept, and so that they will coincide with elementary school curriculum patterns.

Discussion - A discussion session will usually follow the oral and visual presentation. Here, the teacher plays an important part in helping the students to understand the concept through discussion. Hilgard (1956) also believed that teachers have a responsibility to influence the emotional environment for learning. They must try to stimulate interest in the subject and thereby to help students enjoy working with the ideas or materials involved. The teacher may lead his students to conclusions that arouse a sense of accomplishment. Questions to guide the discussions are also provided in the teacher's guide. The discussion session is important because it provides
the necessary feedback to the teacher as well as to the students.

Vocabulary Learning

Technical terms associated with the unit of study will be taught as vocabulary words, and used as another preorganizer of the concept. The learning of vocabulary words also serves other functions. It can strengthen the language arts program, and meaningful vocabulary on technical devices found in the home or community may be the catalyst for interest and motivation, and students should become familiar with the terms that may effect their living in tomorrow's technological society.

Student Workbook Activity

Classroom activities are introduced to further strengthen and add to the concept being discussed. These activities can also be considered as another form of preorganizers of the broad concept. Through these activities the students will also learn how to work together and will become familiar with some skills in manipulating simple tools. The discussion at the end of each activity is designed to collect and summarize the different thoughts and to emphasize the main purpose of the experiments.

Reading

In introducing the broad concepts of electronics technology, the activity will be presented through a
session in oral reading. This method was selected so that the students would be exposed to another facet of the language arts program. Through oral reading, the teacher will be able to help the students pronounce the technical terms correctly and to enhance their general reading ability. Discussion questions are posed at the end of each reading assignment to summarize and review the main points so that the concept will be understood.

Evaluation

At the end of each unit, review and test questions are provided to summarize and evaluate the unit. This section was provided to obtain feedback so that adjustments may be made in the unit to make it more effective. It is recommended that the review and test questions not be used for grading purposes, but mainly as instruments for the evaluation of the program, not the student.

Visual Aids

The use of visual materials, such as films, filmstrips, slides, posters, etc. is recommended wherever feasible in each unit of study. But visual aids other than the transparencies were not included in the instructional system because of the high cost of producing such material. However, the value of visual presentations was not discounted; hence, a resource list for obtaining visual material was provided at the end of the teacher's
guide to acquaint the teacher with the sources of different kinds of visual material. (See Appendix B.)

To enhance interest and motivation, the classroom should also be filled with posters and pictures of electronic devices dealing with the broad concept being introduced. According to Hunt (1967), the physical environment is one of man's best teachers. A rich environment seems to account for the tremendous amount of information children accumulate before ever going to school. Woodruff (1967, pp. 106-107) also contended that all knowledge is about the "real world." The real world consists of objects which are engaged in events, which have consequences that impinge upon the self and affect its sense of well-being. Therefore, the five component elements that constitute the significant aspects of environment as far as learning is concerned are: (1) objects that are around an individual, (2) the events in which the objects take part, (3) the consequences of those events, (4) how they impinge upon him, and (5) how he feels about them. "Real things" must come in through the perceptual senses. Therefore, it cannot be emphasized strongly enough that every effort should be made to develop a classroom setting that stimulates the children's curiosity to learn.

Summary

In the design of the instructional system, certain terms and meanings are repeated in several lessons. This
was done purposely to help the students to become accus-
tomed to seeing and using the word, and to understanding
what it means. Repetition functions to reinforce and
extend learning to make the learned information more
enduring. Variations of instructional methods operate to
sustain attention, to investigate interest, and to broaden
the pattern of learning. Variations also aid students to
generalize and apply more widely and surely what they have
learned.

The instructional system also presents each concept
in the same framework to familiarize the teacher with the
system. This structure also allows any concept to be
introduced by itself without the loss of continuity. This
is possible because the system was designed to let each
unit contribute to the total knowledge of the whole. The
units are independent; therefore, no loss occurs by
switching the order of presentation.
CHAPTER VI

SUMMARY AND RECOMMENDATIONS

This study began with the assumption that most people do not understand electronics technology. But because electronics technology has become so much a part of our way of life, the elementary schools across the nation should begin to teach some broad concepts of electronics technology so that children will be better prepared to cope with and live effectively in a technologically oriented society.

The two basic problems of this research were: (1) to conceptualize, structure, and codify the body of knowledge that may be the basis for an instructional system in electronics technology, within the broader framework of technology, and (2) to design and develop an instructional system in electronics technology that may be used as a model to encourage the development of other similar studies.

The Rationale for and Structure of Electronics Technology

In developing the rationale for and structure of electronics technology, this study began by identifying electronics technology within the broad framework of
industrial technology and communications technology, and both within the still broader framework of technology. It was assumed that only by understanding the whole and the relationships of its parts can we begin to conceptualize, structure, and codify a viable content for electronics technology.

The first step was to identify the total context of technology. A thorough search of the field supported the contention that few studies had identified and defined the context of technology. The only study found that met all the criteria for logically structuring the context of technology was the Industrial Arts Curriculum Project. This study accepted the premises for the logical structuring of the context of technology as identified by the IACP. "Technology," in the broadest sense of the word, was conceived by the IACP as a major domain of man's knowledge, and was defined as: "... the knowledge of practices in all of man's societal institutions" (Towers, Lux, and Ray, 1966, p. 83). The technology of man's five basic societal institutions were identified as (1) familial technology, (2) educational technology, (3) political technology, (4) religious technology, and (5) economic technology. It should be noted that each of man's five basic institutions has its own functions to fulfill, but at the same time, they are all interrelated.

This study then proceeded on the premise that
industrial technology and communications technology were both subelements of the economic institution even though communications technology relates closely to all human behavior and activity. As such, "industry" was defined as "... that subcategory of the economic institution which substantially changes the form of materials in response to man's wants for material goods" (Towers, Lux, and Ray, 1966, p. 85). The combined term "industrial technology" was then defined as "... that subcategory of technological knowledge which is derived from the study of industrial practices" (Towers, Lux, and Ray, 1966, p. 85).

Since this study was mainly concerned with electronics technology and the electronic products used in the process of communicating, it seemed logical to study communication as a subelement of the economic institution. It was further justified because the electronic products used in the process of communicating are essentially the extension of man's actions, and are created and utilized mainly for economic purposes.

In order to conceptualize electronics technology clearly, through the interface between industrial technology and communications technology, the total context of both industrial technology and communications technology needed to be examined, identified, and structured. The IACP had done extensive research in identifying and
structuring industrial technology, and this study accepted their premises for identifying the context of industrial technology.

A search for the identification of the context of communications technology proved to be difficult because the field of study lacked a clear identification of its domain. A thorough review of all of the written works on "communication" indicated that the subject content was usually introduced either from a theoretical viewpoint or as industrial products used in the process of communicating. These descriptions of the context of communication were inadequate for the purpose of this study because they did not show the interface between the communication processes and the industrial products involved in the process of communicating. A distinction must be made between the domain of communications technology and that of industrial technology. The products (constructed and manufactured goods) used in the process of communication provided for an extension of man's actions, and are conceived, developed, and produced through the process of industrial technology and not through communications technology. Communication devices used in the process of communicating must be produced, operated, and serviced. As such, a study of communication devices is a part of the study of industry. Industry creates the body of knowledge used by the individuals and organizations who are
engaged in the research, development, production, operation, and servicing of industrial material goods. For the purpose of this study, "communications technology" was defined as the transferring of ideas, knowledge, information, feelings, gestures, etc. through a process of communications which essentially consists of encoding, transmitting, receiving, decoding, and feedback, from man to man, man to machine, machine to man, or machine to machine. The domain of communications technology was then structured, and its relationship to industrial technology was graphically shown in Figure 9 (see p. 72).

After the relationships of communications technology, industrial technology, and the products used in the communication process were identified within the broader framework of technology, the problem of identifying the context of electronics technology within that framework was brought into focus.

In conceptualizing the context of electronics technology, the relationship between electricity and electronics was reviewed and analyzed from all available literature. Much of the literature reviewed presented vague definitions of both terms, and did not distinguish clearly the domain of electricity and electronics.

For the purpose of this study electricity was defined as the study of electrical phenomena and their application to provide power and energy. Electronics
was then defined as the study of electrical phenomena and their application to carry intelligence. From these definitions it could be seen that the domain of electricity concerned the study of electrical phenomena (physical science concepts) and their applications to provide power and energy. Electronics on the other hand, also studies electrical phenomena, but their application relates mainly to the carrying of intelligence. Hence, a clear distinction can be made between the domain of electricity and electronics. The compound term "electronics technology" was then defined as the study of the application of the operational principles within industrial technology which relate to the research and development, production, and utilization of electronic devices. From this definition it can be inferred that electronics technology is concerned mainly with that part of electronics which applies the operational principles to the research and development, production, and utilization of electronic devices. (See Figure 10, p. 81.)

After identifying the domain of electronics technology, a search was then conducted for the body of knowledge of that field of study. All available literature on the content of electronics was reviewed and analyzed. A content analysis of several books was made. The contents from each book were then categorized and classified under the major heading deemed important by
the writers. These major topics were reviewed, combined, refined, and restructured until five broad concepts were finally identified (conceptualized). The five broad concepts are: (1) conducting, (2) converting, (3) oscillating, (4) amplifying, and (5) switching. These concepts were then taxonomized for instructional purposes.

It should be emphasized that the classification schema presented in this study must not be construed as the ultimate structure for the body of knowledge from which electronics technology subject matter is to be selected. The final evolution of this structure will depend greatly on additional investigations and experimentations.

The Design and Development of an Instructional System for Electronics Technology

In designing the instructional system for this study, it was deemed necessary to consider alternative approaches and the inherent problems involved in formulating objectives, selecting learning experiences, organizing learning experiences, and developing evaluation and measurement procedures. Consequently, in Chapter IV, each section presented differing arguments that must be considered in designing and organizing the total program for the instructional system. The following paragraphs present the outcomes of the decisions that provided the direction for the construction of the instructional
In formulating objectives, this study took the position that the instructional objectives should be determined at the project level, rather than at the local school level. It was also decided that task analysis should be used to determine the instructional objectives, because it was necessary to determine the objectives in terms of observable behavior which students should be able to perform as a result of the instruction.

Following Ausubel's works (1961, 1963) in the subsumption theory, the identified major concepts of electronics technology were organized around a framework of key electronic devices and technical terms, and these electronic devices and technical terms served as the "organizers" which strengthen and amplify the concept being taught.

Keeping in mind the basic characteristics of most elementary school teachers, this instructional system was developed to help teachers who lack training in electronics technology, by giving them a complete packaged system with instructions needed to implement and utilize the program in its proper perspective.

Concerning the nature of the learner, this study took the position that the instructional system should be designed to enhance the learning opportunities of all elementary school students. Therefore, the content of
the system and the developmental patterns of children were not viewed in horizontal grade level stages, but rather as expanding spirals of conceptual development regardless of age placements.

Research studies on instructional media indicated that the use of a variety of instructional media, used for different purposes, would be the most effective way to utilize instructional media. Therefore, it was decided that a varied media approach was to be utilized in presenting the lessons in electronics technology.

Finally, the utility of evaluation was recognized as a continuing process which aids in the improvement of the various stages of curriculum development. Hence, the major purposes of evaluation, as used in this study, were to judge the success of the instructional program and to provide specific information from which the curriculum developer could work necessary changes in the instructional objectives and activities.

The factors mentioned above provided the general framework for constructing the instructional system. Once these decisions were made, construction began of the instructional system which included the design and development of a textbook, a teacher's guide, a student workbook, and other supporting material. A prototype of the constructed instructional system for this study can be seen in Appendices B, C, and D.
Recommendations

Based on the research done in developing the rationale for this study, and in designing and developing the exemplary model of an instructional system on electronics technology for the elementary schools, the writer suggests the following recommendations:

1. Although the structure of electronics technology as identified in this study represents an adequate initial guide for the development of an instructional system, it should not be construed as the ultimate structure for the body of knowledge from which electronics technology subject matter is selected. Additional investigations and experimentations should be conducted to re-evaluate, refine, or restructure the present model. Specialists in the field of curriculum development, electronics, industrial technology, and communication should discuss further the identification of the body of knowledge for electronics technology.

2. The five broad concepts of electronics technology as identified by this study should also be reviewed, re-evaluated, and refined. The identified concepts were obtained mainly from literature in the field, but it would be more valid to have fuller consensus from experts in the field. Therefore, it is recommended that a jury of experts review the identified broad concepts of electronics technology, and form some basis for
consensus in identifying the broad concepts of the field.

3. It should be noted that no attempt was made to try the instructional system in a regular elementary school classroom. Certainly a next step which ought to be taken is to put the suggested instructional program to use. Therefore, it is recommended that the constructed instructional system be field tested for evaluation purposes with continual feedback to provide for program revision. It should be tried on a number of classes over a period of time with any indicated changes made in the learning activities and in the objectives themselves.

4. There is an apparent need to begin where this dissertation stops, and to develop further the instructional system based on the objectives identified. The instructional system developed in this study represents a model that was structured for the sixth-grade level. The complete instructional program on electronics technology for grades one through six should now be developed according to the scope and sequence outlined in Appendix B.

5. A further recommendation growing out of this study is that other investigators should develop alternative strategies for the design of the overall instructional system. The strategies for designing this instructional system were based on an acceptance of the evidence found in the various learning theories. But if
a less theoretical method could be designed which would be just as effective as the method used in this study, it would be an important fact to demonstrate.

6. Because this instructional system includes several types of learning activities, and thus requires a variety of stimuli to be presented, it becomes necessary to have some method of identifying the most appropriate media for presenting the various kinds of stimuli. Therefore, it is recommended that other forms of visual presentations be made to find other effective ways of presenting the different concepts of electronics technology.

7. In writing the material for the textbook, teacher's guide, and student workbook, it was necessary to simplify the language and some of the definitions of technical terminology so that they could be understood by elementary school students. But in simplifying there is always the danger of losing the full meaning of a technical term. Therefore, it is recommended that elementary education specialists, semanticists, and specialists in electronics review the material for verification of terminology.

8. To gain the full benefit of this instructional system, it is recommended that workshops be organized to train teachers in its use. Although the instructional system is designed for any teacher, workshops will
increase the efficiency of the teacher in providing effective learning to students.

In conclusion, this study has attempted to structure a body of knowledge for electronics technology, and also to design and develop an instructional system for use in the elementary schools. It is hoped that through this study other similar studies will evolve to further curriculum development in industrial arts education, elementary education, and education in general.
APPENDIX A

BOOKS REVIEWED FOR CONTENT ANALYSIS OF ELECTRONICS


APPENDIX B

PROTOTYPE OF TEACHER'S GUIDE
TO THE TEACHER

This instructional system is a new approach to teaching about electronics. In this program, the teaching materials are geared to learning broad concepts, rather than to accumulating facts. Much of what is now taught about electronics is highly technical and based heavily on physical science concepts. But this program presents as its content that part of the total field of electronics which focuses on operational principles which apply to the research and development, production, and utilization of electronic products. Many physical science concepts (Ohm's law, magnetism, the electron theory, etc.) are usually presented through a unit in science, and this program does not try to duplicate those efforts. It should also be noted that this program can supplement existing programs in elementary schools or it can be taught as a course in itself.

The content of this instructional system was designed to help students understand and learn about meaningful and relevant aspects of electronics that they see or hear about in their environment. It was also designed to prepare the students for enlightened citizenship by learning to cope with and to live effectively in
a technological society where change is highly accelerated by electronics technology.

Although the lessons are thoroughly structured, this program was not designed to teach itself. The teacher plays an indispensable role in determining the immediate and lasting value that it will have on the students.

**Course Design**

The instructional system was designed to enhance maximum learning of new materials by utilizing the theory of repetition and variability (Carpenter, 1957). Therefore, in order to learn a concept, the student will proceed through five phases of different types of instructional activities. The length of each unit will depend on teacher initiative, student interest, and time allotment. A unit can be taught in one week or one month, depending on the conditions mentioned above. The format for presenting the planned activities for each unit is as follows:

**Phase 1.** A visual presentation, introducing the unit or concept through an important electronic device. The electronic device would be an "organizer" to the concept under study, and chosen from the student's environmental sphere of learning. Elements of the language arts program are included in this method.

**Phase 2.** Vocabulary learning. Student work activity involving use of the technical vocabulary terms found in the unit of study. Elements of the language arts program are included in this method of study.
Phase 3. Student work activity through planned experiments. Working with things and objects to amplify the concept being taught. This is another "organizer" to the concept under study. Elements of science and industrial arts related programs are included in this method.

Phase 4. Class participation in oral reading of the textbook. The content of the textbook focuses on the concept under study. Elements of the language arts program are included in this method.

Phase 5. Evaluation of the unit under study. Feedback to the teacher to evaluate course effectiveness, and feedback to the students for personal satisfaction.

Program Operation

This instructional system is a total educational package geared for the sixth-grade level. It provides the teacher with everything necessary to teach the unit of study. Included in the instructional system are: textbooks, student workbooks, a teacher's guide, visual aids, and the devices that are needed for the experiments.

In order to visualize the total instructional program on electronics technology for the elementary school (grades 1-6), the scope and sequence of the total instructional system are presented in Figure 19. The operational sequence for this system is outlined in the following pages, along with the course objectives.
<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Level of Concept</th>
<th>Conducting</th>
<th>Converting</th>
<th>Oscillating</th>
<th>Amplifying</th>
<th>Switching</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Broad and General Level of Concepts</td>
<td>Electronic devices associated with the Home environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td>Electronic devices associated with the School environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3rd</td>
<td>Electronic devices associated with the Community environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4th</td>
<td>Electronic devices associated with the State environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th</td>
<td>Electronic devices associated with the National environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6th</td>
<td>Electronic devices associated with the World environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 19. Scope and Sequence of the Study of Electronics Technology (Grades 1-6).
<table>
<thead>
<tr>
<th>Lesson</th>
<th>Teacher's Guide</th>
<th>Workbook</th>
<th>Textbook</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vacuum Tubes and Transistors</td>
<td></td>
<td>Reading 1</td>
</tr>
<tr>
<td>2</td>
<td>Vocabulary Learning</td>
<td>Activity 1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Student Experiments</td>
<td>Activity 2</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Oral Reading (Conducting)</td>
<td></td>
<td>Reading 2</td>
</tr>
<tr>
<td>5</td>
<td>Evaluation</td>
<td>Activity 3</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Sonar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Vocabulary Learning</td>
<td>Activity 4</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Student Experiments</td>
<td>Activity 5</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Oral Reading (Converting)</td>
<td></td>
<td>Reading 3</td>
</tr>
<tr>
<td>10</td>
<td>Evaluation</td>
<td>Activity 6</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Radar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Vocabulary Learning</td>
<td>Activity 7</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Student Experiments</td>
<td>Activity 8</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Oral Reading (Oscillating)</td>
<td></td>
<td>Reading 4</td>
</tr>
<tr>
<td>15</td>
<td>Evaluation</td>
<td>Activity 9</td>
<td></td>
</tr>
<tr>
<td>Lesson</td>
<td>Teacher's Guide</td>
<td>Workbook</td>
<td>Textbook</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------------</td>
<td>----------------</td>
<td>------------</td>
</tr>
<tr>
<td>16</td>
<td>Laser</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Vocabulary Learning</td>
<td>Activity 10</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Student Experiments</td>
<td>Activity 11</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Oral Reading (Amplifying)</td>
<td></td>
<td>Reading 5</td>
</tr>
<tr>
<td>20</td>
<td>Evaluation</td>
<td>Activity 12</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Computers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Vocabulary Learning</td>
<td>Activity 13</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Student Experiments</td>
<td>Activity 14</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Oral Reading (Switching)</td>
<td></td>
<td>Reading 6</td>
</tr>
<tr>
<td>25</td>
<td>Evaluation</td>
<td>Activity 15</td>
<td></td>
</tr>
</tbody>
</table>
Total Unit Objectives

These units will enable the student to:

1. Identify electronics technology within the broader framework of industrial technology and all of technology.

2. Identify and understand the broad concepts of electronics technology.

3. Develop an awareness of vocations in the electronic industries.

4. Develop an awareness of other people's ideas through reading and listening, and in turn, expressing ideas effectively to others.

5. Enjoy a wide range of social relationships and work cooperatively with others in common enterprises.

6. Acquire the knowledge, attitudes, action patterns, and values necessary for a satisfying family, civic, and vocational life.

7. Develop motor control essential to using common tools.

8. Develop responsible and safe work attitudes and the ability to function as a member of a group.

9. Develop an understanding of the meaning and use of technical terms.

10. Develop an understanding of significant electronic devices.
INTRODUCTION

ELECTRONICS TECHNOLOGY

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Lecture and Discussion)

1. Given the introductory statement and the reading assignment in the textbook,
   a. define electronics technology
   b. define current flow
   c. state the five main concepts of electronics technology
   d. state some efficient practices of electronics.

SUPPLIES NEEDED

1. Textbooks for students.
2. Any material that the instructor may have to motivate class interest (pictures, posters, magazines, etc.).

INTRODUCTORY STATEMENT

About twenty-five years ago, many people believed that the field of electronics technology had reached its peak. Then all of a sudden the transistor was introduced to the field of electronics technology, and before we knew what was happening, the field of electronics technology became a giant, and new discoveries in electronics began to appear almost regularly in different industries. Now, we can see electronics in action no matter where we turn. The knowledge of electronics technology has almost doubled in twenty-five years, and by the time you grow up, the present knowledge about electronics may double again. What kind of new improvements will be discovered in the next fifteen years? Can you imagine what your life will be like in a future filled with the magic of electronics? You may see electronic brooms to sweep your house at the touch of a button, or a computerized robot to do things for you, just like in some of the cartoons you see on Saturday mornings on television, or you may study from a machine that will help you with your homework.
INSTRUCTIONAL PROCEDURES

1. Have students turn to the introduction of their textbook.

2. Call on several students to read aloud from the textbook.

3. Help the students to pronounce the technical terms correctly. (Do not be concerned about the meanings of the words. There is a glossary at the end of the textbook.)

4. After the oral reading, have a discussion period using the following questions:

   a. What is electronics technology? (the efficient practices of doing things in electronics)

   b. What does current flow mean? (the movement of electrons from one atom to another)

   c. Name the five big ideas in the study of electronics technology. (Conducting, Converting, Oscillating, Amplifying, and Switching)

   d. What are some examples of electronics in action? (television, satellites, radar, radios, etc.)
Lesson 1

CONDUCTING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Class Activity)

1. Given a presentation on vacuum tubes and transistors,
   a. identify three basic purposes of vacuum tubes and transistors
   b. identify some of the uses of vacuum tubes and transistors
   c. explain how vacuum tubes and transistors relate to the concept of "conducting."

EQUIPMENT AND SUPPLIES NEEDED FOR CLASS ACTIVITY

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Supplies</th>
</tr>
</thead>
<tbody>
<tr>
<td>overhead projector</td>
<td>Transparencies #1-4</td>
</tr>
<tr>
<td>with screen</td>
<td></td>
</tr>
</tbody>
</table>

OVERVIEW

You are all familiar with the regular table radio that most of you have in your homes, or the transistor radio that some of you carry around in your pockets or purses. What is the main part of any radio? What is a vacuum tube or transistor? Today you will find out something about vacuum tubes and transistors since they are one of the most important parts of any electronic product.

INSTRUCTIONAL PROCEDURES

1. Show transparencies #1-4.
2. Let the class read along with you.
3. Add any bit of information that you may know, to make the lesson more relevant to the class.
4. Emphasize the underlined technical vocabulary. Have the students look up the meanings of the terms in the glossary of the textbook.
5. After the transparencies have been shown, discuss the following questions:
a. What are the three basic purposes of vacuum tubes and transistors? (1. to create radio waves, 2. to change the waveforms of radio waves, and 3. to amplify or strengthen radio signals)
b. What is the main job of a vacuum tube or transistor? (to conduct or carry electronic signals to do certain kinds of jobs)
c. What does conducting mean? (carrying electronic signals)
d. What are some of the uses of vacuum tubes and transistors? (Name some of the uses in electronic devices such as: in television (tubes and transistors), in computers (mostly transistors), in missiles (mostly transistors), etc.)

6. Add your own questions wherever they seem appropriate.
Lesson 2

CONDUCTING

OBJECTIVES

As a result of the learning experiences, the students should be able to do the following:

(Workbook Activity)

1. Given a list of technical vocabulary terms,
   a. identify their meanings
   b. use the words in meaningful sentences.

SUPPLIES NEEDED

Dictionaries
Encyclopedias
Textbooks and workbooks

OVERVIEW

In the last session, you learned something about vacuum tubes and transistors, and how they conduct electronic signals to do different jobs in electronics technology. You also came across several words that you were not familiar with. Today, we will try to learn some of the meanings of these words, so that we can begin to understand a little more about electronics technology when we read the newspapers, magazines, or see pictures in television programs.

INSTRUCTIONAL PROCEDURES

1. Break the class into five separate groups for group work.

2. Have the students turn to the first lesson in their workbooks.

3. Assign each group two words from the vocabulary list in their workbooks.

4. Each group is to find the meanings of the words that are assigned to them in dictionaries, encyclopedias, and in the glossary in the textbook.

5. Let them know that each group will report their findings to the rest of the class.
6. Allow them sufficient time to find the meanings of the words.

7. Call on students from each group to report what they found.

8. Simplify and discuss each meaning, and put the simplified version on the blackboard so that the class may copy the meanings in their workbooks.

9. After the words have been defined, let the students make meaningful sentences from each word.

10. Call on students to read their sentences to see whether they have used the terms correctly.
Lesson 3

CONDUCTING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Workbook Activity)

1. Given the necessary equipment and supplies, assemble and conduct the experiment on "conducting."
2. Given various kinds of materials, identify each as a "conductor" or "nonconductor."

OVERVIEW

The past few days we have talked about the idea of "conducting" as used in electronics. Thus far, we have learned how electronic signals are conducted in various ways. You have also learned some new words to help you to better understand the field of electronics technology.

Today, you will conduct an experiment to learn a little more about the idea of "conducting." In your experiment you will find out what kinds of materials are good conductors of electricity, and what kinds of materials are poor conductors of electricity. Poor conductors are also called nonconductors.

EQUIPMENT AND SUPPLIES FOR WORKBOOK ACTIVITY

<table>
<thead>
<tr>
<th>Equipment (groups of 3)</th>
<th>Supplies (groups of 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I hammer</td>
<td>1 block of wood 4&quot;x5&quot;x3/4&quot;</td>
</tr>
<tr>
<td>2 8d common nails</td>
<td>1 No. 6 dry cell</td>
</tr>
<tr>
<td>No. 18 magnet wire</td>
<td>No. 18 magnet wire</td>
</tr>
<tr>
<td>1 flashlight bulb 1 1/2 volts</td>
<td>1 flashlight bulb 1 1/2 volts</td>
</tr>
</tbody>
</table>

Materials for Experiment

A penny
A dime
A short length of string
A paper clip
A steel nail

A short piece of copper wire
A rubber band
A comb or plastic material
(Instructor may add to this list)
INSTRUCTIONS FOR WORKBOOK ACTIVITY

1. Break up the class into groups of three.
2. Instruct students to follow the directions in the workbook.
3. Have students elect one member from each group to pick up the material and supplies.
4. Remind students to ask questions if in doubt.
5. Have students record all their answers in the workbook.
6. Have students clean up and return the materials after completion of the experiment.

ANSWERS FOR THE WORKBOOK

Conductor
penny
dime
paper clip
steel nail
copper wire

Nonconductor
string
rubber band
plastic or comb
Lesson 4

CONDUCTING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Class Activity)

1. Given the reading assignment in the textbook,
   a. explain the concept of "conducting"
   b. name three different means of conducting electronic signals
   c. name some radiated forms of waves
   d. describe an electromagnetic wave.

SUPPLIES NEEDED

Textbooks

OVERVIEW

During the past few days you have learned something about one area of electronics technology. You have learned about the idea of conducting through different activities. You have studied and found out something about vacuum tubes and transistors, and how they conduct electronic signals. You have learned some new technical words, used in electronics, and you have conducted an experiment to find out what materials are good conductors of electricity. Today, you will read the textbook to find out more things about the area of conducting as it applies to electronics technology.

INSTRUCTIONAL PROCEDURES

1. Pass out the textbooks to the students.
2. Have the students turn to Chapter I of the textbook.
3. Call on students to read aloud from the textbook.
4. Help students to pronounce any unfamiliar words.
5. After the oral reading, discuss the following questions:
   a. Explain what conducting means. (carrying on electronic signals)
b. What are the three ways of conducting electronic signals? (vacuum tubes or transistors, radiating electromagnetic waves, and wires)

c. Name some radiated forms of waves mentioned in the textbook. (electromagnetic waves, heat waves, and light waves)

d. How can you describe electromagnetic waves? (It resembles the ripples in a pool after a rock is thrown.)
Lesson 5
CONDUCTING
OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Workbook Activity)

1. Given some review and test questions, select the correct responses from a list of items related to the material presented in Lessons 1 to 4.

INSTRUCTIONAL PROCEDURES

1. Review with students any questions they may have which pertain to the material covered.

2. After the review, have students turn to the test items in their workbooks.

3. Instruct the students to follow the directions.

4. Allow the students ample time to finish the test.

5. Review the test with the students to provide feedback.

ANSWERS FOR THE REVIEW AND TEST QUESTIONS

1. c
2. a
3. b
4. c
5. a
6. b
7. c
8. b
9. c
10. d
Lesson 6

CONVERTING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Class Activity)

1. Given a presentation on the sonar,
   a. explain what the sonar is
   b. explain what the sonar is used for
   c. identify how converting relates to the sonar.

EQUIPMENT AND SUPPLIES NEEDED FOR CLASS ACTIVITY

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Supplies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 overhead projector</td>
<td>transparencies #5-8</td>
</tr>
<tr>
<td>with screen</td>
<td></td>
</tr>
</tbody>
</table>

OVERVIEW

Who can tell me how bats are able to fly around in the darkness? Does anyone know what a sonar is? (Elicit some responses to these questions.) Today we will study about the sonar. We will learn what it is, and what it is used for. From this lesson you will also learn how bats are able to fly in darkness.

INSTRUCTIONAL PROCEDURES

1. Show transparencies #5-8.
2. Let the class read along with you.
3. Add any relevant information you can to make the lesson more interesting and relevant to the class.
4. Emphasize the underlined vocabulary terms. If necessary, have the students look up the meanings of the terms in the glossary of the textbook. Do not be too concerned about the meanings except for their correct pronunciation.
5. After the transparencies have been shown, have a discussion period using the following questions as guidelines:
   a. What is a sonar? (The sonar is an electronic device that sends out sound waves in the water.)
When the sound waves hit an object they bounce back to the sonar device. Here, the sound waves are changed into electrical current so that a machine can show where the object is located.

b. What is the sonar used for? (The sonar is used to locate objects underwater. It is also used by ships to see the depths of the ocean floor. Bats use the sonar to find their way around at night, and porpoises use their own sonar when swimming to find their way around in the ocean.)

c. What are sound waves changed into after they bounce back from an object? (electrical current)

d. Add your own questions according to the needs of the students.
Lesson 7
CONVERTING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Workbook Activity)

1. Given a list of technical vocabulary terms,
   a. identify their meanings
   b. use the words in meaningful sentences.

SUPPLIES NEEDED

Dictionaries
Encyclopedias
Textbooks and workbooks

OVERVIEW

Yesterday, we studied about the sonar. You found out that the sonar is an electronic device that sends out sound waves to locate objects underwater. You also learned about some of the uses of the sonar. Today, you will learn some new words that we found in our lesson yesterday. Knowing the meanings of these words will help you to better understand the lessons we will be discussing later on.

INSTRUCTIONAL PROCEDURES

1. Break the class into five separate groups for group work.

2. Instruct the students to turn to Activity 4 in their workbooks.

3. Assign each group two words from the vocabulary list that is given in their workbooks.

4. Each group is to find the meanings of the words that are assigned to them in dictionaries, encyclopedias, and the glossary in their textbooks.

5. Let them know that each group will report their findings to the rest of the class.

6. Allow them sufficient time to find the meanings of the words.
7. Call on students from each group to report what they found.

8. Simplify and discuss each meaning so that the students understand, and put the simplified version on the blackboard so that the class may copy the meanings in their workbooks.

9. After the words have been defined, let the students make meaningful sentences from each word.

10. Call on students to read their sentences to see whether they have used the terms correctly.
Lesson 8

CONVERTING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Workbook Activity)

1. Given the necessary equipment and supplies,
   a. assemble and conduct the experiment on "converting"
   b. explain what a rectifier is
   c. explain why the rectifier is important to the radio.

OVERVIEW

In our lessons for the week, we have thus far, learned something about the sonar. We have also studied some new words that are important to know in understanding our industrial world. Today, we will conduct an experiment to find out something about rectifiers. You will find out that rectifiers play an important part in your radio. Without rectifiers, you will not be able to hear sound from the radio. Rectifiers change the radio waves into a certain kind of electrical wave to make the speaker of the radio work.

EQUIPMENT AND SUPPLIES FOR WORKBOOK ACTIVITY

<table>
<thead>
<tr>
<th>Equipment (per group)</th>
<th>Supplies (per group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 earphone</td>
<td>60 ft. magnet wire #24</td>
</tr>
<tr>
<td></td>
<td>1 cardboard tube from a roll of toilet tissue</td>
</tr>
<tr>
<td></td>
<td>1 rectifier</td>
</tr>
<tr>
<td></td>
<td>1 variable capacitor</td>
</tr>
<tr>
<td></td>
<td>7 connecting wire with clips on each end</td>
</tr>
<tr>
<td></td>
<td>1 12&quot; square piece of wood</td>
</tr>
</tbody>
</table>

INSTRUCTIONS FOR WORKBOOK ACTIVITY

1. Break up the class into five groups.

2. Instruct students to work together in the assembly of the radio.
3. Instruct students to follow the directions in their workbooks.

4. Have students elect one member from each group to pick up the equipment and supplies.

5. Instruct the students to assemble their experiment on the 12" square piece of wood.

6. Remind students to ask questions when in doubt.

7. Walk around the classroom to see that the students are assembling the components properly.

8. Have the students return the equipment and supplies after the completion of their experiment.

9. After the experiment is finished, have a discussion period using the following questions as guidelines:
   a. What is a rectifier? (an electronic component that changes the waveform of the radio waves into an electrical current that will make the headphones work) (It converts or changes electrical waves.)
   b. Why is the rectifier important in the radio? (If the radio waves are not changed, sound will not be heard.)
   c. Add your own questions to continue a fruitful discussion according to the needs of the students.
Lesson 9
CONVERTING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Class Activity)

1. Given the reading assignment in the textbook,
   a. explain the concept of converting
   b. identify some of the uses of the principles of converting
   c. identify some products that utilize the concept of converting.

SUPPLIES NEEDED

Textbooks

OVERVIEW

Today, you will read about the big idea of converting which we have discussed for the past few days. You will also learn about some of the other ideas that are included in the study of converting.

INSTRUCTIONAL PROCEDURES

1. Pass out the textbooks to the students.
2. Have the students turn to Chapter II of the textbook.
3. Call on students to read aloud from the textbook.
4. Help students to pronounce any unfamiliar words.
5. After the oral reading, have a discussion period using the following questions as guidelines:
   a. What does the word converting mean? (In electronics, converting refers to the changing of electrical current or waveforms.)
   b. Can anyone identify where the electrical current goes through a process of change? (in radios, television, stereo speakers, radio stations, etc.)
c. Can you name some uses of the principle of converting? (In the radio, the radio waves are changed into sound waves.)

d. What is a rectifier? (an electronic component that changes the waveform of the electrical current)

e. What is a demodulator? (a part of the radio that changes the radio waves)

f. Add your own questions according to the needs of the class.
Lesson 10

CONVERTING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Workbook Activity)

1. Given some review and test questions, select the correct responses from a list of items related to the material presented in Lessons 6-9.

INSTRUCTIONAL PROCEDURES

1. Review with the students any questions that they may have which pertain to the material covered.
2. After the review session, have the students turn to the review and test questions in their workbooks.
3. Instruct the students to follow the directions.
4. Allow the students ample time to finish the test.
5. Review the test with the students to provide feedback.

ANSWERS FOR THE REVIEW AND TEST QUESTIONS

1. d
2. c
3. b
4. a
5. a
6. b
7. c
8. b
9. a
10. a
Lesson 11

OSCILLATING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Class Activity)

1. Given a presentation on the radar,
   a. explain the basic purpose of a radar
   b. explain how the concept of oscillating is related to the radar
   c. identify some of the uses of a radar.

EQUIPMENT AND SUPPLIES NEEDED FOR CLASS ACTIVITY

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Supplies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 overhead projector with screen</td>
<td>transparencies #9-13</td>
</tr>
</tbody>
</table>

OVERVIEW

How many of you know what a radar is? Perhaps some of you have seen the huge antenna of a radar. Many people think of the radar as a funny dish with a pole sticking out from the middle. You can usually find a radar antenna on huge ships or at the airport. You can easily identify a radar by its funny shape, and because it is always going around and around in a circle. What is the radar used for? Why is it important to man? These are some of the questions that we will try to answer in our study of the radar.

INSTRUCTIONAL PROCEDURES

2. Let the class read along with you.
3. Add any relevant information that you may know to make the lesson more interesting to the class.
4. Emphasize the underlined vocabulary terms. Have the students look up the meanings of the terms in the glossary of the textbook if the need arises. Do not be too concerned with the vocabulary terms except for correct pronunciation.
5. After the transparencies have been shown, have a discussion period using the following questions as guidelines:

a. What is the main purpose of the radar? (to locate objects that are far away and cannot be seen)

b. How is the radar signal produced? (by small oscillating radio signals)

c. Identify some of the uses of the radar. (In an airplane the radar helps the pilot to find his way through a storm, or helps the pilot to locate objects in his path. The radar can also help to protect this country from enemy planes by locating them before they come close to our land.)

d. Add any other questions relevant to this unit of study.
Lesson 12

OSCILLATING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Workbook Activity)

1. Given a list of technical vocabulary terms,
   a. identify their meanings
   b. use the words in meaningful sentences.

SUPPLIES NEEDED

Dictionaries
Encyclopedias
Textbooks and workbooks

OVERVIEW

Yesterday you learned about the radar and some of its uses. You found out that the radar uses the concept of oscillating when producing the small radio waves called microwaves. However, in order to understand more about the concept of oscillating and how it applies to other electronic products, you will have to learn the meanings of more technical words. Today, you will work in groups to find the meanings of more vocabulary words.

INSTRUCTIONAL PROCEDURES

1. Break up the class into five groups for group work.

2. Instruct the students to turn to Activity 7 in their workbooks.

3. Assign each group two words from the vocabulary list in their workbooks.

4. Each group is to find the meanings of the words that are assigned to them in dictionaries, encyclopedias, and the glossary in the textbook.

5. Let them know that each group will report their findings to the rest of the class.

6. Allow them sufficient time to find the meanings of the words.
7. Call on students from each group to report what they found.

8. Simplify and discuss each meaning, and put the simplified version on the blackboard so that the class may copy the meanings in their workbooks.

9. After the words have been defined, let the students make meaningful sentences from each word.

10. Call on students to read their sentences to see whether they have used the terms correctly.
Lesson 13

OSCILLATING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Workbook Activity)

1. Given the necessary materials,
   a. conduct the experiment on resonance
   b. explain resonance
   c. explain how resonance is related to the concept of oscillating.

EQUIPMENT AND SUPPLIES FOR WORKBOOK ACTIVITY

<table>
<thead>
<tr>
<th>Equipment (per group)</th>
<th>Supplies (per group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 tuning forks</td>
<td>2 empty soda bottles exactly</td>
</tr>
<tr>
<td></td>
<td>the same size and shape</td>
</tr>
</tbody>
</table>

OVERVIEW

In order to better understand the concept of oscillating, today, you will conduct some experiments in resonance. Through your experiments you will find that when two similar objects have the same natural frequency, they vibrate together, when one is made to vibrate. This is called resonance. You will work in pairs on each experiment.

INSTRUCTIONAL PROCEDURES FOR WORKBOOK ACTIVITY

1. Divide the class into two groups.

2. Assign one group to work on experiment A, and the other group to work on experiment B.

3. Instruct the students to choose a partner and work in pairs.

4. When the groups have finished the first experiment, let them begin the second experiment.

5. Instruct the students to follow the directions in the workbook.

6. Walk around the room to see that the students are conducting the experiments properly.
7. Remind the students to ask questions when in doubt.

8. Have students return the materials after the completion of their experiments.

9. After the experiments, have a discussion period using the following questions as guidelines:

   a. What did you find out from your experiments? (Call on different students to get their reactions. The answers may vary.)

   b. What is resonance? (When two objects have the same natural frequency, they can be made to vibrate together in harmony.)

   c. Can anyone give some examples of resonance? (Call on different students for their comments. The radio is a good example of resonance. The vibrations of the radio must be in tune with a certain radio station before they can be heard.)

   d. Add any other questions that may be relevant to the discussion.
Lesson 14

OSCILLATING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Class Activity)

1. Given the reading assignment in the textbook,
   a. explain the concept of oscillating
   b. explain some uses of the principles of oscillation
   c. identify some products that utilize the concept of oscillating.

SUPPLIES NEEDED

Textbooks

OVERVIEW

In our unit on oscillating, we have talked about the radar and how it applies some of the concepts of oscillation in its operation. You have learned some new words and their meanings, and yesterday you found through your experiments, what is resonance and how it relates to oscillation. These activities will help you to better understand the concept of oscillating which you will read about today.

INSTRUCTIONAL PROCEDURES

1. Pass out the textbooks to the students.
2. Have the students turn to Chapter III of the textbook.
3. Call on students to read aloud from the textbook.
4. Help students to pronounce any unfamiliar words.
5. After the oral reading, have a discussion period using the following questions as guidelines:
   a. What does the term oscillating mean? (a forward and backward movement of electrons; vibrating)
   b. Can anyone give some examples of how oscillation is being used in electronics? (Explain that
resonance relates to oscillation. A radio station sends signals out through oscillation, and the radio set receives the signals through oscillation. Both must be vibrating in the same frequency.)

c. Can anyone name some products that use the concept of oscillation? (radar, radio, computers)

d. Add any other questions that may be applicable to the discussion.
Lesson 15

OSCILLATING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Workbook Activity)

1. Given some review and test questions, select the correct responses from a list of items related to the material presented in Lessons 11-14.

INSTRUCTIONAL PROCEDURES

1. Review with students any questions that they may have which pertain to the material covered.
2. After the review, have students turn to the test and review questions in their workbooks.
3. Instruct the students to follow the directions.
4. Allow the students ample time to finish the test.
5. Review the test with the students to provide feedback.

ANSWERS FOR THE REVIEW AND TEST QUESTIONS

1. c
2. b
3. a
4. b
5. c
6. b
7. a
8. c
9. a
10. b
Lesson 16
AMPLIFYING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Class Activity)

1. Given a presentation on the laser,
   a. explain how the concept of amplifying is related to the laser
   b. explain briefly how the laser works
   c. name some uses of the laser.

EQUIPMENT AND SUPPLIES NEEDED FOR CLASS ACTIVITY

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Supplies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 overhead projector with screen</td>
<td>transparencies #14-19</td>
</tr>
</tbody>
</table>

OVERVIEW

How many of you know what a laser is? Is it some kind of a weapon? Is it used for useful purposes? Can you buy one from a store? Do you know where you can probably find one? What is it used for? (Let the students respond to some of the questions.) Today, we will try to find out something about the laser. We will also try to find out the answers to some of the questions that I have asked.

INSTRUCTIONAL PROCEDURES

1. Show transparencies #14-19.

2. Let the class read along with you.

3. Add any relevant information that you may know to supplement the transparencies.

4. Emphasize the underlined technical vocabulary. Have the students look up the meanings of the terms in the glossary of the textbook.

5. After the transparencies have been shown, have a discussion period using the following questions:
   a. What is a laser? (a machine that greatly amplifies light energy into a thin concentrated
b. How does the laser work? (Light energy is bounced around in the laser machine until it gets stronger and stronger and finally flashes out as a thin powerful ray of light.)

c. What are some of the uses of the laser? (Today it is used for medical purposes, for industrial purposes, for the military, and for communications.)

d. Add your own questions to continue the discussion if feasible.
Lesson 17
AMPLIFYING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Workbook Activity)

1. Given a list of technical vocabulary terms,
   a. identify their meanings
   b. use the words in meaningful sentences.

SUPPLIES NEEDED

Dictionaries
Encyclopedias
Textbooks and workbooks

OVERVIEW

Yesterday, you learned something about the laser. You found out that the laser is a machine that amplifies light energy. The thin ray of light from the laser is so strong that it can melt steel. The laser has many uses now, but it will have many more uses in the future when man learns more about the laser. To prepare you to live in the future where the laser will be a common thing, you will need to know some of the terms associated with the laser. Knowing technical terms will help you to better understand the laser. Today, we will examine ten new words.

INSTRUCTIONAL PROCEDURES

1. Break up the class into five groups for group work.
2. Instruct the students to turn to Activity 10 in their workbooks.
3. Assign each group two words from the vocabulary list found in Activity 10 of their workbooks.
4. Each group is to find the meanings of the words that are assigned to them in dictionaries, encyclopedias, and the glossary in their textbooks.
5. Let them know that each group will report their findings to the rest of the class.
6. Allow them sufficient time to find the meanings of the words.

7. Call on students from each group to report what they found.

8. Simplify and discuss each meaning. Put the simplified version on the blackboard so that the class may copy the meanings in their workbooks.

9. After the words have been defined, let the students make meaningful sentences from each word.

10. Call on students to read their sentences to see whether they have used the terms correctly.
Lesson 18
AMPLIFYING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Workbook Activity)

1. Given a magnifying glass and paper,
   a. create heat through concentrated light energy
   b. explain how amplification is related to this activity.

SUPPLIES NEEDED FOR EXPERIMENT

Magnifying glasses
Scrap paper
Sunlight or a sun lamp

OVERVIEW

The other day, you found out that the laser is a machine that amplifies light energy. Today, you will conduct an experiment to see how sunlight can be amplified. From sunlight, you will create a thin concentrated ray of light to burn a piece of paper. This should help you to understand how strong a ray of light can become when amplified.

INSTRUCTIONAL PROCEDURES

1. Give a short demonstration on how to hold the magnifying glass to produce a concentrated beam of light. (Angle the glass until the light flowing through the magnifying glass becomes concentrated. Hold the glass steady at edge of the paper until the paper smoulders.)

2. Divide the class into groups of five students.

3. Instruct students not to play with the magnifying glass.

4. Instruct students not to let the paper burn because it may damage the furniture in the room.

5. Assign each group a magnifying glass.
6. Walk around the room to see that the students are doing the experiment properly.

7. Experiment may be conducted outside the classroom where sunlight is available.

8. After the experiment, have the students clean up their rubbish and return the magnifying glass.

9. Make sure that the ashes are well extinguished.

10. After the experiment, discuss the following questions:

   a. Why did the paper burn? (The light energy from the sun was amplified many times to produce heat.)

   b. How did this experiment resemble the laser? (the amplification of light energy)

   c. What does amplification mean? (to make something bigger or stronger)
Lesson 19
AMPLIFYING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Class Activity)
1. Given the reading assignment in the textbook,
   a. explain the concept of amplifying
   b. name three forms of amplification found in electronic circuits.

SUPPLIES NEEDED

Textbooks

OVERVIEW

Today, we will try to learn more about the concept of amplifying. So far, you have studied how the concept of amplifying is applied to the laser; you have seen how light is amplified through the experiment that you have conducted, and you have learned some new words to help you to better understand the lessons we are studying. Today, you will read in class the chapter on amplifying in your textbook.

INSTRUCTIONAL PROCEDURES

1. Pass out the textbook to the students.
2. Have the students turn to Chapter IV in the textbook.
3. Call on students to read aloud from the textbook.
4. Help students to pronounce any unfamiliar words.
5. After the oral class reading, have a discussion period using the following questions as guidelines:
   a. Explain the meaning of amplifying. (Amplifying means to make something bigger or stronger.)
   b. Give an example of amplifying in the radio. (The small sound signals are amplified by the radio so that we are able to hear the sounds.)
c. Name three forms of amplifying usually found in electronic circuits. (strengthening different kinds of frequencies, combining amplification stages, and amplification through feedback circuits)

d. Give an example of amplifying heat energy. (the stove)

e. Add other questions to continue the discussion.
Lesson 20

AMPLIFYING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Workbook Activity)

1. Given some review and test questions, select the correct responses from a list of items related to the material presented in Lessons 16-19.

INSTRUCTIONAL PROCEDURES

1. Review with students any questions that they may have about the material covered.

2. After the review, have the students turn to the test items in their workbooks.

3. Instruct the students to follow the directions.

4. Allow the students ample time to finish the test.

5. Review the test with the students to provide feedback.

ANSWERS FOR THE REVIEW AND TEST QUESTIONS

1. b
2. c
3. a
4. c
5. b
6. d
7. b
8. a
9. b
10. d
Lesson 21

SWITCHING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Class Activity)

1. Given a presentation on computers,
   a. explain what a computer is
   b. name the two different types of computers
   c. identify some of the uses of a computer
   d. explain how switching is related to the computer.

EQUIPMENT AND SUPPLIES NEEDED FOR THE CLASS ACTIVITY

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Supplies</th>
</tr>
</thead>
<tbody>
<tr>
<td>overhead projector</td>
<td>transparencies #20-25</td>
</tr>
<tr>
<td>with screen</td>
<td></td>
</tr>
</tbody>
</table>

OVERVIEW

What is a computer? Where do you think we can find a computer? Have any of you seen a computer? (Elicit responses from the students.) I'm sure that many of you have at least heard the term being used by adults, in cartoons, in magazines, etc. Because the computer is becoming such an important part of our business and industrial world today, we will try to learn something about computers and how they are being used. Someday, we can expect computers to be a common part of our way of living. Therefore, it would be helpful to prepare ourselves for the future by at least knowing what it is and how it works.

INSTRUCTIONAL PROCEDURES

1. Show transparencies #20-25.

2. Let the class read along with you.

3. Add any information that you may have about computers to make the lesson more relevant and interesting to the students.

4. Emphasize the underlined technical vocabulary. Have some students look up the meanings of the terms in the glossary of the textbook.
5. After the transparencies have been shown, have a discussion period using the following questions:

a. Who can tell me what a computer is? (Computers are electronic machines that are used to solve problems in a hurry.)

b. What are the two different kinds of computers that are being used today? (analog computers and digital computers)

c. What are analog computers used for? (They are used to solve scientific and difficult problems.)

d. What are digital computers used for? (They are used mainly to solve problems in counting, such as adding, subtracting, dividing, multiplying, etc.)

e. How can you simply explain how a computer works? (The computer in simple terms is a switching system. All the information fed into the computer is changed into electrical pulses by fast electronic switches.)
Lesson 22

SWITCHING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Workbook Activity)

1. Given a list of technical vocabulary terms,
   a. identify their meanings
   b. use the words in meaningful sentences.

SUPPLIES NEEDED

Dictionaries
Encyclopedias
Textbooks and workbooks

OVERVIEW

Yesterday, you learned something about computers. You learned that computers are electronic machines that are used to solve problems quickly. You also learned that computers are complex switching systems. Today, you will learn some new words to help you to better understand the concept of switching and how it applies to many different things.

INSTRUCTIONAL PROCEDURES

1. Break the class into five groups for group work.

2. Have the students turn to Activity 13 in their workbooks.

3. Assign each group two words from the vocabulary list in their workbooks.

4. Each group is to find the meanings of the words that are assigned to them in dictionaries, encyclopedias, and the glossary in the textbook.

5. Let them know that each group will report their findings to the rest of the class.

6. Allow them sufficient time to find the meanings of the words.
7. Call on students from each group to report what they found.

8. Simplify and discuss each meaning, and put the simplified version on the blackboard so that the class may copy the meanings in their workbooks.

9. After the words have been defined, let the students make meaningful sentences from each word.

10. Call on several students to read their sentences to see whether they have used the term correctly.
Lesson 23
SWITCHING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Workbook Activity)

1. Given the necessary equipment and supplies,
   a. conduct the experiment on switching
   b. explain the idea of switching.

EQUIPMENT AND SUPPLIES FOR WORKBOOK ACTIVITY

<table>
<thead>
<tr>
<th>Equipment (per group)</th>
<th>Supplies (per group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 hammer</td>
<td>2 3x3x3/4 scrap wood</td>
</tr>
<tr>
<td></td>
<td>2 1&quot; strip of tin (from a tin can)</td>
</tr>
<tr>
<td></td>
<td>6 1d common nails</td>
</tr>
<tr>
<td></td>
<td>1 flashlight bulb</td>
</tr>
<tr>
<td></td>
<td>1 1½ volt dry cell</td>
</tr>
<tr>
<td></td>
<td>some copper wire</td>
</tr>
<tr>
<td></td>
<td>sandpaper</td>
</tr>
</tbody>
</table>

OVERVIEW

Thus far, you have learned something about computers. You have also learned some new words to help you understand the terms that are commonly used in electronics technology. Today, we will continue our study of switching by conducting an experiment to give you a better understanding of the concept. You will also learn to work together with some of your classmates through group participation.

INSTRUCTIONAL PROCEDURES

1. Break up the class into groups of three.

2. Instruct the students to follow the directions in their workbooks.

3. Have the students elect one member from each group to pick up the materials and equipment.

4. Walk around the room to see that the students are conducting the experiment properly.

5. Remind students to ask questions when in doubt.
6. After the experiment is through, have a discussion period using the following questions as guidelines:

a. What is a switch? (a device used to turn on or turn off or to change the flow of electricity)

b. In your experiment, how was switching conducted? (Elicit student responses in their own words.)

c. Where can you find more examples of switching? (switch on the wall for lights, switch to turn on the stove, computer circuits, switch for the movie projector, etc.)
Lesson 24
SWITCHING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Class Activity)

1. Given the reading assignment in the textbook,
   a. explain the concept of switching
   b. name two types of circuits that are considered as switching circuits
   c. identify some uses of switching circuits.

SUPPLIES NEEDED

Textbooks

OVERVIEW

Yesterday, you conducted an experiment in switching. You found out that switching means to turn on, turn off, or change the direction of current flow. You also found out how switching is used in computers. Today, you will read more about the big idea of switching.

INSTRUCTIONAL PROCEDURES

1. Pass out the textbooks to the students.

2. Have the students turn to Chapter V of the textbook.

3. Call on students to read aloud from the textbook.

4. Help students to pronounce any unfamiliar words.

5. After the oral reading, have a discussion period using the following questions as guidelines:

   a. Can anyone explain what switching means? (to turn something on or off or change its direction)

   b. What are two kinds of switching circuits that may be found in a computer? (gating circuits and multivibrating circuits)
c. What are some uses of switching circuits? (used in computers, in televisions, detecting flaws in some industrial products, etc.)
Lesson 25
SWITCHING

OBJECTIVES

As a result of their learning experiences, the students should be able to do the following:

(Workbook Activity)

1. Given some test and review questions, select the correct responses from a list of items related to the material presented in Lessons 21-24.

INSTRUCTIONAL PROCEDURES

1. Review with the students any questions they may have about the material covered.

2. After the review, have the students turn to the test items in their workbooks.

3. Instruct the students to follow the directions in the workbook.

4. Allow the students ample time to finish the test.

5. Review the test with the students to provide feedback.

ANSWERS FOR THE REVIEW AND TEST QUESTIONS

1. c
2. b
3. d
4. b
5. c
6. b
7. c
8. b
9. a
10. d
RESOURCE LIST OF FREE FILMS

Conducting
1. "We Learn About the Telephone" - Bell System Telephone
2. "Building a Ceramics Cathode Ray Tube" - Tektronix, Inc.
3. "Cathode Ray Tube-Window to Electronics" - Tektronix, Inc.
4. "Genesis of the Transistor" - Bell System Telephone
5. "Hughes Electronic News I (Vacuum Tubes)" - Hughes Aircraft Company
6. "The Transistor" - Bell System Telephone

Converting
1. "Sounds Familiar" - Bell System Telephone
2. "Tasi-The Time Machine" - Bell System Telephone
3. "Your Voice and the Telephone" - Bell System Telephone

Oscillating
1. "Accuracy Plus (Radar)" - White Sands Missile Range
2. "Aleutian Sky Watch" - Bell System Telephone
3. "Dewline Story" - Department of the Air Force

Amplifying
1. "Conquest of Light (Laser)" - Bell System Telephone
2. "Hughes Electronic News II (Laser)" - Hughes Aircraft Company
3. "World Behind Your Light Switch" - Bonneville Power Administration
RESOURCE LIST OF FREE FILMS—Continued

Switching
1. "Systems" - IBM Corporation
2. "The Information Machine" - IBM Corporation
3. "Memory Devices" - Bell System Telephone

Manufacturing
1. "Automation in Television" - Admiral Corporation
2. "Instrument Assembly and Production Flow" - Tektronix, Inc.
3. "Language of Electronics" - Raytheon Company

LIST OF ADDRESSES

Admiral Corporation
Public Relations Dept.
3800 Cortland St.
Chicago, Illinois 60647

Bell System Telephone
(Consult local telephone directory)

Bonneville Power Administration
U. S. Dept. of Interior
P. O. Box 3621
Portland, Oregon 97208

Department of the Air Force
Air Force Film Library Center
8900 South Broadway
St. Louis, Missouri 36125

Hughes Aircraft Company
Mr. K. G. Brown
Building 114 Mail Station 13
P. O. Box 90515
Los Angeles, California 90009

IBM Corporation
Branch Offices in U. S.
(Consult local telephone directory)

Raytheon Company
Mr. Martin Curran,
Manager
141 Spring St.
Lexington, Massachusetts
02173

Tektronix, Inc.
Film Library
P. O. Box 500
Beaverton, Oregon 97005

White Sands Missile Range
Commanding General
Attention NR-DK
White Sands Missile Range
New Mexico 88002
VACUUM TUBES AND TRANSISTORS

DO YOU KNOW WHAT A VACUUM TUBE OR TRANSISTOR LOOKS LIKE? DO YOU KNOW WHAT THEY ARE USED FOR? LET'S FIND OUT SOMETHING ABOUT THEM. VACUUM TUBES AND TRANSISTORS ARE THE MOST IMPORTANT ELECTRONIC DEVICES IN THE FIELD OF ELECTRONICS. WITHOUT THEM, MANY OF THE NEW INVENTIONS THAT WE SEE TODAY COULD NOT HAVE BEEN CREATED.

Illustrations of the various kinds of vacuum tubes and transistors
VACUUM TUBES ARE USUALLY MADE OF GLASS OR METAL. EACH TUBE CONTAINS MANY SMALL ELECTRONIC PARTS THAT ARE NEEDED TO CONDUCT CURRENT. TO MAKE MOST KINDS OF VACUUM TUBES, ALMOST ALL THE AIR IS PUMPED OUT TO MAKE A VACUUM. AFTER THE AIR IS PUMPED OUT, THE TUBE IS SEALED. SOME TUBES ARE FILLED WITH GAS. VACUUM TUBES ARE MADE IN MANY SHAPES AND SIZES DEPENDING ON WHAT THEY WILL BE USED FOR.

Illustration of a vacuum tube with all the elements listed

THIS IS WHAT MOST VACUUM TUBES LOOK LIKE.

Illustration of a transistor being formed, and another with all the elements listed

THIS IS HOW TRANSISTORS ARE MANUFACTURED.
VACUUM TUBES AND TRANSISTORS ARE LIKE ELECTRICAL LEVERS. WHEN A SMALL AMOUNT OF ELECTRICITY IS CONDUCTED THROUGH THESE DEVICES, IT IS AMPLIFIED OR STRENGTHENED. IT IS STRENGTHENED ENOUGH SO THAT IT CAN EVEN CONTROL A TRAIN. ONE TUBE OR TRANSISTOR HAS AN AMPLIFYING POWER OF ABOUT 10,000. VACUUM TUBES AND TRANSISTORS ARE ALSO USED TO MAKE RADIO WAVES OR TO CHANGE THE WAVEFORMS OF THE RADIO WAVES.

Illustration of the different functions of vacuum tubes and transistors

These are the different kinds of work that are done by vacuum tubes and transistors.
WHAT IS A SONAR? Do you know that bats have a natural sonar system? Have you heard a bat screeching? A bat sends out sound waves by screeching. He also receives the echo from his screeching which tells him the location of objects and the insect food which he seeks at night.

Illustration of a bat sending out sound waves and receiving an echo

THE SONAR SYSTEM OF A BAT.
FROM THE DESCRIPTION OF THE SONAR SYSTEM OF BATS, YOU MAY GUESSED THAT THE SONAR IS A DEVICE THAT SENDS OUT SOUND WAVES. THE WORD SONAR STANDS FOR SOUND NAVIGATION AND RANGING. TO EXPLAIN THE SONAR, WE CAN SIMPLY SAY THAT IT IS AN ELECTRONIC DEVICE THAT SENDS OUT SOUND WAVES IN WATER.

PORPOISES ALSO USE A NATURAL SONAR SYSTEM.

Illustration of a ship sending out sonar signals to locate a submarine

THE SONAR IS OFTEN USED TO LOCATE ENEMY SUBMARINES.
SOME USES OF THE SONAR

THE SONAR IS USED BY MANY FISHERMEN TO LOCATE SCHOOLS OF FISH UNDERWATER. SHIPS AT SEA ALSO USE THE SONAR TO TELL THEM THE DEPTH OF THE OCEAN FLOOR. IN TIMES OF WAR, THE SONAR IS USED TO LOCATE SUBMARINES. CAN YOU NAME SOME OTHER PLACES WHERE THE SONAR CAN BE USED?

Illustrations of the various uses of the sonar

THE VARIOUS USES OF THE SONAR.
RADAR

WHAT IS A RADAR? CAN ANYONE DESCRIBE WHAT A RADAR LOOKS LIKE? WHERE HAVE YOU SEEN OR HEARD THE WORD BEFORE?

THE RADAR IS A MACHINE THAT IS SIMILAR TO A RADIO BROADCASTING STATION. IT WAS FIRST INVENTED DURING WORLD WAR II IN ENGLAND TO LOCATE ENEMY PLANES.

Illustration of the instruments in a radio station

THE RADAR IS A MACHINE THAT RESEMBLES THE INSTRUMENTS IN A RADIO STATION.
THE NAME RADAR WAS INTRODUCED BY THE U.S. NAVY FROM RADIO DETECTION AND RANGING. THE OPERATION OF THE RADAR IS VERY SIMPLE. A RADAR SIGNAL IS BROADCAST IN SHORT RADIO WAVES. THESE SHORT RADIO WAVES TRAVEL UNTIL THEY HIT A SOLID OBJECT. THE WAVES BOUNCE BACK FROM SOLID OBJECTS THE SAME WAY THAT LIGHT IS BOUNCED OFF A WALL.

THE RADAR BROADCASTS RADAR SIGNALS THE SAME WAY THAT A RADIO STATION BROADCASTS RADIO SIGNALS.
RADAR WAVES ARE SO SMALL THAT THEY ARE CALLED MICROWAVES. THESE MICROWAVES ARE PRODUCED THROUGH AN OSCILLATING CIRCUIT, JUST LIKE RADIO WAVES ARE CREATED. HOWEVER, MICROWAVES ARE CREATED BY A DIFFERENT KIND OF AN OSCILLATING CIRCUIT. THE SHORTER THE MICROWAVE, THE BETTER IT BOUNCES OFF AN OBJECT.

Illustrations of examples of radio waves and microwaves

CAN YOU SEE THE DIFFERENCE BETWEEN THE REGULAR RADIO WAVES AND MICROWAVES?
A RADAR ANTENNA IS SHAPED LIKE A BIG BOWL WITH A ROD STICKING OUT FROM THE MIDDLE. THE SHORT RADIO WAVES ARE SENT OUT FROM THE ROD. WHEN THE WAVES HIT AN OBJECT, THEY BOUNCE BACK TO THE ANTENNA. THE BOUNCED WAVES THEN CREATE A CURRENT IN THE ANTENNA, AND GO TO A SPECIAL SCREEN TO BE OBSERVED. THE OBJECT IS SEEN AS A BLIP ON THE SCREEN.

Sequence of illustrations showing the radar signals being sent out by the antenna, being bounced off an object, and being recorded on a screen.

THE ILLUSTRATIONS SHOW THE SIMPLE OPERATION OF THE RADAR.
SOME USES OF THE RADAR

THE RADAR HAS MANY USES WHICH ARE HELPFUL TO MAN. IN AN AIRPLANE, THE RADAR HELPS THE PILOT TO LOCATE STORMS SO HE CAN FLY AROUND THEM. THE PILOT ALSO USES THE RADAR TO WARN HIM OF THE DANGERS THAT MAY BE NEAR THE PLANE. THE POLICE ALSO USE RADAR TO LOCATE SPEEDING CARS. RADAR IS ALSO USED TO PROTECT OUR COUNTRY FROM ENEMY PLANES OR MISSILES. THERE ARE MANY OTHER USES OF THE RADAR. CAN YOU THINK OF ANY?

Illustrations of some of the uses of the radar
LASER

CAN YOU IMAGINE A VERY THIN RAY OF LIGHT SO POWERFUL THAT IT CAN CUT THROUGH A THICK PIECE OF METAL? THIS SAME LIGHT CAN ALSO CARRY MESSAGES TO THE MOON. MANY OF YOU WATCH THE CARTOON PROGRAMS ON TELEVISION ON SATURDAY MORNINGS. YOU HAVE SEEN SPACE MEN USE A RAY GUN TO DESTROY BUILDINGS OR MAKE PEOPLE VANISH. DO YOU KNOW THE NAME OF THE RAY GUN?

Illustrations of a Laser
being used to cut through metal, and being used for communications purposes

SOME OF THE MANY USES OF A LASER.
THE RAY GUN IS BETTER KNOWN AS THE LASER. THIS MODERN INVENTION PRODUCES A PENCIL-THIN BEAM OF LIGHT THAT IS SO POWERFUL IT CAN DESTROY MANY THINGS. LASERS ARE ALSO USED TO DO MANY USEFUL THINGS IN ALL PARTS OF THE WORLD. YOU MAY SOON BEGIN TO SEE SOME OF THE USES OF THE LASER IN THE NEAR FUTURE. CAN YOU SEE YOURSELF SITTING IN A DENTIST'S CHAIR BEING DRILLED BY A RAY OF LIGHT? CAN YOU IMAGINE A DOCTOR USING A RAY OF LIGHT TO OPERATE WITH? IT WILL NOT BE TOO LONG BEFORE THESE USES WILL BECOME COMMON.

Illustrations of a dentist drilling a tooth and a doctor performing an operation

LASERS MAY SOON REPLACE THESE METHODS IN MEDICINE.
WHAT DOES LASER MEAN?  HOW DOES IT WORK?  THE DEFINITION OF THE LASER SHOULD GIVE YOU A CLUE AS TO HOW IT WORKS.  LASER STANDS FOR LIGHT AMPLIFICATION BY STIMULATED EMISSION OF RADIATION.  IN SIMPLE TERMS, THE LASER IS A MACHINE THAT AMPLIFIES OR STRENGTHENS LIGHT.  INSIDE THE MACHINE, A FORM OF LIGHT ENERGY CALLED "PHOTON" IS BEING BORN.  THE PHOTON IS THE ENERGY THAT COMES OUT FROM OR IS RADIATED FROM ATOMS OF SPECIAL MATERIALS.

Illustration of photons being released from an atom

PHOTONS BEING RADIATED FROM AN ATOM.
WHEN THE LASER MACHINE IS TURNED ON, THE PHOTON GETS EXCITED AND IS BOUNCED AROUND INSIDE THE MACHINE. THE PHOTON BECOMES STRONGER AND STRONGER WHILE BOUNCING AROUND INSIDE THE MACHINE. FINALLY IT BECOMES SO STRONG THAT IT FLASHES OUT FROM THE MACHINE AS A THIN, POWERFUL, CONCENTRATED RAY OF LIGHT.

Sequence of Illustrations of the photon bouncing inside the laser, becoming stronger and flashing out

THE SEQUENCE OF HOW THE LASER BEAM IS BORN.
THE MAIN JOB OF A LASER MACHINE IS TO AMPLIFY LIGHT WAVES. THE LASER CAN AMPLIFY LIGHT WAVES TO AN ENERGY THAT IS GREATER THAN ANYTHING KNOWN ON THIS EARTH. THE LASER CAN CREATE LIGHT THAT IS A BILLION TIMES BRIGHTER THAN THE SUN. CAN YOU IMAGINE ANYTHING THAT POWERFUL? ALTHOUGH THE LASER IS A POWERFUL MACHINE, IT CAN BE CONTROLLED SO THAT IT IS NOT DANGEROUS TO USE. A GOOD EXAMPLE OF THE TINY RAY OF LIGHT MAY BE SEEN BY LOOKING AT A PAPER CLIP. THE LASER CAN MAKE A HOLE THROUGH THE PAPER CLIP. CAN YOU IMAGINE A HOLE THAT SMALL?

Illustration of the Laser making a hole through a paper clip
SOME APPLICATIONS OF THE LASER

TODAY THE LASER IS BEING USED IN INDUSTRY, THE MILITARY, MEDICAL AND SCIENTIFIC RESEARCH, AND IN COMMUNICATIONS.

Illustration of the Laser being used for each of the following: industry, medicine, communications, graphic arts, and defense
WHAT ARE COMPUTERS? MANY PEOPLE CALL THE COMPUTER AN "ELECTRONIC BRAIN." SOME PEOPLE EVEN THINK THAT COMPUTERS HAVE MAGICAL POWERS. DO YOU KNOW WHAT A COMPUTER IS?

Illustration of a person using a computer

COMPUTERS ARE USED IN MANY WAYS TO HELP MAN SOLVE LONG AND DIFFICULT PROBLEMS.
COMPUTERS ARE ELECTRONIC MACHINES THAT ARE USED FOR SOLVING PROBLEMS IN A HURRY. THERE ARE TWO KINDS OF COMPUTERS. ONE TYPE IS CALLED THE ANALOG COMPUTER. THE OTHER TYPE IS CALLED A DIGITAL COMPUTER. DOES ANYONE KNOW THE DIFFERENCES BETWEEN THE TWO TYPES OF COMPUTERS?

Illustrations of an analog and digital computers with animated configurations depicting numbers for the digital computer, and equations and formulas for the analog computer
THE ANALOG COMPUTER IS USED MAINLY TO SOLVE SCIENTIFIC AND ENGINEERING PROBLEMS. FOR EXAMPLE, IF YOU WANTED TO FIND OUT HOW LONG IT WOULD TAKE A SPACESHIP TO TRAVEL TO MARS, THE ANALOG COMPUTER WOULD BE USED TO GIVE YOU THE ANSWER. THE COMPUTER WILL TELL YOU THE EXACT DAYS, HOURS, AND MINUTES THAT THE SPACESHIP TAKES, TO TRAVEL TO MARS. ISN'T THIS A HANDY MACHINE TO HELP YOU WITH YOUR HOMEWORK?

A THERMOMETER WORKS LIKE AN ANALOG COMPUTER. IT RECORDS THE TEMPERATURE AUTOMATICALLY WHEN THE WEATHER CHANGES. ONCE THE SCALES ARE SET IT READS CONTINUOUSLY.
THE SECOND TYPE OF COMPUTER WHICH IS CALLED THE DIGITAL COMPUTER, IS USED MAINLY TO SOLVE PROBLEMS IN COUNTING. THEREFORE, IF YOU WANTED TO ADD, MULTIPLY, SUBTRACT, OR DIVIDE HUGE NUMBERS IN A HURRY, YOU WOULD USE THE DIGITAL COMPUTER. WOULDN'T YOU LIKE TO HAVE A MACHINE LIKE THIS TO HELP YOU WITH YOUR MATH?

Illustration of a digital computer

Illustration of a light switch

A LIGHT SWITCH WORKS LIKE A DIGITAL COMPUTER. THE SWITCHES IN THE COMPUTER ARE TURNED "ON" AND "OFF" EACH TIME INFORMATION IS FED INTO THE MACHINE. IT IS NOT CONTINUOUS LIKE THE ANALOG COMPUTER.
IN ALL COMPUTERS, THE MAIN CONTROLLING DEVICE IS A SWITCHING SYSTEM. A SWITCHING SYSTEM IS MANY SWITCHES OPERATING DIFFERENTLY AT ONE TIME. ALL INFORMATION THAT IS FED INTO THE COMPUTER IS CHANGED INTO ELECTRICAL PULSES BY VERY FAST ELECTRONIC SWITCHES. IT IS THESE PULSES THAT ARE STORED IN THE COMPUTER.

Illustration of a panel of "on" and "off" switches

CAN YOU SEE THE IMPORTANT PART THAT SWITCHING PLAYS IN A COMPUTER? YOU CAN EVEN SAY THAT THE COMPUTER IS A SWITCHING SYSTEM.
COMPUTER USES FOR THE FUTURE

BOTH ANALOG AND DIGITAL COMPUTERS HAVE OPENED UP MANY NEW AREAS IN MEDICINE, INDUSTRY, BUSINESS, AND IN DEFENSE. CAN YOU NAME SOME OTHER AREAS WHERE COMPUTERS ARE BEING USED?

Illustrations of the various uses of computers in medicine, industry, business, and defense
APPENDIX C

PROTOTYPE OF TEXTBOOK
INTRODUCTION

ELECTRONICS TECHNOLOGY

Today, no matter where you go, no matter where you look, you will be able to see some form of electronics technology at work.

The television set in your home...

...The radio that you listen to

The satellite circling the earth...

These are all examples of electronics technology at work.
Through electronics technology machines like the computer "think" for man...

Electronics technology can help the doctor, too. The doctor can use the latest electronic equipment to find out what is wrong with you when you are sick. The doctor can also use electronics technology to cure you...

Almost everywhere you look, the efficient practices of doing things through electronics can be seen. This is Electronics Technology.
Electronics technology sounds like two hard words. They could scare many people. Let's look at each word more closely. The word "technology" simply means "the efficient way of doing things." Add the word "electronics" to "technology." Now we have the term "electronics technology." It simply means, "the efficient way of doing things in electronics."

Now you may ask what is electronics? Electronics has no smell. It has no weight. It has no size or shape. It has been a mystery for many many years. Even today, no one really knows the answer. Yet today, man has learned how to control, and use electronics in many different ways.

Let us begin to find out something about electronics. To do this, we must look at a different kind of world. We must visit the world of the atom.

The Atom

The atom is one of the smallest particles that is known to man. It is so small that we cannot see it. The scientists tell us that an atom is like a small solar system. In the solar system the sun is at the center. In an atom the nucleus is located at the center. In our solar system the earth circles the sun. In the atom, a small particle called the electron circles around the nucleus.
Do you see how the atom and the solar system look alike?

The atom

The solar system

There are many different kinds of atoms. Some atoms have more electrons than others. Electrons can also move from atom to atom. The atoms move when something forces them to move.

When the electrons move from atom to atom in a wire it is known as electricity. Electricity is the same as current flow.

Electrons moving from atom to atom in a wire.
When the electrons move from atom to atom through space it is called **electronics**.

Electrons moving through space.

You have learned what **electricity** is. You have also learned what **electronics** is. Can you tell the difference between the two? Now that you know what **electrical current** is, we can look at some of the big ideas in electronics technology.

In order to better understand electronics technology, we will study the five big ideas. These ideas are: (1) **Conducting**, (2) **Converting**, (3) **Oscillating**, (4) **Amplifying**, and (5) **Switching**. We will study each of the five areas separately. You will see how each applies to the modern electronic devices that you can find in your home, community, or school.
CONDUCTING

What makes a frying pan hot? How is electricity brought to your home? How is the picture on the television set brought to your home? Do you know the answers to these questions? Well, the answers to all the questions can be found in the idea of **conducting**. What is **conducting**? In simple terms, conducting means "to carry on something." For example: In the first question, the frying pan becomes hot because...

the heat from the stove is **carried** on the frying pan...

In the second question, electricity is **carried** on wires from the power plant to your homes...

Photograph of a frying pan on a stove

Photograph of telephone poles with electrical wires
In the last question, the picture on the television set is carried on electrical signals. The electrical signals travel through the air from the television station to the television set in your home...

Can you see how the word conducting is almost the same as carrying on? You can think of conducting as carrying on things such as solids, gases, or liquids.

Now that you know the meaning of conducting, let us look at how electronic signals are conducted. Electronic signals are conducted in three ways. The first way is through electronic parts, such as the vacuum tube or transistor. The second way is through radiation. Radio waves are radiated through space. The third way is by electrical wires. You can see electrical wires almost everywhere you look.
Conducting through Electronic Parts

The Vacuum Tube - The vacuum tube is sometimes called the radio tube. The vacuum tube comes in all kinds of shapes and sizes.

Photograph of the various kinds of vacuum tubes

When the first vacuum tube was invented, electronics was born. The vacuum tube is used to do many different kinds of jobs. The vacuum tube is used to form a certain kind of current called alternating current. The vacuum tube is used to change electrical current. Another job of the vacuum tube is to strengthen radio waves. You can see how important the vacuum tube is to electronics. The main purpose of the vacuum tube is to conduct electrical current to do the different kinds of jobs.

Vacuum tubes are manufactured. The glass covering and metal parts are baked in the tube. After the parts are baked for a while, a certain kind of gas is introduced. It is then sealed and tested. This is all done by machines in a plant.
The Transistor - Recently, radio tubes are being replaced by transistors. The transistors can do the same jobs as the radio tubes. Transistors are no bigger than the eraser on your pencil. They come in all kinds of shapes and sizes...

The transistor has changed the size of many electronic products. Today, radios are ten times smaller than what they were twenty years ago. Like radio tubes, the main purpose of the transistor is to conduct electrical current.

Conducting through Radiation

The second form of conducting that we will discuss is called radiating. Radiating can be looked at in a form called the electromagnetic waves. Electromagnetic waves are also called radio waves. The radiated waves travel
through the air. Radiated waves look like the ripples in the water when a rock is thrown in a pond.

Radio waves cannot be seen. They cannot be smelled. They cannot be tasted or heard. However, we do have ways of detecting them. When radio waves are broadcast from a radio station, they travel outward. They also move out in a series of circles. The circles are much like the layers of an onion. Have you seen the layers of an onion? Peel an onion and you can imagine how radiated waves travel outward.
Conducting through Electrical Wires

The third form of conducting is through the use of electrical wires. Electrical wires carry the signals directly to the destination. You are all familiar with electrical wires in many places. These wires carry many different kinds of messages to different places.

Photograph of the different kinds of wires
CONVERTING

In the last chapter, you learned that electronic signals are conducted to do different kinds of work. In this chapter, we will talk about how electrical current or signals are changed. To talk about change, we will use the word converting. The word converting means to change something. In the study of electronics you will learn that there are many ways to change electrical current. We will study about some of them. We will look at four ways in which these changes are made. The four kinds of changes are called: (1) rectifying, (2) filtering, (3) demodulating, and (4) clipping. These four words describe the different ways that electrical current is converted. Electrical current is converted from one kind of current to a different kind of current. It is converted to do certain kinds of jobs. To give you an example, let's see how rectifying works. In order to make your transistor radio work from the electrical outlet in your home, alternating current will have to be converted into direct current. Alternating current is current that goes back and forth. The wave pattern of an alternating current looks like the picture shown on the following page.
Direct current is a current that goes in one direction. The wave pattern looks like a straight line. It looks like the picture below.

To change the current we can use an electronic device called the **rectifier**. The rectifier can change alternating current into direct current. When the current is changing, we can say that we are **rectifying** the current. The changing current would look like the picture below.

Can you see the difference between the two wave patterns? You can also see that a **rectifier** is the part that is used to change the wave patterns of the current.

We learned that there are four ways to change electrical current. Let us examine each one more closely.
Rectifying - In this type of change, electricity in the form of alternating current is changed into direct current. This change is necessary to take the place of battery power. Batteries cannot last for a long time and are too expensive to replace. Therefore, electricity from the outlet is used to take the place of the battery. Before it can be used it must be changed to direct current. All radios can work only on direct current.

Demodulating - In this type of change, the sound signals are separated in a radio. The radio waves from the radio station contain two kinds of waves. One of the waves is called a carrier wave. The other wave is the sound signals. The carrier wave carries the sound signals to your radio. When the radio waves reach the radio, the sound waves are separated from the carrier waves. Usually a vacuum tube is used to separate the two waves. The sound waves are separated in the radio so that only the sound
can be heard. Demodulating is the separating of the two different kinds of waves that come into the radio.

Filtering - In this type of change, electrical current is changed by a smoothing or taking out process. The rectified wave that was shown on the other page went through a smoothing process in the rectifier. After the current was filtered it became a smooth direct current. Unwanted radio waves that come into the radio are also taken out or filtered. Filtering means to take out or smooth out any unwanted parts of an electrical current or signal.

These electronic parts are often used for filtering purposes.
Clipping - In this type of change, an electronic signal is clipped or cut-off. The electronic signal is cut-off to produce a different form of waveshape. This form of change is usually necessary to separate sound signals and picture signals in a television set.

Now that we have discussed the four different kinds of changes in electrical current, you can see that the idea of converting refers to the different kinds of changes that the electrical current or electronic signals must go through. These changes are important in order to make certain parts of an electronic device work well.
OSCILLATING

So far, you have learned several things about electronics technology. You found out how electronic signals are conducted (carried). You also found out how electronic signals are converted (changed) to do efficient work in electronics. In this chapter we will discuss how radio waves are sent out. We will also discuss how they are received by a radio.

In any big city, there are usually many different radio stations...

Photograph of a radio station

The radio stations usually all broadcast at the same time. Have you wondered why your radio can only catch one station at a time? When you turn the dial of your radio to a certain spot, only one station is heard. Why can't all
the stations be heard at one time? To find the answer to the questions, we need to know something about the idea of oscillating. What is oscillating? The word oscillating means to go back and forth. In your radio there is a section that allows the electrons to go back and forth (oscillate).

In a playground, you have all seen children riding a swing...

Photograph of children riding swings

The swing goes back and forth until it slowly comes to a stop. The back and forth motion of a radio wave is similar to the back and forth motion of the swing. This is known as oscillation.

At the radio station, there is a machine that makes the electrons oscillate (go back and forth) at a very high speed. Through this oscillating process, radio waves are created. The radio waves that are created at the radio station are sent out from the antenna at the
radio station. The radio waves then travel to all parts of the community...

Photograph of the antenna located at a radio station

This antenna sends out the radio waves.

To capture the radio waves, the electrons in your radio must oscillate at the same speed as the electrons that are oscillating at the radio station. When this happens, you will be able to hear the radio station. When the oscillations of your radio and that of the radio station are the same, they are said to be in resonance.

What is resonance? When any two similar materials have the same natural frequency, they are in resonance. Through an experiment, you may be able to see how resonance works. To do the experiment, obtain two similar tuning forks. Strike one tuning fork and you will hear the other tuning fork vibrating. This is an example of resonance.
In the same manner as the tuning forks, the radio station sends out a certain amount of vibrating radio waves. The tuning dial of your radio is made so that a certain spot on the dial will cause your radio to vibrate also. This allows you to hear only that station. The tuning dial on your radio has many different settings...

Photograph of a variable capacitor with the dial settings

The different settings on the radio allow the radio to oscillate differently at the different spots on the dial. The numbers on the radio dial tell you how much a certain radio station is oscillating.

Oscillations are used in many different ways in electronic devices. Can you name some electronic devices where the idea of oscillating is being used?
Do you know that there are radio waves floating all around you now? Why can't you hear them? Part of the reason is that the radio waves that surround you are very, very weak. To hear these weak waves, we need special things like the radio to help us. One of the many jobs of the radio is to amplify or strengthen radio waves so that they can be heard. The word amplifying means "making something stronger." Examples of amplifying are shown in the following pictures.

Photograph of a laser

The laser amplifies light.
Photograph of an electric stove

The electric stove amplifies heat energy.

Photograph of a stereo set

The stereo set amplifies sound.

When a small amount of force is used to control a larger force, we call the process "amplifying." A good example of amplifying is the lifting of an automobile by the use of a jack. A jack is the device used to lift up the car when a person has a flat tire. When the jack is used to lift up the automobile, the jack acts as a device to amplify your power to lift heavy things.
The jack amplifies your strength.

In electronics, the efficient way to strengthen the weak radio waves is to use a vacuum tube or a transistor. Vacuum tubes and transistors are made so that a small change in one part of the tube will cause a larger change in another part of the tube.

Transistors and vacuum tubes are used to amplify weak electronic signals.
Amplifying Frequencies

There are usually several things that need to be amplified in electronic devices. These are mainly the different kinds of frequencies or waves that are found in the different parts of any electronic device. The television is a good example. In the television, you can normally find audio or sound signals, intermediate frequency signals, video or picture signals, and radio frequency signals. All of these signals must be amplified or strengthened before the television can operate properly.

Combining Stages for Amplification

Sometimes, when amplifying one part of the radio, by using radio tubes or transistors, the radio signals are still too weak. When this happens, two radio tubes are combined to strengthen the weak electronic signals. This process is called combining stages. There are many ways to combine stages. Some examples are shown in the illustration below.

Illustration of several ways to combine stages
Feedback

Feedback means to return or reintroduce the same signals back into the circuit. When the signals are reintroduced into the circuit, they become stronger. This is another form of amplification.

Illustration of a feedback circuit

The electronic signals are being reintroduced into the circuit.
SWITCHING

How do you turn on your house lights? You use a switch, don't you? Everyone knows what a switch looks like.

A light switch.

The word switching is not a mysterious word. It simply means to turn something "on" or "off." Sometimes switching can also mean "opening" and "closing" something. An example of "open" is when the wires in a circuit are cut.

Electricity cannot pass through an open circuit.
When the wires in a circuit are cut, it is called an open circuit because electricity cannot pass through cut wires. When the cut wires are joined together again, it is called a closed circuit, because electricity can once again pass through the wire.

Illustration of electricity flowing through a closed circuit

A closed circuit.

Can you see how the "on" and "off" switch works? When the lights are turned off, it is an open circuit. When the lights are turned on, it is a closed circuit. Can you see how switching works?

Modern computers are made up of many, many of these switches. The main difference between the computer switches and the ordinary light switches is the tremendous speed of the switches in the computer.

Photograph of a computer

Computers are made up of many switches.
Switching is usually done in several different ways. One of the switching methods is called gating. The word gate, as used in electronics, is similar to the gate in a fence. In electronics, the gate must be closed before electricity can flow through the wires. The gate is many "on" and "off" switches combined to work together.

Illustration of an electronic gate and a fenced yard with a gate

Another kind of switching circuit is called the multivibrating circuit. The word multivibrating means to change or switch back and forth in a circuit at a high rate of speed. These circuits are commonly found in computers for very fast switching. When you see or hear about computers, just remember that the computer is nothing more than many, many switches working very fast through electronic signals.
GLOSSARY

alternating current - Current of electrons that move first in one direction then in the other.

amplification - Ability to control a relatively large force by a small force.

analog computer - A type of calculating machine that operates with numbers represented by directly measurable quantities as voltages, resistances, rotations, etc. Example: slide rule, automobile speedometer.

antenna - A wire of a radio station for radiating waves into space.

audio frequency - Oscillations between 20 to 20,000 cycles per second produce a sound which one may hear.

beam - A ray or collection of parallel rays emitted, as from the sun or other luminous body.

broadcast - Reaching by radio or television transmission an unlimited number of receiving stations.

carrier wave - A radio frequency wave sent out by a transmitting station.

circuit - The complete path of an electric current.

clipping - Changing the wave form by cutting off a part of a wave.

communication - A system, as of telephone, telegraph, etc. for conveying information.

computers - Calculating machines.

concentrated - To bring or come to a common center.

constructing - Putting together the parts of something, building.
converting - Changing.
current - The flow of electrons.
cycle - An interval of time in which a group of events occur.
demodulating - Process of removing the sound signals from the carrier waves in a receiver.
detection - Process of removing sound signals from the carrier wave in a radio receiver.
devices - That which is devised or formed by design; as a mechanical device or appliance.
digital computer - A type of calculating machine that operates with numbers expressed directly as digits in the decimal or some other system.
direct current - Flow of electrons in one direction.
electricity - Movement of electrons through a conductor.
electromagnetic waves - A wave produced by the oscillation of an electric charge, as a light wave and a radio wave.
electronics - The science of controlling the movement of electrons.
emission - Escape of electrons from a surface.
energy - Capacity for performing work.
feedback - To return again to starting point.
filtering - A circuit used to keep out certain frequencies, or smooth out a pulsating current.
frequency - The number of vibration or cycles of oscillations in a given time, usually a second.
gating - A circuit which permits an output only when a predetermined set of input conditions are met.
manufacturing - The making of anything by hand, by machinery, or by other agency.
microwave - A very short electromagnetic wave.
multivibrating - Having many vibrations.
nucleus - The central part of an atom.
oscillating - Moving or swinging back and forth like a pendulum; vibrating.
particle - A small part of matter.
pattern - Anything designed as a guide or model for making things.
photon - A packet of radiant energy traveling in waves.
pulses - Sudden rise and fall of a voltage or current.
radar - Radio detecting and ranging; a radio detector for locating, by means of reflected radio waves, objects beyond sight or hearing.
radiating - Issuing in rays, as light or heat.
radiation - The action or process of sending out in rays.
radio frequency - A frequency above 30,000 cycles per second.
ranging - A line of direction.
rectifying - Changing alternating current to a pulsating direct current.
reflected - To bounce back.
resonance - A condition in an electrical circuit containing inductance, capacitance, and resistance, when the capacitive and inductance reactance are equal and canceling each other out leaving only resistance in the circuit.
semiconductor - Conductor somewhere in range between conductors and insulators.
signal - The intelligence, message, or effect to be sent over a communications system; an electrical wave corresponding to intelligence.
solar - Pertaining to the sun.
sonar - Sound, navigation and ranging.
stimulated - Excited.
switching - Shifting to another circuit by means of a switch (a device for directing or controlling current flow in circuit).

technology - The science of efficient practices.

television - A way of sending and receiving visual scenes by radio broadcasting.

transistor - A semiconductor device derived from two words, transfer and resistor.

vacuum - A space entirely without matter; hence, a space exhausted to a high degree by an air pump.

vacuum tube - Electron tube or radio tube.
APPENDIX D

PROTOTYPE OF STUDENT WORKBOOK
ACTIVITY 1

CONDUCTING

Today, you will learn some new words that will help you to better understand the lessons we are now studying in electronics technology.

SUPPLIES NEEDED

Dictionary
Encyclopedias
Textbook and workbook

PROCEDURES

1. Find the meanings of the following words and record your answers:
   a. conducting
   b. current
   c. electricity
   d. vacuum
   e. radiation
   f. electromagnetic waves
   g. manufacturing
   h. constructing
2. Using the words above, make meaningful sentences for each word.

   a. conducting
   
   b. current
   
   c. electricity
   
   d. vacuum
   
   e. radiation
   
   f. electromagnetic waves
   
   g. manufacturing
   
   h. constructing
   
   i. circuit
   
   j. devices
Activity 2

CONDUCTING

Today you will do an experiment to find out which kinds of materials can conduct electrical current and which kinds of materials cannot conduct electrical current.

EQUIPMENT AND SUPPLIES NEEDED

<table>
<thead>
<tr>
<th>Equipment (per group)</th>
<th>Supplies (per group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 hammer</td>
<td>1 block of wood 4&quot;x5&quot;x3/4&quot;</td>
</tr>
<tr>
<td>1 ruler</td>
<td>2 8d common nails</td>
</tr>
<tr>
<td></td>
<td>1 No. 6 drycell</td>
</tr>
<tr>
<td></td>
<td>No. 18 magnet wire</td>
</tr>
<tr>
<td></td>
<td>1 flashlight bulb 1½ volts</td>
</tr>
<tr>
<td></td>
<td>sandpaper</td>
</tr>
</tbody>
</table>

Materials for Experiment

A penny
A dime
A short length of string
A paper clip
A steel nail
A short piece of copper wire
A rubber band
A comb or plastic material

Preparing the Experiment

1. Obtain the equipment and supplies from the teacher. Make sure you have everything listed above.

2. With the hammer, drive the two nails into the block of wood. (Look at the picture.)

3. Cut three pieces of wire 12 inches long.

4. Take the sandpaper and clean about two inches from the ends of each wire. (Look at the picture.)

5. Wrap one wire around the light bulb and one nail. (Look at the picture on the next page.)

6. Wrap another wire around the light bulb and one pole of the battery. (Look at the picture on the next page.)
7. Wrap the last wire around the other nail and the other pole of the battery. (Look at the picture above.)

**Conducting the Experiment**

1. Place each different type of material across the nail and watch to see if the light bulb glows.

2. If the light glows, list the material under conductors.

3. If the light does not glow, list the material under nonconductors.

<table>
<thead>
<tr>
<th>Conductors</th>
<th>Nonconductors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ACTIVITY 3

CONDUCTING

Review and Test Questions

Circle the correct answer for each question.

1. What is electronics technology?
   a. the study of the radio.
   b. the study of electronics.
   c. the efficient practices in electronics.
   d. the study of the things that are made through electronics.

2. Vacuum tubes are used to
   a. conduct electrons.
   b. conduct electronics.
   c. conduct atoms.
   d. conduct protons.

3. What are transistors?
   a. portable radios.
   b. important electronic devices that conduct current.
   c. electronic devices that are better than vacuum tubes.
   d. electronic devices that are made of glass.

4. Another name for the radio waves is
   a. heat waves.
   b. light waves.
   c. electromagnetic waves.
   d. radiating waves.

5. What is electricity?
   a. electrons in motion through a wire.
   b. electrons in motion through space.
   c. electrons in motion through a radio.
   d. electrons in motion through a television.

6. What is electronics?
   a. electrons in motion through a wire.
   b. electrons in motion through space.
   c. electrons in motion through a radio.
   d. electrons in motion through a house light.

7. Conducting means
   a. stopping the electrical current.
   b. strengthening the electrical current.
   c. carrying on the electrical current.
   d. amplifying the electrical current.
8. Vacuum tubes are filled with
   a. air.
   b. gases.
   c. liquids.
   d. solids.

9. Electrical wires conduct
   a. light.
   b. liquids.
   c. electricity.
   d. electromagnetic waves.

10. Transistors are made up of
    a. special electronic material.
    b. special kinds of metals.
    c. three specially coated steel wires.
    d. semiconductor materials.
ACTIVITY 4

CONVERTING

Today, you will learn some new words that will help you to better understand the lessons we are now studying in electronics technology.

SUPPLIES NEEDED

Dictionary
Encyclopedias
Textbook and workbook

PROCEDURES

1. Find the meanings of the following words and record your answers:
   a. converting
   b. rectifying
   c. filtering
   d. alternating current
   e. direct current
   f. clipping
   g. demodulating
   h. signals
2. Using the words above, make meaningful sentences for each word.

a. converting

b. rectifying

c. filtering

d. alternating current

e. direct current

f. clipping

g. demodulating

h. signals

i. carrier wave

j. sonar
ACTIVITY 5

CONVERTING

Today, you will construct a simple radio to find out the important part that rectifiers have in the radio. You will see that without rectification we cannot hear the sound produced by a radio station.

EQUIPMENT AND SUPPLIES NEEDED

<table>
<thead>
<tr>
<th>Equipment (per group)</th>
<th>Supplies (per group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 earphone</td>
<td>60 ft. magnet wire #24</td>
</tr>
<tr>
<td></td>
<td>1 cardboard tube from a roll of toilet tissue</td>
</tr>
<tr>
<td></td>
<td>1 rectifier (diode)</td>
</tr>
<tr>
<td></td>
<td>1 variable capacitor</td>
</tr>
<tr>
<td></td>
<td>7 connecting wires with clips on each end</td>
</tr>
<tr>
<td></td>
<td>1 12&quot; square piece of wood</td>
</tr>
</tbody>
</table>

Preparing the Experiment

1. Obtain the equipment and supplies from the teacher. Make sure you have everything listed and shown in the photograph below.

   Photograph of all the equipment and supplies needed

2. Wrap the 60 ft. of magnet wire around the cardboard tube as shown in Illustration #1.

3. Make two small holes on both ends of the cardboard tube. Stick the two ends of the wire through the holes as shown in Illustration #1.
4. Clean the two ends of the wire with sandpaper.

5. With the connecting wire, clip one end to the rectifier and the other end to point A on the variable capacitor. (See Illustration #2.)

6. With another connecting wire, clip the other end of the rectifier and one end of the earphone. (See Illustration #2.)

7. With another connecting wire, clip one end to one wire of the cardboard tube, and the other end to point B of the variable capacitor. (See Illustration #2.)

8. With another connecting wire, clip one end to the other wire of the cardboard tube, and clip the other end of the connecting wire to point C of the variable capacitor. (See Illustration #2.)

9. With another connecting wire, clip one end to point C and the other end to the other end of the earphone. (See Illustration #2.)

10. With another connecting wire, clip one end to point D and the other end to a heater for ground.

11. With the last connecting wire, clip one end to point E and the other end to the antenna.

Illustration #2
Conducting the Experiment

1. Put on the earphones and listen for sounds.

2. Turn the variable capacitor to the left and to the right until sound is heard.

3. If no sound is heard, check all the connections to see that they are clipped on tightly.

4. When the sound is heard, take off the rectifier, and clip the two loose ends together. What do you hear?

5. Now replace the rectifier in its original position. You should now be able to hear sound again. You can see that without a rectifier, the radio cannot play.

How the Parts of Your Radio Work

The antenna - The antenna picks up the radio waves in the air and sends them down to the coil.

The coil of wire - Helps to make the radio waves stronger.

The rectifier - Changes the radio waves to an electrical sound signal to make the earphones work.

The earphones - Changes the electrical sound signals to sound.

The variable capacitor - Selects the radio stations.
ACTIVITY 6

CONVERTING

Review and Test Questions

Circle the correct answer for each question.

1. What does converting mean?
   a. combining electrical current.
   b. separating electrical current.
   c. reversing electrical current.
   d. changing electrical current.

2. What is rectifying?
   a. changing electrons to electricity.
   b. changing alternating current to radio waves.
   c. changing alternating current to direct current.
   d. changing direct current to alternating current.

3. What is filtering?
   a. changing alternating current to direct current.
   b. smoothing out the direct current.
   c. changing the electrical current by blocking it.
   d. changing direct current to alternating current.

4. What is alternating current?
   a. current that changes its direction.
   b. current that travels in one direction.
   c. current that pulsates.
   d. current that is needed to make the radio work.

5. The sonar is a machine that sends out
   a. sound waves.
   b. electrical current.
   c. electronic signals.
   d. radio waves.

6. The sonar is used to
   a. locate airplanes.
   b. locate submarines.
   c. locate mountains.
   d. locate buildings.

7. Demodulating means to
   a. amplify signals.
   b. conduct signals.
   c. convert signals.
   d. switch signals.
8. What is direct current?
   a. current that changes its direction.
   b. current that travels in one direction.
   c. current that separates electrical signals.
   d. current that combines electrical signals.

9. Which of these fishes have natural sonar systems?
   a. porpoises
   b. whales
   c. tuna fish
   d. sharks

10. Sonar systems convert
    a. sound waves into electrical pulses.
    b. sound waves into radio waves.
    c. electrical waves into sound waves.
    d. radio waves into electrical waves.
ACTIVITY 7

OSCILLATING

Today, you will find out the meanings of some new words that will help you to better understand the unit we are now studying.

SUPPLIES NEEDED

Dictionary
Encyclopedias
Textbook and workbook

PROCEDURES

1. Find the meanings of the following words and record your answers:
   
   a. radar

   b. detection

   c. ranging

   d. microwave

   e. signal

   f. oscillating

   g. broadcast

   h. resonance
2. Using the words above, make meaningful sentences for each word.
   a. radar
   b. detection
   c. ranging
   d. microwave
   e. signal
   f. oscillating
   g. broadcast
   h. resonance
   i. antenna
   j. reflected
ACTIVITY 8

OSCILLATING

Today, you will conduct two experiments. Both of the experiments deal with "resonance." Resonance relates to oscillating. See if you can tell why it relates to oscillating.

EQUIPMENT AND SUPPLIES NEEDED

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Supplies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Several pairs of different</td>
<td>Several pairs of different</td>
</tr>
<tr>
<td>pitches of tuning forks</td>
<td>kinds of empty soda bottles</td>
</tr>
</tbody>
</table>

Experiment with Resonance

Experiment A

1. Choose a partner to work with you.
2. One student will hold a soda bottle to his ear and listen for a tone. (See the picture below.)
3. The other student will stand a few feet away and blow strongly across the top of the bottle.
4. Blow strongly until a musical tone can be heard.
5. The vibrations from one bottle should produce resonant vibrations in the other bottle.
6. If no vibrations can be heard, change partners and try again.
7. Keep changing until you can find the right bottle that will produce a sound.
8. When you are finished with experiment A, go on to experiment B.

Experiment B

1. Choose a partner to work with you.

2. Obtain a pair of tuning forks from the teacher.

3. One student will strike the tuning fork and bring it close to the other tuning fork.

4. The other student will hold the other tuning fork steadily and listen for the sound.

5. The vibrations from one tuning fork should produce a resonant vibration in the other tuning fork.

6. If no vibrations can be heard, change partners and try again.

7. Keep changing until you can find a partner whose tuning fork will vibrate with yours.
ACTIVITY 9
OSCILLATING

Review and Test Questions

Circle the correct answer for each question.

1. What does oscillating mean?
   a. electrons being strengthened in a circuit.
   b. changing the waveforms of electricity.
   c. electrons swinging back and forth in a circuit.
   d. electrons going around in a circle.

2. What is resonance?
   a. the swinging motion of electrons.
   b. when two objects vibrate at the same frequency.
   c. when two frequencies oppose each other.
   d. the frequency of a soda bottle.

3. What is a radar?
   a. a machine that sends out microwaves.
   b. a machine that sends out regular radio waves.
   c. a machine that sends out bouncing waves.
   d. a machine that sends out sound waves.

4. The radar is used to
   a. locate submarines.
   b. locate airplanes.
   c. locate fishes.
   d. measure the depth of the ocean floor.

5. In the radar, the microwaves are created by
   a. an amplifying circuit.
   b. a switching circuit.
   c. an oscillating circuit.
   d. a converting circuit.

6. In order to hear a certain radio station, a radio must
   a. conduct electricity.
   b. be oscillating at the same frequency.
   c. amplify the radio waves.
   d. convert the radio waves to sound waves.

7. Microwaves are
   a. very short radio waves.
   b. very long radio waves.
   c. medium size radio waves.
   d. very wide radio waves.
8. The radar antenna is used to
   a. send out microwaves only.
   b. receive microwaves only.
   c. send and receive microwaves.
   d. protect the radar from the sun.

9. The tuning dial on the radio
   a. helps the radio to be in resonance with the radio station.
   b. changes the radio waves going into the radio.
   c. amplifies the weak radio waves.
   d. converts the radio waves to sound waves.

10. An example of oscillating is
    a. alternating current changing directions.
    b. playground swings going back and forth.
    c. neon signs blinking on and off.
    d. the traffic lights changing colors.
ACTIVITY 10

AMPLIFYING

Today, you will find out the meanings of some technical words to help you to better understand the technical world we live in. You will also work in groups to learn to cooperate and work with others.

SUPPLIES NEEDED

Dictionary
Encyclopedias
Textbook and workbook

PROCEDURES

1. Find the meanings of the following words and record your answers:
   a. radiating
   b. amplification
   c. stimulated
   d. emission
   e. concentrated
   f. energy
   g. photon
   h. beam
2. Using the words above, make meaningful sentences for each word.

a. radiating

b. amplification

c. stimulated

d. emission

e. concentrated

f. energy

g. photon

h. beam

i. industry

j. communication
ACTIVITY 11
AMPLIFYING

Today, you will conduct an experiment to find out how light energy can be amplified to produce heat.

SUPPLIES NEEDED FOR THE EXPERIMENT

A magnifying glass
A scrap piece of paper
A sunlamp or sunlight

Conducting the Experiment

1. Watch the demonstration by the teacher.
2. Each group will have one magnifying glass, so please work together.
3. Do not play with the glass.
4. Do not let the paper burn, because it is a hazard.
5. Hold the magnifying glass at an angle so that the rays become very thin. (See the picture below.)
6. Focus the ray of light to the edge of the paper.
7. Hold the magnifying glass steady until the paper turns brown and begins to smoke. Stop, do not let the paper burn.
8. Let everyone in the group try the experiment.

9. After the experiment is finished, return the magnifying glass back to the teacher.

10. Clean up your rubbish and make sure that the fire is out before throwing the paper into the wastebasket.
ACTIVITY 12
AMPLIFYING

Review and Test Questions

Circle the correct answer for each question.

1. What is amplifying?
   a. to stop current flow.
   b. to strengthen electron signals.
   c. to reverse current flow.
   d. to mix up the different kinds of current.

2. What are audio signals?
   a. picture signals.
   b. radio signals.
   c. sound signals.
   d. television signals.

3. What are video signals?
   a. picture signals.
   b. radio signals.
   c. sound signals.
   d. television signals.

4. Combining stages of amplification means
   a. to join two radio tubes together in a circuit.
   b. to join two transistor stages together.
   c. the two statements above are correct.
   d. the two statements above are wrong.

5. The laser is a machine that
   a. creates light waves.
   b. amplifies light waves.
   c. amplifies radio waves.
   d. converts light waves into thin rays.

6. An example of amplifying is
   a. using a car jack to change tires.
   b. electrons being converted into sound waves.
   c. electrons being conducted into radio waves.
   d. using a car jack to lift up an automobile.

7. Transistors and vacuum tubes are combined to
   a. strengthen the atoms in the radio.
   b. amplify weak signals.
   c. change alternating current into direct current.
   d. make the transistors oppose each other.
8. A laser machine is not used
   a. to kill people.
   b. to weld metals together.
   c. to cut thick pieces of metal in half.
   d. to operate on human beings.

9. Concentrated means
   a. to join electrons together.
   b. to bring together to a common point.
   c. to make something bigger.
   d. to convert light waves.

10. A frequency is
    a. the amount of work done in a certain time.
    b. the controlling of the electrons.
    c. a very short electromagnetic wave.
    d. the number of vibrations of oscillations in a given time.
ACTIVITY 13

SWITCHING

Today, you will learn some new words in the area of switching. The meanings of the words will help you to understand what you will be learning for the rest of the week.

SUPPLIES NEEDED

Dictionary
Encyclopedias
Textbook and workbook

PROCEDURES

1. Find the meanings of the following words and record your answers:
   a. computers
   b. analog computer
   c. digital computer
   d. switching
   e. pulses
   f. multivibrating
   g. gating
   h. electronics
2. Using the words above, make meaningful sentences for each word.

a. computers

b. analog computer

c. digital computer

d. switching

e. pulses

f. multivibrating

g. gating

h. electronics

i. technology

j. pattern
ACTIVITY 14

SWITCHING

Today, you will conduct an experiment to find out how switches can turn on, turn off, and change the direction of current flow.

EQUIPMENT AND SUPPLIES NEEDED

<table>
<thead>
<tr>
<th>Equipment (per group)</th>
<th>Supplies (per group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 hammer</td>
<td>2 blocks of wood 3&quot; square</td>
</tr>
<tr>
<td></td>
<td>2 1&quot; strips of metal</td>
</tr>
<tr>
<td></td>
<td>6 1d common nails</td>
</tr>
<tr>
<td></td>
<td>1 flashlight bulb</td>
</tr>
<tr>
<td></td>
<td>1 1½ volt dry cell</td>
</tr>
<tr>
<td></td>
<td>some connecting wire</td>
</tr>
<tr>
<td></td>
<td>sandpaper</td>
</tr>
</tbody>
</table>

Preparing the Experiment

1. Obtain the material and equipment from the teacher. Make sure you have everything that is listed above.

2. With the hammer drive two nails into the blocks of wood. Do not drive the nail all the way in. Leave about \( \frac{1}{4} \)" above the wood. (Two nails for each block of wood.) Look at the picture below.

3. With the hammer drive another nail through the piece of metal strip and into the wood. Do not drive the nails all the way through. Leave about \( \frac{1}{4} \)" above the wood. Look at the picture below.

4. Do the same thing on the other piece of wood block.

5. Cut five pieces of wire, each about 12" long.

6. Clean all the ends of the wire with sandpaper. Look at the picture below.
7. Wrap one wire around one of the pole of the battery. Wrap the other end to point A of the block of wood. (Look at the picture below.)

8. Wrap one wire around point B of one block and around point B of the other block of wood. (Look at the picture below.)

9. Wrap one wire around the nail at point C of one block and the other end of the wire at point C of the other block of wood. (Look at the picture below.)

10. Wrap one wire around the nail at point A of Block Z and the other end of the wire to the bottom of the light bulb. (Look at the picture below.)

11. Wrap another wire around the bottom of the light bulb and the other end of the wire to the empty pole of the battery. (Look at the picture below.)

Conducting the Experiment

1. Make sure that everything is assembled as shown in the picture above.

2. Make sure all the connections are wrapped tightly.
3. Place the metal strip of both blocks on point B. Make sure that the metal is touching the nail. The light bulb should now glow. If it does not glow, call the teacher to check your work.

4. Now place both metal strips on point C on both blocks of wood. Make sure that the metal is touching both nails.

5. The light bulb should once again glow. If it does not glow, call the teacher and ask for help.

6. Now place one metal strip on point B on one block, and on the other block place the metal strip on point C.

7. The light did not go on. Why can't the light go on in this position?

Summary

You have observed that when the switches are both on point B the lamp glows. It also glows when the switches are both on point C. But when one switch is on point B and the other switch is on point C the light does not go on. You can see that you can turn the light on and off with either switch. It goes on when you complete the circuit and off when the circuit is not complete.
ACTIVITY 15

SWITCHING

Review and Test Questions

Circle the correct answer for each question.

1. What is the analog computer used for?
   a. adding long numbers.
   b. multiplying long numbers.
   c. solving scientific problems.
   d. counting.

2. What is the digital computer used for?
   a. solving difficult scientific problems.
   b. solving long addition and math problems.
   c. finding the location of Mars.
   d. finding why a person is ill.

3. What is an electronic switch?
   a. an electronic "on" and "off" device.
   b. a device to turn on the house lights.
   c. a device to turn on some kind of power.
   d. an electronic device that "opens" and "closes" a circuit automatically.

4. Electricity cannot pass through an "open" circuit because
   a. the wires are tangled up.
   b. the wires are not joined together.
   c. there is something blocking the path.
   d. the wire is not covered.

5. Computers are machines that
   a. are used in an office for typing.
   b. are used to tell the time of day.
   c. are used to help man solve difficult problems.
   d. are used to build spaceships.

6. Computers are made up of
   a. many, many other machines.
   b. many, many switches.
   c. many different typewriters.
   d. many different kinds of adding machines.

7. The word "gating" in electronics
   a. describes an electronic part.
   b. is another word for transistors.
   c. is a switching method.
   d. is another word for joining vacuum tubes.
8. A thermometer works like which of the following:
   a. a digital computer
   b. an analog computer
   c. a gating computer
   d. a regular computer

9. A light switch works similarly to which of the following:
   a. a digital computer
   b. an analog computer
   c. a switching computer
   d. a counting computer

10. Multivibrating means
    a. having many switches.
    b. having many gates.
    c. having many frequencies.
    d. having many vibrations.
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