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A Guide for Introducing Power Mechanics into the Yakima Public Junior High Schools

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A GUIDE FOR INTRODUCING POWER MECHANICS INTO THE YAKIMA PUBLIC JUNIOR HIGH SCHOOLS

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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

When one takes a glance at our modern society he sees a society dependent upon industry, and that industry is primarily dependent upon mechanical power (28:367). Mechanical power exists and has existed in many different forms for an extremely long period of time. Some of these sources of power, for some purpose or other, are as follows: human, animal, levers, gears, cams, electricity, fluid dynamics, chemical energy, fuel cells, thermal energy, and solar cells. Ground effect and vertical take-off machines, while not in widespread use by consumers, are a reality and worthy of study. Internal and external combustion engines have played an important role in history as well as some of the newer types of power such as jets, turbines, and solid fuel (65:1-4; 62:40).

While discussing power technology and its importance to the United States, Shank states:

> One needs only to look at the poverty of those countries limited to the use of only human and animal energy, and the very simplest machines to be more appreciative of our resources (62:40).

I. THE PROBLEM

Statement of the Problem

In a power dependent society such as ours, it is important that the knowledge of mechanical power and its utilization be offered to the student through the industrial arts curriculum. There are no existing courses in power mechanics in the Yakima Public Junior High Schools, and this is the problem the writer attempts to solve. Therefore, the purpose of this study is to propose a guide containing sufficient information for the inauguration of a basic power mechanics course into the school system.

Need for the Study

At the present time our growth in technical knowledge is increasing at a very rapid rate. In fact, it has been stated that knowledge is doubling every ten years in this century (59:10). What is needed then, is a well-organized program to be of immediate significance to the student. This writer suggests that power mechanics is such an activity-centered program. In line with this, Atteberry suggests in his article, "The Rationale of Power Mechanics", that power mechanics may be able to bridge the gap between the traditional industrial arts courses and the phenomenally expanding technology (6:43). Power mechanics then, as expressed by Atteberry is "an attempt to give meaning by application to the basic principles or mechanical systems found on our most commonly used machines, both vehicle and appliances" (6:42).

People from every segment of our society, regardless of how rich or poor they are, own some of these most common machines. Examples of these might be autos, mowers, outboards, inboards, small electric generators, personal aircraft, snowblowers, golf carts, and many others. Other common items that have contributed to our society are the U-controlled or radio-controlled planes and boats of hobbyists. Go-carts, drag racing, and hot rods have also defined their place in our society (62:40; 20:5). The knowledge needed for the care and maintainance of these common machines is basic to an accepted pattern of living and can be justifiably disseminated by the public school system. With this in mind, it would seem logical that the industrial arts area of the curriculum should offer this program since it is most likely to have the space and the instructors qualified to teach this program.

Importance of the Study

The relevancy of this program to the period of time when most areas of education are being challenged and questioned, may offer some small foothold toward a better, more challenging program. It is intended then, that the instruction in power mechanics be another source of motivation from which to draw upon as well as a source of knowledge and inspiration to the student. A course such as this offers a wide variety of opportunities for the instructor to teach not only power mechanics, but to integrate it with other curriculum areas. English, mathematics, social studies, science and others can be utilized when the opportunity presents itself. In this way the instructor can capitalize upon the interest of the students through correlation with other subjects, thus broadening the learning experiences of the students.

This writer feels that this type of course is necessary, if not paramount, from the standpoint that our entire nation's mobility and economy is based upon some form of motor-driven appliance. At present there is no formal instruction being offered in the Yakima Public Schools at the junior high level in the area of power mechanics as a laboratory class. This might infer that we have missed an opportunity to capitalize upon the native interest of students, because boys (and girls) of the eighth and ninth grade level are extremely interested in anything that has a motor in it, on it, or around it. Also, some students are further motivated by the realization that they are about to be old enough to qualify for a driver's license. In fact, some ninth grade students do own automobiles.

Limitations of the Study

This study is intended to be a guide for the inauguration of power mechanics as a proposed course of study as it pertains to the junior high level of the Yakima Public School System. The general information that the student might receive will be suggested, but the writer will make no attempt to fix the sequence of the suggested units or to instruct the reader as to what aids should be used and when. However, a list of free materials which can be used to implement the program appears in Appendix B. The problems of placement and scheduling that arise in each of the four junior high schools that now exist in Yakima, will not be precisely defined. However, some suggestions will be made regarding these areas.

Procedure of the Study

The necessary information pertinent to this study was obtained from books, state and city curriculum guides, and pamphlets obtained from the Central Washington State College Library, the Yakima Regional Public Library, and the personal file of the writer. The basic concern of this information was to explore the historical development of mechanical power; the cost and space requirements needed for setting up a power mechanics course; the power mechanics courses that exist in other districts; and the available material for facilitating instruction.

II. DEFINITION OF TERMS USED

Power Mechanics

A term intended to define a course of study concerned with the history of mechanical power, the kinds and types of mechanical power such as water power, wind power, steam power, internal combustion engines (gasoline, diesel, etc.), nuclear power, solar power, and electrical power. Experimentation in small gas engines will provide the laboratory experience necessary to develop generalizations between types of engines and parts relationships.

Accident

Accident is defined by Silvius, Baysinger, and Olson, as follows:

> An undesirable or unfortunate happening; casualty, mishap. This means that even when, by chance, a mishap does not result in personal injury or property damage, it is still the occasion of loss to all concerned (63:1).

Industrial Arts

That part of the public school curriculum which deals with industry, industry-related activities, materials, tools, processes, occupations, and organizations as they effect society.

General Shop

That specific part of the industrial arts program in which the instructional materials are selected from more than one area of industry and all activities are conducted at the same time within the same physical room.

Unit Shop

The unit shop implies that only one specific type of industrial activity is carried on within a given confine at one specific time.

Proposed Course

For the purpose of this study, "proposed course" identifies a description of information suggested as being important to the student's total general education in modern society, as well as implying other necessary information needed for adoption including costs, materials, space requirements, and audio-visual aids.

Laboratory Experience

Defined as an opportunity for the student to manipulate tools and materials in a work setting.

Experimentation

A term used to imply the investigation by a student into a specific area with the careful guidance of the instructor. It also implies the unification and correlation of the students findings to his class work and daily life.

Mock-Up

A mock-up is a three-dimensional representation of an actual object used in the direct or indirect instruction of students.

Cut-Away

An actual object which has been cut in such a manner as to reveal the inside of that object for the purpose of seeing the working parts and their relationship to one another.

Tune-Up

This denotes the process of inspecting, analyzing, repairing and adjusting an engine to its new or best running condition.

Motivation

A term used to define the practical art of applying incentives and arousing interest for the purpose of causing a pupil to perform in a desired way. This usually means the choosing of study materials of such a sort and presenting them in such a way that they appeal to the pupil's interest and cause him to do his work willingly. This also implies that the student will want to complete his work as well as sustaining his enthusiasm for the subject (34:354).

Learning

Broadly defined, is a process which brings about a change in the individual's way of responding as a result of practice, study, or other experience (60:297).

General Education

A term to define those phases of learning which should be the common experiences of all men and women. Such a broad type of education would be aimed at developing attitudes, abilities, and behaviors considered desirable by society but not necessarily preparing the learner for a specific type of vocational or avocational pursuits (34:245).

Junior High

A school that enrolls pupils in grades 7, 8, and 9 and carries out the purposes of general education. As to industrial arts at this level, it has as its primary function the provision of industrial experience of an exploratory or orientational nature for all boys and girls.

Safety

The act of preventing or anticipating potential accidents so that bodily harm does not come to any of the personnel of the shop or on-lookers. Also implied, is the prevention of damage to any of the tools or materials in the shop.

CHAPTER II

HISTORY AND DEVELOPMENT OF MECHANICAL POWER

The early history of mechanical power is one of those things that one can only speculate about because there were no writings to substantiate the facts. The sun has been credited with being the source of all power in as much as human and animal muscle power is rooted in the food consumed which could not have grown without the sun. The wind, water, wood, coal, and petroleum are resources from which man has drawn to provide power for one or another of his mechanical contrivances. All of these without exception are indirectly related to the sun which has provided for their growth as in the case of wood, or for their movement as in rain and water. The sun has provided electricity in more recent years through the use of solar cells (31:6).

Nuclear energy is the exception to the sources of power in that the sun did not play a major role in its development. However, nuclear reaction is similar to the energy produced by the sun itself, and has been predicted by Einstein to be equal to the amount of mass times the speed-of-light-squared (31:6).

The secret of the early history of mechanical power is kept in antiquity, leaving historians to logically speculate that man's first efforts at mechanical power development were purely happenstance. It may have happened that a man needed to move some large object such as a boulder in his path or cave, and out of frustration grabbed a large branch from a tree, stuck the branch between the large boulder he wanted to move and perhaps another rock, and by giving a sharp tug on the end of the branch, discovered that the object could be moved, thus inventing the lever (65:1-10). Perhaps it happened that a man observing animals decided to imitate their actions. A beaver felling trees may have been, in this case, the incentive leading to the use of a sharp stone as a crude hand ax (30:2).

Sometime during this slow, difficult time, man also discovered and perpetuated the knowledge of the wedge, screw, and the inclined plane. Later the wheel and axle, and the pulley were developed (21:1-20). These six simple machines and their adaptations are the basis of all of our modern machines. Of the six, the wheel is the most important of the group since the whole of industry is dependent upon it (21:1-3).

As man progressed from the old stone age to the new stone age (5000 B.C.) his developments were probably passed on from father to son. Man achieved many things during this new period, but the taming and using of fire probably had the most far reaching effects because it eventually led to the smelting of metals. The first metal used may have been copper and undoubtedly was discovered quite by accident between 4000 and 3000 B.C. (21:3). Thus, the age of metals with all of its tools, weapons, and mechanical devices came into being.

Archimedes (? - 212 B.C.) is credited as being the originator of mechanics as a science. To him belongs the credit for the theory on the center of gravity and of the lever. Archimedes, as reported by Cajori, exclaimed "Give me a fulcrum on which to rest, and I will move the earth" (14:6). Other great men also contributed to the physical aspect of the world. Such men as Aristarchus (310 - 230 B.C.), Pythagoras (572 - 497 B.C.), Plato (427 - 347 B.C.), Aristotle (384 - 322 B.C.), Leonardo da Vinci (1452 - 1519 A.D.), Galileo (1564 - 1642 A.D.) and Bacon (1561 - 1626 A.D.) all contributed to mechanics with their philosophy, mathematics, drawings and devices. These and others began the scientific processes of investigating aspects of the universe (12:1-15).

The next big step came with the first practical steam engine which is credited to an English mechanic named Newcomen (21:21). The event took place in 1711, and unveiled a large, stationary machine which was later used to pump water from mines. It has been stated, however, that this was not the first steam engine because the engine's pistons were actually activated by atmospheric pressure and the steam was used to drive the air from the cylinder creating a partial vacuum (21:19-22). Steam was instrumental in the operation of Newcomen's engine and it could not have functioned without it. The valves on Newcomen's engine were operated by hand, thus, leaving something to be desired in the efficiency of the engine until a boy named Humphrey Potter developed a system to operate the valves of the Newcomen engine automatically (21:23). The Newcomen engine went unchanged until a Scotch instrument maker named James Watt decided to improve upon the efficiency of the engine. Mr. Watt discovered the great waste of steam in the Newcomen engine and set about to improve the condensating technique (21:26-36).

After that, the external combustion engine became quite popular and others such as Joseph Cugnot of France adapted the engine to self-propelled mechanisms (31:15).

After 1800 there were several successful steam locomotives and this began to revolutionize transportation. The steam piston locomotive then dominated the scene for the next century. Toward the end of the nineteenth century, the domination of the steam-driven piston engine was followed by the steam turbine engine (31:15-16).

Though there were attempts with varying degrees of success, the first really successful internal combustion engine was developed in Germany by Dr. Nicholas August Otto in 1876. His four-stroke principle still retains his name and is known as the Otto cycle (31:19).

Another German, Dr. Rudolph Diesel, made an engine in which the fuel was ignited from the heat of the compression of the air within the cylinder (31:21). His first engine is reportedly to have blown up, but in 1877 he developed the type of engine that still bears his name (31:21-22).

The Second World War did much in the way of speeding up discoveries that led to more sophisticated types of power. Jets, rockets, gas turbines are but a few of these developments. The use of nuclear power directly in an engine has not been discovered to date. A nuclear engine is basically a steam turbine with liquid sodium to remove the heat of fusion and transferring it to a fluid system in the heat exchanger to make steam (31:19).

Electricity as a power source is a story unto itself. Magnetism (which can induce electricity) has been known about and used since the time of early man, however, it has not been until the twentieth century that electricity has found its place as an economical source of power. Most people of the United States own some sort of electrical appliance. In fact, electricity probably is now our largest source of industrial power and personal comfort.

Power mechanics as a course in its own right has begun to gain in popularity since the 1950's. However, the concept of a power mechanics course in the industrial arts curriculum has existed for more than forty years (41:40). In its early conception, power was probably taught as an automobile repair course since the automobile was the most significant application of the internal combustion engine. This is no longer true as the emphasis in mechanical power has become dispersed, shifting the needs of the student to include more diverse knowledge of power machines (41:46-47).

CHAPTER III

REVIEW OF LITERATURE

This chapter will examine the rationale of power mechanics and will review selected curriculum materials and courses of study. The writer will suggest course materials for the Yakima Public Schools.

During these times, manual labor has been replaced to a large extent by the implementation of machines. It is desirable that the layman have a basic knowledge of power mechanics in order that he may gain full use of these new products. It has been said that "more people will make one work, buy one, or care for one than will be called upon to make one" (6:43). Laborers, housewives, and even school students will be called upon to operate some type of motor-driven machine, and thus a shift in viewpoint in industrial arts. This is not meant to say that a power mechanics course should replace the traditional industrial arts, but rather a means to compliment and strengthen the program. Harrison comments in this respect and says:

> Industrial arts is a course unto itself and needs no further justification. The main purpose of industrial arts is learning not the project itself, rather the project is the means by which learning is established (36:10-11).

Most students take for granted the products of industry and do not realize the romance, the work, and the struggle that goes on behind the scenes. However, Harrison believes that "as an intelligent member of society and as a wise consumer, he must know more than appears on the surface" (36:3).

Any modern industrial arts program should include a study of power. A comprehensive program in power mechanics, if it is to live up to its name, must include in the course: (1) a study of power in historical perspective, (2) contemporary uses, and (3) future development (28:367).

Harrison suggests that we should teach the total concept of mechanical power regardless of the time alloted or the grade level (36:39).

Power utilization can be taught throughout the course with each unit. If all of the opportunities of the course are taken advantage of by the instructor, the power mechanics course can be developed " so that the non-verbal, the average, and the gifted student can progress in an area of unlimited possibilities" (41:48). In fact, Buttery suggests "many of the 'black-leather jacket' set proceed to 'set the pace' in such a situation and develop healthy educational attitudes" (14:48).

The learning that takes place in such a laboratory experience comes from the intense motivation of the group and the advantage of learning while doing. It has been stated that the most efficient way to learn about anything is to have all of the attention and senses integrated and focused on finding out about the subject by presenting the theory and the manipulation at the same time. One must recall that we learn from questioning and by being curious rather than by pouring material into the head (6:56).

When knowledge is desired in any area, including knowledge of machines, concepts are most permanently learned when we "see, handle, and place parts in their proper relationship" (6:43). <u>The Washington State Guide for Industrial Arts</u> discusses abstract theory and the use of concrete examples and states:

> It may be assumed that all of the senses should be involved in the learning process, that students are active by nature, that they are motivated to pursue knowledge when they are actively engaged in actual work on machines solving problems, hence the theory and the manipulative experiences should be presented simultaneously or as nearly at the same time as is practical. In no instance should the theory be presented in one course and the practical work in the next (69:41).

One of the main considerations in the instruction of power mechanics is that study should be exploratory learning situations. Thus, it should follow that the major emphasis is on broadening the <u>student experience</u>

rather than the production of mechanics (20:6; 33:22). While there is much emphasis on understanding about power rather than teaching a salable skill through tool manipulation, an alert instructor cannot overlook the "belief that it is better to let a learner stumble through tearing down an engine before he has had the theory" (6:56). This would indicate that a student possesses the ability to learn from taking a machine apart and putting it together again provided he is observant and thinks while he is doing it (6:43).

I. REVIEW OF SELECTED CURRICULUM GUIDES

A few selected guides from various cities and states are presented in this chapter to give a broad picture of courses as they appear throughout the United States. It should be noted that the courses related here are for the junior high level only. The length of the courses vary from nine weeks to thirty-six weeks with most operating for one hour per day for five days a week. Other programs investigated at the junior high level ranged in time limits from a few minutes a day for three weeks to a two-hour block of time with one hour for theory and one hour for laboratory experiences (14:48).

Colorado State Guide (50)

Power mechanics, as a general field, has been more instrumental in the development of our industrial might of today than perhaps has any other single factor. The power scooter, motor bike, lawn mower, outboard motor, and the automobile are the special interest areas in the field of power mechanics, but the possibilities are unlimited when one considers the related interest areas and services industries connected to this field.

Power mechanics is adaptable to almost any phase of the industrial arts program. Its teaching should logically follow courses in drawing, metals, and woodwork since these areas help to establish fundamental operations beneficial to the completion of suggested units of learning. Power mechanics lends itself well to integration with other courses in the school. General science, history, and mathematics are directly related while avocational interest, consumer knowledge and prevocational skills are other aspects of the course.

With the increasing number of power scooters, motor bikes, lawn mowers, and outboard motor boats being operated, there is an increasing need for power mechanics to be taught in the junior high school. The course is designed to acquaint the student with the basic concept of power, progressing into the fundamentals of typical power units accessible to them.

The Colorado State Guide describes its first course as being directed specifically at the ninth grade students. The course design is intended for a class which meets five days a week for eighteen weeks. As described in the guide, there is no prerequisite for the course. The basic operations described in this course were: (1) hand tools, (2) metal fastening devices, (3) simple machines and power transfer, (4) V-belts, gears, and clutches, (5) basic electricity and magnetism, (6) storage cells and dry cells, (7) motor bikes and scooters, and (8) servicing simple gasoline engines. The fundamental knowledge gained, the related information, and the investigating materials suggest a broad area of study which investigates the very basic aspects of power mechanics (50).

Edmonds School District, Alderwood Manor, Washington (27)

The curriculum guide published by the Edmonds School District contains a long continuum of power mechanics courses beginning in the junior high and continuing through high school. In the junior high it is part of a two semester elective for ninth grade boys requiring no prerequisite. Basically, the course lists the following material as instructional units: (1) occupational and consumer information; (2) opportunities in the field; (3) criteria of good workmanship; (4) how to check a product; (5) safety; (6) overview of internal combustion, jets, steam, water, wind, and diesel; (7) gasoline engine parts identification and nomenclature; (8) science of the internal combustion engines, chemical applications, automotive math, horse power, gear ration, micrometer, feeler gauges, electrical operation; and (9) tools of the industry (27).

<u>Evansville-Vanderburgh School Corporation, Indiana</u> (28)

The Evansville-Vanderburgh system has produced a very comprehensive guide for industrial arts. The area of power mechanics in this guide is quite heartily stressed and all units are meticulously planned. Their feeling of the importance of power mechanics can be seen in one of their introductory statements when they say that "a modern Industrial Arts program must include a study of power--not only power in its contemporary forms, but also the history of power and its future potential" (28:367).

Evansville does not state the exact level for which the course is intended nor for whom the course is intended or the prerequisites involved. From the tone of the study, however, the first course in power mechanics could be adapted to the eighth or ninth grade level. The guide lists the following as the basis for the first course:

1. History of the development of power
    A. Muscle
    B. Wind
    C. Water
    D. Heat
    E. Engines: external and internal combustion (steam, gasoline, diesel, ram jet, pulse jet, turbo jet, turbo prop, free piston, nuclear energy, and cosmic radiation).

2. The common tools and procedures
    A. Hand tools (screwdrivers, pliers, wrenches, hacksaw, files, chisels and punches, arbor press, hand reamers, measuring tools, and power tools).
    B. Procedures: taps and dies, stud removing, fasteners, safety procedures.

3. The basic machines
    A. Simple machines (levers, wheel and axle, inclined plane, pulley, wedge, screw, pulley and belt, sprocket and chain, cams and eccentric, bell crank and lever, and springs).
    B. Shafts (extension, drive, cam, and crank).
    C. Bearings (plain, anti-friction, and coupling).
    D. Gears (spur, helical, spiral, worm, bevel, bear and rack, and planetary combination).

4. Measurement of power
    A. Definition of horse power
    B. Factors affecting output of power
    C. Types of horsepower (28).

<u>Utah State Guide</u> (73)

The state guide for Utah in the area of power mechanics begins with a course to be taught to ninth grade students of the junior high level. The course is intended to run for a period of nine weeks and has no prerequisite. The subject as pursued is to give the owners of small engines the knowledge and background needed to repair and maintain their engines. The first nine weeks covers the following material: (1) history and development of power; (2) engine parts and functions; (3) cleaning an engine; (4) minor disassembly and tune-up of an engine; (5) home maintainance; and (6) trouble shooting. Each unit is carefully planned giving the unit sequence, the time involved, and the instructional aids and activities. Sample lessons are also given (73).

Dallas Independent School District, Texas (20)

Power mechanics as interpreted by the Dallas School District, is offered to ninth grade students at the junior high level for one hour a day, five days a week for thirty-six weeks. The learning experiences gained by the students are stated as being: (1) the nature of power mechanics; (2) the importance of a course in power mechanics; (3) importance of the power mechanics field; (4) how to get the most out of a power mechanics course; (5) skills basic to power mechanics work; (6) occupations and professions in the field of power mechanics; (7) practical applications in power mechanics of language arts, mathematics, science, and methods of research; (8) student responsibilities in laboratory management; (9) safety practices in the use and care of tools equipment, and supplies in power mechanics; (10) the common power mechanics tools and equipment; (11) historical development of power-driven mechanisms; (12) fuels and lubricants; (13) small engine fuel systems; (14) small engine oil systems; (15) engine air-cooling systems; (16) compression of four-cycle and two-cycle gasoline engines; (17) fundamentals of electricity; (18) small engine ignition systems; (19) trouble shooting small engines; (20) disassembling and inspecting small engines; and (21) designing, planning, and constructing mock-ups, models, and power-driven mechanisms (20).

School Shop Magazine (75)

An article entitled "Teach a Unit about the Small Gas Engine," published in the January, 1962 issue of School Shop, describes a course of study offered for ninth grade students over a period of nine weeks for at least 280 minutes a week. Walgren, also indicates that units of shorter or longer duration could be adapted, but he states:

> . . . it would seem advisable for schools, large or small, to broaden their industrial arts programs and offer a unit or even a full semester in this small-gas-engine area (75:18).

The course described is offered as a first year exploratory course thus offering much latitude in achievement gained by the students. Students in this course would appear to learn the following operations: (1) fill a crankcase with oil; (2) fill oil bath cleaner with oil; (3) fill fuel tank with gas; (4) start engine with either a rope starter, a recoil starter, or a handcrank; (5) operate the engine; (6) stop the engine; (7) adjust the gravity feed carburetors; (8) check the crankcase breather; (9) inspect and clean the air cleaner; (10) remove and disassemble the carburetor; (11) inspect and clean the fuel system; (12) inspect and adjust the governor; (13) inspect the wiring in the ignition system; (14) remove, clean, and adjust the spark plugs; (15) adjust the breaker points; (16) check engine compression; (17) check the engine vacuum; (18) set the ignition timing; (19) adjust the carburetor; (20) grind the valves; (21) check the gaskets; (22) check the bearings; (23) check the piston rings; (24) check the valve timing; (25) inspect the water jackets; (26) inspect the thermostats; (27) inspect the cylinder blocks; (28) tune the motor; (29) adjust nuts with a torque wrench; (30) remove carbon; (31) clean motor parts and motor; and (32) check for fuel leaks (75).

After reviewing the past group of courses, it is plain to see that there is considerable variance in the concept of what should be taught. Other courses that this writer explored varied in emphasis from a strictly book-oriented program to a class in automotive tinkering.

Courses in power were suggested from the elementary level, where the subject was treated more as a transportation unit all the way through high school. The seventh grade level was the first level suggested for laboratory experience in power with the ninth grade receiving most of the favor as being suitable for the beginning of laboratory centered experiences in power. However, successful nine week units on the internal combustion engine were taught at the eighth grade level (14:47).

II. THE WRITER'S SUGGESTED COURSE CONTENT

The general material that follows is felt to be the most desirable information for the operation of a power mechanics course in the Yakima Public Junior High Schools. A complete course of study will follow in Chapter V.

The general philosophy of the junior high school and general education are uninterrupted when it is stated that the "purpose of any power mechanics course should be to bring about a broad understanding of energy conversion to power" (71:50). The intensity of the course should be "exploratory" (33:22). A minimum course length of at least eighteen weeks at one hour per day, five days a week is suggested for the Yakima school system; however, an open mind should be kept toward other possible course lengths.

The suggested course content for the Yakima Public Junior High Schools would include: (1) introduction to power mechanics; (2) safety in power mechanics; (3) history and development of power mechanics; (4) power generation through the prime movers: sun, wind, water, etc.; (5) power measurement: proney brake; (6) power transmission: mechanical, hydraulic, pneumatic, electrical; (7) fuels and lubricants; (8) internal combustion engines: small gas engines, outboard engine, automotive engine, diesel engine, reaction engine, rocketry, gas turbines; (9) external combustion engines: steam; and (10) experimental power sources (53:39).

The arrangement of this material may be grouped in any logical sequence capitalizing upon the interests and motivations of the group at hand. "Skills can be imitated; but design, procedures and ideas, in so far as possible, should be original" (36:12). This writer suggests that the history of power might be interspersed throughout the course and make widespread use of films and aids whenever possible (41:47).

Power mechanics is exciting with its possibilities because it is relatively new to curricula throughout the country and is therefore not chained to tradition. This allows the imaginative instructor much latitude in course sequence. As Atteberry states:

> Power mechanics is more than a new set of units of content of activities in that it is a new methodology. It is a move away from the idea that you must make one to understand it (6:43).

CHAPTER IV

THE ADAPTABILITY OF POWER MECHANICS TO THE YAKIMA SCHOOL SYSTEM

The probable point of concern to the Yakima School District will be cost. In this chapter a close look at the space, materials, and costs of setting up a power mechanics course at the junior high level will be investigated.

I. SPACE REQUIREMENTS

Ideally, a power mechanics course should have its own laboratory facilities providing for the student the best environment in which to learn. This not being possible in Yakima at this time, the next best situation will be investigated: that of adapting power mechanics to existing facilities. The most appropriate area for a power mechanics course has been pointed out in the Washington State Curriculum Guide for Industrial Arts where it stated the following:

> Since the tools, materials, processes and basic principles of operation are similar in the areas of power mechanics and metals, it is recommended that they be organized together as a unit at the basic or exploratory level (69:41).

The opinion of this writer concurs with the guide because it does seem logical that the metal area would have the best tools on hand for this kind of course as well as having the necessary storage. Perhaps, at some later date, a power mechanics facility could be added to the building program. As of now, all four junior highs in the Yakima system have metals areas in their curriculum which, with small adjustments, would allow a most functional power mechanics course. Scheduling is perhaps the most important factor affecting the space. Each instructor will need to determine the maximum number of students that his available space will handle as it is "perhaps most important to consider adequate space to insure maximum safety for the students" (75:18). The number of students should never be greater than 24 at anytime, although it ideally could be a much smaller figure. Space then, is not a serious problem for the addition of power mechanics to the industrial arts curriculum in Yakima, causing little or no expense to the school district.

II. TOOLS

Tables I - VII, shown in the Appendices, contain lists of tools selected to give the <u>maximum</u> flexibility of learning activities without being extravagant. Most of the metals areas in the schools previously mentioned have some of the tools described in these tables of tools which are needed to operate such a course at this time.

The total cost for the tools and miscellaneous supplies comes to $1029.07. It is felt that this list of tools is sufficiently comprehensive to start a program of power mechanics (57:15). As instruction broadens in scope, additional equipment may be added. Each instructor will need to evaluate the list, as his shop may already contain a number of the items mentioned. Also, he may wish to add some tools to the list in order to fulfill what he will anticipate the needs of the class to be.

III. MATERIALS

There are no materials that are consumed in a power mechanics shop such as there are in a woods class, for example. Consequently this side of the budget could be allowed for tools, etc.

The small gas engine is suggested as the basis for the beginning laboratory experience because of its ready availability to the class situation. This choice was also made because the principles of such an engine are basic to more sophisticated and larger types of engines. These small gas engines can be obtained in a number of ways. They may be purchased directly from suppliers such as Brodhead-Garrett, who will either supply the completed engine or a kit--each for a nominal fee. They may also be obtained from individuals after the engine has been worn out, or engines can be purchased from the junk yard for about 7 cents a pound.

Industry is a firm supporter of the power mechanics area and will supply, free, such things as motors, pamphlets, mock-ups, etc. A prime example of this was related in an article in Industrial Arts and Vocational Education entitled "Industrial Support for Power Programs":

> To qualify for a free engine, school authorities stipulate that the small engine training is conducted on a regular basis, every year or every semester and not just at sporadic intervals. In addition to one free engine, each school may also receive others at half the list price.
>
> Upon request, Briggs and Stratton also donates these instructional materials to schools which qualify:
>
> 1. A manual or booklet on the "general theories of operation" of a four-cycle, single-cylinder engine for each student in the class.
>
> 2. A second manual of repair instruction for each student.
>
> 3. A set of 17 by 24 inch turnover wall charts for the school. These cover the theory of compression, carburetion, and ignition.
>
> Schools also may obtain, at half cost, any of six different sets of scripts and colored slides. These cover the following subjects: (1) complete overhaul of aluminum alloy engines--68 slides; (2) proper methods of checking compression, carburetion, and ignition--27 slides; (3) when, why, and how to resize the cylinder--11 slides; (4) inspection and refacing of valves and seats--12 slides; (5) bearing replacement--12 slides; and (6) how to start, stop, maintain, and store an engine during the off season--28 slides (10:45).

Any number of other manufacturers of small engines would be happy to send charts, literature, and sometimes an actual unit upon request (14:47-48). Depending on the ambition of the school district and the instructor, the cost of a power mechanics course may well be one of the reasonable and encouraging arguments for the establishment of the power mechanics course (14:47-48). Koenig also indicates that cost should not be a problem when he states:

> Excuses for little or no comprehensive course in power should fall on deaf ears because there are a number of major lawn mower and outboard manufacturers who offer one or two weeks' free training at their factories. These companies also offer reams of free literature and charts, and will give or loan the school cutaways and or working models. . . Most all leading automobile and diesel manufacturers, aircraft companies, manufacturers of electrical and electronic equipment offer free literature, charts and usually equipment (41:47).

Students may also have access to such things as old lawn mower engines, defunct go-carts, model aircraft engines, electric model car motors, and etc. These items, when brought to school, provide extra incentive for the students as well as aid in cutting costs as long as the class does not loose direction and become a tinkering session (6:43,54).

A list containing many good teaching materials, such as films, and charts, which can be obtained rent free appears in Appendix B. It should be noted that some items in that list may require some postage fee.

Thus, space requirements and material needs can be worked out with little or nominal cost to the district. The initial cost of tools and perhaps textbooks, would constitute the only expense in setting up a very basic course in power mechanics. This writer feels that a forward looking district can justify this expense in order to maintain a quality program and in fulfilling the objectives of industrial arts and general education.

CHAPTER V

PROPOSED COURSE OF STUDY

It has been stated that power mechanics at the junior high level should be strictly exploratory in nature (30:22). At the same time this implies that the "major emphasis is on broadening the student experience /while/ workmanship is stressed so that the student develops safe precise work habits" (20:6).

At the present time, industrial arts as it is taught in most schools, is geared mostly to the instruction of boys. This does not mean that girls should be excluded from these courses. In fact, courses in which girls have enrolled have been provided with a very wholesome influence (37:20). Girls as a group do not elect these courses with a great deal of frequency, which may show an area for imporvement. This improvement may be necessary because women purchase and use many of the products of industry which are found in the home. The Raleigh, North Carolina Curriculum Guide states that women:

> . . . plan homes and in general manage them. Statistics show that more women are employed in certain industries than men. With the mechanization of the home and with the increase of women in our labor force, technical knowledge is becoming more important for girls (37:20).

All this is to suggest that an open mind should be kept toward the scheduling of girls into power mechanics and other industrial arts courses. Perhaps, even to the point of constructing specially designed laboratory classes to provide them with some technical understanding (37:20).

Regardless of whether the class consists of boys, girls, or both, a paramount concern of the instructor is for their safety. Safety in power mechanics should be one of the first topics of discussion and should be reinforced throughout the entire course:

> The emphasis here is on developing wholesome attitudes toward safety rather than safety training. This is because of the importance of correct attitude in accident prevention (63:iii).

Of secondary importance is the liability of the teacher, as the courts have become most strict in their interpretation of the laws regarding liability. One must keep in mind that "negligence is considered to exist if harm befalls as the result of an accident which could have been foreseen by a prudent teacher" (38:411). Therefore, safety should be included in the first lesson of the power mechanics course and it should be continued throughout the course with the goal of constructing proper attitudes toward safe practices.

The following course of study purposefully does not have any unit numbers or proposed time schedules. The units are divided by subject name only, allowing a greater flexibility of use and emphasis of the materials.

This was done in an attempt to eliminate rigidity in the course, creating a collection of materials which could be shuffled and used intact or impart to the best advantage of each instructor.

Every class differs from one to another (71:51). Therefore, student needs will be different, demanding a different approach to the course materials. The basic course is intended to be an exploratory course aimed at the ninth grade level, one hour per day, five days a week for eighteen weeks. The course material is such that any number of course lengths can be derived from it simply by changing the intensity of instruction. The methods for using this material are not exactly stressed in the course itself. However, it is suggested that the instructor use the techniques of lecture-demonstration, field trips, written reports, oral reports audio-visual materials (films, mock-ups, cutaways, slides, and etc.), and laboratory experiences (53:39). Teaching materials have been listed in Appendix B, most of which are free. It is also recommended that student projects from home be allowed in the laboratory if they foster a learning experience. "A person who has had the opportunity to develop creativeness and resourcefulness will have more confidence in his ability to do unusual and different things" (36:12).

The objectives give a complete guide as to the outcomes a student should receive from a power mechanics course. The suggested course materials are divided into the categories of student knowledge, time, and teacher activities. "Student knowledge" suggests possible areas of information that the student should know about, whereas "Teacher activities" suggests possible information that the teacher can give to the students. Often these two areas cross for added or repeated information. The time column is left blank and can be filled in by the instructor as to the time that he wants to spend in each area.

Atteberry's Power Mechanics was selected by this writer as the basic text because it most nearly fits the reading and comprehension level of the junior high level. No one text can dominate the course, for pamphlets, manuals and other books should be on hand for easy access (See Bibliography and Appendix B).

PROPOSED POWER MECHANICS COURSE

OBJECTIVES OF POWER MECHANICS

1. To impress upon the students the importance of safety rules and practices in the operations of small gas engines as well as related areas of industrial activities and the home in such a manner as to foster good attitudes toward accident prevention.

2. To develop within each student an appreciation of good design and workmanship of small gas engines in such a manner that this appreciation will transfer to all areas of endeavor.

3. To acquaint the student with the historical perspectives, the contemporary uses, and the future development of mechanical power.

4. To acquaint the student with a number of the tools used in power mechanics and to impart to these students the knowledge of proper care and use of these tools.

5. To impart to the students the knowledge of processing, safe use, care, and storage of flamable liquids.

6. To increase the student's knowledge in the selection, purchase, use, and care of small gas engines.

7. To provide the student with exploratory experiences in power mechanics aiding him to establish his interest, abilities, and aptitudes and to impart knowledge of mechanical terms and nomenclature.

   A. To develop in the student a respect for machines as well as the small gas engine as a precision device requiring expert care and adjustment to insure proper operation.

   B. To instruct the student in the necessary details involved in the operation, maintainance, and adjustment of small gas engines.

   C. To acquaint the student with the various major systems of small gas engines and to aid him in generalizing these to other machines.

D. To allow the student some exploratory experience in minor overhauling of small gas engines and to aid him in generalizing these experiences to other machines.

8. To provide the student with exploratory opportunities in the measurement and transmission of small gas engines and related areas.

9. To provide information to the student on the available occupational fields in the small gas engines area as well as others.

10. To correlate power mechanics to other areas such as Mathematics, Science, English, etc.

11. To foster a cooperative group spirit.

UNIT - INTRODUCTION

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
A. The nature of power		A. Explain to the student what power mechanics is about.
B. The importance of a course in power		B. Explain to the student what he can hope to accomplish by taking a course in power mechanics.
C. Importance of the power mechanics field		C. Explain to the students the importance of the power mechanics field.
D. How to get the most out of a power mechanics course		D. Give the students instruction on how to get the most out of a power mechanics course.
E. Skills basic to power mechanics work		E. Present and explain the skills that are basic to power mechanics.
F. Occupations and professions in the field of power mechanics		F. Explain to the student the different occupations and professions that are available in the power mechanics field.
G. Practical applications in power mechanics of language, art, mathematics, science and methods of research		G. Present and explain the practical applications in power mechanics of language, art, mathematics, science, and methods of research.

UNIT - INTRODUCTION (Continued)

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
H. Student responsibility in laboratory management		H. Give instruction on student responsibilities in the laboratory (20:7). Film: "Our Mr. Sun" Chart: Energy Production in the Sun

UNIT - SAFETY

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
A. Safety practices in the use and care of tools, equipment, and supplies of power mechanics		A. Present and explain the safety practices to follow while doing power mechanics work.
B. Safety Practices 1. Attitudes 2. Personal safety 3. Safety for others 4. Safety in the use and care of tools, equipment, and supplies 5. Electricity 6. Batteries 7. Lifting devices 8. Presses 9. Carbon monoxide poisoning		B. Make sure that the student follows all safety practices in the laboratory. 1. Dress safely: shirt tail tucked inside, shirt sleeves buttoned at the wrist, wear hard sole shoes when possible. 2. Wear safety eye protectors at all times. 3. Keep all waste material in an enclosed container. 4. Keep all fuels and solvents in explosive proof cans. 5. Clean and return all tools to their place after use.
C. Related safety knowledge 1. Other School situations 2. Home 3. Community 4. Water sports 5. Traffic		Film: "Safe Shop" Supplementary text: Exploring Power Mechanics, pages 133-134. (20:7; 28: 16:2; 8:35).

UNIT - TOOLS AND USES

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
A. Appreciation of tools 1. Development 2. Value to society		A. Give the student information on the development of tools and their value in society.
B. Care of tools and equipment 1. Maintenance of tools and equipment a. Lubricating b. Cleaning c. Sharpening		B. Show and explain how to care for tools and equipment. Include: 1. Maintenance of tools a. Lubricating b. Cleaning c. Sharpening 2. Storage
C. Power mechanics tools 1. Screwdrivers a. Straight b. Magnetic c. Phillips d. Offset 2. Pliers a. Combination slip joint b. Pump-type c. Vise grip d. Needle nose e. Diagonal f. Special 3. Wrenches a. Open-end b. Box-end c. Combination box-end and open-end d. Sockets 1. Standard 2. Deep 3. Thin wall 4. Universal 5. Point e. Adjustable open end f. Torque wrench g. Pike wrench		C. Power Mechanics tools 1. Exhibit and explain the available tools and equipment to include: a. Name b. Purpose 2. Arrange for the students to examine the tools and equipment. 3. Demonstrate tools and equipment 4. Supervise the students while they are using the tools Film: "A B C's of Hand Tools" Booklet: <u>Machine Tools--America's Muscles</u> Chart: <u>Learning Through Tools</u>

UNIT - TOOLS AND USES (Continued)

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
4. Wrench handles a. Ratchet handles b. Break-over (flex) c. Speed (spinner) d. Sliding tee e. Extension f. Universals 5. Chisels a. Cape chisel b. Cold chisel c. Diamond point d. Half round chisel e. Round nose 6. Files a. Classification of files b. Shapes of files c. Care of files d. Method of filing 7. Punches a. Pin punch b. Prick punch c. Center punch d. Drift punch 8. Hammering tools a. Ballpeen hammer b. Rawhide mallet c. Plastic mallet d. Rubber mallet 9. Drilling tools a. Hand drill b. Electric drill c. Drill pren d. Twist drill e. Reamers		

UNIT - TOOLS AND USES (Continued)

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
10. Tap and die set a. For U.S.S. thread b. For S.A.E. thread 11. Thread gage 12. Screw extractor 13. Hacksaw 14. Soldering tools a. Soldering gun b. Soldering iron c. Soldering torch 15. Flaring tool set 16. Valve spring compressor 17. Piston ring compressor 18. Valve grinder 19. Valve groove cleaner 20. Rig-reamer 21. Ignition tools a. Point files b. Feeler gauge c. Miniature wrenches 22. Measuring tools a. Steel ruler b. Caliper 1. inside 2. outside c. Micrometers d. Tachometer e. Spark gaper 23. Special tools and equipment		

(20:8-10)

UNIT - HISTORY AND DEVELOPMENT

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
A. Chemical principles of power or energy 1. Sun 2. Wind 3. Water 4. Steam 5. Internal combustion 6. Electrical 7. Nuclear		A. Chemical principles of power or energy 1. Assign the students a reading assignment on the chemical principles of power or energy. 2. Explain the chemical principles of power or energy to the students.
B. Physical principles of power or energy (simple machines) 1. Levers a. First class lever b. Second class lever c. Third class lever 2. Wheel and axle 3. Pulley 4. Inclined Plane 5. Screw 6. Wedge		B. Physical principles of power or energy (simple machines) 1. Show and explain the principles of each simple machine to include: a. Levers b. Wheel and axle c. Pulley d. Inclined plane e. Screw f. Wedge 2. Give a reading or research assignment to cover simple machines. 3. Give the students a written test on the historical development of power to include:

UNIT - HISTORY AND DEVELOPMENT (Continued)

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
		a. Chemical principles of power b. Physical principles of power or energy Supplementary Text: *Small Gasoline Engines*, pages 1-4. Dittoed study questions: see page 4 of above text. Film: "Men, Machinery, and Imagination" (20:10)

UNIT - HEAT ENGINES

STUDENT KNOWLEDGE

TIME

TEACHER ACTIVITIES

STUDENT KNOWLEDGE

A. Heat engine
  1. External combustion
  2. Internal combustion

B. Types of engines
  1. Piston engine
    a. Two-stroke cycle
      1. intake-compression
      2. power-exhaust
    b. Four-stroke cycle
      1. Intake
      2. Compression
      3. Power
      4. Exhaust
  2. Diesel engine
    a. Two-stroke
      1. Intake-compression
      2. Power-exhaust
    b. Four-stroke
      1. Intake
      2. Compression injection
      3. Power
      4. Exhaust
  3. Jet engine
  4. Turbojet
  5. Rockets

TEACHER ACTIVITIES

A. Basic types of engines
  1. Explain the basic types of engines to the students
  2. Assign reports from library in related areas

B. Steam engines
  1. Features
  2. Operating principles
  3. Disadvantages

C. Piston engine
  1. Features
  2. Operating principles
    a. Two-stroke
    b. Four-stroke

D. Diesel engine
  1. Features
  2. Operating principles
    a. Two-stroke
    b. Four-stroke
    c. Injection

E. Turbojet
  1. Show and explain the principles of jet propulsion
  2. Explain thrust of a turbojet
  3. Use a chart or a model of a turbojet engine and point out the parts and explain the purpose and function of each part of a turbojet engine.

UNIT - HEAT ENGINES (Continued)

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
		4. Discuss uses of the jet engine in aircraft. 5. Explain the characteristics of the turbojet engine. F. Give the student information on rockets to cover: 1. Fuels 2. Problems 3. Guidance 4. Firing Films: "A B C of the Diesel Engine" "A B C of Jet Propulsion" Chart: The Automobile Engine Use two-cycle or four-cycle mock-ups or cutaways. Text: Power Mechanics (5:4-15). Quiz on this unit. See page 15 of text. (20:10-12; 16:5)

UNIT - POWER MEASUREMENT

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
A. To measure the horsepower 1. Piston displacement 2. Meaning of horsepower 3. Piston displacement computation formula Displacement = $\frac{(\text{Bore})^2}{4} \times \pi \times \text{stroke}$		A. Piston displacement and horsepower 1. Explain the meaning of displacement and horsepower. 2. Show and explain how to compute displacement by the use of the piston displacement formula. Example: Compute the displacement of an engine which has a 2" stroke. Displacement = $\frac{2 \times 2}{4} \times 3.1416 \times 2$ Displacement = 6.2832 cu. in.
B. Horsepower = 33,000 foot pounds per minute 1. Torque a. $\frac{D^2N}{2.5}$ 1. D=diameter of bore 2. 2 = square 3. N = Number of cylinders 4. 2.5 = Constant (related to 33,000)		B. Apparatus 1. Proney brake 2. Dynamometer Text: *Power Mechanics* (5:16-18) Demonstrate formulas on overhead projector. Quiz. (16:8; 20:14-15)

UNIT - POWER MEASUREMENT (Continued)

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
2. Brake a. $\frac{F \times 2L \times 3.14 \times RPM}{33{,}000}$ 1. F = Force exerted 2. L = Length of lever arm 3. 3.14 = (pi) 4. RPM = Revolutions per minute 5. 33,000 = 1hp		

UNIT - FUELS AND LUBRICANTS

STUDENT KNOWLEDGE

A. Fuels in general use
1. Gasoline
2. Diesel fuel
3. Propane and butane
4. Jet Fuel
5. Natural gas
6. Benzene
7. Alcohol

B. Gasoline
1. Grades
2. Nature
3. Additive

C. Chemical union of air and gas
1. Atomization
2. Vaporization
3. Oxidation

D. Lubricants
1. Types of oil
   a. Detergent oil
   b. Use of lubricant

E. Mixing of gasoline and oil for two cycle engine

F. Safety practices

TIME

TEACHER ACTIVITIES

A. Where does it come from?

B. Fuels and lubricants
1. Explain the uses of the various types of fuels.
2. Give the student information on gasoline to include:
   a. Grade
   b. Nature
   c. Additives
3. Give information on the chemical union of air and gas.
   a. Atomization
   b. Vaporization
   c. Oxidation
4. Give information on lubricants to include:
   a. Types of oil
   b. Additive
   c. Uses of lubricants
5. Show and explain how to mix gasoline and oil together for two cycle engine.
6. Show and explain safety in handling and storage of fuel and lubricants.
7. Test student knowledge
8. Fuel transportation report.

UNIT - FUELS AND LUBRICANTS (Continued)

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
		Films: "The Story of Gasoline" "The Story of Lubricating Oil" See Appendix B, page 88, number 10, page 12, page 91 number 24. (20:12)

UNIT - POWER TRANSMISSION

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
A. How does the power get from the engine to the machine? 1. Purpose of a clutch a. Couple and uncouple engine and transmission 2. Standard geared transmission 3. Synchromesh 4. Overdrive 5. Automatic a. Torque converter b. Fluid coupling		A. Discuss aspect of power transmission Review 1. Levers 2. Gears 3. Wheels 4. Torque Demonstrate the advantages of having a clutch rather than a direct drive. Discuss the disadvantages of a clutch mechanism rather than direct drive.
B. Electrical transmission		Films: "Power for a Nation" Text: <u>Power Mechanics</u> (5:63-75) Quiz. Cut-aways and mock-ups.

UNIT - ENGINE CLEANUP AND DISASSEMBLY

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
A. External cleaning 1. Methods and safety a. Tools b. Solvents c. Gasoline d. Fumes e. Compressed air		A. This unit provides a good opportunity to allow exploration of the engine by the student. 1. Provide each student with a procedure sheet. 2. Materials a. Engine manuals b. Parts containers for students to prevent loss and mixing c. Two-cycle and four-cycle engines would be ideal.
B. Disassembly 1. Order and techniques a. Prevent parts loss b. Drain oil c. Gas tank d. Carburetor and linkage e. Muffler f. Flywheel g. Coil, points, and condenser h. Cylinder head i. Valves j. Sump cover or pan k. Camshaft and tappits l. Piston assembly m. Crankshaft		B. Have student clean engines to dirt free condition. C. Having the students disassemble the engines in the order listed at the left, develop order and technique.
C. Cleaning internal parts 1. Tools 2. Solvent 3. Storage of parts waiting assembly		D. Have student clean internal parts of engine and store so that they stay clean, undamaged and accounted for. E. Allow more apt students to bring machinery from home and repair in the

UNIT - ENGINE CLEANUP AND DISASSEMBLY (Continued)

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
		shop if space and time permit as much learning can be gained from this.
		Supplementary text: Small Gas Engines (66:24-26) Exploring Power Mechanics (31:73-121).

(73:9)

UNIT - HOME MAINTENANCE OF SMALL ENGINES AND MACHINES

STUDENT KNOWLEDGE

A. Safety and cleaning requirements
   1. Lawn mowers
   2. Tillers
   3. Travel vehicles
   4. Pump
   5. Outboard engines
   6. Generators

B. Lubrication
   1. Types of oil
      a. Service ML-MM
      b. Service MS
      c. Service DG
   2. Pre-use check and lubrication
      a. Machine
         Bearings
         Gears
         Chain
         Others
   3. Engine oil change
      a. Purpose
      b. Frequency
   4. Periodic Check
      a. Engine
         Crankcase oil
         Air filter
         Air cooling system
         Settling bowl
   5. Storage precedure
      a. In storage
      b. Out of storage

TIME

TEACHER ACTIVITIES

A. Break class into groups of four and have groups bring an engine and its machine parts from home to work on.

   Use charts and technical manuals

B. Students clean and service an engine and machine.
   --Change engine oil
   --Clean and lubricate a bearing
   --Check oil level
   --Service air filter
   --Check flow of cooling air
   --Drain and clean a settling bowl

C. Students can make wall charts of pre-use check and lubrication.

D. Chart on storage precedures to hang on garage wall at home.

Filmstrip: Set 2 of Briggs and Stratton series, "Check-up".

(73:15)

UNIT - MALFUNCTION ANALYSIS

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
A. Compression tests		A. Provide engine manual and chart
B. Ignition tests		B. Test equipment
C. Fuel system tests		C. Demonstrate the use of equipment
D. Governing system tests		D. Have class perform the tests A-F and report their findings in writing.
E. Starter checks		E. There is a good possibility that the instruction could bug class engines having the students find, identify, and repair the malfunction.
F. Cooling system		Film: "No Trouble At All", "ABC of Internal Combustion", "Spark in Time on the Firing Line". Filmstrips: "Diagnose It First", "Know Your Carburetor", Set 2, Briggs and Stratton, "Check-up" Use ignition and carburetor for mock-ups.

(73:8)

UNIT - TROUBLE SHOOTING

STUDENT KNOWLEDGE

I. Before starting engine
   A. Check oil level
   B. Fill new engine to correct level
   C. Check air cleaner
      1. Oil bath
      2. Felt
      3. Moss
         a. Clean all parts
         b. Replace worn parts
         c. Fill with oil (oil bath)
   D. Check fuel tank
      1. Clean tank
      2. Fill with gas
      3. Mix gas for two-cycle motor
         a. 1/2 pint oil--1 gallon gas
         b. Never interchange gasoline
   E. Check spark plug
      1. Clearance
      2. Corrosion

II. Engine fails to start or starts with difficulty
   A. Causes
      1. No fuel in tank
      2. Obstructed fuel line
      3. Tank cap vent obstructed
      4. Water in fuel
      5. Engine over-checked

TIME

TEACHER ACTIVITIES

A. Fuel system troubles
   1. Show and explain the causes and remedies of fuel system troubles.
   2. Have the students trouble-shooting the fuel system and find and fix troubles

B. Arrange demonstration involving the following problems
   1. Carburetor
   2. Spark plug
   3. Magneto
   4. Mechanical

C. Have students trace and fix the troubles where they occur.

Text: Power Mechanics (5:77-84).
Supplementary text: All About Small Gas Engines (54:115-122).
Films: "No Trouble At All",
"ABC of Internal Combustion",
"Spark in Time on the Firing Line".
Test: See page 85 of text.

UNIT - TROUBLE SHOOTING (Continued)

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
6. Improper carburetor adjustment		Observe and guide student activities.
7. Loose or defective wire		
8. Faulty magnets		
9. Spark plug porcelain cracked		
10. Spark plug fouled		
11. Poor compression		
B. Engine knocks		
1. Carbon in combustion chamber		
2. Loose or worn connecting rod		
3. Loose flywheel		
4. Worn cylinder		
5. Improper magneto timing		
C. Engine misses under load		
1. Spark plug fouled		
2. Porcelain cracked		
3. Improper plug gap		
4. Pitted magneto breaker points		
5. Faulty condensor		
6. Improper carburetor adjustment		
7. Reed valves fouled		

UNIT - TROUBLE SHOOTING (Continued)

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
D. Engine lacks power 1. Choke partially closed 2. Improper carburetor adjustment 3. Improper timing 4. Warn piston and ring 5. Lack of lubrication 6. Valves leaking E. Engine overheat 1. Improper timing 2. Carburetor improperly adjusted 3. Cooling fins clogged 4. Carbon in combustion chamber F. Engine surges or runs unevenly 1. Fuel tank cap vent hole clogged 2. Governor parts sticking or binding 3. Carburetor throttle linkage sticking G. Engine vibrates excessively 1. Engine not securely mounted 2. Bent crankshaft 3. Associated equipment out of balance		Observe and guide student activities.

UNIT - TROUBLE SHOOTING (Continued)

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
H. Poor compression 1. Loose spark plug 2. Loose head or blown gasket 3. Piston rings carboned, worn, or broken 4. Worn cylinder 5. Poor lubrication 6. Damaged piston ring 7. Defective seals		Observe and guide student activities. (16:10-12; 20:19-20)

UNIT - DESIGNING, PLANNING, AND CONSTRUCTING MOCK-UPS, MODELS, AND POWER-DRIVEN MECHANISMS

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
A. Trends in power mechanics devices design 1. Function 2. Style 3. Type of construction 4. Kind of material used B. Kinds of power mechanics devices 1. Experimental devices 2. Utility projects 3. Mock-ups 4. Models a. Cut-aways b. Working c. Transparent		Observe and guide student activities. Film: "Firebird III", "Fluid Power", "Turbocopter Odyssey", "Principle of Optical Maser", "Electric Propulsion". Library planning and oral reports.
C. Planning a power mechanics device 1. Make a drawing or a layout of the device 2. Make a bill material or a list of supplies of items needed for the device 3. Make a list of tools, machines, and equipment needed for the construction of the device 4. Make a list of procedures or steps to follow to construct device		

UNIT - DESIGNING, PLANNING, AND CONSTRUCTING MOCK-UPS, MODELS, AND POWER-DRIVEN MECHANISMS (Continued)

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
D. Constructing power mechanics devices 1. Simple machines a. Levers b. Wheels and axles c. Pulley d. Inclined plane e. Screw f. Wedge 2. Steam engine 3. Air operated engine 4. Magnets a. Permanent b. Electro 5. Electrical circuits 6. Transformers 7. Electrical switches 8. Small engine ignition system parts layout board 9. Small engine ignition system mock-up 10. Sectional engine cut-away 11. Small engine fuel system lay-out board 12. Motor, parts, etc. 13. Jets, rockets, etc.		Observe and guide student activities. (20:21-22)

UNIT - RECONDITIONING

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
A. Compression system 1. Block a. Acceptability check Cylinder Bearings Valves Oil seals b. Cylinder preparation Ream ridge Deglaze c. Valve seats and guides Refacing Reaming d. Cleaning and oiling block for reassembly 2. Crankshaft acceptability a. Bearings surfaces b. Straightness 3. Piston assembly a. Acceptability check Piston Piston pin Rings Connecting rod b. Assembly Connecting rod to piston Ring on piston Piston into block (lubrication requirements connecting rod, slinger and keeper Torque requirements		A. Engine manuals and engine for instructor to demonstrate operations on Students work through compression system as teacher gives step by step instruction on how to recondition each part. Keep class together. Observe and guide student activities. Filmstrips: Set 1, Briggs and Stratton, "Complete Overhaul". Set 3, Briggs and Stratton, "Resizing Cylinder". Set 4, Briggs and Stratton, "Valves and Seats". Set 5, Briggs and Stratton, "Bearing Replacement". Films: "Frontiers of Friction". "Success Story"--The Story of Valves, "ABC of Internal Combustion". Charts: Ignition, Fuel System Text: *Power Mechanics*, (5:25-56) Supplementary text: *Small Gasoline Engines* (66:133-150).

UNIT - RECONDITIONING (Continued)

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
4. Tappits and cam-shaft a. Acceptability check b. Installation 5. Valves a. Acceptability check b. Refacing c. Grinding tappit clearance d. Lapping e. Install valves f. Valve chamber cover and crankcase breather 6. Head a. Acceptability check b. Installation Torque require-ments		Observe and guide student activities.
B. Ignition system 1. Acceptability check a. Breaker points Point shuttle or plunger b. Condensor 2. Reconditioning a. Reface or replace points --proper gap b. Condensor c. Sealing point cover 3. Flywheel a. Magnetism check b. Install Key alignment Torque require-ments		B. Engine manual and demonstration engine Have students tune up electrical system, install points, con-densor and cover. Install flywheel and key. Set armature air gap. Spark test magneto.

UNIT - RECONDITIONING (Continued)

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
4. Armature and coil a. Setting air gap b. Spark test		
C. Fuel system 1. Carburetors a. Acceptability checks b. Cleaning procedures Proper solvents Obstruction check c. Assembly Jets and valves Float level Gasket Carburetor body d. Governor linkages Connectors Adjustments e. Temporary adjustments 2. Fuel tank, filter, and lines a. Acceptability checks b. Cleaning		C. Engine manuals and demonstration engine Have students clean and overhaul fuel system.
D. Governing system 1. Mechanical a. Acceptability checks b. Assembly c. Linkages to carburetor d. Adjustments Spring tension Running RPM check		D. Engine manual and engines with air vane and mechanical governors Have students assemble governors. NOTE: Running RPM checks will not be made at this time by students.

UNIT - RECONDITIONING (Continued)

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
2. Air vane a. Acceptability check b. Assembly c. Linkages to carburetor d. Adjustments Spring tension Air vane position Freedom of movement Running RPM check		
E. Starters 1. Simple rope pull a. Inspection b. Assembly c. Torque requirements for flywheel nut 2. Automatic rewind a. Acceptability check b. Spring removal c. Cleanups and lubrication d. Spring rewind e. Rope installation f. Clutch disassembly and cleanup g. Clutch lubrication and assembly h. Torque requirements for flywheel nut		E. Engines with different types of starters Have students recondition engine starters.

UNIT - RECONDITIONING (Continued)

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
F. Cooling system 1. Check test a. Flywheel fins and air screen b. Cooling fins on head and block c. Air passages d. Air shroud		F. Have students check cooling system and finish complete assembly of engine
G. Running adjustments 1. Starting a. Prestart check Oil in crank-case Air filter condition Clean fuel in tank Fuel valves open b. Choke setting c. Throttle setting d. Rope pull procedure safety e. Warm up period 2. Make running adjustments a. Carburetor function High speed valve Idle valve Idle speed screw b. Governor function Running RPM check c. Safety while making checks		G. Have students make prestart checks, then start engine. Make running carburetor adjustments. Make running RPM tests of idle and top speeds. Encourage students to recondition another engine. Have them do this on their own and comment upon what they have learned.

UNIT - RECONDITIONING (Continued)

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
3. Stopping a. Proper speed for stopping b. Shorting electrical system for stopping c. Safety practices		

(68:10-15)

UNIT - EXPERIMENTAL

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES
A. Rotary combustion engine 1. Kinds and types of experimental rotary engines 2. Epitrochoidal design of the Wanket engine a. Allows four-cycle operation b. No problems with hot spot on the crank-shaft 3. Principles of operation a. Valving ports provided for four stroke action b. Sealing chamber 4. Advantages a. Small b. Light weight c. High power to weight ratio d. Able to sustain high RPM e. No cooling problem f. Burns almost any octane fuel down to 50 g. Small number of moving parts h. Simple to build		A. Rotary combustion engine 1. Have students make reports from "Popular Mechanics" and other references on the types of rotary engines. B. Use films as source of material. Films: "Firebird III", "Fluid Power", "Turbocopter Odyssey", "Principle of Optical Maser", "Electric Propulsion".
B. Gas turbine 1. Kinds and types a. History and development b. First turbine		

UNIT - EXPERIMENTAL (Continued)

STUDENT KNOWLEDGE	TIME	TEACHER ACTIVITIES

2. Gas turbine today
   a. Simple
   b. Regenerative (open cycle)
   c. Closed-cycle (one shaft)
3. Advantages
   a. Light weight
   b. Small number of moving parts
   c. No cooling problems
   d. Vibration free
   e. Multi-fuel capability
4. Principles of operation
   a. Impeller
   b. Diffuser
   c. Combuster or burner
   d. Compressor

C. Free-piston
1. Development
2. Principles
   a. Diesel
   b. Gasifier turbine
   c. Cylinders
   d. Bounce chambers
   e. Fuel injectors
   f. Intake port
   g. Exhaust port
3. Application
   a. Automotive
   b. Truck

(24:209-232)

When using the course of study one must remember that the key purpose of this course is "exploratory" and that there are a number of ways to arrange the selected course materials to broaden these exploratory experiences of the student. Projects must be evaluated by each instructor as to their value in that given situation. As Glenn reports in "Power Mechanics Blast Off!":

> The project must be a means to an end, a means of achieving objectives established before the project is selected. Then, the method of implementing the objectives comes to the fore (33:23).

The instructor can ask himself questions regarding the value of projects such as "Am I teaching my students how to clean spark plugs, adjust points, and set ignition timing?" or, "Am I using these projects to develop an interest in applied science, in the application of algebra to solve simple equations, and for skill in reading?". In this way an instructor can identify and justify projects, particularly projects brought from home.

CHAPTER VI

SUMMARY AND CONCLUSIONS

It is the opinion of this writer that power mechanics should be introduced into the industrial arts curriculum in the Yakima School District at the junior high level as soon as adaptation can be made.

There have been a number of reasons pointed out for this introduction in the past few chapters; outstanding among these is the fact that society has changed considerably in the past few years. One of the characteristics of that change is that individual families everywhere are purchasing more and more motor-driven appliances. The trend is toward more appliances creating more leisure time. Additional motorized appliances are purchased to make leisure time more fun: riding lawn mowers and garden tillers to get the job done in a hurry, then to the lake for water skiing, etc. Motor bikes, go-carts, hot rods, and model planes are but a few of the motorized machines that our young people own. Each has made its own unique contribution to our society. As a real testament of what will be in the future there exists as a fact such exciting inventions as ground effect machines, vertical take-off machines, and STOL aircraft that can land and take-off in a distance shorter than the length of a football field.

Also a fact, are exciting ideas in motors such as the rotary engine, the free piston engine and the gas turbine engine. These promise even more exciting devices such as tele-transportation, anti-gravity, and etc. for the future.

There are too many machines to mention in this short paper. However, those that have been mentioned point out an urgent need for comprehensive courses in the industrial arts curriculum to meet the needs of the students' understanding of power from its historical perspective, contemporary uses, and future developments.

Tools, materials, and classroom space should provide no problem to a far-sighted district as most schools presently have a metals shop in which power mechanics units can be presented. Materials can be rounded up inexpensively and in most cases can even be obtained free. Films and charts listed in Appendix B are free except for postage requirements on some items, which is minor. Tools present the bulk of the initial expense. However, the list of tools and the total expenses found in Appendix A may be reducable after the instructor has compared his inventory with the tools suggested in Appendix A. He may find that his inventory presently includes a number of these items.

The course materials presented are designed to be flexible allowing each instructor to handle his power mechanics course in a manner fitting his individual situation. With this material, he has the possibilities of having any number of courses, ranging from a basic book course to an activity-centered program. The activity-centered approach is much preferred by this writer as it allows the instructor to capitalize upon the native interest of the students.

The feasibility of power mechanics has been shown to exist in a positive manner and it is recommended that power mechanics be adopted as soon as possible into the Yakima Public Junior High Schools.

BIBLIOGRAPHY

BIBLIOGRAPHY

1. American Council on Industrial Arts Teacher Education. *Classroom Research in Industrial Arts*. Bloomington, Illinois: McKnight and McKnight, 1964.

2. _______. *Planning Industrial Arts Facilities*. Bloomington, Illinois: McKnight and McKnight, 1959.

3. Anderson, G. D. "Three-way Unit in Transportation and Power," *American Vocational Journal*, 30:16-17, December, 1955.

4. Association of Casuality and Surety Company. *Education for Safety through the School Shop*. New York: Association of Casuality and Surety Company, 1952.

5. Atteberry, Pat H. *Power Mechanics*. Chicago: The Goodheart-Willcox Company, Inc., 1961.

6. _______. "The Rationale of Power Mechanics," *Industrial Arts and Vocational Education*, 51:42-43+, November, 1962.

7. Bell, Herbert Y. *Industrial Arts in Action*. Olympia, Washington: Office of Public Instruction, 1968.

8. Bellevue Public Schools. *Junior High School Industrial Education Guide*. Bellevue, Washington: Bellevue Public Schools, 1962.

9. Braithwaite, Eric R. (ed.). *Lubrication and Lubricants*. Amsterdam: Elseview Publishing Company, 1967.

10. Briggs and Stratton. "Industrial Support for Power Program," *Industrial Arts and Vocational Education*. 51:45, November, 1962.

11. Brodhead-Garrett Company. *Brodhead-Garrett Catalog*. Sacramento, California: Brodhead-Garrett Company, 1968.

12. Buckley, H. *A Short History of Physics*. New York: D. Van Nostrand Company, Inc., 1927.

13. Burke, C. O. "Industrial Arts Objectives at the Junior High Level," Industrial Arts and Vocational Education, 45:216-217, September, 1956.

14. Buttery, Wilbar A. "Power Mechanics Activity in the Junior High School," Industrial Arts and Vocational Education, 50:47, September, 1961.

15. Cajori, Florian. A History of Physics. New York: The MacMillan Company, 1938.

16. Champaign Community Schools. Suggested Guidelines for Junior High School Industrial Arts. Champaign, Illinois: Champaign Community Schools, 1966.

17. Chase, Stuart. Men and Machines. New York: The MacMillan Company, 1929.

18. Clark, Danny. "Visualizing Engine Operation," School Shop, 26:19, January, 1967.

19. Conant, James B. "The Prestige Image and Industrial Education," Industrial Arts and Vocational Education, 50:15, January, 1961.

20. Dallas Independent School District. Power Mechanics. Dallas, Texas: Dallas Independent School District, 1966.

21. Decker, W. F. The Story of the Engine. New York: Charles Scribner's Sons, 1920.

22. Detrick, J. H. "Comprehensive Facilities for Industrial Education," Industrial Arts and Vocational Education, 51:43-45, March, 1962.

23. Dudley, Stan. "A Study of the Industrial Arts Safety Conditions in the County and Public Schools of Yakima, Washington," Unpublished Master's Thesis, Central Washington State College, 1953.

24. Duffy, Joseph W. Power--Prime Mover of Technology. Bloomington, Illinois: McKnight and McKnight, 1964.

25. ______. Power--Prime Mover of Technology, Laboratory Manual. Bloomington, Illinois: McKnight and McKnight, 1965.

26. Eberhardt, Norman. "Custer's Program in Power and Transportation," Industrial Arts and Vocational Education, 51:44-50, November, 1962.

27. Edmonds School District. Curriculum Guide--Industrial Arts. Alderwood Manor, Washington: Edmonds School District, 1962.

28. Evansville-Vanderburgh School Corporation. Guide for Industrial Arts in the Secondary School. Evansville, Indiana: Evansville-Vanderburgh School Corporation, 1962.

29. Feirer, J. L. "Case for Power Mechanics," Industrial Arts and Vocational Education, 49:17, November, 1960.

30. ______ and Lindbeck. Industrial Arts Education. Washington, D.C.: The Center for Applied Research in Education, Inc., 1964.

31. Glenn, Harold T. Exploring Power Mechanics. Peoria, Illinois: Charles A. Bennett Company, Inc., 1962.

32. ______. Power Mechanics Workbook. Peoria, Illinois: Charles A. Bennet Company, Inc., 1962.

33. ______. "Power Mechanics Blasts Off!" School Shop, 21:22, September, 1961.

34. Good, Carter V. (ed.). Dictionary of Education. New York: McGraw-Hill Book Company, 1959.

35. Hammack, C. R. and G. J. Makin, Jr. "Internal-Combustion Engine Model," Industrial Arts and Vocational Education, 53:40-41, December, 1964.

36. Harrison, O. S. Industrial Arts and Handcraft Activities. Minneapolis, Minnesota: Burgess Publishing Company, 1959.

37. Hostetle, Ivan and Talmage B. Young. A Guide to Curriculum Study. Raleigh, North Carolina: State Board of Education, 1959.

38. Howard, Windall. "Introducing a Power Mechanics Area Into a General Shop," Industrial Arts and Vocational Education, 78:35, March, 1964.

39. Howard, A. W. "Teacher Liability and the Law," Clearing House, 42:411-413, March, 1968.

40. Johnson, Rupert. "Objective Projects Rating and Grading," Industrial Arts and Vocational Education, 51:50-51, October, 1962.

41. Koenig, John H. and others. "Ideas for a Superior Program in Power," Industrial Arts and Vocational Education, 51:46-48+, November, 1962.

42. McCulley, J. L. "Do-It Yourself Cutaways for Power Mechanics Instruction," School Shop, 26:43, May, 1967.

43. McInnis, Don Wallace. "Establishing Power Mechanics in the Industrial Arts Curriculum at Morgan Junior High School, Ellensburg, Washington," Unpublished Master's Thesis, Central Washington State College, Ellensburg, Washington, 1964.

44. Madison Public Schools. Industrial Arts. Madison, Wisconsin: Madison Public Schools, 1962.

45. Mays, Arthur B. Essentials of Industrial Education. New York: McGraw-Hill Book Company, Inc., 1952.

46. Milwaukee Public Schools. Industrial Arts in the Junior High School. Milwaukee, Wisconsin: Milwaukee Public Schools, 1963.

47. Milwaukee Public Schools. Power and Transportation and Automotive Engine Tune-up. Milwaukee, Wisconsin: Milwaukee Public Schools, 1966.

48. Myslivicek, E. M. "Power Mechanics Visual Self-teaching Station," Industrial Arts and Vocational Education, 54:36-37, February, 1965.

49. Nulski, John H. "How to Record Individual Progress," Industrial Arts and Vocational Education, 51:28-29, January, 1962.

50. Office of Instructional Services. Industrial Arts--A Guide for Colorado Schools. Denver: Office of Instructional Services, 1962.

51. Penley, D. W. and F. Ronninger. "Gear Train Demonstration," Industrial Arts and Vocational Education, 45:14, January, 1956.

52. Prakkin, Sarah L. and Ruth P. Shively (eds.). Subject Guide of Books in Print, U.S.A. New York: R. R. Bowker Company, 1967.

53. Pritchett, S. L. "Teaching Power Mechanics," Journal of Industrial Arts Education, 24:39, September, 1964.

54. Purvis, Jud. All About Small Gas Engines. Chicago: The Goodheart-Willcox Company, 1956.

55. Risher, C. G. "Why Power Mechanics," Industrial Arts and Vocational Education, 49:46-47, November, 1960.

56. ________. "Resource Material for Power Mechanics," Industrial Arts and Vocational Education, 50:21-22, January, 1961.

57. ________. "Tools and Equipment for Power Mechanics," Industrial Arts and Vocational Education, 51:15, February, 1961.

58. ________. "Planning Facilities for the Course in Power Mechanics," Industrial Arts and Vocational Education, 50:48-59, March, 1961.

59. Rosenberg, Jerry M. Automation, Manpower, and Education. New York: Random House, 1966.

60. Ruch, Floyd L. Psychology and Life. Chicago: Scott, Foresman and Company, 1958.

61. Saterstorm, Mary Horkheimer (ed.). Educators' Guide to Free Science Materials. Randolph, Wisconsin: Educators' Progress Service, 1967.

62. Schank, K. L. "Power Technology," Journal of Industrial Arts Education, 23:40, January, 1964.

63. Silvius, Baysinger, and Olson. Safe Practices in Woodworking and Plastics. Chicago: American Technical Society, 1954.

64. Sperce, William P. "Information Achievement in Industrial Arts," *Industrial Arts and Vocational Education*. 53:48, May, 1964.

65. Stephenson, George E. *Power Mechanics*. Albany, New York: Delmar Publishers, Inc., 1963.

66. ______. *Small Gasoline Engines*. Albany, New York: Delmar Publishers, Inc., 1964.

67. Struck, F. Theodore. *Foundations of Industrial Education*. London: John Wiley and Sons, Inc., 1930.

68. Stuttles, Patricia A. (ed.). *Elementary Teachers' Guide to Free Curriculum Materials*. Randolph, Wisconsin: Educators Progress Service, 1963.

69. Superintendent of Public Instruction. *Industrial Arts Guide*. Olympia, Washington: Office of the Superintendent of Public Instruction, 1964.

70. *Textbooks in Print*, 1966. New York: R. R. Bowker Company, 1966.

71. Trudeau, T. "Planning an Area in Power Mechanics for the Junior High," *Industrial Arts and Vocational Education*, 56:50-53, March, 1967.

72. U. S. Department of Health, Education, and Welfare. *Three Dimensional Teaching Aids for Trade and Industrial Instruction*. Washington, D.C.: United States Government Printing Office, 1952.

73. Utah State Board of Educators. *Power Mechanics and Small Engines*. Salt Lake City, Utah: Utah State Board of Educators, 1967.

74. Valdes, P. J. "Power Mechanics Teaching Aid," *Industrial Arts and Vocational Education*, 54:54, April, 1965.

75. Walgren, John W. "Teach a Unit on the Small Gas Engine," *School Shop*, 21:19, January, 1962.

APPENDICES

APPENDIX A

TABLE I

SOCKETS AND ATTACHMENTS

QUAN-TITY	NAME OF ITEM	SPECIFICATIONS	APPROX-IMATE COST
1	Socket	1/4" drive, 6-pt. 3/16" #4706	$ .89
1	Socket	" " " 7/37" #4707	.89
1	Socket	" " " 1/4" #4708	.89
1	Deep socket	" " " 1/4" #4708L	1.39
1	Socket	" " 8-pt. 1/4" #4708S	.99
1	Socket	" " 6-pt. 9/32" #4709	.89
1	Deep socket	" " " 9/32" #4709L	1.39
2	Socket	" " " 5/16 #4710	1.78
1	Deep socket	" " " 5/16 #4710L	1.45
2	Socket	" " 8-pt. 5/16" #4710S	.99
1	Socket	" " 6-pt. 11/32" #4711	.89
1	Deep socket	" " " 11/32" #4711L	1.45
1	Socket	" " " 3/8" #4712	.89
1	Deep socket	" " " 3/8" #4712L	1.45
1	Socket	" " 8-pt. 3/8" #4712S	.99
1	Socket	" " 6-pt. 7/16" #4714	.89
1	Deep socket	" " " 7/16" #4714L	1.49
1	Socket	" " 12-pt. 1/2" #4716	.89
1	Phillips socket	" " No. 1 Bit #4737	2.09
1	Long Phillips socket	" " No. 1 Bit #4737L	2.19
1	Phillips socket	" " No. 2 Bit #4738	2.19
1	Long Phillips socket	" " No. 2 Bit #4738L	2.19
1	Screwdriver socket	" " 3/16" Bit #4744	1.75
1	Screwdriver socket	" " 1/4" Bit #4745	1.75
2	Reversible ratchet	" " 5" long #4749	10.98
1	Extension	" " $3\frac{1}{2}$" long #4760	1.39
1	Extension	" " 6" long #4761	1.59

TABLE I (continued)

QUANTITY	NAME OF ITEM	SPECIFICATIONS				APPROXIMATE COST
1	Extension	1/4" drive,		14" long	#4763	$ 2.49
1	Flexible extension	"	"	4" long	#4765	2.09
1	Plastic handle	"	"	5-3/8" long	#4766	3.39
1	Plastic handle	"	"	2-5/32" long	#4767	1.65
2	Plastic handle	"	"	5-7/8" long	#4769	3.98
1	Universal joint	"	"		#4770	3.25
1	Speed handle	"	"	16" long	#4780	3.25
1	Sliding bar handle	"	"	4-1/2" long	#4785	1.79
1	Allen-type socket	"	"	1/8" Bit	#4990-1/8	1.19
1	Allen-type socket	"	"	5/32" Bit	#4990-5/32	1.10
1	Allen-type socket	"	"	3/16" Bit	#4990-3/16	1.29
1	Allen-type socket long	"	"	3/16" Bit	#4990-3/16L	1.55
1	Allen-type socket	"	"	7/32" Bit	#4990-7/32	1.29
1	Allen-type socket	"	"	1/4" Bit	#4990-1/4	1.35
1	Allen-type socket long	"	"	1/4" Bit	#4990-1/4L	1.55
1	Allen-type socket	"	"	5/16" Bit	#4990-5/16	1.37
1	Allen-type socket	"	"	3/8" Bit	#4990-3/8	1.45
2	Allen-type socket long	"	"	3/8" Bit	#4990-3/8L	3.30
1	Deep socket	3/8" drive,		12 pt. 3/8"	#5012	1.29
1	Deep socket	"	"	6 pt. 3/8"	#5012H	1.29
1	Deep socket	"	"	12 pt. 7/16"	#5014	1.29
1	Deep socket	"	"	6 pt. 7/16"	#5014H	1.29
1	Deep socket	"	"	12 pt. 1/2"	#5016	1.29
1	Deep socket	"	"	6 pt. 1/2"	#5016H	1.29
2	Deep socket	"	"	12 pt. 9/16"	#5018	2.70

TABLE I (Continued)

QUANTITY	NAME OF ITEM	SPECIFICATIONS					APPROXIMATE COST
1	Deep socket	3/8"	drive,	6 pt.	9/16"	#5018H	1.35
1	Deep socket	"	"	12 pt.	5/8"	#5020	1.45
1	Deep socket	"	"	6 pt.	5/8"	#5020H	1.45
1	Deep socket	"	"	12 pt.	11/16"	#5022	1.49
1	Deep socket	"	"	6 pt.	11/16"	#5022H	1.49
1	Deep socket	"	"	12 pt.	3/4"	#5024	1.75
1	Deep socket	"	"	12 pt.	13/16"	#5026	1.85
1	Deep socket	"	"	12 pt.	7/8"	#5028	2.09
1	Socket	"	"	8 pt.	1/4"	#5028S	1.19
2	Dynaflow Sk.	"	"	4 pt.	9/32"	#5209S	2.38
1	Socket	"	"	12 pt.	5/16"	#5210	1.09
1	Socket	"	"	6 pt.	5/16"	#5210H	1.09
1	Socket	"	"	8 pt.	5/16"	#5210S	1.19
1	Socket	"	"	12 pt.	3/8"	#5212	2.18
1	Socket	"	"	6 pt.	3/8"	#5212H	1.09
1	Socket	"	"	8 pt.	3/8"	#5212S	1.09
3	Socket	"	"	12 pt.	7/16"	#5214	3.57
1	Socket	"	"	6 pt.	7/16"	#5214H	1.09
1	Socket	"	"	8 pt.	7/16"	#5214S	1.10
4	Socket	"	"	12 pt.	1/2"	#5216	4.36
1	Socket	"	"	6 pt.	1/2"	#5216H	1.09
1	Socket	"	"	8 pt.	12"	#5216S	1.19
4	Socket	"	"	12 pt.	9/16"	#5218	1.09
1	Socket	"	"	6 pt.	9/16"	#5218H	1.09
3	Socket	"	"	12 pt.	5/8"	#5220	1.19
1	Socket	"	"	6 pt.	5/8"	#5220H	1.19
2	Socket	"	"	12 pt.	11/16"	#5222	2.38
1	Socket	"	"	6 pt.	11/16"	#5222H	1.19
1	Socket	"	"	12 pt.	3/4"	#5224	1.19
1	Socket	"	"	12 pt.	13/16"	#5226	1.29
1	Socket	"	"	12 pt.	7/8"	#5228	1.35
1	Screwdriver socket	"	"		5/16 Bit	#5240	2.19
1	Phillips socket	"	"		#2	#5241	2.29
1	Phillips socket	"	"		#3	#5242	2.45
1	Phillips socket	"	"		#4	#5243	2.49
1	Screwdriver socket	"	"		5/8" Bit	#5244	1.19

TABLE I (Continued)

QUAN-TITY	NAME OF ITEM	SPECIFICATIONS	APPROX-IMATE COST
1	Screwdriver socket	3/8" drive, 1/4" Bit #5246	$ 2.19
4	Reversible ratchet	" " 7" long #5249	29.00
1	Adapter	" " 3/8"F. 1/4"M #5255	1.49
1	Adapter	" " 1/4"F. 3/8"M #5256	1.35
1	Extension	" " 1-3/4" long #5259	1.29
1	Extension	" " 3-1/2" long #5260	1.79
1	Extension	" " 7-1/2" long #5261	2.29
1	Extension	" " 12" long #5262	2.75
1	Extension	" " 17-3/16" long #5263	3.59
1	Hinge handle	" " 7-3/8" #5265	4.69
1	Hinge handle	" " 12" #5266	4.89
2	Universal joints	" " #5270	7.18
1	Speed handle	" " 16-7/8" #5280	3.45
1	Sliding bar handle	" " 8" #5285	2.89
			(11:58)

The above mentioned tools can be purchased as a set complete with tool rack for $180. This set, Proto sockets (52-SP Panel A), was selected because it has enough sockets to supply the needs for an entire class at one time. Also, the tool panel is designed with a striped area for each socket and wrench allowing for easy recognition of tools that are mislaid or that remain unreturned at the end of the laboratory period.

TABLE II

FLAT WRENCHES

QUANTITY	NAME OF ITEM	SPECIFICATIONS		APPROXIMATE COST
2	Combination Wrench	1/4"	#1208	$ 3.10
3	Combination Wrench	5/16"	#1210	5.37
4	Combination Wrench	3/8"	#1212	7.80
6	Combination Wrench	7/16"	"1214	13.74
6	Combination Wrench	1/2"	"1216	14.70
6	Combination Wrench	9/16"	#1218	15.30
5	Combination Wrench	5/8"	#1220	13.95
4	Combination Wrench	11/16"	#1222	12.36
3	Midget Wrench	13/64" x 15/64"	#3210	4.05
2	Midget Wrench	15/64" x 13/64"	#3211	2.70
3	Midget Wrench	7/32" x 1/4"	#3215	4.05
2	Midget Wrench	1/4" x 7/32"	#3216	2.70
3	Midget Wrench	9/32" x 5/16"	#3220	4.05
2	Midget Wrench	5/16" x 9/32"	#3221	2.70
4	Midget Wrench	11/32" x 3/8"	#3225	5.40
2	Midget Wrench	3/8" x 11/32"	#3226	2.70
4	Tappet Wrench	7/16" x 1/2"	#3425	9.56
4	Midget Wrench	9/16" x 5/8"	#3430	9.96
3	Tappet Wrench	11/16" x 3/4"	#3435	8.25
2	Tappet Wrench	13/16" x 7/8"	#3440	5.98 (11:459)

The set of Proto Flat Wrenches (60a-SP) complete with panel totals $149.92 and contains enough tools to allow functional laboratory experiences for the class.

TABLE III

MISCELLANEOUS POWER MECHANICS TOOLS

QUANTITY	NAME OF ITEM	SPECIFICATIONS		APPROXIMATE COST
1	Ignition Gauge Set		#000D	$ 1.55
1	Brake Gauge Set		#000E	1.55
1	Spark Plug Gauge Set		#000K	1.59
1	Offset Screwdriver	1/4" Bit	#36-1/4	1.35
1	Cold Chisel	5/16" Cut	#86A-1/4	.91
1	Cold Chisel	7/16" Cut	#86A-3/8	1.09
1	Cold Chisel	5/8" Cut	#86A-1/2	1.39
1	Drift Punch		#96-5/16	1.29
1	Lever Wrench Plier	8"	#291	3.39
1	Dinging Hammer		#1421	5.89
1	Pecking Hammer		#1453	8.49
1	Screw with Two Tips		#4022	3.49
3	Reversible Jaws		#4056J	7.47
5	Jaws		#4056PN	1.45
1	Yoke for Two Puller Jaws		#4061	2.99
1	Adjusting Nut		#4063	1.05
3	Outside Jaw		#4066	8.67
1	Yoke for Three Jaws		#4071	4.19
1	Allen Wrench Set in Kit		#4978	2.49
1	Short Square Blade Screwdriver		#9752	2.35
				(11:459)

The set of Proto tools (#55-SP) and panel totals $63.73, and fills the needs for some of the miscellaneous power mechanics tools.

TABLE IV

PLIERS, WRENCHES, AND SNIPS

QUAN-TITY	NAME OF ITEM	SPECIFICATIONS	APPROX-IMATE COST (ea.)
1	Snap Rip Plier	#251	$ 5.54
2	Multi-Leverage	Left, 10-1/2 #303L	5.79
2	Multi-Leverage	Right, 10-1.2 #303R	5.79
1	Straight Snip	12" #322	5.25
2	Adjustable Wrench	6" #706L	3.36
2	Adjustable Wrench	10" #710L	4.80
1	Adjustable Wrench	16" #716	11.36
2	Heavy Duty Pipe Wrench	10" #810HD	5.35
2	Thin Nose Slip Jt. Plier	6" #202	2.02
1	Diagonal Cutting Plier	4-1/2" #204	3.54
2	Diagonal Cutting Plier	7" #207	4.98
1	Diagonal Cutting Plier	7" #209	4.27
2	Needle Nose Plier	6" #226	4.32
1	Multi-Purpose Plier	8" #234	3.97
1	Slip Jt. Ingition Plier	4-1/2" #235	2.38
2	General Utility Plier	9-1/2" #241	2.60
2	Multi-Groove Jt. Plier	9-1/2" #243	3.80
3	Slip Joint Plier	8" #278	2.27
1	Slip Joint Plier	10" #280	3.25
2	Lever Wrench Plier	8" #291	3.39
			(11:457)

The total price of panels 32-SP and 32a-SP is $110 complete with marked storage panels. These two panels should be sufficient to fill the needs of pliers, wrenches, and snips for a power mechanics class.

TABLE V

SCREW DRIVERS

QUANTITY	NAME OF ITEM	SPECIFICATIONS		APPROXIMATE COST (ea.)
1	Offset SD.	1/4" Bit	#36-1/4	$1.35
6	Key Ring Screwdriver		#100	.30
3	Round 4" Blade	1/4" Bit	#9604	1.59
3	Round 6" Blade	5/16" Bit	#9606	2.19
1	Round 2-1/2" Blade	1/8" Bit	#9622	1.05
1	Round 4" Blade	1/8" Bit	#9624	1.19
2	Round 4" Blade	3/16" Bit	#9632	1.29
1	Round 5" Blade	3/16" Bit	#9633	1.39
1	Square 1" Blade	7/32" Bit	#9651	1.15
1	Square 1-1/2" Blade	9/32" Bit	#9652	1.19
1	Round 9/16" Blade Phillips	No. 2 Bit	#9671	1.45
2	Round 3" Blade Phillips	No. 2 Bit	#9682	1.65
2	Round 4" Blade Phillips	No. 2 Bit	#9684	1.85
2	Round 6" Phillips	No. 3	#9686	2.29
1	Round 8" Phillips	No. 4	#9688	2.79
2	Clutch Head	5/32" Bit	#9693	1.85
2	Clutch Head	3/16" Bit	#9694	1.85
2	Clutch Head	1/4" Bit	#9695	2.29
2	Clutch Head	5/16" Bit	#9696	2.79
1	Square 7-1/2" Blade	7/32" Bit	#9833	1.29
1	Square 9" Blade	9/32" Bit	#9842	1.75
				(11:457)

The total price of Proto panel 36-SP containing screwdrivers is $43.95 and should fill the screwdriver needs for the class.

TABLE VI

SMALL MOTOR TOOLS

QUANTITY		NAME OF ITEM
1	#131	Valve Spring Compressor
1	#165	Cylinder Gage
1	#203	Piston Ring Expander
1	#217	Piston Ring Compressor
1	#225-A	Piston Groove Cutter and Cleaner
1	#287	Cylinder Ridge Reamer
1	#301-S	Valve Grinder
1	#311	Valve Grinder
1	#516	Valve Refacer
1	#601	Gear Puller
1	#842	Magnetic Key Inserter (11:421)

The total price of Small Motor Tool Panel (No. SD-1) is $69.00.

TABLE VII

MISCELLANEOUS TOOLS

QUANTITY	ITEM	SPECIFICATIONS		APPROXIMATE COST
3	Bench Oilers	1/2 pint, 5" spout	#145C	$ 2.07
1	Tachometer	0-4000 RPM	#757W	12.70
1	Extractor Set	#2-3-4-5	#S-25	5.50
1	Nut Cracker	25,000 lb. pressure	#NC50	7.95
1	Spark Plug Socket	13/16" 6 pt.	#LTP626	1.60
3	Adapter	1/2" F., 3/8" M.	#LS10	3.30
1	Double Flex Ratchet	3/8" drive, 10" long		9.95
1	Torque Wrench	0-100 lbs. pressure	#T100	10.50
1	Torque Wrench	0-150 lbs. pressure	#T150	13.95
2	Rawhide Mallets	6 oz.	#2	4.20
2	Lead Hammers	1 lb.	#113	2.50
1	Retaining Ring Plier	twin plier--internal and external		7.95
2	Ball Peen Hammer	8 oz.	#3080	5.80
2	Hack Saw Frame	Adjustable 10, 12"	#368	6.80
1	File, Triangle	8" Regualar taper		.95
1	File	Round Bastard, 10"		1.00
1	File	Round Bastard, 6"		.65
6	File	Mill 2nd, 10"		6.60
1	Torch Kit		#TX25	11.49
1	Soldering Gun Kit		#450K2	13.95
1	Flaring and Cutting Kit	1/8" to 1-1/8" O.D.	#124-FA	15.75
1	Drill Set	High Speed, 1/16" to 1/2" by 32nd.	#86	20.60
1	Tap and Die Set	4-36 through 1/4-20	#S%87	19.70
2	Reamer	Repairman 1/8" to 1/2"	#130	4.20
1	Screw pitch gage	11-1/2-28 threads	#258	.70
2	Thickness gage	.0015 to .025, 26 leaves		9.50
3	Center punch	4"	#117B	1.80
2	Depth Gage	6" long, 32nds. and 64ths.	#236HB	17.80
1	Micrometer	0 to 1"	#436P	16.50
1	Micrometer	1" to 2"	#436P	20.50
1	Micrometer	2" to #"	#436P	23.15
6	Point Files	Double cut, 2-1/2"		1.10
1	Compression tester	0 to 250 lbs.	#AG-32	5.35
1	Oil Measurer	1 quart		9.70

APPENDIX B

FREE MATERIALS

FILMS

1. Bearings

   "Let 'Er Roll", color, 16mm, sound, 50 min.
   Timken-Roller Bearing Company

   "No Trouble At All", color, 16mm, sound, 32 min.
   Timken-Roller Bearing Company

   "Timken Bearing Equipped--Your Key to Better Maintainance," color, 16mm, sound, 28 min.
   Timken-Roller Bearing Company

   "Magnificent Miniatures", color, 16mm, sound, 20 min.
   Miniature Precision Bearings, Inc.

   "The Mysterious Precision Ball", color, 16mm, sound, 15 min.
   Industrial Tectonics, Inc.

   "Oil Films in Action", color, 16mm, sound, 17 min.
   General Motors Corporation

2. Brakes

   "When the Chips Go Down", color 16mm, sound, 22 min.
   Modern Talking Picture Service

3. Carburetor

   "ABC of Internal Combustion", color, 16mm, sound, 13 min.
   General Motors Corporation

4. Engines

   "Where Mileage Begins", black and white, 16mm, sound, 19 min.
   General Motors Corporation

5. Diesel Engine

"ABC of the Diesel Engine", color, 16mm, sound, 20 min.
General Motors Corporation

6. Gas Turbine Engine

"Turbocopter Odyssey", color, 16mm, sound, 21 min.
Sikorsky Aircraft

7. Exhaust System

"Ya Gotta Let 'Em Know", color, 16mm, sound, 30 min.
A P Parts Corporation

8. Fluid Power

"Hidden Giant", color, 16mm, sound, 18 min.
Vickers, Incorporated

9. Friction

"Challenge and Response", color, 16mm, sound, 20 min.
General Motors Corporation

10. Gasolines and Oils

"Fill 'Er Up", black and white, 16mm, sound, 11½ min.
du Pont de Nemours and Company, Inc., E. I.

"Story of Gasoline", color, 16mm, sound, 23 min.
Bureau of Mines

"Story of Lubricating Oil", color, 16mm, sound, 22 min.
Bureau of Mines

"More Oil and Gas", color, 16mm, sound, 25 min.
American Gass Association

"Under Pressure", color, 16mm, sound, 23 min.
Rutledge Drilling Company

11. Generator

"Principles of the Optical Maser", color, 16mm, sound, 6 min.
Bell System Telephone Offices

Generator--Isotopes

"Nuclear Reactors for Space", color, 16mm, sound, 17 min.
United States Stomic Energy Commission

12. Grease

"Grease, the Magic Film", color, 16mm, sound, 26 min.
National Lubricating Grease Institute

13. Hydraulics

"Hydraulics Turret Traversing Mechanism--Principles of Operation", black and white, 16mm, sound, 25 min.
The Oilgear Company

14. Ignition System

"ABC of Internal Combustion" (see number 3)

"Spark in Time on the Firing Line", (animated) color, 16mm, sound, 22 min.
Champion Spark Plug Company
Modern Talking Picture Service

15. Inertial Guidance

"Inertial Guidance for Ballistic Missile", color, 16mm, sound, 21 min.
Autonetics Division

16. Jet Engine

"This is United Aircraft", color, 16mm, sound, 14 min.
United Aircraft Corporation

17. Jet Propulsion

"ABC of Jet Propulsion", color, 16mm, sound, 17 min.
General Motors Corporation

18. Lubrication and Lubricants

"Grease, the Magic Film" (see number 12)

"Oil Films in Action" (see number 1)

"Story of Lubricating Oil" (see number 10)

19. Magnets

"Theory of Operation of the Four Pole Magnets", (animated) 16mm, sound, 30 min.
The Bendix Corporation, Electrical Components Division

20. Manufacturing

"Men, Machinery, and Imagination", color, 16mm, sound, 19 min.
McDonnell Aircraft Corporation

21. Nuclear Fission

"Principles of Thermal, Fast, and Breeder Reactors", (animated) color, 16mm, sound, 9 min.
United States Atomic Energy Commission

22. Nuclear Power

"The Atom and Eve", color, 16mm, sound, 15 min.
United States Atomic Energy Commission

"Plowshare", color, 16mm, sound, 15 min.
United States Atomic Energy Commission

"Operation Cue", color, 16mm, sound, 14 min.
United States Atomic Energy Commission

"Power for the Moonship" (fuel cells), black and white, 16mm, sound, 28½ min.
National Aeronautics and Space Administration

"SNAP 8: System for Nuclear Auxiallary Power", color, 16mm, sound, 10 min.
United States Atomic Energy Commission

23. Nuclear Propulsion

"The International Atom", color, 16mm, sound, 27 min.
United States Atomic Energy Commission

24. Petroleum and Petroleum Products

"Barrel Number One", black and white, 16mm, sound, 29 min.
American Petroleum Institute
United World Free Film Service

"Grease, the Magic Film" (see number 12)

"It Never Rains Oil", (animated) color, 16mm, sound, 15 min.
Texaco, Inc.

"More Oil and Gas" (see number 10)

"Nature's Golden Touch", color, 16mm, sound, 18 min.
Kendall Refining Company

"Story of Colonel Drake", color, 16mm, sound, 29 min.
Texaco, Inc.

"Story of Lubricating Oil" (see number 10)

25. Pistons and Piston Rings

"Background for Leadership", color, 16mm, sound, 30 min.
Dana Parts Company

"Case of the Slippery Oil", color, 16mm, sound, 40 min.
Dana Parts Company

26. Propellants and Propulsion

"Out of this World" (SFP1146) Story of Propulsion, color, 16mm, sound, 14 min.
Department of Air Force

"Electric Propulsion", color, 16mm, sound, 23½ min.
National Aeronautics and Space Administration

"Power for Propulsion" History of Propulsion, color, 16mm, sound, 15 min.
United States Atomic Energy Commission

27. Rocket Motors

"Solid Propellant Rocketry", black and white, 16mm, sound, 17 min.
Thiokol Chemical Corporation, Bristol Office

28. Spark Plugs

"The Spark of Power" (animated) color, 16mm, sound, 14 min.
Champion Spark Plug Company
Modern Talking Picture Service

"Spark in Time on the Firing Line" (see number 14)

29. Steam Power

"Nuclear Power Goes Rural", color, 16mm, sound, $14\frac{1}{2}$ min.
United States Atomic Energy Commission

30. Storage Batteries

"Story of the Modern Storage Battery", color, 16mm, sound, 27 min.
Bureau of Mines
Ideal Pictures, Inc.

31. Sun

"Our Mr. Sun", color, 16mm, sound, 60 min.
Bell System Telephone Office

"Bell Solar Battery", color, 16mm, sound, 12 min.
Bell System Telephone Office

32. Tires

"Tommy Looks at Tires", color, 16mm, sound, $20\frac{1}{2}$ min.
Farm Film Foundation
The B. F. Goodrich Company
Sterling Movies, U.S.A., Inc.

33. Turbo-generator

"Power from Paradise", color, 16mm, sound 12 min.
Tennessee Valley Authority

34. Valves

"Success Story", history, black and white, 16mm, sound, 30 min.
Rockwell Manufacturing Company

35. Water Power

"Power for a Nation", color, 16mm, sound, 28 min.
Bonneville Power Administration
Bureau of Reclamation

"Borax; Construction and Operation of a Boiling Water Power Reactor", black and white, 16mm, sound, 14 min.
United States Atomic Energy Commission

"TVA Builds the Johnsonville Steam Plant", color, 16mm, sound, 21 min.
Tennessee Valley Authority

"World Behind Your Light Switch", color, 16mm, sound, 28 min.
Bonneville Power Administration

36. Electrical Power

"The Atom and Eve" (see number 22)

"Electric Propulsion" (see number 26)

37. Atomic Power

"Atomic Power Production", color, 16mm, sound, 14 min.
United States Atomic Energy Commission

"Atom in Industry", black and white, 16mm, sound, 12½ min.
United States Atomic Energy Commission

"Basic Principles of Power Reactors", (animated) color, 16mm, sound, 8½ min.
United States Atomic Energy Commission

"Principles of Thermal, Fast, and Breeder Reactors" (see number 21)

"Atomic Power Today--Service with Safety", color, 16mm, sound, 28½ min.
United States Atomic Energy Commission

"Atomic Venture", color, 16mm, sound, 23½ min.
United States Atomic Energy Commission

"The Industrial Atom", black and white, 16mm, sound, 12½ min.
United States Atomic Energy Commission

"Borax: Construction and Operation of a Boiling Water Power Reactor" (see number 35).

FILMSTRIPS

1. Bearings

"Automotive Engine Bearings, Part I"	sound
"Automotive Engine Bearings, Part II"	"
"Automotive Wheel Bearings, Part I"	"
"Automotive Wheel Bearings, Part II"	"
"Automotive Wheel Bearings, Part III"	"
"Automotive Wheel Bearings, Part IV"	"

Federal-Mogul Service

2. Cranking Circuit

"Cranking Circuit" sound
Delco-Remy Division

3. Engines

"Diagnose It First" silent
Dana Parts Company

"Preventing Oil Loss Through the Valve Guides" silent
Dana Parts Company

"20,000 Volts Under the Hood" (DR-9020K) sound
Delco-Remy Division

"Diagnosing Excessive Oil Consumption and Engine Overhaul Procedure" silent
Dana Parts Company

4. Internal Combustion Engine

"From Ingot to Engine--The Story of a Piston"
silent
Dana Parts Company

5. Generator

"Regulation and the Charging Circuit" (DR-9015K)
sound
Delco-Remy Division

"Introducing the "Delcotron" Generator and the
Charging Circuit" (DR-9011K) sound
Delco-Remy Division

6. Ignition Systems

"Cranking Circuit" (DR-9025K) sound
Delco-Remy Division

"Introduction to Automotive Electricity"
(DR-9010K) sound
Delco-Remy Division

7. Piston Rings

"Diagnosing Excessive Oil Consumption and
Engine Overhaul Procedure" silent
Dana Parts Company

"From Ingot to Engine--The Story of a Piston"
silent
Dana Parts Company

"Installing Piston Rings in a Farm Tractor"
silent
Dana Parts Company

"That High Power Top Inch" silent
Dana Parts Company

8. Valves

"Prescription for Longer Valve Life" silent
Dana Parts Company

BOOKS, BOOKLETS, AND PAMPHLETS

1. Battery

    Portable Power Handbook
    Union Carbide Consumer Products Company, Long Island City Office

    Facts about Storage Batteries
    Electric Storage Battery Company, The

2. Carburetor

    Know Your Carburetor
    Pennsylvania Refining Company

3. Gas and Oils

    The Story of Gas N00480
    American Gas Association, Incorporated

    The Story of Oil and Gas
    Phillips Petroleum Company

    Kit of Education Materials: 1. Story of Quaker State; 2. Why Change Crankcase Oil?; 3. The Story of Oil; 4. Birthplace of the Petroleum Industry; 5. Petroleum and Its By-Products; 6. Start to Finish (a refining chart); 7. Alphabet Game
    Quaker State Oil Refining Corporation

    The Story of Petroleum
    Shell Oil Company

    Oil for Today...And For Tomorrow
    Interstate Oil Compact Commission

4. Radiant Energy

    Light and Man--Radiant Energy
    Sylvania Electric Products, Inc.

5. Nuclear Power

    Fusion Power
    Use of Radioisotopes in Industry
    Nuclear Power Plants
    Cyclotrons and Accelerators
    Careers in Atomic Energy
    United States Atomic Energy Commission
    Division of Technical Information Extension

6. Nuclear Propulsion

    Nuclear Propulsion for Rockets
        Las Alamos Scientific Laboratory

7. Rocket Propulsion

    Spacelines
        Aerojet-General Corporation

8. Spark Plugs

    Facts about Spark Plugs and Engines
        Champion Spark Plug Company
        School Aid Section

9. Tools

    Machine Tools--America's Muscles
        National Machine Tool Builders' Association

10. Atomic Energy

    Atomic Energy
        Con Edison

CHARTS, EXHIBITS, AND POSTERS

1. Battery

    Parts of a Dry Cell 8½" x 11"
        Burgess Battery Company

    Parts and Assembly of a Lead Type Storage Battery 22" x 17"
        Electric Storage Battery Company, The

2. Engine

    The Automobile Engine
        Ford Motor Company
        Educational Affairs Department

    Automobile Fuel System Wall Chart 8½" x 11"

    8 Cylinder Engine Cooling System Wall Chart 30" x 25"

    Engine Cooling System Wall Chart 8½" x 11"

Hydraulic Brake System Wall Chart

6 Cylinder Engine Cooling System Wall Chart
30" x 25"
Union Carbide Consumer Products Company
Park Avenue Office

3. Spark Plugs

Used Plugs Tell A Story
Champion Spark Plug Company
School Aid Section

4. Sun

Energy Production in the Sun A2463 15½" x 24½"
Scott, Foresman and Company

5. Tools

Learning Through Tools
National Education Association Commission on Safety Education

6. Brakes

Stop-O-Dial (stopping distance dial)
Aetna Life and Casualty

ADDRESSES FOR FREE MATERIALS

Aerojet-General Corporation
Corporate Public Relations
9100 East Flair Drive
El Monte, California 91731

Aetna Life and Casualty
Educational Services
Public Relations and Advertising
Hartford, Connecticut 06115

American Gas Association
Film Service
605 Third Avenue
New York, New York 10016
Borrower pays return postage

American Gas Association, Inc.
Educational Service
605 Third Avenue
New York, New York 10016

American Petroleum Institute
Committee on Public Affairs
1271 Avenue of the Americas
New York, New York 10020
Borrower pays return postage

A-P Parts Corporation
Attention: Mr. Robert J. Andrews
Public Relation Manager
1801 Spielbusch Avenue
Toledo, Ohio 43601
Borrower pays return postage

Autonetics Division
North American Aviation, Inc.
Film Library
Public Relations Department
3370 Miraloma Avenue
Anahiem, California 92803
Borrower pays return postage

Bell System Telephone Office
Local Office
Borrower pays return postage

The Bendix Corporation
Electrical Components Division
Service Department
Sidney, New York 13838
Borrower pays return postage and insurance

Bonneville Power Administration
U. S. Department of Interior
P. O. Box 3621
Portland, Oregon 97208
Borrower pays return postage

Bureau of Mines
U. S. Department of Interior
Motion Pictures
4800 Forbes Avenue
Pittsburgh, Pennsylvania 15213
Borrower pays return postage

Bureau of Reclamation
Chief Engineer
Building 53
Denver Federal Center
Denver, Colorado 80225
Borrower pays return postage

Burgess Battery Company
Division of Tervel, Inc.
Freeport, Illinois

Champion Spark Plug Company
Film Department
900 Upton Avenue
Box 910
Toledo, Ohio 43611
Borrower pays return postage

Champion Spark Plug Company
School Aid Section
900 Upton Avenue
Toledo, Ohio 43611

Con Edison
Charles E. Hoppen, Assistant Director
Public Information Bureau
4 Irving Place Room 1633-S
New York 3, New York

Dana Parts Company
Librarian, School Assistance
Technical Service Department
Hagerstown Distribution Center
P. O. Box 508
Hagerstown, Indiana 47346
Borrower pays return postage

Delco-Remy Division
General Motors Corporation
Technical Library Section
Anderson, Indiana 46011
Borrower pays all postage

du Pont de Nemours and Company, Inc., E. I.
Motion Picture Section
Advertising Department
Wilmington, Delaware 19898
Borrower pays return postage

Electrical Storage Battery Co.
Public Relations Department
2 Penn Center Plaza
Philadelphia, Pennsylvania 19102

Farm Film Foundation
1425 H Street, Northwest
Washington, D. C. 20005
Borrower pays return postage and insurance

Federal-Mogul Service
Division Federal-Mogul Corp.
P. O. Box 1966
Mr. James W. Davie
Supervisor of Advertising
Detroit, Michigan 48235

General Motors Corporation
Public Relations Staff
Film Library
General Motor Building
Detroit, Michigan 48202
Borrower pays return postage

The B. F. Goodrich Company
Public Relations Department
Akron, Ohio 44318
Borrower pays return postage

Ideal Pictures, Inc.
1201 S. W. Morrison Avenue
Portland, Oregon 97205
Borrower pays all postage

Industrial Tectonics, Inc.
Ball Division
P. O. Box 1128
Ann Arbor, Michigan 48106
Borrower pays return postage

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