AN ABSTRACT OF THE THESIS OF

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for the M.S. in Education

(Date)

Title

A Course of Study in General "Power Mechanics" for the

Secondary Schools

Abstract Approved

(Major Professor)

It is the purpose of this thesis to present a course of study in general "Power Mechanics" which would enable the junior high school student to understand the elementary principles of power generation and distribution, and to appreciate the relationships of the use of power to our social order. The course is "general" in that it includes a study of all forms of power used by man, which naturally implies that emphasis has been placed on present forms of power generation and consumption. The course is "mechanical" in that the student studies the elementary principles of generation. He manipulates and makes models whenever it is deemed advisable.

The procedure followed in the construction of this course of study was to:

1. Analyze the uses of power by society.
2. Make a historical study of the development of power in Man's progress through the ages.
3. Make an analysis of the characteristics of the newer courses of study. These characteristics are included as part of the thesis.
4. Set up aim, select and organize content and method in accordance with the newer courses of study and the general aims of education.

The following aims were set up to guide the construction of the course of study:

First, to orientate youth with the elementary principles of power generation and distribution and to show the relationship of power to civilized life.

Second, to integrate the different phases of the industrial arts program and to integrate that program with other areas of the school curriculum.

Third, to develop manipulative abilities which will serve as pre-vocational and leisure-time activities now and in the future.

Fourth, to maintain the interest of the student in curricular activities by helping him reconstruct the story of power and by pointing out to him the fact that the material covered in this course is definitely related to other subjects in his secondary school program.
Fifth, to develop an appreciation of the mechanical refinements which are our heritage, and of the qualifications and characteristics of the men who made these refinements possible.

In order to achieve the above aims, the following phases of the subject were presented: man and animal power; the principle of the wheel and axle and how it affects power generation and transmission; wind and water power; steam power; internal combustion engines; and electric power.

The study includes only the elementary principles of these different phases of power, for it is believed that more technical information would be beyond the capacity of junior high school students. However, the application of the functional principles of these different phases of power will meet the aims stated, giving the student insight into many of the mysteries which surround his everyday life.

At the close of each of the units, outcomes are given in an analyzed form, making it possible for the teacher to see the relationship of outcomes within a section; also the relation of that section to other sections and to the aims of general education.

In addition to the general bibliography of reference material contributing to this thesis, the course of study carries a selected bibliography particularly useful in the teaching of such a course. A chronological chart of significant events in the progress of power is included as a supplement to the thesis.

It is believed that the course of study exhibits a reasonable validity, especially in terms of its pioneering nature. The author realizes that experimentation and evaluation will be required; that the program is too new for a definite statement of values, and that future applications will undoubtedly develop additional criteria for revision.
A COURSE OF STUDY IN GENERAL "POWER MECHANICS"
FOR THE SECONDARY SCHOOLS

by

PAUL ROBERT BOWERS

A THESIS

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Approved:

Professor of Industrial Education
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Section I

Introduction
A Course of Study in General "Power Mechanics"
for the Secondary Schools

STATEMENT OF THE PROBLEM  It is the purpose of this thesis to present a course of study in General "Power Mechanics" which will enable the junior high school student to understand the elementary principles of power generation and distribution, and to appreciate the relationships of the use of power to our social order. The course is "general" in that a study will include all forms of power used by man, which naturally implies that emphasis will be placed on present forms of power generation and consumption. The course is "mechanical" in that the student will study the elementary principles of power generation. He will also manipulate and make models whenever it is deemed advisable.

This course should be included in a secondary school curriculum because of the accepted theory that the school should give training which is not adequately given by some other social agency. Society is constantly reducing the contact between the child and industry; therefore the child has little opportunity to learn of power from one of the social agencies which was its teacher a generation ago. Yet, industry has placed into the hands of every man, woman, and child mechanical slaves equal to or surpassing in power the human slaves held by the kings of antiquity. It is impossible for man to realize the depths of savagery to which society would sink if all forms of power were cut off. We are constantly depending upon these mechanical slaves to labor for us. Power is a part of our dynamic society.
GENERAL "POWER MECHANICS"

TYPES OF POWER USED BY MAN

- Man Power
- Animal Power
- Wind Power
- Water Power
- Steam Power
- Internal-Combustion Engine Power
- Electric Power

"Power Mechanics" Content as Used in Everyday Life

Adolescent Orientation
- Travel
- Hobbies
- Sports

Leisure Time

General
- Average Citizen
- Home
- Industry
- Distribution
- Servicing Occupations
- Agriculture

Vocational

Principles of early use and modern application of:
1. Wind Power
2. Animal Power
3. Water Power
4. Steam Power
5. Internal-Combustion Engine Power
6. Electric Power
7. Automation
8. Airplane
9. Steam Train
10. Diesel-Electric
11. Ship
12. Horse or Pack Exursions
13. Construction of Model Power Machinery
14. Amateur Radio Operation
15. Amateur Motion Picture Operation
16. Construction and Use of Home Workshop
17. Boating
18. sailing
19. Boating
20. Cycling
21. General Education
22. Consumer Appreciation
23. Intelligent Use of Power Appliances
24. Illumination
25. Cleaning
26. Heating
27. Cooking
28. Entertainment
29. Beauty Culture
30. Air Conditioning
31. Refrigeration
32. Automobile operation

Condensed Analysis of How Society Uses Power
Paul R. Bowers
Oregon State College, Corvallis
1937
The author has attempted to analyze the activities of society in which power plays a part and has prepared a condensed chart which includes these activities. (See insert following p. 1) Since power does play such a great part in the everyday life of the average citizen, it becomes the duty of the school to present such instruction as will enable the student to orientate himself and to make his greatest contribution to society. At present the secondary schools offer no such orientation course covering the use and application of power by society as a whole.

The need for such a course is evident. Dr. Homer J. Smith, Professor of Industrial Education, University of Minnesota, in discussing the junior high school industrial arts program states that one of the six courses offered in this program should be:

"POWER AND GAS ENGINES Now the last one of the six junior high school subjects is some kind of power or engines—steam, water, gas—all kinds of power. Here is a thing we have not represented anywhere else; it is a thing with which the boy is surrounded; it is a permanent and important thing. Whatever you do, don't call it automobile mechanics and put a lot of engines on blocks for study, or bring in a car for tinkering. That may be all right for the senior high schools or trade schools, but not in the junior high school where you are trying to help him (the boy) select the thing to do. Bring his attention not to gas engines alone, but to all kinds of devices that are known to the power field" (1)

The University of Chicago High School is the only secondary school now offering such a program. The course is called "Power Laboratory". "Provision is made for the study of and experience in manipulating the common power devices of our modern industrial and social environment. Lesson guide-sheets and a large reference library are used. Instruction is carried on through supervised study and individual or small group lecture demonstrations.

...Credit is given when the outlined lists of units are completed, and the pupil may take up a new course or do supplementary work along the lines of his greatest interest." The first sponsorship of such a course in a state program was in Oregon, where the state Industrial Arts Curriculum Revision Committee included "General Power Mechanics" as a unit in the industrial arts program for secondary schools. This 1937 revision of the course of study is now in press. From the analysis chart (following p. 1) and from the experiences of an experimental high school such as the University of Chicago High School, it appears that power is highly functional to every citizen in our civilized world, and that the fact is being recognized by leading educators.

Until recently it has been the practice to survey existing courses of study and school practice to determine content which

should be included in the new course of study. **Within the past few years,** the curriculum builder has analyzed society to determine whether or not material was functional, and has included only that content which was found to be functional.

In preparing this thesis, the author has been ever conscious of the objectives of general education, and particularly conscious of the fact that the subject matter of the proposed course in General "Power Mechanics" is most suited to the exploration purposes of the junior high school. It will act as an integrating core for the industrial arts program and such other phases of the curriculum as it touches. No excuse is offered for the presenting of only the elementary principles of the different forms of power, for it is believed that more technical information would be beyond the experience and capacity of junior high school students.

It is impossible to evaluate the content included in this course of study in the light of current practice. However, someone will have to pioneer in this field. One cannot say, "We can't set up a course of study because there has never been one before."

The curriculum builder should:

1. Set up aims which will contribute to the general aims of education.
2. Set up criteria to evaluate content.
3. Select content applying the above measuring sticks rigidly.
4. Select method in the light of the best psychological
data available for the type of content presented.

5. Provide for a try-out period.

6. Revise content in light of period of experimentation.

It is trite to say that the adolescent youth is interested in orientating himself into the affairs of the world which surrounds him. The scores of construction sets and power toys on the market indicate that industry sees a perpetual market in the youth of our country. What boy lives who at one time didn't want to be an engineer, a sailor, an aviator, or an auto racer? This course of study is designed for this exploratory age of youth. The problem of motivation would be nil. The greatest problem of the instructor would be the directing of student enthusiasm into channels which would give desirable outcomes.

**METHODS OF PROCEDURE** The procedure followed in the construction of this course of study was to:

1. Analyze the uses of power by society.
2. Make a historical study of the development of power in man's progress through the ages.
3. Make a careful study of the characteristics of the newer courses of study which are more completely outlined in Section II of this thesis.
4. Set up aims, select and organize content and method in accordance with the newer courses of study and the general aims of education.
Section II

Characteristics of a Good Course of Study
Characteristics of a Good Course of Study

INTRODUCTION Within the past twenty years many thousands of courses of study have been written. Earlier courses of study were evaluated in order that the better features might be included in the newer ones. The curriculum and course of study phase of our education has received much emphasis within the past five years. At present nearly every state in the union is in the process of curriculum revision for all levels of education. The educators of our country have sensed the need for curriculum revision in order that the school can more successfully fulfill its duty to society.

An attempt is being made to construct and organize the course of study so that it will become very vital to instruction. This is possible by having:

1. A clear and well-defined set of aims.
2. Carefully selected and evaluated content.
3. Well illustrated methods to aid the teacher in planning instruction.
4. A clear statement of outcomes expected.

In order to get a clear conception of these points they will be discussed in detail.

AIMS An aim for a subject is very important as it indicates the goal toward which instruction is being planned, and it also tells the instructor and the students when they have reached that goal.
Second, it tells the curriculum maker what content to accept or reject. This in itself denotes that the aims should be selected before content. The general aims of education should grow out of the needs of a dynamic society, and the course or subject aims should contribute to the general aims of education. The third function of the aim is to indicate the type of method which should be employed in attaining the desired outcomes. Correct content and correct method are necessary if we expect the desired outcomes. We cannot expect the desired outcomes merely because we have an admirable set of aims. The outcomes may be entirely different from the aims set up for the subject.

In order for an aim to serve the three functions mentioned, it is necessary that several characteristics be present. They are:

1. An outgrowth of the aim of the particular branch of study or subject matter field.
2. An outgrowth of the aim of education.
3. Specific enough to outline the field involved.
4. Specific enough to determine the selection of subject matter.
5. An outgrowth of the subject content.
6. Specific enough to determine the selection of direct outcomes.
7. Definite enough to indicate the mental processes involved.
8. Definite and practical enough to carry conviction and offer incentive for action to pupils.
9. Attainable by a majority of pupils.

10. An outgrowth of the present experiences of children.

11. Capable of suggesting possibilities for continued growth

12. Related to the capacity of pupils. (1)

All aims cannot be evaluated in the light of all these criteria, as there must be some allowance made for subjects, age, maturity, and experience of pupils. However, the course of study maker will do well to evaluate aims with these criteria.

The number of aims set up for any given subject should be sufficient to enable that subject to contribute its part to the general aim of education.

The subject aim should be so selected that when the student has attained the aims of all subject fields, he has also attained the general aim of education. Content should be selected which will contribute to the aims.

The form in which the aim is stated is quite important.

"Mere listing of principles is of very doubtful value. In such cases they very possibly exert influence on development of the curriculum through the guidance of certain individuals, but there is little help provided by such a statement for other individuals (1) Hopkins, L. Thomas, CURRICULUM PRINCIPLES AND PRACTICES, p. 91, Benj. H. Sanborn & Co., New York, 1929
who may have a limited outlook." A more desirable form is a comprehensive and systematic statement of point of view. This will enable all teachers to view the principle as the curriculum maker intended it.

**CONTENT** After the aims are chosen, select only that content which will contribute to the goals. Content is the material which enables one to get from where he is to where he wants to be. This is the point where so many curriculum makers fall down. When the aims are used as criteria for content selection and are rigidly applied, some of the traditional content may be eliminated. If such content is eliminated, the course will operate more efficiently in reaching the desired outcomes.

Ideally speaking, outcomes should be equivalent to aims, but under practical conditions this is seldom possible. If we select content which contributes only to the aims set up, the lag between aims and outcomes can be greatly reduced. If, however, irrelevant content is included, the lag is increased and education is not serving society, for the outcomes reached are not desirable.

The content in the better courses of study may be selected according to a set of criteria such as the following:

"1. Have a high frequency of occurrence in the common

activities of present social life. For this reason it ought to be taught in the schools.

2. Have a high frequency of occurrence in the common activities of present social life, but not be taught by any outside social agency.

3. Have a high frequency of occurrence in social life as it ought to be in the next generation.

4. Be of interest to pupils.

5. Serve as the basis for acquiring more learning.

6. Be within the capacity of individual pupils.

7. Be within the training and experience of individual pupils.

8. Be of value in meeting the basic needs of a possible future career.

9. Include only those topics of the greatest relative value out of the total possible range of topics.

10. Include an intensive treatment of a small number of topics rather than an extensive treatment of a larger number of topics.

11. Include the same topics or activities in the same subject in succeeding grades, only when there is new material, or a new emphasis, a new objective, a new approach, or a new outcome.

12. Be selected in such a way as to contain the maximum amount of the most desirable indirect content.

13. Make possible the maximum correlation with other subjects.

14. Be selected for its value in reaching the objective as determined by scientific experimental studies." (3)

Just as a judge must know how to apply the law, the curriculum maker must know how to utilize the criteria set up for content

selection. The following three steps should be followed before full utilization is possible:

"1. Those criteria which will apply to the construction of the given course of study should be selected.

2. The criteria which are selected should be rated in terms of relative importance.

3. Once the criteria have been selected and their relative values determined, they should be applied fearlessly and relentlessly, no matter how much the result may differ from the preconceived notions of the curriculum maker." (4)

After the content is selected it must be organized properly.

Criteria for proper organization of content are:

"1. Proceed from the psychological to the logical.

2. Be of maximum good to the extent to which it is pursued.

3. Permit no sudden break in the progressive development toward the aim.


5. Provide the most desirable grade placement.

6. Meet individual differences in capacity.

7. Provide for individual differences in previous training.

8. Care for the probable future destinies of individual pupils.

9. Provide definite divisions for instructional purposes, such as projects, problems, units, and movements.

10. Show the relative value of topics in achieving the aim.

(4) Ibid, p. 150-151
11. Indicate the range and degree of efficiency expected in outcomes.

12. Permit the best use of textbooks.

13. Provide for maximum correlation with other subjects. (5)

**METHOD** Method can be defined as the manipulation of content in such a way as to achieve desirable outcomes. Therefore it follows that method should be given in connection with content so that when the instructor sees what to teach he cannot help seeing how to teach. If the method is given in a separate section, the instructor has a tendency to teach the materials as has been his custom. There are three instances where specific method should be given:

"1. Where old content has been given new objectives.
2. When new content is introduced to meet an old aim.
3. Where new content and new aims are introduced." (6)

Content loses its effectiveness if not presented properly. Therefore we must have some criteria by which we can evaluate method. Characteristics of a good method are:

"1. It keeps the aims and objectives clearly and definitely before the pupils.
2. It utilizes pupil motivation or drive.
3. It utilizes pupil activity.


(6) Ibid, p. 196-197
4. It utilizes pupil judgement as to the quality of the results.

5. It considers the type of result to be produced.

6. It takes into account the education level upon which the pupil begins.

7. It proceeds from the psychological to the logical.

8. It leads with certainty and dispatch toward the goal.

9. It integrates the material with social life.

10. It furnishes the maximum amount of desirable indirect outcomes." (7)

The only way that method can be evaluated accurately is through experimentation. By experimentation with several methods, one can tell accurately which method reaches the desired outcome with the greatest effectiveness and economy of time. Elementary methods have been fairly well tested by research. However, methods for the secondary level have not gone through such rigid experimental processes, so it is not possible at all times to evaluate specific method. However, a careful examination of data now available should guide method evaluation until such time as we have scientific data on phases of every subject.

Method should be prescribed so instructors will know how to manipulate content, but it should be flexible enough to allow for further scientific experimentation, or to allow for adjustments in the light of scientifically tested data as it becomes available.

(7) Ibid, p. 177-178
OUTCOMES  "The outcomes of education represent the sum total of all changes which have been brought about in an individual as a result of organized education. The outcomes of a subject are the sum of the changes which have been brought about in an individual as a result of the study of that subject." Many times the outcomes are entirely different from the aims. Upon careful analysis, it can be found that outcomes can be divided into the following four classes:

1. In relation to the aims of a subject, outcomes are
   a. direct
   b. indirect
2. In relation to control of conduct, outcomes are
   a. fixed
   b. adaptive
3. In relation to method, outcomes are
   a. insights or understandings
   b. habits or skills
   c. attitudes or appreciations
4. In relation to content, outcomes are
   a. primary
   b. associate
   c. concomitant" (9)

(8) Ibid, p. 204
(9) Ibid, p. 204
Since outcomes determine the success or failure of education, it behooves American educators to organize the curricula and courses of study in such a manner so as to insure that desirable outcomes can be reached by a majority of the school population.

Outcomes should be stated in the course of study. If outcomes are not set up, the teacher will have to formulate his own. Due to differences in teacher training and experience, there will be no uniformity of outcomes selected, and therefore there will be no uniformity of outcomes reached by the students for a given subject in different schools.

Outcomes should be more exacting than aims. However, creative instruction should not be stifled in an effort to achieve stated outcomes, but rather, they should be a natural outgrowth of proper instruction. They should act as criteria for the evaluation of instruction all through the course, in order that remedial treatment can be given where it is needed.
A very good plan for the arrangement of outcomes is given by Hopkins. (10)

**Fig. 2 A PLAN FOR THE ARRANGEMENT OF OUTCOMES IN COURSES OF STUDY**

<table>
<thead>
<tr>
<th>Name of Outcome</th>
<th>Aim</th>
<th>Control</th>
<th>Method</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>Indirect</td>
<td>Fixed</td>
<td>Adaptive</td>
<td>Insight</td>
</tr>
<tr>
<td>Ability to carry in column addition</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Ability to locate London</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Ability to start and stop electric motors</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Enjoyment of Beethoven's Fifth Symphony</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

This plan for the arrangement of outcomes in courses of study enables the teacher to get a bird's-eye view of the relationship of each outcome, and that outcome with others in the course.

A Course of Study in General "Power Mechanics"

for the Secondary Schools

INTRODUCTION

The average citizen does not realize just how much power he has at his command until the power supply is cut off. Power is so well developed and perfected that the average citizen takes it as a matter of course. Yet at the present time there is no social agency which is striving to organize youth in an organized way in this functional area of every-day living. It is the purpose of this course of study to provide a base for student experimentation that it can be used by the secondary schools for student experimentation.

In setting up the course of study the student is expected to select, evaluate, and organize the data, analyze, synthesize, and conclude in the light of criteria given in Section II of this thesis.

AIMS

The following aims have been set up to guide this course of study:

Adolescent Orientation

The first aim is to orientate youth with the elementary principles of power generation and distribution and to show the relationship of power to civilized life. Every boy reaches the stage when he wants to know how different types of power energy. He does not understand the elementary principles of power, but he is eager to reconstruct for himself the story of power himself. The use of power only one available as a normal mode.

This course will be experimental in that it will attempt a
INTRODUCTION

The average citizen does not realize just how much power he has at his command until that power supply is cut off. Power is so well developed and perfected that the average citizen takes it as a matter of fact. Yet at the present time there is no social agency which is striving to acquaint youth in an organized way in this functional area of everyday living. It is the purpose of this course of study to so organize this field of human experience that it can be used by the secondary schools for student presentation.

In setting up this course of study an attempt has been made to select, evaluate, and organize the aims, content, method, and outcomes in the light of criteria given in Section II of this thesis.

AIMS

The following aims have been set up to guide this course of study:

Adolescent Orientation

The first aim is to orientate youth with the elementary principles of power generation and distribution and to show the relationship of power to civilized life. Every boy reaches the stage when he wants to know how different types of power are generated. He does not understand the elementary principles of power, but he is eager to reconstruct for himself the story of power through the use of power toys now available at a nominal cost. This course will be manipulative in that it will approach a
laboratory technique. Only those models should be constructed which will contribute to the aims and desired outcomes, and which cannot be secured in a commercial form. The presentation of the historical background for all phases of power will enable the student to realize the contribution power has made to civilization.

**Integration** The second aim is to integrate the different phases of the industrial arts program and to integrate that program with other areas of the school curricula. It is believed that this core of functional material will become a very satisfactory foundation for the industrial arts program. It is also believed that it can be made to touch upon and become integrated with other phases of the high school curricula such as the social studies, general science, physics, home economics, agriculture, and vocations.

**Manipulative Activities** The third aim is to develop manipulative abilities which will serve as prevocational or leisure-time activities now and in the future. Time will not permit the construction of many models; however, the course will not accomplish its greatest possibilities unless there is some direction given to the students who care to do additional work. A very good method of giving such direction to students is to make available plans of projects of a power nature. It is also possible to provide kits of tools which can be loaned to the boys for overnight use, similar to a circulating library. The circulating tool kits will stimulate manipulative activities and would be the beginnings of home workshops.
Maintain Student Interest  The fourth aim is to maintain the interest of the student in curricular activities by helping him reconstruct the story of power and by pointing out to him the fact that the material covered in this course is definitely related to other subjects in his secondary school program.

Appreciations  The fifth aim is to develop an appreciation of the mechanical refinements which are our heritage and of qualifications and characteristics of the men who made these refinements possible. The study of power developments will show that each man has contributed only a small portion to the advancement of power. This fact, together with an appreciation of the length of time necessary to bring power to its present stage of development, should develop an appreciation of our heritage and of the fact that it is our duty to society to make contributions according to our abilities.
Unit I

ELEMENTARY PRINCIPLES OF POWER

It is the aim of this unit to show how man-power compares with horse-power (our standard unit of measurement), and to teach the elementary principles of the inclined plane and the lever.
INSTRUCTIONAL UNIT 1

How Much Can a Person Lift, Push, or Pull?

Aim: It is the aim of this instructional unit to determine man's strength in relation to animal strength, and to show how man should conserve his muscular energy.

Method Laboratory technique and class discussion

Suggested Activities Lifting with arm muscles, with back muscles, with combined arm, back, and leg muscles; pull and push against a bar attached to spring balance scales or "pull-o-meter"

Suggested Tools and Equipment* Spring balance scale or pull-o-meter, rope, bar

Related Information
1. History of use of man power
2. Relation of bulk to weight
3. Proper body coordination in performing tasks
4. Effect of over-exertion on the body
5. First aid in case of physical exhaustion

Outcomes See p. 27-28

References**
2. Vowels, THE QUEST FOR POWER, p. 3-6
3. AMERICAN RED CROSS FIRST AID TEXT BOOK, p. 133-136

* Only the new tools and equipment will be included in each unit.
** References with no specific pages cited have been examined and contain valuable information relative to the unit. However, at the time when it was decided to cite pages, the books were unavailable from the Oregon State Library.
INSTRUCTIONAL UNIT 2

How to Use Animal Power

Aim: It is the aim of this instructional unit to determine how man can use animals to lighten his burden.

Method Laboratory technique, research, and class discussion

Suggested Activities Move heavy objects with animal power.

Note: In cases where actual experiments with animals cannot be conveniently performed, this will of necessity be an informational unit.

Suggested Tools and Equipment Animal, harness, single and double trees, hooks, chains or ropes, plow or drag to be moved

Related Information

1. History of the use of animals for power
2. Meaning and value of one horse power
3. Advantages and disadvantages of animal power

Outcomes See p. 27-28

References

1. Bush & Waddell, HOW WE HAVE CONQUERED DISTANCE, p. 24-28
2. Black & Davis, THE NEW PRACTICAL PHYSICS, p. 48-50
3. Nida, MAN CONQUERS THE WORLD WITH SCIENCE, p. 85-112
INSTRUCTIONAL UNIT 3

How to Use the Inclined Plane

Aim: It is the aim of this instructional unit to determine how man can accomplish work with a given amount of force by the use of the inclined plane.

Method Laboratory technique and class discussion

Suggested Activities Lift heavy objects by use of inclined plane and compare force required with that required for direct lift.

Suggested Tools and Equipment Planks and supports for making inclined track, heavy boxes, blocks, and barrels

Related Information

1. Physical principles involved
2. Effect of friction
3. Application of the inclined plane for mechanical advantage in machines or other devices

Outcomes See p. 27-28

References

2. Collins, THE BOY'S BOOK OF EXPERIMENTS
3. Henderson, THE NEW PHYSICS IN EVERYDAY LIFE, p. 242
4. Reh, LIGHT, FORCES AND MACHINES, p. 121-127
5. Meister, ENERGY AND POWER, p. 160-163
INSTRUCTIONAL UNIT 4

How to Use the Lever

Aim: It is the aim of this instructional unit to give the elementary principles of the lever, and to show the effect of position of fulcrum and length of lever arm.

Method  Laboratory technique and research

Suggested Activities  Cut wire with pliers; break nuts with nutcracker; weigh objects on a balance scale; pull nails with hammer or wrecking bar; lift heavy objects with lever; construct a see-saw.

Suggested Tools and Equipment  Pliers, nutcracker, balance scale, hammer, nails, wrecking bar, levers of different lengths, planks, heavy objects.

Related Information

1. Effect of position of fulcrum
2. Effect of length of lever arm
3. Applications of the lever principle in common machines and devices

Outcomes  See p. 27-28

References

2. Collins, THE BOY’S BOOK OF EXPERIMENTS
3. Henderson, THE NEW PHYSICS IN EVERYDAY LIFE, p. 236-239
4. Meister, ENERGY AND POWER, p. 142-152
5. Reh, LIGHT, FORCES AND MACHINES, p. 104-111
## OUTCOMES EXPECTED FROM THIS UNIT

After completing Unit I, the student should:

<table>
<thead>
<tr>
<th>Name of Outcome</th>
<th>Aim</th>
<th>Control</th>
<th>Method</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Be able to render first aid in case of physical exhaustion</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Be able to perform tasks with proper body coordination</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Know effects of over-exertion on the body</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Know how man-power has been used thru the ages</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Know relationship between man and animal strength</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Be able to use animal power</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Be able to harness animals</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Be able to estimate horse power</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Know advantages and disadvantages of animal power</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Know how animal power has been used by man</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Be able to use the inclined plane</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Be able to determine the advantage of the inclined plane</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><strong>Be able to use levers</strong></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
### Outcomes Expected from This Unit

Outcomes for Unit I, continued,

<table>
<thead>
<tr>
<th>Name of Outcome</th>
<th>Aim Direct</th>
<th>Aim Indirect</th>
<th>Control Fixed</th>
<th>Control Adaptive</th>
<th>Method Insight</th>
<th>Method Skill</th>
<th>Method Attitude</th>
<th>Content Primary</th>
<th>Content Associate</th>
<th>Content Concomitant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Know the effect of position of the</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>fulcrum</td>
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</tr>
<tr>
<td>Know the effect of the length of the</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lever</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Know the types of levers</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Know how the lever is used in common</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>machines</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Know the effect of position of the fulcrum.
Know the effect of the length of the lever.
Know the types of levers.
Know how the lever is used in common machines.
UNIT II

THE WHEEL

It is the aim of this unit to show how the wheel is basic to all mechanical power.
INSTRUCTIONAL UNIT 1

How to Use the Windlass and Blocks

Aim: It is the aim of this instructional unit to show the mechanical advantage of the wheel and axle.

Method Laboratory technique

Suggested Activities Lift objects by use of windlass, blocks, and hoists.

Suggested Tools and Equipment Rope, one, two, three, and four pulley blocks, differential block, windlass, chains of suitable sizes

Related Information

1. Principle of blocks
2. Principle of windlass
3. Common applications of the windlass, blocks, and differential hoist principle

Outcomes See p. 35-36

References

1. Black & Davis, THE NEW PRACTICAL PHYSICS, p. 31-36, 46-47
2. Henderson, THE NEW PHYSICS IN EVERYDAY LIFE, p. 239-242, 252
3. Kerr, POWER AND POWER TRANSMISSION, p. 93-95
4. Meister, ENERGY AND POWER, p. 155-158
5. Reh, LIGHT, FORCES AND MACHINES, p. 113-121
INSTRUCTIONAL UNIT 2

How to Use the Wheel and Axle for Transportation

Aim: It is the aim of this instructional unit to show that the wheel and axle are essential to transportation.

Method: Research and laboratory technique

Suggested Activities: Practical demonstrations and discussion of model chariots, wagons, trains, and automobiles

Suggested Tools and Equipment: Models of vehicles mentioned above

Related Information

1. Evolution of transportation by wheeled vehicles
   a. Wheelbarrow
   b. Chariots and carts
   c. Wagons
   d. Bicycles
   e. Power-driven vehicles

2. Relation of transportation to industry

3. Physical principles of the wheel and axle

Outcomes: See p. 35-36

References

1. Bock, WHAT MAKES THE WHEELS GO 'ROUND
2. Bush & Waddell, HOW WE HAVE CONQUERED DISTANCE, p. 29-45
4. Nida, MAN CONQUERS THE WORLD WITH SCIENCE, p. 160-178
5. Vowels, THE QUEST FOR POWER, p. 75-82

Commercial Material Helpful to Teachers

Wyer, FUNDAMENTALS OF TRANSPORTATION PROBLEM
AN OUTLINE OF THE HISTORY OF TRANSPORTATION,
Fisher Body Corporation, Detroit, Mich.
INSTRUCTIONAL UNIT 3

How to Transmit Power by Belt and Pulley

Aim: It is the aim of this instructional unit to show how power may be transmitted by use of belt and pulley.

Method Laboratory technique

Suggested Activities Operate small machines with belt and pulley drive, testing results of different combinations, and calculate speed ratios.

Suggested Tools and Equipment Small electric motor, flat belts, V belts, round belts, flat pulleys, V pulleys, sprocket and chain, machines and devices of different kinds to be driven, speed counter, improvised prony brake

Related Information
1. Advantages and disadvantages of belt drives
2. Effects of different amounts of contact surfaces
3. Effect of belt tension
4. Lacing belts
5. Kinds of material used for belts
6. Efficiency of belts of different types
7. Care of belts; belt dressing

Outcomes See p. 35-36

References
1. Black & Davis, THE NEW PRACTICAL PHYSICS, p. 50-51
2. Book, WHAT MAKES THE WHEELS GO 'ROUND
4. Kerr, POWER AND POWER TRANSMISSION, p. 17-65
INSTRUCTIONAL UNIT 4

How to Transmit Power by Gears

Aim: It is the aim of this instructional unit to show how power may be transmitted by gears.

Method Laboratory technique

Suggested Activities Arrange different combinations of gears and test speed ratios.

Suggested Tools and Equipment Simple mechanical tools, matched sets of common types of gears (Construction sets such as "Erector" and "Structo" provide ideal equipment for the above projects.)

Related Information

1. Types of gears
2. Manufacture of gears
3. Advantage and disadvantage of gear drives

Outcomes See p. 35-36

References

1. Bock, WHAT MAKES THE WHEELS GO 'ROUND
2. Kerr, POWER AND POWER TRANSMISSION, p. 66-74
3. Meister, ENERGY AND POWER, p. 160
INSTRUCTIONAL UNIT 5

How to Minimize the Effect of Friction

Aim: It is the aim of this instructional unit to show the effect of friction in power machinery.

Method Laboratory technique

Suggested Activities Test different materials for bearings; experiment with and without lubrication; experiment with roller and ball bearings.

Suggested Tools and Equipment Lubricating oil, bearing material, woodworking tools, ball and roller bearings, babbitt pouring equipment, grease gun, and oil can

Related Information

1. Material used for bearings
2. Effects of friction
3. Sources of lubricants
4. Evolution of bearings

Outcomes See p. 35-36

References

2. Henderson, THE NEW PHYSICS IN EVERYDAY LIFE, p. 246-250
3. Reh, LIGHT, FORCES AND MACHINES, p. 85-94
4. Meister, ENERGY AND POWER, p. 122-130

Commercial Material Helpful to Teachers

### OUTCOMES EXPECTED FROM THIS UNIT

After completing Unit II, the student should:

<table>
<thead>
<tr>
<th>Name of Outcome</th>
<th>Aim</th>
<th>Control</th>
<th>Method</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Be able to use pulley blocks</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Be able to use the differential block</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Be able to use the windlass</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Know the principle of blocks</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Appreciate the importance of the wheel and axle</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Know the relationship of transportation to industry</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Know the physical principles of the wheel and axle</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Be able to lace belts</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Be able to care for belts</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Know the effects of tension</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Know the effect of amounts of contact surface</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Be able to line up pulleys</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Be able to adjust belt tension</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Know the effect of pulley sizes</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Be able to line up gears</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Name of Outcome</td>
<td>Aim Direct</td>
<td>In-direct</td>
<td>Control Fixed</td>
<td>Adaptive</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
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<td>---------------</td>
<td>----------</td>
</tr>
<tr>
<td>Know advantages and disadvantages of gear drives</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Know the types of gears</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Know what materials are used for bearings</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Be able to construct simple bearings</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Be able to lubricate bearings</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Know the effect of lubrication in bearings</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
UNIT III

HARNESSING NATURE'S GREAT FORCES

It is the aim of this unit to show how man has harnessed the forces of nature to generate power.
INSTRUCTIONAL UNIT 1

Construction and Use of Sails

Aim: It is the aim of this instructional unit to show how sails have affected civilization.

Method Research, discussion, and demonstration

Suggested Activities Operate model sail boats, ice sail sleds, and sails for skaters.

Suggested Tools and Equipment Scissors, cordage, pulleys

Related Information
1. History of the sail
2. Power exerted by wind
3. Tacking and other methods of sailing

Outcomes See p. 41

References
1. Bush & Waddell, HOW WE HAVE CONQUERED DISTANCE, p. 46-61
2. Caviller, MODEL BOAT BUILDING FOR BOYS, p. 1-72
3. Horst, MODEL BOATS FOR JUNIORS, p. 1-78
4. Nida, MAN CONQUERS THE WORLD WITH SCIENCE, p. 120-134
5. Vowels, THE QUEST FOR POWER, p. 69-75
INSTRUCTIONAL UNIT 2

Construction and Use of Windmills

Aim: It is the aim of this instructional unit to show how sails may be fastened to a stationary object to generate power.

Method Laboratory technique and research

Suggested Activities Construct model paper and metal windmills.

Suggested Tools and Equipment Pocket knife, sheet-metal tools, scissors

Related Information
1. History of the windmill
2. Modern uses and applications of windmills

Outcomes See p. 41

References
2. Finch, WATERMILLS AND WINDMILLS
3. Murphy, THE WINDMILL, ITS EFFICIENCY AND ECONOMIC USE, p. 1-147
4. Vowels, THE QUEST FOR POWER, p. 121-125
INSTRUCTIONAL UNIT 3

Construction and Use of Water Wheels

Aim: It is the aim of this instructional unit to show the development of water wheels and how they can be used to generate power.

Method Laboratory technique and research

Suggested Activities Operate model water wheels and turbines; test results.

Suggested Tools and Equipment Hose, nozzle, hose connections, models of water wheels and turbines

Related Information
1. History and use of water power
2. Types of water wheels and turbines
3. Modern water-power projects
4. Weight and nature of water

Outcomes See p. 41

References
2. Bock, WHAT MAKES THE WHEELS GO 'ROUND
3. Harris & Rice, POWER DEVELOPMENT OF SMALL STREAMS, p. 13-177
5. Kerr, POWER AND POWER TRANSMISSION, p. 297-313
## OUTCOMES EXPECTED FROM THIS UNIT

After completing Unit III, the student should:

<table>
<thead>
<tr>
<th>Name of Outcome</th>
<th>Aim Direct</th>
<th>In-direct</th>
<th>Control Fixed</th>
<th>Adaptive</th>
<th>Method Insight</th>
<th>Skill</th>
<th>Attitude</th>
<th>Primary</th>
<th>Associate</th>
<th>Concomitant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appreciate the effect of sails upon civilization</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Be able to construct a simple sail</td>
<td>X</td>
<td></td>
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</tr>
<tr>
<td>Be able to construct a simple wind wheel</td>
<td>X</td>
<td></td>
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</tr>
<tr>
<td>Know the uses of sails</td>
<td>X</td>
<td>X</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Know the uses of windmills</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appreciate the effect of water wheels on civilization</td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Be able to construct a simple water wheel</td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Know the types of water wheels and turbines</td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Know how water turbines are used</td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Be able to make simple hose connections</td>
<td>X</td>
<td></td>
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</tr>
</tbody>
</table>
UNIT IV

STEAM POWER

It is the aim of this unit to show the development of steam power and how steam is generated and controlled for the purpose of power generation.
INSTRUCTIONAL UNIT 1

Construction and Operation of Steam Boilers

Aim: It is the aim of this instructional unit to show the development and principles underlying steam power generation.

Method Laboratory technique, research, and class discussion

Suggested Activities Operate simple steam boiler and demonstrate its operation. Demonstrate steam engine.

Suggested Tools and Equipment Soldering equipment, tinned cans, model steam engine, alcohol lamp, bunsen burner, or electric plate, thermometer, steam gauge

Related Information
1. Theory of evaporation
2. Theory of conservation of energy
3. Effect of pressure on boiling point
4. Theory of combustion
5. Sources of different types of fuel
6. Historical development of the steam boiler

Outcomes See p. 45

References
1. Bock, WHAT MAKES THE WHEELS GO 'ROUND
2. Bush & Waddell, HOW WE HAVE CONQUERED DISTANCE, p. 62-76
3. Kerr, POWER AND POWER TRANSMISSION, p. 112-153
4. Meister, ENERGY AND POWER, p. 167-184
5. Reh, LIGHT, FORCES AND MACHINES, p. 129-131
INSTRUCTIONAL UNIT 2

Construction and Operation of Steam Engines and Turbines

Aim: It is the aim of this instructional unit to show the development and principles underlying the operation and construction of steam engines and turbines.

Method Laboratory technique, class discussion, research

Suggested Activities Operate model steam engines and turbines.

Suggested Tools and Equipment Metal casting equipment, metal working tools and machines, simple pipe-fitting tools

Related Information
1. Efficiency of steam power plants
2. Advantages and disadvantages of steam power
3. Modern uses of steam power
4. Use of compressed air
5. Historical development of steam engines and turbines

Outcomes See p. 45

References
1. Book, WHAT MAKES THE WHEELS GO 'ROUND
5. Meister, ENERGY AND POWER, p. 171-184
6. Meister, WATER AND AIR, p. 139-142
7. Reed, RAILWAY ENGINES OF THE WORLD, p. 11-154
8. Reh, LIGHT, FORCES AND MACHINES, p. 132-138
After completing Unit IV, the student should:

<table>
<thead>
<tr>
<th>Name of Outcome</th>
<th>Aim Direct</th>
<th>In- direct</th>
<th>Control Fixed</th>
<th>Adaptive</th>
<th>Method Insight</th>
<th>Skill</th>
<th>Attitude</th>
<th>Prim- ary</th>
<th>Assoc- iate</th>
<th>Con- comitant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Be able to operate a simple steam boiler</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Appreciate the progress made possible by the steam boiler</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Know the theory of evaporation</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Know the types of fuel used in steam boilers</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>Know the effect of pressure on the boiling point</td>
<td>X</td>
<td></td>
<td>X</td>
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<tr>
<td>Be able to operate a simple steam engine</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Be able to operate a simple steam turbine</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
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<td></td>
</tr>
<tr>
<td>Know advantages and disadvantages of steam power</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>Appreciate the progress made possible by the steam engine</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
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<tr>
<td>Know elementary principles in the operation of steam engines and turbines</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>Be able to make simple pipe fittings</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
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</table>
UNIT V

INTERNAL COMBUSTION ENGINES

It is the aim of this unit to show how internal combustion engines operate to generate power, and how that power is used.
INSTRUCTIONAL UNIT 1

How a Single Cylinder Gasoline Engine Operates

Aim: It is the aim of this instructional unit to teach the elementary principles underlying the operation of an internal combustion engine.

Method Laboratory technique and research

Suggested Activities Operate single cylinder gasoline engine; make drawings of four cycle operation of engine; construct model of simple engine.

Suggested Tools and Equipment Wrenches, small single cylinder engine, drawing equipment, gasoline samples, oil samples

Related Information

1. Sources of fuel
2. Purpose of carburization
3. Purpose of ignition
4. Chemistry of combustion
5. Efficiency of gasoline engines
6. Other types of gasoline engines
7. Uses of internal combustion engines
8. Function of each part of the engine
9. Relation of two and four cycle engine

Outcomes See p. 52-53

References

1. Adams, ELEMENTS OF DIESEL ENGINEERING
2. Anderson, DIESEL ENGINES, p. 1-491
4. Bock, WHAT MAKES THE WHEELS GO 'ROUND
Instructional Unit 1, continued

9. Reh, *Light, Forces and Machines*, p. 139-148
10. Verrill, *Gasoline-Engine Book for Boys*

**Commercial Materials Helpful to the Teacher**

*Chemistry and Wheels*

*Diesel, the Modern Power*

*When the Wheels Revolve We Drive*

*Metallurgy and Wheels*

General Motors Corporation, Detroit, Mich.
INSTRUCTIONAL UNIT 2

How a Multi-Cylinder Internal Combustion Engine Operates

Aim: It is the aim of this instructional unit to show the advantages of multiple cylinder engines for economical power generation, together with its use.

Method Laboratory technique and research

Suggested Activities Tear down, reassemble, and demonstrate the operation of an automobile engine.

Suggested Tools and Equipment Standard automobile type motor, voltmeter, ammeter

Related Information

1. Identification of parts
2. Timing
3. Theory of ignition
4. Advantages of multi-cylinder engines
5. Uses of multi-cylinder engines
   a. Stationary engines
   b. Tractors
   c. Trucks
   d. Boats
   e. Aircraft
6. Types of multi-cylinder engines
7. Diesel engines
   a. Principles of operation
   b. Advantages and disadvantages

Outcomes See p. 52-53

References

1. Same as Unit V, Instructional Unit 1
INSTRUCTIONAL UNIT 3

How to Operate an Automobile

Aim: It is the aim of this instructional unit to teach how to operate an automobile properly.

Method Lecture, demonstration, and class discussion

Suggested Activities Demonstrate the proper care and operation of a modern automobile.

Suggested Tools and Equipment Standard type automobile in good mechanical condition

Related Information

1. History of development and manufacture of automobiles
2. Simple electric circuits
3. Principle of the clutch
4. Types and operation of brakes
5. Traffic regulations
6. Types of lubricants
7. Principles of head light focusing
8. Danger of carbon monoxide
9. Types of tires
10. Principles of inertia and momentum
11. Patching tires
12. Types of road surfaces
13. Centrifugal force on curves
14. Purpose and operation of the differential
15. Uses of automotive vehicles

Outcomes See p. 52-53

References

1. Bush & Waddell, HOW WE HAVE CONQUERED DISTANCE, p. 120-132
2. Lent, WIDE ROAD AHEAD: THE BUILDING OF AN AUTOMOBILE
3. Meister, ENERGY AND POWER, p. 198-234
4. Reh, LIGHT, FORCES AND MACHINES, p. 149-178
5. Snell, OPERATOR'S MANUAL, p. 1-39
INSTRUCTIONAL UNIT 4

How Airplanes are Operated

Aim: It is the aim of this instructional unit to show how airplanes are operated and what contribution they have made to civilization.

Method Laboratory technique and class discussion

Suggested Activities Build and fly model airplanes.

Suggested Tools and Equipment

Related Information

1. History and development of the airplane
2. Types of airplanes in use
3. Requirements for success in aeronautics
4. Theory of flight

Outcomes See p. 52-53

References

1. Bush & Waddell, HOW WE HAVE CONQUERED DISTANCE, p. 134-152
2. Day & Vincent, MINIATURE AIRCRAFT
3. Harney, SKYCRFAT BOOK
4. Nida, MAN CONQUERS THE WORLD WITH SCIENCE, p. 217-227
5. Romer & Romer, SKY TRAVEL, p. 1-270
6. Webster, TRAVEL BY AIR, LAND, AND SEA
After completing Unit V, the student should:

<table>
<thead>
<tr>
<th>Name of Outcome</th>
<th>Aim</th>
<th>Control</th>
<th>Method</th>
<th>Content</th>
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</thead>
<tbody>
<tr>
<td>Be able to operate a single-cylinder gasoline engine</td>
<td>X</td>
<td>X</td>
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</tr>
<tr>
<td>Know the difference between diesel and gasoline engines</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Know the uses of internal combustion engines</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Know the difference between two and four cycle engines</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Know the essential parts of an internal combustion engine</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
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<tr>
<td>Know the types of fuel</td>
<td>X</td>
<td>X</td>
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<td>X</td>
</tr>
<tr>
<td>Know advantages of multi-cylinder engine</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Know advantages and disadvantages of internal combustion engines</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Be able to manipulate tools for tearing down and reassembling engines</td>
<td>X</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Be able to operate an automobile intelligently</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Know the road signs</td>
<td>X</td>
<td>X</td>
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<td>X</td>
</tr>
<tr>
<td>Name of Outcome</td>
<td>Aim</td>
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<td>Method</td>
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<tr>
<td>Know operator's license laws</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Know traffic regulations</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Appreciate the development of manufacture of automobiles</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>Know the danger of carbon monoxide</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Know when a car is properly serviced</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Appreciate the contribution of the airplane to civilization</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Be able to construct a simple model airplane</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Know the requirements for success in aeronautics</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Know the types of airplanes in use</td>
<td>X</td>
<td>X</td>
<td>X</td>
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</tbody>
</table>
UNIT VI

ELECTRIC POWER

It is the aim of this unit to show the conditions which surround the generation, transmission, and use of electrical energy.
INSTRUCTIONAL UNIT 1

How Magnets Operate

Aim: It is the aim of this instructional unit to show how magnets operate.

Method Laboratory technique and class discussion

Suggested Activities Demonstrate permanent and electro-magnets; make permanent magnets; make electro-magnets.

Suggested Tools and Equipment Wire cutting tools, simple coil, winding equipment

Related Information
1. Theory of magnetism
2. Theory of the solenoid
3. Uses of magnets
4. History of magnetism

Outcomes See p. 61-62

References
2. Collins, THE BOY'S BOOK OF EXPERIMENTS
3. Collins, FUN WITH ELECTRICITY
5. Lehmann, SHOP PROJECTS IN ELECTRICITY, p. 52-60, 123-128
7. Meister, MAGNETISM AND ELECTRICITY, p. 1-206
8. Vogelback, MAGNETS
10. Willoughby, PRACTICAL ELECTRICITY FOR BEGINNERS
INSTRUCTIONAL UNIT 2

How Electricity is Generated

Aim: It is the aim of this instructional unit to show how electricity is generated.

Method Laboratory technique and research

Suggested Activities Operate automobile type generator; make simple battery cells; demonstrate telephone type generator and "shocking machines".

Suggested Tools and Equipment Small electric motor, automobile type generator, telephone type generator, "shocking machine", glass jars, tin cans

Related Information

1. Principles of the generator
2. Units of measure of electrical energy
3. A. C. and D. C. current
4. Types of generators in use
5. Types of batteries in use
6. Storage batteries
7. "Safety First" and electricity

Outcomes See p. 61-62

References

2. Collins, THE BOY'S BOOK OF EXPERIMENTS
3. Collins, FUN WITH ELECTRICITY
4. Jones, ESSENTIALS OF APPLIED ELECTRICITY, p. 119-132
INSTRUCTIONAL UNIT 3

How Electricity is Transmitted

Aim: It is the aim of this instructional unit to teach the principles which govern electrical transmission.

Method Lecture and laboratory technique

Suggested Activities Construct simple circuits from battery and A. C. sources.

Suggested Tools and Equipment Bells or buzzers, push buttons, batteries, bell wire, rubber covered copper wire, bell ringing transformer, simple switches, lamp sockets, electric lamps, fuse block, fuses

Related Information
1. Types of conductors
2. Theory of conductance
3. Principle of fuses
4. Insulation
5. Types of switches
6. Transformation

Outcomes See p. 61-62

References
2. Dragoo & Dragoo, GENERAL SHOP ELECTRICITY, p. 10-50
3. Collins, THE BOY'S BOOK OF EXPERIMENTS
4. Collins, FUN WITH ELECTRICITY
5. Jones, ESSENTIALS OF APPLIED ELECTRICITY, p. 28-57, 90-117
6. Morgan, THE FIRST ELECTRICAL BOOK FOR BOYS
INSTRUCTIONAL UNIT 4

How Electric Motors Operate

Aim: It is the aim of this instructional unit to teach the underlying principles which govern motor operation.

Method Laboratory technique and lecture

Suggested Activities Construct simple battery driven motor.

Suggested Tools and Equipment Permanent magnets, batteries

Related Information
1. History and development of the electric motor
2. Principle of the electric motor
3. Types of electric motors
4. Efficiency of electric motors
5. Uses of electric motors
   a. In industry
   b. In the home

Outcomes See p. 61-62

References
1. Black & Davis, THE NEW PRACTICAL PHYSICS, p. 403-413
2. Dragoo & Dragoo, GENERAL SHOP ELECTRICITY, p. 55-60
3. Collins, THE BOY'S BOOK OF EXPERIMENTS
4. Collins, FUN WITH ELECTRICITY
5. Jones, ESSENTIALS OF APPLIED ELECTRICITY, p. 133-160
6. Morgan, THE FIRST ELECTRICAL BOOK FOR BOYS
INSTRUCTIONAL UNIT 5

How Electrical Communication Devices Operate

Aim: It is the aim of this instructional unit to teach the elementary principles of communication devices

Method Laboratory technique and research

Suggested Activities Operate simple telegraph set; construct simple microphone; construct simple radio receiving set.

Suggested Tools and Equipment Improvised parts for telegraph set, improvised parts for microphone, radio parts

Related Information

1. History of electrical communication
2. Principle of the telephone
3. Principle of the radio
4. Television
5. Radio beam
6. Electric eye

Outcomes See p. 61-62

References

1. Bush & Waddell, HOW WE HAVE CONQUERED DISTANCE, p. 233-270
2. Burns, RADIO: A STUDY OF FIRST PRINCIPLES
4. Collins, RADIO AMATEUR'S HANDBOOK
5. Dashiell, THE BEGINNER'S STORY OF RADIO
6. Lambert, TALKING WIRES
7. Nida, MAN CONQUERS THE WORLD WITH SCIENCE, p. 5-78
INSTRUCTIONAL UNIT 6

How Electricity is Used for Light and Heat

Aim: It is the aim of this instructional unit to teach the elementary principles of electrical heat and illumination.

Method Laboratory technique

Suggested Activities Demonstrate electric lighting and heating devices; repair household heating and lighting appliances.

Suggested Tools and Equipment Circuit testing equipment, sample lighting and heating devices

Related Information

1. History of the electric light
2. Theory of electric lighting
3. Types of electric heating elements
4. Uses of special lighting devices
5. Uses of electric heating devices
6. Electric Welding

Outcomes See p. 61-62

References

2. Dragoo & Dragoo, GENERAL SHOP ELECTRICITY, p. 48-49
3. Collins, THE BOY'S BOOK OF EXPERIMENTS
4. Collins, FUN WITH ELECTRICITY
5. Jones, ESSENTIALS OF APPLIED ELECTRICITY, p. 162-174
6. Morgan, THE FIRST ELECTRICAL BOOK FOR BOYS
<table>
<thead>
<tr>
<th>Name of Outcome</th>
<th>Aim</th>
<th>Control</th>
<th>Method</th>
<th>Content</th>
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<tr>
<td></td>
<td>Direct</td>
<td>In-direct</td>
<td>Fixed</td>
<td>Adaptive</td>
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<tr>
<td>Know the theory of magnetism</td>
<td>X</td>
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<td>X</td>
<td></td>
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<tr>
<td>Know the theory of the solenoid</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Be able to magnetize metal</td>
<td>X</td>
<td></td>
<td>X</td>
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<tr>
<td>Be able to construct a simple electric magnet</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Be able to operate simple electric generative equip</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Know the principal parts of an electric generator</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>Know the &quot;Safety First&quot; rules of electricity</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Be able to read volt and amperes meters</td>
<td>X</td>
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<tr>
<td>Be able to wire simple electric circuits</td>
<td>X</td>
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<tr>
<td>Be able to construct a simple dry cell</td>
<td>X</td>
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<tr>
<td>Appreciate progress made possible by use of electric energy</td>
<td>X</td>
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<tr>
<td>Know the types of conductors</td>
<td>X</td>
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### Outcomes Expected from This Unit

<table>
<thead>
<tr>
<th>Name of Outcome</th>
<th>Aim</th>
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<tr>
<td>Control Method</td>
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<td>Direct</td>
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- **Know the theory of conductance**
- **Know the use of fuses**
- **Know the purpose and kinds of insulation**
- **Know the purpose of transformers**
- **Be able to construct a simple motor**
- **Know the principal parts of an electric motor**
- **Know the uses of electricity**
- **Be able to construct simple communication devices**
- **Appreciate the progress made possible by use of electricity for light**
- **Be able to test circuits**
SPECIAL METHODS

The presentation of content in the general "Power Mechanics" course will follow a different procedure from other industrial arts subjects. There will be few articles actually constructed as part of the organized classroom procedure. Most of the instruction will follow a laboratory technique which means that the student will become acquainted with the elementary principles of power by manipulation rather than by construction procedure. Laboratory facilities including tables with vises, power models of power equipment, supplies and tools for the assembling and operation of power equipment are essential. An adjoining room separated by a glass partition should be used for a recitation and research room. Adequate library facilities should be provided. The student should be taught how to use the research technique in order that he may be able to locate desirable materials quickly.

It is possible to make excursions to industrial and power plants. Such excursions can be very valuable if properly managed. If they are not properly handled, their educational value is very questionable. No good teacher tries to present content which he has not organized into teachable units; likewise, no good teacher takes a class on an excursion of any nature without first having made the trip and organized the points of educational value into a teachable outline. After this outline is complete, added research is made on points where the teacher's experience is limited. When the preparation is completed, the points of educational value are presented to the students. Then the trip is made and special attention is called to points of interest. As soon as possible
after the trip, the students should write about their observations
in order to fasten them clearly in their minds. Class discussion
following the excursion is very profitable.

Since this course is general, all students will not be working
on identical activities at the same time. In order to receive the
greatest teacher efficiency and allow for individual differences,
individual instruction sheets should be prepared on different phases
of the subject matter. It is not within the scope of this study to
present these different instruction sheets; however, the industrial
arts teacher will profit by having available a copy of Selvidge, R. W., INDIVIDUAL INSTRUCTION SHEETS--HOW TO WRITE AND USE THEM. (1)

Many phases of this field are covered in educational motion
pictures available from the different distributive agencies. These
pictures usually have animated drawings showing the operation more
plainly than if the actual machine were seen in operation.

Slides made by the teacher and students can be of great value
for instructional purposes. Material is available which gives
complete instructions on how to make slides. Many of the students
will be more than pleased to do additional work preparing slides if
they can see that these slides are performing a very functional
instructional need. The alert teacher will use such a device to
care partially for individual differences and at the same time

(1) Selvidge, R. W., INDIVIDUAL INSTRUCTION SHEETS, Manual Arts
Press, Peoria, Ill., 1926
improve instruction.

The teacher in dealing with adolescent boys will soon realize that they wish to construct articles for themselves. This urge should be satisfied by making available plans for different power devices which are within the boy's ability to construct. Creative abilities will be greatly encouraged if the school also makes available kits of tools which the boy can check out for over night use. Each tool should have its silhouette painted in the kit so that it could be checked readily. The tools should be kept in good order at all times so that the kit will be ready for immediate use.

The teacher may find it desirable to organize the home activities on a club basis. Clubs of such a nature are desirable if properly conducted.
Bibliography of
Reference Materials Used in Course of Study

Adams, Orville, ELEMENTS OF DIESEL ENGINEERING,
Norman W. Henley Publishing Co., New York, 1936

Anderson, J. W., DIESEL ENGINES,

Black, N. H., and Davis, H. N., THE NEW PRACTICAL PHYSICS,
The Macmillan Co., New York, 1929

Bock, George E., WHAT MAKES THE WHEELS GO 'ROUND,
The Macmillan Co., New York, 1931

Brangwyn, Frank, and Preston, Hayter, WINDMILLS,
Dodd, Mead and Co., New York, 1923

Brown, Thomas G., and Ziegenhagen, F. W., and others
ELEMENTARY PRINCIPLES OF DIESEL ENGINE CONSTRUCTION
The Bruce Publishing Co., Milwaukee, Wis., 1936

Burns, E. E., RADIO: A STUDY OF FIRST PRINCIPLES,
D. Van Nostrand Co., 350 4th Ave., New York, 1932

Bush, M. G. and Waddell, J. F., HOW WE HAVE CONQUERED DISTANCE,
The Macmillan Co., 60 5th Ave., New York, 1934

Cavileer, John W., MODEL BOAT BUILDING FOR BOYS,
The Bruce Publishing Co., Milwaukee, Wis., 1923

Collins, Fredrick A., THE BOY'S BOOK OF EXPERIMENTS,
Thomas Y. Crowell Co., 393 4th Ave., New York, 1927

Collins, Fredrick A., FUN WITH ELECTRICITY,
D. Appleton-Century Co., Inc., New York, 1936

Collins, Fredrick A., RADIO AMATEUR'S HANDBOOK,
Thomas Y. Crowell Co., 393 4th Ave., New York, 1933

Collins, Hubert E., SHAFTING, PULLEYS AND BELTING AND ROPE
TRANSMISSION, McGraw-Hill Book Co., New York, 1908

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Section IV

Summary and Recommendations
SUMMARY AND RECOMMENDATIONS  In conclusion, it has been the purpose of this thesis to present a course of study in General "Power Mechanics" which has a workable, organized plan of procedure applicable to the secondary school level. This course is designed to vitalize the principles of power generation, use, and distribution, and to develop an appreciation for the mechanical aids and devices of modern civilization which are a part of youth's heritage.

Since this study is a pioneer effort in this field, the following procedure was used:

1. A study was made of the historical development of power.
2. Society's application of power to present day problems was analyzed.
3. Newer courses of study were examined to determine desirable characteristics.
4. Aims and objectives were set up in the light of society's needs and in keeping with the recognized criteria for the construction of courses of study.
5. The aims were used as criteria for content selection.
6. Methods were selected which appeared to produce the most desirable outcomes.
7. Expected outcomes for the course of study were listed.
8. References were selected which treated the content most adequately and which were best adapted to the secondary school level.
A chronological chart was prepared showing the succession of events which have contributed to the development of power.

It is believed that the course of study exhibits a reasonable validity, especially in terms of its pioneering nature. The author realizes that experimentation and evaluation will be required; that the program is too new for a definite statement of values, and that future applications will undoubtedly develop additional criteria for revision. Suggestions for further study include the following:

1. Evaluate this course of study by experimental evidence.
2. Make a more intensive study of the historical development of power.
3. Determine by scientific experimentation the grade in which general "Power Mechanics" can be taught most efficiently.
4. Set up new objectives and expected outcomes, and make whatever other modifications the experimental application may justify.
Section V

General Bibliography

(See p. 65 for bibliography of reference materials used in course of study.)
General Bibliography


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SUPPLEMENT

A CHRONOLOGICAL CHART OF SIGNIFICANT EVENTS IN THE PROGRESS OF POWER

The author has compiled a chronological chart of the progress of power through the ages, listing the machines and events which have contributed to power development. It is hoped that such a chronological chart will help the teacher to get a bird's-eye view of power development. There is no claim made that this is a complete list, but it is believed to be sufficient for the purpose for which it was intended. The author cannot be responsible for the validity of all dates. Historians disagree on the dates of some events; therefore, the date selected is the one which had the greatest agreement among historians.
Chronological Order in the Progress of Power

Progress in the ages B. C.

3000  Sumerians were using rollers and wheels

1160  Magnetic compass (Chinese)

600   Attractive properties of amber and loadstone (Thales of Miletus)

400   Loadstone called magnet (Euripides)

2nd Century: Reference made to coal (Theophrastus of Euesus)

150   Descriptions of windmills (Hero of Alexandria)

150   Whirling aeolipile steam (Hero of Alexandria)

Days of Caesar Augustus: 400 h.p., 4,116 slave unit, prime mover central station

85    First mention of water wheel antipater

65    Hydraulic machine built at Cabira by Mithradates, King of Pontus

16    Vitruvius describes horizontal water wheel driving grain wheel by means of gearing—earliest known reference to power transmission

Progress before the tenth century A. D.

Fire: its application in furnaces, ovens, kilns

Simple machines, inclined plane, screw

Use of horse for transport

Mining, metallurgy, and smithing

Water wheels, boats with sails, probably windmills

Bow drills and lathes
Water clocks

**Tenth Century**

Use of water clocks
The iron horseshoe
Effective harness for horses
Multiple yoke for oxen

**Eleventh Century**

1065 Oliver of Malmesbury attempted flight

**Twelfth Century**

Military use of gunpowder in China

1105 First recorded windmill in Europe (France)

1118 Cannon used by Moors

1125 Organ blown by air compressed "by heated water" (Gerbert)

1130 Fixed steering rudder

1191 First account of windmill in England (Dean Herbert)

**Thirteenth Century**

Mechanical clocks invented

**Fourteenth Century**

Mechanical clock became common
Water power used to create draft for blast furnace

Threadle loom

1338 Guns

1345 Division of hours and minutes into sixties
Fifteenth Century

Invent turret windmill
Trip-hammer
Two-masted and three-masted ships
1410 Paddle-wheel boat designed
1420 Velocipede (Fontana)
1430 Turret Windmill
1438 Wind turbine (Mariano)
1457 Rediscovery of wagon on springs, referred to by Homer
1471 Iron cannon balls
1472-1519 Leonardo da Vinci made or discovered the following inventions:
Centrifugal pump
Dredge for canal-building
Breech-loading cannon
Rifled firearms
Antifriction roller bearing
Universal joint
Conical screw
Rope-and-belt drive
Link chains
Submarine boat
Bevel gears
Spiral gears

Sixteenth Century

Tinning for preservation of iron
Windmills of 10 h. p. became common
Progress in mining, blast furnaces, and iron molding
1500 First portable watch with iron main-spring (Peter Henlein)
1500-1650 Intricate cathedral clocks reach height of development
1554 Paddle-wheel boat (Blasco de Garay)
1546 Railway in German mines
1550 First mention of ball bearing (Memoirs of Benvenuto Cellini)
1552 Iron rolling machine
1489-1564 Magnetic dip discovered (Hartmann)
1558 Military tank
1568 Besson produced cone-shaped pit wheel which extracted energy from both water's velocity and weight
1569 Description of steam generation (Besson)
1571 Description of simple steam engine (Matthesius)
1548-1620 Discovery of principle of hydraulic press (Stevinus)
1576 Magnetic and geographic poles same thing (Norman)
1578 Screw lathe (Besson)
1582 Tide-mill pump for London (Morice)
1595 Wind turbine (Veranzio)

Seventeenth Century

Water wheels of 20 h.p. introduced
Transmission by means of reciprocating rods over distances of one-quarter mile
1600 "De Magnete", epoch-making book (Gilbert)
1600 Simple steam turbine (Branca)
1600 Treatise on terrestrial magnetism and electricity (Gilbert)
1601 Steam pump with boiler and prime mover separate (Porta)
1605 Tremendous force of steam under pressure (Rivault)
1613 Gunpowder in mine blasting
1615 Steam pressure water fountain (DeCaus)
1619 Use of coke instead of charcoal in blast furnaces
1624 First patent law protecting inventions (England)
1628 Steam engine (described in 1663 by Worcester)
1630 First English patent on steam engine (Ramseye)
1652 Air pump (Guericke)
1663 Static electric generation (Guericke)
1665 Steam automobile model (Verbiest)
1671 Speaking tube
1680 Gas engine using gunpowder (Huygens)
1680 First power dredge (Meyer)
1680 Steam safety valve (Papin)
1682 100 h.p. pumping works at Marly (Ranneguin)
1683 Industrial exhibition at Paris
1688 Distillation of gas from coal (Clayton)
1695 Atmospheric steam engine (Papin)

Eighteenth Century
1700 Water power for mass-production (Polhem)
1702 Atmospheric water pump (Savery)
1705 Atmospheric steam engine (Newcomen)
1708 Wet sand iron casting (Darby)
1709 Coke used in blast furnace (Darby)
1713 Steam valve gear automatic (Breighton)
1729 Static electric charge carried 860 feet on silk suspended wire (Grey and Wheeler)
1736 Accurate chronometer (Harrison)
1736 First machine to use electricity—a bell (Gordon)
1738 Cast-iron rail tramway (at Whitehaven, England)
1740 Cast steel (Huntsman)
1745 Leyden jar (Musschenbroek and Leyden)
1749 Scientific calculation of water resistance to ship (Euler)
1750 Automatic gearing to bring windmill into the wind (Meikle)
1755 Iron wheels for coal cars
1756 Cement manufacture (Smeaton)
1761 Air cylinder; piston worked by water wheel—more than tripled production of blast furnace (Smeaton)
1761 Coal cutting machine
1763 Modern type chronometer (Le Roy)
1763 Slide rest (French Encyclopedia)
1765-1769 Improved steam pumping engine with separate condenser (Watt)
1765 Water tube boiler (Blakey)
1767 Cast iron rails at Coalbrookdale
1770 Caterpillar tread (Edgeworth)
1772 Description of ball bearing (Varlo)
1774 Cylinder-boring machine (Wilkinson)
1775 Reciprocative engine with wheel
1776 Reverberatory furnace (Brothers Cramege)
1781-1786 Steam engine as prime mover (Watt)
1781 Steamboat
1782 Balloon (J. M. and J. E. Montgolfier) Original invention Chinese
1784 Puddling process—reverberatory furnace (Cort)
1785 Interchangeable parts for muskets (LeBlanc)
1785 First steam spinning mill at Papplewick
1785 Power loom (Cartwright)
1787 Screw propeller (Bramah)
1787 Iron boat (Wilkinson)
1787 Electroscope designed (Bennet)
1787 Screw propeller steam boat (Fitch)
1791 Gas engine (Barber)
1794 Ecole Polytechnique founded
1794 Sliding tool rest for lathe (Maudslay)
1796 Toy helicopter (Cayley)
1796 Hydraulic press (Bramah)
1797 Screw-cutting lathe (Maudslay)
1799 Compressed air operating mine machinery (Medhurst)

**Nineteenth Century**

1800 Large over-shot wheel at Cyfarthfa Iron Works, South Wales, England, 50' x 6', 156 buckets
1800 Galvanic cell (Volta)
1801 Public railroad with horse-power, Wandsworth to Croydon, England
1801 Steamboat CHARLOTTE DUNDAS (Symington)
1801-1802 Steam carriage (Trevithick)
1802 Planing machine (Bramah)
1803 Side-paddle steamboat (Fulton)
1804 Oliver Evan's amphibian steam carriage
1805 Twin screw propeller (Stevens)
1807 First patent for gas-driven automobile (Isaac de Rivaz)
1814 Steam printing press (Koenig)
1816 Safety lamps for coal mines (Clanny, Stephenson, Davey)
1817 Push cycle (Drais)
1818 Milling machine (Whitney)
1819 Magnetic effect of flowing current discovered (Oersted)
1820 Incandescent lamp (De la Rue)
1820 Principles of magnetism explained (Ampere)
1821 Principle of motor (Faraday)
1822 Steel alloys (Faraday)
1823 First gas engine to do real work (Brown)
1824 Portland cement (Aspdin)
1825 Electric magnet (Sturgeon)
1827 High pressure steam boiler—1,400 pounds (Jacob Perkins)
1828 The word turbine used for first time (Bardin)
1831 Dynamo (Faraday)
1832 Water turbine (Fourneyron)
1835 Commutator for dynamo (Sturgeon)
1837 Electric motor (Davenport)
1838 Diverging nozzle for steam (Heath)
1838 Two-cycle, double-acting gas engine (Barnett)
1838 Inward-flow water turbine (Samuel Howd)
1838 Flame ignition gas engine (Barnett)
1839 Manganese steel (Heath)
1840 Grove's incandescent lamp
1842 Electric engine (Davidson)
1845 Electric arc patented (Wright)
1845 Mechanical boiler stoker
1845 Use of electric magnets (Cooke and Wheatstone)
1846 Nitroglycerine (Sobrero)
1846 Gun Cotton (C. F. Schonbein)
1847 Electric locomotive (M. G. Farmer)
1849 Electric locomotive (Page)
1849 Improved inward-flow water turbine (Francis)
1851 Electric motor car (Page)
1851 Electro-magnetic clock (Shepard)
1853 Great Eastern steamship--600 ft. long--watertight compartments
1855 Commercial production of aluminum (Deville)
1855 Hot metal igniters for gas engine (Newton and Drake)
1855 800 h.p. water turbine at Paris
1855 Iron plated gunboats
1856 Double bucket with center ridge water wheel--improved by Pelton (Cheetham)
1856 Open hearth furnace (Siemens)
1856 Improved Fourneyron's turbine (Girard)
1856 Bessemer converter (Bessemer)
1857 Rough spark ignition gas engine (Barsanti and Matteweei)
1859 Storage cell (Plante)
1861-1864 Dynamo motor (Pacinnoti)
1861 Machine gun (Gatling)
1862 MONITOR (Ericsson)
1862 Four-cycle engine (Beau de Rochas)
1863 Gas engine (Lenoir)
1866 Practical dynamo (Siemens)
1867 Dynamite (Nobel)
1867 Gas engine (Otto and Langen)
1867 Two-wheeled bicycle (Michaux)
1868 Tungsten steel (Mushet)
1870 Electric steel furnace (Siemens)
1872 Model airplane (A. Penaud)
1872 Automatic airbrake (Westinghouse)
1872-1873 First notable application of compressed air
(Montcenis and St. Gotthard tunnels)
1873 First auto-screw lathe (Spencer)
1874 Stream lined locomotive
1875 Electric car (Siemens)
1876 Four-cycle gas engine (Otto)
1877 Model flying machine (Kress)
1877 Central steam generation station (Holly)
1879 Carbon glow lamp (Edison)
1879 Electric railroad
1880 Cup and cone ball bearing in bicycle
1882 First alternator patented (Ferranti)
1882 First central steam power station (Edison)
1882 Windmill experiment and improvement (Perry)
1882 Steam turbine (De Laval)
1882 First hydro-electric plant lighting 250 lamps, Appleton, Wisconsin
1883 High speed gasoline engine (Daimler)
1883 Multiple-stages turbine (Parsons)
1884 Water turbine for high falls (Pelton)
1886 Aluminum by electrolytic process (Hall)
1887 Electromagnetic waves (Hertz)
1893-1898 Diesel motor
1895 Improved steam turbine (Curtis)
1896 Steam-driven aerodrome flight--one-half mile without passengers (Langley)

**Twentieth Century**
1900 High speed tool steel (Taylor and White)
1902 Caterpillar tread improved
1902 Radial type airplane engine (Charles Manly)
1903 First man-lifting airplane (Wright brothers)
1903 Oil-burning steamer
1909 Duralumin (Wilm)
1917 Mercury used instead of water for steam engine (Emmet)
1919 Propeller type water turbine with adjustable blade (Kaplan)