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IDENTIFIERS	*Energy Conversion; *Energy Education; Gasohol; Indiana

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Energy education units (consisting of a general teacher's guide and nine units containing a wide variety of energy lessons, resources, learning aids, and bibliography) were developed for the Indiana Energy Education Program from existing energy education materials. The units were designed to serve as an entire curriculum, resource document, supplementary materials, or as a laboratory manual of "hands-on" activities which could be infused into existing grades 9-12 curricula. Unit VII, focusing on energy conversions, consists of an introduction (rationale, unit objective, and general background information), 10 activities, materials list for first 4 lessons, bibliography, and teacher evaluation form. Each lesson includes lesson title, objectives, background information, activities, evaluation techniques, and resources. Titles of lessons are: (1) Calories for Heating Our Homes, the Cost of Heating; (2) Do We Know the Heat Produced Per Unit of Measure? (3) Measuring Heat Transfer: The Calorie; (4) Kilowatt-Hours, Calories, and BTU's; (5) The Most Economical Home Heat Source; (6) Construction of a Hydroelectric Generator; (7) Heat Exchangers; (8) Moonshine Travel: Sunshine Solutions (Gasohol); (9) Seeing Dust as a Fuel; and (10) Pedal Power. (Author/JN)

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LESSONS FROM AN ENERGY CURRICULUM

FOR THE SENIOR HIGH GRADES

Unit VII

Energy Conversion

Division of Energy Policy
Indiana Department of Commerce
Lt. Governor John M. Mutz, Director

Division of Curriculum
Indiana Department of Public Instruction
Harold H. Negley, Superintendent

January 1982

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The materials included in the senior high segment of the Energy Education Curriculum Project (EECP) were adopted with permission from the following:

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George E. Cannon, Patricia Shutt and Joe E. Wright, Energy Education Consultants and Carol Hahn Wood, Program Developer with the EECP, assumed responsibility for designing this Energy Education Teacher's Guide. They also coordinated the Senior High Review Panel and the Senior High Energy Education Steering Committee.

Members of the Senior High Energy Education Steering Committee are -- John A. Harrold, Director, Division of Curriculum; Darrell Morken, Director, Division of Traffic Safety; Gary Geswein, Agribusiness Education Consultant; Jerry Colglazier, Science Consultant, Joyce Konzelman, Home Economics Chief Consultant; Jane Lowrie, Social Studies Consultant; Victor Smith, Research and Evaluation Coordinator; Gregg Steele, Industrial Education Consultant.

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FOREWORD

Indiana educators have always responded to the demands placed upon them by society to resolve natural and human resource issues and problems. The task of teaching energy concepts and conservation practices to Indiana's youth is a response to energy problems facing our state and nation. It will be accomplished by many high school teachers and students getting involved in energy education.

We feel that students of all ages must be taught an energy conservation ethic. This ethic will enable each student to use Indiana's and America's energy resources more efficiently and with less waste. To help high school teachers accomplish this major goal, we are pleased to introduce a new Senior High School Energy Education Curriculum. This exciting and innovative program contains energy education activities, programs and resources for you and your students.

We encourage you and your students to get involved in the lessons contained in our materials. We hope you will use these materials as a starting point and go far beyond by involving other classroom teachers, students, resource agencies and citizens in your community. A broad educational effort is needed to help prepare students to deal with a growing problem which affects us all.

Harold H. Negley
State Superintendent of
Public Instruction

John M. Mutz
Lieutenant Governor
State of Indiana

Unit VII
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INTRODUCTION
(Rationale)

ENERGY EDUCATION - WHAT IT IS - Past, Present, Future

Energy education is the attempt to resolve the conflict between our present life style and the energy costs in both dollars and resources to produce and maintain that life style.

Energy education is reality education in that it deals with what exists here and now.

But, energy education is also a study of futuristics. The future that all of us must be willing to live in and accept is the one that we are creating right now by our daily decisions. We must examine the beliefs that "growth is good" and "bigger is better" and determine the impact these beliefs will have on our future.

Energy educators interested in the challenge to teach students about local, state, national and global energy resources, problems and issues should consider the the following questions:

1. Can you help prepare your students to make wise and careful decisions about our remaining non-renewable energy resources?

2. Can you help prepare them to investigate and make wise decisions about research and development efforts for alternate and renewable resources, recycling programs, more efficient transportation systems, better personal consumption habits, and a personal commitment to efficient energy usage?

3. Can you explain to your classes where energy comes from, what the basic sources of energy are, how long our non-renewable energy resources will last, and the energy options among which our nation's people must choose if we are to survive?

The three questions above suggest that energy education is a challenge which encompasses all facets of living. Energy education is an opportunity for students to have impact on a long-lived problem, an opportunity to apply traditional content and skills to an important problem situation, and an opportunity for students to participate in personal and social decisions.

WHY STUDY ENERGY?

"One of the best ways to deal with a crisis is to consider it as an opportunity. From this point of view, the energy crisis provides almost endless possiblities for children to learn about themselves. Energy after all is what makes all things go. We need to realize that the energy crisis isn't just the newest fad.

By studying the energy crisis, students can see where humanity has been, where it is now, and where it might be going. The energy crisis is another chapter in the story of mankind's continuing effort to reshape the world and the inevitable cost of doing that."[1]

To ensure proper utilization of energy sources, our society must be educated about alternate life styles, energy resources, technology, consumer behavior and occupations.

The Indiana State Department of Public Instruction, in cooperation with the Indiana Energy Section, has organized the Energy Education Curriculum Project (EECP) to meet the challenge of educating young people (our future adults) about energy, the energy crisis and the role they can play to help conserve America's economy and resources.

One way the Energy Education Curriculum Project staff has dealt with the task of disseminating energy information and education is through the Indiana Energy Curriculum Units. The units have been organized to help provide educators in many areas with lessons, charts, materials and "hands-on" activities to be used in the classroom.

[1]Quote taken from: The Science Teacher -- September 1978.
Article: "Teaching the Energy Lesson"
Author: David J. Kuhn

The Curriculum - Background Information

The Energy Education Units contained in the Senior High School materials were adopted from existing energy education materials. A team of teachers from Indiana reviewed and evaluated energy documents from across the nation, and only those activities or lessons which proved to be effective in educating students were chosen for Indiana's program.

The units are designed to be used as the individual teacher wishes. The energy units could be used as an entire curriculum or as a resource document, supplement or laboratory manual of "hands-on" activities which can be infused into already existing curricula.

The Indiana Energy Education materials for grades 9-12 consists of a Teacher Guide, nine units containing a wide variety of energy lessons, resources, learning aids and a bibliography.

Unit Objective

Upon completion of this unit the student will be able to define the common units for measuring heat energy (Calorie, BTU) and convert measurements from one set of units to another, given the conversion formulas. Also, the student will be able to calculate the heat transferred to water by different heat sources, given its mass and change in temperature.

Unit VII Background Information

All forms of energy can be converted to heat. Some sources of energy are used to produce heat energy for heating our homes and offices. In this unit students seek to determine the most economical source of heat for homes and offices in order to introduce them to the measurement of heat energy and its standard units: the Calorie and the BTU.

It would be interesting to note the cost of heating homes in the past, present and future! How has the energy crisis had an affect on home heating costs and what is the outlook for the future in our everyday living?

Unit VII lessons can be infused easily into many disciplines, specifically; General Science, Chemistry, Physics and Math. The lessons consist of "hands-on" activities and experiments for students to do. In addition to experiments in energy conversion there are also lessons designed for the student to construct various simple machines or devices to demonstrate the energy conversion concept.

LESSON TITLE: "Calories for Heating Our Homes, The Cost of Heating"

LESSON OBJECTIVE

Students will become familiar with the common units for measuring heat energy (calorie, BTU) and be able to calculate the heat transferred and the cost per unit of heat energy that could be produced by an energy source.

BACKGROUND INFORMATION

Key Ideas

1. Many forms of energy can be converted to heat energy in order to heat homes and offices.
2. The observed temperature change of a substance is directly proportional to the amount of heat energy transferred to the substance, and indirectly proportional to its mass.
3. Standard units of heat energy, such as Calorie or BTU, can be defined in terms of the energy required to change the temperature of a specified mass (1 kilogram or 1 pound) of a standard substance (water) by a specified number of degrees (1° Celsius or 1° Fahrenheit).
4. The relative costs of heat energy from different sources can be determined by converting the known price per unit of measure to price per unit of heat energy (i.e., price per Calorie or BTU).

Teaching Suggestions

Pre-lesson Preparation

This lesson can best be employed in the context of other studies of heat and energy. In particular, students should have aquired some simple understanding of the concepts of:

1. Energy-how do we know it is being used? (We observe energy in use as either light,* motion, or warmth.)
2. Energy sources-what materials or processes are capable of producing light,* motion, and warmth? (Fuels, electricity, sun, etc.)
3. Temperature and how it is measured.
4. Heat-a form of energy which is transferred from a hot substance to a cooler substance in its vicinity.

*Includes radiant energy.

ACTIVITIES

Students are asked, in response to an introductory story, to determine the most economical source of heat energy. They are led to enumerate possible sources, both past and present, and to investigate their price per unit of measure (volume, weight, or electric energy).

1. Begin lesson by posing a problem situation in which one needs to compare and determine the most economical source of heat energy.

For example, relate the following story to students:

"In a conversation one evening with several of my friends, we began discussing some of the newspaper and magazine stories related to the energy crisis. Each of us was particularly concerned about the rising costs of fuels and electricity. (Do you know what I mean by fuels? Can you name some?" Answer: fuels are substances, such as coal, oil, natural gas, alcohol, wood, etc., which release their stored energy upon burning.)

"One friend, Mr. Smith, said that his home (apartment) was heated by the burning of heating oil, and his bills were increasing each month because of the rising cost of oil. Another friend, Ms. Jones, said that her place was being heated by the burning of natural gas, and her bills were rising because of the increased gas prices. The home of Ms. Green was recently built and was all electric. Each room in the house was heated by baseboard heaters. Her heating bills were also rising.

"The conversation was like a conversation between fishermen: each friend claimed his heating bill was larger, in much the same way each fisherman relates that the fish he caught was larger. Each friend, however, was interested in the heat sources which would be the most economical - the one which would provide the greatest amount of heat for the least money.

"I suggested that since we were studying heat and energy here in class, we might be able to help them determine whether electricity, oil, natural gas, or some other fuel would be the most economical."

2. Brainstorming with students to obtain a list of current and previous sources of home heating.

"Before we try to determine the cost of these fuels, let's construct a list of fuels that are now being used for heating homes and offices in our community."

Have students brainstorm and list on the board as many fuels as they can think of. The list might include:

- Heating Oil
- Natural Gas
- Electricity (not a fuel)
- Coal, Hardwood
- Others, such as gasoline and alcohol

The first three energy sources in this list were mentioned in the story. Coal and wood are used in only a small percentage of buildings at present, but were once used extensively. If these fuels are not mentioned, these might be introduced into the discussion by displaying Figure 1.

3. Discuss with students, using Figure 1, the history of fuel usage during the past 100 years.

Ask students:

"from this graph, which fuel is most used used nowadays as our source of energy? Which was most used 25 years ago? 50 years ago? 75 years ago? 100 years ago?

As an option, one might discuss at this point the possible reasons for the change in fuel usage in the last 100 years. (See NSTA Energy-Environment Source Book, Volume II, Chapter 4.) (Note: the figure displays consumption of fuel for all uses, not just home heating.)

Suggest to students that it might be worthwhile to include coal, hardwood, and other petroleum derivatives such as gasoline on the list.

4. Through discussion of how fuels and electricity are produced, direct student attention toward specifying their cost as their price per unit of measure.

Ask students to construct their own table of heat sources from the list on the board. Instruct them to leave room for six other columns for later work. "We now have our shopping list of heat sources. Let's find out how much each costs."

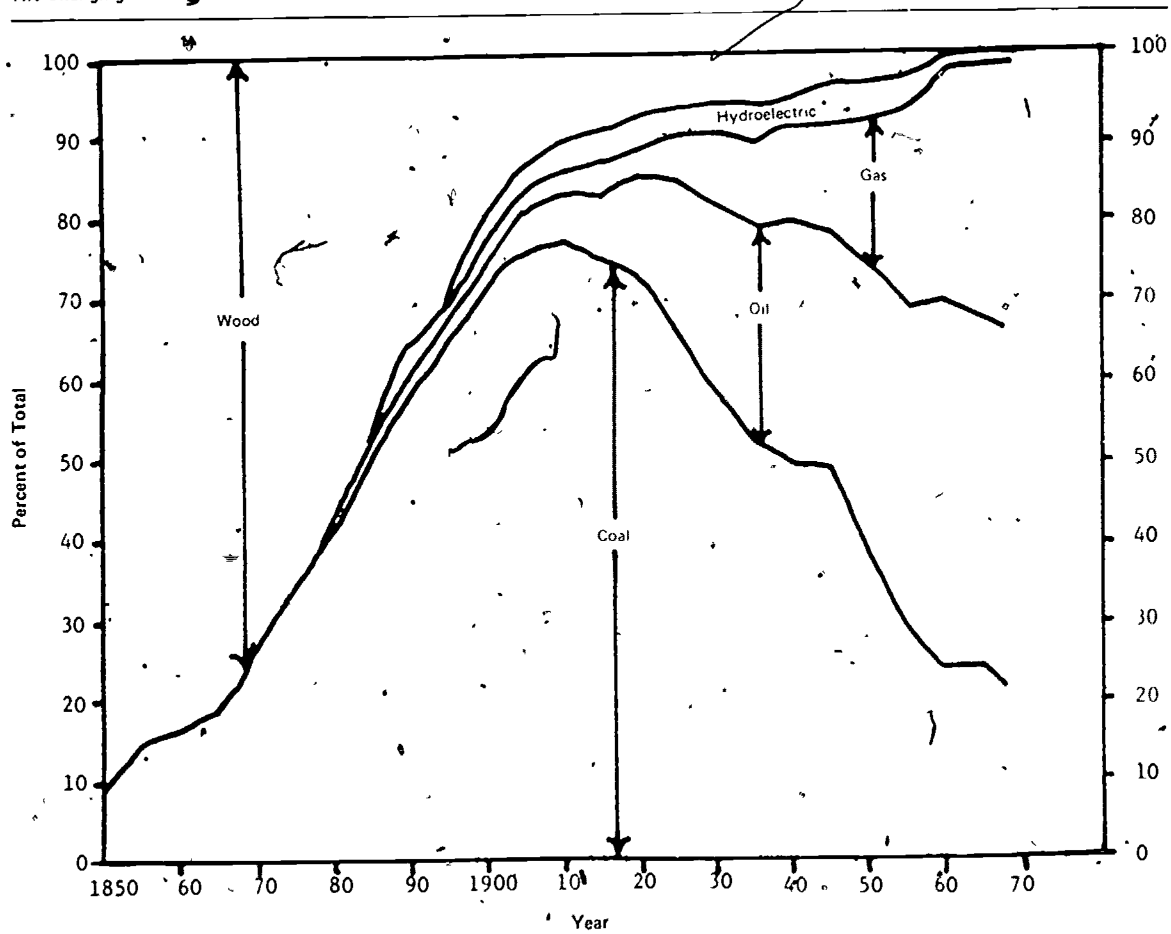
Make the observation, or develop the idea through discussion, that the cost of an item in a market is always given as so much money for a given quantity of the item being sold. For example: strawberries may be sold for $1 a quart, stringbeans for 39 cents a pound, milk for $1.20 a gallon. Quart, pound, and gallon are units of measure.

Request that students, therefore, add as columns 2 and 3 to their table the headings "Units of Measure" and "Price Per Unit" respectively. Students may know some of the units and prices; these should be solicited and recorded.

5. End lesson by assigning students the task of determining "price per unit of measure" for all heat sources in table.

Divide class into several groups, one group for each heating source listed. Ask each group to determine the unit of measure and the price per unit for those sources here. This information is lacking. Explore with students the possible sources of this information: Their families' heating and utility bills or local gas, oil, and electric companies.

FIGURE 1
The Changing Fuel Mix



LESSON TITLE: "Do We know the Heat Produced Per Unit of Measure?"

LESSON OBJECTIVE:

The student will be able to compare the relative cost of different energy sources using their costs per unit of heat energy and identify the most economical one.

BACKGROUND INFORMATION

In order to determine the most economical heat source, students are led to realize the need for knowing the heat produced per unit of volume or weight measure for each fuel (and heat per kilowatt-hour for electricity). Demonstrations are performed to suggest experimental means for measuring these quantities.

ACTIVITIES

Set up four tripods (or ring stands and rings) with wire gauze pads. Place an uninsulated 500 milliliter pyrex beaker filled two-thirds with water on each tripod and pad. Prepare materials necessary to heat each beaker by a different method: a Bunsen burner for one, an electric immersion heater for another, an alcohol lamp for another. (At minimum, set up two tripods with the first two heat sources.)

1. Complete the table of heat sources and their price per unit of measure found at the end of the lesson.

   Record in the table the units of measure and the average price per unit for each of the heat sources as they were obtained by your students. The information on costs may differ to some extent for a variety of reasons: for example, the price per unit of electricity may differ depending on the amount used in each home. Approximate averages are satisfactory, however.

   (For demonstration purposes we will use here the prices prevailing in the Washington, D.C., area in mid-1974.)

2. Develop the need for a common unit of measure (price per heat produced) by attempting to determine the most economical heat source from table entries.

   Ask students:

   "Which source of heat is the most economical to use? Which has the lowest cost per unit of measure? Is it more costly to heat a home with heating oil or natural gas, for example?"

In all probability, students will point out that one cannot compare the cost per 100 cubic feet for natural gas with that for gallons of heating oil. If this is not suggested it may be useful to add the following:

"If this question is not clear, let's try a slightly different question. When you're at the supermarket, can you determine which food can give you the most nutrition for the least meoney? For example, can you tell me which gives you more nutrition: a gallon of milk or a pound of cheese? Why not? Art the units the same? (No.) Then what is the problem in determining the most economical source of heating?" (The cost of the sources are not the same unit of measure.)

3. Have students determine the quantities that they need to know in order to change each price per unit of measure to the price per unit of heat energy.

Ask:

"When we buy these sources, what are we interested in?" Their weight? (No.) Their volume? (No.) How about the amount of heat they produce?" (Yes.)

"Why do we quote their price per weight or price per volume? What are we really interested in?" (The price per unit of heat they produce.)

(1) Heat Source	(2) Unit of Measure	(3) Price Per Unit	(4)	(5)	(6)	(7)
Heating Oil	Gallon	$ 0.36				
Natural Gas	100 Cubic Feet	0.22				
Electricity	Kilowatt-Hour (*)	0.05				
Coal	Ton	51 65				
Hardwood	Cord (*)	40 00				
Gasoline	Gallon	0.56				

(*) These units may need to be explained to students:

a kilowatt-hour is the unit of electric energy. It is calculated from the wattage of the appliance or device and the time it is used. A 100 watt bulb used for 1 hour uses 100 watt-hours or 0 1 kilowatt-hours. If used for 10 hours, it uses 100 X 10 = 1,000 watts-hours, or 1 kilowatt-hour

a cord of wood is a pile of logs 8 feet long, 4 feet high, and 4 feet wide.

(The above discussion would not be needed if in the previous discussion some students already indicated the energy sources as they are given in the table. What you want to buy is not coal, wood, or oil itself but the energy it stores.)
Ask students:

"How can we determine the price of heat produced by each source? If we know, for example, the price per gallon or per kilowatt-hour, what do we need to know to determine the price of heat produced?" (We need to know the heat produced per gallon or kilowatt-hour.)

Demonstrate that if you know the price per gallon, you can determine the price of heat produced by knowing the heat produced per gallon:

price per gallon divided by ? = price of heat produced

$$\frac{(\$ \text{ per gallon})}{?} = (\$ \text{ of heat produced})$$

$$\text{Thus } \frac{(\$ \text{ per gallon})}{(\$ \text{ of heat produced})} = (?)$$

$$\text{or } ? = \frac{(\text{heat produced})}{(\text{gallon})} = \text{heat produced per gallon}$$

Have students fill in column 4, Quantity We Need to Know, of their tables.

4. Perform demonstration of heating water by various energy sources in order to suggest methods for measuring heat produced per unit of measure.

   Pose the questions:

   "How can we determine or measure the amount of heat produced by a gallon of oil, or 100 cubic feet of natural gas? Do you have any ideas? Let me show you some experiments which might suggest a method."

   Light the Bunsen burner, the wood splints, the alcohol lamp, and turn on the immersion heater. Explain each set-up. Place a thermometer in each beaker.

"What is occurring in each case? (Water is being heated.) how do you know it is being heated?" (The temperature of the water is increased.)

Ask students if they can then suggest a way to measure heat by measuring something that is always associated with our concept of heating (an increase in temperature of the water when heated.) The change in temperature of a substance can then be used as an indication that heat is being transferred to the substance.

5. End lesson by assigning students the task of devising experiments to measure the amount of heat produced by each fuel.

Summarize discussion:

"We have determined that in order to compare the cost of the different heat sources, we need to know the heat produced per unit of volume or weight (or electric energy) measure. We have also seen how the heat produced is related to the temperature change of heated material. Does this suggest a way to determine the heat produced per unit of volume or weight?"

Assign students the task of devising, on the basis of this information, experiments to measure the quantities in column four of their tables. Have them write down the materials they would need, the procedure they would follow, and the means they would use to calculate the heat transferred. Ask them to note any additional information they still need.

If students have no previous knowledge of heat units, it is likely that they will not be able to calculate the heat produced from the temperature change measurement that they will probably suggest as part of their experiment. In addition, they may not specify the quantity of water or other substance employed in their experiments. These may serve as points for discussion in the next lesson.

(1) Heat Source	(2) Unit of Measure	(3) Price Per Unit	(4) Quantity We Need to Know	(5)	(6)	(7)
Heating Oil	Gallon	$ 0.36	(Heat per Gallon)			
Natural Gas	100 Cubic Feet	0.22	(Heat per 100 Cubic Feet)			
Electricity	Kilowatt-Hour	0.05	(Heat per Kilowatt-Hour)			
Coal	Ton	51.65	(Heat per Ton)			
Hardwood	Cord	40.00	(Heat per Cord)			
Gasoline	Gallon	0.56	(Heat per Gallon)			

LESSON TITLE: "Measuring Heat Transfer: The Calorie"

LESSON OBJECTIVE

Students will be able to determine that the change in temperature depends also on the mass of the substance being heated by conducting a series of experiments.

BACKGROUND INFORMATION

Experiments are performed to demonstrate that one can not equate the heat transferred to a substance to its change in temperature. The change in temperature depends also on the mass of the substance being heated. From this result the definition of the Calorie is developed.

Advance preparation:

Set up apparatus (see materials list at end of lessons) to heat a beaker of water with a Bunsen burner. Experiment may be performed as a demonstration or as a student experiment (in which case materials are needed for each student or group of students).

1. Review student suggestions for measuring the amount of heat produced per unit of volume or weight of the heat energy sources.

   Ask students to descirbe how they would determine how much heat would be produced by burning the wood splints, alcohol, natural gas, etc. What equipment would they use? Would they use water as the substance to be heated? Would they measure its temperature change? How much fuel would they burn or use? Suppose they measured a temperature change, then what? Is the amount of heat transferred equal to the temperature change?

2. Perform, or have students perform, an experiment to determine if the temperature change of the heated water can be equated with the heat transferred.

   "Let's perform an experiment to determine if we can say that the amount of heat transferred from, for example, the burning gas of a Bunsen burner to the water in a beaker can be set equal to the temperature change of the water."

   Have students construct a data table similar to Table 2 in this lesson. Explain that since it is difficult to measure volume of gas burned by a Bunsen burner, you will measure instead the time of heating for each trial. If the rate (volume per second) of the gas flow is not changed, then the heating time will be directly proportional to the volume of gas burned.

Heat successively three 500 milliliter uninsulated beakers of water which are about two-thirds full for a short period of time after recording the masses of the beaker, and the beaker plus water. Use a slightly different amount of water each time.

Measure the initial temperature and final temperature for each trial. The gas-flow setting should not be varied. Sample data are found in table 2.
In these trials a thermometer was left in the water and used to stir the water while it was being heated. The beaker was removed from the heat source at the end of four minutes in each trial: the final water temperature was recorded as the highest temperature reached. To obtain useful results with this simple apparatus, the volume of water was not varied by more than 20 percent. (The heat transferred to the beaker was also neglected.)

ACTIVITIES

A. When the experiment has been completed, ask students questions which develop the point that for the same heating time (and therefore, volume of gas burned) the temperature change was different. For example:

1. "Was the measured temperature change the same or different for each trial? (Different.)

2. Was the volume of gas burned the same or different? (Same, since the time of heating was the same.)

3. If the same amount of gas was burned, was the same amount of heat transferred? (Yes.)

4. Then why is the temperature change different if the heat transferred is the same?" (The masses of water were different.)

Help students to conclude that the heat transferred cannot be set equal to the temperature change because the temperature change depends on the amount of water being heated: a large amount of water will have a small change in temperature, while a smaller amount will have a larger change in temperature for the same amount of heating.

B. Introduce the MKS (Metric) unit of heat energy, the Calorie.

"Since we cannot equate the heat transferred to the temperature without considering the amount of water being heated, we need to define a new unit for heat energy which will take this into account. In the metric (MKS) system of units this is called the Calorie. If we heat 1 kilogram of water and raise its temperature by 1°C, then we have transferred 1 Calorie to the water."

(You might want to note that the calorie, spelt with a small c, is the CGS unit of heat energy. The Calorie -- kilocalorie -- equals 1,000 calories. The Calorie is the unit most commonly applied to food.)

TABLE 2

Trial	Source of Heat	Time of Heating (minutes)	Mass (in kilograms)			Temperature (°C)		
			Beaker	Beaker + H_2O	H_2O	Initial	Final	Change
1	Natural Gas	4	0 186	0 584	0 398	15	54	39
2	Natural Gas	4	0 186	0 609	0 423	15	52	37
3	Natural Gas	4	0 186	0 670	0 484	15	48	33

C. Have students determine if the heat transferred to the water in each trial was, in fact, the same.

Ask your students to calculate the number of Calories of heat energy tranferred to the water in their first trial. If they appear to be puzzled on how to proceed, use the data for trial 1 (in Table 2, or preferably, the data they collected) and work through the first calculation with them. Help them to see that if it takes 1 Calorie (or 1 calorie) of heat to raise the temperature of 1 kilogram (or 1 gram) of water 1oC that, using the data in Table 2, it would take 0.398 (or 398) times as much to raise the temperature of 0.398 kilograms (or 398 grams) by 1°C, and that it would take 39 times as much to raise the temperature of 0.398 kilograms (or 398 grams) of water 39°C. This reasoning is summarized in the expression:

Heat transferred = 1 (Calorie/kg/°C) x mass (kg) x change in temperature (°C)

Heat transferred = 1 (Calorie/kg/°C) x 0.398 kg x 39°C

Heat transferred = 16 Calories or 16,000 calories

Ask:

"Is it possible to check our earlier assumption that the natural gas burning at a constant rate for the same period of time would provide the same amount of heat energy to different quantities of water? Is the heat transferred in trials 2 and 3 the same as that in trial 1?" (Ask students to check if this is so. Their calculations will probably indicate that the assumption is valid.)

D. End lesson by asking students to think about how they could determine how much heat is produced by 1 kilowatt hour of electric energy as measured in Calories.

Related Activity

Have students research the amount of energy stored in different foods as measured by the number of Calories each is said to contain. Which foods contain more heat energy than the amount transferred to the water? Which less?

*Note this relationship is exact only for water, which has a specific heat of 1.0. A later lesson might be developed to introduce specific heat by performing the same experiment with a different liquid: use the same mass and the same burning time. The energy transfer will be the same, but the temperature change will be different because the specific heat will not be equal to 1.0.

RESOURCES

Energy-Environmental Mini-Unit-Guide - A product of the NSTA (National Science Teachers Association) Energy - Environmental Materials Project, John M. Fowler, Director.

The development of these materials was supported by the Office of Environmental Education under the Environmental Education Act of 1970 (P.L. 93-278).

Books

Articles

LESSON TITLE: "Kilowatt-hours, Calories and BTUs".

LESSON OBJECTIVE

By performing a simple experiment, students will determine the number of Calories that are equivalent to one kilowatt-hour. Students will become familiar with the BTU and compare it to the Calorie and Kilowatt-hour.

BACKGROUND INFORMATION

Set up apparatus as in Lesson C, but substitute immersion heater(s) for Bunsen burner(s) and 250 milliliter beakers for the 500 milliliter beakers previously used.

1. Review previous lesson.

   Recall with students that although you have together developed a unit of measure of heat energy and have found that the heat energy transferred by burning the same quantity of gas was the same, you still cannot say how much heat energy there is in a cubic foot of gas because the volume of gas burned was not measured. Tell them that you will ask them to research later what the number of Calories produced per unit of volume or weight measure is for the various energy fuels by checking with the library references and local utilities. However, you would like to determine in class one of the quantities that is needed in column four of Table 1.

2. Introduce and perform, or have students perform, an experiment to determine heat equivalent of kilowatt-hour.

   Solicit student suggestions as to how to measure the heat produced as measured in Calories by 1 kilowatt-hour of electric energy. Suggest that an immersion heater can be employed to heat the water by electricity.

   Call their attention to the wattage marked on the stem of the immersion heater.

   "Since we know the wattage, can we calculate the heat equivalent of 1 kilowatt-hour of electric energy by using it to heat water just as the burning gas was used?" (Yes.)

   To do so it will be necessary to record the time of heating, the mass of the water, the initial temperature, and the final temperature. Ask students to record in their notebooks a table with the appropriate heading in which data for three trials can be recorded. The data table acceptable to your students should be placed on the board before the trials are run.

The data in Table 3 were obtained with a 250 watt immersion heater and a thermometer placed in a 250 milliliter beaker containing approximately 200 milliliters of water each time. The initial temperature was read with the immersion heater in the water but before it was turned on. The immersion heater was turned off and removed from the water at the end of 180 seconds. The final temperature was the highest temperature recorded on the thermometer during the time the immersion heater was on.

ACTIVITIES

A. Have students calculate the number of Calories produced by 1 kilowatt-hour of electric energy.

Ask students to calculate, using their data, the number of Calories produced by 1 kilowatt-hour of electric energy. The calculations for the data in Table 3 follow:

Electric energy supplied by immersion heater = heat energy gained by water

.0125 kilowatt-hour = 10.4 Calories (mean of three trials)

1 kilowatt-hour = 832 Calories (or 832,000 calories)

B. Introduce BTU (British Thermal Units) - as unit of heat energy and have students calculate the number of BTUs per Calorie.

At this time students might be interested in knowing how their value for the heat equivalent of 1 kilowatt-hour of electric energy compares with the literature value. One kilowatt-hour equals 860 Calories. Also tell them that although our country is switching to metric units, heat energy is still measured and reported most frequently by engineers in British Thermal Units. The BTU is operationally defined as the heat required to raise the temperature of 1 pound of water (about 1 pint) by $1^{o}F$ (Fahrenheit). Thus, it would be useful to convert the unit of Calories to BTUs or to redo the experiment with the immersion heater taking measurements of the mass of water in pounds and temperature readings in degrees Fahrenheit. Choosing the former, instruct the students to convert the mass data in Table 3 from kilograms to pounds with the conversion equation 1 kilogram = 2.2 pounds, and the temperature readings from ^{o}C to ^{o}F with the conversion equation $^{o}F = 9/5\ (^{o}C + 32)$.

The calculations using the data for trial 2 in Table 3 follow:

$T\ (^{o}F)$ initial = 9/5 (14 + 32) = 83°
$T\ (^{o}F)$ final = 9/5 (64 + 32) = 173°F
$T\ (^{o}F)$ = $T_f - T_i$ = 173 - 83 = 90°F

Water heated = (0.208 kg) x (2.2 pounds per kilogram)
= 0.458 pound

Energy gained by water = 1 (BTU per pound °F) x Mass (pound) x T (°F)

= 1 (BTU per pound °F) x 0.458 (pound) x 90°F
= 41.2 BTUs

Electric energy supplied by immersion heater	=	heat energy gained by water
.0125 kw-hr	=	41.2 BTUs
1 kw-hr	=	3,300 BTUs*

*The literature value for kw-hr is 2,412 BTUs.

Since the heat transferred to the water should be the same whether it is measured in Calories or BTUs, it is possible to use these results to determine how many Calories equal 1 BTU.

.0125 kw-hr	=	10.4 Calories
.0125 kw-hr	=	41.2 BTUs
41.2 BTUs	=	10.4 Calories
1 BTU	=	0.25 Calories or 1 Calorie $\simeq$ 4 BTU

C. End lesson by assigning students task of completing column five, BTUs Per Unit of Measure, of Table 1.

Recall Table 1 and the search for the most economical energy source which began this study of energy. Ask students to complete column five as homework:

"What is the heat energy in BTUs that can be obtained from 1 gallon of heating oil, 1 ton of coal, 100 cubic feet of gas, 1 kw-hr of electricity (check own results), 1 gallon of gasoline, and 1 cord of wood?"

The specific references listed in the bibliography for this activity should be suggested. Also, some students should make calls to local energy suppliers for information regarding their particular product.

TABLE 3

Heat Equivalent in Calories of a Kilowatt-hour of Electric Energy

Trial	Electrical Power (kilowatts)	Time (seconds)	Total Energy Transferred Kilowatt-hour	Mass (in kilograms)			Temp. (°C)			Energy Transferred to H_2O (calories)
				Beaker	Beaker + H_2O	H_2O	T_i	T_f	ΔT	
1	0.250	180	0.0125	0.101	0.292	0.191	15	69	54	10.3
2	0.250	180	0.0125	0.101	0.309	0.208	14	64	50	10.4
3	0.250	180	0.0125	0.101	0.308	0 207	14	65	51	10.5

EECP
Unit VII
Lesson E

LESSON TITLE: "The Most Economical Home Heat Source"

LESSON OBJECTIVE:

Students will determine the most economical heat source from the information they have obtained in previous lessons.

BACKGROUND INFORMATION:

In this lesson students determine the most economical heat source from the information they have obrained in previous lessons.

1. Review previous lesson and students' assignment.

   Begin class by discussing the results of their literature search for the standard values for the number of Calories equal to a BTU and the number of BTUs equivalent to a Kilowatt-hour. The percentage difference between the standard values and their measured values could be calculated.

   Refer students to Table 1 in previous lessons and to the copy which you have placed on the board. Write "BTUs Per Unit of Measurement" in the heading for column five. Ask students to give you the values they have researched for the number of BTUs per unit of measurement for each source. (Columns five, six, and seven of Table 1 in this lesson contain information for the teacher's reference.)

2. Have students determine cost per million BTUs and the relative cost of each heat source.

   Write "Cost Per Million BTUs" in the heading for column six. Assign different groups of students to calculate the cost of 1 million BTUs of energy obtainable from each energy source. (The average amount of heat required to heat a home in the United States for one year is roughly 100 million BTUs.) Write "Relative Cost" in the heading for column seven, and before proceeding, ask what this means and how each of the values could be obtained (divide the smallest cost per million BTUs into each of the other costs).

3. Close lesson by identifying the most economical heat source and possible reasons for the cost variation in the sources.

   Ask:

   "As a result of our investigations, which heat source would you recommend to my friends, Mr. Smith, Ms. Jones, and Ms. Green, to heat their homes? Are there any other factors, in addition to the cost of each million BTUs of energy stored within a heat source, that you would consider in your decision?"

Take a survey in the class of the number of families who use each of the energy sources (excluding gasoline) to heat their homes.

Ask:

"Why is electricity so much more costly than the other energy sources?" (One reason: electricity is primarily generated by the burning of fossil fuels. Approximately 25 percent of the energy stored in these fuels is converted to electricity; the remainder is given off as waste heat at the power plant site. In other words, electric power plants are only 35 percent efficient. The use of electricity for heating thus involves an extra step in energy conversion:

fuel —burning at power plant→ 65 percent becomes waste heat
→ 35 percent becomes electricity for home heating

as compared to direct heating by fuel in home furnaces:

fuel —burning in home furnace→ home heating

At this point, further discussion might occur on the reasons for the differences in the cost per million BTUs. Are some heat sources more available in your area? Are environmental costs added to the price? Are they greater for some sources than for others? Are supplies of some fuels greater than others? Is extraction of the fuels hazardous or costly?

TABLE 1

(1) Heat Source	(2) Unit of Measure	(3) Price Per Unit*	(4) Quantity We Need to Know	(5) BTUs Per Unit of Measure	(6) Cost Per Million BTU	(7) Relative Cost
Heating Oil	Gallon	$ 0.36	(Heat per Gallon)	145,000	$ 2 48	1.24
Natural Gas	100 Cubic Feet	0.22	(Heat per 100 Cubic Feet)	103,100	2.16	1.08
Electricity	Kilowatt-hour	0.041	(Heat per Kilowatt-hour)	3,412	12.00	6.00
Coal	Ton	51 65	(Heat per Ton)	25,000,000	2.07	1.03
Wood	Cord		(Heat per Cord)	20,000,000	2.00	1.00
Gasoline	Gallon	0.56	(Heat per Gallon)	125,000	4.50	2.25

*Prices quoted are those prevalent in the Washington, D.C. area in mid-1974. Have students research prices prevailing in their area to replace these.

ACTIVITIES:

1. Ask the students:
"What is a Calorie? A BTU?"

Acceptable responses:

All are units of heat energy.

1 Calorie = amount of heat energy needed to raise the temperature of 1 kilogram of H_2O by 1^oC.

1 BTU = amount of heat energy needed to raise the temperature of 1 pound of H_2O by 1^oF.

2. Give the students the following information:

1 kilowatt-hour (kw-hr) = 3,412 BTUs
1 BTU = 0.252 Calories

Ask questions such as:
(a) "How many kilowatt-hours of electricity are needed to produce 700 Calories of heat energy?"

Acceptable response:

700 Calories = 700 ÷ (0.252 C per BTU) = 2,778 BTU
2,778 BTU = 2,778 ÷ 3,412 (BTU per kw-hr) = 814 kw-hr

(b) "How many Calories are there in 1 kilowatt-hour?"

Acceptable response:

1 kw-hr = 2,412 BTU
3,412 BTU x 0.252 Calories per BTU = 860 Calories

3. Give the students the following information:

Heating Oil	has	145,000 BTU per gallon
Coal	has	25,000,000 BTU per ton
Natural Gas	has	103,100 BTU per 100 cubic feet
Electricity	has	3,412 BTU per kw-hr

And the following hypothetical prices:

Heating Oil	costs	$ 0.30 per gallon
Coal	costs	30.00 per ton
Natural Gas	costs	0.30 per 100 cubic feet
Electricity	costs	0.02 per kw-hr

Ask students to:

Calculate the cost per BTU for each energy source.

Determine the most economical one.

Acceptable responses:

The cost per BTU is calculated by dividing the price per unit of measurement by the BTU per unit of measurement:

Heating Oil	–	0 30 ÷ .145 (MBTU per gallon)	=	\$2.70 per MBTU
Coal	–	30. – 25 (MBTU per ton)	=	\$1.20 per MBTU
Natural Gas	–	0 30 ÷ 1031 (MBTU per 100ft³)	=	\$2.95 per MBTU
Electricity	–	0.02 ÷ 003412 (MBTU per kw-hr)	=	\$5.86 per MBTU

Coal has the lowest cost per million BTUs and is thus the most economical one in this example.

4. Alternatively, if price data in your region have been employed in these lessons, use the date for the Washington area given in this activity as problem data. If the Washington, D.C. Data were employed in the lessons, use the local price data for problem data.

RESOURCES

Energy-Environmental Mini-Unit-Guide - A product of the NSTA (National Science Teachers Association) Energy - Evnironmental Materials Project, John M. Fowler, Director.

The development of these materials was supported by the Office of Environmental Education under the Environmental Education Act of 1970 (P.L. 93-278).

Books

The Concept of Energy Simply Explained, Morton Mott-Smith (New York: Dover) 1964.

Energy and Engines, D.S. Holacy (New York: World) 1967.

Energy, Matter and Change, Ronald D. Townsend (New York: Scott Foresman) 1973.

For a discussion of the history of our changing fuel mix, see Energy in the United States: Sources, Uses and Policy Issues, H.H. Landsberg and S.H. Schurr (New York: Random House) 1968 (230 pp., \$3.50 pa.) and the NSTA Energy-Environment Source Book, Volume II, Chapter 4.

Articles:

"The Conversion of Energy" Scientific American 224 (3), September 1971 (pp. 148-163).

"Energy" Encyclopedia Britannica 6 15th edition (Macropedia).

"Mathematics for Heat," Chapter 6, in Energy Does Matter by Scientists of Westinghouse Research Laboratories (New York: Walker) 1964.

Note: Additional references to books, articles, and films are provided in the NSTA Energy-Environment Materials Guide.

Materials List for Lessons A-D.

Lesson A

Make transparency of Figure 1 or distribute a copy to each student.

Lesson B

4 tripods (or ring stands and rings)
4 wire gauze pads
4 500 milliliter pyrex beakers
4 thermometers
1 Bunsen burner
1 alcohol lamp
1 250-watt electric immersion heater
a pile of wood splints or tongue depressors

LESSON C

From the materials in Lesson B, use one Bunsen burner, tripod, wire gauze pad, thermometer, and 3 beakers. In addition, a small scale for measuring up to 1 kilogram. If students perform the experiment, collect a set of these materials for each student or student group.

Lesson D

Same materials as in Lesson C except substitute the electric immersion heater(s) for the Bunsen burner(s) and three 250 milliliter beakers instead of the 500 milliliter beakers.

LESSON TITLE: "Construction of a Hydroelectric Generator"

LESSON OBJECTIVE

Students will be able to construct a simple hydroelectric power generating system.

BACKGROUND INFORMATION

In addition to learning how to construct the hydroelectric power generating system students will also have the opportunity to do some experimenting. The students can experiment with differences of volume, water pressure, propeller size and determine how they relate to electrical power output. Also by experimenting, the student can show how demand affects output of current.

NOTE: Use compressed air or steam as an alternative power source.

ACTIVITIES

1. Construct a hydroelectric generator using a bicycle generator. Make a propeller or cup-like device to fasten to generator and turn as water strikes it.

2. Connect a milliampmeter or bicycle light to generator to show output.

3. Use water from sink or other suitable source. Make different size nozzles, possibly reducing them from garden hose size to 3/8" copper tubing.

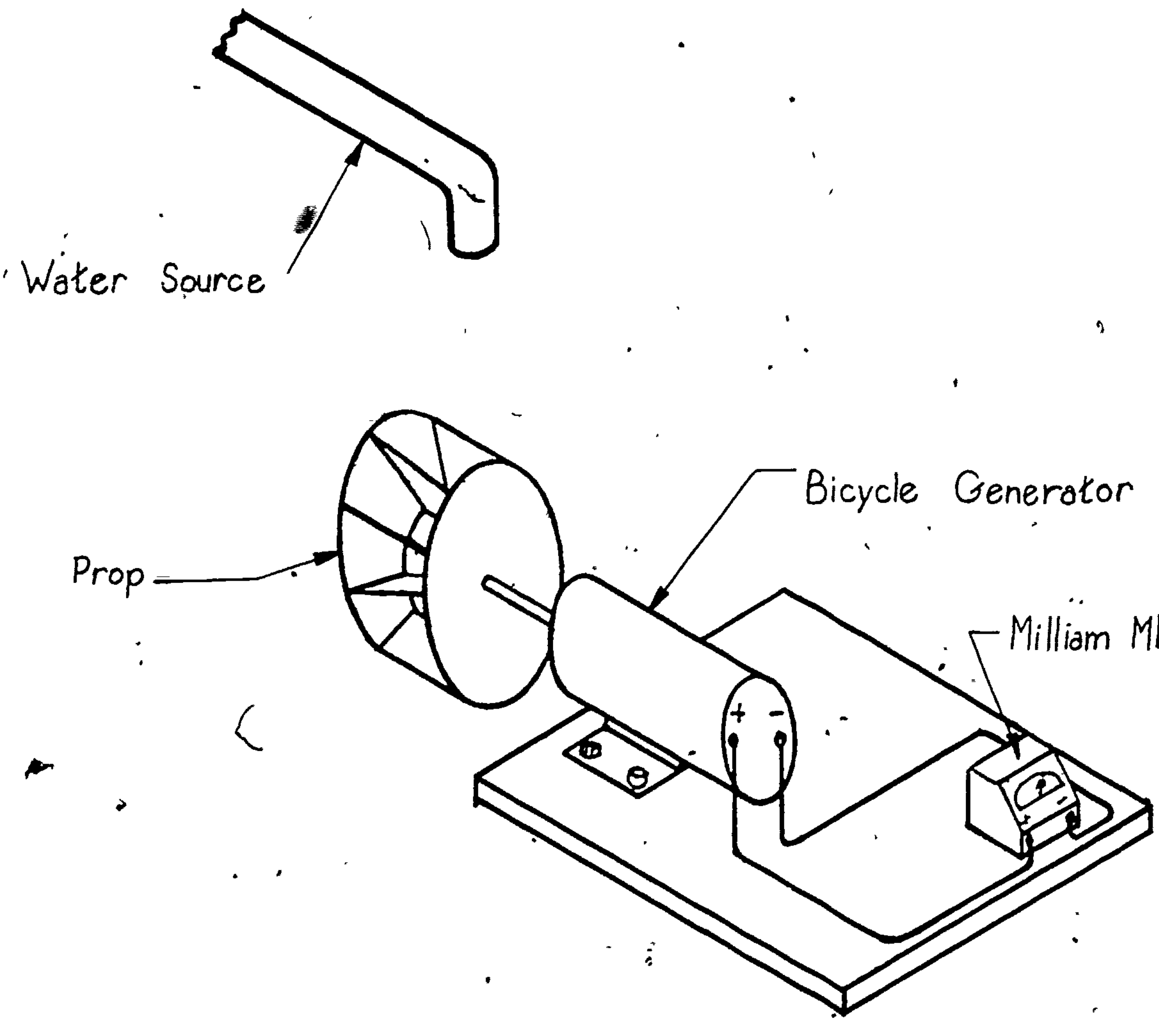
4. Hook up lights in parallel: turn on one at a time to see effects in current output.

NOTE: Use compressed air or steam as an alternative power source.

RESOURCES

The Minnesota Trial Test Materials
Minnesota Department of Education
625 Capitol Square Building
St. Paul, Minnesota 55101

Developer of Minnesota Program
Mr. Tom Ryerson - Supervisor
Industrial Education


Water Source
Prop
Bicycle Generator
Milliam ME
+
-

LESSON TITLE: "Heat Exchangers"

LESSON OBJECTIVE

1. Students will be able to build a simple liquid to air heat exchanger, in order to see how the process of heat exchange takes place.

2. Students will be able to determine temperature differential across a simple liquid to air heat exchanger and the influence of flow rate on heat exchanger efficiency.

BACKGROUND INFORMATION

In order to analyze any heating and cooling system, a study of heat exchangers becomes necessary. The reason for studying heat exchangers is that the heat gathered within a heating or cooling system usually must be transferred or exchanged into air, if it is to be used effectively.

A heat exchanger is a unit within any heating or cooling system that transfers the energy from one medium to another. For example, the heat energy generated within a gasoline or diesel engine cooling system is transferred from the liquid coolant to the air by the use of a heat exchanger called a radiator. Heat is also transferred out of a refrigerator by the use of a heat exchanger. In fact, most industrial or commercial air conditioners and heaters utilize some type of heat exchanger.

There are three basic methods of transferring heat: convection, conduction and radiation. Conduction is defined as heat flow by actual contact from a body at a higher temperature to a body at a lower temperature. For example, if the coils on a range were at a higher temperature and the pan on the coils were at a lower temperature, the thermal energy would be transferred to the pan through conduction. The key consideration is that both bodies are at rest during the heat transfer.

Convection is defined as that method of heat transfer which transfers thermal energy from a solid body by a liquid or gas that is in "motion." The key factor is that one medium is in motion, and will convey the thermal energy away from the hot body to a colder substance. For example, as air is heated by a hotter body, the air will rise causing the air to be in motion. The hot air then comes in contact with the cooler air above it, thus raising its temperature and lowering the temperature of the original air. As the thermal energy is transferred by convection, the cool air will then drop causing it to be reheated by the original hotter body.

Radiation allows thermal energy to be transferred from one substance to another by infrared rays. Infrared rays are not visible to the human eye. Radiant energy is transmitted at the speed of light. Radiant heat transfer, unlike conduction, can pass through a medium such as air without heating it appreciably and is best transferred through a vacuum. This is how most of the energy comes to the earth from the sun. The waves flow through a vacuum to the earth's atmosphere and are either absorbed or reflected into space.

By applying these three heat transfer methods to heat exchangers, heat can be transferred to any medium whichever is most practically used in the application.

The most common types of heat exchangers used to transfer heat within a solar collector system are: 1) air to liquid, 2) liquid to air, and 3) liquid to liquid. In order to accomplish this needed exchange, two types of heat exchangers are normally designed in heating and cooling systems. By combining these exchangers any type of heat transfer can be obtained.

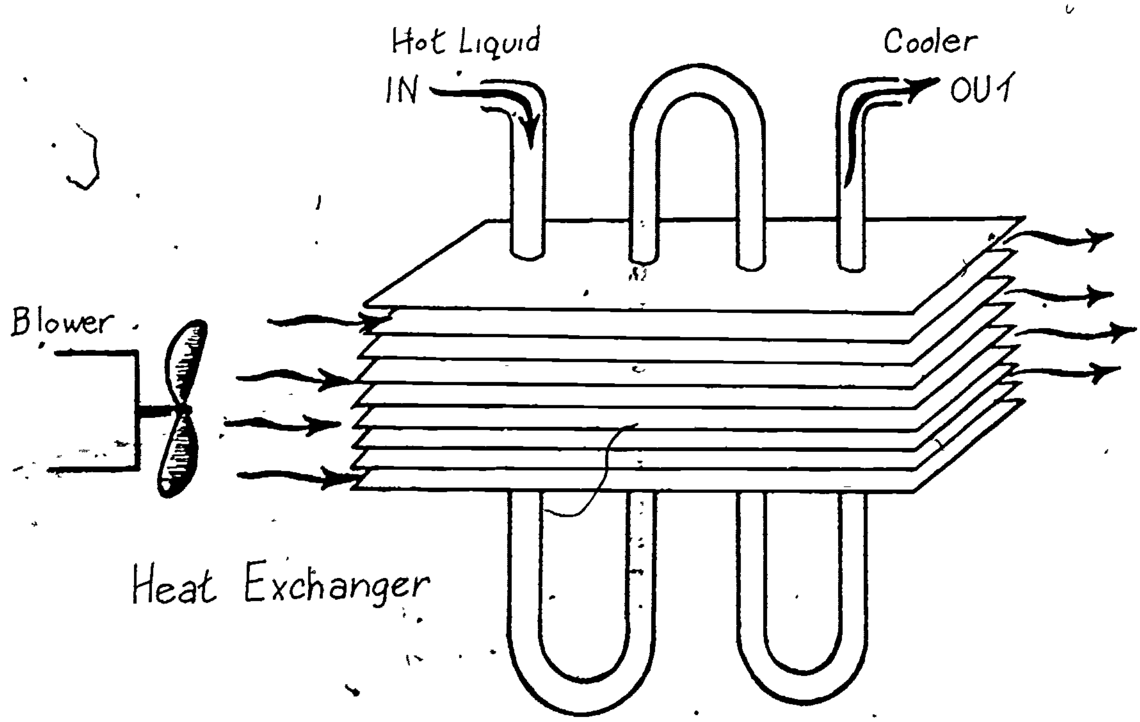


Figure 1. A liquid to air and air to liquid heat exchanger.

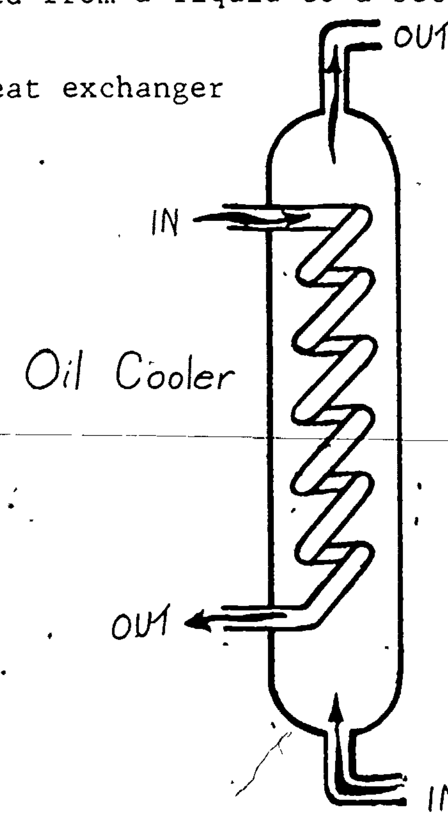
The first type of heat exchanger is shown in Figure I. In order to transfer heat from a liquid to air which is needed, for example, when hydronic collectors are used for space heating, the liquid medium for the collector is pumped through the piping into the exchanger. The heat from the liquid is then conducted or transferred into the surrounding pipe and fin area. This occurs because heat always moves from a hotter to a colder material. The heat is then radiated from the fins and forced air is then blown through the fins to remove the heat. The larger the surface area of the fins, the greater the heat dissipation.

One of the most common applications for this type of heat transfer is the cooling sytems used on all air cooled engines. Fins on the block of the engine radiate large amounts of heat because of the increased surface area.

This process can easily be reversed so that heat can be transferred from air to liquid, providing the air is hotter than the liquid. A typical applicaton for this type of heat exchanger is an air type of solar collector, transferring energy to the hot water system of a residential home. Although possible, this method of heat transfer is a little difficult because the density of air is far less than that of water, causing poor heat capability.

The second method of heat transfer is illustrated in Figure 2. In this case, heat is transferred from a liquid to a second liquid.

Figure 2. A liquid to liquid heat exchanger



A typical example would be an oil cooler used to cool the heat within a transmission of an automobile. The heat build-up in the transmission fluid is sent to the lower part of a radiator to be cooled by the water system.

Although many designs exist, the more common types use coils of tubing placed directly within the second liquid. In this case, the heat from the first liquid is conducted into the metal tube and then conducted into the second liquid.

Another method of liquid to liquid heat exchanger is to have the tubes of each system physically contacting each other. Through conduction, the heat will transfer from the hotter liquid to the colder liquid.

ACTIVITIES

Description

List of Materials

1. 2 copper tubes, ½" diameter x 3' long
2. 2' x 2' base board
3. Wooden supports
4. Aluminum sheet metal
5. Thermometers
6. 2 male connectors
7. 2 control valves
8. Solder
9. Soldering iron/Propane torch
10. Tin snips

NOTE: The fins and copper tubing can be obtained as a unit (fin tube) from many heating/cooling suppliers. You may also be able to salvage a unit.

Project Construction

A simple liquid to air heat exhanger can be made as illustrated in Figure 3.

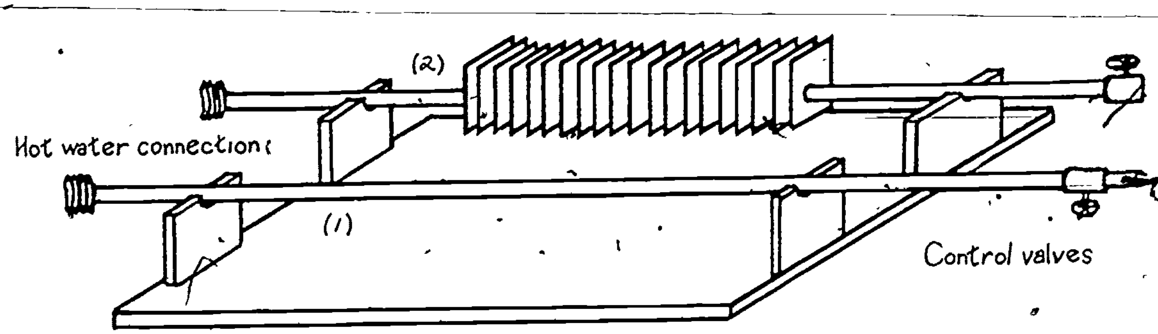


Figure 3. A model liquid to air heat exchanger.

Two copper tubes are mounted on a frame with a control valve placed on each end. Hot water from a hose can then be supplied to the end of each tube. The hot water from the faucet, generally near 140°F, can be used as the hot water source. (This water could also be heated from a hydronic solar collector.) The fins are made from aluminum sheet metal and can be press fit to the copper tubing. The fins should be spaced equally (3-4 per inch of pipe).

TEST PROCEDURES

1. When the demonstration model is complete, measure water temperature input with thermometer and record on the chart.
2. Hook up hot water to tube #1.
3. Turn on control valve to allow a small amount of water to run out.
4. Measure temperature output and record on the chart.
5. Determine the drop in temperature due to heat exchange by subtracting the output from the input and record on the chart.
6. Measure Radiant temperature approximately 2" above tube #1 and record on the chart.
7. Repeat steps 1-6 using tube #2 (with the fins) and record on the chart.
8. Repeat steps 1-7 using a high flow rate and record on the chart.

TEST RESULTS

	Low Flow		High Flow	
	Tube Without Fins	Tube With Fins	Tube Without Fins	Tube With Fins
Input Temperature (I_t)				
Output Temperature (O_t)				
Difference ($I_t - O_t$)				
Radiant Temperature (R_t)				
Air Temperature (A_t)				
Difference ($R_t - A_t$)				

Questions to Ask:

1. Ask students to examine the data they collected. What effect do the fins have on the amount of heat radiated into the air?

2. Ask students to review the data they collected. What effect does the rate of flow have on the heat exchange process?

3. In this system, where is heat being transferred by conduction, convection and radiation?

4. The difficult part of the heat's journey is into and out of the exchanger, not through it. If your class has built at least two models you might want to try a contest. You could title it "THE MOST HEAT EXCHANGER FOR THE MONEY" or....? Challenge your students to improve the efficiency of the model heat exchanger. (This could also be a special project for a group of interested students.) Larger fins? Closer fins? Painted fins? Fanned fins? Soldered fins? Etc. The students who participate in the contest must be able to convince you and the class that they have improved the design.

RESOURCES

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Duffy, Joseph W. 1972. Power, Prime Mover of Technology, McKnight and McKnight Publishing Company, Bloomington, Illinois.

Hand, A.J. 1972. Home Energy How-To. Popular Science, Harper and Row, New York, New York.

Kates, Edgar J. 1968. Diesel and High Compression Gas Engine Fundamentals, American Technical Society, Chicago, Illinois.

Meinel, Aden B. and Marjorie P. Meinel. 1977. Applied Solar Energy, An Introduction. Addition-Wesley Publising Company, Reading, Massachusetts.

The Minnesota Trial Test Materials
Minnesota Department of Education
625 Capitol Square Building
St. Paul, Minnesota 55101

Developer of Minnesota Program
Mr. Tom Ryerson - Supervisor
Industrial Education

LESSON TITLE: "Moonshine Travel: Sunshine Solutions"

LESSON OBJECTIVE

Students will be able to run a dynamometer test, plot the horsepower and torque characteristics for 3 different fuels, and compare the exhaust characteristics of 3 different fuels.

BACKGROUND INFORMATION

One of many ways that is being suggested for bridging the gap to the post-oil age is the exploration of alternatives to gasoline. Gasohol, a blend of 90 percent gasoline and 10 percent alcohol is one such alternative that has been the subject of considerable attention and debate. As of September, 1979 it is being used as automobile fuel at more than 800 service stations in 28 states across the nation.

Proponents of gasohol contend that since gasohol can be made from many different kinds of plant products, precious oil and gasoline supplies can be preserved. Distillers dried grain, a by-product of the ethanol-producing process, is a very concentrated, high protein animal feed. Ethanol enhances the octane rating of gasoline, and this alleviates the problem of engine knock. Gasohol reduces carbon monoxide emissions and, according to some engineers, can produce better mileage than straight gasoline.

Critics of gasohol contend that the amount of acreage to grow the fuel, plus the amount of energy expended in planting, harvesting and processing, make alcohol fuels, whether in pure form or as a mixture, a doubtful solution. Opponents claim it takes more energy to produce gasohol than can be gained from it. Most studies on which this claim is based assume that fossil fuels provide all the energy for the distillation process and that only pure alcohol will be used as a fuel. Straight alcohols, for example from 140 to 190 proof, can be used although there are certain engine modifications that must be made. They also point out that alcohol costs more to make than gasoline.

The use of alcohol as a fuel is not a recent technology. The idea is old and nearly universal. In a high school graduating class speech in Washington D.C. in 1917, Alexander Graham Bell said, "Alcohol can be manufactured from corn stalks and from almost any vegetable matter capable of fermentation: growing crops, weeds - even the garbage from our cities. We need never fear the exhaustion of our present fuel supplies so long as we can produce an annual crop of alcohol."

The use of alcohol/gasohol appeared with the depression when farmers could not sell their products, and reappeared with each succeeding recession and fall in grain prices. The logic made sense: the technology was there; alcohol was easily made by fermenting grain or other plant material, and could be used for fuel either alone or in combination with ordinary gasoline. The mixture (in a 90 percent gasoline, 10 percent alcohol combination) is gasohol. But gasoline was cheaper than alcohol, and readily available. And Americans adopted gasoline.

Now Americans don't have enough fuel. In 1977, they drove 113.7 million cars 1.12 trillion miles and burned 80.2 billion gallons of gas - and the number of cars, miles, and gallons is rising every year.

In a recent report of the U.S. Department of Energy, alcohol's potential for petroleum savings is stated as follows:

> Through 1985, the contribution of alcohol fuels is expected to be modest nationally--perhaps displacing as many as 40,000 barrels per day of oil once recent presidential initiatives are put into practice. Production will be limited by the capacity to convert agricultural and waste material into alcohol. In agricultural states, alcohol fuels may become quite significant sources of local supply.

<u>Materials List to Be Used in Lesson:</u>

1. A small engine loading device or a commercial dynamometer for a small engine (Note: any type of chassis dynamometer will also work).
2. Torque meter on the dynamometer or loading device.
3. RPM meter.
4. Either a 2 or 4-cycle small engine.
5. Small paper filters (vacuum cleaner filters or equivalent)
6. Fuels - gasoline; if available, gasohol; alcohol. Use the highest percentage (95%) ethyl or ethanol rubbing alcohol that you can buy. The label will also indicate that the alcohol is denatured. Do <u>not</u> use methanol or propanol!

A NOTE ON ALCOHOLS

The alcohol used in gasohol is grain alcohol or ethanol. The raw materials appropriate for conversion to ethanol are diverse and include products such as cheese whey, citrus wastes, substandard corn and grain sorghum, Jerusalem artichokes, etc. The variety of possiblities is only just being explored.

The greatest use of grain alcohol today as a fuel is in combination with gasoline to form gasohol. This blend, which is 10 percent alcohol and 90 percent gasoline, does not require any engine modifications.*

(Gasohol should be used only in 1975 - model or newer cars.)

When straight alcohol is used as a fuel, whether it be ethanol or methanol, there are some adjustments that need to be made. (See Crombie, Resources).

Alcohol content, "proof," is expressed in units equal to twice the percentage, e.g., 200 proof is 100 percent alcohol; 160 proof is 80 percent alcohol. 200 proof ethyl or pure alcohol is not available for classroom use. Unless commercial gasohol is available, you can use at least a 95% denatured, ethyl alcohol as a reasonable substitute (available from your pharmacy as rubbing alcohol).

Do NOT use methanol. It is a poison. Furthermore, methanol/gasoline blends require engine modifications. In general, methanol's properties differ more from gasoline's than do ethanol's. The domestic supply of methanol comes primarily from natural gas and petroleum. Methanol can also be made from coal, oil shales and tar sands.

DEFINITIONS

In order to perform the experiment, you will want to review some terms and definitions with your students.

Work--Work is defined as the result of applying a force, created by a source of energy, to a body or mass through a certain distance. Work is actually energy in transition. For example, if a person pushes a stalled automobile and the force causes the automobile to move several feet, work is then being done. The definition then means that a body moved a certain distance by a force, creating work. Force is measured in pounds and distance is measured in feet. Work is then measured in foot pounds. If should be understood that if a force is applied to a body and it doesn't move, then no work is being done although it may seem like it.

Horsepower--Horsepower is defined as a measure of work being done. More specifically, horsepower is actually considered the rate at which work is being done in a straight line direction.

The amount of horsepower depends upon how fast the work is done, which means time must be considered. In other words, power is the number of ft. lbs. being performed per second or ft. lbs./sec. When 33,000 pounds have been lifted one foot in a period of one minute, then one horsepower has been created.

Torque--Torque is defined as a "twisting force." This is in contrast to the definition of horsepower which was defined as work applied in a straight line direction per time period. Twisting force tends to cause rotation of objects. Most of the energy conversion systems and power transmission systems use torque as a convenient measurement. Some of these applications are motors, generators, gears, transmissions, engines and wheels. Torque is normally expressed in foot pounds.

An example of the difference between torque and horsepower is that torque is generated within a diesel engine by the crankshaft which, in turn, pushes the vehicle forward in a straight line motion. The straight line motion can be measured in horsepower, but the twisting motion from the engine crankshaft is called torque. An example may help students understand this. A large truck pulling 40,000 lbs. and an automobile pulling 2,000 lbs may both be rated very close in horsepower, say, 200 horsepower. The truck engine must produce a great deal more torque though than the automobile engine because the truck must overcome a heavier force. Diesel engines are generally used where torque is the primary need while gasoline engines generally do not produce as much torque.

Performance Charts--The terms work, torque, and horsepower all play an important role when studying performance of energy converters. They are usually displayed on Performance charts.

Performance charts are used in the power converter industry to display the output characteristics of the individual converter. In fact, most any converter from gasoline engines to high speed turbines utilize performance charts. From these charts optimum speeds (and different fuels) can be selected for the highest fuel efficiency at specific power outputs.

In addition, each engine application has a different set of requirements placed upon it. With the use of performance charts the most efficient fuel can be selected for the best application (Figure 1).

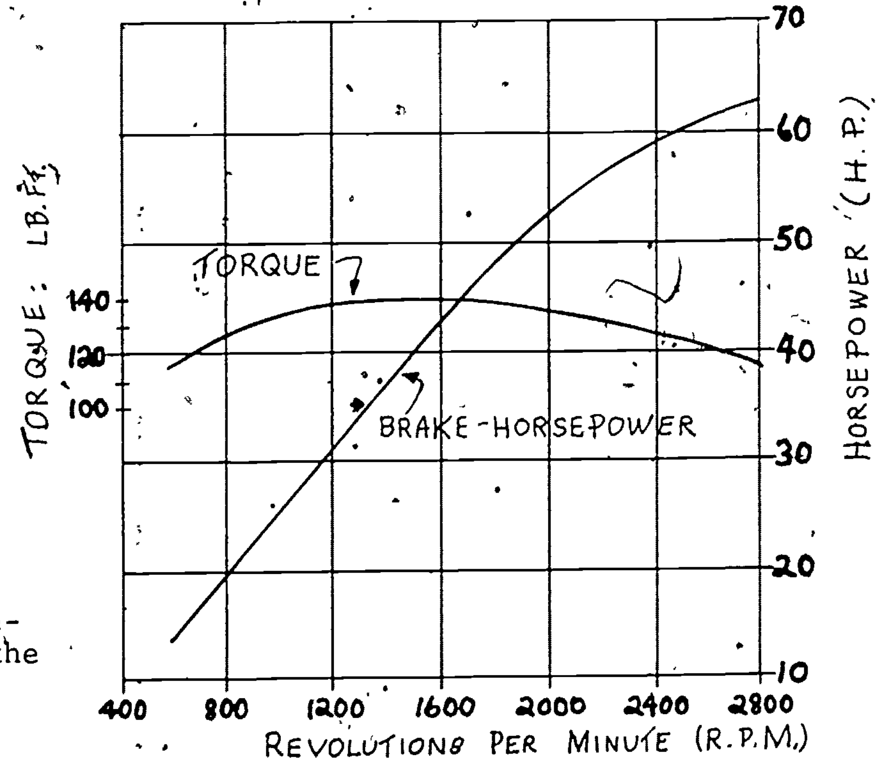


Figure 1.

A gasoline engine performance chart. The speed or revolutions per minute is shown on the horizontal axis. The right vertical axis shows the horsepower output while the left vertical axis shows torque output.

ACTIVITIES

Procedure

1. Use regular gasoline.
2. Start the engine and increase the throttle so that the engine operates at maximum engine RPM without any load applied. Record RPM on Chart A.
3. Apply a slight load by increasing the load control so that the RPM drops approximately 500. Record torque and RPM on Chart A.
4. Increase the load so that another 500 RPM is dropped. Record both RPM and torque on Chart A.
5. Continue increasing load and dropping RPM by 500 until the engine stalls. Record each reading--torque and RPM--on Chart A.
6. Calculate the horsepower rating for each torque and RPM rating using the formula:

$$\text{Horsepower} = \frac{T \times RPM}{5252^{*}}$$

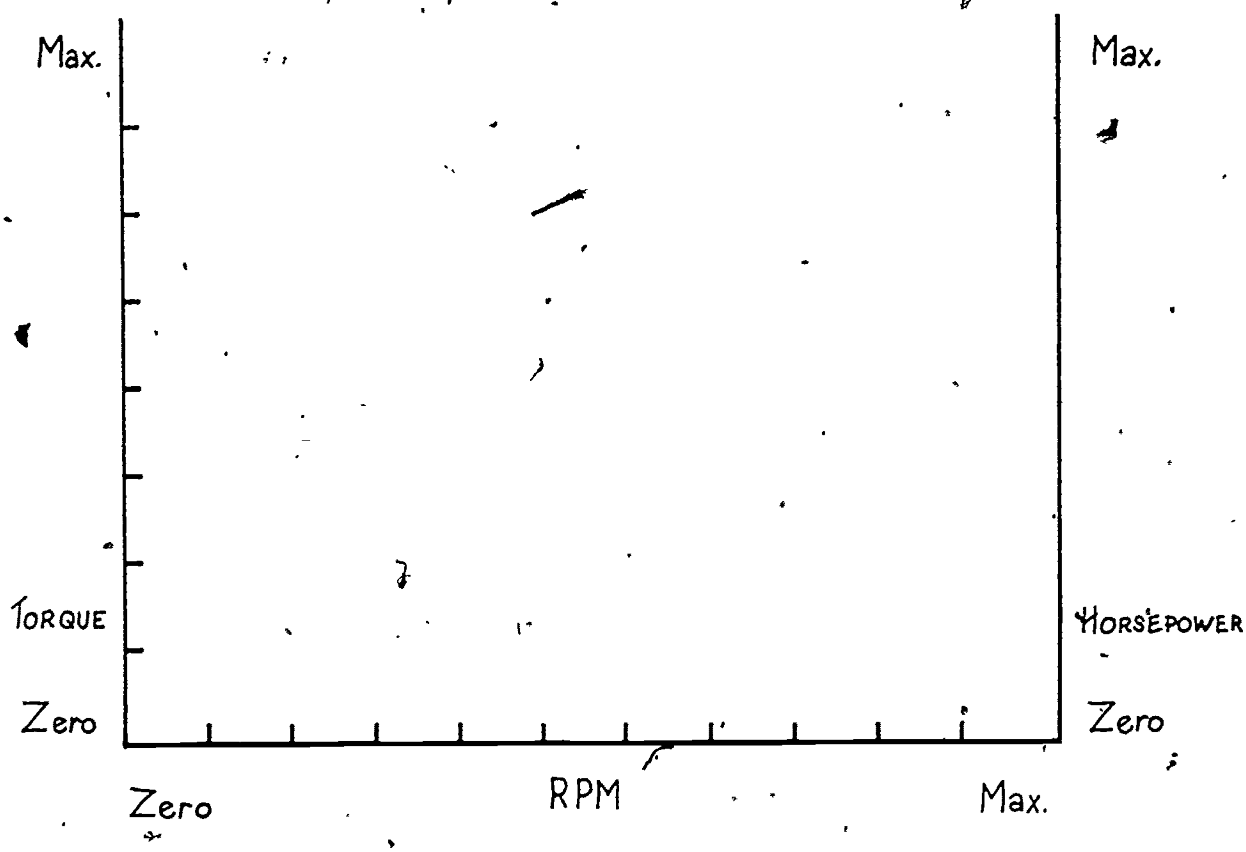
7. Have students develop performance curves by plotting the torque, HP, and RPM on Chart B. Label these curves according to the type of fuel used.
8. Place the paper filter over the exhaust under a heavy load and record the color of the paper after the test on Chart A.
9. Empty the fuel tank. Make a 10% alcohol and a 90% gasoline mixture and add it to the fuel tank. Keep all conditions the same as for the previous test.
10. Plot a second performance curve with this fuel by following steps 2-8 and record the data on Charts A and B respectively. Label the curves.
11. Empty the fuel tank. Now make a 30% alcohol and a 70% gasoline mixture. Keeping all conditions the same as for the previous test, plot a third performance curve with this fuel by following steps 2-8. Record on Charts A and B respectively. Label the curves.

*NOTE: Some commercial dynamometers use a different figure. 10,000 may be used if the dynamometer is measuring ½ ft. lbs, rather than straight ft. lbs.

CHART A

READING NUMBER	RPM	TORQUE	HP	EXHAUST CHARACTERISTIC
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

Chart B



ALTERNATIVES

Other fuels may be used as well in this experiment. Comparisons may be made between low and high octane, leaded fuels, oil mix fuels, propane fuels or other ratios of alcohol in fuels in the same manner.

Questions to Ask

1. As alcohol was added to the gasoline what happened to torque?

2. What engine speed produces the highest horsepower on any type of fuel?

3. Which fuel is most useful for maximum horsepower?

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The Minnesota Trial Test Materials
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Industrial Education

LESSON TITLE: "Seeing Dust As A Fuel"

LESSON OBJECTIVE

Students will have the opportunity to study the concept of recycling by constructing a useful product, fireplace starters, made from recycled sawdust.

BACKGROUND INFORMATION

The energy crisis is bringing renewed interest in recycling materials. There can be a savings in money, energy consumption and natural resources.

In a recent issue of the Iowa Energy Bulletin (see Resources) there was a report of a study of a unique energy opportunity conducted by the City of Pella, Iowa.

> The Pella Muncipal Power Plant is located adjacent to a manufacturing plant that could provide 20 percent of the city's fuel requirements with a clean burning fuel at approximately one-half the cost of coal.
>
> The fuel is sawdust and 190,000 pounds are produced each work day as a by-product of the Rolscreen Company. Rolscreen could seel the City of Pella approximately 47.3 million pounds per year, representing 282,130 million BTU's of energy. Presently, the sawdust is sold to particle board manufacturers and shipped to the buyer by rail.

The word "recycle" means to process or treat something in order that it may be used again. While many products can be recycled, few products are. As we look to the future, it is likely that more attention will be given to recycling in order to save energy and other resources.

Materials List

1. Paraffin - Use old candles or purchase slabs of paraffin.

2. Double Boiler - (A low temperature crock pot will work. Never heat paraffin directly in a pan because it may ignite if it gets too hot.)

3. Hot plate with adjustable heat control

4. Soup ladle

5. Sawdust - The coarse sawdust from a jointer or surfacer works very well.

6. Support base - To hold paper tube while it is being filled with the sawdust/paraffin mixture. These blocks can be made by gluing a 1 inch long piece of 1 inch diameter dowel rod to a piece of scrap board. Two dozen or more are required.

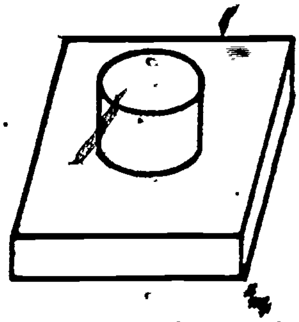

Figure 1. Support base for holding the paper tubes while they are being filled.

7. Tape - cellophane

8. Paper - 8½ x 11 inch ditto paper in various colors

9. Candy thermometer - For safety, use the all metal type with the bimetalic sensing element and dial at the top. Candy thermometers are usually better than meat thermometers because they have a lower temperature range.

10. Large can - To be used for stirring the sawdust and melted paraffin (A three pound coffee can works well).

11. Wood stirring stick or wooden spoon with a long handle.

12. Funnel

13. Dowel Rod - ¼ inch diameter by 15 inches long (approximately)

ACTIVITIES

Procedure

1. Roll sheets of 8½" x 11" paper into tubes and adjust the size to fit snug over the support bases. (The paper should be rolled so that the finished tube is 8½ inches long.) Tape the paper tubes on the outside (Fig. 2). NOTE: Colored ditto paper may be used to brighten up the project. Also, before rolling the paper into tubes, you may wish to ditto (or print) the name of your school, the instructions for using the starters, etc.

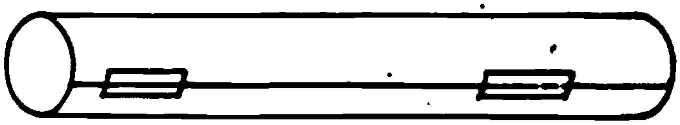

Figure 2. Tube rolled from 8½" x 11" ditto paper and taped on the outside. This tube is adjusted to a size that will be snug around the support base.

2. Set the tubes in an upright position on the support bases. They are now ready to be filled with the paraffin/sawdust mixture.

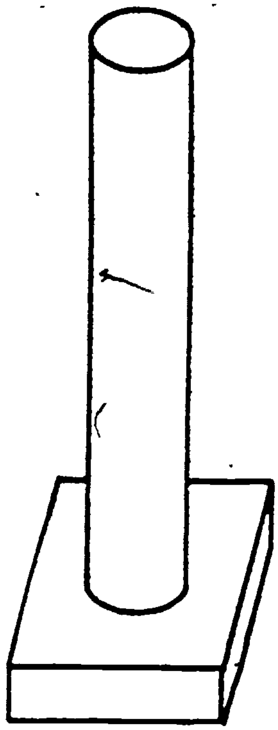

Figure 3. The support base will hold the paper tube in an upright position so that the tube may be filled with sawdust/paraffin mixture.

Melt the paraffin in a double boiler. Keep a thermometer in the melted paraffin at all times and never let the temperature exceed 125-150°F. Observe the following safety rules:

a) Use a double boiler or a wax melting pot. Don't, for example, heat wax in a kettle over a open flame.

b) Always keep a thermometer in the melting paraffin and keep the temperature as low as possible. Unlike water, which boils, paraffin looks the same at a safe temperature (125 - 150°F) as it does at an unsafe temperature. When paraffin is overheated it can reach it's flash point and start to burn.

c) Use a metal thermometer rather than a glass thermometer.

d) Do not over fill the container. A container filled to 1/3 of its capacity is satisfactory.

e) Always use a electric heating element. It is safer than an open flame.

f) Use a metal double boiler rather than a glass double boiler.

4. Mix one ladle of paraffin and two ladles of sawdust together in a 3 pound coffee can. Stir with a long wooden spoon or a wood stick until the sawdust is coated with the parrafin. Experiment with different ratios of sawdust and paraffin.

5. Carefully spoon the mixture into the paper tubes while the mixture is still hot and pliable. Students may spoon the mixture into a funnel and then use a ¼" dowel to ram the mixture into the tube (Fig. 4).

6. Allow the mixture to cool and then carefully remove the paper tube assembly from the support bases.

7. To use the fireplace starter just light the paper tube with a match. The fireplace starter will burn for 30 to 45 minutes. It may be used for campfires, fireplaces, or for starting charcoal grills.

Questions To Ask

1. Has this activity made you more aware of the need to be more concerned about the use of materials and energy? What are some of your reasons?

2. What are the advantages and/or disadvantages of these fireplace starters?

3. What would you do to improve the design of the starter? How would you know that the improvement is really an improvement?

4. What is the optimum length of the starter for various kinds of fire starting applications?

5. Find someone in your community who knows the do's and don'ts of wood burning. Ask that person whether these starters have hazards associated with them.

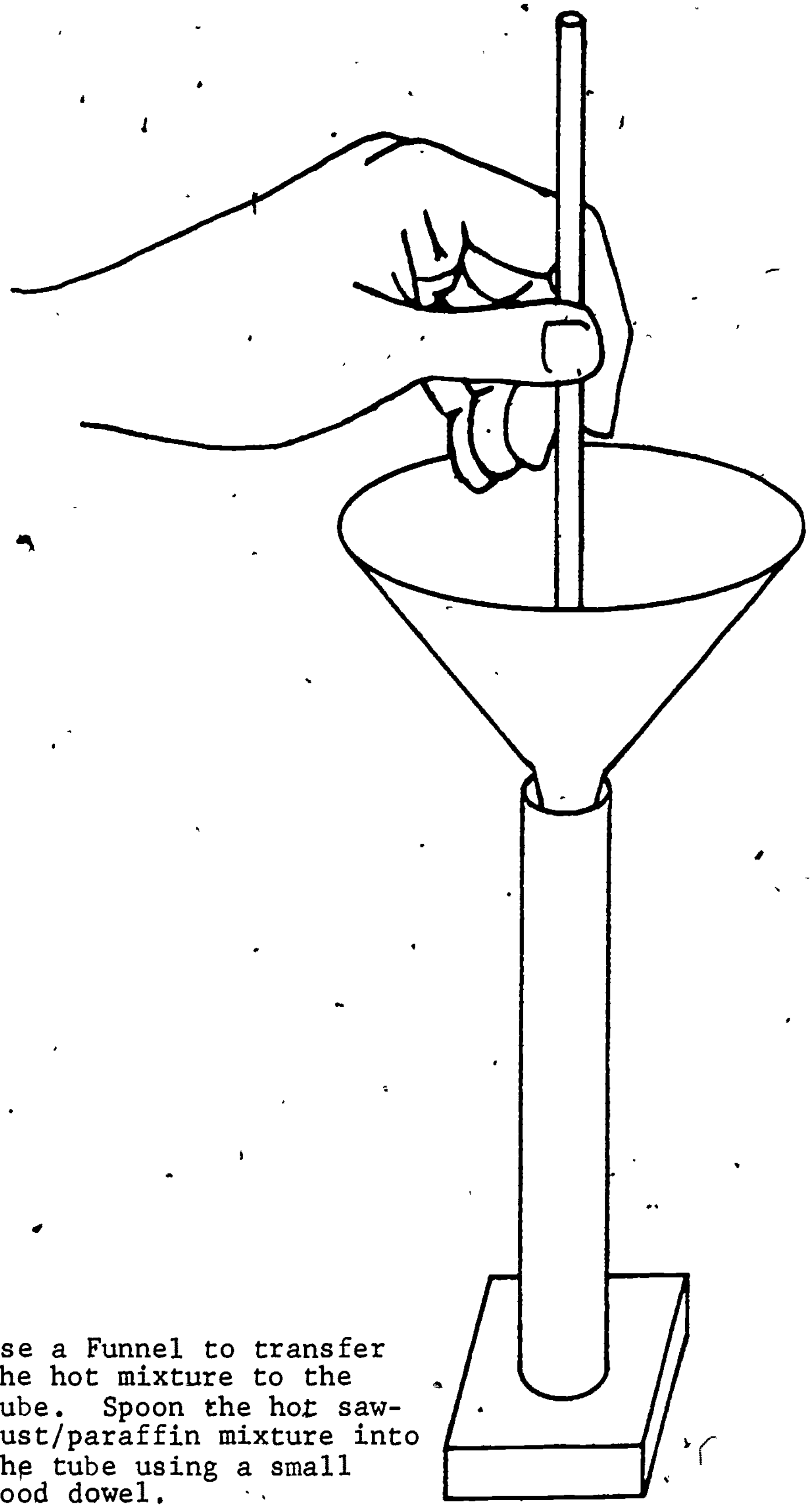

Figure 4. Use a Funnel to transfer the hot mixture to the tube. Spoon the hot saw-dust/paraffin mixture into the tube using a small wood dowel.

RESOURCES

1979. Pella Considers Sawdust as Fuel. Iowa Energy Bulletin. March/April.

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LESSON TITLE: "Pedal Power"

LESSON OBJECTIVE

Students will construct a machine that will enable a person to generate electricity by pedaling a bicycle, providing students with practical and useful insights into the production and transfer of energy.

BACKGROUND INFORMATION

As we contemplate solutions to the energy crisis we usually find ourselves listing a variety of possible alternative sources such as: solar, wind, water, geothermal, tidal, etc. Somewhere at the bottom of this list we would probably remember to mention humans as an energy source.

Humans have always used their muscle power, however, as technology has developed we rely less and less on our own muscle power as a means of serving our basic needs. Some observers are suggesting that society may have to slow its pace, change some of its values and make use of more human power.

Materials List

Regular bicycle frame
Generator - a. a 12 volt, automobile generator, or
b. a 120 volt, 1800 rpm, 1000 watt generator. (The cost is approximately $175.00 if purchased new)
Leather belt material
Angle iron - ¼" x 2"
Voltage meter
Miscellaneous materials - 12 volt car battery, nichrome wire, bulbs, pulleys, assorted sprockets

ACTIVITIES

Construction

Alternative A. Remove the rubber tire from a regular bicycle and suspend it in a stand as shown in Figure 1. Couple the generator to the rear wheel of the bicycle with a leather belt.

Alternative B. Elevate the rear tire of a bicycle and use the tire to drive various generators by holding them aganist the revolving tire. The small motors and generators could be fitted with rubber, plastic, or wooden drums which serve as friction drive mechanisms.

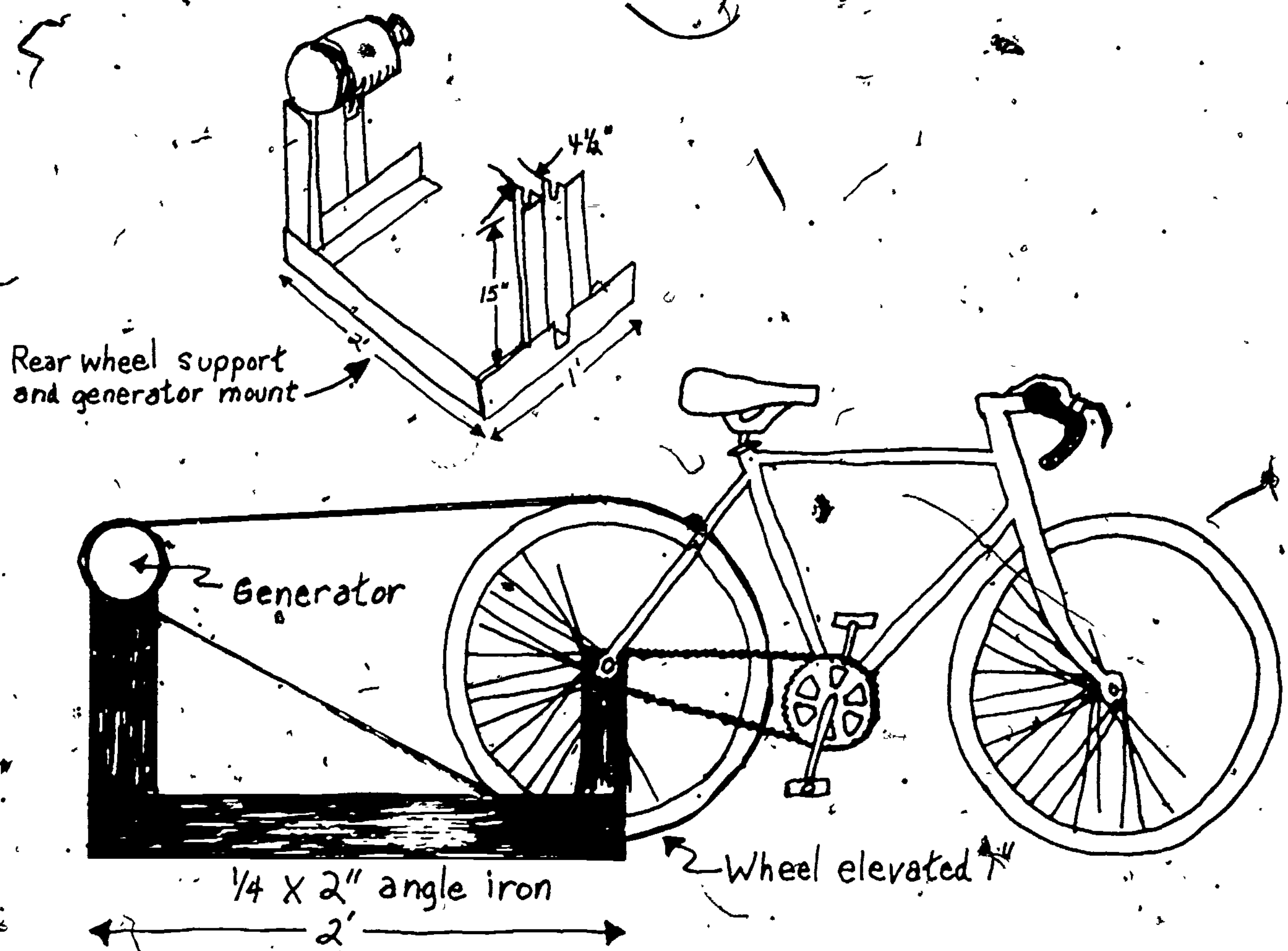

Figure 1. Construction details of the bicycle generator.

Test Procedures

This bicycle powered generator should be a device that all students can have access to on a regular basis. If you have used the 120 volt generator, observe all safety precautions. As students work with this "alternative energy machine" you may want them to answer some questions based on their experience with the machine and materials, for example:

Questions to Ask During Test Procedure:

1. How much voltage can be generated with leg power? For how long?

2. What is the effect of changing the pulley size on the voltage generated? On duration? If you have a multispeed bike, compare the effects of varying the gear ratio on the voltages generated.

3. Can a battery be charged with this machine? How long does it take?
4. Can you light a bulb? Several bulbs? How many? Make an electromagnet. Improve the electromagnet. Heat a length of nichrome wire. (Vary the diameters. Which heats faster? Why?) Of copper wire? Can you heat a cup of water with it?
5. Compare flat and vee belts. Do they increase/decrease shaft speed? What is their effect on voltage?
6. What are the practical uses of this machine?
7. How can you improve this machine? (After the machine has been in use, ask students to suggest some improvements and try them).
8. Build a simple current detector by coiling fine magnet wire around a compass and use it to prove that your bicycle powered generator is producing a current.

Questions to Ask

1. How does a simple generator work?

2. What are the factors which determine how much voltage and wattage are produced?

3. Draw a schematic and a pictorial diagram of the bicycle generator.

RESOURCES

Geil, John J. 1976. Energy And Transportation: Power. Prentice Hall, Inc., Englewood Cliffs, New Jersey.

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The Minnesota Trial Test Materials
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The Minnesota Trial Test Materials, Minnesota Department of Education, 625 Capital Square Building, St. Paul, Minnesota 55101 Mr. Tom Ryerson - Director of Program.

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Please Note: Refer to "Resources" section in each lesson for further reference information.

PLEASE TELL US WHAT YOU THINK ABOUT THE SENIOR HIGH SCHOOL ENERGY MATERIALS

Your position: (check)
_____ teacher
_____ dept. head
_____ administrator
_____ other

Your grade level: __________

Subject(s) taught: __________

If possible, please answer these questions after you have taught unit lesson(s) in your class and examined teacher's guide. If this is not possible, please answer based on your personal inspection of the unit materials.

1. What project materials are you evaluating? (Check all that apply)
   _____ Unit I
   _____ Unit II
   _____ Unit III
   _____ Unit IV
   _____ Unit V
   _____ Unit VI
   _____ Unit VII
   _____ Unit VIII
   _____ Unit IX
   _____ Teacher's Guide
2. What is the basis for this evaluation? (Check all that apply)
   _____ (1) teaching 4 or more lessons
   _____ (2) teaching 1 to 3 lessons
   _____ (3) personal inspection
   _____ (4) discussion with others who know materials
3. Have you shared these units with other educators? (Check one)
   _____ (1) No
   _____ (2) Yes, with 1-4 others
   _____ (3) Yes, with 5-10 others
   _____ (4) Yes, with more than 10

Circle the number from 1 (Definitely No) to 7 (Definitely Yes) which best reflects your answer.

	DEFINITELY NO			NEUTRAL			DEFINITELY YES
4. Are these materials easy to understand and use?	1	2	3	4	5	6	7
5. Do these materials fit with the curriculum of your district?	1	2	3	4	5	6	7
6. Are you likely to make use of these materials in the future?	1	2	3	4	5	6	7
7. Are these materials appropriate for the level of your students?	1	2	3	4	5	6	7
8. Are these materials interesting to your students?	1	2	3	4	5	6	7
9. Is the reading level appropriate?	1	2	3	4	5	6	7
10. Do you think these materials will reduce energy consumption?	1	2	3	4	5	6	7

What did you like best? __________

What did you like least? __________

Suggestions/Comments (Use the back as needed): __________

RETURN TO: Energy Education Curriculum Project, Division of Curriculum, Department of Public Instruction, Room 229, State House, Indianapolis, IN 46204.