THE UNIVERSITY OF ALBERTA

THE UTILIZATION OF AN OPERATING AUTOMOBILE ELECTRICAL SYSTEM TO TEACH SELECTED CONCEPTS OF ELECTRICITY AT THE JUNIOR HIGH SCHOOL LEVEL

BY

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF EDUCATION

IN

INDUSTRIAL ARTS

DEPARTMENT OF INDUSTRIAL AND VOCATIONAL EDUCATION

EDMONTON, ALBERTA

FALL, 1973

ABSTRACT

A primary concern among industrial arts teachers has been the apathetic attitude of students regarding the electricity area. This study was carried out in an attempt to improve student reaction to the learning of selected concepts of electricity. An operating automobile electrical system was utilized as an audiovisual aid.

An investigation of learning psychology indicated some agreement on a number of generalizations that appeared helpful for designing audiovisual materials. Comparing the capabilities of an operating automobile engine to these generalizations was considered sufficient justification for the selection of an operating automobile electrical system as an audiovisual aid.

Concepts of electricity that an operating automobile electrical system could teach were selected from the <u>Junior High School Curriculum Guide for Industrial Arts</u> (Department of Education, 1969). A student workbook was designed to aid the teaching of those concepts selected.

The instructional activities were evaluated in a short feasibility study. Although the study was not designed to compare learning by alternate methods, it seems safe to say that some learning definitely occurred. The relevancy of the automobile appeared to be a positive motivational

factor.

Some activities contained too much research and to little "hands on" activity with the electrical system. Activities varied considerably in difficulty and time required.

To improve the efficiency of the instructional aid, the writer would suggest reducing in size a complete automobile chassis with all systems operable. Such an aid could then be utilized in several areas.

ACKNOWLEDGEMENTS

The writer wishes to express a sincere thank you to those who made this study possible.

To Dr. A. Meyers, who unfortunately left on sabbatical just before the completion of the study, for his guidance and encouragement when it was most needed.

To Assistant Professor D. W. Manuel who stepped in and notably fulfilled the supervisory task of bringing the study to a close.

To Dr. J. F. D. Ilott and Dr. K. L. Bowers for their helpful suggestions as members of the advisory committee.

To Mrs. Louise Wickware who typed the final manuscript.

To my children, Darryl, Patti Rae, and Craig, who although too young to understand the whole business cooperated to aid completion of the study.

Finally to my good wife Jean for her constant encouragement, her endless typing, and her humor.

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THE PROBLEM

Introduction

In June of 1967 a teacher in southern Alberta gave his 61 grade eight students a questionnaire concerning industrial arts activities (Harder and Day, 1967, p. 10, 11). Among other findings he discovered that students disagreed on their area of preference but agreed on the least desirable area. Such results could be expected in most junior high school industrial arts laboratories today. We expect and desire disagreement on a preferred area, but there is cause for alarm when students agree that the least desirable area is electricity!

Since students dislike electricity, one might question its inclusion in the curriculum. However, upon reflection, it is evident that electricity is a well founded area of study by reasons of its contributions to mankind--past, present, and future.

Provided students should study electricity, what factors could have created this apparent disinterest? Possibly Nelson's (1968) comment is applicable.

> Youth, wherever you find them, are beginning to discriminate sharply between relevant and irrelevant education experiences. They are beginning to demand

> something out of education not necessarily produced by mere compulsory attendance (p. 47).

If what is taught is relevant, it is probable that the problem lies in the methodology of teaching. This will be the area of concern for this study.

Methodology and the Study of Electricity

While many of the subject areas in industrial arts lend themselves to learning through the construction of carefully designed products, electricity is one of the exceptions. Products are not suitable in electricity, for such reasons as: time, cost, limited opportunity for experimentation, and limited correlation to objectives of the course (Gerrish, 1968, p. 26).

An alternative to the conventional project is a teaching system which uses solderless connectors and pre-mounted components to construct temporary circuits. It is known by a variety of names: circuit board, wiring board, and quick-connect method (Baker, Fowler, and Schuler, 1967, p. 55). Included in the system are a student workbook, a textbook, and a teachers' guide.

Such systems offer many advantages. The course content of most systems meets accepted standards regardless of the experience and knowledge of the teacher. Exact cost of the course is easily budgeted. Fast assembly and disassembly of experiments provides for maximum usage of students' time thus allowing a wide range of material to be covered. Their for individual instruction. Inventory control is simplified. A teacher can confidently train himself (Gerrish, 1968, p. 27).

However, such systems also have disadvantages. Most systems are designed for specific learning activities thus restricting research and development. Few systems provide for modification of existing components with technological change. Many systems are advertised as being suitable for junior-senior high school instruction, but such systems often are in too much detail for junior high school students. This is understandable as many systems were initially designed for use in military, industrial, technical, and trade schools (Pankowski, 1968, p. 40, 41). Furthermore, all too often the experiments are not meaningful to many students. They conduct the manual exercises without recognizing the underlying concepts or principles (Trudeau, 1967, p. 94).

> Complicating both the media _selection_ and the media _utilization_ problem, teachers also face other problems which are the result of the current educational scene—increased range of ability to be dealt with in an 'education for all' milieu, the need for educational acceleration, the 'knowledge explosion', the 'comprehensive school' (Briggs, Campeau, Gagne, and May, 1967, p. 7).

Although there has been an exponential development in communications technology (Harden and Day, 1967, p. 2), all to often, Herrick (1966) alleges, industrial arts teachers present to classes ". . . separated segments of content in the hope that the unsophisticated learner will grasp the particulars, connect them and acquire the knowledge or behavior desired (p. 59)."

However, Bruner's (1967, p. 31-32) observation is a reminder of the fallacy of this methodology. Such teaching makes it difficult for students to relate new learning to past and future learning. To create interest, learning must be useable beyond the situation in which the learning occurred. Unstructured knowledge that cannot be tied together is likely to be forgotten.

Feirer (1969) reflects that:

> In spite of all that has been written about audio-visual education and instructional technology, the fact remains that the varying techniques now available have made very little inroad into the average industrial education program (p. 15).

The truth of this statement is reiterated when one surveys the Alberta Junior High School Curriculum Guide for Industrial Arts (1969). It contains suggestions like the following: "Predesigned and programmed laboratory exercises will assist in the degree of student understandings (p. 6)." "The use of a product, whether individually produced, mass-produced or co-operatively developed, creates strong motivation for learning the concepts introduced (p. 51)." The suggested instructional media for the electricity area include one textbook and some pamphlets that one might obtain from a counselling and guidance office (p. 52-58).

Why have innovative techniques of instruction found limited usage in the classroom?

Barnard (1969) comments:

> Unfortunately, the development of the so called 'new media' tools has always been far ahead of the nations' teachers' ability to acquire and harness them to the specific software that will really realize the potential of the teaching devices (p. 18).

Wendt (1957) reasons:

> Busy teachers believe that it is easier to talk and to assign readings in the textbook than it is to spend time and effort selecting and using audio-visual materials. The ease with which words can be used in teaching constitutes their great danger to education. (. . . .) We forget that they are an artificial means of communication. We forget that the important thing in life is the meanings that we carry in our heads. We forget that teachers are trying to communicate meanings and that words and language are only an incidental means of doing this. We forget that they need to have rich experiences as well as an adequate vocabulary to describe their experiences (p. 30).

Whatever the reason, teaching methodology in the study of electricity is not utilizing the innovative potential available. Thus the significance of this study.

Purpose of the Study

Confronted with the need to augment student interest in the study of electricity, the general purpose of this study was to design, produce, and test the feasibility of an instructional aid for the study of electricity at the junior high school level. The specific purposes of the study were:

1. Justify the selection of an operating automobile electrical system as an instructional aid for teaching selected concepts of electricity.

2. State the selected concepts of electricity that

instructional activities would teach.

3. Design and produce instructional activities utilizing an operating automobile electrical system to teach selected concepts of electricity.

4. Conduct a feasibility study to determine if the instructional activities would teach selected concepts of electricity.

The Procedure of the Study

The utilization of an operating automobile electrical system as an instructional aid was justified by comparing its capabilities to the requirements of an instructional aid as suggested by learning theory.

Concepts of electricity to be taught were selected from the Alberta Junior High School Curriculum Guide for Industrial Arts. Only those concepts demonstrable by an operating automobile electrical system were selected.

An automobile engine was mounted on a stand and made operable. A student workbook was designed and produced. It contained 14 activities which utilized the operating automobile electrical system to teach selected concepts of electricity.

To determine if the instructional activities would teach selected concepts of electricity, a small feasibility study was conducted.

Definitions

Because some of the terms used in this study have a variety of meanings they are here defined in order to avoid ambiguity.

Electricity--"a form of energy present when electrons move through circuits (Buban et al, 1964, p. 437)."

Electronics--"the study of electrons and how they move through space and through special conducting materials (Buban et al, 1964, p. 437)."

Instructional activity--an activity by means of which the learning process can be carried on.

Instructional aid--"activity or illustrative material by means of which the learning process may be encouraged or carried on; includes audio and visual aids as well as other sensory aids (Good, 1959, p. 22)."

Concepts of electricity--abstract general notions about electricity as stated in the Alberta Junior High School Curriculum Guide for Industrial Arts (1969). In the student workbook (see appendix A) these concepts are parceled into sub-concepts to facilitate and organize teaching.

Limitations

This study was concerned with only selected concepts of electricity. Such a limitation was necessary because an automobile electrical system utilizes electricity of a direct current nature or a pulsating direct current nature. Futhermore, an operating automobile electrical system like most teaching devices has inherent restrictions.

The main purpose was to augment student interest in the study of junior high school electricity, not to compare the operating automobile electrical system as an instructional aid to other devices. Thus the feasibility study is brief and uncomprehensive.

Assumptions

The fact that electricity is a required area of study in the Alberta Junior High School Curriculum Guide for Industrial Arts (1969) implies that pupils need knowledge and appreciation of this area in order to be effective participating members of our industrial society.

If an operating automobile electrical system can be utilized to teach some concepts of electricity to junior high school students it will be useful.

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter is divided into three main divisions. Part one discusses the significance of electricity as an area of study. Portion two comprises a survey of research in industrial arts education. Item three presents a rationale for the utilization of an operating automobile electrical system as an instructional aid.

The Significance of Electricity as an Area of Study

The ability of electricity to serve mankind has become such an integral part of our modern way of life that we seldom realize how recently this genie has been harnessed for service (Crow, 1967, p. 18).

Prominent energy source. Leach (1965) reminds us that, ever since man made the first tools some 400,000 years ago, progress of civilization has largely depended upon harnessing energy and developing new sources.

From muscle slavery, man progressed to sails and windmills, water-mills, gunpowder, and finally the family of heat engines. With the era of heat engines, fuel acquisition became an ever present concern. Using wood as a fuel appeared to spell extinction for the forests. But coal was found to be a useful fuel and the pressure on the forests was relieved. Before coal reserves were depleted [illegible] invented the internal combustion engine and liquid fuel began to replace coal. With the heavy drain on liquid fuels they have recently been supplemented by natural gas. Man's present concern is the eventual exhaustion of both liquid fuel and natural gas reserves.

Electricity is rather a young energy source. But due to increasingly efficient production, ease of transport, and extreme flexibility, electricity is fast becoming the energy source of the future (Leach, 1965, p. 9-16). Since the first electric service was inaugurated some ninety years ago, the growth of the utility industry in economically advanced societies has doubled every ten years (Sporn, 1966, p. 2-3).

Electricity is one of the most important sources of energy in the world today--it is used almost everywhere (Mileaf, 1966, p. 1). Brady (1963, p. 296) adequately expresses the importance of electricity when he labels it the most important agent of our modern industrial system. Buban, Schmitt, and Kirchner (1964, p. 2-3) suggest that without electricity life today would be similar to pioneer days. To think of communications as we know them would be absurd. Electrically operated telephones, telegraphs, radios, televisions, and space satellites now facilitate almost instant communication all about the globe. Printing presses powered by electricity produce seemingly endless amounts of printed material. Newspapers even carry pictures sent by electrical means.

Air, land, and sea teem with vehicles utilizing electricity. Aided by an array of electrical devices, they deliver goods and services, quickly and safely, almost everywhere.

The host of electrically operated labour saving devices in the home and the world of work have now invaded the agricultural scene. Sporn (1966) remarks that human labor for farm chores such as: grain handling, milking, stock feeding, and watering can now be substituted by electric applications. Electricity is also utilized in: environmental control for cattle, poultry, and swine; hydroponic grass growing; and grain drying.

Electric computers and data processing equipment, so necessary to the modern business world, require exact environmental control and electric energy is the most effective for such control. Industry has substituted electric power for many applications formerly powered by gas and steam. Several industrial processes uniquely use electricity: electroplating; metal refining; resistance welding; the reduction of aluminum, magnesium, and titanium; and the production of ammonia, chlorine, and oxygen (Sporn, 1966, p. 4-7).

<u>Pollution free energy</u>. The industry and technology that produced the so called "good" things in life are also responsible for many of our problems (Feirer, 1970, p. 19). Because of misuse of technology, our number one challenge is environmental quality (McCammon, 1970, p. 286).

Leach (1965, p. 40) warns of the danger of pouring carbon dioxide into the atmosphere. The past century has seen the content rise by ten percent. This is fine for plants but not people. Furthermore, the increased concentration of carbon dioxide has created a green house effect. It stops some of the Earth's heat from escaping into space and in time the warmer atmosphere will raise the temperature of the seas with the result that plant life will increase and fish will move to cooler waters. The increased temperature will melt ice caps and glaciers thus raising the sea level and flooding large portions of now habitable land.

Recent newspaper headlines warn of the dangers of pollution from internal combustion engines. During the last week of July, 1970, a white smog blanketed the city of Tokyo for five days. The smog was formed by the sun's ultraviolet rays affecting automobile exhaust fumes. It killed trees and shrubs and sent 81,000 people to hospital (Oka, 1970).

Smog formed from exhaust fumes of automobiles and industrial plants in Los Angeles has been accredited with killing 100 acres of ponderosa pines. Pacific breezes carried the smog 80 miles to affect the trees (Faust, 1970).

Electricity on the other hand, can be a "clean" source of energy--the production of which can be nonpolluting. Although thermal electric plants contribute to air and water pollution, they continue to be used because of their efficiency. Hydroelectric plants are less efficient but are pollution free and as well benefit recreation, fish, and wildlife (Stout, 1965, p. 28-29). Some may disagree.

Survey of Research

"Teaching and learning in the area of electricity--electronics are complex processes about which little is understood (Baker, Fowler, and Schuler, 1967, p. 54)." A survey of research in industrial arts education attest to this statement.

The U.S. Department of Health, Education, and Welfare (1957, 1961, 1962) have published three volumes of summaries of studies in industrial education. In total they summarized 4,335 studies conducted between 1930-1961. Only 98 were in the field of electricity--electronics and of this number some 24 were concerned with developing and comparing methodology.

Although no studies mention the use of an operating automobile electrical system, one study did use an operating automobile engine to teach the internal combustion engine. Akers (1954) mounted a six cylinder Plymouth engine on a castored stand. Systems were color coded and windows cut at strategic points to permit student observation of the operating engine. The engine operated on the rear three cylinders. He concluded that the operating engine held the students' interest and attention and stimulated learning.

Phi Delta Kappa is another organization that prepares summaries of research in education. In the years spanning

1953-1969 they reported 727 studies in the field of industrial arts education. Of the 30 studies involving electricity--electronics some 15 were concerned with developing and comparing methodology. No reported methods utilized an operating automobile electrical system.

Abstracts of Instructional Materials in Vocational and Technical Education (AIM) from the fall of 1968 through to winter 1970 make no mention of utilizing an operating automobile electrical system.

Neither do the Abstracts of Research and Related Materials in Vocational and Technical Education (ARM) for the same time period. Furthermore, ARM report three reviews of research in Industrial Education, none mention the automobile. Streichler (1966) reviewed dissertations, theses, staff studies, personal research, journal articles, yearbooks, and speeches from 1960-1966. He discussed 31 methodology studies, six of which concerned electricity--electronics--not one mentioned an automobile.

Suess (1969) reported at a national conference concerning research in industrial arts. His appendix included annotated bibliographies by Miller and Streichler. Miller categorized 43 staff studies and other non-degree research under the headings of: Industrial Arts Teacher Education, Teaching Methods and Media, and Status and Need. None of the studies involved electricity--electronics.

Streichler commented on 336 doctoral theses completed in the years 1955-1968. Some 22 theses were in the area of electricity--electronics and 14 of these were concerned with developing and comparing methodology. Not one method mentioned an automobile.

Householder and Suess (1969) reviewed dissertations, staff studies, periodical articles, and reports of funded research from 1966-1968. Of the 65 methodology studies discussed, 12 were in the field of electricity--electronics--but again no mention of an automobile.

Householder (1968, p. 182) attributed the recent increase in methods studies to the availability of modes of instruction which had not traditionally been available.

A search of the literature produced one reference concerning the utilization of automobile parts to teach electricity. Ruiter (1969) a lecturer in electronics technology uses a mock-up of a working automobile electrical system for building, performing measurements, and trouble-shooting, automotive electrical circuitry. Systems are colored for easy identification. Parts are color coded to aid comparison of interrelated devices. A heater blower motor operates the distributor to allow students to adjust the dwell angle and check spark plug firing on an ignition analyzer. An electric motor operates the generator to allow students to adjust the voltage regulator.

Obviously this project is quite different from that proposed by this study. Besides being a mock-up and powered by electrical power, its purpose is to teach building, measuring, and troubleshooting automotive ele[illegible] circuitry. This is quite different from utilizing an operating automobile electrical system to teach selected concepts of electricity.

Rationale for the Utilization of an Operating Automobile Electrical System as an Instructional Aid

The Necessity of Audiovisual Materials

Education is defined by Thorndike-Barnhart (1957) as the " . . . science or art that deals with the principles, problems, etc. of teaching and learning (p. 263)." Smith (1968) reflects that:

> We know that learning is something people do for themselves; and people, places, and things can either impede or facilitate the process. Today's learner comes to school with a vast array of experiences and loosely related facts learned through active, dynamic, sensory involvement and discovery. This is a new kind of learner and only through modern media can he continue to learn (p. 19).

Bruner (1960) sees the teacher's task as one of " . . . communicator, model, and identification figure (p. 91)" and this task " . . . can be supported by a wide use of a variety of devices that expand experience, clarify it, and give it personal significance (p. 91)." Both Smith and Bruner suggest the need for audiovisual materials. This section will present a rationale for the design of such materials.

Guidelines for Designing Audiovisual Materials

When planning and producing audiovisual materials, Kemp (1968, p. [illegible]) suggests three areas of concern.

Fundamentally there is a need to know: how people perceive things, how they communicate, and how they learn. Secondly, reports on research studies can provide evidence of effectiveness of audiovisual materials. Thirdly, utilizing the preceding information one can then develop objectives and plan how to meet them. Therefore, let us investigate each of these areas and see what they advocate.

<u>Perception</u>. Webster (1963) defines perception as "the act, state, or faculty of receiving knowledge of external things by the medium of the senses (p. 539)." This knowlege makes communication possible and communication usually results in learning (Kemp, 1968, p. 10). Kemp suggests that:

> . . . an individual reacts to only a small part of all that is taking place around him at any one instance. He 'selects' that part of the world he wants to experience, or that attracts his attention at any one time. (Hence one needs to design materials that will attract the attention and hold the interest of the learner.) The experience of perception is individual and unique. It is not exactly alike for any two people. A person perceives an event in terms of his past experience, present motivation, and present circumstances.

Kassay (1969, p. 36) reminds us that the visual sense accounts for approximately 85% of learning and the aural sense 10%. Therefore in designing audiovisual materials, it is essential to provide desirable perceptual experiences involving these two senses.

<u>Communication</u>. Webster (1963, p. 168) defines communication as the act of imparting or sharing. Dale (1969) more specifically defines it ". . . as the sharing of ideas and

feelings in a mood of mutuality (p. 10)." Kemp (1968, p. 11-12) presents a model to illustrate the sequences involved in communication.

A mental message originates in the brain of an individual. It is encoded into a transmittible form and passes through a transmitter (film, print, telephone, television) via a channel (light, page, wire, air) to a receiver (eyes, ears, nerve endings) where the message is decoded. When there is a response from receiver to sender it is called feedback. This allows the sender to correct his message and assist the receiver in decoding. Any disturbance that interferes with the message is classified as noise. Where possible noise should be avoided, but if it cannot the factor of redundancy is often used to overcome its effect.

In the design of audiovisual materials it is essential to be cognizant of where they fit within this communication framework and exactly how the process operates for effective communication.

<u>Psychology of learning</u>. Gagne (1967) defines learning as " . . . a change in human disposition or capability, which can be retained, and which is not simply ascribable to the process of growth (p. 5)." Kemp (1968) states:

> Since a major purpose for preparing audio-visual materials is to effect behavio[illegible] serve objectives, it is appropriate to [illegible] psychology of learning for some help in [illegible] principles that would guide the planning of effective audio-visual materials. Unfortunately, learning theory, as a body of knowledge, as yet has contributed

> little directly to the design of such materials (p. 12).

Gagne (1970) comments that it is necessary " . . . to recognize that learning theory as it exists today is a highly inelegant and unfinished entity (p. 51)." However, they both agree that learning theory does provide a number of useful generalizations. Therefore we shall now take a brief look at a number of learning theories, report their areas of emphasis and agreement as related to the design of audiovisual materials, and present a rationale for the utilization of an operating automobile electrical system to teach selected concepts of electricity.

Learning Theories

Gagne (1970, p. 52-56) presents an overview of four learning theorists--Miller, Skinner, Gagne, and Ausubel--whose ideas are important to designing instruction.

Miller suggests four principles for effective instruction: motivation, cue, response, and reward. To be motivated the learner must want something. A cue involves noticing something. In response the learner must do something. As a reward the learner must get something he desires.

Skinner is in agreement with Miller's principles but tends to be more specific concerning the importance of the cue in learning. Skinner calls it stimulus control and imparts three further principles: shaping, successive approximation, and chaining. Shaping applies to learning motor acts. [illegible] motor response, reinforcement is such as to [illegible] response to be more and more exact. Successive approximation involves the learner responding correctly even as the prompts progressively fade. Chaining involves proceeding in a step-by-step fashion such that each step is connected with the others which precede it.

Gagné presents two principles of learning. Initially he emphasizes eight different kinds of learning, each of which occurs under a different set of conditions (Gagné, 1967, p. 33-57).

1. Signal learning. An involuntary behavior acquires a connection with some sort of signal.

2. Stimulus-response learning. A specific stimulus produces a voluntary precise response.

3. Chaining. The connecting in a sequence two or more previously learned stimulus-response motor learnings.

4. Verbal association. A new learning is coded to one or more previously learned verbal stimulus-responses.

5. Multiple discrimination. One takes a series of stimulus response learnings and renders the stimuli for each as highly distinctive as possible to facilitate discrimination.

6. Concept learning. One learns to respond to stimuli in terms of abstracted properties--color, number, position and shape.

7. Principle learning. The chaining of two or more

concepts.

8. Problem solving. "Thinking out" of new principles using previously learned principles.

Gagné's second principle is that new learning builds upon prior learning and each new learning requires a minimal prerequisite. Related to his eight conditions of learning this means each condition depends on the conditions sequentially preceding.

Ausubel proposes four principles of learning.

1. Subsumption. New learning must be subsumed into a meaningful structure of already existing knowledge.

2. Progressive differentiation. Content should be presented from general ideas to more specific ones.

3. Consolidation. Ongoing lessons must be mastered before proceding to new material.

4. Integrative reconciliation. New ideas must be related to old ideas.

Learning Theories Related to the Design of Audiovisual Materials

Upon reviewing these four theories of learning Gagné (1970, p. 59-60 proposes what would appear to be the most important events of instruction in the learning of principles, facts, generalizations, and rules.

1. Initially attention must be attracted and maintained. It has been known for some time that attention can be attracted by such things as change, nove[illegible] and appeal

to dominant interests. However, somewhat less is known about the maintenance of attention. It is presumed that attention can be maintained by achieving a set goal which relates to one or more individual goals.

2. Before undertaking new learning a learner must keep in mind or be reminded of what he already knows which is applicable to the new learning.

3. Learning is guided by verbal or pictorial instructions that suggest new principles without actually stating them.

4. The learner must receive feedback. If the instructional objectives are clearly defined, the learner will be aware when he has accomplished each specific goal.

5. Conditions must be established for remembering and transfer of learning. Remembering requires review. Transfer requires that the newly learned principle, fact, generalization, and/or rule be applied to carefully designed problems.

6. Outcomes must be assessed frequently. Specifics need to be assessed more so than learning of the generalities.

Kemp (1968, p. 12-13) cites Carpenter and Dale as additional writers who offer practical interpretations of learning theories. Although they offer a greater number of important events of instruction they relate well to the preceding conclusions of Gagné.

1. Importance of motivation to the learner.

Carpenter (1957) states:

> . . . provided the stimulus materials are adequate, i.e., have stimulus values which fall above thresholds of perception and cognition of perceiving and understanding, then the amount and kind of learning is predominately determined by the capacities and motivational processes of the individual learner rather than the stimulus situations. Therefore, it would seem that the most important and persistently basic task of teaching is to release, instigate, and increase such motivational processes and forces as interest, the need, desire or wish to learn (p. 363).

Ruiter (1969) suggests we: "Capitalize on student interest in automobiles to give meaning to basic electrical formulas (p. 64)." Akers (1954) concluded that an operating automobile engine held the student's interest and attention and stimulated learning.

2. Personal relevance concept. Carpenter (1957) reflects that:

> Facts and principles, systems of knowledge and values, patterns of perception and motor skills all become alive and significant only within the context of individuals and the relevant parts of their 'life space' (p. 364).

The automobile is certainly relevant to many as most of us accept it as a way of life (Alberta Motorist, Summer 1971, p. 4).

3. Individual Difference. Gagne (1970 states: "The site of learning is the individual's central nervous system. For this fundamental and unarguable reason, learning is individual (p. 58)."

However, just what is involved in individual instruction is unclear to some people. Barnard (1969) comments:

> Certainly there is a definite trend toward individualization and self-instruction. But haven't industrial arts teachers always subscribed to the philosophy of individualized instruction? Teachers have always moved from student-to-student in the shop, observing and giving help when it was needed (p. 18).

In clarification, Wolfson (1966) maintains:

> Merely permitting different rates of speed will not provide for individual differences. Essentially, individualizing instruction requires the teacher to encourage individual interests, allow for individual styles, and respond to individual needs (p. 32).

Carpenter (1957) reflects:

> The question of how to achieve desirable common educational standards, while at the same time managing the problem of great individual variability, is a persisting problem for all educators including the professionals in the audio-visual field. . . . In this complex area, as yet reaching decisions as to how and when to use different audio-visual materials and methods is perhaps more of an art than a science (p. 366).

Baker (1968) proposes that this means for industrial arts:

> If it is generally recognized that all students are different, it would also seem logical that no single type of industrial arts program will be sufficient to meet the needs of all. Logically then, the desirable industrial arts program will include many methods, a varied interest, a flexible system of presentations and a continual self-evaluation process (p. 13).

4. Need for organization. Carpenter (1957) asserts:

> The processes of organizing separate facts and "bits" of information into meaningful cohesive wholes are of basic importance in presenting materials to be learned. Given constant amounts of effort and time, organized materials advance and extend achievement more effectively than unorganized or poorly organized materials. . . . It should be clear to teachers as well as to students that the primary responsibility for learning any subject

> and integrating it into a 'life frame' is that of the student. Getting students to accept the responsibility for their own learning, including organization, interpretation, and application of what they learn, is a major task of teaching (p. 367).

Baker et al (1967, p. 72), in summarizing findings of 12 research studies concerning electricity-electronics, found no method of teaching was clearly superior. They conclude that the organization of the course and its content may be more important than the method employed.

5. Participation and practice. Carpenter (1957, p. 367-368) declares: Audio-visual materials and methods have received widespread criticism for an alleged reduction of participation and overt practice. This criticism springs from the lack of knowledge concerning the actions inherently involved in learning. Perception is activity. Hearing, seeing, thinking are activities. Abstracting, using symbols, deducing, generalizing, inferring, and concluding are all activities. In fact, the need in learning for: active interest, personal involvement, 'sharing', cooperative effort and goal directed work, may not be satisfied by only overt action.

Whitehead (1952, p. 166) feels that the inactiveness and passiveness required of students in most educational programs relates to our ineffectiveness.

Bruner (1960, p. 72) alleges our mass-communication entertainment-oriented culture sees too much passivity and spectatorship.

Support for participation and practice is found in several surveys of research cited by Kemp. Hoban and Van Ormen (1950) surveyed experiments and studies conducted from 1918-1950 concerning the instructional value of motion pictures. Of their 25 findings, one related to "hands on" learning. They found that learning increases if the learner practices a skill while it is presented on the screen providing the film speed is slow or the film stops to allow for practice.

May and Lumsdaine (1958) report on a series of experimental studies between 1946 and 1954 conducted by the Yale Motion Picture Research Project. They also reported the value of participation by the learner.

Travers (1967) reviewed studies from 1950 to 1964 relating to the transmission of information through the senses. Among his findings he too found that participation--overt or covert--results in increasing learning.

6. Repetition and variation of stimuli. Carpenter (1957, p. 368) alleges that nothing absolutely new can be learned effectively with one exposure. Repetition reinforces and extends learning. Variations sustain attention, instigate interest, and broaden the pattern of learning. Repetition with variations provides time for learning and time for learning is essential.

An Operating Automobile Electrial System as an Instructional Aid

Many students are interested in automobiles (Ruiter,

1969) and an operating engine retains their attention (Akers, 1954). Therefore, an operating automobile electrical system would appear to be a good motivational device.

Because automobiles are so numerous and so many people depend upon them, an operating automobile electrical system should be relevant.

Learning, however, is an individual matter and the value of an operating automobile electrical system as an instructional aid will vary among students. The instructional activities can be organized in a meaningful manner. Students will participate in hearing, seeing, thinking as well as doing. Repetition and variation can be built into the instructional activities.

Thus an operating automobile electrical system should be useful as an instructional aid.

Summary

Although electricity has been serving mankind but a short time its contribution has been extensive. Efficient production, ease of transport, and flexibility have elevated electricity to the most important agent in our modern industrial system. From farm to factory, home to office, it is utilized in various applications.

At a time when pollution is a key concern, it is significant that electricity can be a clean source of energy. Unfortunately at present, the most efficient method of production is the most polluting.

A review of research in industrial arts education revealed little about teaching and learning in the area of electricity. Methodology studies are in the minority and few of these deal with electricity. In reviewing 5441 studies in industrial education spanning the years 1930-1970,[8] no mention was found of utilizing an operating automobile electrical system to teach selected concepts of electricity. Only two studies related to an automobile but both were different from this study.

Because today's learner comes to school with a variety of experiences from involvement and discovery, it is generally agreed that audiovisual materials are needed to further his school learning. The design of audiovisual materials must take heed of three main areas: how people receive knowledge, how they share ideas and feelings, and how they retain changes in their dispositions or capabilities.

From a review of various learning theories there appear to be a consensus on several events. Attention must be attracted and maintained. New learning must be related to previous learning. Without stating them, new principles can be suggested by verbal or pictorial instructions. Review and application of new learning is required. Assessment of outcomes must be frequent.

An operating automobile electrical system should be relevant and motivating for many students. Students will be involved through several senses. Activities can be repeated and varied. Thus it should be a useful instructional aid.

CHAPTER III

PROCEDURE OF THE STUDY

The purpose of this study as previously outlined in Chapter I, was to design, produce, and test the feasibility of an instructional aid for the study of electricity at the junior high school level. This chapter will discuss the design and production of the instructional aid. The feasibility study will be dealt with in Chapter IV.

Design for the Utilization of an Operating Automobile Electrical System as an Instructional Aid

The selection of an operating automobile electrical system as an instructional aid came about for two reasons. Primarily, confronted with the need to augment student interest in the study of electricity, it appeared plausible that such a system might be interesting to many students. Secondly the study presented an informative challenge to the writer.

Upon selecting the topic the preceeding task was to research a rationale, to determine if electricity was a valid area of study and to determine if an operating automobile electrical system could be an instructional aid.

Rationale for the Utilization of an Operating Automobile Electrical System as an Instructional Aid

A review of research in industrial arts education revealed but two mentions of the automobile in teaching. Akers (1954) stated that an operating automobile retained student attention. Ruiter (1969) observed that many students are interested in automobiles.

Upon reviewing various learning theories there appeared to be a consensus on several events necessary for learning. The event of attracting and maintaining attention could perhaps be accomplished by an operating automobile electrical system. Other events--new learning related to previous learning, suggesting principles by verbal or pictorial instructions, reviewing and applying new learning, frequent assessment of outcomes--could be provided for in the production of the instructional activities. Thus it appeared an operating automobile electrical system could be a useful instructional aid.

Production of Instructional Activities Utilizing an Operating Automobile Electrical System as an Instructional Aid

Identification and Selection of Electrical Concepts to be Taught

In order to identify the electrical concepts to be taught this writer referred to the Alberta *Junior High School Curriculum Guide for Industrial Arts* (1969, p. 51-58) which contains the suggested course content for electricity.

An operating automobile electrical system like most teaching devices was unable to teach a complete electricity course. Naturally only those concepts demonstrable by such a system were selected.

Following is the curriculum guide's recommended topics and related concepts. The asterisk denotes those concepts selected.

A. Uses of Electricity

The conversion, application and control of energy is basic to the development and perpetuation of a technological society.

1. Heating*
2. Lighting*
3. Motor (magnetic induction)*

B. Safety

Safe attitudes and knowledge of proper procedures in the use of equipment and materials is vital to man's survival.

1. Machines*
2. Clothing*

C. Sources of Electricity

a) Electrical energy can neither be created nor destroyed but can be changed in form.

b) Variables governing electron movement can be detected and/or measured.

1. Friction
2. Generator*
3. Crystal Cartridge
4. Solar cell
5. Thermocouple
6. Batteries*
7. Thermo-Electric Generator
8. Fuel cells

D. Controlling Electric Energy

Electron movement can be controlled and manipulated.

1. Circuit--switches*, breakers*, relays*, fuses*, photo cells, resistors*--rheostat*, capacitors*, coils*, transformers*

2. Series circuits*
3. Parallel circuits*
4. Telephone circuit
5. Telegraph circuit
6. Teletype circuit

E. Educational and Occupational Projections

A productive society must prepare its youth to make realistic vocational choices.

1. Guidance

Instructional Activities

Upon selecting the electrical concepts the subsequent step was to design and write a student workbook to facilitate the teaching of these concepts (see Appendix A). The main portion of the workbook consisted of 14 activities each concerned with one or more related concepts.

Activities were organized as follows:

A. Sources of Electricity

1. Storage Battery--Discharging
2. Storage Battery--Charging
3. Generator

B. Controlling Electricity

4. The Electric Circuit
5. Circuit Loads and Paths
6. Protective Devices
7. Relay
8. Solenoid
9. Rheostat
10. Step-up Transformer
11. Capacitor (condenser)
12. Ohm's Law

C. Utilization

13. Lighting
14. Motion

Such an organization groups similar activities and logically leads students through concepts of: production, control, and utilization. However, the activities are written such that they can be used separately or referred to when they relate to a particular teacher's own outline of study.

Students participate in hearing, seeing, thinking, as well as doing. Concepts are generally repeated and varied to provide for different learning rates. Students can stop when they have learned a concept, but should they require additional practice they can work through varied sections of the activity which deal with the same concept until they learn the concept.

The inclusion of a pre-test allows those students who already know the concept simply to receive credit for their knowledge. Other students who know part of a concept may be able to work on part of an activity and receive credit for the part they know.

In addition to a bibliography sheet of suitable reference texts, the workbook also contains an Engine Operation Safety sheet and information sheets for measuring current, voltage, and resistance.

A separate manual was written for the teacher (see Appendix B). It describes the physical setup of the operating automobile electrical system utilized by this study. As well as outlining a procedure for the use of the workbook, a suggested safety program is provided.

A photograph was taken to aid the reader in comprehending the physical setup of the operating automobile electrical system (see Appendix C).

The feasibility study is described in the following chapter.

CHAPTER IV

FEASIBILITY STUDY

Planning

The terminating step of the study was to conduct a simple feasibility study. It was assumed that if junior high school students could work through the activities and learn some concepts of electricity, then the instructional aid would be useful.

Construction of Hardware

When the topic of the study was initially selected, it became imperative to obtain an automobile engine. Upon making the need known to the students, a complete but collision damaged 1957 Chevrolet came forth the first week.

The engine was removed and mounted on a metal stand. Before attempting to operate it, the engine was partially dismantled and checked. The cylinder head, pistons, starter, generator, carburetor and fuel pump were removed. Starter brushes were replaced. An exhaust valve was stuck and had caused three rocker arm supports to break. These were welded and the valve repaired. A cylinder ridge reamer was utilized and the ring seats cleaned. Upon cleaning all parts, the engine was reassembled. The exhaust system was shortened to include the muffler closer to the exhaust manifold. With the addition of a radiator, battery, and small fuel tank, the engine was operable.

In the early stages of the study, the instructional activities had been designed and tested, for the most part, on crude makeshift hardware. To facilitate student involvement much of the hardware had to be modified or re-built.

An instrument panel was attached to the side of the supporting frame. It included: the speedometer; temperature, fuel and ammeter gauges; generator, oil, and directional indicator lamps; lighting, ignition, and door jamb switches; horn button; fuse panel; voltage regulator; and choke and throttle controls. Instrument panel lamps were mounted in the temperature and fuel gauges and speedometer housing. In rendering the components operable, often separated connections were color coded to facilitate re-connection.

The heater circuit, horn circuit, and brake circuit were mounted on movable upright panels with appropriate leads to join them to the engine electrical system. Circuit validity was maintained while attempting to simplify circuit identification.

Mounts were designed for head and tail lamps. In order to simplify the headlamp circuit, one lamp was a high beam, the other a low beam.

The fuel tank unit was mounted in a cutaway wooden box about the size of a small engine fuel tank. A hole cut in one side of the tank unit housing, allowed observation of the rheostat.

Selection of Students

The sample for the feasibility study comprised some 52 boys from ten industrial arts classes at St. Brendan Junior High School, Edmonton.

Because some of the activities required two participants it was decided that all students would work in pairs. Initially, four students were randomly selected from each class. Students were told that their participation was entirely voluntary and five chose not to be involved. At the end of the first week, ten activities had been studied. However, random selection seemed unfair to some students who were working in other areas and the comprehensiveness of the feasibility study did not require it. Thus the remainder of the study was completed by asking for volunteers among grade seven and grade nine students who were presently working in electricity and electronics.

Control of Activities

There was no particular order in which the activities were carried out. Activities were dispatched to students when the necessary hardware was made operable. The only structure was an attempt to have a variety of grade levels performing a specific activity.

Upon beginning an activity, each pair of students received a loose leaf notebook containing: an Engine Operation Safety sheet; information sheets for measuring current, voltage, and resistance; and the activity they were to perform.

The writer pointed out to the students the concept(s) and sub-concept(s). Their objective was noted and the purpose of the pre-test explained. They were encouraged to answer as much of the pre-test as possible and told they would receive credit for their knowledge.

All activities were carried out during regular industrial arts classes. The writer was in the laboratory teaching the remainder of the class. Participants in the feasibility study received the same attention as their classmates.

Data Collected

Students recorded on their activity sheet their names, time started and time finished. Upon completing the activity they were asked to write a comment comparing the activity to other activities in electricity. Those with no experience in electricity were asked to compare it to any industrial arts activity.

While the students worked, the writer made periodic observations and recorded a comment as to how they approached their task and how they carried it out.

Upon completing the activity, the answers were graded and discussed with the students. The results of their performance is summarized in table one. Comments concerning their performance will follow in chapter five.

TABLE I

SUMMARY TABLE OF STUDENT PERFORMANCE

Instructional activity	Grade of student pairs	Time taken in minutes	Possible grade	Actual grade
# 1	7	70	7	5/7
# 2	9	65	13	13/13
	9	73	13	8/13
# 3	9	50	12	2/12
# 4	*8	60	92	31/37
	*7	90	92	31/59
# 5	9	80	28	7/10
	7	80	28	26/28
# 6	*8	80	27	17/27
	7	80	27	17/27
# 7	*7	50	13	9/13
	9	100	13	7/13
	9	72	13	11/13
# 8	*8	50	9	9/9
	9	40	9	6/9
# 9	*9	70	33	20/33
#10	*8	120	8	6/8
	9	35	8	4/8
#11	*7	85	7	5/7
	9	40	7	4/7
#12	*9	90	40	20/25
#13	*7	20	23	21/23
	9	70	23	22/23
#14	*9	95	10	4/10
	7	85	10	8/10
	9	50	10	10/10
	N=52			

Note * Indicates the students randomly selected.

Summary

The terminating step of the study was to conduct a simple feasibility study to determine if the instructional activities, that had been designed and produced, could teach selected concepts of electricity.

An automobile engine was obtained and mounted on a stand. Necessary repairs and cleaning were carried out, and the engine made operable. Hardware was modified or re-built to facilitate student involvement.

Fifty-two boys from ten industrial arts classes at St. Brendan Junior High School, Edmonton, comprised the sample for the study. Four students in each class were randomly selected. At the end of one week random selection was abandoned as it seemed unfair to some students. The study was completed by asking for volunteers among the grade seven and grade nine students who were presently working in electricity and electronics. A summary of student performance appears in table I.

CHAPTER V

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Summary

Although electricity is a significant area of study, many students are apathetic in their inquiry. The general purpose of this study was to design, produce, and test the feasibility of an operating automobile electrical system as an instructional aid for the study of selected concepts of electricity at the junior high school level.

It was surmised that an operating automobile electrical system could be justified as an appropriate instructional aid if it complied with certain requirements. Such requirements, it was conjectured, could be derived from learning theories.

A review of learning psychology indicated an absence of real principles but it did propose a number of useful generalizations to guide the planning of effective instructional materials.

Sparse deductions concerning the automobile, or any of its systems, as an instructional aid were unearthed in the literature. But it appeared that an operating automobile electrical system may possess some of the requirements of an instructional aid. The remaining requirements could be instituted when designing the activities utilizing the aid.

Bearing the requirements in mind, a student workbook of 14 activities was designed and produced. Concepts of electricity to be studied were selected from the Alberta Junior High School Curriculum Guide for Industrial Arts.

The instructional activities were evaluated in a short feasibility study.

Conclusions

Purposes of the study

The specific purposes of this study, as outlined in chapter one, were accomplished. An operating automobile electrical system meets some of the requirements of an instructional aid for teaching selected concepts of electricity. Although the curriculum guide listed a number of concepts, it was possible to state several that instructional activities could teach. Instructional activities utilizing an operating automobile electrical system to teach selected concepts of electricity were designed and produced. The feasibility study indicated that the instructional activities would teach selected concepts of electricity.

Feasibility study

Although this study was not designed to compare learning by alternate methods, it seems safe to say that some learning definitely occurred.

Student reaction was generally favourable. The operating automobile electrical system was a relevant instructional aid for many students. Some students interpreted the activities to be learning about the electrical parts of an automobile rather than selected concepts of electricity. However as the parts they mentioned--storage battery, horn relay, solenoid, capacitor--all demonstrate concepts of electricity, this was not misleading.

Most students approached the instructional activities with some degree of keeness. The variation in degree related more to the students involved than to the activity. Five students chose not to cooperate and in each instance other students volunteered to take their place.

In some cases, especially grade nine, motivation decelerated when students encountered questions which required their personal research. For the most part the grade seven and grade eight students maintained their initial level of motivation.

Only two students, both in grade seven, were able to complete a pre-test satisfactorily. Most students could not correctly answer any portion of a pre-test.

The instructional aid presented an excellent opportunity to reinforce practical safety, especially concerning carbon monoxide poisoning.

With a simple feasibility study it is impossible to make profound conclusions. Where one pair of students encountered stumbling blocks another pair had no difficulty. However, it seems safe to say that there were problems.

Some activities contained too much research and too little "hands on" activity with the electrical system. Activities varied considerably in difficulty and in time required for performance. Some circuits, although simplified, were difficult to trace. The fact that electricity involves a number of arduous concepts does not aid its teachability.

The workbook of instructional activities is by no means a panacea to the problem of teaching concepts of electricity, but it was interesting and educational to many people, especially the writer.

Implications

The results of this study should indicate that we have a wealth of inexpensive and relevant systems around us that should be explored as instructional aids. It is hoped that others will go beyond the feasibility stage and rigidly test and compare the learnings from such systems.

Possibly we have been so concerned with buying the "latest system" to solve our problems that we have forgotten to be cognizant of what is at our doorstep.

Suggestions

Hardware. Because of the work required to design and produce such instructional activities, one may question if it is worth the time. To increase the efficiency of the instructional aid the writer would suggest the following idea.

Reduce a small automobile chassis to half its length and a width of about 54 inches. A number of industrial arts laboratories have a 60 inch side door. Thus one could move the automobile outside for operation or move it to other schools. Because the exhaust output of an automobile is too much for the exhaust fan system found in many junior high schools, outside operation becomes convenient. Furthermore, exhaust systems on older automobiles are difficult to maintain in a leakage free condition.

If all the automobile systems were made operable, with appropriate sections cut away, the aid could also be utilized for the study of power and power transmission. A self propelled automobile would also be most realistic and probably add further motivation.

Software. Two activities in particular require special mention. Activity number four is quite lengthy compared to the other activities. It involves some eight different circuits. However, many students do not need five examples of series circuits and three examples of parallel circuits in order to understand the appropriate concepts. Students should be given the opportunity to complete the post-test when they are prepared and not wait until they have worked through all eight circuits.

Activity number nine takes considerable time because it necessitates some nine measurements with various meters. As well, students develop Ohm's Law in three instances. Although difficult to shorten in content, time would be saved if students were more accustomed to using meters.

Further research. All of the students involved in the feasibility study were somewhat accustomed to following instructions prepared by the writer. Before adopting the student workbook on a large scale, one should test the readability and content of each activity with a large sample of students under rigid testing conditions.

It may be beneficial to compare the results of student pairs working through all 14 activities with the results of student pairs completing just one activity.

Upon analyzing the results in Table I it is evident that further research should investigate the optimum length of activities. In this case those activities with a possible grade of more than 33 were not completed.

BIBLIOGRAPHY

SELECTED BIBLIOGRAPHY

Akers, O.B. "An Audio Visual Aid for Teaching the Internal Combustion Engine." Unpublished master's thesis, Ohio State College, 1954. Reviewed in Research in Industrial Education. Summaries of Studies 1930-1955. Washington: U.S. Government Printing Office, 1957.

Baker, G.E. "Teachers--Their Own Worst Enemy." Journal of Industrial Arts Education, 27 (February, 1968), 13.

Baker, G.E.; Fowler, R.J.; and Schuler, C.A. "Research in the Area of Electricity-Electronics." Industrial Arts and Vocational Education, 56 (December, 1967), 54-56, 72.

Barnard, D.P. "Change, Educational Technology, New Media, and You." Industrial Arts and Vocational Education, 58 (June, 1969), 18-19.

Barnhart, C.L. Thorndike-Barnhart Comprehensive Desk Dictionary. New York: Doubleday, 1957.

Buban, P.; Schmitt, M.L.; and Kirchner, H.B. Electricity and Electronics. Toronto: McGraw-Hill, 1964.

Brady, R.A. Organization, Automation, and Society. The Scientific Revolution in Industry. Los Angeles: University of California Press, 1963.

Briggs, L.J.; Campeau, P.L.; Gagné, R.M.; May, M.A. Instructional Media: A Procedure for the Design of Multi-media Instruction, A Critical Review of Research, and Suggestions for Future Research. Pittsburgh: American Institute for Research, 1967.

Bruner, J.S. The Process of Education. New York: Vintage, 1960.

Carpenter, C.R. "Psychological Concepts and Audio-Visual Instruction." Audio-Visual Communication Review, 5 (January, 1957), 361-369.

Cochran, L.H. "A Review of Research in Energy and Propulsion." Industrial Arts and Vocational Education, 58 (May, 1969), 80-84.

Crow, L.R. Learning Electricity Fundamentals. Slough: Foulsham, 1967.

Dale, E. Audiovisual Methods in Teaching. New York: Holt, Rinehart and Winston, 1969.

Department of Education. Junior High School Curriculum Guide for Industrial Arts. Edmonton: Department of Education, 1969.

Faust, J.L. "But Air Pollution Threatens," New York Times, (October 25, 1970), 39.

Feirer, J.L. "Audio-Visual Education in Industrial Education." Industrial Arts and Vocational Education, 58 (June, 1969), 15-16.

Feirer, J.L. "MURC, Pollution and Industrial Education." Industrial Arts and Vocational Education, 59 (October, 1970), 19.

Gagné, R.M. The Conditions of Learning. New York: Holt, Rinehart and Winston, 1967.

Gagné, R.M. "Learning Theory, Educational Media and Individualized Instruction." Educational Broadcasting Review, 4 (June, 1970), 49-62.

Gerrish, H. "Projects or Breadboards--an Appraisal." Industrial Arts and Vocational Education, 57 (November, 1968), 26-27.

Good, C.V. Dictionary of Education. New York: McGraw-Hill, 1959.

Harder, J.D. and Day A.A. "Statistics." Industrial Arts Newsletter. 5 (September, 1967), 10-11.

Harder, J.D., and Day A.A. "Making Audio-Visual Media Pertinent." Industrial Arts Newsletter, 5 (October, 1967), 2-6.

Herrick, I.W. "Let's go to Work." Journal of Industrial Arts Education, 25 (April, 1966), 58-59.

Hocking, C. "How Use of Media Can Help the Industrial Arts Instructor." Industrial Arts and Vocational Education, 58 (June, 1969), 24-26.

Householder, D.L. "Techniques and Modes of Instruction." Review of Educational Research, 38 (October, 1968), 382-394.

Householder, D.L., and Suess, A.R. Review and Synthesis of Research in Industrial Arts Education. Research Series No. 42. Columbus: Ohio State University, 1969. (ERIC: ED 034 898).

Kassay, J. "Self-Instructional Systems." Journal of Industrial Arts Education, 29 (September, 1969), 35-40.

Kemp, J.E. Planning and Producing Audiovisual Materials. Scranton: Chandler, 1968.

Lauda, D.P. "Seven Rules for Effective Media Usage." School Shop, 27 (April, 1968), 72-73.

Leach, G. New Sources of Energy. London: Phoenix House, 1965.

Lundy, L.L. "Programed Instruction and its Application to Teaching Industrial Arts." Industrial Arts and Vocational Education, 58 (June, 1969), 37-39, 46.

Moore, T., ed. "Air Pollution Isn't New." The Alberta Motorist. (Summer, 1970), 4, 12.

McCammon, L.C. "Man's Greatest Challenge: The Quest for Environmental Quality." The Journal of School Health, 40 (June, 1970), 284-289.

Mileaf, H., ed. Electricity One-Seven. New York: Hayden, 1966.

Nelson, H.F. "Industrial Arts Malnutrition--and a Prescription." School Shop, 1 (January, 1968), 45-47, 85.

Oka, T. "Sato Plans Action to Meet Pollution Crisis in Japan." New York Times, (July 29, 1970), 1.

Pankowski, D. "The Packaged Teaching System." Journal of Industrial Arts Education, 27 (May, 1968), 40-41.

Phillips, V. "It's Feeding Time at the Zoo." Industrial Arts and Vocational Education, 56 (May, 1967), 79, 82.

Ruiter, W.M. "Automotive Electricity Comes to Life with a Mock-up." School Shop, 28 (March, 1969), 64-65.

Smith, H.R. "Media Men Arise: What if McLuhan is Right?" Educational Screen and Audiovisual Guide, 47 (June, 1968), 18-19.

Sporn, P. Energy it's Production, Conversion and Use in the Service of Man. New York: MacMillan, 1963.

Sporn, P. Research in Electric Power. New York: Pergamon, 1966.

Stout, J.J. "The Future of Hydoelectric Power in the United States." Electric Power Today and Tomorrow. Conference Papers published by American Society of Civil Engineers. New York, N.Y., 1965.

Suess, A.R. "The SNAFU Regarding Teaching Methods in Industrial Education." Journal of Industrial Teacher Education, 4 (September, 1966), 4-10.

Suess, A.R. National Conference on Research in Industrial Arts. Final Report. Leadership Series 20. Columbus: Ohio State University, 1969. (ERIC: ED 029 986).

Trudeau, T. (panel member). "Round Table: Industrial Electricity in Industrial Arts." Industrial Arts and Vocational Education, 56 (May, 1967), 92, 94.

Webster, N. Webster's New School and Office Dictionary. New York: Fawcett World Library, 1959.

Wendt, P.R. Audio-Visual Instruction. #14 in the series What Research Says to the Teacher. American Educational Research Association, National Education Association, 1957.

Whitehead, A.N. The Aims of Education. New York: MacMillan, 1952.

Wolfson, B.J. "Individualizing Instruction." National Education Association Journal, 55 (November, 1966), 31-40.

APPENDIX A

STUDENT WORKBOOK FOR

Utilization of

an Operating Automobile

Electrical System

to Teach

Selected Concepts

of

ELECTRICITY

at

the

Junior

High

School

Level

TABLE OF CONTENTS

To the Student

This is a workbook of activities which requires you to work with an operating automobile electrical system. It is designed to help you learn some selected concepts of electricity.

The activities are organized in like fashion. They begin with the statement of one or more concepts and sub-concepts concerning electricity. The objective of each activity is stated in such a manner that upon completion of the activity you will know if you accomplished the objective. Your responses on a pre-test will determine your knowledge of the concept(s) and sub-concept(s) involved in an activity. You will receive credit for your knowledge, so work carefully through each pre-test.

The last page of this workbook contains a list of appropriate reference texts. They will aid you in answering the questions asked through the activities.

In each activity you are requested periodically to check with your teacher. These checks are essential! They are necessary for: your safety, the safety of equipment, and review or clarification of some learning experience.

If you have to wait for your teacher, make good use of your time--read ahead and understand exactly what will be expected of you.

Enjoy yourself!

Engine Operation Safety

Date operated and activities undertaken

Name-
Date-
Teacher-

A. Before operating engine:	Consequences:
1. Check yourself for dangling apparel.	1. Dangling apparel may catch in fan or generator. It may also hinder your view when working on some part.
2. Check oil level.	2. An engine will start and operate for a time without sufficient oil, but if it should seize it will be expensive to repair.
3. Check fuel level.	3. Stopping to replenish the fuel supply is inconvenient.
4. If fuel tank requires re-filling, do so in the absence of sparks or flames. Wipe up any fuel you might spill.	4. Gasoline, when exposed to the air, readily evaporates and forms a combustible mixture which could easily ignite in the presence of a spark or flame.

5. Check level of electrolyte in the battery. If level is below the top of the battery plates, check with your teacher.	5. A certain amount of water is necessary in the electrolyte because oxygen (from the water) is required in the charging process.
6. Wash hands thoroughly after handling battery screw caps.	6. The electrolyte also contains sulfuric acid (H_2SO_4).
7. Connect the exhaust pipe to the exhaust fan and switch fan to "on".	7. Exhaust gases contain carbon monoxide, an odorless and deadly gas. One should not operate any engine in an enclosed area.
B. <u>While operating engine</u>:	<u>Consequences</u>:
8. Wear a safety shield or safety glasses.	8. They will protect your eyes should something fly off a rotating part such as the generator pulley or fan. Safety glasses are a good precaution anytime you are around an operating engine.
9. Wear heat resistant gloves when working ~~on areas~~ of the electrical system which are close to the hot exhaust system.	9. Severe burns can result from touching hot parts of the exhaust system.

10. Keep fingers away from moving parts such as the fan.

10. If fingers contact a moving part such as the fan they will be severely injured.

11. Take care not to shock yourself or others with the voltage produced by the ignition coil

11. A person with a weak heart could be seriously injured.

12. Only operate the engine at the R.P.M. specified by an activity sheet.

12. An engine not under load can easily be damaged by high R.P.M.

13. Take care not to cause sparks close to a battery.

13. A charging battery produces highly explosive hydrogen gas.

C. <u>After operating engine:</u>

<u>Consequences:</u>

14. Remove the ignition key and give it to your teacher.

14. If ignition key is left "on", the battery will discharge.

15. Turn exhaust fan to "off". Disconnect and store exhaust hose. Clean up oil drippings.

15. Removal of unsafe conditions prevents possible accidents.

Information Sheet

Conway and Automotive

Measuring Current

In order to use electrical energy to do some kind of work, the electricity must be set in 'motion'. This is done when an electric current is produced. This electric current is developed when many free electrons in a wire are moved in the same direction (Mileaf, 1966, p. 1-45).

If 6,280,000,000,000,000,000 electrons pass a given point in a period of one second, the movement of electrons is referred to as an ampere. The ampere is the unit of measurement of current flow (Miller and Culpepper, 1966, p. 3).

An ammeter is a current measuring device (Miller and Culpepper, 1966, p. 26).

Operating Conway Direct Current (D.C.) Ammeter

Note—this ammeter will measure up to a maximum of ten amperes.

__1. An ammeter must be placed in series in a circuit. Switch the power supply of the circuit to "off" and separate the circuit at some point.

__2. Plug a black lead into the negative post of the ammeter and clip the other end to the side of the circuit going to the negative terminal of the power supply.

__3. Clip a red lead to the side of the circuit going to the positive terminal of the power supply.

__4. Read the procedure in steps 6,7,8—do not carry out these steps until you have the procedure clear and have checked with your teacher.

[ ]5. Teacher approval.

__6. Turn the circuit switch to "on".

__7. Always carry out the next step beginning with the 10 post. If it fails to give a suitable reading try in turn the 5, 1, 0.5, 0.1, 0.05, 0.01 posts.

__8. Simultaneously touch the free end of the red lead to the __ post and note the movement of the pointer. If it moves past the top end of the scale or moves to the left of zero, immediately release contact with the __ post. If it moves to the left of zero check with your teacher. If the pointer remains on the scale, maintain contact with the __ post and take a reading. The following chart will aid you.

Touch __ post	Read __ scale	[illegible] get corrected reading:
10	0-10	x1
5	0-5	x1
1	0-10	÷10
0.5	0-5	÷10
0.1	0-10	÷10
0.05	0-5	÷100
0.01	0-10	÷100

__9. The corrected reading indicates the amount of current in amperes flowing in the circuit.

Operating Automotive Ammeter

Note--this ammeter will measure up to a maximum of sixty amperes.

__1. An ammeter must be placed in series in a circuit. Switch the power supply of the circuit to "off" and separate the circuit at some point.

__2. Attach a black lead to the negative terminal of the ammeter and clip the other end to the side of the circuit going to the negative terminal of the power supply.

__3. Attach a red lead to the positive terminal of the ammeter and clip the other end to the side of the circuit going to the positive terminal of the power supply.

__4. Turn the circuit switch to "on".

__5. The scale reading indicates the amount of current flowing in the circuit.

Information Sheet

Conway and Canex

Measuring Voltage

The force which moves . . . electrons is exerted between the ends of the conductor. The force is usually a difference in the number of electrons at one end of the conductor and the number at the other end. The excess electrons are constantly trying to move to the end where there are fewer electrons--in order to balance the number of electrons at each end. This difference in electrons is referred to as potential difference or voltage (Miller and Culpepper, 1966, p. 2).

Operating Direct Current (D.C.) Voltmeter

1. Set the range switch higher than the voltage to be measured. The use of a range switch allows a single voltmeter to measure voltages ranging from one volt to one thousand volts. When the range switch is set at one, the voltmeter will measure up to one volt. When the range switch is set at five, the voltmeter will measure up to five volts. When the range switch is set at one thousand, the voltmeter will measure up to one thousand volts.
2. Decide which scale you must read and what you will do with the reading. The following chart will aid you.

When range switch set at:	Read ___ scale	To get correct reading:
1	0-10	÷10
2.5	0-25	÷10
5	0-5	x1
10	0-10	x1
25	0-25	x1
50	0-5	x10
100	0-10	x10
250	0-25	x10
500	0-5	x100
1000	0-10	x100

3. Plug a black lead into the negative or black post of the voltmeter and a red lead into the positive or red post of the voltmeter.

To measure a source of voltage

4. Clip the free end of the black lead to the negative terminal of the source of voltage to be measured.
5. Simultaneously touch the free end of the red lead to the positive terminal of the voltage to be measured and note the movement of the pointer. If it moves past the top end of the scale or moves to the left of zero, immediately release contact with the positive terminal and check with your teacher. If the pointer remains on the scale, maintain contact with the positive terminal and record the reading.

To measure the voltage drop across a load in a circuit

4. Clip the free end of the black lead to the negative side of the load.
5. Simultaneously touch the free end of the red lead to the positive side of the load and note the movement of the pointer. If it moves past the top end of the scale or moves to the left of zero, immediately release contact with the positive side of the load and check with your teacher. If the pointer remains on the scale, maintain contact with the positive side of the load and record the reading.

Information Sheet

Conway

Measuring Resistance

When there is movement, there is friction (except in a perfect vacuum). The movement of electrons through a conductor meets with some opposition. This opposition is called resistance.

Resistance is measured in ohms.

An ohm is the amount of resistance when one volt is needed to force one ampere through the material (Miller and Culpepper, 1966, p. 3).

Resistance is measured by an ohmmeter.

Operating the Conway Ohmmeter

1. Ensure that any power source in the circuit is switched "off".
2. Clip ohmmeter leads to the terminals of the resistance to be measured.
3. Rotate selector switch until pointer deflects to the right half of the scale.
4. Zero adjust the ohmmeter. To do this, unclip a lead from a resistance terminal and clip or touch other ohmmeter lead. Rotate the "0 Adj." knob until the pointer is set at zero.
5. Reclip lead to the resistance terminal as in step one.
6. Record the ohmmeter reading.
7. To determine the resistance, multiply this reading by the number the selector switch indicates. For example: If the pointer reads 1.3 and the selector switch indicates R x 100K:

   R x 100K = "x" ohms

   1.3 x 100K = "x" ohms

   1.3 x 100,000 = 130,000 ohms

   The resistance measured in this example would be 130,000 ohms.

Checking Continuity with a Conway Ohmmeter

A continuity test determines if a circuit or a part of a circuit provides a complete path for the flow of electrons (Buban et al, 1964, p. 436).

1. Rotate selector switch to R x 1.
2. Clip ohmmeter leads to the ends of circuit or part of circuit to be tested for continuity.
3. If the pointer does not move there is an open circuit.
4. If the pointer deflects to zero there is a closed or continuous circuit.

Activity No. 1.

Storage Battery--Discharging

Concepts

1. " . . . energy can neither be created nor destroyed but can be changed in form.
2. Variables governing electron movement can be detected and/or measured (Department of Education, 1969, p. 54)."

Sub-concept

A discharging storage battery coverts chemical energy into electrical energy (Mileaf, 1966, p. 6-23).

Objective

Given an operating automobile electrical system, appropriate references, voltmeter, and leads, student will:

1. demonstrate that electrical energy can be obtained from a storage battery
2. define electrical energy
3. measure and define voltage

Pre-test

Select the statement which best explains each term.

1. Electrical energy:
   ___ a) produces light by moving rapidly in solids, liquids, or gases
   ___ b) produces heat when its speed is increased
   ___ c) produces magnetism by induction
   ___ d) is the ability to do work possessed by a flow of electrons
2. Voltage is:
   ___ a) the electrical pressure or force which causes the flow of electrons
   ___ b) the electrical pressure or force that an electron produces
   ___ c) a measure of the electrical power of an electron

__ d) a measure of the electrical power of a flow of electrons

[]3. Check with your teacher.

Activities

__1. Review Engine Operation Safety.

[]2. Check with your teacher.

__3. The instrument panel of the automobile engine contains several switches and dials. Select any switch and test each of its operating positions. Observe what happens and place switch in "off" position. Repeat this procedure for each switch on the instrument panel.

__4. Remove the cables attached to the terminals of the storage battery.

__5. Return to the instrument panel and again test each switch in all of its operating positions. Note the change. In step three each time you operated a switch you got a reaction--lamps glowed or flashed, fan motor hummed, horn honked, the engine cranked over and started etc. Now you removed one item, the storage battery, and nothing operates. The energy that caused all the reaction in step three is called electrical energy.

__6. Consult appropriate references and define electrical energy.

__7. See information sheet Measuring Voltage. Set range switch at 25 and measure the voltage of the storage battery. Storage battery __ volts.

__8. Consult appropriate references and define voltage.

[]9. Check with your teacher.

Activity No. 2.

Storage Battery--Charging

Note--Due to the nature of the activities involving an operating automobile electrical system, the storage battery will often become too low in charge to start the engine. When this occurs the following activity can be carried out.

Concept

" . . . energy can neither be created nor destroyed but can be changed in form (Department of Education, 1969, p. 54)."

Sub-concepts

1. When a storage battery is charged electrical energy is converted to chemical energy.
2. A storage battery does not produce electrical energy but it can store electrical energy because it converts it to chemical energy. When discharging it re-converts the chemical energy into electrical energy (Mileaf, 1966, p. 6-23).

Objective

Given a trickle charger, appropriate references, and an operating automobile electrical system with a lead-acid storage battery too low in charge to start the engine, the student will:

1. charge the storage battery sufficiently to start the engine
2. compare the basic parts of a charged lead-acid storage battery to the basic parts of a carbon-zinc dry cell
3. explain in simple terms how a lead-acid storage battery charges and discharges

Pre-test

__1. Compare the basic parts of a charged lead-acid storage battery to the basic parts of a carbon-zinc dry cell.

__2. Explain in simple terms how a lead-acid storage battery charges and discharges.

[ ]3. Check with your teacher.

Activities

__1. Review Engine Operation Safety.

[ ]2. Check with your teacher.

__3. Turn ignition key to "start". Note the engine will not crank over fast enough to start.

__4. Turn ignition key to "off".

__5. Remove cables from both terminals of the storage battery.

__6. CAUTION Highly explosive hydrogen gas may be present around a storage battery--especially during charging. To prevent possible sparks one should connect the trickle charger to the storage battery then plug the trickle charger into a 110 volt outlet. Reverse the procedure to disconnect. (Gerrish, 1964, p. 25).

__7. Connect the charger to the storage battery. Clip the red lead to the positive terminal. Clip the black lead to the negative terminal.

__8. Plug charger into 110 volt wall outlet.

__9. Place the trickle charger up to your ear. A hum indicates correct operation. If it clicks or bangs, unplug from wall outlet and check with your teacher.

__10. While the trickle charger is operating refer to appropriate references and:

a) compare the basic parts of a charged lead-acid storage battery to the basic parts of a carbon-zinc dry cell.

b) explain in simple terms how a lead-acid storage battery charges and discharges.

__11. After the storage battery has been charging for about an hour, unplug the trickle charger from the wall outlet.

__12. Disconnect trickle charger from the storage battery, wrap up the leads and put unit in storage.

__13. Re-connect the storage battery to the automotive electrical system.

[]14. Check with your teacher.

Activity No. 3.

Generator

Concepts

1. " . . . energy can neither be created nor destroyed but can be changed in form.
2. Variables governing electron movement can be detected and/or measured (Department of Education, 1969, p. 54)."

Sub-concept

A generator is a device which converts mechanical energy into electrical energy (Mileaf, 1966, p. 6-61).

Objective

Given appropriate references, an operating automobile electrical system, cutaway generator, D.C. voltmeter, automotive ammeter, and leads, student will:

1. demonstrate the purpose of a generator
2. with the aid of a cutaway generator, explain the principles of operation of a generator

Pre-test

__1. Explain the principle of operation of a generator.

[ ]2. Check with your teacher.

Activities

__1. See information sheet <u>Measuring Voltage</u>. You will measure the voltage produced by the generator.

__2. Set range switch of D.C. voltmeter to 25.

__3. The "A" terminal of the generator is positive, the automobile frame or the generator housing is negative. Voltage output of generator ____ volts.

__4. Review Engine Operation Safety.

[]5. Check with your teacher.

__6. Start the engine and set throttle at 500 R.P.M.

__7. Voltage output of generator at 500 R.P.M. is ____ volts.

__8. Observe the voltmeter as engine speed is increased to 1500 R.P.M. Voltage output of generator at 1500 R.P.M. is ____ volts.

__9. Decrease engine speed to idle and turn ignition key to "off".

__10. Disconnect D.C. voltmeter and put unit in storage.

__11. See information sheet Measuring Current. Using the automotive ammeter you will measure the current produced by the generator.

__12. Disconnect the wire attached to the "A" terminal of the generator. Connect the ammeter.

__13. Start the engine and set the throttle at 500 R.P.M. Current produced at 500 R.P.M. is ____ amperes.

__14. Observe the ammeter as engine speed is increased to 1500 R.P.M. Current produced at 1500 R.P.M. is ____ amperes.

__15. Decrease engine speed to idle and turn ignition key to "off".

__16. Disconnect automotive ammeter and put unit in storage.

__17. Reconnect wire to "A" terminal of generator.

__18. Consult appropriate references and explain the principle of operation of a generator.

[]19. Check with your teacher.

Activity No. 4.

The Electric Circuit

Concept

"Electron movement can be controlled and manipulated Department of Education, 1969, p. 56)."

Sub-concept

The electric circuit is the physical means by which electricity performs some work or function (Mileaf, 1966, p. 2-1)."

Objective

Given an operating automobile electrical system and appropriate references, student will:

1. sketch and explain in terms of: source, control, path, and load any three series circuits and any two parallel circuits
2. define an electric circuit and explain its purpose

Pre-test

__1. Sketch and label a simple series circuit.

__2. Sketch and label a simple parallel circuit.

__3. Define an electric circuit and explain its purpose.

[ ]4. Check with your teacher.

Activities

Horn Circuit

__1. Press and release horn button.

__2. Trace the circuit.

__3. Sketch and label: source, control, path, and load.

__4. Disconnect a wire from the horn relay.

__5. Press and release horn button.

__6. Explain the result.

__7. Re-connect the wire to the horn relay.

[]8. Check with your teacher.

Heater Circuit

__1. Flip heater fan switch to "high", "medium", then "low".

__2. Trace the circuit. Flip switch "off".

__3. Sketch and label: source, control, path, and load.

__4. Disconnect the wire going to the fan motor.

__5. Flip heater fan switch to "high", "medium", "low", and back to "off".

__6. Explain the result.

___7. Re-connect the wire going to the fan motor.

[ ]8. Check with your teacher.

Oil indicator light circuit

___1. Review Engine Operation Safety.

[ ]2. Check with your teacher.

___3. Turn ignition key to "on". Note oil indicator lamp glows.

___4. Start the engine and set throttle at 500 R.P.M. Note oil indicator lamp goes off.

___5. Turn ignition key to "off". Trace the circuit.

___6. Sketch and label: source, control, path, and load.

___7. Separate the connector between the ignition key and the oil indicator lamp.

___8. Turn ignition key to "on". Observe oil indicator lamp and start engine.

___9. Set throttle at 500 R.P.M., allow to run for five seconds then turn ignition to "off".

___10. Explain the result of step 8.

___11. Re-connect the wire to the oil indicator lamp.

[ ]12. Check with your teacher.

Fuel gauge circuit

___1. Note the position of the fuel gauge needle.

___2. Turn ignition key to "accessory".

___3. Manually operate the float on the tank unit and note the fuel gauge needle.

___4. Trace the circuit.

___5. Sketch and label: source, control, path, and load.

___6. Disconnect the cable attached to the positive terminal of the storage battery.

___7. Manually operate the float and observe the fuel gauge needle.

___8. Explain the result.

___9. Turn ignition key to "off".

___10. Re-connect the battery cable.

[]11. Check with your teacher.

Courtesy light circuit

___1. Release left door jamb switch. Observe the result.

___2. Release right door jamb switch. Observe the result.

___3. Trace the circuit.

___4. Sketch and label: source, control, path, and load.

___5. Depress and look left door jamb switch.

___6. Explain the result.

___7. Disconnect the cable attached to the negative terminal of the storage battery.

__8. Explain the result.

__9. Re-connect the battery cable.
__10. Depress the lock right door jamb switch
[]11. Check with your teacher.

Tail light circuit

__1. Pull lighting switch out to the first notch. Tail lamps should glow.
__2. Trace circuit.
__3. Sketch and label: source, control, path, and load.

__4. Remove a tail lamp bulb.
__5. Explain the result.

__6. Replace the tail lamp bulb.
__7. Disconnect the tail lamp wire from the lighting switch.
__8. Explain the result.

__9. Re-connect tail lamp wire to the lighting switch.
__10. Push lighting switch to "off".
[]11. Check with your teacher.

Stop light circuit

__1. Depress brake pedal. Stop lamps should glow.
__2. Release brake pedal and trace circuit.

___3. Sketch and label: source, control, path, and load.

___4. Remove a stop lamp bulb.
___5. Depress and release brake pedal.
___6. Explain the result.

___7. Replace the bulb.
___8. Separate the connector between stop light switch and the stop lamps.
___9. Depress and release brake pedal.
___10. Explain the result.

___11. Re-connect the connector between stop light switch and the stop lamps.
[ ]12. Check with your teacher.

Headlight circuit

___1. Pull lighting switch out fully. Headlamps should glow.
___2. Trace circuit.
___3. Push lighting switch to "off".
___4. Sketch and label: source, control, path, and load.

__5. Disconnect a sealed beam unit.
__6. Pull lighting switch out fully.
__7. Explain the result.

__8. Re-connect the sealed beam unit.
__9. Disconnect headlamp wire from lighting switch.
__10. Explain the result.

__11. Push lighting switch to "off".
__12. Re-connect headlamp wire to lighting switch.
[]13. Check with your teacher.

Answer the following questions then consult appropriate references to check your responses.

__1. Define an electric circuit.

__2. Explain the purpose of an electric circuit.

__3. The horn, heater, oil indicator, fuel gauge, and courtesy light circuits are classified as series circuits. Formulate a general statement useful for distinguishing series circuits.

__4. The tail, stop, and headlight circuits are classified as parallel circuits. Formulate a general statement useful for distinguishing parallel circuits.

[]5. Check with your teacher.

Activity No. 5

Circuit Loads and Paths

Concept

"Electron movement can be controlled and manipulated (Department of Education, 1969, p. 56)."

Sub-concepts

1. "The type of load used determines the amount of energy taken from the power source (Mileaf, 1966, p. 2-4)."
2. "The resistance of a wire determines how much current will flow through the wire when it is connected across a voltage source (Mileaf, 1966, p. 2-19)."
3. "The greater the cross-sectional area of a wire, the lower its resistance (Mileaf, 1966, p. 2-12)."

Objective

Given an operating automobile electrical system, appropriate references, Conway ammeter, leads, and wire gauge, student will:

1. demonstrate that the circuit load determines current flow
2. explain how and why the circuit load determines current flow
3. demonstrate that the circuit load determines the cross-sectional area of the path.

Pre-test

__1. Explain how and why the circuit load determines current flow.

[ ]2. Check with your teacher.

Activities

__1. Press and release horn button.

__2. Trace the circuit.

__3. Sketch and label: source, control, path, and load.

__4. See information sheet Measuring Current.

__5. Separate the connector in the wire between horn relay and "B" terminal of the voltage regulator. Connect the Conway ammeter.

[]6. Check with your teacher before pressing horn button.

__7. Press horn button and observe ammeter scale.

__8. Release horn button.

__9. Ammeter indicates a current flow of ____ amperes.

__10. Remove ammeter from the horn circuit.

__11. Re-connect connector in wire between horn relay and "B" terminal of the voltage regulator.

__12. Pull lighting switch out to first notch. Tail lamps should glow.

__13. Trace circuit.

__14. Sketch and label: source, control, path, and load.

__15. Push lighting switch to "off".

__16. See information sheet Measuring Current.

__17. Separate tail lamp wire at lighting switch and connect Conway ammeter.

[]18. Check with your teacher before switching circuit "on".

__19. Pull lighting switch out to first notch and observe ammeter scale.

__20. Ammeter indicates a current flow of ____ amperes.

__21. Push lighting switch to "off".

__22. Remove ammeter from the tail light circuit.

__23. Re-connect tail lamp wire to the lighting switch.

__24. Consult appropriate references and explain how and why the circuit load determines current flow.

__25. Use a wire gauge to measure the gauge of the wire in the horn circuit and tail light circuit.

- horn circuit - ____ gauge ____ gauge
- tail light circuit - ____ gauge

__26. Consult appropriate references and explain why the wire gauges differ in the two circuits measured.

[]27. Check with your teacher.

Activity No. 6.

Protective Devices

Concept

"Electron movement can be controlled and manipulated (Department of Education, 1969, p. 56)."

Sub-concept

"Fuses and other circuit breakers are the major means of protecting against the dangers of short circuits (Mileaf, 1966, p. 2-68)."

Objective

Given an operating automobile electrical system, appropriate references, and a 12 gauge lead, student will:

1. demonstrate purpose of a fuse and circuit breaker
2. explain why short circuits are dangerous
3. explain operation of a one-time cartridge fuse and a bimetallic circuit breaker

Pre-test

__1. Explain why short circuits are dangerous.

__2. Explain operation of a one-time cartridge fuse and a bimetallic circuit breaker.

[]3. Check with your teacher.

Activities

One-time cartridge fuse

__1. Pull lighting switch out to the first notch. Tail lamps should glow.

__2. Trace circuit.

__3. Sketch and label: source, control, fuse, path, and load.

__4. Remove a tail lamp bulb.
__5. Have a partner observe the fuse while you insert a screwdriver in the tail lamp socket and ground the power supplying lead.
__6. Explain the result. Consult appropriate references if necessary.

__7. Replace the tail lamp bulb.
__8. Push lighting switch to "off".
__9. Consult appropriate references and explain why short circuits are dangerous.

[ ]10. Check with your teacher and ask for a new one-time cartridge fuse.

<u>Bimetallic circuit breaker</u>

__1. Pull lighting switch out fully. Headlamps should glow.
__2. Trace circuit. Note a bimetallic circuit breaker joins the battery terminal of the lighting switch to all other terminals.
__3. Sketch and label: source, control, circuit breaker, path and load.

___4. Note two terminals of the lighting switch are connected to the circuit breaker regardless of the position of the switch. Clip one end of a 12 gauge lead to either of these terminals.

___5. Ground the free end of the lead to the automobile frame. When the headlamps go off, release the end of the lead touching the automobile frame.

___6. Press the circuit breaker open with a pencil. Do not use your finger, the bimetallic strip will be hot. Note the result.

___7. Push lighting switch to "off".

___8. Consult appropriate references and explain the operation of a bimetallic circuit breaker.

[ ]9. Check with your teacher.

Activity No. 7

Relay

Concept

"Electron movement can be controlled and manipulated (Department of Education, 1969, p. 56)."

Sub-concepts

1. A relay is a device which utilizes a low voltage, low current circuit to control a large flow of current (Gerrish, 1964, p. 62).
2. A relay converts electrical energy to mechanical energy.

Objective

Given an operating automobile electrical system, appropriate references, ohmmeter, and leads, student will:

1. demonstrate how the horn relay controls the horn circuit
2. explain how a relay operates
3. state at least two advantages of a relay

Pre-test

___1. Explain how a relay operates.

___2. State at least two advantages of a relay.

[ ]3. Check with your teacher.

Activities

___1. Remove the cover from the horn relay.

___2. Operate the horn button and observe the action of the relay.

___3. Remove all three wires connected to the horn relay.

__4. See information sheet Measuring Resistance. Use an ohmmeter as a continuity tester to determine the relationship of the three terminals of the horn relay.

__5. Sketch a circuit diagram to illustrate how the horn relay operates the horn.

__6. Consult appropriate references to check your circuit diagram and state at least two advantages of a relay.

[ ]7. Check with your teacher.

Activity No. 8.

Solenoid

Concept

"Electron movement can be controlled and manipulated (Department of Education, 1969, p. 56)."

Sub-concept

1. "A solenoid is an electromagnet with a movable soft iron core (Glenn, 1967, p. 88)."
2. A solenoid converts electrical energy to mechanical energy (Purvis, 1960, p. 297).

Objective

Given an operating automobile electrical system, cutaway 12 volt starter and solenoid, battery booster cable, lamp socket with 12 volt bulb, leads, and appropriate references, student will:

1. demonstrate the purpose of a solenoid
2. explain the operation of a solenoid
3. describe at least three common applications of a solenoid

Pre-test

__1. Select the statement which best explains the operation of a solenoid.
   a) A magnetic soft iron core is attracted into a coil of wire.
   b) The magnetic field around a magnetic soft iron core moving into a tightly compressed coil induces an electric current in the coil.
   c) A current passing through a tightly compressed coil produces a strong magnetic field which draws a soft iron core inside the coil.
   d) A strong spring forces a soft iron core into a coil.

__2. Describe at least three common applications of a solenoid.

[ ]3. Check with your teacher.

Activities

__1. Review Engine Operation Safety.

[ ]2. Check with your teacher.

__3. Remove the cable attached to the positive terminal of the storage battery.

__4. Disconnect all three wires connected to the solenoid and, following their color coding, re-connect them to the cutaway starter and solenoid.

__5. Use the battery booster cable to ground the cutaway starter and solenoid to the automobile frame.

__6. Re-connect battery cable to the positive terminal of the storage battery.

[ ]7. Check with your teacher.

__8. While observing the cutaway starter and solenoid, turn the ignition key to "ignition" for two seconds, then to "start" for two seconds, and then to "off".

__9. a) Describe what happened when the key was turned to "ignition".

b) Describe what happened when the key was turned to "start".

__10. Remove the flexible copper strap connecting the solenoid to the starter.

__11. Use an appropriate lead to connect a 12 volt lamp to the solenoid terminal from which you removed the flexible copper strap.

___12. Ground the 12 volt lamp socket to the starter housing.

___13. Turn ignition key to "ignition" for two seconds, then to "start" for two seconds. Repeat two or three times and then turn to "off".

___14. Consult appropriate references and:

a) explain the operation of a solenoid

b) describe at least three common applications of a solenoid

___15. Remove the cable attached to the positive terminal of the storage battery.

___16. Disconnect the wires connected to the cutaway starter and solenoid and re-connect them, following their color code, to the automobile starter and solenoid.

___17. Return battery booster cable and cutaway starter and solenoid to storage.

___18. Re-connect battery cable to the positive terminal of the storage battery.

[]19. Check with your teacher.

Activity No. 9.

Rheostat

Concept

"Electron movement can be controlled and manipulated (Department of Education, 1969, p. 56)."

Sub-concept

A rheostat is a device which controls electron flow in a circuit (Buban, et al, 1964, p. 134).

Objective

Given an operating automobile electrical system, appropriate references, ohmmeter, and leads, student will:

1. demonstrate the function of a rheostat.
2. explain how a rheostat controls electron flow in a circuit.

Pre-test

__1. Explain how a rheostat controls electron flow in a circuit.

[]2. Check with your teacher.

Activities

Rheostat in circuit for instrument panel lights

__1. Pull lighting switch out to the first notch. Note the instrument panel lamps glow.

__2. Trace the circuit. Note the wirewound resistor in the circuit.

__3. Sketch and label: source, control, path, and load.

___4. Rotate the lighting switch knob fully clockwise. Note the brightness of the instrument panel lamps.

___5. Continue to observe the instrument panel lamps as you slowly rotate the lighting switch knob fully counter-clockwise.

___6. Describe the result.

___7. Push the lighting switch to "off".

___8. See information sheet Measuring Resistance. Rotate selector switch to R x 10. Zero adjust the ohmmeter.

___9. Connect one lead of the ohmmeter to a terminal of the wirewound resistor. Connect other lead to the movable contact which is rotated by the shaft of the lighting switch.

___10. Rotate lighting switch knob and observe ohmmeter.

___11. Explain the action of the ohmmeter.

___12. Consult appropriate references and explain how a rheostat controls electron flow in a circuit.

[]13. Check with your teacher.

<u>Rheostat in fuel gauge circuit</u>

___1. Turn the ignition key to "accessory".

___2. Manually operate the float on the tank unit and note the fuel gauge needle.

___3. Trace circuit. Look in the hole cut in the side of the tank unit and note the wirewound resistor in the circuit.

__4. Sketch fuel gauge circuit (see McGuffin, 1962, p. 78) and label: source, control, path, and load.

__5. Turn ignition key to "off".
__6. Disconnect tank unit from fuel gauge.
__7. See information sheet <u>Measuring Resistance</u>. Rotate selector switch to R x 10. Zero adjust the ohmmeter.
__8. Connect ohmmeter to the tank unit and manually operate the float on the tank unit.
__9. Explain the action of the ohmmeter.

__10. Turn ignition key to "accessory".
__11. Use an appropriate lead to ground the "T" terminal of the fuel gauge to the automobile frame.
__12. The fuel gauge needle moved from ____ to ____.
__13. Remove the lead grounding the "T" terminal of the fuel gauge.
__14. Connect the tank unit to the "T" terminal of the fuel gauge and manually operate the float on the tank unit.
__15. a) When the float is up the fuel gauge registers ___.
b) When the float is down the fuel gauge registers ___.
__16. Turn ignition key to "off".
__17. Consult appropriate references, refer to fuel gauge circuit step 4, and explain how a rheostat controls electron flow in a circuit.

__18. Check with your teacher.

Activity No. 10.

Step-up Transformer

<u>Concepts</u>

1. "Electron movement can be controlled and manipulated (Department of Education, 1969, p. 56)."
2. "Variables governing electron movement can be detected and/or measured (Department of Education, 1969, p. 54)."

<u>Sub-concepts</u>

1. A step-up transformer increases the voltage in relation to the current (Gerrish, 1964, p. 95).
2. The ignition coil is a step-up transformer (Buban et al, 1964, p. 297-298).

<u>Objective</u>

Given an operating automobile electrical system, appropriate references, an 18 gauge lead, and a length of string, student will:

1. demonstrate the action of a step-up transformer.
2. explain the principle of operation of a step-up transformer

<u>Pre-test</u>

[ ]1. Explain the principle of operation of a step-up transformer.

[ ]2. Check with your teacher.

<u>Activities</u>

[ ]1. Review <u>Engine Operation Safety</u>.

[ ]2. Check with your teacher.

[ ]3. Remove the wire connecting the center terminal of the ignition coil to the center terminal of the distributor

__4. At the ignition coil disconnect the wire that goes to the distributor.

__5. Connect to the now vacant ignition coil terminal an 18 gauge lead that will conveniently ground to the automobile frame.

__6. Turn the ignition key to "start" and while the engine is cranking hold the free end of the lead close to the automobile frame.

__7. The approximate distance the lead has to be from the frame to produce a spark is ____ inch.

__8. Turn ignition key to "off".

__9. Remove the 18 gauge lead and re-connect the wire from the distributor.

__10. The spark produced between the 18 gauge lead and the frame was forced by a voltage of about 12 volts. Voltage you will recall is:

__11. Take the wire you removed in step three and replace one end into the center terminal of the ignition coil. Secure about sixteen inches of string and tie it close to the other end of the wire.

__12. Turn the ignition key to "start" and while the engine is cranking use the string to move the free end of the wire close to the engine block.

CAUTION--Keep body parts at least two inches from the end of the wire.

__13. The furthest distance the wire can be from the engine block and produce a spark is approximately ___ inch. A voltage of 15,000 - 20,000 volts produced this spark.

__14. Turn ignition key to "off".

__15. Remove string and connect the free end of the wire to center terminal of the distributor.

___16. Consult appropriate references and explain the principle of operation of a step-up transformer.

[]17. Check with your teacher.

Activity No. 11.

Capacitor (Condenser)

Concept

"Electron movement can be controlled and manipulated (Department of Education, 1969, p. 56)."

Sub-concepts

1. An application of a capacitor is to prevent arcing across the contact of an electric switch in a D.C. circuit (Mileaf, 1966, p. 3-115).
2. Condenser is an old name for capacitor (Gerrish, 1964, p. 321).

Objective

Given an operating automobile electrical system, appropriate references, and a cutaway fixed capacitor, student will:

1. demonstrate the use of a capacitor to prevent arcing across the contacts of an electrical switch in a D.C. circuit.
2. explain the construction and operation of a fixed paper capacitor.

Pre-test

___1. Explain the construction and operation of a fixed paper capacitor.

[ ]2. Check with your teacher.

Activities

___1. Review Engine Operation Safety.

[ ]2. Check with your teacher.

___3. Remove the wire connecting the center terminal of the ignition coil to the center terminal of the distrib[illegible]

__4. Remove the distributor cap.
__5. Turn the ignition key to "start" and crank the engine for about five seconds.
__6. Observe the opening and closing of the breaker points. Check for an arcing across the points when they open. "The breaker points act as a switch that rapidly turns the current on and off (Buban et al, 1964, p. 298)."
__7. Turn the ignition key to "off" and remove the condenser from the distributor.
__8. Turn the ignition key to "start" and crank the engine for about five seconds.
__9. The arcing is ____________ (more than, less than) in step five.
__10. Turn ignition key to "off".
__11. Replace the condenser.
__12. Secure distributor cap in place.
__13. Replace the wire connecting the center terminal of the ignition coil to the center terminal of the distributor.
__14. Consult appropriate references and:

a) explain construction of a fixed paper capacitor (see cutaway fixed capacitor)

b) explain operation of a fixed capacitor

[ ] 15. Check with your teacher.

Activity No. 12

Ohm's Law

Concept

"Variables governing electron movement can be detected and/or measured (Department of Education, 1969, p. 54)."

Sub-concept

"In a d-c circuit, the current is directly proportional to the voltage and inversely proportional to the resistance (Mileaf, 1966, p. 2-37)."

Objective

Given an operating automobile electrical system with a three speed heater motor, appropriate references, ammeter, voltmeter, and leads, student will make adequate measurements and calculations to illustrate the use of Ohm's Law in the three heater motor circuits.

Pre-test

Select the best response in each of the following problems.

___ 1. A heater motor circuit with a resistance of 4.7 ohms is connected to a 22 volt battery. The current drawn by the motor is approximately:

___ a) 4.7 amperes
___ b) 17.3 amperes
___ c) 22 amperes
___ d) 103 amperes

___ 2. The resistance of an emergency flasher is 2.6 ohms and it draws 2.3 amperes of current. The power supply must be approximately:

___ a) 6 volts
___ b) 9 volts
___ c) [illegible] volts
___ d) [illegible] volts

__3. If an interior car warmer connected to a 110 volt outlet draws 3.7 amperes, the approximate resistance of the heater element is:

__ a) 3.7 ohms

__ b) 30 ohms

__ c) 113.7 ohms

__ d) 106.3 ohms

[]4. Check with your teacher.

Activities

Illustrating Ohm's Law

__1. Flip heater switch to "high".

__2. Trace the circuit.

__3. Sketch and label: source, control, path, and load.

__4. See information sheet Measuring Voltage. Use a D.C. voltmeter to measure the voltage drop in the circuit.

__5. Voltage drop is____ volts.

__6. Flip heater switch to "off".

__7. See information sheet Measuring Current.

__8. Separate the connector in the wire to the motor and connect the Conway ammeter.

[]9. Check with your teacher before flipping heater switch to "high".

__10. Flip heater switch to "high".

__11. Ammeter indicates a current flowing of ____ amperes.

__12. Flip heater switch to "off".

__13. Remove ammeter from the circuit.

__14. See information sheet Measuring Resistance. Use ohmmeter to measure the resistance of the circuit.

[]15. Ohmmeter indicates a resistance of ____ ohms in the

___16. Remove the ohmmeter from the circuit.

___17. Re-connect the connector in the wire to the motor.

___18. Apply your measurements to illustrate Ohm's Law.

[ ]19. Check with your teacher.

Calculate resistance

___1. Flip heater switch to "medium".

___2. Trace the circuit.

___3. Sketch and label: source, control, path, and load.

___4. See information sheet Measuring Voltage. Use a D.C. voltmeter to measure the voltage drop in the circuit.

___5. Voltage drop is ____ volts.

___6. Flip heater switch to "off".

___7. See information sheet Measuring Current.

___8. Separate the connector in the wire to the motor and connect the Conway ammeter.

[ ]9. Check with your teacher before flipping heater switch to "medium".

___10. Flip heater switch to "medium".

___11. Ammeter indicates a current flowing of ____ amperes.

___12. Flip heater switch to "off".

___13. Remove ammeter from the circuit.

__14. Use Ohm's Law to calculate the resistance of the circuit.

__15. See information sheet Measuring Resistance. Use ohmmeter to measure the resistance of the circuit.

__16. Ohmmeter indicates a resistance of ____ ohms in the circuit.

__17. Remove the ohmmeter from the circuit.

__18. Re-connect the connector in the wire to the motor.

[]19. Check with your teacher.

Calculating voltage

__1. Flip heater switch to "low".

__2. Trace the circuit.

__3. Sketch and label: source, control, path and load.

__4. Flip heater switch to "off".

__5. See information sheet Measuring Current.

__6. Separate the connector in the wire to the motor and connect the Conway ammeter.

[]7. Check with your teacher before flipping heater switch to "low".

__8. Flip heater switch to "low".

__9. Ammeter indicates a current flow of ____ amperes.

__10. Flip heater switch to "off".

__11. Remove the ammeter from the circuit.

__12. See information sheet Measuring Resistance. Use ohmmeter to measure the resistance of the circuit.

___13. Ohmmeter indicates a resistance of ____ ohms in the circuit.

___14. Remove the ohmmeter from the circuit.

___15. Re-connect the connector in the wire to the motor.

___16. Use Ohm's Law to calculate the voltage drop across the resistors in the circuit.

___17. Flip heater switch to "low".

___18. See information sheet Measuring Voltage. Use a D.C. voltmeter to measure the voltage drop in the circuit.

___19. Voltage drop is ____ volts.

___20. Flip heater switch to "off".

___21. Remove voltmeter from across the circuit.

[]22. Check with your teacher.

Activity No. 13.

Lighting

Concept

"The conversion, application and control of energy is basic to the development and perpetuation of a technological society (Department of Education, 1969, p. 52)."

Sub-concept

Rapid molecular movement in some solids can produce light (Department of Education, 1969, p. 52).

Objective

"Electricity in the automobile is used for the operation of several different kinds of lights (Buban et al, 1964, p. 299)." Given an operating automobile electrical system, appropriate references, and a Weston Master IV light meter, student will:

1. list at least six types of lighting circuits utilized in an operating automobile electrical system and explain the purpose of each circuit
2. explain how light is produced in an incandescent lamp

Pre-test

___1. List at least six types of lighting circuits utilized in an operating automobile electrical system and explain the purpose of each circuit.

__2. Explain how light is produced in an incandescent lamp.

[]3. Check with your teacher.

Activities

__1. Use light meter to measure the relative intensity of the headlamps when on "low" beam and "high" beam.

Operation of Weston Master IV Light Meter

Hold the light meter about 30 inches from the center of the lamp to be measured. Move slide switch to the right and the red needle registers the intensity of the light. When it stops moving, move slide switch to the right and record the reading.

"low" beam reading ____
"high" beam reading ____

__2. What does the difference in intensities suggest as to their purposes?

__3. Use light meter to measure the relative intensity of a tail lamp, stop lamp and directional indicator lamp. See step one.

tail lamp reading ____
stop lamp reading ____
directional indicator lamp reading ____

__4. What does the difference in intensities suggest as to their purposes?

___5. In your study of controlling electricity through circuits and components, you encountered several lighting circuits utilized by an operating automobile electrical system. List at least six types of lighting circuits utilized by an automobile electrical system, and explain the purpose of each circuit.

___6. Consult appropriate references and explain how light is produced in an incandescent lamp.

[ ]7. Check with your teacher.

Activity No. 14.

Motion

Concept

"The conversion, application and control of energy is basic to the development and perpetuation of a technological society (Department of Education, 1969, p. 52)."

Sub-concept

"Electron movement resulting from induction produces mechanical energy (Department of Education, 1969, p. 53)."

Objective

Given an operating automobile electrical system, battery booster cables, 12 gauge lead, cutaway generator, and appropriate references, student will:

1. demonstrate how a D.C. electric motor converts electrical energy to mechanical energy
2. explain how a D.C. electric motor converts electrical energy to mechanical energy
3. list at least four examples in an operating automobile electrical system where electrical energy is converted to mechanical energy

Pre-test

__1. Explain how a D.C. electric motor converts electrical energy to mechanical energy.

__2. List at least four examples in an operating automobile electrical system where electrical energy is converted to mechanical energy.

[]3. Check with your teacher.

Activities

"D.C. motors and D.C. generators have essentially the same components and are very similar in outward appearance. They differ only in the way they are used (Van Valkenburgh et al, 1954, p. 5-44)."

__1. Review Engine Operation Safety.

[]2. Check with your teacher.

__3. Attach one end of a 12 gauge lead to the "F" terminal of the cutaway generator.

__4. Ground the free end of the 12 gauge lead to the cutaway generator frame.

__5. Clip one end of a red battery booster cable to the "A" terminal of the cutaway generator.

__6. Clip the free end of the red battery booster cable to the positive terminal of the storage battery.

__7. Clip one end of a black battery booster cable to the negative terminal of the storage battery.

__8. Touch the free end of the black battery booster cable to the cutaway generator frame. Release contact after five seconds.

__9. Describe the result.

__10. Un-clip the black battery booster cable from the negative terminal of the storage battery.

__11. Un-clip the red battery booster cable from the positive terminal of the storage battery.

__12. Un-clip the other end of red battery booster cable from the "A" terminal of the cutaway generator.

__13. Return battery booster cables to storage.

__14. Disconnect 12 gauge lead and return to storage.

__15. Consult appropriate references and explain how a D.C. electric motor converts electrical energy to mechanical energy.

__16. In your study of controlling electricity with circuits and components you encountered several examples of electrical energy converted to mechanical energy. Check over the automobile electrical system and list at least four such examples.

[]17. Check with your teacher.

BIBLIOGRAPHY SHEET

BUBAN, P., SCHMITT, M.L., KIRCHNEY, H.B. Electricity and Electronics. Toronto: McGraw-Hill, 1964.

DAVIES, E.J., ATTEBERRY, P.H. Power Mechanics. Toronto: General Publishing, 1964.

DEPARTMENT OF EDUCATION. Junior High School Curriculum Guide for Industrial Arts. Edmonton: Department of Education, 1969.

DUFFY, J.W. Power Prime Mover of Technology. Toronto: General Publishing, 1966.

GERRISH, H.H. Electricity and Electronics. Homewood, Ill.: Goodheart-Willcox, 1964.

GLENN, H.T. Exploring Power Mechanics. Peoria, Ill.: Chas. A. Bennett, 1967.

McGUFFIN, M.J. Automotive Mechanics Principles and Operation. Toronto: Macmillan, 1962.

MILEAF, H. (Ed.) Electricity One-Seven. New York: Hayden, 1966.

MILLER, R., CULPEPPER, F.W. Jr. Experiences With Electrons. Bloomington: McKnight and McKnight, 1966.

PURVIS, J. All About Small Gas Engines. Goodheart-Willcox, 1963.

STEPHENSON, G.E. Power Mechanics. New York: Delmar, 1963.

VAN VALKENBURGH, NOOGER, NEVILLE, INC. Basic Electricity. New York: John F. Rider, 1954. 5 Vols.

APPENDIX B

TEACHER'S MANUAL

To The Teacher

The operating automobile electrical system. The learning activities described herein were formulated on an actual operating automobile electrical system. Whereas almost any engine would work, the author utilized a 1957 Chevrolet six cylinder engine mounted on a stand.

The chassis wiring was realistic but simplified to facilitate: identification and tracing of circuits and measurement of electrical properties. Often separated connections were color coded to facilitate re-connection.

A Plymouth lighting switch was used because the circuit breaker was more clearly visible. In place of using actual automobile doors to operate the door jamb switches, simple turnbuttons locked the switches open.

Instrument panel lights were mounted in the open so that their brightness could be more easily observed.

For realism the fuel [illegible] unit was mounted in a cut-away box about the size of a small engine fuel tank. A hole was cut in one side of the rheostat housing to allow observation of its movement.

A Ford three-speed heater switch and motor replaced the one-speed Chevrolet system to facilitate activities concerning Ohm's Law.

An old Chevrolet generator, starter and solenoid were cutaway to facilitate observation of operation. On the starter, a flexible copper strap replaced the metal motor connector strap to facilitate removal by the students.

A metal screen guarded the fan area.

The activities. Each [illegible] in a similar [illegible] course.

Consultation with the student after completion and checking of the pre-test will allow you and the student to decide:

a) that his or her knowledge of the concept(s) involved is such that it would be a waste of time to carry out the activity. Therefore the student should receive credit for his or her knowledge and proceed to another activity.

b) that his or her knowledge of the concept(s) involved is such that only sub-parts of the activity be carried out. Student should receive credit for what he or she knows about the concepts(s).

c) student must do the complete activity.

The responses to the questions posed throughout the activities have not been supplied. This will allow you to better provide for individual differences among your students and insure that you go through the activities before the student to foresee some of the problems they may encounter.

<u>Engine operation safety</u>. Many teachers may wish to design their own safety program but for those who do not, or for those who may appreciate another idea, the writer indicates this program.

The student is given the sheet <u>Engine Operation Safety</u>. He or she is asked to study each step and think about the "consequences." When ready, student covers the "consequences" column, takes each step in turn and writes in his or her own words the "consequences" concerning each step. Student can check and correct his or her responses before consulting you. Together you go over the sheet. When you are satisfied he or she is aware of what to do and [illegible] he or she signs the sheet, you date and initial it.

of the sheet. Observe student, if you doubt his or her knowledge and appreciation, take whatever action deemed necessary. Each time he operates engine he or she must show you the Engine Operation Sheet with his or her "consequences" stapled to it. You can ask questions at that time and record date and activity. If the student responds poorly, the complete "consequences" column can again be written out in his or her own words.

This procedure indicates that the student is aware of the consequences of each step and the fact that the signed Engine Operation Sheet must be presented before each activity and the student must be prepared to respond correctly to any questions, helps to generate and sustain an awareness of the importance of safety.

Meter safety. Each meter should be demonstrated to the student. After a demonstration most students will be able to safely use the ohmmeter and voltmeter. The ammeter however, can easily be damaged and probably you should require them to check with you each time (as indicated in the activity sheets) before switching power "on" in the circuit.

APPENDIX C

Photograph of Hardware