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ABSTRACT

This unit is one part of a three-part National Science Teachers Association (NSTA) series on energy-environment. The goal of this NSTA project is to create a collection of mini-units that provide materials for science and social studies teachers in grades K-12. These materials are intended to make teaching more interdisciplinary and to stimulate decision making in young children. Activities are sought that will enable students to: understand and use existing fundamental concepts in the energy-environment area; identify and evaluate personal and community practices, attitudes, and values related to energy-environment issues; and make effective decisions and/or define their views of appropriate actions on energy-environment issues. (Editor/CP)

ENERGY—ENVIRONMENT MINI-UNIT GUIDE

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A product of the
NSTA Energy-Environment Materials Project
John M. Fowler, Director

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PREFACE

What is a mini-unit? Briefly, a mini-unit is a series of plans for lessons which focus on several related energy-environment concepts, relationships, and student objectives. The core of each mini-unit is a group of teaching suggestions that describe in detail the purpose of a lesson, the main tasks for the teacher, and suggested student-teacher interactions.

This Guide is a collection of seven mini-units that provide materials for science and social studies teachers in grades K-12. A Teacher Guide to Mini-unit Use and an Abstract of each mini-unit follow this Preface.

Our overall goal in constructing these mini-units has been to provide teachers with examples of materials which would enable them to make their teaching more broadly interdisciplinary and related to immediate as well as local problems. For students our main concern has been with decision-making. We sought to provide activities that would enable students to:

1. *Understand* and use existing fundamental concepts in the energy-environment area;
2. *Identify* and evaluate personal and community practices, attitudes, and values related to energy-environment issues;
3. *Make effective decisions* and/or define their views of appropriate actions on energy-environment issues.

The Guide's mini-units, of course, do not cover the full range of important energy-environment concepts or objectives. They represent a set of models or exemplars of materials that can be constructed by teachers, given the resource materials of the NSTA *Energy-Environment Source Book* and the *Energy-Environment Materials Guide*.

In developing this Guide, we were particularly aided by Carol Euston of the Environmental Education Department of the Washington, D.C. Public Schools, who served as a part-time staff member; she provided us with many creative materials for student activities. Other teachers who were associated with the project for short periods were Lance Curlin of the Prince Georges County, Maryland, school system and Judith Tonkeray from Montgomery County, Maryland. Richard Hildenbrand assisted us greatly in organizing the teacher review of the mini-units and in assessing the results. We are also very grateful to Joanna Vogelsang for the artwork which enhances the mini-units.

Of course we are indebted to the other members of the project staff: John Fowler, project director, Carol Lee Bloom, executive secretary; Dianne Schroeder, secretary, and Brenda Gainor, typist. Rebecca Cawley and Kay Mervine produced the bibliographic listings. The materials would not have reached their present form without these friends.

SMS

January 1975

FOREWORD

The members of the Advisory Committee of the NSTA Energy-Environment Materials Project are united in their belief in the importance of this project. The complex energy-environment subject contains in it some of the most crucial issues of our time. It is a subject that deserves a place in school curricula. We hope and believe that these materials will be of great assistance to teachers and students who wish to bring these concepts and issues into their courses.

The Advisory Committee was assembled to gain the diverse perspectives of a variety of interests and points of view. We have read these materials, discussed them at several meetings and with individual staff members, and have made suggestions and comments. Many of these have been incorporated in the materials. With the diverse points of view represented, complete unanimity cannot be expected, but the Committee is satisfied that the materials represent a balanced presentation. Dr. John Fowler, his staff, and the National Science Teachers Association should be commended for this fine effort. The Division of Technology and Environmental Education of the U.S. Office of Education should be likewise commended for financial support of this project.

Finally, it should be noted that members of the Advisory Committee speak as individuals and not in an official capacity for the organizations with which they are associated.

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[1]Represented by Burrell Wood, October 29 and December 17

[2]Represented by Paul Loris, July 31

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Teacher Guide to Mini-unit Use

Each mini-unit is preceded by an *Abstract*, a brief descriptive paragraph and unit specifications designed, to enable the teacher to quickly determine its applicability to his/her class. Abstracts for mini-units are drawn together following this section.

The Abstract includes:

- *A descriptive paragraph* setting out the basic content and rationale of the mini-unit as well as its importance relative to energy-environment issues.
- *Recommended grade level:* a suggested range of applicability the writers and reviewers of this Guide thought would be most appropriate. However, student abilities and skills vary greatly and mini-units might be used or modified for higher or lower grade levels.
- *Time required:* an estimate of the number of 45-minute class periods needed to complete the mini-unit. Each lesson is generally allotted one period. They are, however, defined more as conceptual units than as time units. As lessons are presented in concentrated form, it might be necessary to expand discussion and allot a slightly greater time period.
- *Major teaching strategies:* different types of teaching methods employed in the mini-unit are generally listed under this heading. They may also be found in the Abstract's descriptive paragraph.
- *Advance preparation:* briefly sets out necessary preparations. A more complete listing is found under the *Materials List* at the end of each mini-unit.

  Note: All necessary tables or figures are provided in the lessons. These may be presented to students either by duplicating a copy for each student or by making a transparency and displaying it with an overhead projector.

Key Ideas and Objectives: Each mini-unit begins by setting out the *Key Ideas and Objectives* of the unit. These are followed by a list of three to five student objectives — the behaviors believed to indicate successful understanding of the major concepts and relationships presented. They are broadly phrased, but specific conditions and criteria are suggested in the *Evaluation Suggestions* that follow the lesson plans.

Teaching Suggestions is the series of lesson plans which constitute the core of a mini-unit. All are structured in the same way.

Each lesson, titled to indicate its general focus, begins with a statement of its purpose.

A series of numbered statements provides overall directions: steps to take to begin the lesson, general development of the lesson, suggested activities to end the lesson, and student assignments or preparations for the next lesson.

Each numbered direction includes a suggestive description of how the instruction might proceed and how students and teacher may interact. Inquiry questions are suggested and appropriate student responses are given.

Frequently, related activities are suggested at the end of a lesson as generalizing experiences for students.

Evaluation Suggestions follow the lesson plans. As the title implies, these are suggestive procedures and criteria keyed to evaluate how well each mini-unit's objectives have been met; they can be modified or supplemented.

Bibliography: A bibliography of text and non-text materials generally available for classroom use is included in each mini-unit. Some time should be allowed prior to presentation of a mini-unit to acquire those materials desired. Materials in this listing, however, are not required in order to present the mini-unit.

Additional resource materials and references are listed in the NSTA *Energy-Environment Materials Guide*.

A listing of references to further information for teachers on the content in the NSTA *Energy-Environment Source Book* follows the grouping of Abstracts.

Review: The mini-units were reviewed or tested by teachers outside the project in the following way: initial drafts were submitted to various groups of eight teachers around the country. (A list of these reviewers concludes this volume.) As a result of their comments as to clarity, appropriateness, development, compatibility, etc., on each Objective, Key Idea, Lesson, and Evaluation Suggestion, mini-units were revised and edited. The mini-units were also reviewed by members of the Project's Advisory Board, which consists of individuals from industry, environmental groups, utilities, Federal and state agencies, school systems, and professional associations. Their comments were also considered in the revisions. No classroom testing of the mini-units has been performed as yet.

MINI-UNIT

Abstracts

COLOR US ENERGY USERS

Primary packet: Activities include Pictorial Inventories, Picture Books, Energy Stamps, and Energy Games — *Bingo* and *Goin' Fishin'*.)

This packet of activities for students in grades K-3 is designed to increase their awareness of energy and environmental concepts. The activities focus on how people use energy in their daily lives, what energy does, how people obtain and use fossil fuels (oil, coal, gas) and electricity, and how people can conserve energy. Students use a variety of familiar skills in completing these activities; namely, discussion, word games, sequencing, critical thinking, and motor skills involved in coloring (or painting) and cutting-and-pasting.

Recommended level: K-3. A basic set of lessons is described for K-2. Additional lessons are suggested for students in grades 2 and 3.

Time required: One to two weeks, depending upon the ability-level of the students and whether the activities are used in total or in part. The lessons are presented in a concentrated form. The teacher may want to spread some lessons over more than one day, or over a morning period and an afternoon period, depending on the age, ability, and concentration level of his/her students.

Advance preparation: Duplicate the Pictorial Inventories, Energy Stamps, and the appropriate sections of Picture Book drawings. Certain activities are suggested for the entire class and others for small groups. See materials list for optional lesson materials and bibliography for student books.

KEEP IT COOL!

Thirty percent of the national use of electricity during the summer consists of air-conditioning for homes and apartments. Power system overloads with brownouts and blackouts during very hot weather are increasingly likely. The relationship between keeping things cool and insulation is investigated in activities in which students try to prevent the melting of ice cubes. The desirability of insulating homes to use less electricity is examined through student experiments and classroom discussion.

Recommended level: grades 3-6.

Time required: Three to four 45-minute periods. To allow time for ice cubes to melt, first and third lessons require a 5-15 minute period roughly two hours after the initial activity period of 30-40 minutes in which the ice cube melting game begins.

Major teaching strategies: Individual experiments and classroom discussion.

Advance preparation: Collect ice cubes and insulating materials (see materials list).

WHICH SOURCE OF ENERGY IS BEST FOR HEATING MY COMMUNITY?

A significant fraction (more than 60 percent) of our residential and commercial use of energy is devoted to the heating and cooling of homes and offices. This use of energy influences and is influenced by personal, local, and national policy decisions related to the wise or unwise use of our energy resources and our environment. In order to investigate the trade-offs that result from a particular energy-related decision, students are asked to pretend they are citizens of a model community and to choose the energy source they consider the best to heat and cool their homes and offices. Students research each source (fossil fuels, solar, geothermal, etc.) and compare in a mock community meeting their cost, availability, environmental effects, and other characteristics. Students are given opportunities to use their critical thinking skills in doing research and evaluating sources, and also to engage in group decision-making processes.

Recommended level: Social studies and general science classes grades 5-8.

Time required: Five to eight 45-minute class periods, depending on student research time allocated.

Major teaching strategies: Classroom discussion, individual and group research, simulation of community meeting, student charting, notetaking, and reporting.

Advance preparation:

- ☐ Collect cartoons, headlines, newspaper articles, brochures on energy-environment problems and on the seven sources of energy (coal, electricity, geothermal, natural gas, nuclear, oil, and solar) examined in this mini-unit, and prepare a bulletin board using these materials. (See bibliography for a list of available materials.)
- ☐ Duplicate enough copies of each of the seven Data Sheets on energy sources so each student in the corresponding research group has a copy.

ENERGY AND ITS NATURAL SOURCES

What is energy? How do we know we are using energy? What are the sources of energy naturally available to us? These questions are investigated in this mini-unit, which might serve as a first introduction to other discussions related to energy. Students develop criteria for identifying when energy is being used, and identify energy sources. The five primary sources of energy (solar, fossil fuel, nuclear, geothermal, and tidal) are investigated. Students increase their awareness of the origin of our energy dilemma by associating the most frequently used primary sources with their non-renewability.

Recommended level: Science and social studies classes, grades 6-8, depending on reading and vocabulary skills.

Time required: Four to five 45-minute periods.

Major teaching strategies: Classroom discussion, demonstrations, and critical reading.

Advance preparation: Duplicate reading material and assemble items on materials list.

NO GAS TODAY. TOMORROW?

The gasoline shortages in many regions of our country in 1973 indicated that our nation's supplies of petroleum products, such as gasoline and heating fuel oil, are falling behind demand. This situation is studied to introduce students to the concepts of shortages, supply, demand, and consumption. Classroom discussions and group activities are suggested to enhance skills of interpreting graphs while developing the following concepts. that the supplies of fossil fuels are finite, that their lifetimes can be estimated, and that some estimated lifetimes of the United States supplies of oil and natural gas are comparable to the students' expected lifetimes.

Recommended level: Social studies, science, and math classes, grades 6-9, depending on mathematical ability. Student familiarity with large numbers, such as billions, is assumed. Joint math-science or math-social studies classes may be appropriate, given the emphasis on developing pictograph interpretation skills.

Time required: About seven to eight 45-minute periods.

Major teaching strategies: Classroom discussion, graph interpretation.

Advance preparation: Make transparencies of several figures and duplicate copies of figures and task sheets for each student.

GOING PLACES

(Transportation Choices and Oil Supplies)

Our industrial and mobile society relies heavily on the use of oil — a nonrenewable resource. Transportation in various forms — private and public — is the major consumer of the available oil supply. Domestic oil production has not been sufficient to meet our nation's demand for oil; our need to import oil has been increasing each year. This demand has affected domestic prices of oil products, international relations between oil importing and exporting countries, and the intensiveness of searches for new domestic sources of oil. In this mini-unit students express their initial preference for a mode of personal transportation and for a type of car. They then examine the impact of their personal transportation choices on our nation's need for oil and oil products by exploring our domestic supply of oil, our major uses of oil, and our need to import oil. Students then have an opportunity to re-evaluate their choice of a form of personal transportation. Critical thinking skills in interpreting graphs and written materials, and math computation skills of finding percentages and multiplying and dividing 6 to 9-place numbers are utilized.

Recommended level: Social studies classes, grades 6-9.

Time required: Five to 10 45-minute class periods, depending on optional activities chosen.

Major teaching strategies: Classroom discussion, group research.

Advance preparation: Make copies of the transparencies which accompany the lessons (see materials list). Assemble current periodicals and references which address themselves to United States oil policy and decisions, both domestic and foreign (see bibliography for suggestions).

CALORIES FOR HEATING OUR HOMES

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 mini-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. This mini-unit can best be employed in the context of other studies of heat and energy.

Recommended level: General science, chemistry, and physics classes, grades 9-12.

Time required: Five 45-minute periods.

Teaching strategies: Classroom discussion, demonstrations and student experiments (if equipment supply permits).

Advance preparation: Assemble materials on materials list.

References to Related Source Book Chapters

In addition to the bibliographic material included at the end of each mini-unit and in the NSTA *Energy-Environment Materials Guide*, discussion related to the contents of each mini-unit also appears in the NSTA *Energy-Environment Source Book*. Chapters of the Source Book relating to each mini-unit are listed below

Mini-Unit	Volume I Chapters	Volume II Chapters	Appendices
COLOR US ENERGY USERS	2-4, 7	1, 2	–
KEEP IT COOL!	7	–	4
WHICH SOURCE OF ENERGY IS BEST FOR HEATING MY COMMUNITY?	4	1-3, 5, 7	5, 6
ENERGY AND ITS NATURAL SOURCE	–	1, 2, 7	–
NO GAS TODAY. TOMORROW?	1	1, 2, 4, 5	–
GOING PLACES	1, 7	3	–
CALORIES FOR HEATING OUR HOMES	–	1, 3	4

MINI-UNIT 1
Color Us Energy Users

Color Us Energy Users

Primary Packet

Activities include pictorial inventories, Energy Picture Books, Energy Stamps, and Energy Games — *Bingo* and *Goin' Fishin'*.

ABSTRACT

This packet of activities for students in grades K-3rd is designed to increase their awareness of energy and environmental concepts. The activities focus on how people use energy in their daily lives, what energy does, how people obtain and use fossil fuels (oil, coal, gas) and electricity, and how people can conserve energy. Students use a variety of familiar skills in completing these activities; namely, discussion, word games, sequencing, critical thinking, and motor skills involved in coloring (or painting) and cutting-and-pasting.

Recommended level: K-3. A basic set of lessons is described for K-2. Additional lessons are suggested for students in grades 2 and 3.

Time required: One to two weeks depending upon the ability level of the students and whether the activities are used in total or in part. The lessons are presented in a concentrated form. The teacher may want to spread some lessons over more than one day, or over a morning period and an afternoon period, depending on the age, ability and concentration level of his/her students.

Advance preparation: Duplicate the attached inventories, energy stamps and the appropriate sections of Picture Book drawings. Certain activities are suggested for the entire class and others for small groups. See materials list for optional lesson materials and bibliography for student books.

Key Ideas

1. Energy in various forms is used by us every day.
2. Energy can be seen as heat, light, or motion.
3. Energy can be conserved by developing energy-saving habits.
4.* Fossil fuels provide most of the energy we use today.
5.* Energy production and use affects our surroundings.

*Key ideas for additional lessons for students in grades 2 and 3.

Objectives

At the end of this mini-unit students will be able to:

1. *Name or draw* at least three ways they or other people use energy.
2. *Name or draw* one example of energy seen as heat, light, or motion.
3. *Name or draw* two or more ways they can use less energy.
4.* *Trace* one fossil fuel from its start in nature to its point of use.
5.* *Name or draw* two or more ways that the use of energy affects their surroundings.

*Objectives for additional lessons for students in grades 2 and 3.

Teaching Suggestions

Lessons 1-3 and 10 form the basic set of lessons suitable for students in grades K-3. Lessons 4-9 require beginning reading, and abstract reasoning capability.

Lesson 1 — Student Energy Inventory

Students are led to identify the ways they individually use energy—with the energy inventory sheet, "How Do You Use Energy?"

1. Introduce concept of energy by providing examples of activities that use energy.
   - ☐ Play *Simon Says* with class doing simple motions such as tapping foot, clapping hands, patting top of head, rubbing stomach, etc. After about three minutes, ask students to name some of the actions and record these or make stick drawings of these on the board. Examples of simple stick drawings for non-readers:

running | patting head | clapping hands | tapping foot

   Tell class that when they did these activities they were *using energy*.
   - ☐ Plug in several electric or battery-powered toys and ask students what makes them move. Plug in blinking Christmas lights and ask students what makes them light and blink. (Possible answers: energy, battery, wires, electricity, etc.)
   - ☐ Wind up several toys and watch them move or push a toy car or truck and ask what made them move. (Possible answers: we did, our muscles, our energy, I pushed it.)
   - ☐ Lead students to observe that people, electricity, etc. that make things *move*, use energy.
2. Have students identify the ways they use energy in their daily lives—with the energy inventory sheet, "How Do You Use Energy?"
   - ☐ Distribute to each student an inventory sheet. Introduce it with lead questions such as:

   "Let's look at the pictures on this page. What is happening in picture number one?" (Boy is pushing on light switch.) "Have you turned the light switch on or off at home? What happens when you do?" (Lights go on or off.) "When we turn on our lights, we are using energy. Let's put a check (√) in the box to show one way we use energy."

   "Let's look at the next picture. What is happening here?" (Girl is riding bicycle.) "How many of you have ridden a tricycle or a bicycle? When we use our muscles to do things, we are also using energy. So if you ride a bicycle or tricycle, put a check (√) in the box by this picture."

Energy Inventory Sheet

Lesson 2 — People Use Energy
(Energy Picture Book 1)

Students observe and identify other ways they and other people use energy at home, in school, on the street, for entertainment, and at work using *Energy Picture Book 1.*

1. Review previous lesson. Ask students to recall some of the ways *they* use energy. Allow students to refer to inventory sheets if necessary.

2. Have students identify how they and other people use energy.
   - ☐ Introduce and distribute *Energy Picture Book 1.* Allow students to skim through the pages. Then ask:
     "What do you think this book is about?" (List ideas.)
   - ☐ If students can read, have them read the title page, "Everywhere we look people are using energy." Briefly discuss the meaning of this.
   - ☐ Then carefully examine each set of pictures and identify the energy users. Students may circle, or place a check mark, or a red dot on each energy user. Also identify a few non-users of energy for contrast. Examples of non-energy users in the *At Home* series would be the picture on the wall, the shovel, the suitcases, etc. Mark as many of the pages as are appropriate for the age level, ability, and attention span of your group. Take sufficient time to examine the pages carefully and answer any questions. After completing one or two with the class, allow students to mark the next set(s) themselves.

3. Summarize lesson.
   Review and discuss the energy users in the sets completed. Have students name 3-5 energy users. Allow students to color their favorite parts or draw other pictures of how they and others use energy. Add this section to their folders.

Lesson 3 — Energy as Heat, Light, and Motion
(Energy Picture Book 2)

Students develop and explore the concept of energy by identifying its capacity to move, heat, and light things

Option 1. If students could not complete Picture Book 1, use this lesson to finish the activities.

Option 2: If students have completed Picture Book 1, proceed with the suggestions below for *Energy Picture Book 2*. (Note: Save last two pages of Picture Book 2 — pages 7 and 8 — for review in the next lesson.)

1. Review previous lesson. Have students state a few examples of how energy was used at home, in school, on the streets, etc.

2. Develop connection between heat, light, and motion with energy using Picture Book 2. Then ask students: "How do we know energy is being used?" (List ideas.)
   "Today let us look at some pictures which can help us find out about what energy can do."
   - ☐ Distribute copies of *Energy Picture Book 2*. Read and discuss title page. Have students identify three qualities of energy — heat, light, and motion — by examining the pictures and offering their own examples. Develop the meaning of the terms heat, light, and motion by discussing pictures.
   - ☐ Have the students orally or in writing compose a statement for each picture. Examples:
     Energy Moves Things — "The man's muscles are moving the chair." "The water is turning the water wheels."
     Energy Heats Things – "The sun's energy is heating and tanning the person." "The coal in the furnace is being burned and is heating the house."
     Energy Lights Things – "Electricity lights the TV sets." "Using a form of light, the x-ray machine can take pictures of the bones in our bodies."
     Students may want to copy these sentences onto the pictures or write them on a separate piece of paper and paste them below the pictures.

3. Summarize the lesson. (Energy use is connected with heat, light, and motion.)
   Have students orally or in writing complete this statement:
   "Energy can (heat), (light), or (move) things."
   Have students draw examples of energy moving things, energy heating things, and energy lighting things.
   Students may want to color their favorite pictures. Add this section to their folders.

Lesson 4 — Energy Sources *(Energy Picture Book 3: Natural Gas)*

Students are introduced to the sequencing format in Picture Books 3, 4, 5, and 6. They trace, with teacher guidance, one form of energy from its point of start in nature to point of use. Optional preparation — acquire a bicycle pump and either a bunsen burner or a handyman's propane torch and safety goggles.

1. Review previous lesson.
   - ☐ Begin lesson by reviewing with students the three ways they can observe energy in use.
   - ☐ Distribute pages 7 and 8 of *Energy Picture Book 2* and ask student to read directions, or read them to the students, and to complete the exercise. Correct and discuss the exercise.

2. Help students trace the story of one fossil fuel, natural gas, from its start in nature to points of use using Picture Book 3.

   Natural Gas Series

   Distribute copies of *Energy Picture Book 3* and allow students to skim the pages. Then guide the picture interpretation. (Some reading ability is assumed in the following discussion. Adapt questions to ability of students where necessary.) Use questions such as:

   a. Title Page
   Either read the title page or ask:
   "What does the title say? What does the *E* on our

symbol stand for? (Energy) (Students may want to name the energy symbol.) Does anyone know what natural gas is? (Colorless, odorless, air-like substance that can burn.) Do any of you have gas stoves or hot water heaters at home? Describe how they work."
(Optional — light a bunsen burner or a propane torch for students to observe gas burning. Use safety goggles.)

b. Page 1
"What is this a picture of? (Gas well.) How do we get gas from the ground?" (Briefly mention drilling a hole and using pipes to get gas from the ground.)

c. Page 2
"What does this title say? (Pumping station.) What is a pump?" (Refer to bicycle pump or demonstrate the use of one. A straw in a milkshake cup could also be used to give students the concept of a pump.) "We use pumps to move the gas along the pipeline."

d. Page 3
"If we have too much gas, we store it underground in tanks until we are ready to use it. How can gas get to your house or our school?" (Pipes.)

e. Page 4
"What is shown in this picture? (Gas meter.) What does it tell us?" (It tells how much gas we use.) If possible, observe the school's gas meter.

f. Page 5
"What is shown in each picture? Gas is used to help make such items as synthetic materials and plastics."
Discuss how the burning of gas provides heat for the clothes dryer and the furnace.

g. Page 6
"What does the title tell us?"
Discuss the forms of energy in terms of the heat, light, and motion which they directly or indirectly provide. For example: oil-heat, gasoline for cars, etc. Explain that they will learn more about these forms as they proceed through the unit.

3. End lesson by summarizing the process shown in the series.
Review process developed with students (i.e., gas well→ pumping station→ underground storage→ homes and businesses→ products and uses). Again, students may write sentence captions for each picture or develop these as a class and copy each under the appropriate picture. Students may color favorite parts and add these sections to their folders.

Lesson 5 — Energy Stamps

Students are presented with follow-up activity on sequencing the route of natural gas from its start in nature to point of use by using Energy Stamp Sheet 1. Sequencing concepts are generalized by using Energy Stamp Sheet 2 on the food chain. Students form groups to explore route of other fossil fuels from extraction to use in next lesson.
Materials needed: scissors and paste or glue.

1. Review route and sequence of natural gas series. Begin lesson by distributing Energy Stamp Sheet 1 for natural gas series. Have students cut out and paste the stamps in the correct spaces. Allow about 5 minutes to complete the activity, then discuss and correct the sequence.
2. Generalize sequencing concept by introducing food chain stamps. Ask students where people get their energy and see if they can trace it to the sun. Example: People→ meat and vegetables→ sunlight. Pass out Energy Stamp Sheet 2, Food Chain, and allow student to cut, paste, and complete this picture. Discuss and correct this sequence.
Allow students to color Energy Stamps and place these in folder.
3. End lesson by forming groups of students to study other forms of energy.
Write other sources of energy on the board.
Coal Oil Electricity
Allow students to choose the form they would like to investigate. Electricity series is best for more able students because it is an intermediate form of energy using a variety of basic fuels.

Lessons 6 and 7 — Other Energy Sources *(Energy Picture Books 4, 5, and 6: Oil, Coal, and Electricity)*

Students use sequencing skills to examine a series of pictures and trace other fossil fuels and electricity from point of extraction to point of use.

Note to the teacher: The next two to three lessons should be handled as directed reading lessons using the skills of sequencing and picture interpretation. A series of follow-up questions is suggested for each of the series. The teacher can meet with one group for instruction and allow the other groups to color, look for or draw pictures or any other related activity to their energy topic or other independent activities. The Energy Stamps should be used as a follow-up to the instruction.

1. Meet with one of the energy groups. Distribute the appropriate Picture Book to the students. Discuss with each group the particular book they are using. Sample discussion questions for each follow. While discussing a book with one group, have other groups perform independent activities. See schedule on following page for suggested sequence.

2. **Oil Series** *(Energy Picture Book 4)*

a. Title Page
"Describe oil." (Liquid, brownish-blue to clear in color, thick like cream.) Obtain sample of oil for students to touch and smell.

b. Page 1
"What is shown in this page? (Oil wells.) Is the land hilly or flat? (Flat.) Where is the oil that we

find? (Underground.) How is the oil removed?" (Pumped through pipes.) Remind students of examples of pumps discussed for natural gas book.

c. Page 2
"What is shown on this page? (Boat, ship, or tanker.) How is an oil tanker used?" (To carry oil from place to place.)

d. Page 3
"What has happened here? (Oil has spilled on the water.) Is this harmful? To whom? (People, marine plants, and animals.) Would it be difficult to clean water with oil on it?" Have students examine an oil spill by pouring some oil into a pan of water.

e. Page 4
"What is a refinery? (Place where crude oil is changed into different oil products, such as gasoline, heating oil, asphalt, etc.) Trace where crude oil comes in, tell what happens and show where it leaves."

f. Page 5
"How does the oil get from the refinery to the gas station? (Trucks.) Where might these trucks take the oil?" (Homes, businesses, gas stations, etc.)

g. Page 6
"Name some of the uses of oil shown on this page. Oil helps make asphalt roads, oil products make new materials for sporting goods and clothing, oil is changed into gasoline for cars, trucks, etc." (Make display of products made from petrochemicals.)

h. Page 7
"What happens when gasoline is burned? (Smoke comes out the car exhaust.) Is it good for people to breathe this? Why or why not?" (Harmful to lungs.)

☐ Review vocabulary. Have students place a check by the forms of energy they have studied so far.
☐ End lesson by allowing students to color favorite parts and add section to folder.
☐ Next day have students complete Oil Energy Stamp sequence.

3. **Coal Series** *(Energy Picture Book 5)*

a. Title Page
"What color is coal? (Black.) Does anyone know where we find it?" (Underground.) Obtain sample of coal for students to feel and examine.

b. Page 1
Describe what is shown in the picture — mountains, trees, sun, sky etc.
"This is a picture of a place where coal is found. We could say then that coal is found where? (In the mountains.) Can it also be found in other places?" (In the Midwest plains.)

c. Page 2
"What do we call a person who takes coal from the ground? (Miner.) Describe how a miner is dressed — hard hat with light, work clothes, heavy shoes, face mask, etc. Tell what he does — uses drills and other equipment to dig out the coal. Why does he wear a face mask?" (To prevent breathing coal dust.)

PROPOSED SCHEDULE FOR THREE GROUPS

	Coal Group	Oil Group	Electricity Group
Day 1	Introduce *Energy Picture Book 4: Coal.* Guide picture interpretation	Do independent activities	Locate pictures in magazine which are related to electric uses of energy, or draw such pictures
Day 1	Do Coal Stamps follow-up; add captions to pictures	Introduce *Energy Picture Book 4: Oil.* Guide picture interpretation	Do independent activities
Day 2	Do independent activities; color Coal Picture Book	Do Oil Stamps follow-up; add captions to pictures	Introduce *Energy Picture Book 6: Electricity.* Guide picture interpretation
Day 2	Do independent activities; color Coal Picture Book	Do independent activities; color Oil Picture Book	Do Electricity Stamp follow-up; add captions to pictures; color Electricity Picture Book

Independent activities may include, depending upon student's ability, reading assignments from books on bibliography.

d. Page 3
"Where does a miner work? (Coal mine.) How is the coal dug from the inside of the mine?" (A large mining machine with many teeth on a rotating wheel tears the coal from the mine walls.)

e. Page 4
"Some coal that is found near the surface of the earth is obtained by 'strip mining.' What kind of equipment is used to mine this coal? (Huge power shovels and bulldozers. Point out the size comparison between the man and the power shovel.) To reach the coal, the earth above it is dug away and piled high in rows. Would you like to see these piles in your community? What could be done to make the land look better?"

f. Page 5
"How is coal moved from place to place? (Truck and railroad car.) Why isn't it sent by airplane?" (Too heavy and bulky.)

g. Pages 6 and 7
"Where is most of the coal sent? (To power plants to produce electricity.) What happens at the power plant? (Coal is burned to produce heat and, the heat is used to make steam. The steam is then used to produce electricity.) What is coming out of the smokestacks of the power plant? (Smoke, gases, and heat.) Is it good for people to inhale smoke? Why not? (Harms the lungs.) What could be done to prevent the smoke from going into the air?" (Put screens or 'catchers' in the chimney.)

h. Page 8
"What are some of the uses made of coal? (Coal products help make paint, plastic for records and dishes, and coal is used to make heat to produce electricity.) Name three things in our room that were made partly from coal." (Make display of products made with the aid of coal.)

i. Page 9
Review vocabulary.
"Place a check by the forms of energy you have studied so far."

End this lesson by allowing students to color their favorite parts. Next day pass out Coal Energy Stamps and have students complete the picture. Again, students may add captions to pictures.

4. **Electricity Series** *(Energy Picture Book 6)*

a. Title Page
"What is electricity? (List ideas.) Is it found in the ground like coal and oil?" (No — it is made from fuels like coal and oil.)

b. Pages 1 and 2
"What is needed to create electricity? (Fuel.) What kinds of fuels are used?" (Geyser-steam, gas and oil, water power, coal.)

c. Page 3
"Where is electricity made?" (In a power plant.)

d. Pages 4 and 5
"Let's see how electricity is made." (Coal is burned in a furnace, heat creates steam in the boiler, the steam turns the turbine and causes it to spin, the generator changes this energy into electric energy, wires carry it to a transformer which sends it to power lines and into homes, etc.)

e. Pages 6 and 7
"How can an electric power plant affect your surroundings if we're not careful?" (Add heat to rivers, which affects plant and animal life; add particles and gases to air and cause air pollution if no devices are used to clean smoke.)

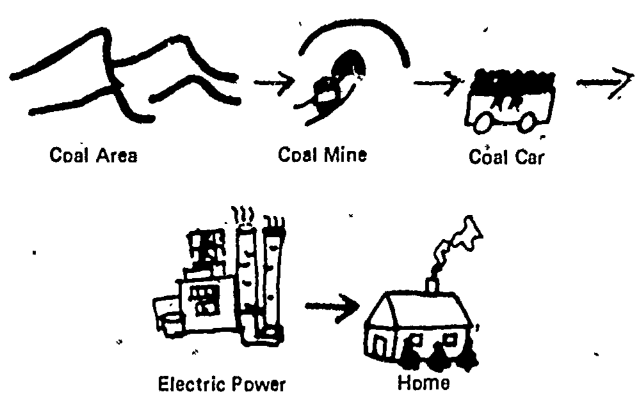
f. Page 8
"How do people use electricity?" (Neon signs to advertise, lamps, T.V., appliances, heating, etc.)

- ☐ Review vocabulary. Check the forms of energy studied.
- ☐ End lesson by having students color favorite parts and add section to folder.
- ☐ Have students complete Electricity Energy Stamps as a follow-up activity.

Lesson 8 — Sharing Energy Learnings

Student groups summarize the form of energy they studied and share their new learnings with the rest of the class.

- ☐ Ask the groups to meet and prepare a little story to explain the source of energy they studied and be prepared to present this to the rest of the class. They may show the pictures they colored and read their captions. They may also read and explain the energy stamps. Each person in the group should explain one part.
- ☐ Allow time for groups to plan and practice their brief presentations. Circulate and help groups or individuals as needed.
- ☐ If possible, have students present their stories at the end of this lesson. If needed, use another lesson for their presentations. Allow time for students to finish coloring any section they wish.
- ☐ The audience for each presentation may do a brief summary of the material by drawing a simple sequence of events. For example:



- ☐ Name two or more ways that fossil fuels affect your surroundings. Draw a picture of one or more.
- ☐ Invite parents who have jobs related to these topics to come to class and discuss their work. Other parents might also be invited to discuss how they use energy.

Lesson 9 — Reviewing Energy Terms *(Goin' Fishin')*

In order to review energy terms and concepts used in this mini-unit, see energy game entitled *Goin' Fishin'*, which is enclosed, and play game as directed.

Goin' Fishin'

Students will play a classroom game, *Goin' Fishin'*, to review some of the by-products and uses of coal, oil, natural gas, and electricity.

Advance preparation:

Cut out sample drawings (attached) or have students collect magazine pictures of similar items and attach each picture to a separate 3" by 5" index card. (Cards may be in shape of fish.) Place a paper clip on each card. Also bring in a cardboard box for the cards.

Make a "fishing pole" by affixing a string to a yardstick or pole and attaching a magnet to the string.

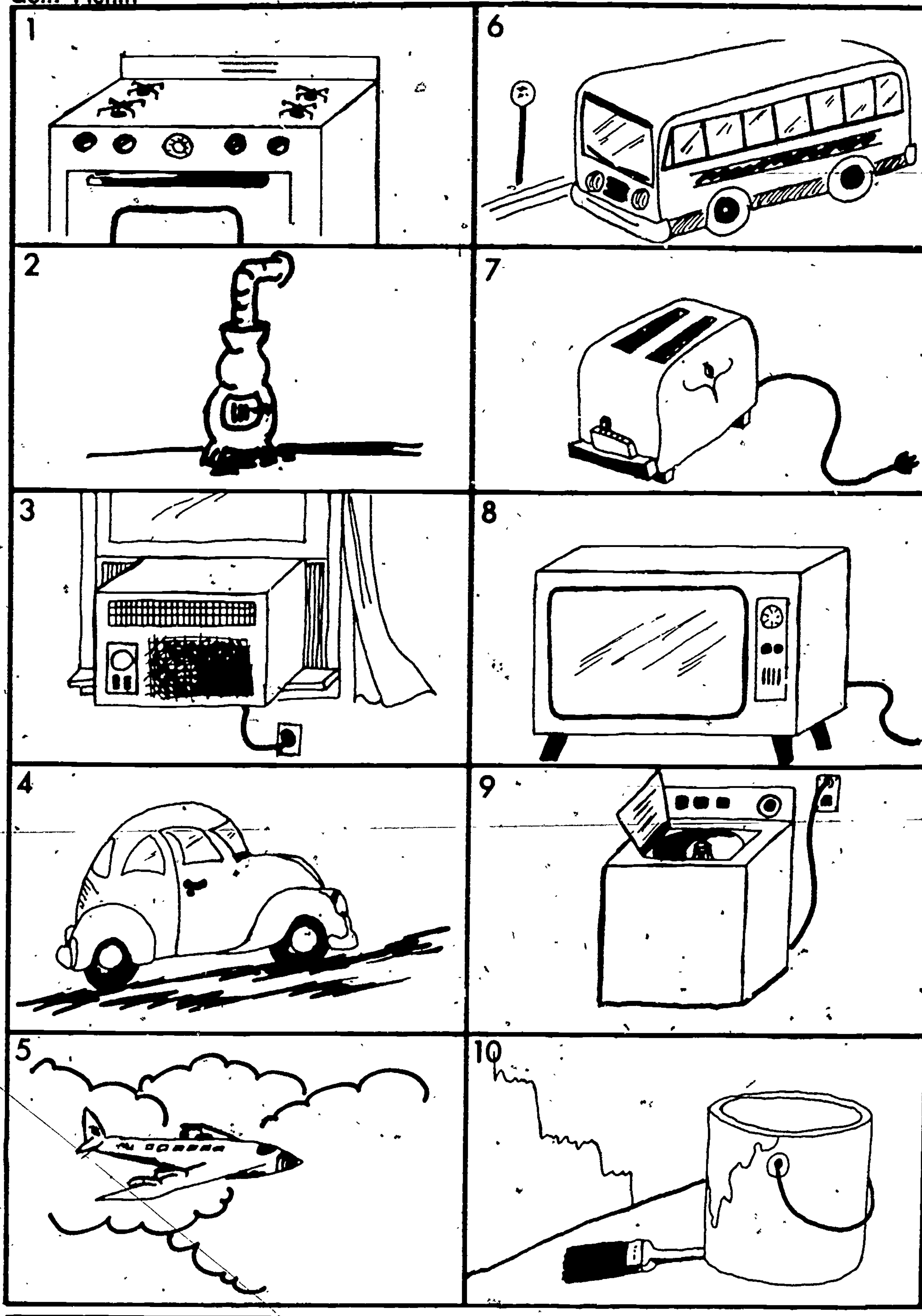
Directions:

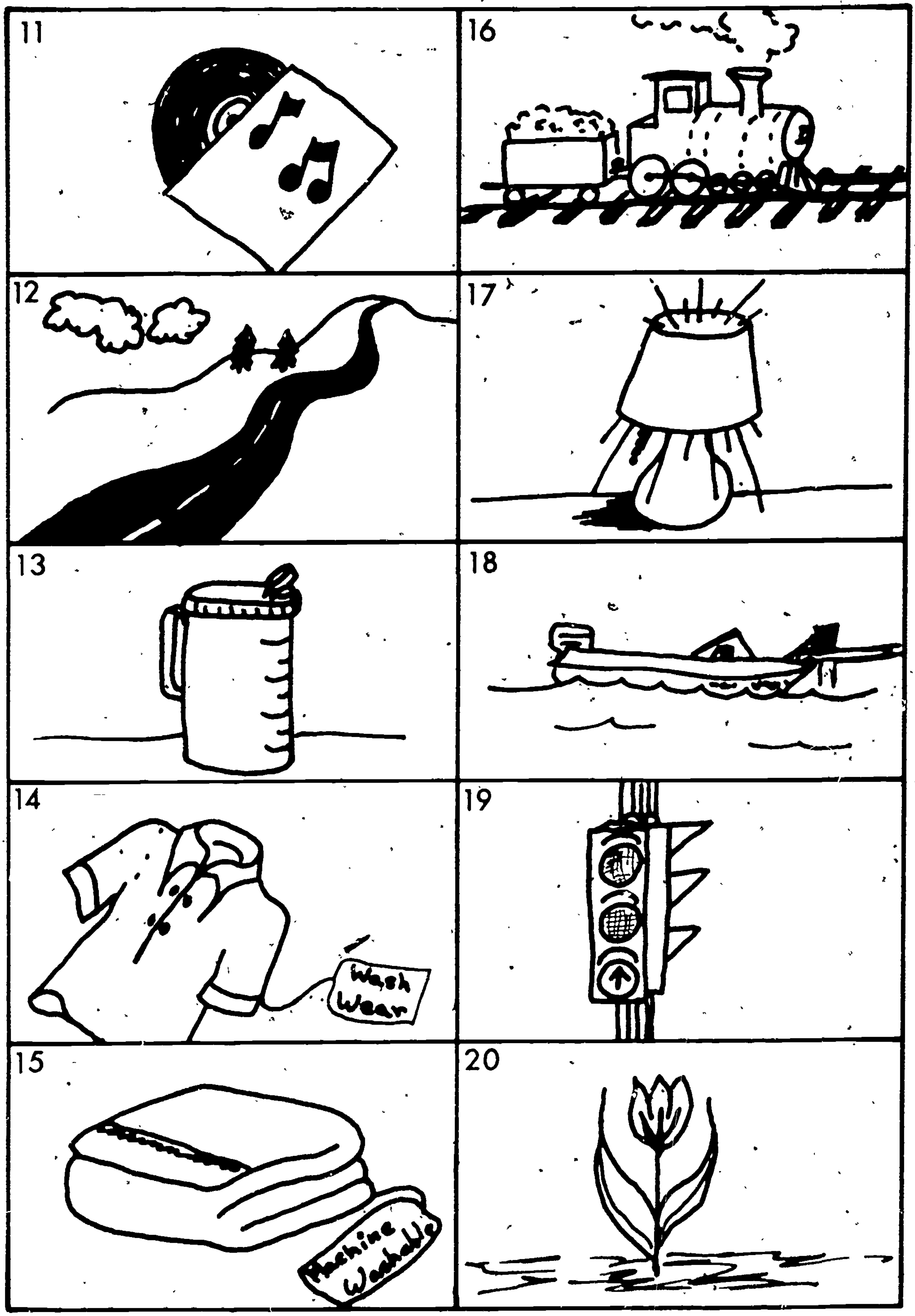
Divide class into two teams. Each student "goes fishing" by lowering magnet into the box filled with picture cards. When he "catches" a card, he looks at the picture and tells which source of energy powers the object or is used to make the object. If student answers correctly, his/her team gets a point. The team with the most points wins.

Suggestions for energy card pictures:

1. Gas Stove (gas)
2. Potbellied Stove (coal)
3. Air-conditioner (electric)
4. Car (oil)
5. Airplane (oil)
6. Bus (oil)
7. Toaster (electric)
8. TV (electric)
9. Washing Machine (electric)
10. Paint (coal)
11. Record (coal)
12. Asphalt Road (oil)
13. Plastic Container (gas-oil)
14. Shirt (gas-oil)
15. Blanket (gas-oil)
16. Train (oil)
17. Lamp (electric)
18. Boat (oil)
19. Traffic Light (electric)
20. Flower (sun)
21. Umbrella (gas-oil)
22. Pear (sun)
23. Hamburger (sun)
24. Person (sun)
25. Refrigerator (electric)
26. Vacuum Cleaner (electric)
27. Neon Sign (electric)
28. Plastic Toy (gas-oil)
29. Cat (sun)
30. Newspaper (sun)

Goin' Fishin'

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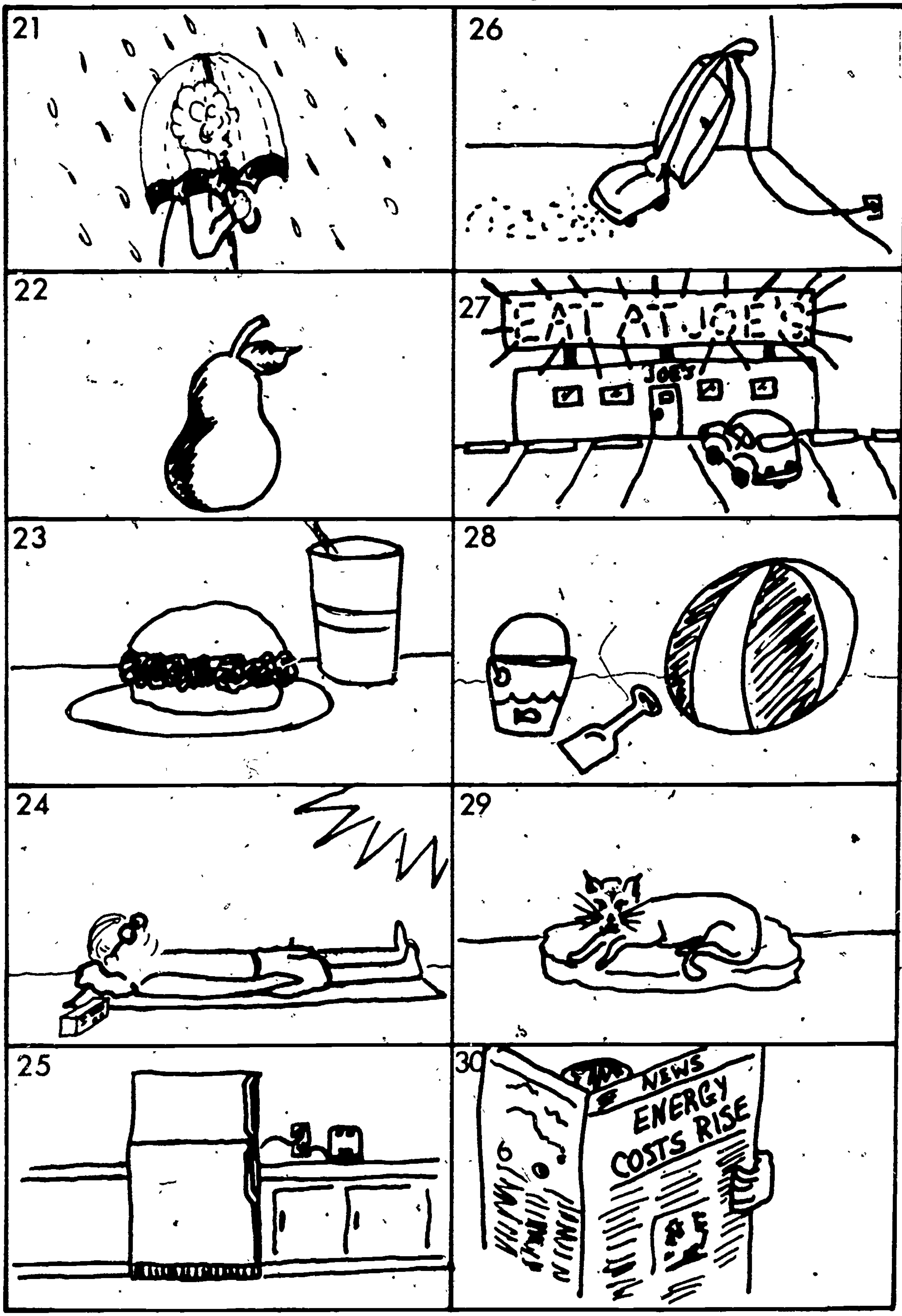
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JOE'S
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NEWS
ENERGY COSTS RISE

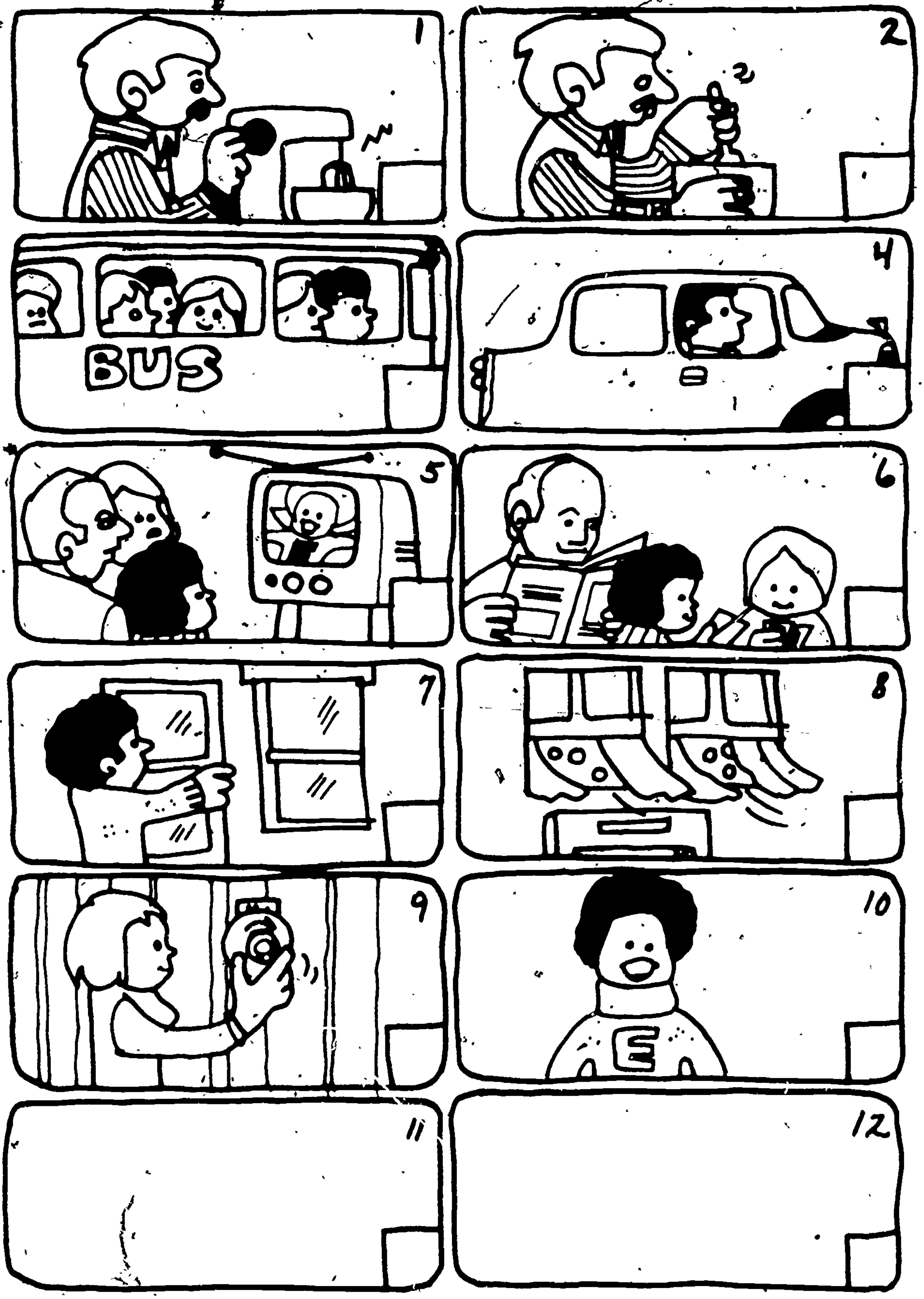
Lesson 10 — Energy Conservation *(Energy Picture Book 7)*

Students' awareness of ways people can conserve energy is developed by using Picture Book 7 and Conservation Checklist.

1. Develop the meaning of *conserve*.
   "What would happen if we used all our coal, oil, and gas? (Must find other forms or we'll be cold and hungry.) If we use less money now by not wasting it, will we have some money to spend later? If we use less coal, oil, and gas now by not wasting them, will we have some later to use? When we save energy by using less coal, oil and natural gas, we say that we *conserve* it."
   - ☐ Have group pronounce *conserve*.
   - ☐ Ask several students to use it in a sentence.
2. Demonstrate examples of energy conservation using Picture Book 7.
   Distribute copies of *Energy Picture Book 7* to the entire class and guide picture interpretation by asking:
   a. Title Page
   "What does our title page say? What does it mean?" (Energy can be saved.)
   b. Page 1
   "What is shown in this picture? Where might these people be going? How else could the people get where they are going? Do people save energy by using bicycles rather than cars? What form of energy do you use when you ride a bicycle? A car? Which would you choose?"
   c. Page 2
   "Describe what is happening in this picture. When do we need the lights on? When should we turn them off? What else is light used for besides helping us to see?"
   d. Page 3
   "What is happening in this picture? How warm should we keep our home and school? What can you do to keep warm without increasing the heat?"
   e. Page 4
   "What is happening in this picture? How are storm windows useful? Are there any other things around a house that we can do to keep our homes warm in winter and cool in summer?"
   f. Page 5
   "How are these people saving energy? How else might they get where they are going? How are the children in sweaters saving energy? Do you know any other ways to save energy?"
3. Evaluate student knowledge of energy conservation methods. Pass out Conservation Checklist. Explain that there are two pictures in a set — one showing a way to save energy and one showing a way to use more energy. Have students check the pictures which show how you can *conserve* energy. Allow time for students to complete this activity. Then correct and briefly discuss it.
4. Students may color favorite pictures and add these to energy folder. They may want to share these folders with their families or with other classes.

Optional: Class may go on a field trip to a mine, power plant, oil field, or any other place related to their study of energy.

Conservation Checklist



Evaluation Suggestions

Evaluation of student objectives has been built into the lessons as follows:

Objective 1 — Name or draw at least three ways people use energy.

Lesson 2 — Students are asked to name 3-5 energy users or draw pictures of how they and others use energy.

Objective 2 — Name or draw one example of energy seen as heat, light, or motion.

Lesson 3 — Students are asked to complete the sentence "Energy can ___, ___, or ___things" and draw examples of energy moving things, energy heating things, and energy lighting things.

Objective 3 — Name or draw two or more ways they can use less energy.

Lesson 10 — Conservation Checklist can be used to evaluate students' understanding of ways to save energy. In addition they can be asked to draw ways they can use less energy.

Objective 4 — Trace one fossil fuel from its start in nature to point of use.

Energy Stamps may be used to determine if students can complete the sequence involved in tracing a fossil fuel from its start in nature to point of use.

Objective 5 — Name or draw two or more ways the use of energy affects your surroundings.

Lesson 8 — Students name and draw pictures of several ways fossil fuels and electricity affect our environment.

In addition, general concepts involved in this mini-unit can be further evaluated and reinforced by playing the game Energy Bingo. (See attached game and play as directed.)

BINGO!!

AN ENERGETIC GAME!

ABSTRACT

Examples of an energy-environment BINGO game are illustrated as an appealing method to reinforce or evaluate cognitive knowledge of energy concepts or vocabulary at the culmination of a previous energy-environment mini-unit or activity.

Recommended level: Grades 2-6. Two versions are included; one for non-readers and one for readers.

Time required: One hour.

Major teaching strategy: Classroom game.

Advance preparation: Duplicate copies of items for BINGO scorecard for each student.

Key Ideas

Key ideas are dependent on choice of clues and answers for scoreboard items, and should have been developed in some previous mini-unit or activity.

Objectives

At the completion of this activity the student should be able to:

1. *Define* energy-related terms presented in some previous lesson and included as clues and answers in the BINGO game.
2. *Answer* simple questions related to cognitive information presented in some previous lesson and included as clues and answers in the BINGO game.

Teaching Suggestions

The games included here are examples of the format that might be employed at the culmination of any unit on energy. You can construct your own game by substituting clues and corresponding answers that are suitable to the content and level of difficulty you have covered.

Distribute a mimeographed copy of the 16-square card to each student. Ask the student to cut out the squares and *rearrange them in any order he/she wishes*. This is essential if students are not all to attain "BINGO" at the same time. The squares should then be glued onto another sheet of paper.

Either a student or the teacher can be the "caller" and read the energy-related clue to the other students. Do *not* read the numbers of the clue. The clues may also be cut out and chosen randomly from a box by an assistant.

As the clue is read, the players will mark the answer on their card with an *X*. The first player to get four boxes in a row is the winner and should call out "BINGO." The teacher should very quickly check his answers to be sure they are marked correctly. If the student was not correct then he is eliminated and the game continues.

As a follow-up activity, divide the class into small groups. Each group of students should prepare another set of 16 clues and answers that can be duplicated for the remainder of the class. The group who composed the clues and answers would administer the game.

Example for Primary Grades

BINGO CLUES

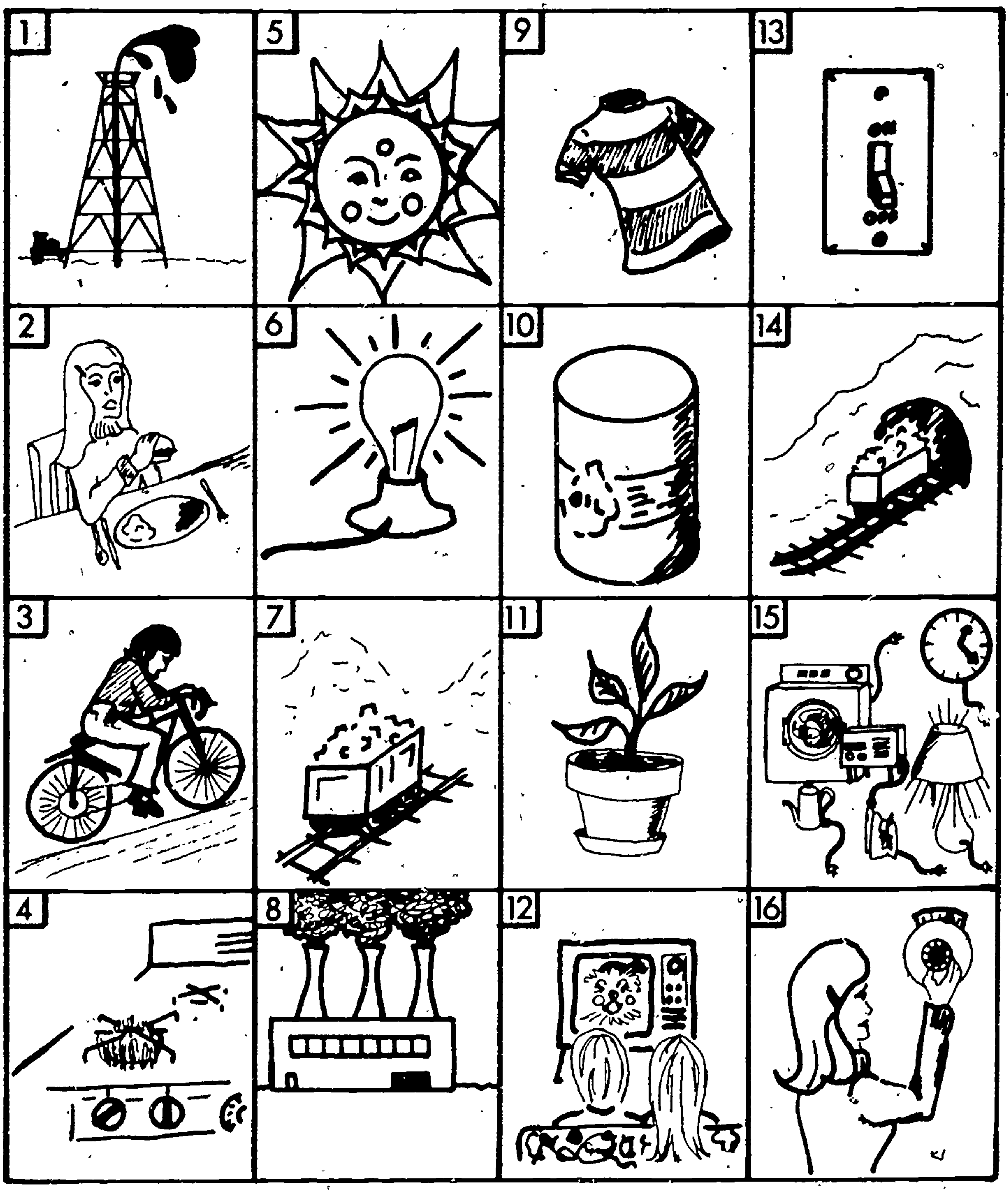
1.	This is how we get oil out of the ground.	9.	Oil and gas help to make this product.
2.	When we do this we are making more energy for our body.	10.	This is the liquid fuel that heats some of our homes, helps make our cars run, and does many jobs in our homes.
3.	We use muscle energy when we do this.	11.	These need energy from the sun in order to grow.
4.	This gives us heat energy.	12.	When we watch this for too long, we use a lot of electric energy.
5.	Our greatest source of energy in nature.	13.	This turns the electric power on and off in our house.
6.	This gives us light energy.	14.	A place where coal is mined.
7.	This fuel can be mined and used to produce electricity to light our homes.	15.	Too many of these in our home use a great deal of electric energy.
8.	Factories that use a lot of fuel and energy sometimes create this problem.	16.	This is one way to save heat energy.

Example for Intermediate Level

BINGO ENERGY CLUES

(Do not mention number!)

1.	The major source of energy found in nature.	9.	The name of the energy that results from splitting an atom.
2.	The three fossil fuels are oil, ________, and ________.	10.	The fuel that is used to produce nuclear energy.
3.	Most of the appliances in our homes are powered by ________.	11.	Natural gas and oil are obtained from the ground with ________.
4.	A fossil fuel that is in liquid form.	12.	Electricity is transmitted to our homes through ________
5.	An energy source that is obtained from deep or surface mines.	13.	The process of removing coal from the surface of the earth is called ________.
6.	Energy source in the form of steam.	14.	Most food items are obtained from, or can be traced back to ________.
7.	The fossil fuel that has the shortest predicted life span is ________.	15.	One of the products of an oil refinery is ________.
8.	Black lung disease was obtained by working in ________.	16.	Humans obtain their energy from ________.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BINGO Scoreboard

(Duplicate a copy for each student, cut into squares and glue in differing order on another sheet of paper.)

1 SUN	5 COAL	9 NUCLEAR	13 STRIP MINING
2 COAL, NATURAL GAS	6 GEOTHERMAL	10 URANIUM	14 GREEN PLANTS
3 ELECTRICITY	7 NATURAL GAS	11 WELLS	15 GASOLINE
4 OIL	8 MINES	12 WIRES	16 FOOD

Bibliography

Books:

First Book of Energy. G.R. Harrison (New York: Watts) 1965.

Living Science: Energy. Jordon Moore (New York: Grosset & Dunlap) 1967.

Things Are Made to Move. Illa Podendort (Chicago: Childrens) 1970.

Let's Find Out What Electricity Does. Madeline Carlisle (New York: Reilly & Lee) 1973.

Electricity: A Book to Begin On. Leslie Waller (New York: Holt, Rinehart & Winston) 1961.

Films:

Energy: A First Film, 8 minutes, sound, color. B.F.A. Educational Media, 2211 Michigan Avenue, Santa Monica, California 90404.

Free Materials:

American Gas Association, Educational Service, 1515 Wilson Boulevard, Arlington, Virginia 22209, Booklet N00170 "Natural Gas Serves Our Community," 28 bulletin board pictures and descriptive booklet written for 2-3 grade level (free from local gas company in most cases).

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

Materials List

☐ Required materials

For grades K-3, duplicate for each student the following:

a. Energy Use and Conservation Checklists
b. Picture Books 1, 2, and 7

If Lessons 4-9 are used for grades 2 and 3, additionally duplicate:

1. for each student
   a. Picture Book 3
   b. Energy Stamps
   c. Bingo Game Cards
2. for students in one of three small groups
   a. Picture Book 4
   b. Picture Book 5
   c. Picture Book 6
3. for entire class one or two sets of "Goin' Fishin'" cards

☐ Optional materials

Lesson 1 — Collect several wind-up, battery operated or electrically powered toys.

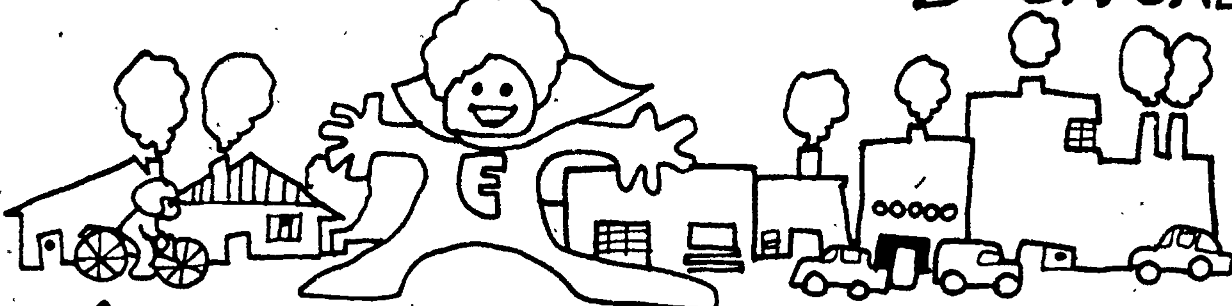
Lesson 4 — Acquire a bicycle pump, a bunsen burner or a handyman's propane torch and safety goggles, a straw and milkshake cup with lid, several items made of synthetic materials and plastics.

Lesson 5 — Scissors and paste or glue for each member of the class.

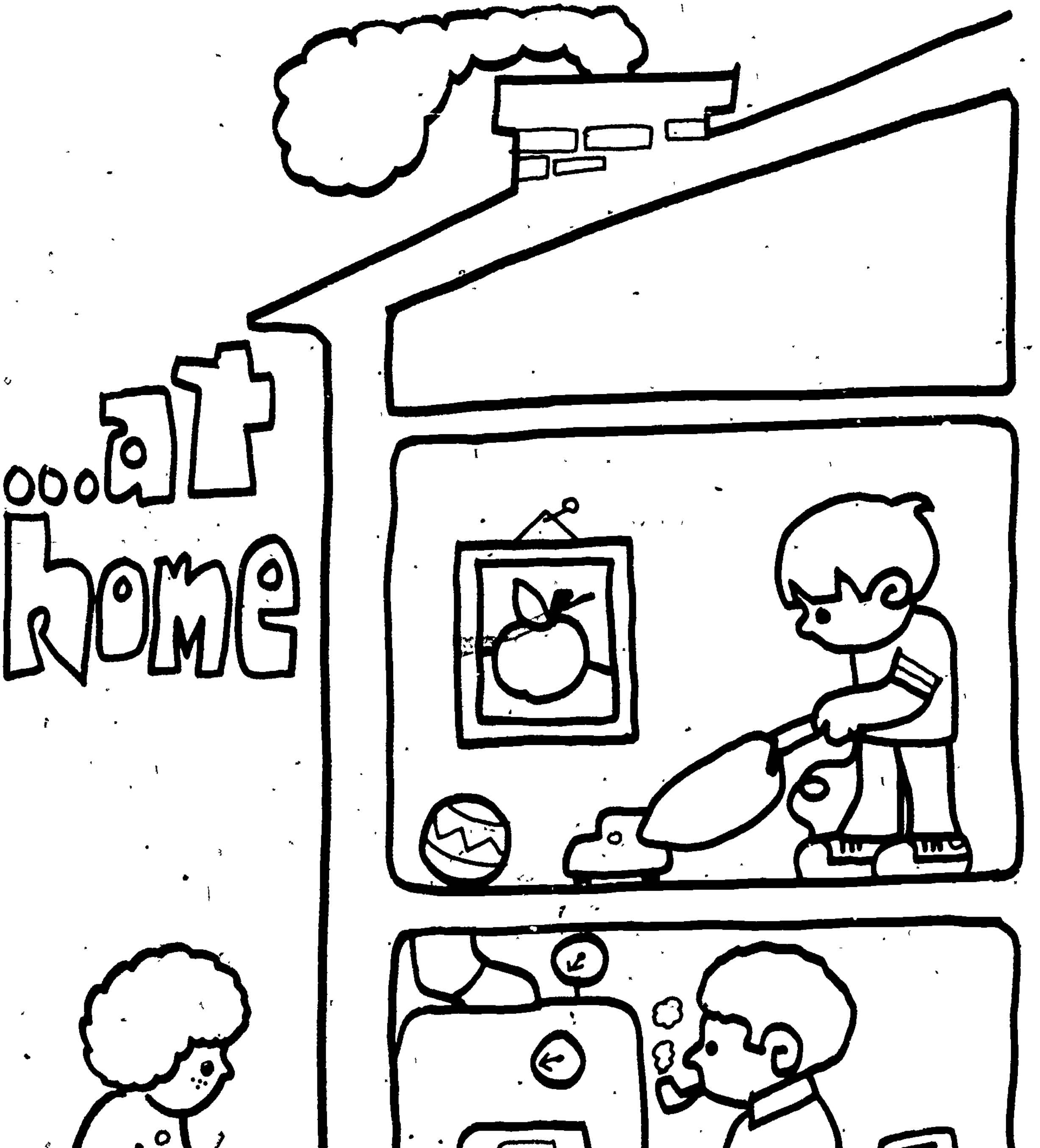
Lessons 6 and 7 — Samples of coal and oil, pan of water, petrochemical products.

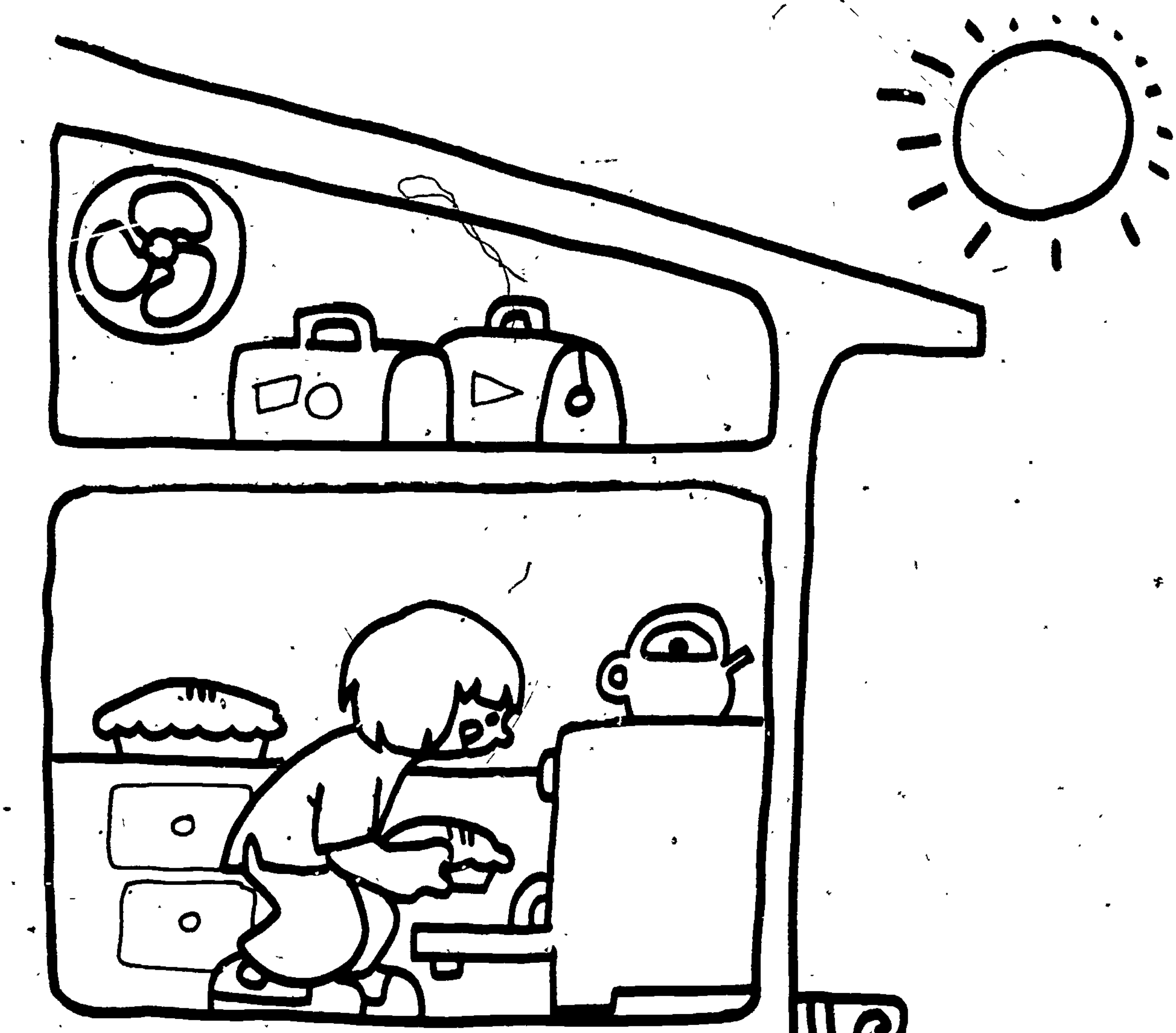
ENERGY PICTURE BOOKS

BOOK ONE

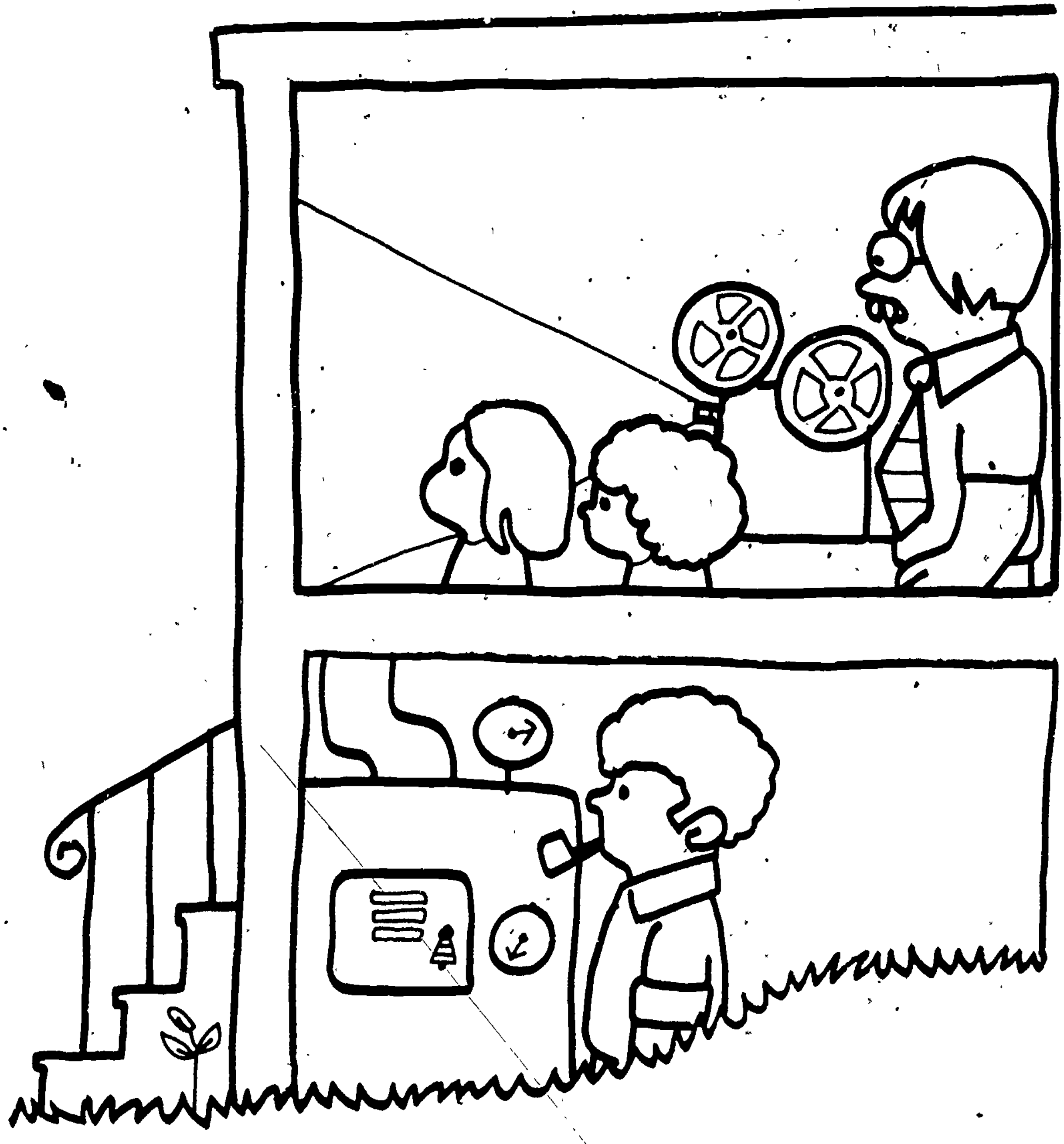


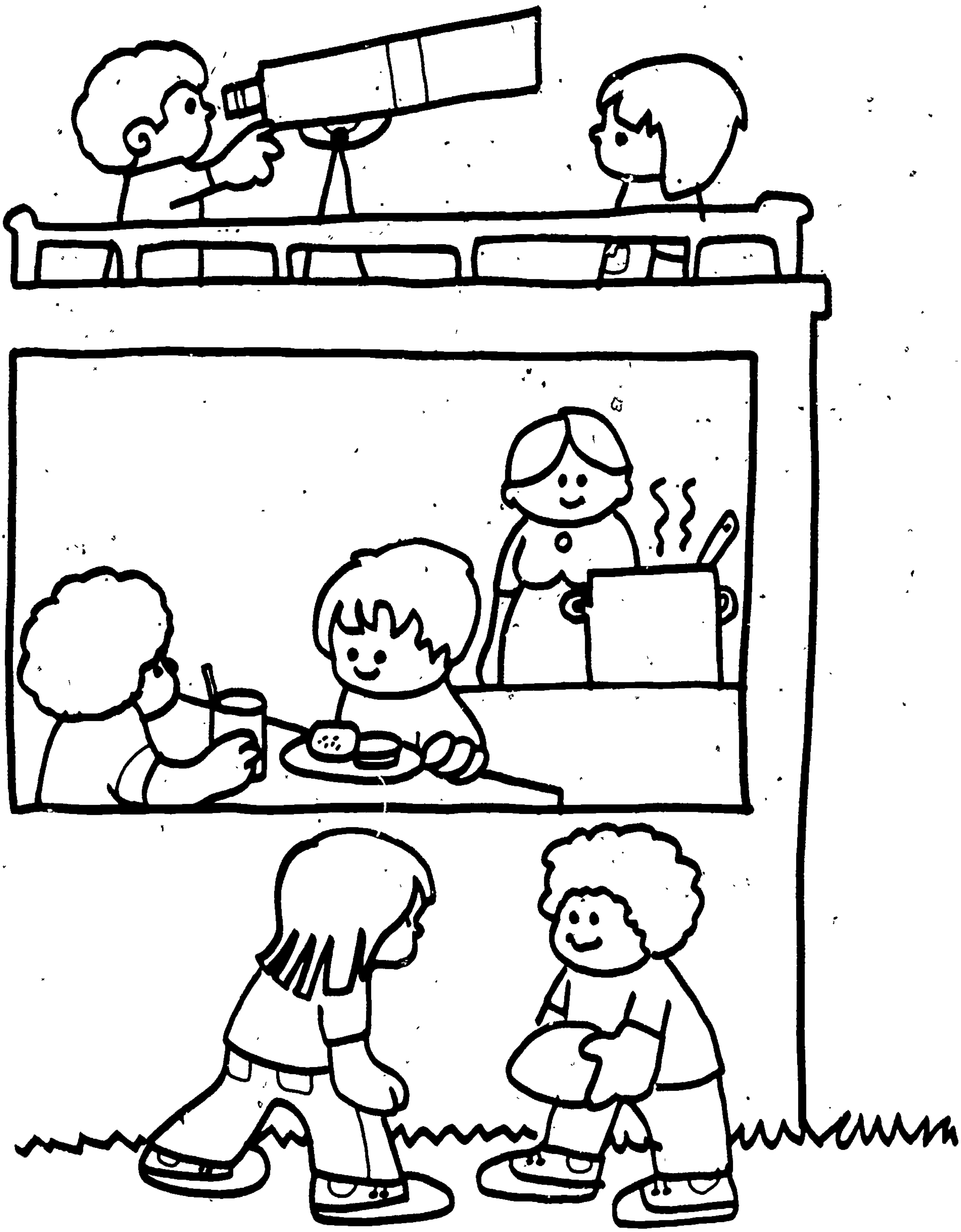
EVERYWHERE WE LOOK... PEOPLE ARE USING ENERGY!


...at home



....at school





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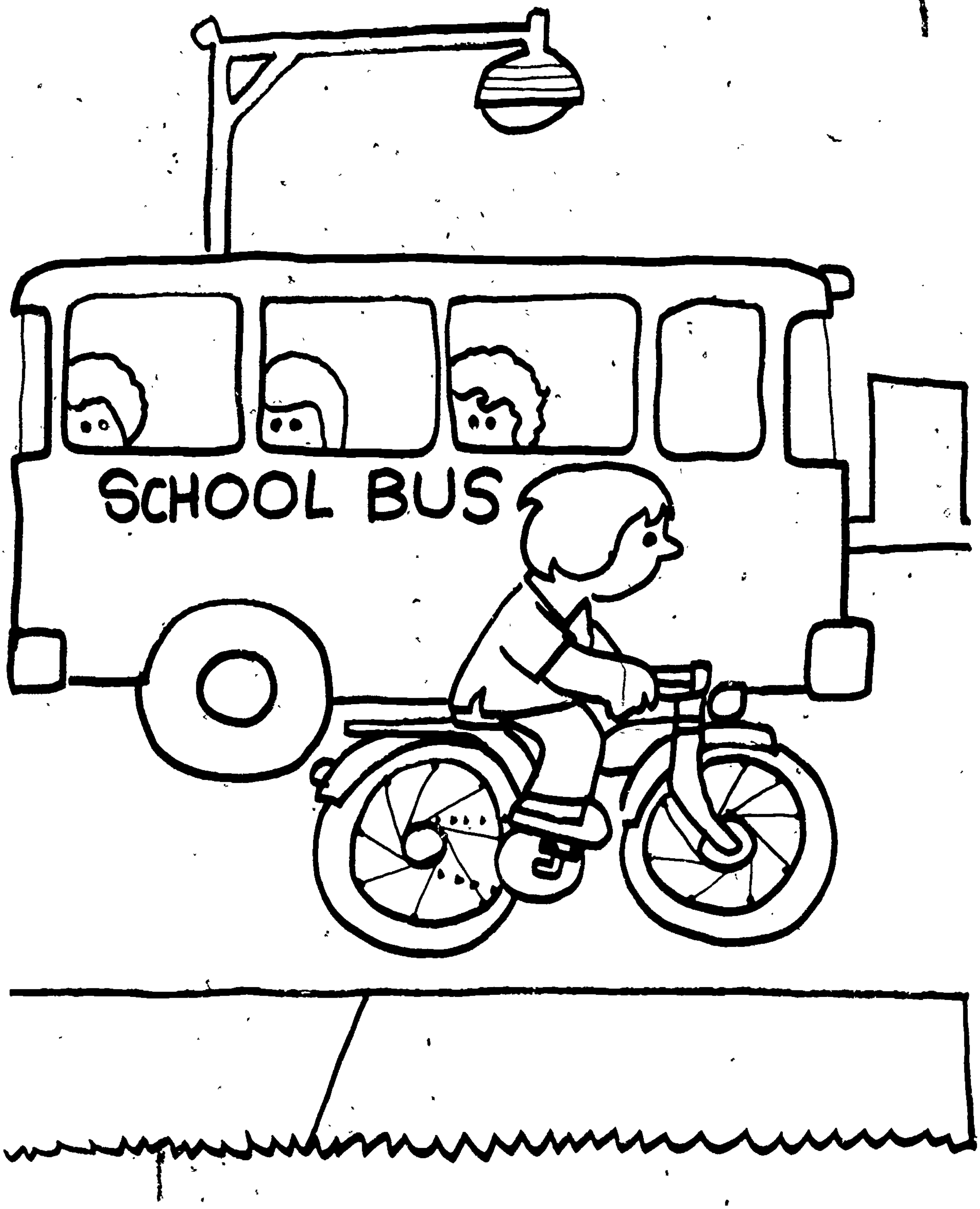

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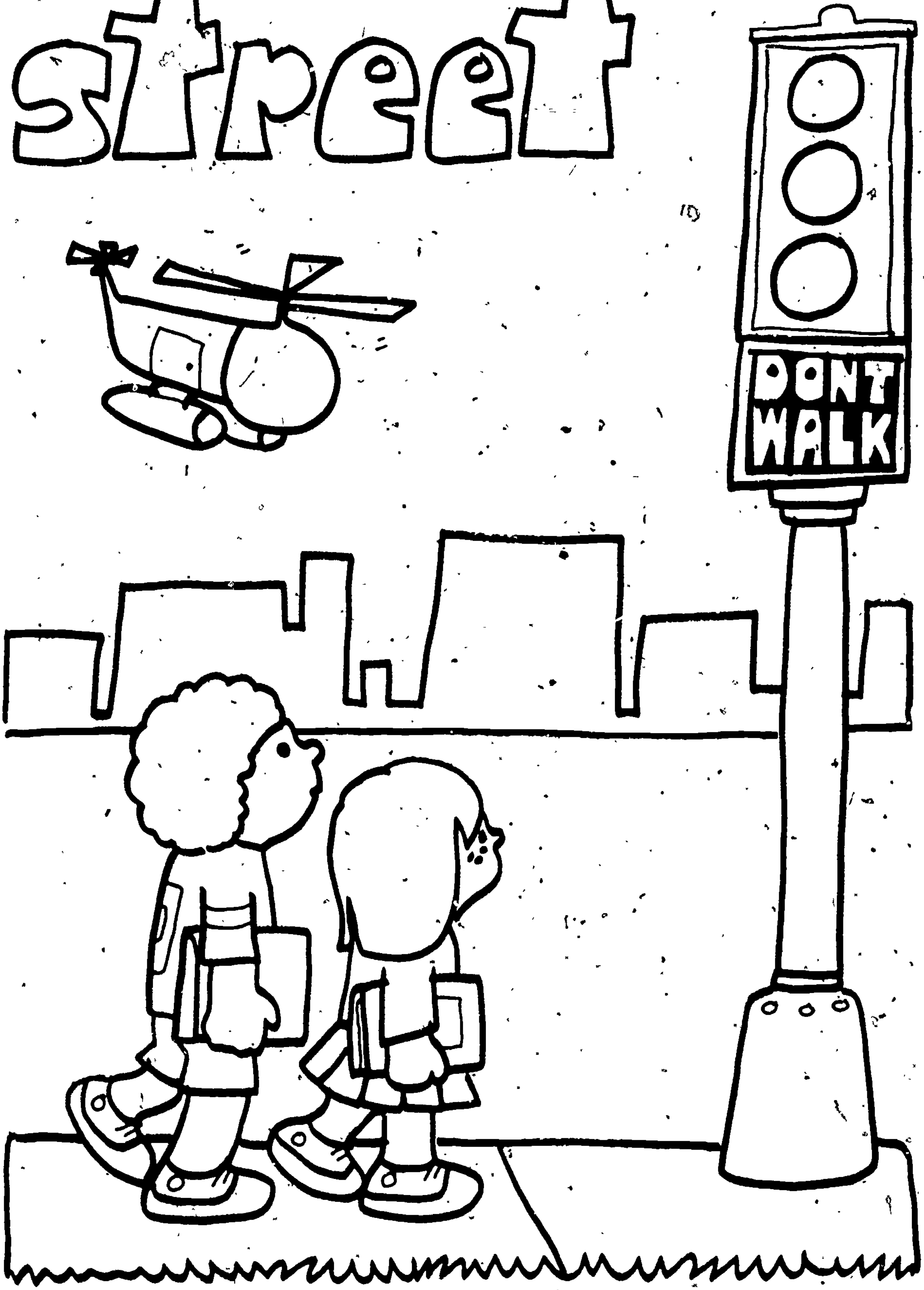

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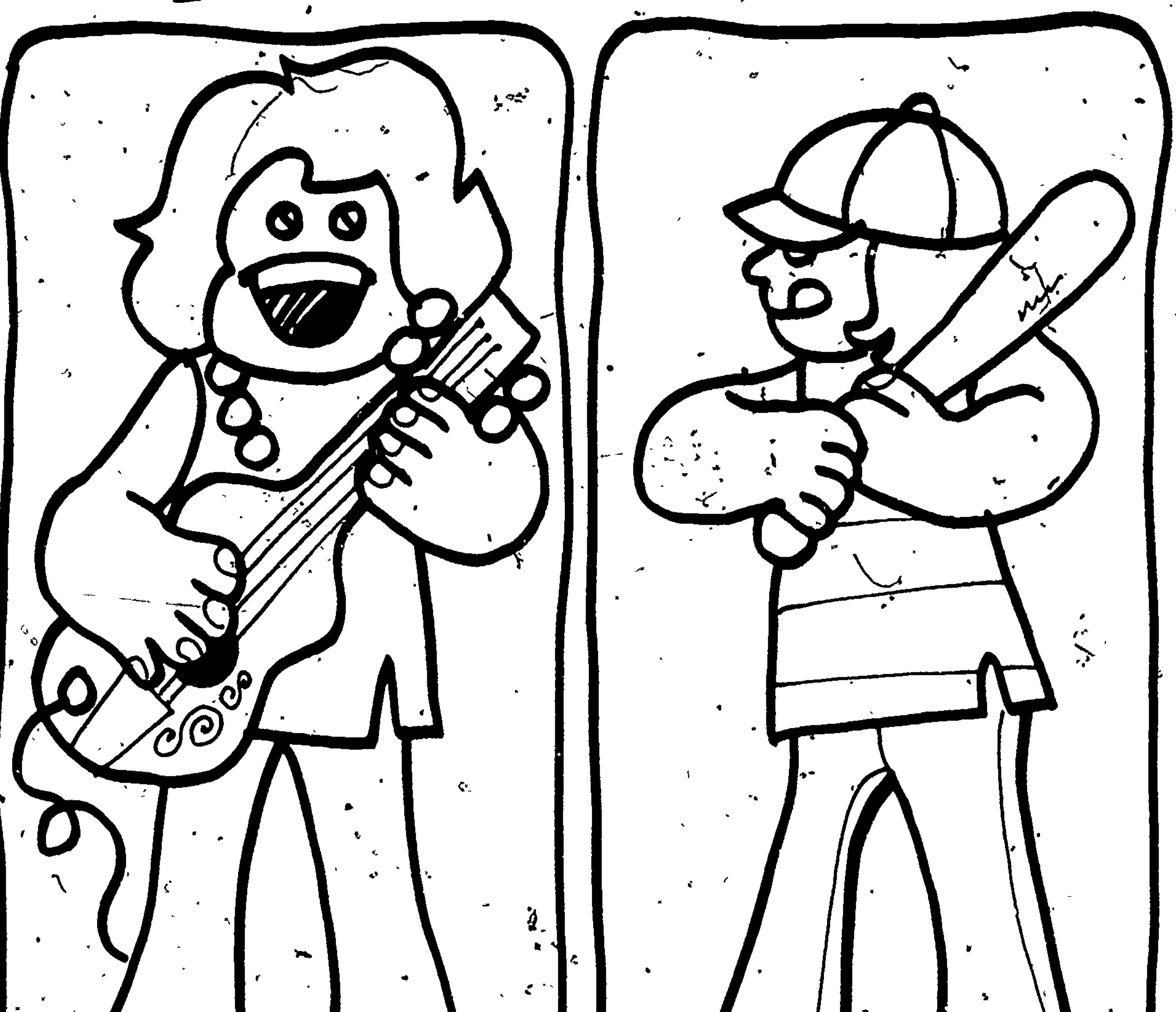

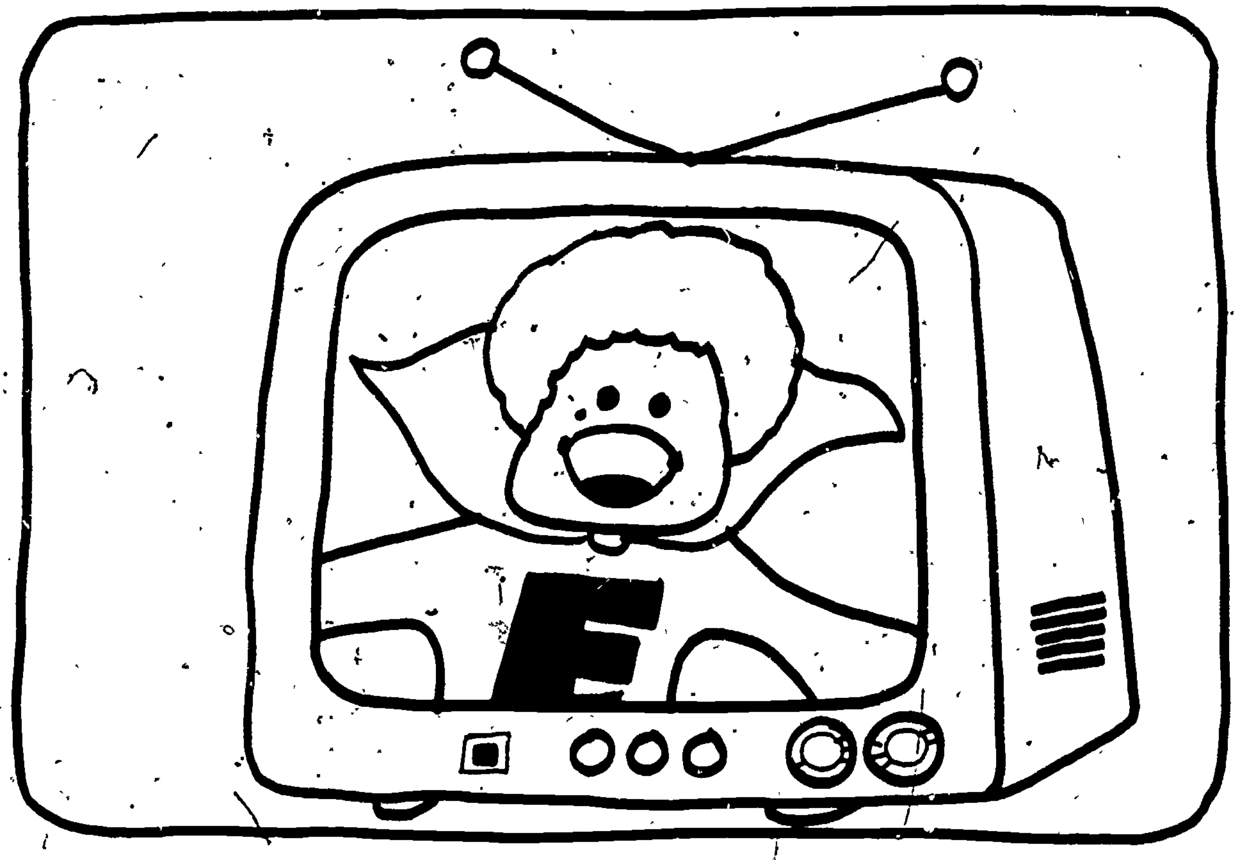
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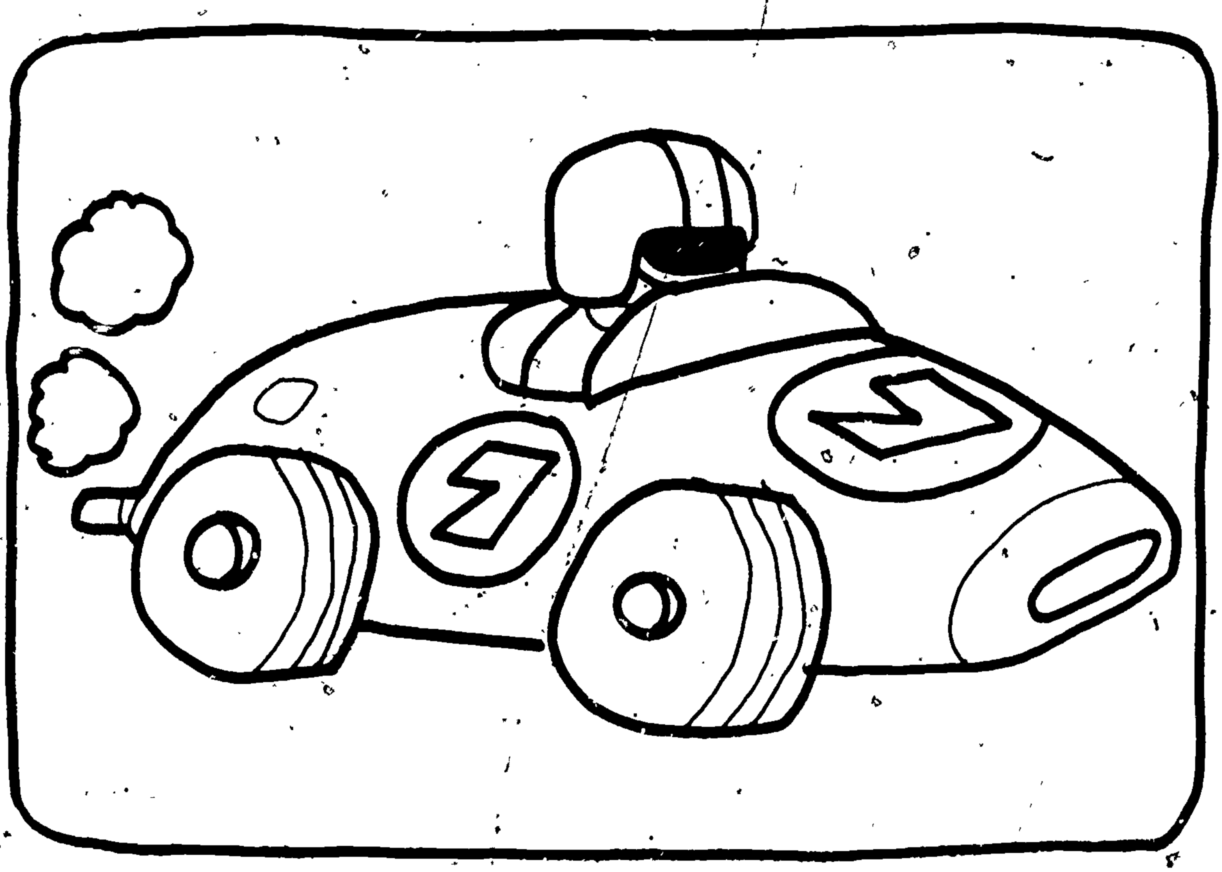

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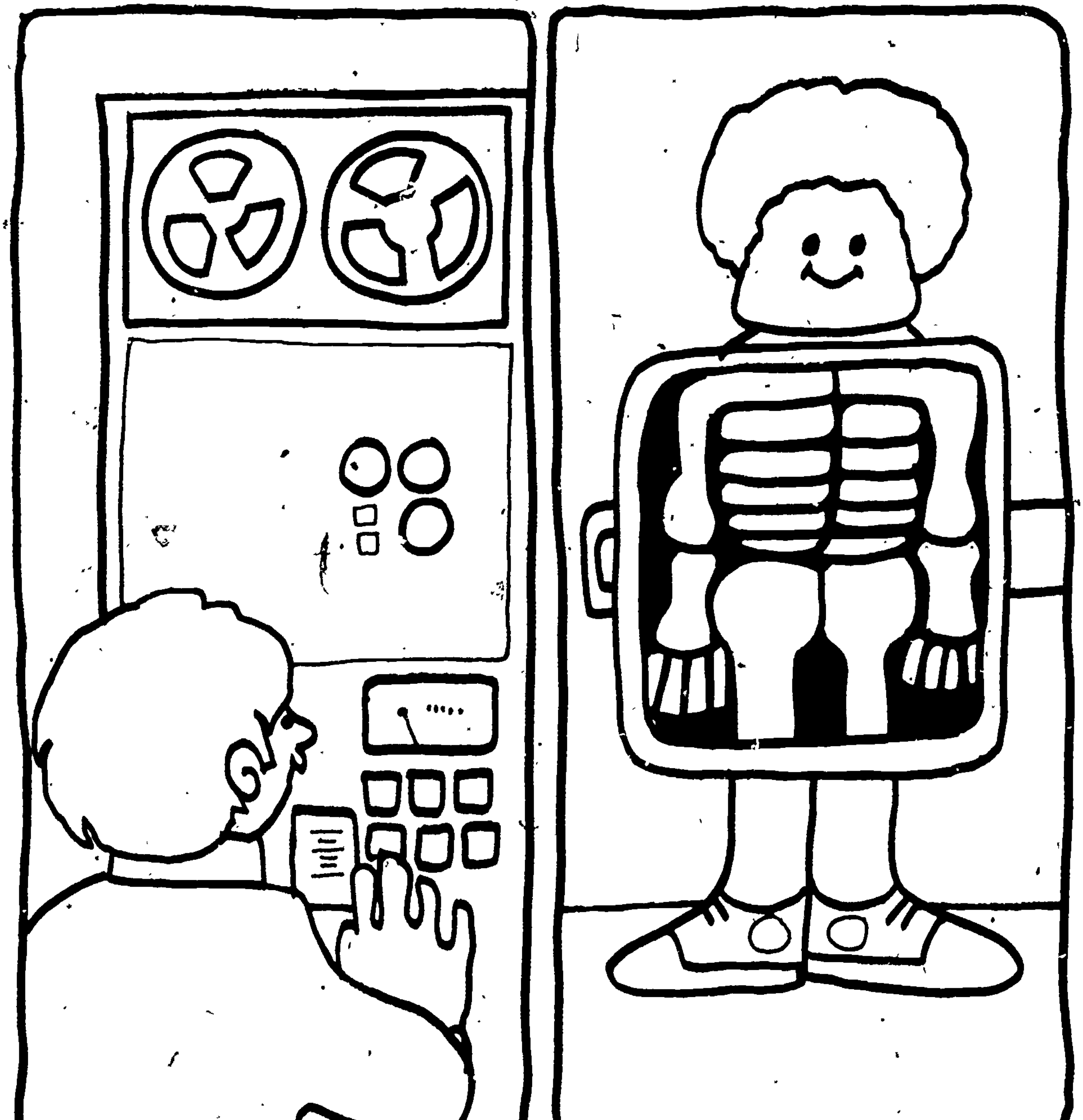
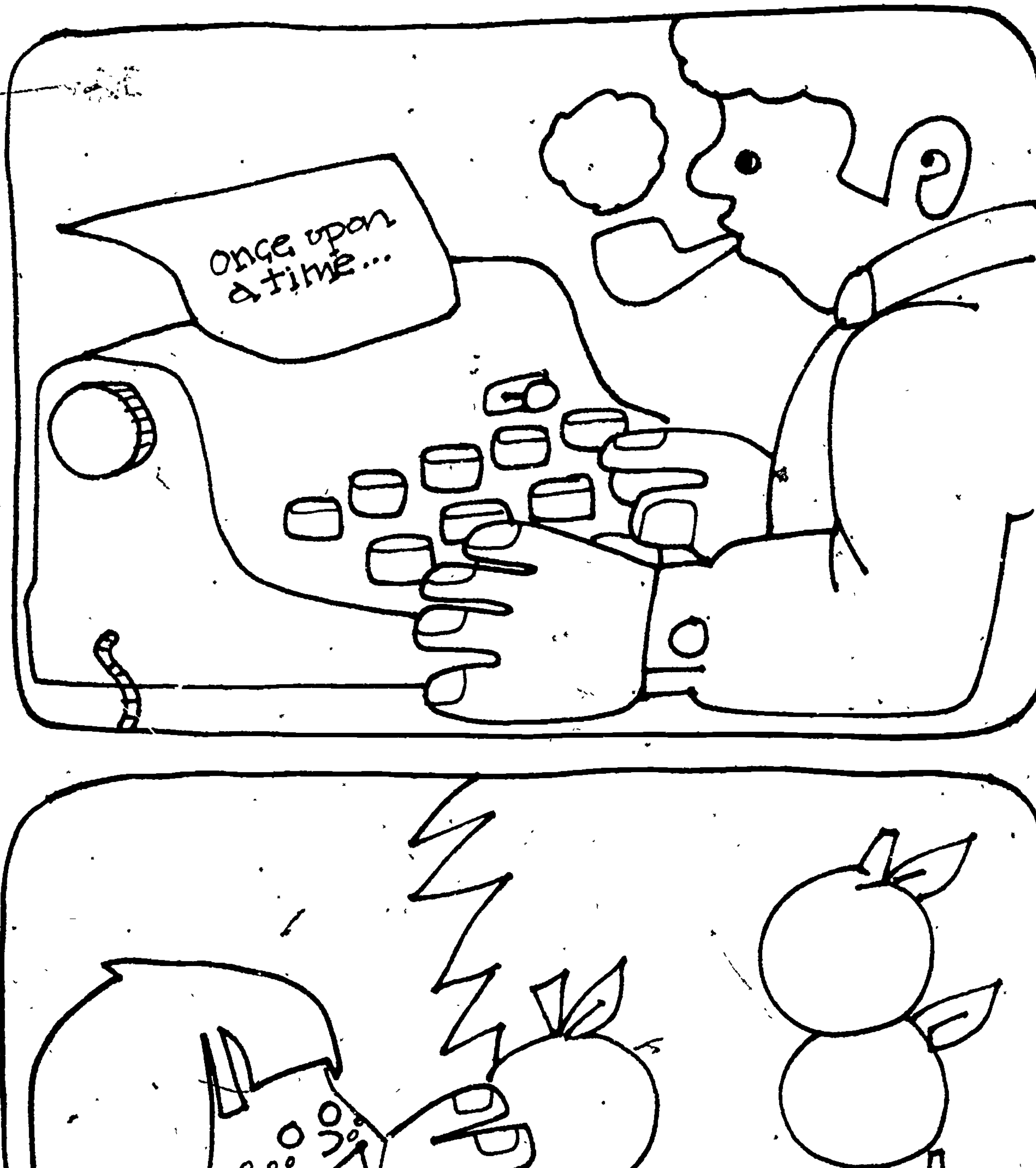
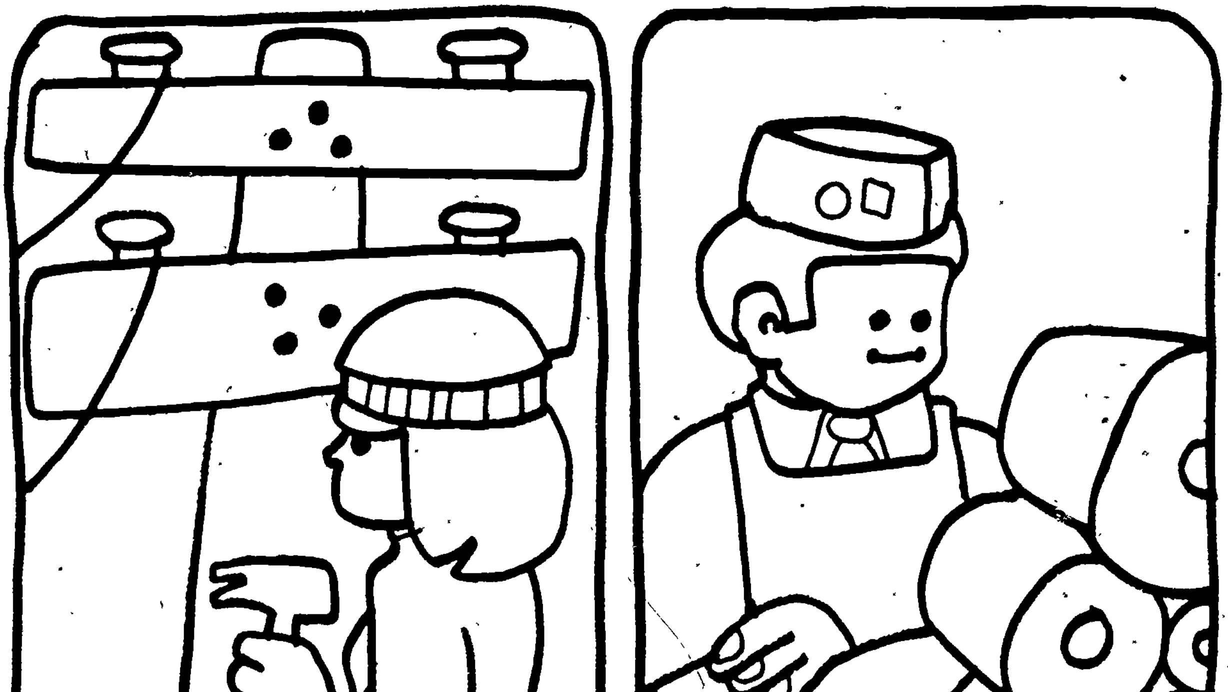
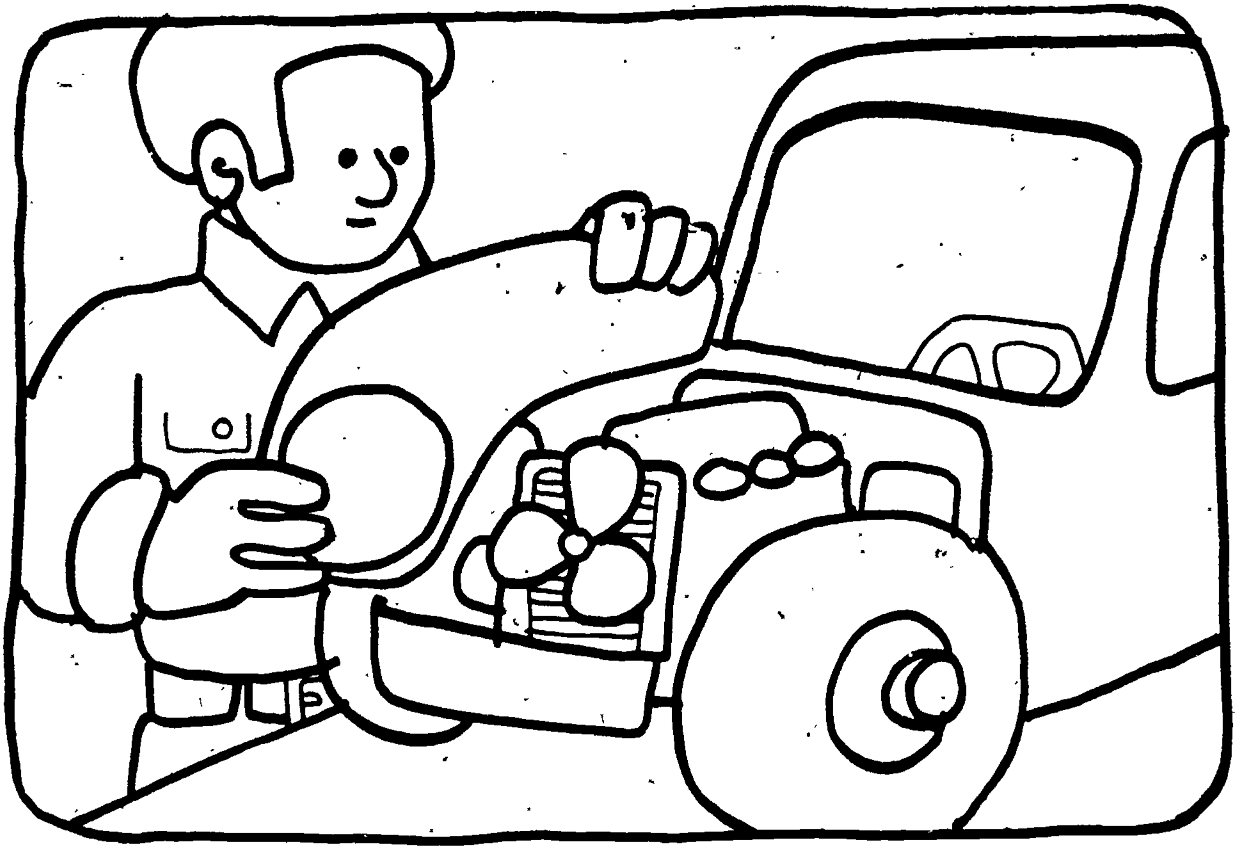
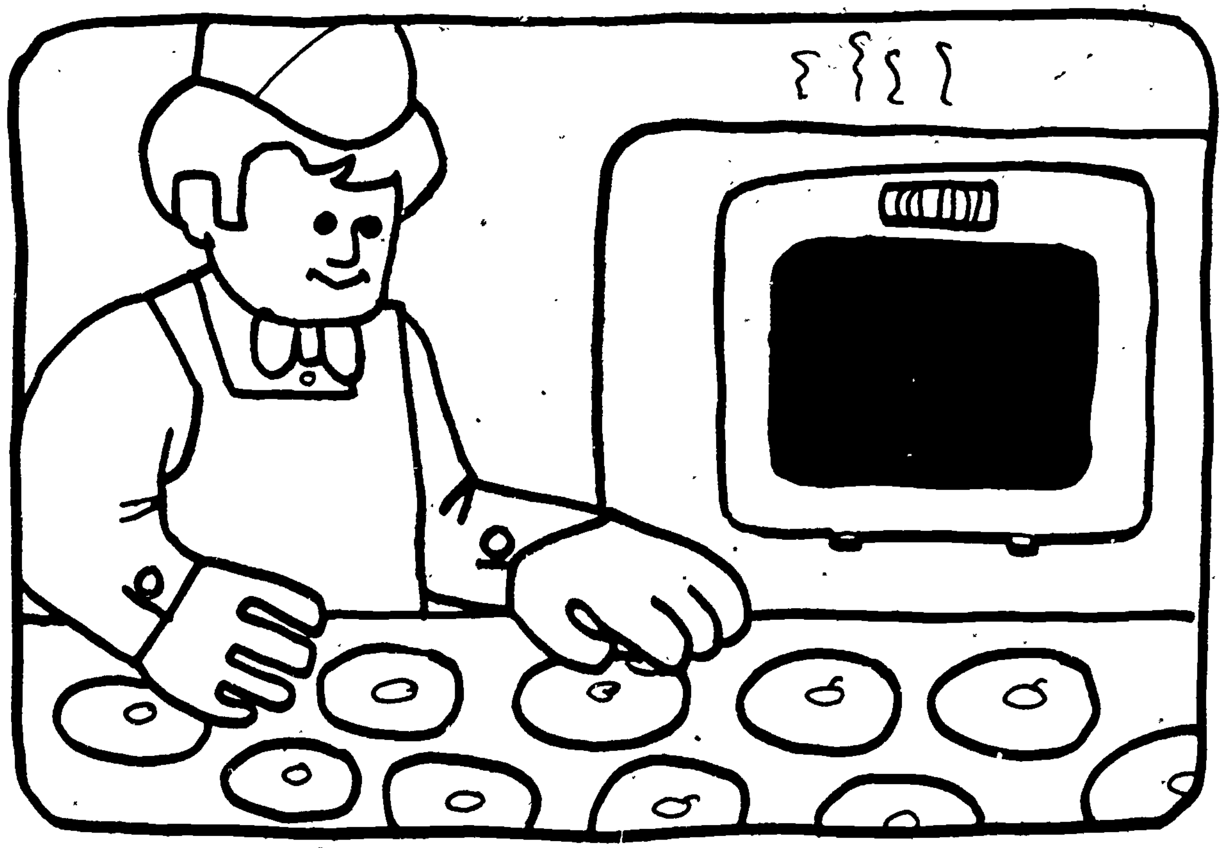



Once upon a time...

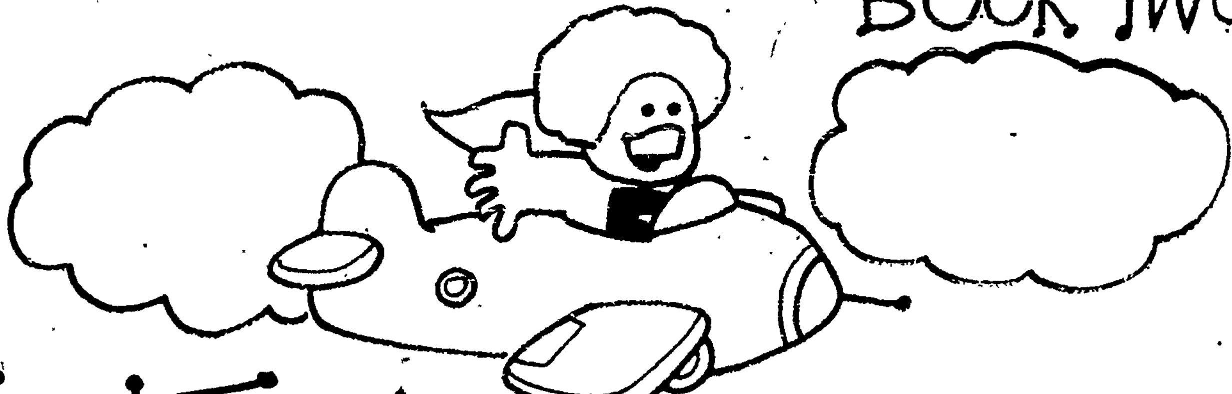
...in industry





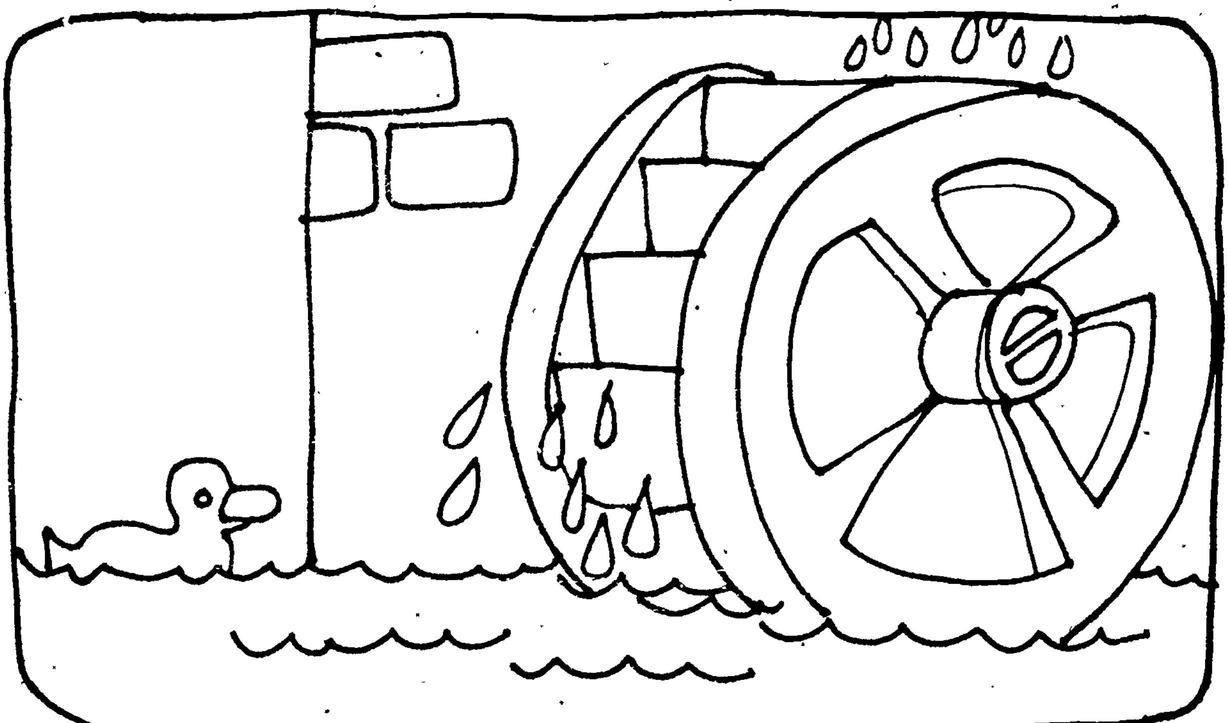


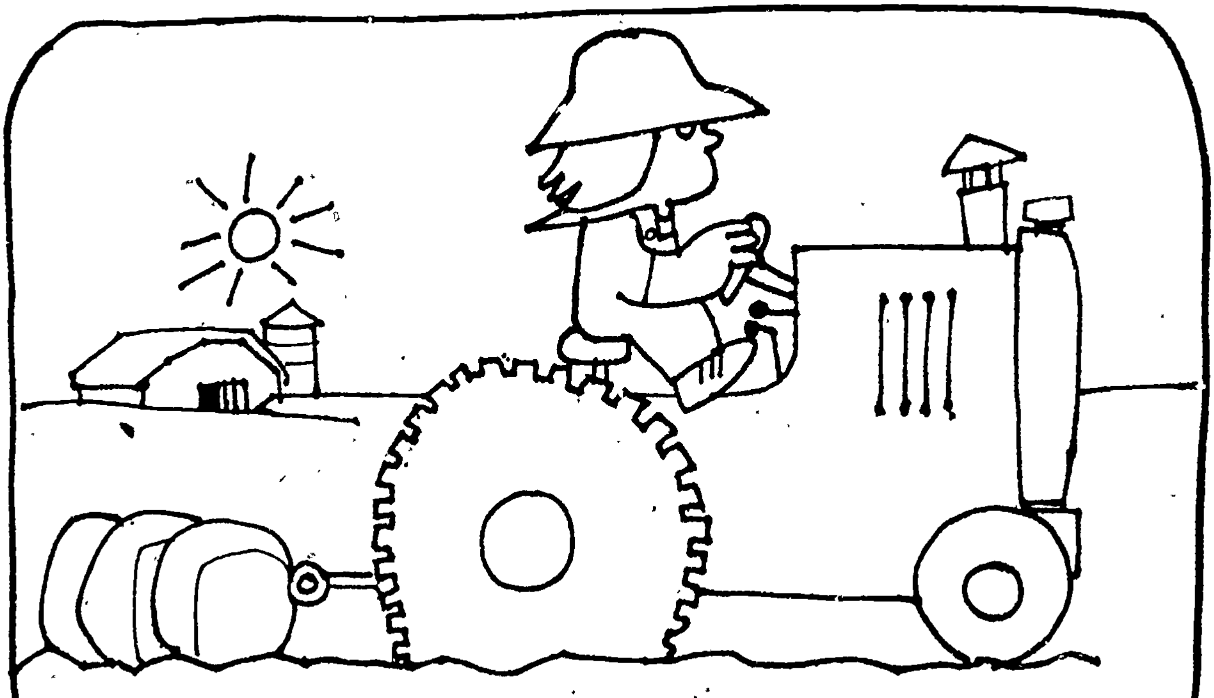
BOOK TWO



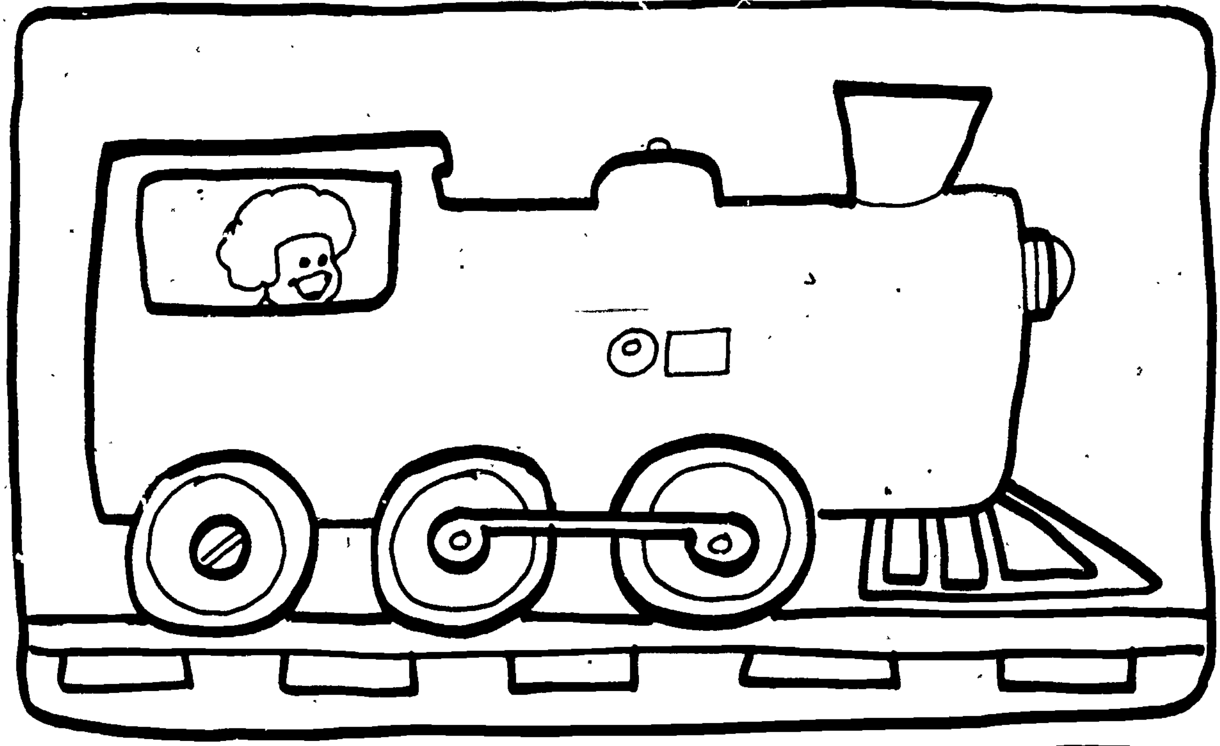
WE KNOW ENERGY BECAUSE OF WHAT IT DOES

ENERGY

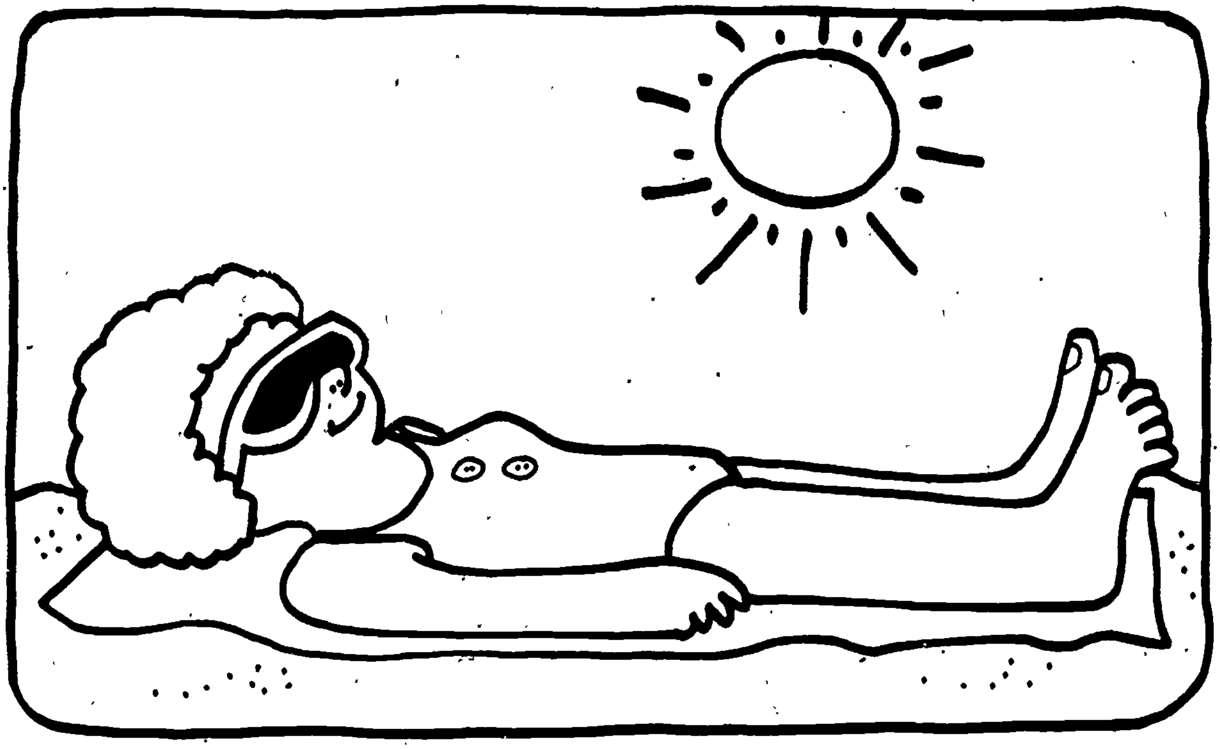


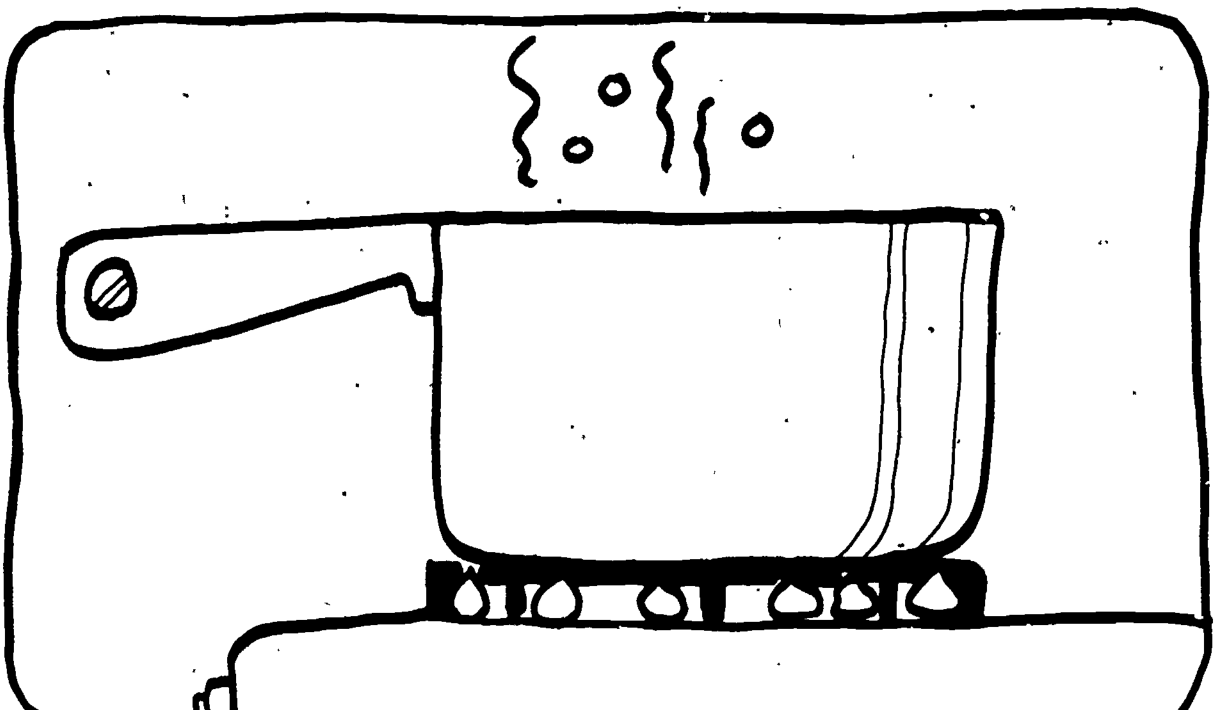


moves things

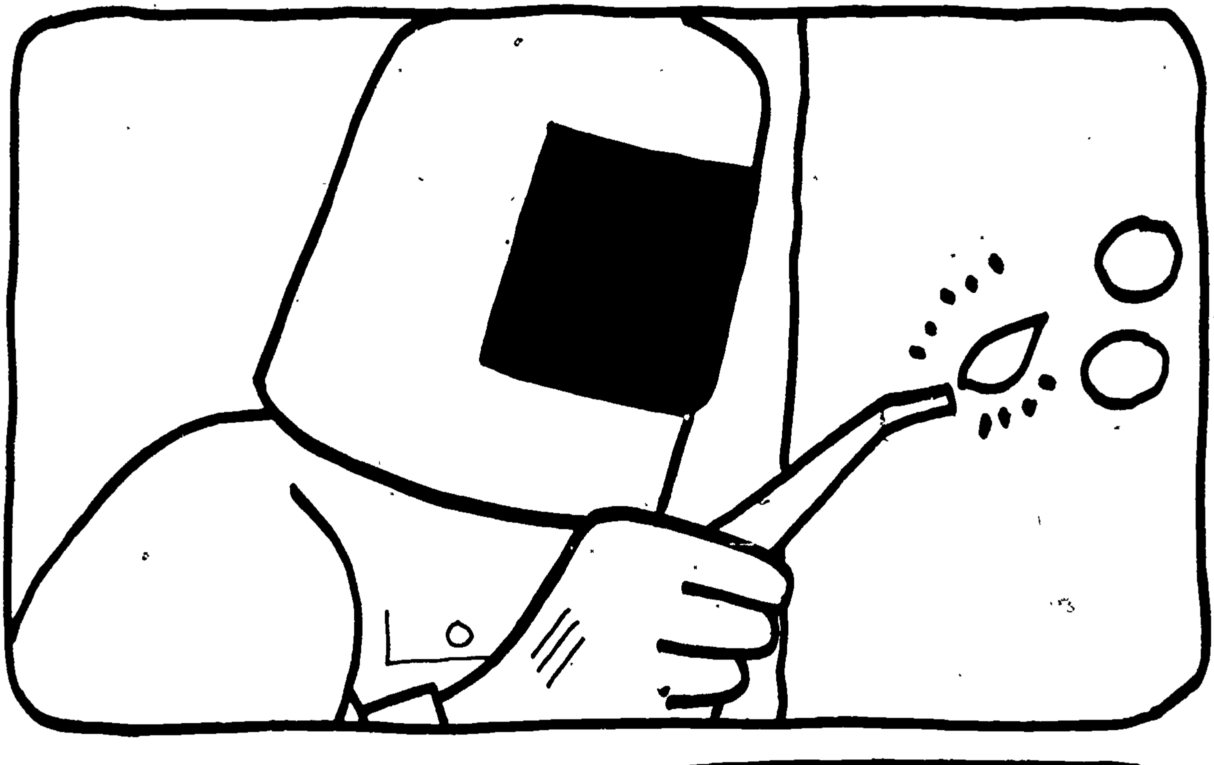


ENERGY

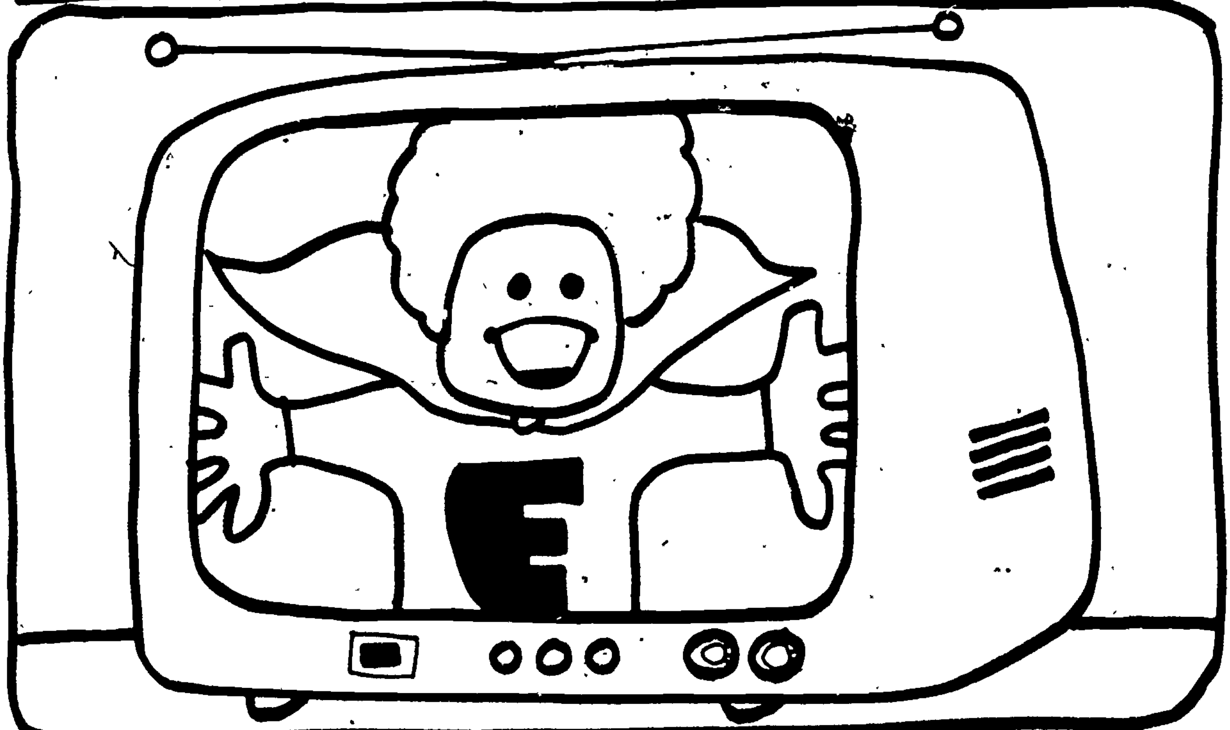


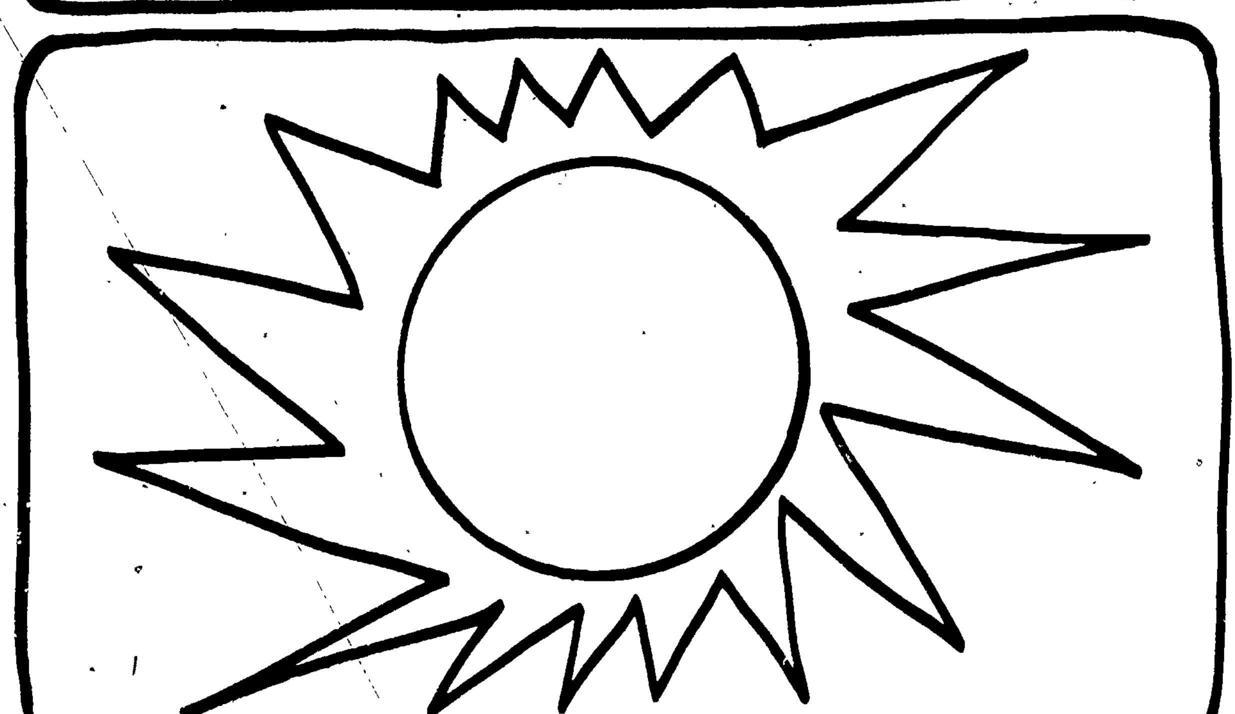


heats things

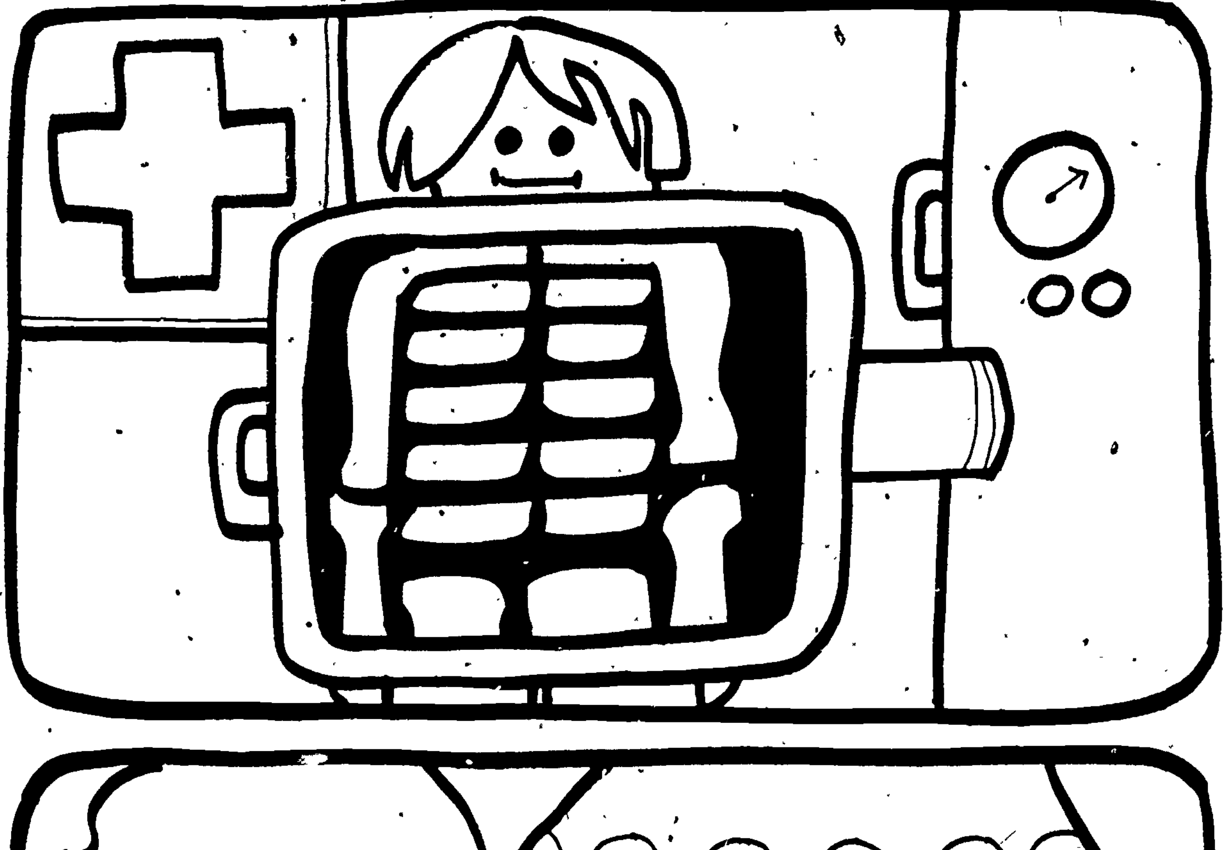


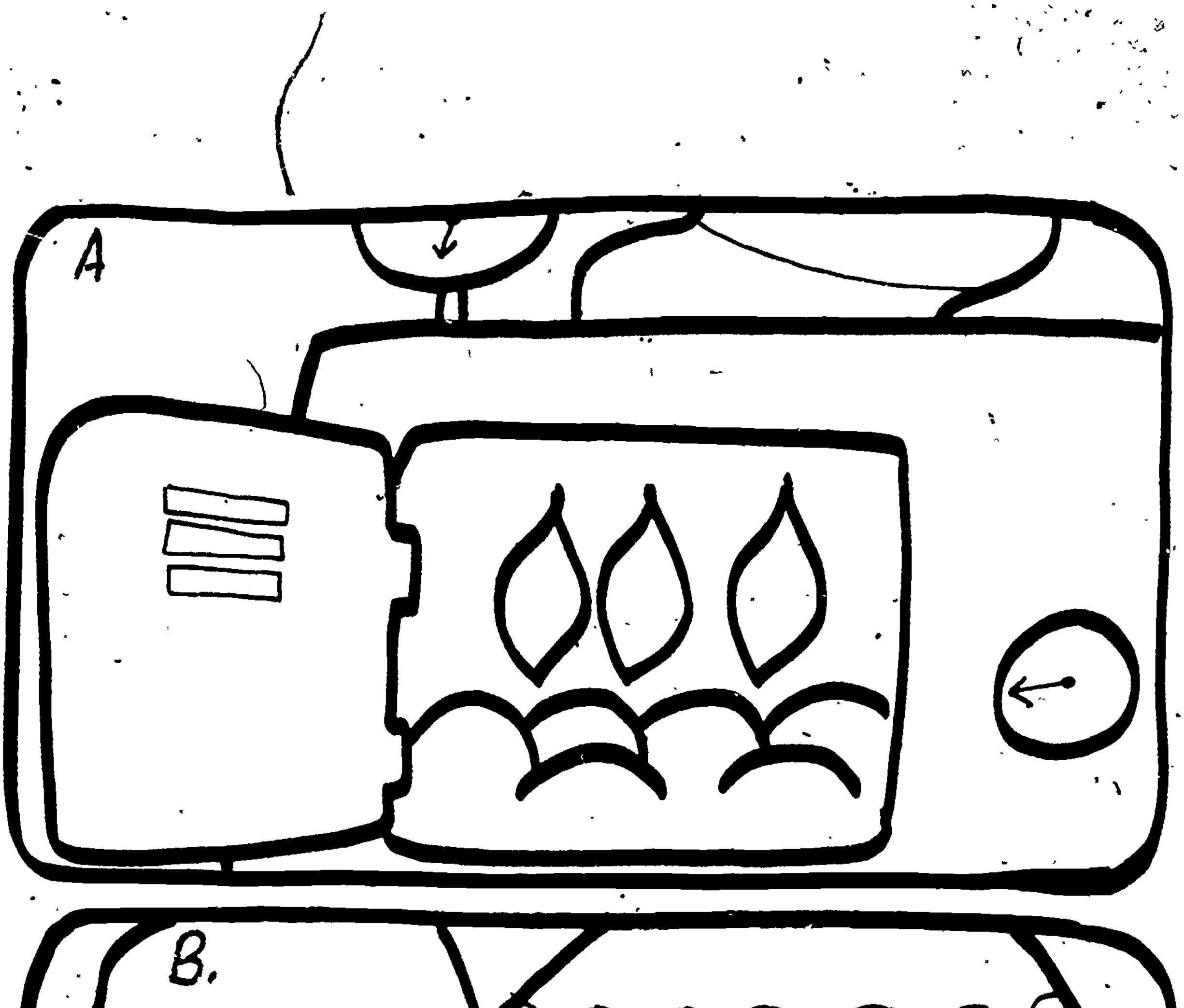
ENERGY





lights things

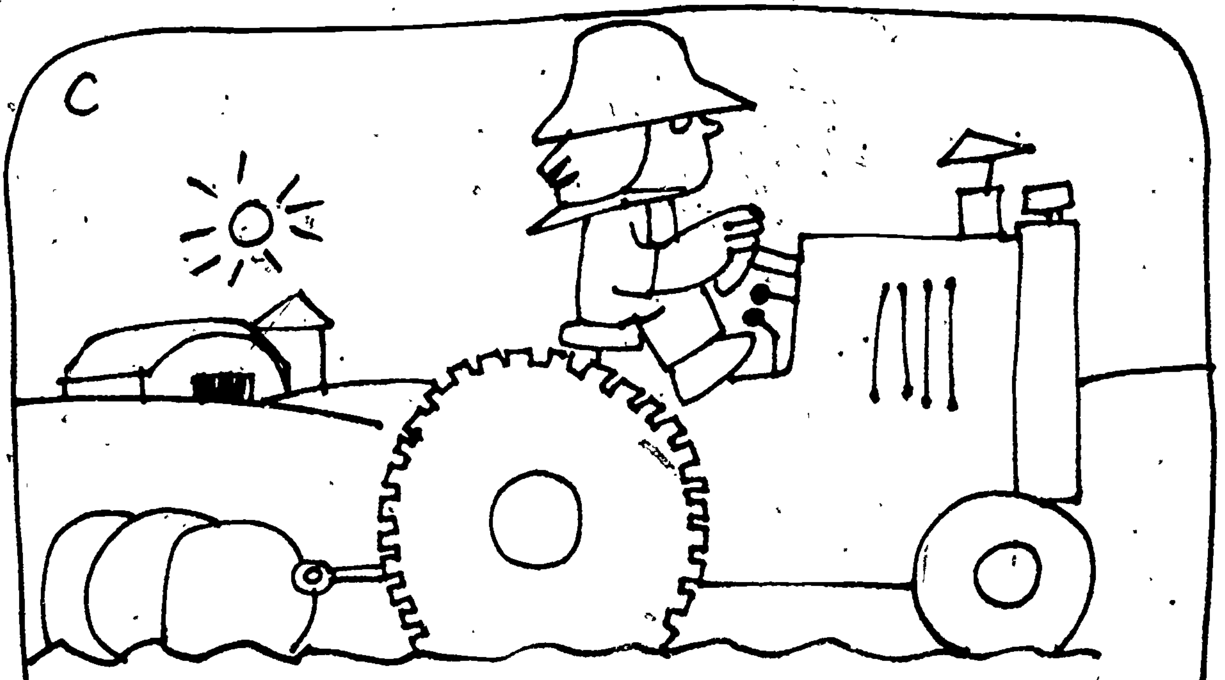



A
B.

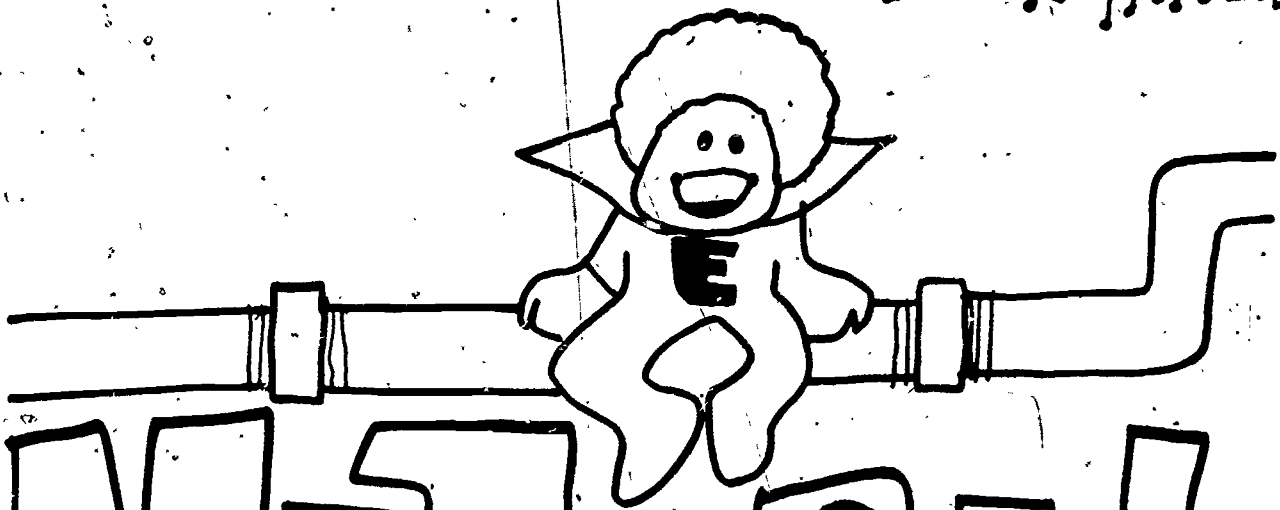
ENERGY IN USE

Look at each picture and decide how energy is being used. Write A, B, or C by the correct form of energy:

____ 1. Motion
____ 2. Heat
____ 3. Light

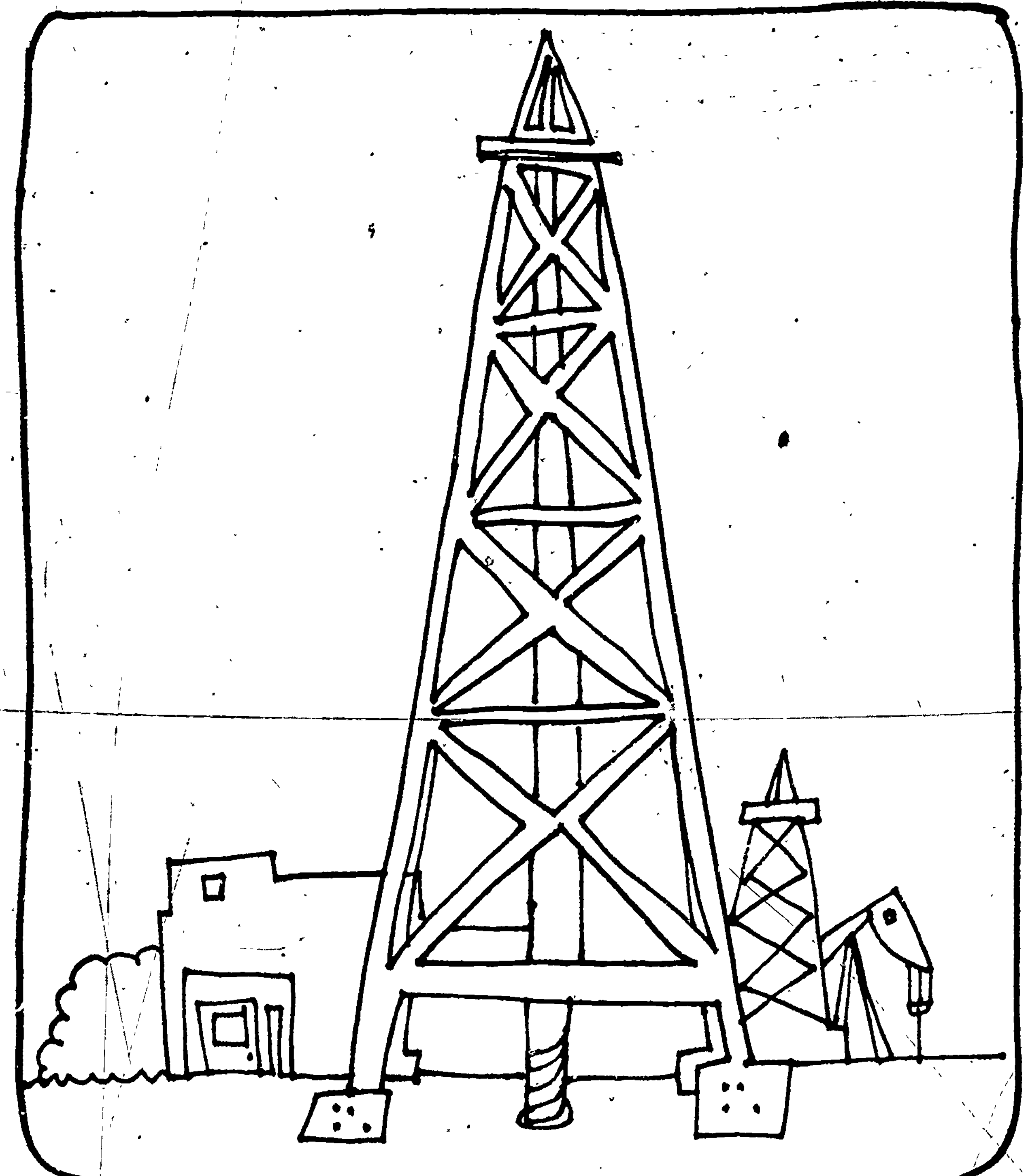


BOOK THREE

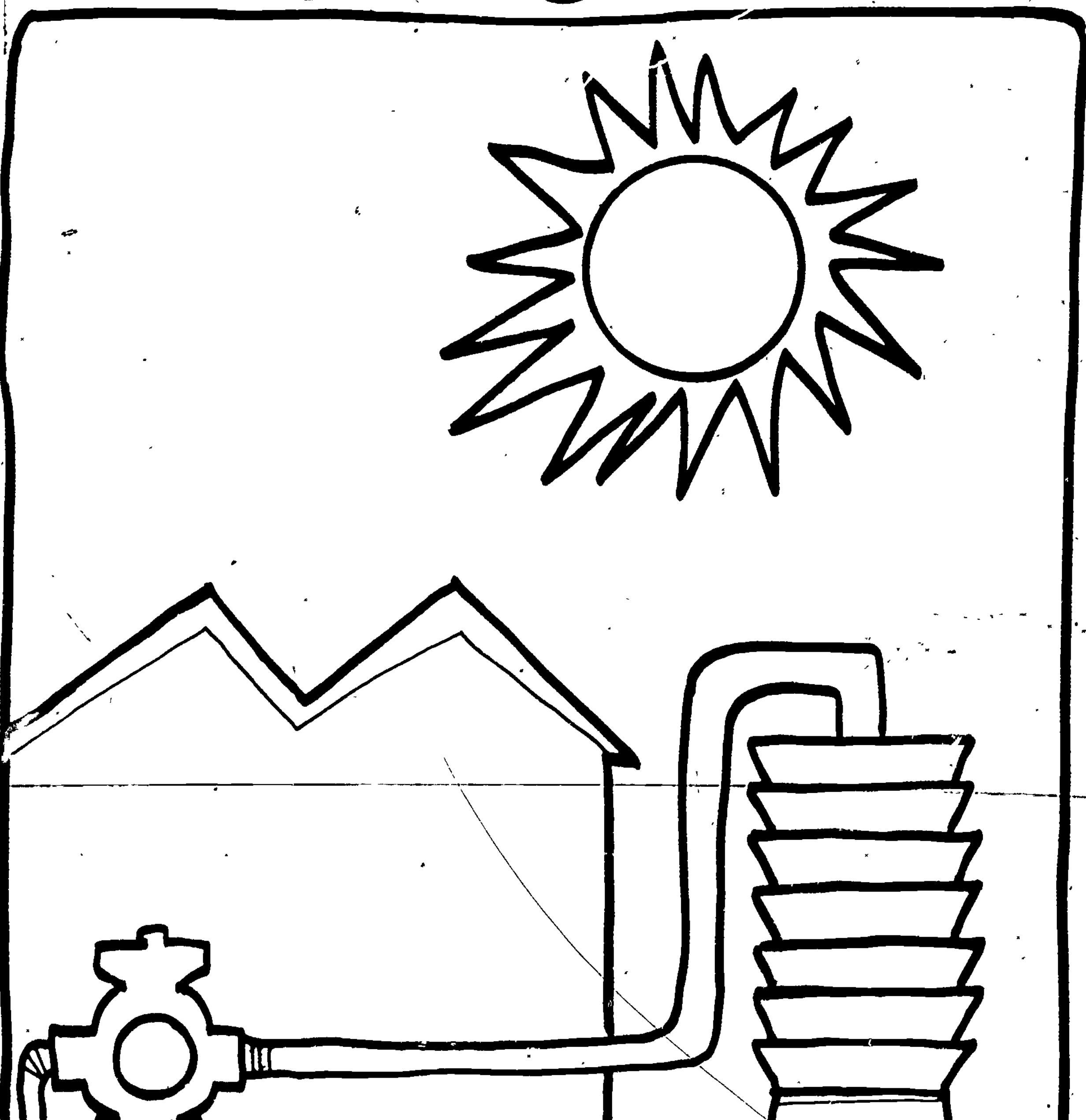


NATURAL GAS AND ENERGY

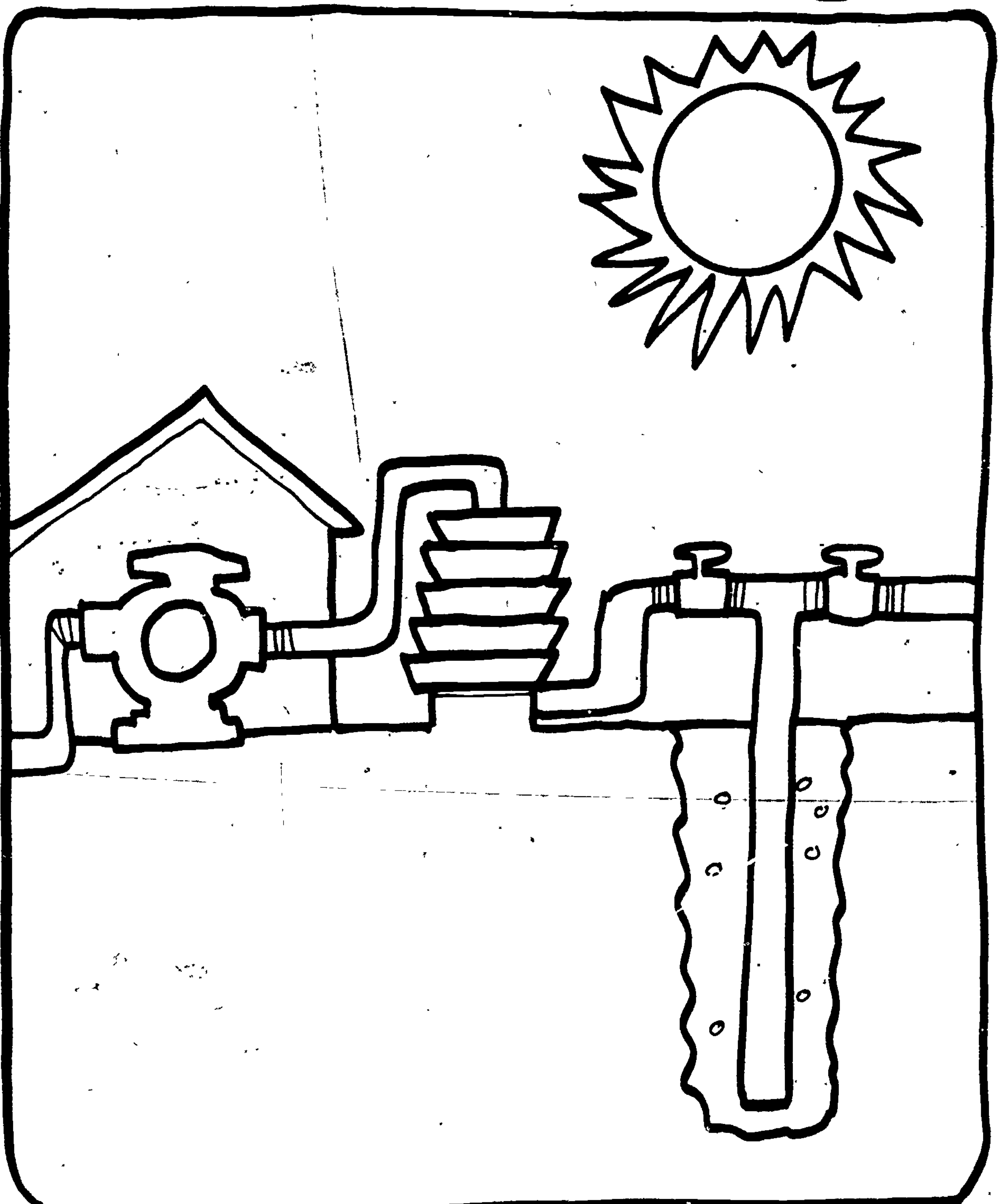
gas well



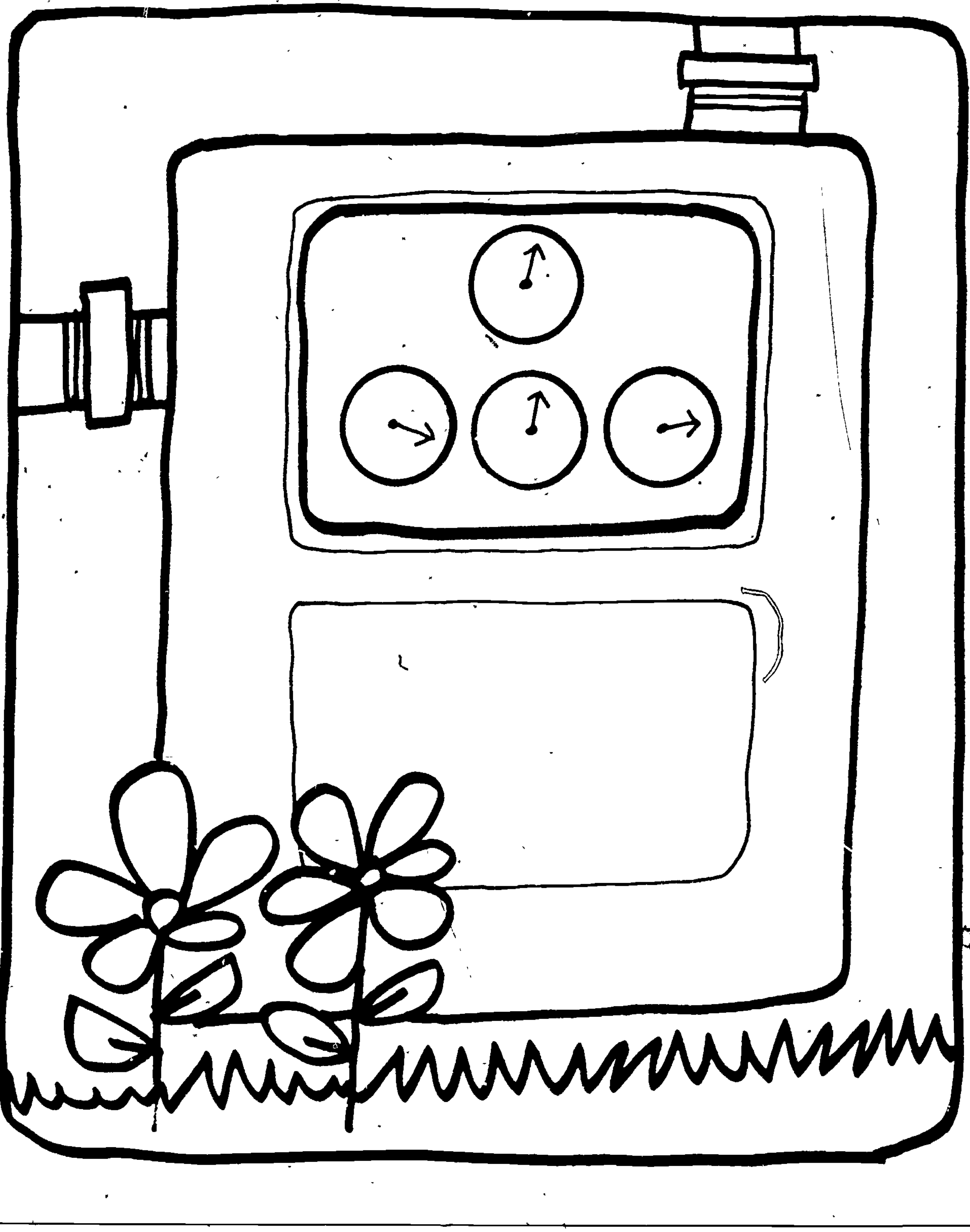
Pumping Station



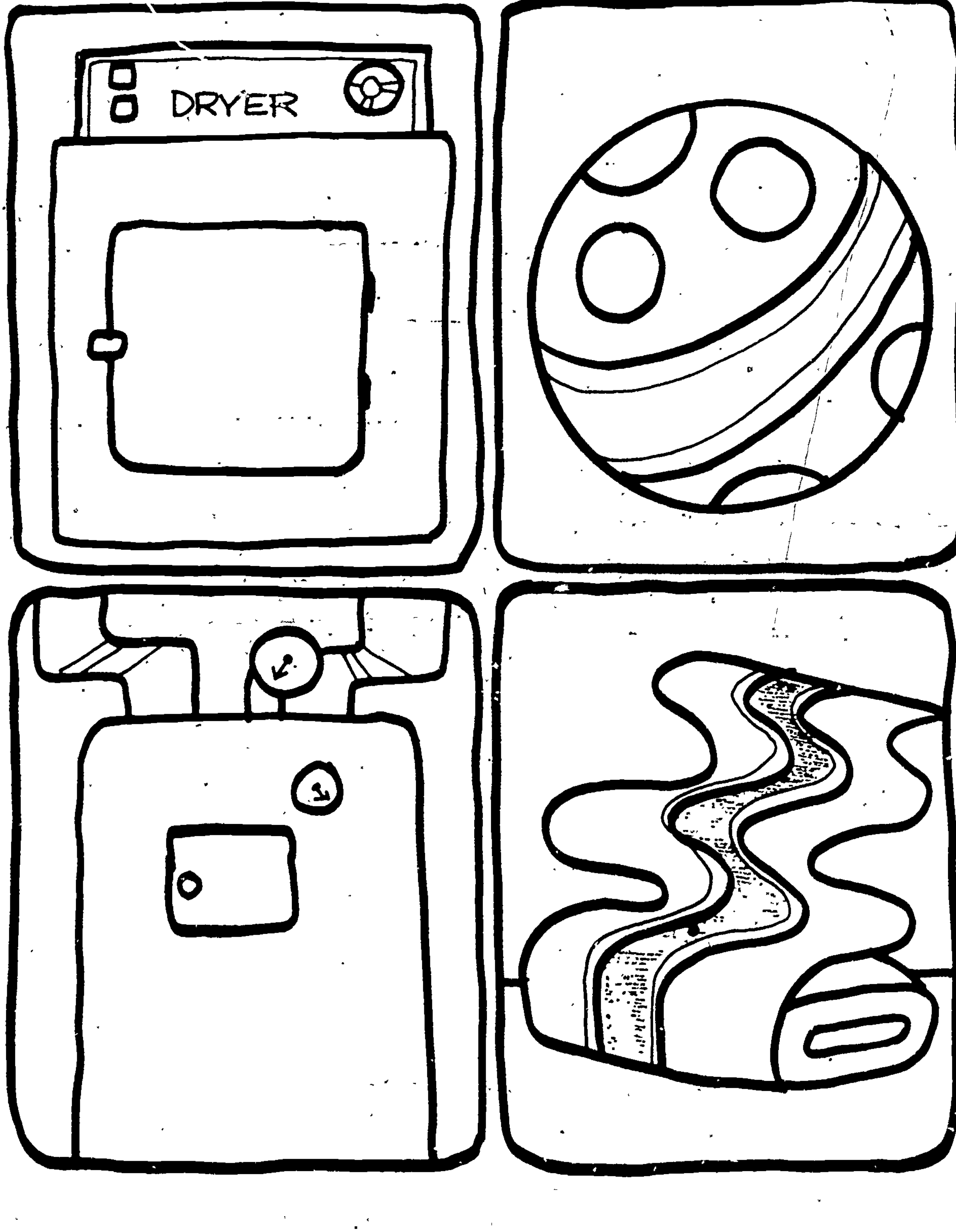
Underground Storage

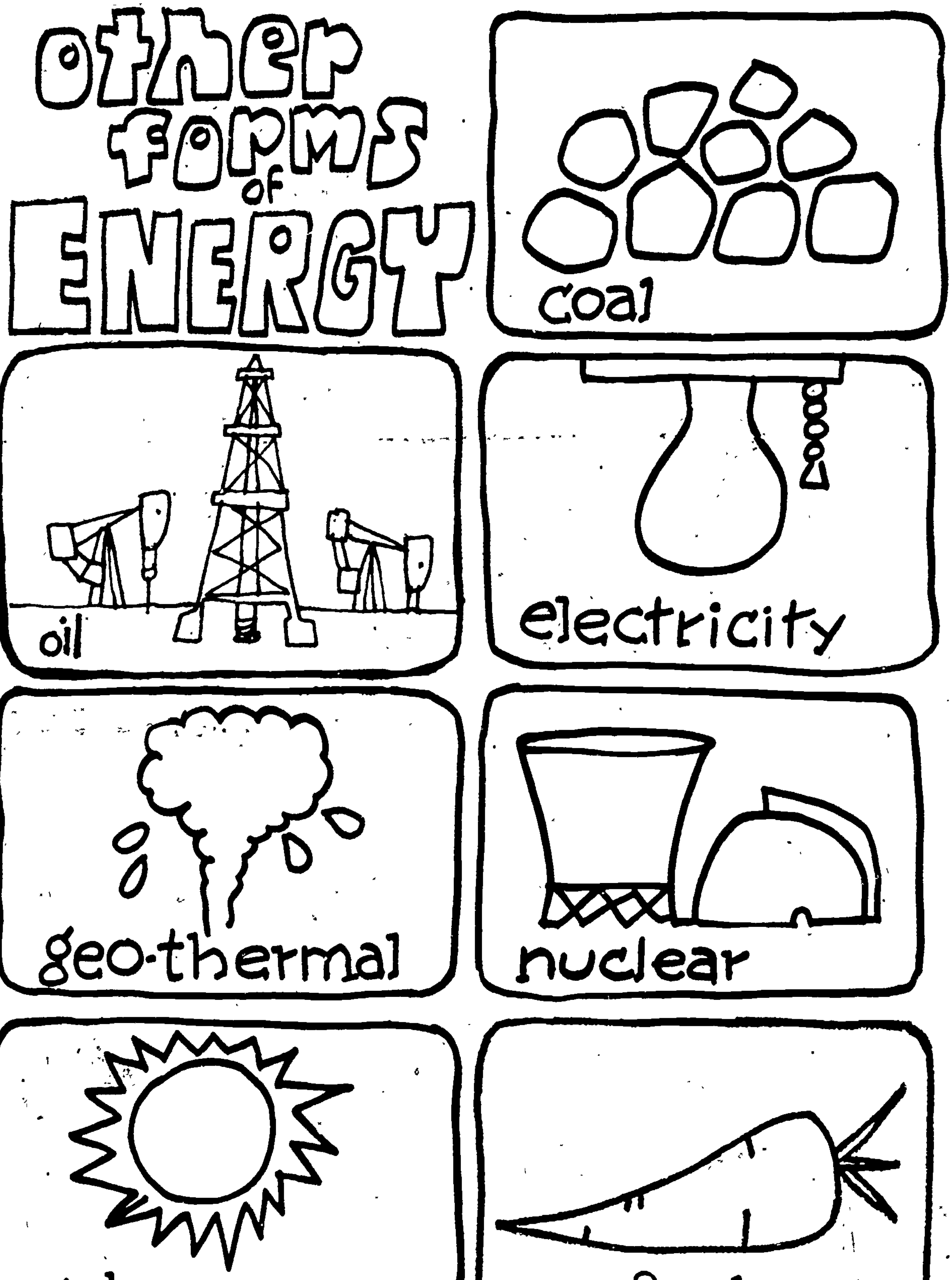


gas meter

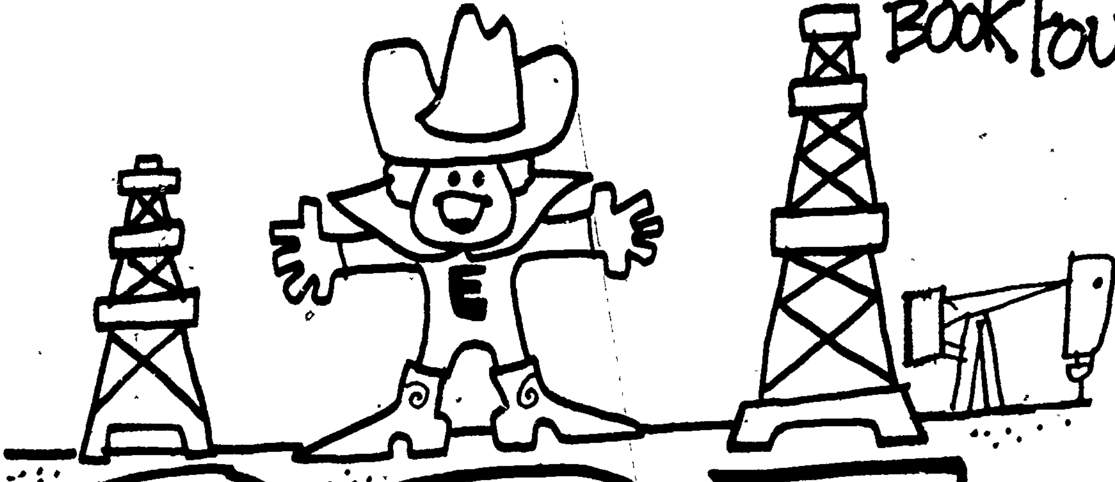


natural gas uses



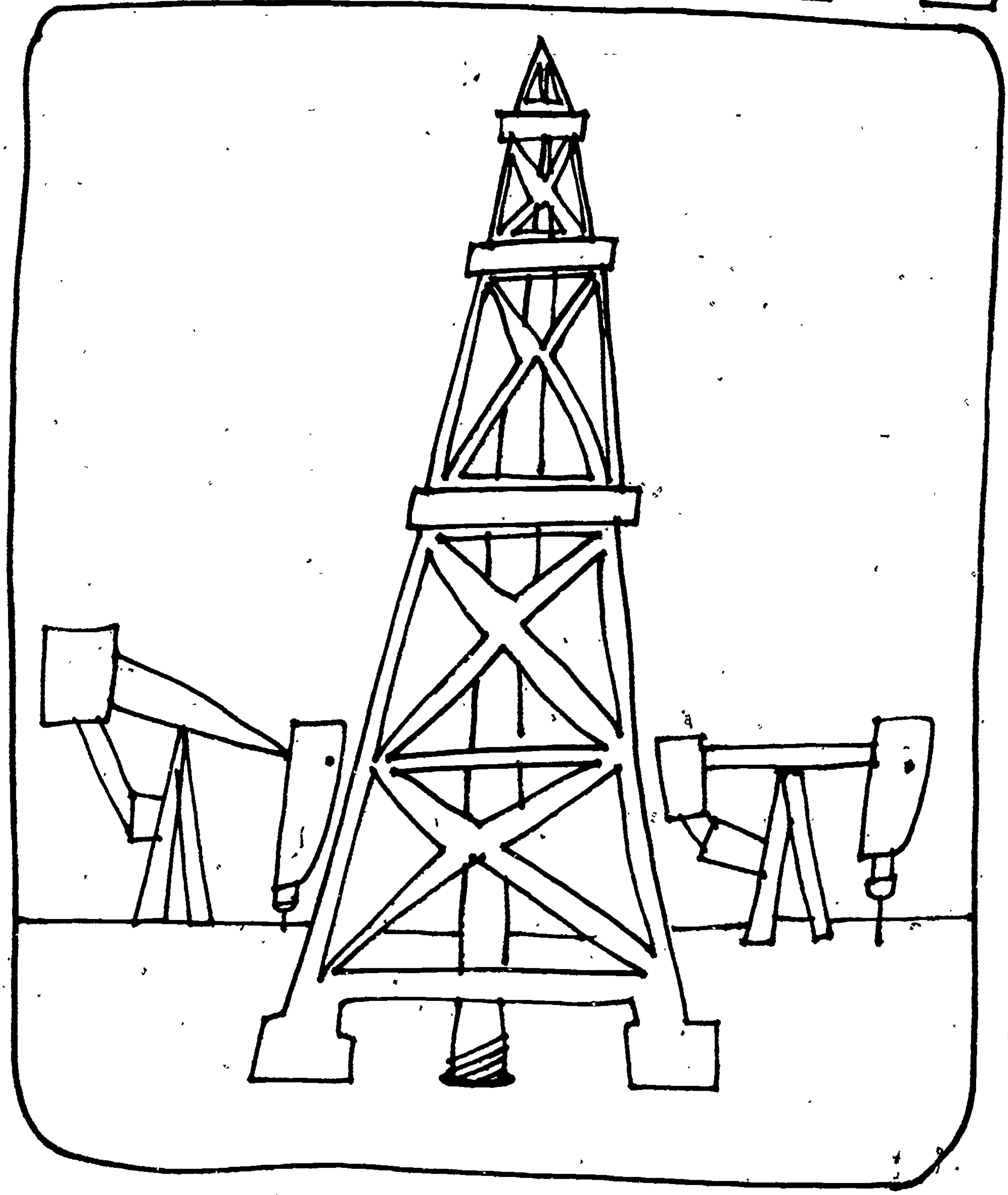

other forms of ENERGY
coal
oil
electricity
geo-thermal
nuclear
solar
food

BOOK FOUR

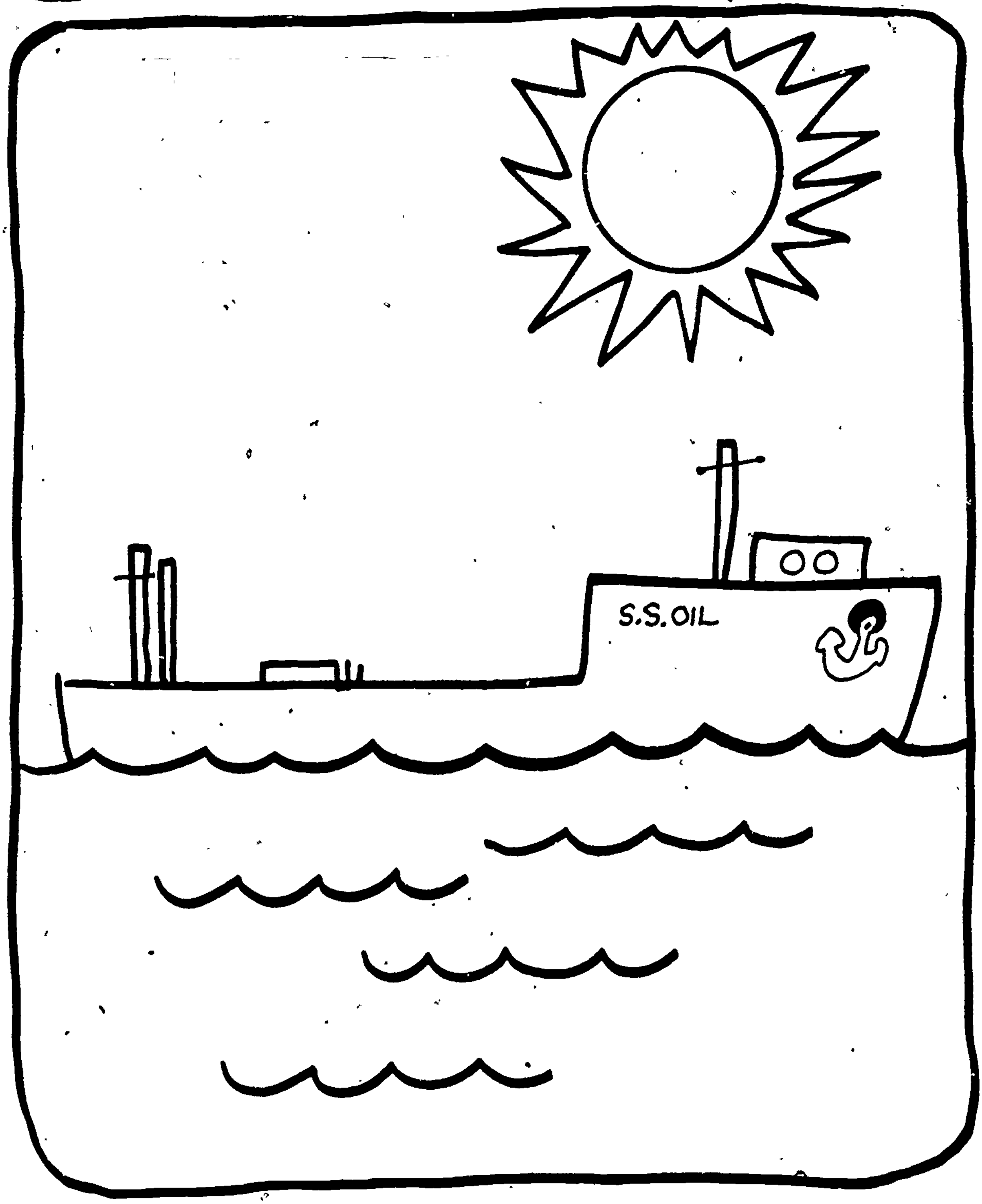


OIL AND ENERGY

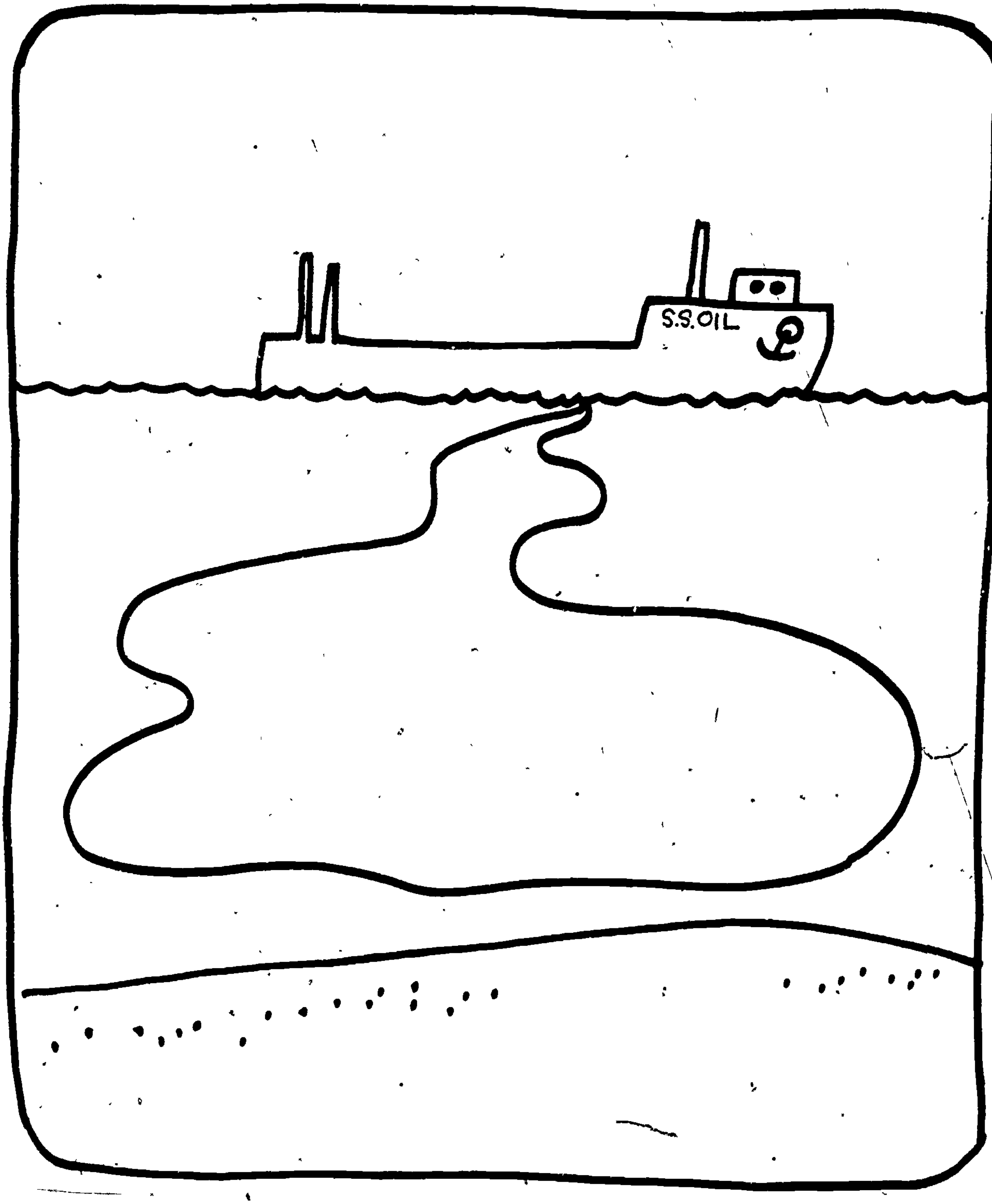
oil field



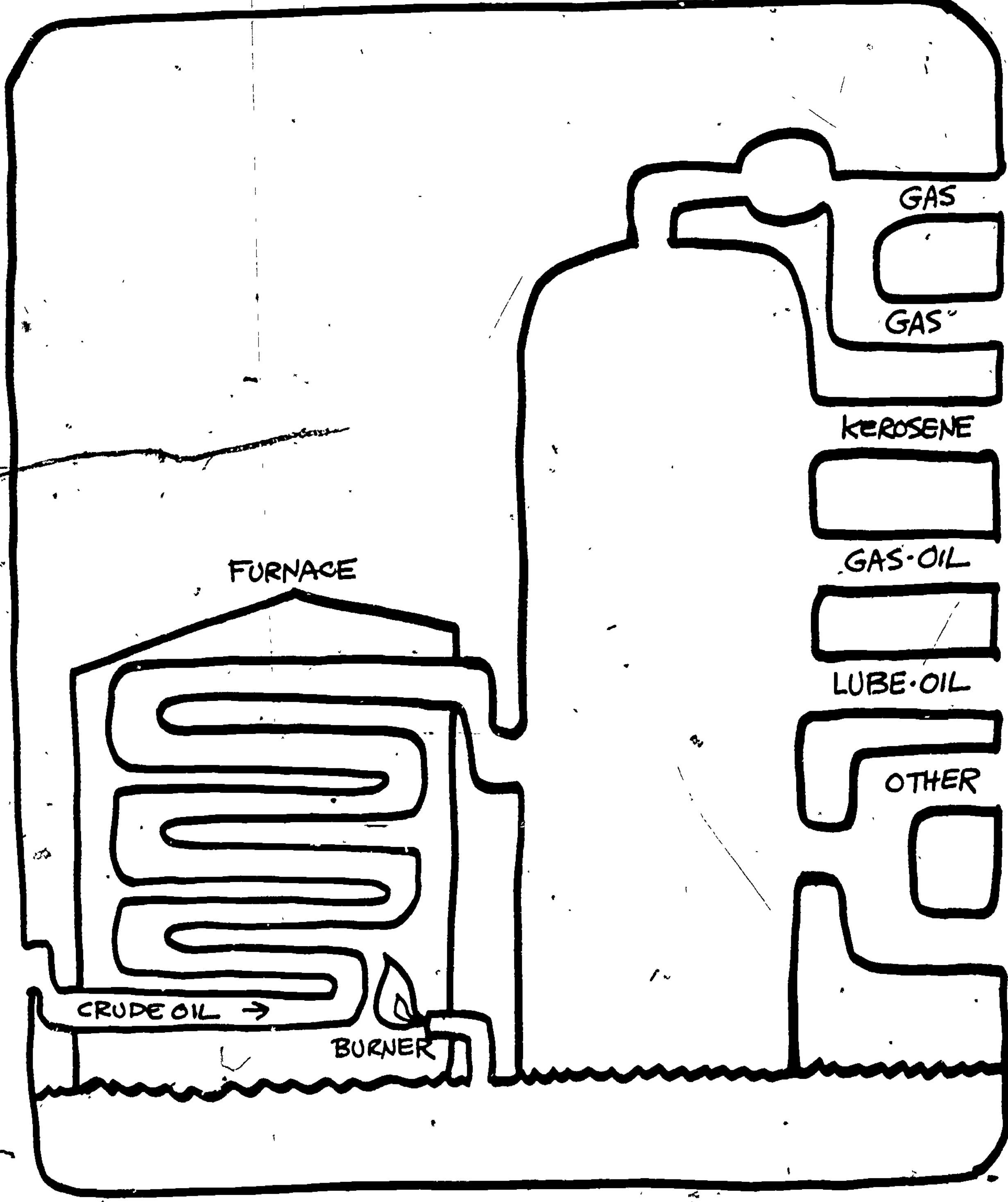
oil tanker



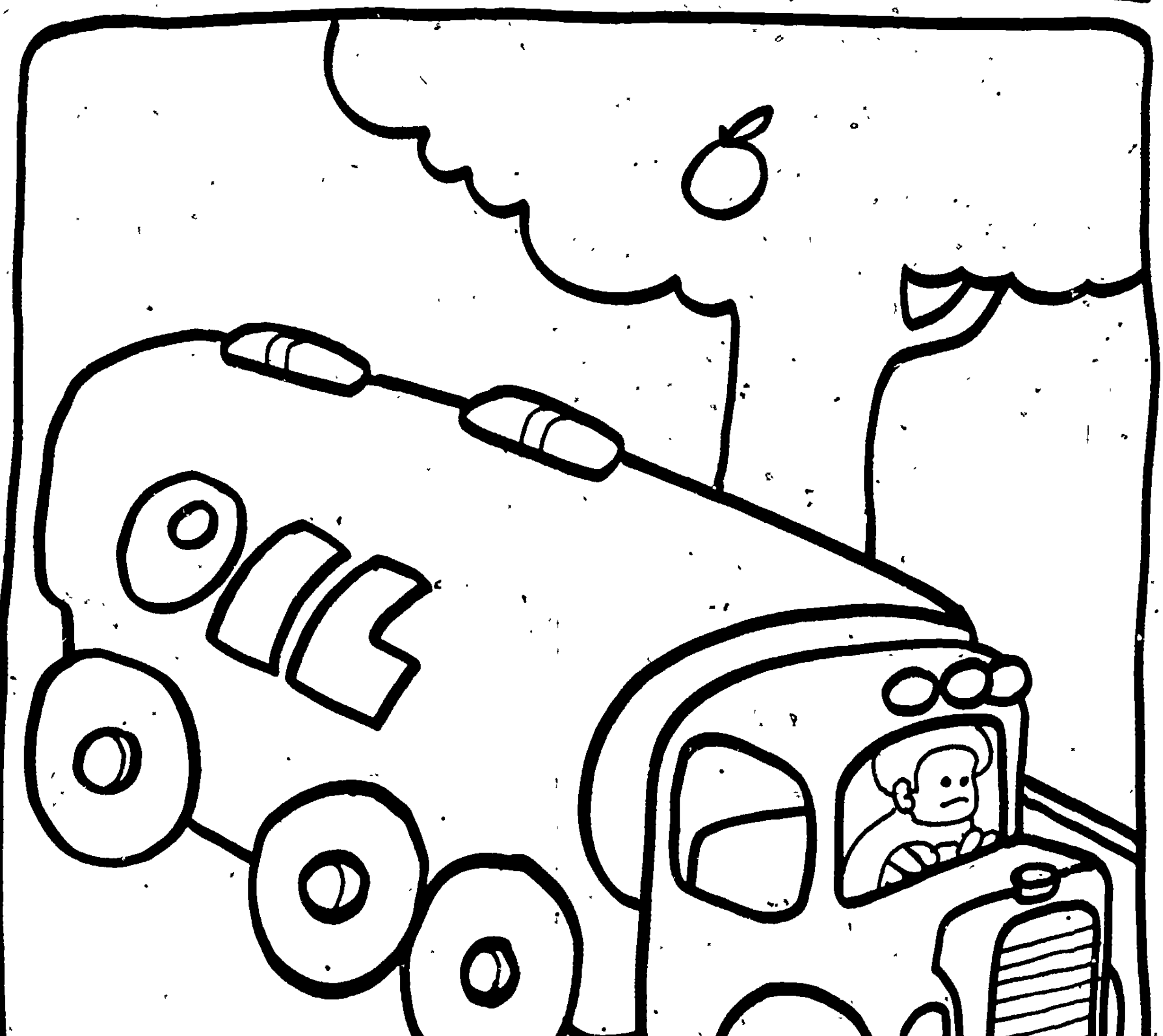
OIL SPILL



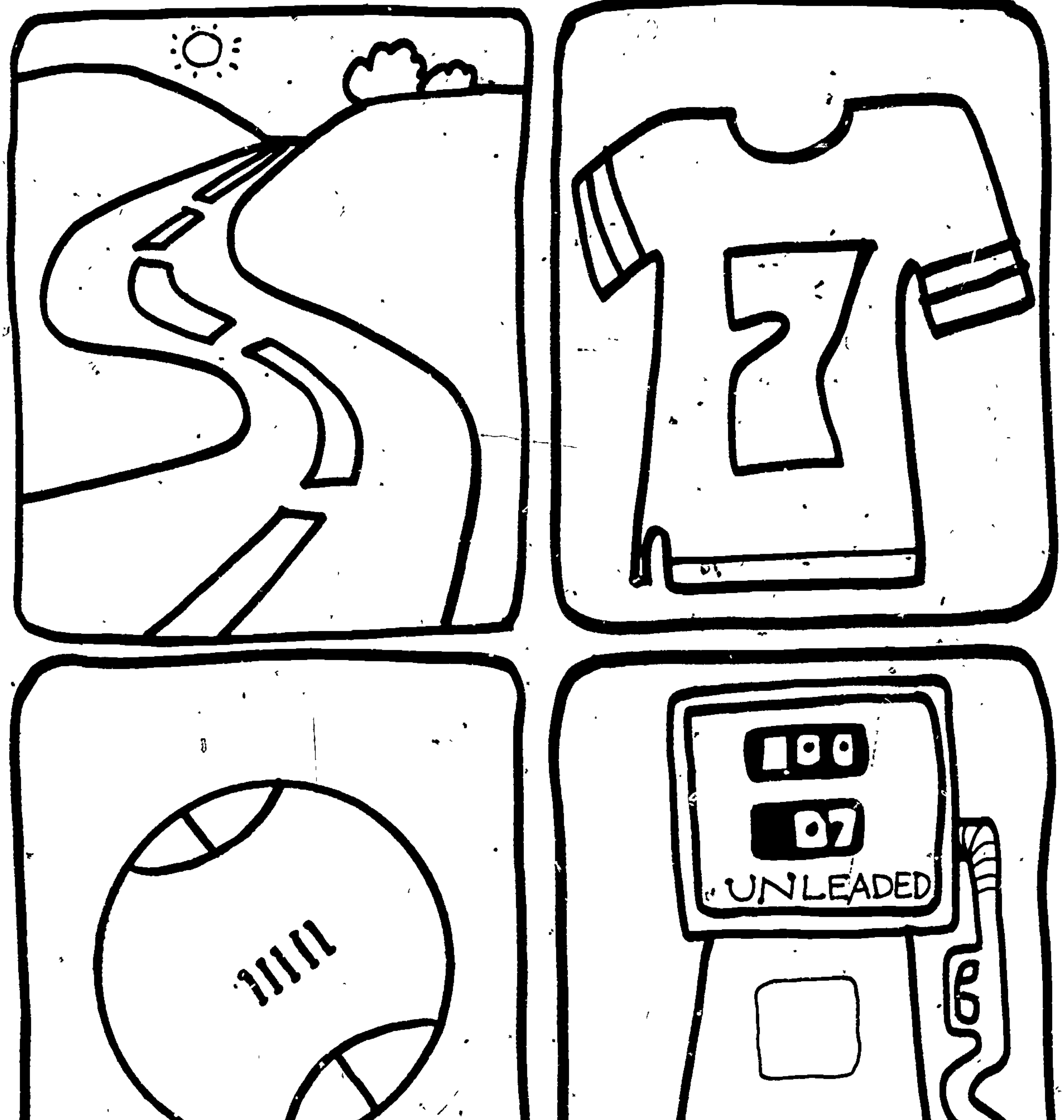
refinery


GAS
GAS
KEROSENE
GAS·OIL
LUBE·OIL
OTHER
FURNACE
CRUDE OIL →
BURNER

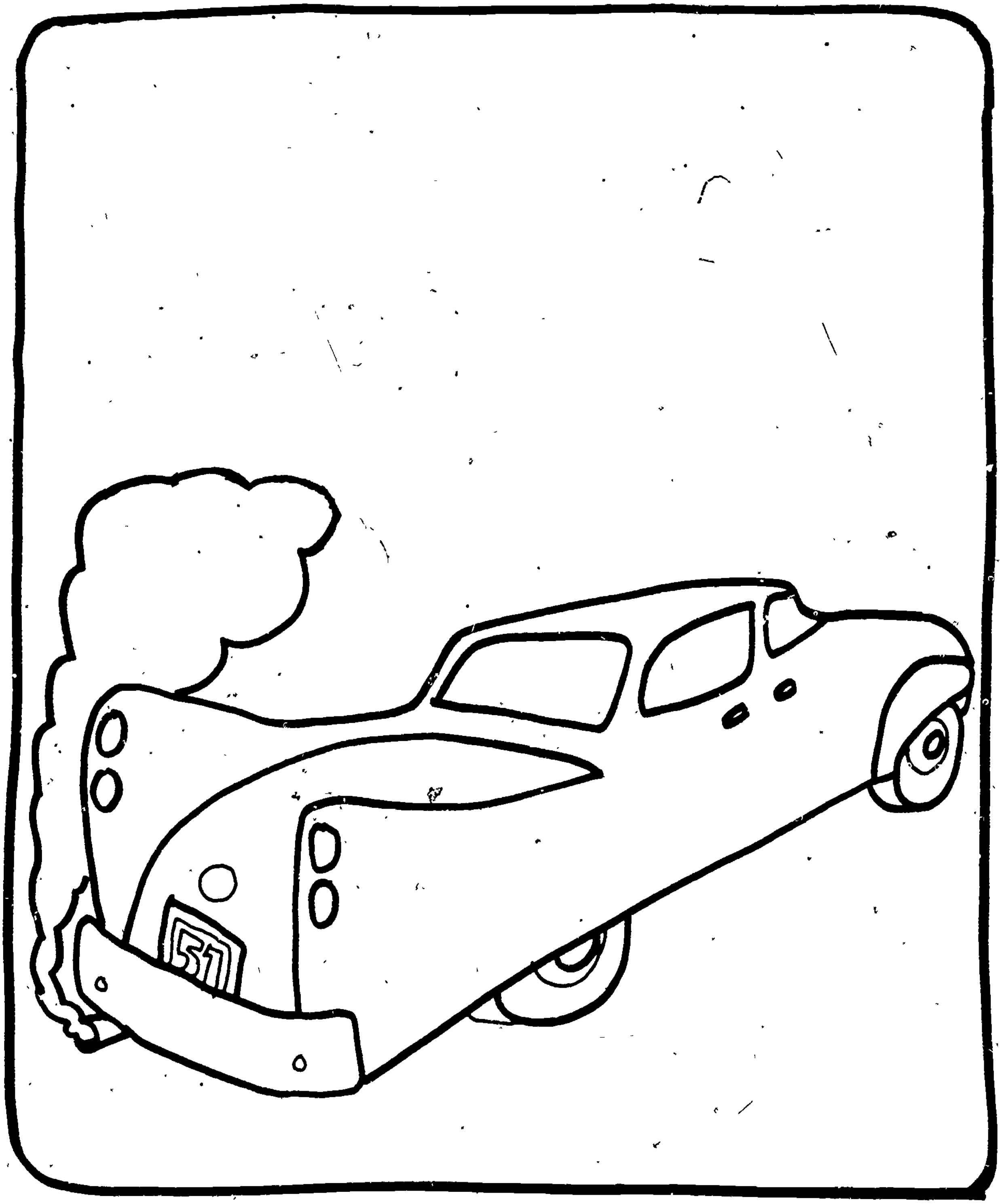
Oil truck



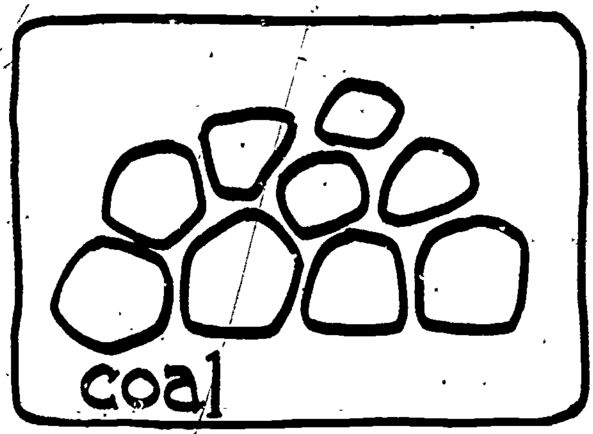
SOME OIL USES

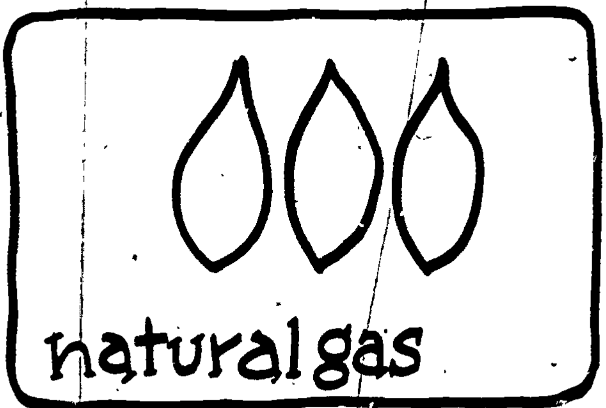


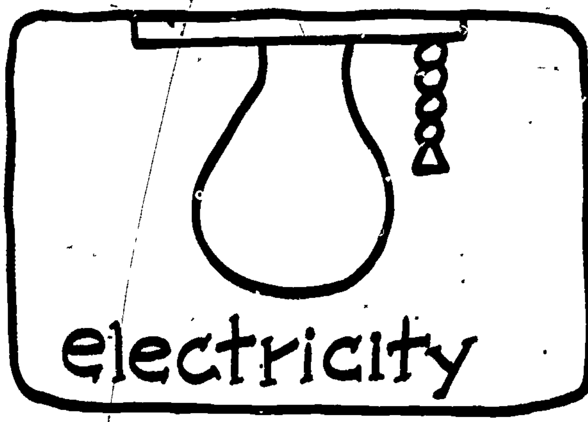
exhaust

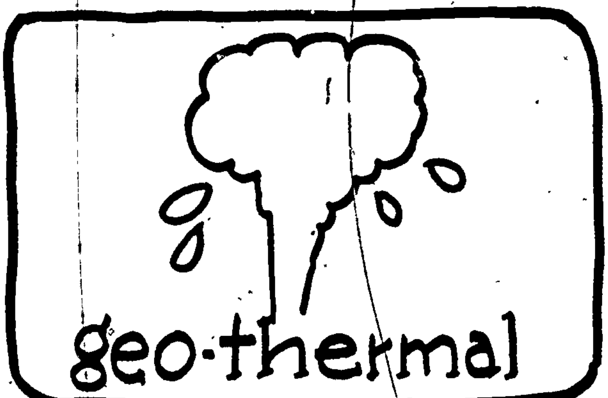


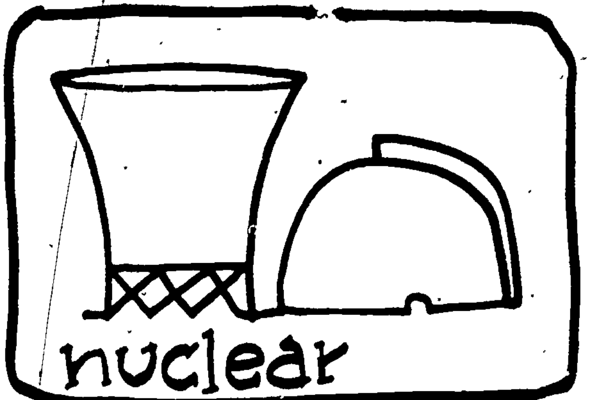
other forms of ENERGY

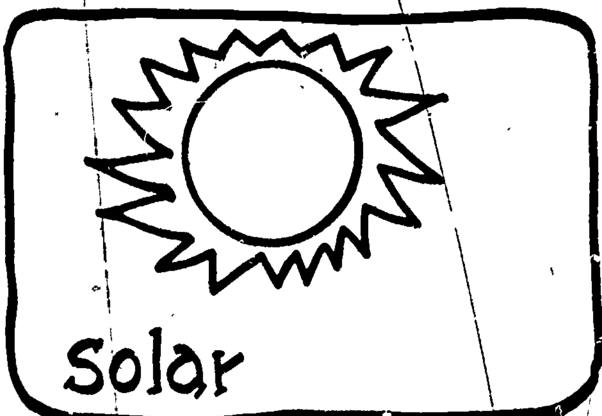


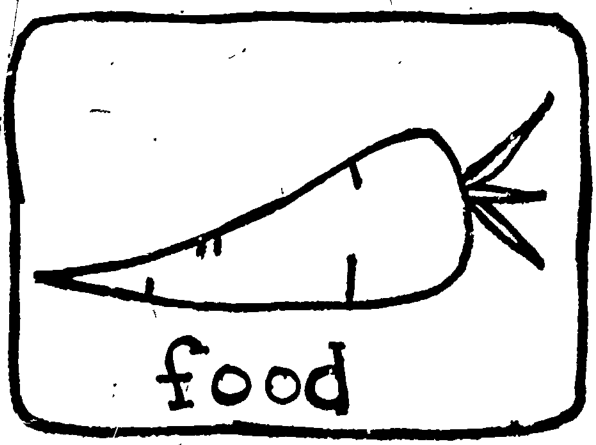




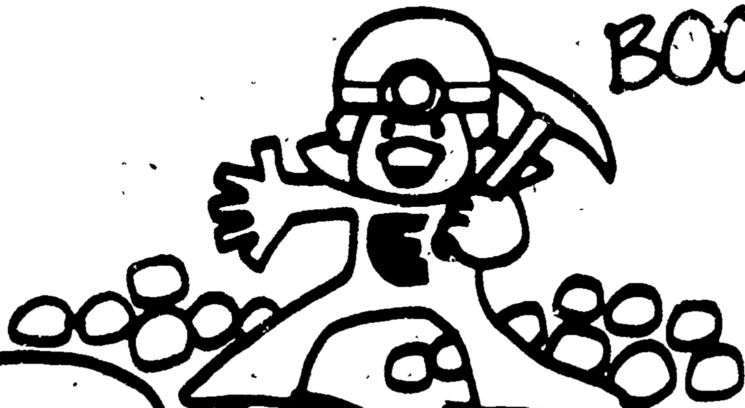




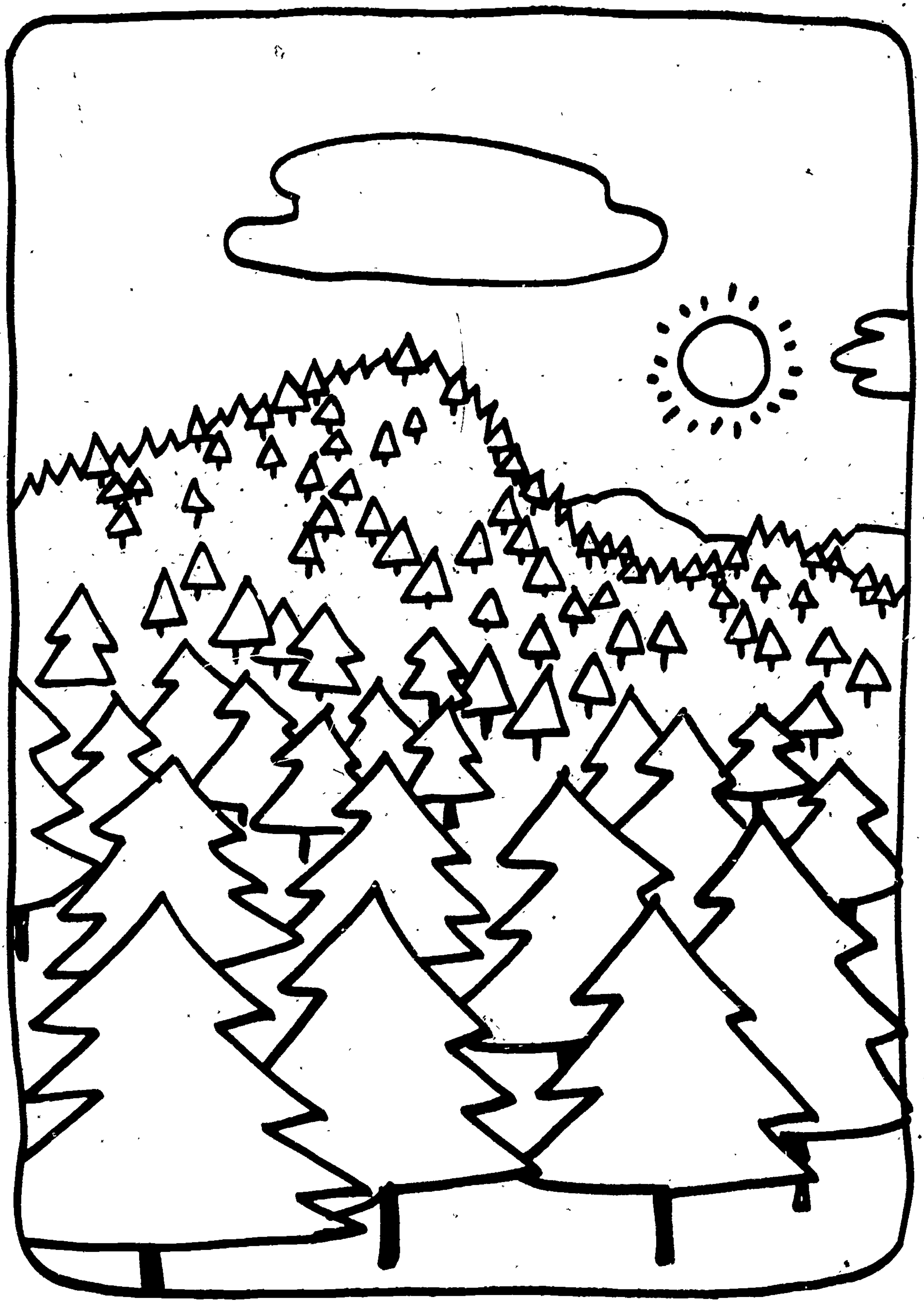




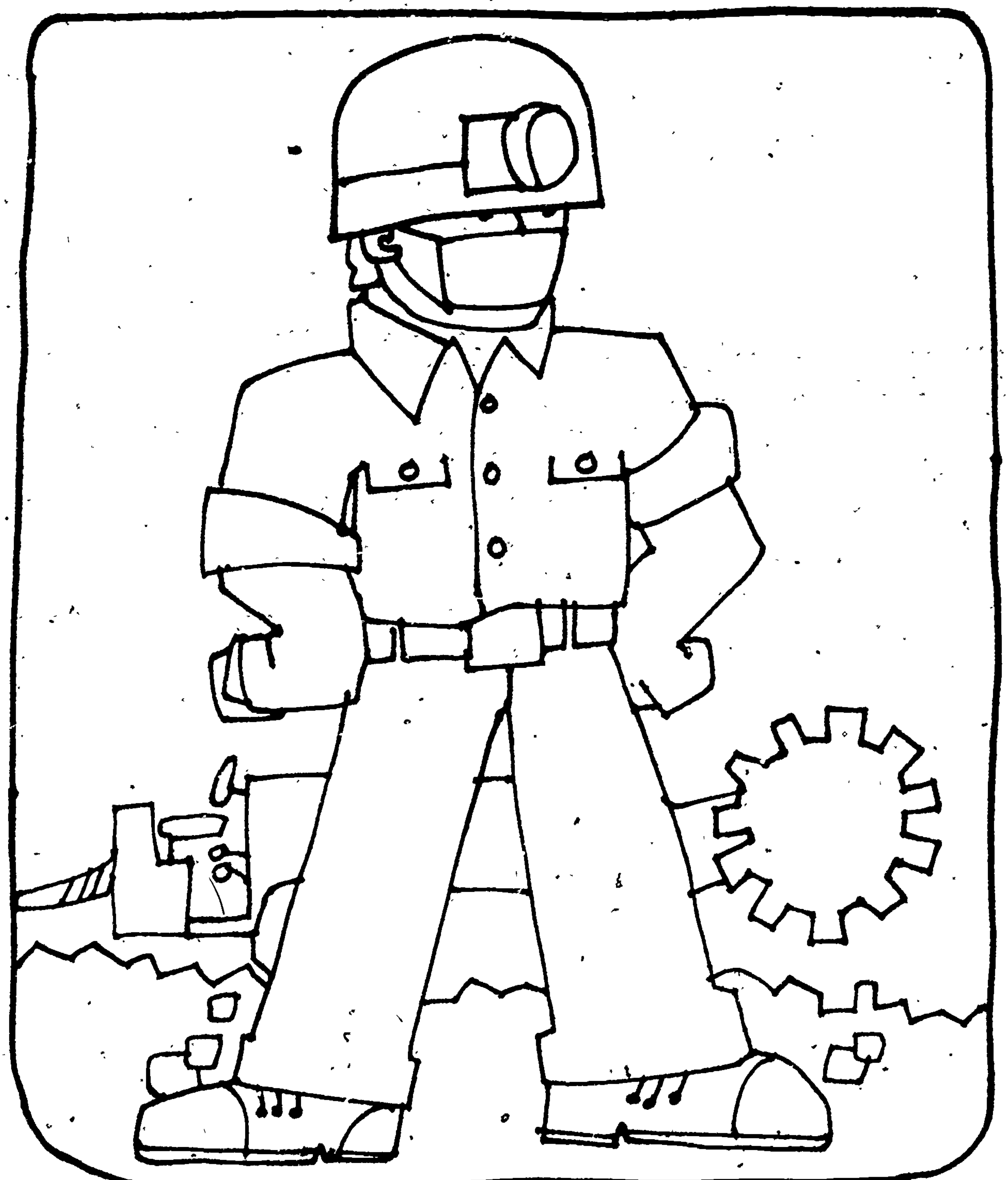
BOOK FIVE



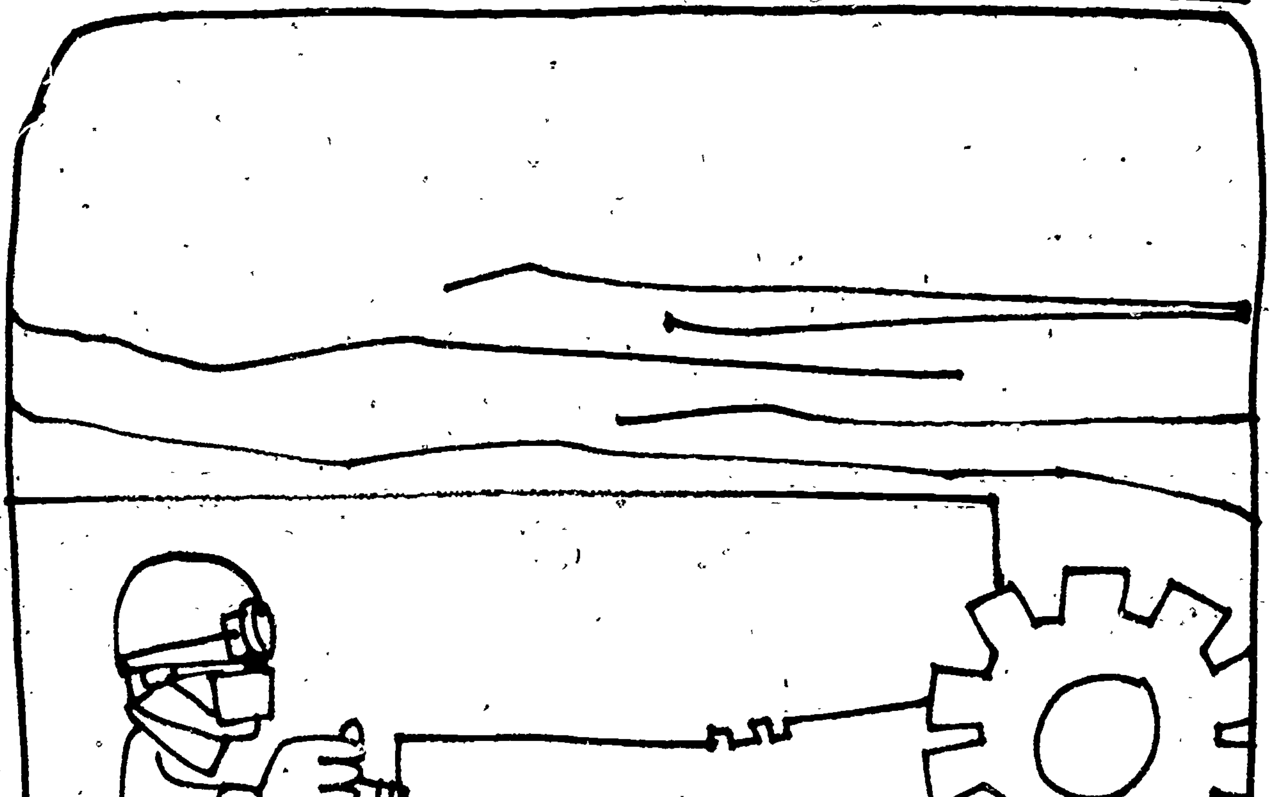
COAL AND ENERGY



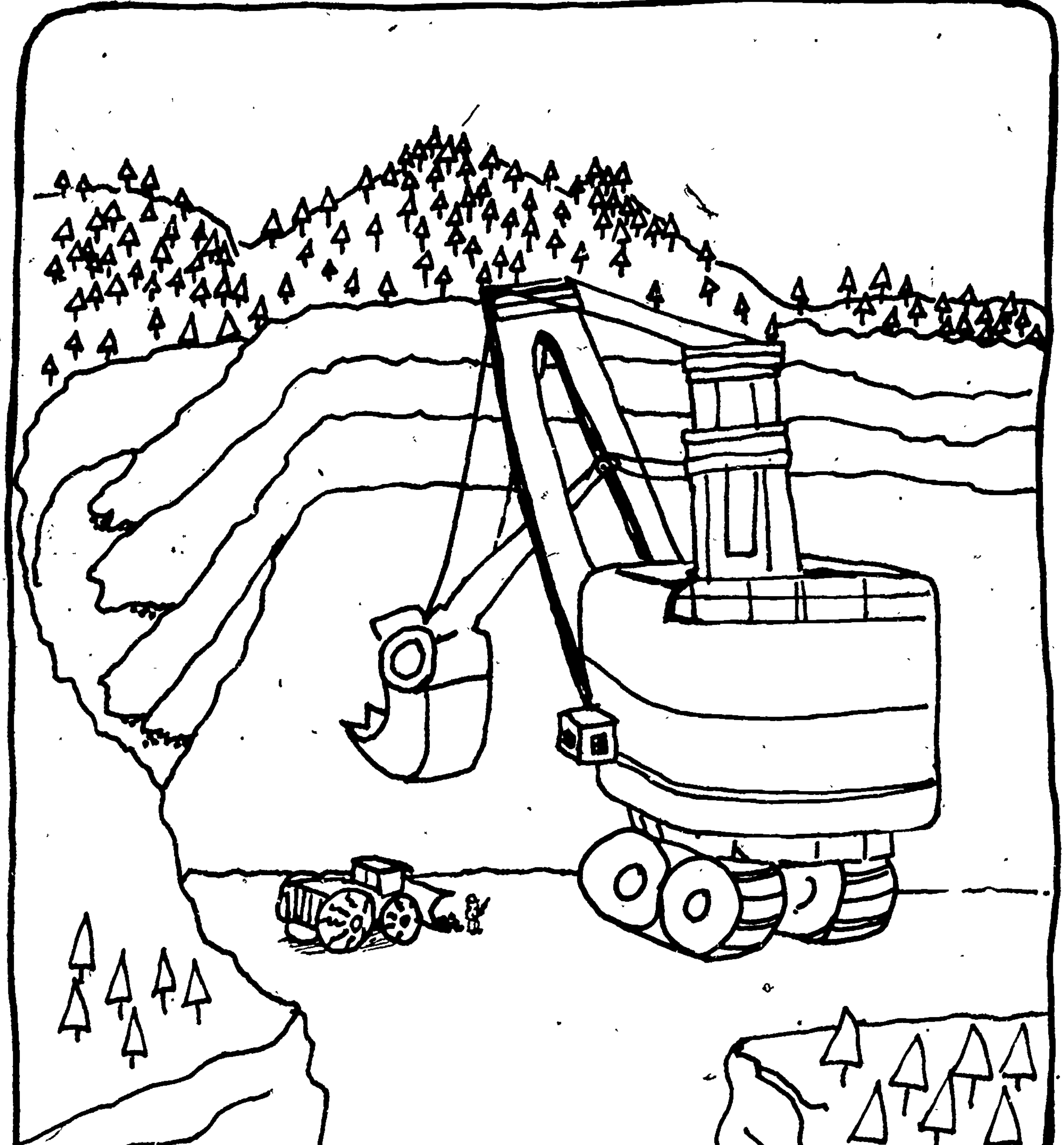
miner



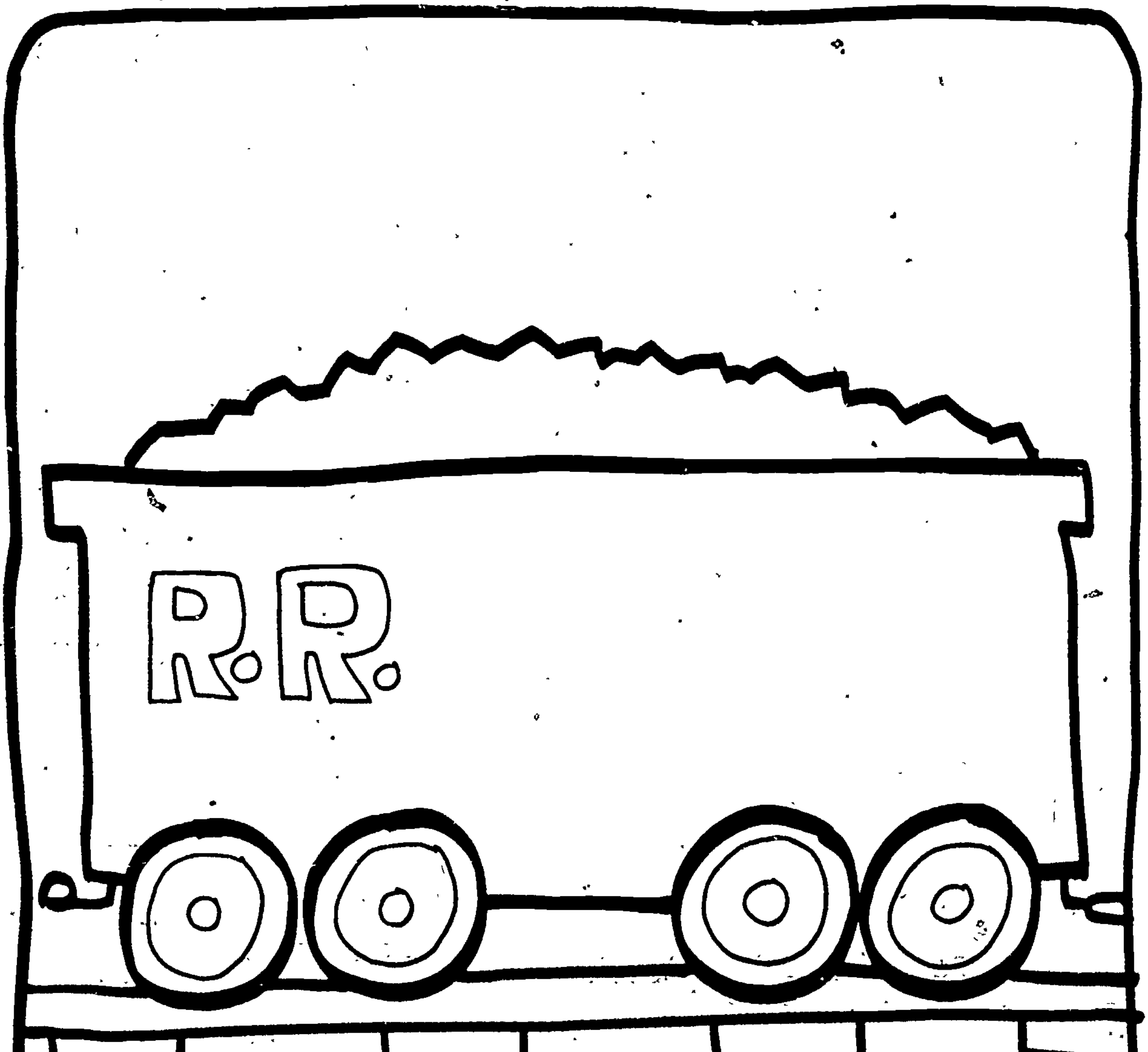
mining machine



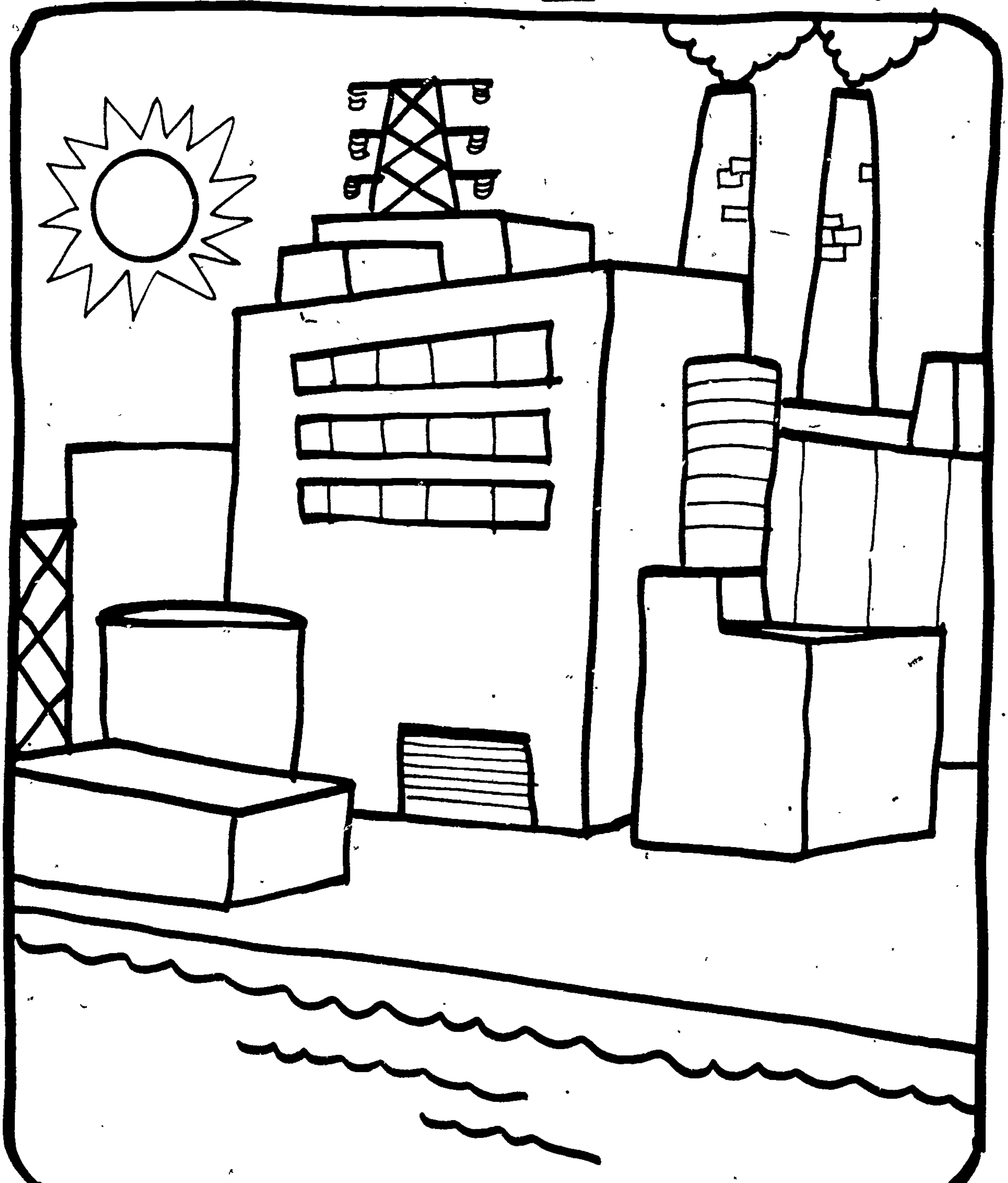
Strip mine



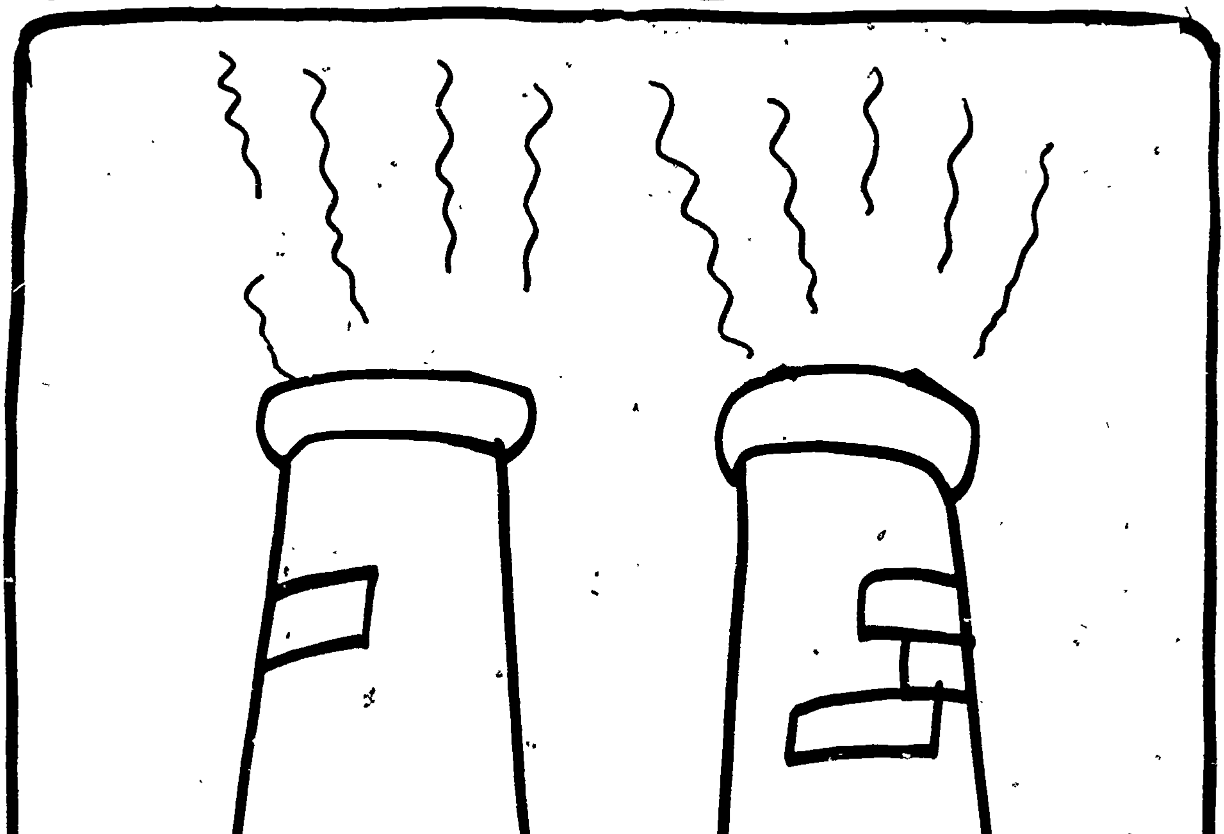
Coal Car



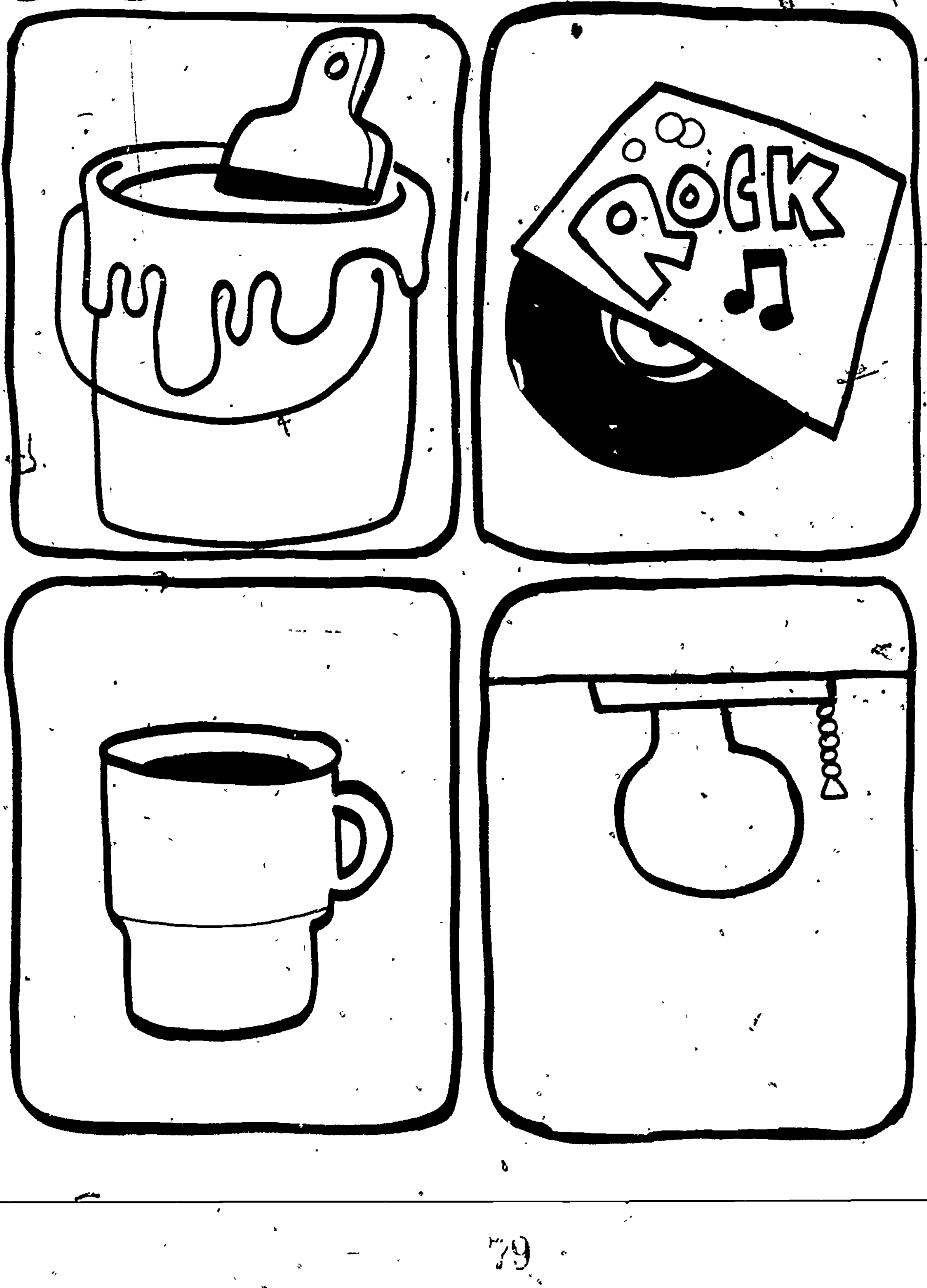
POWER PLANT

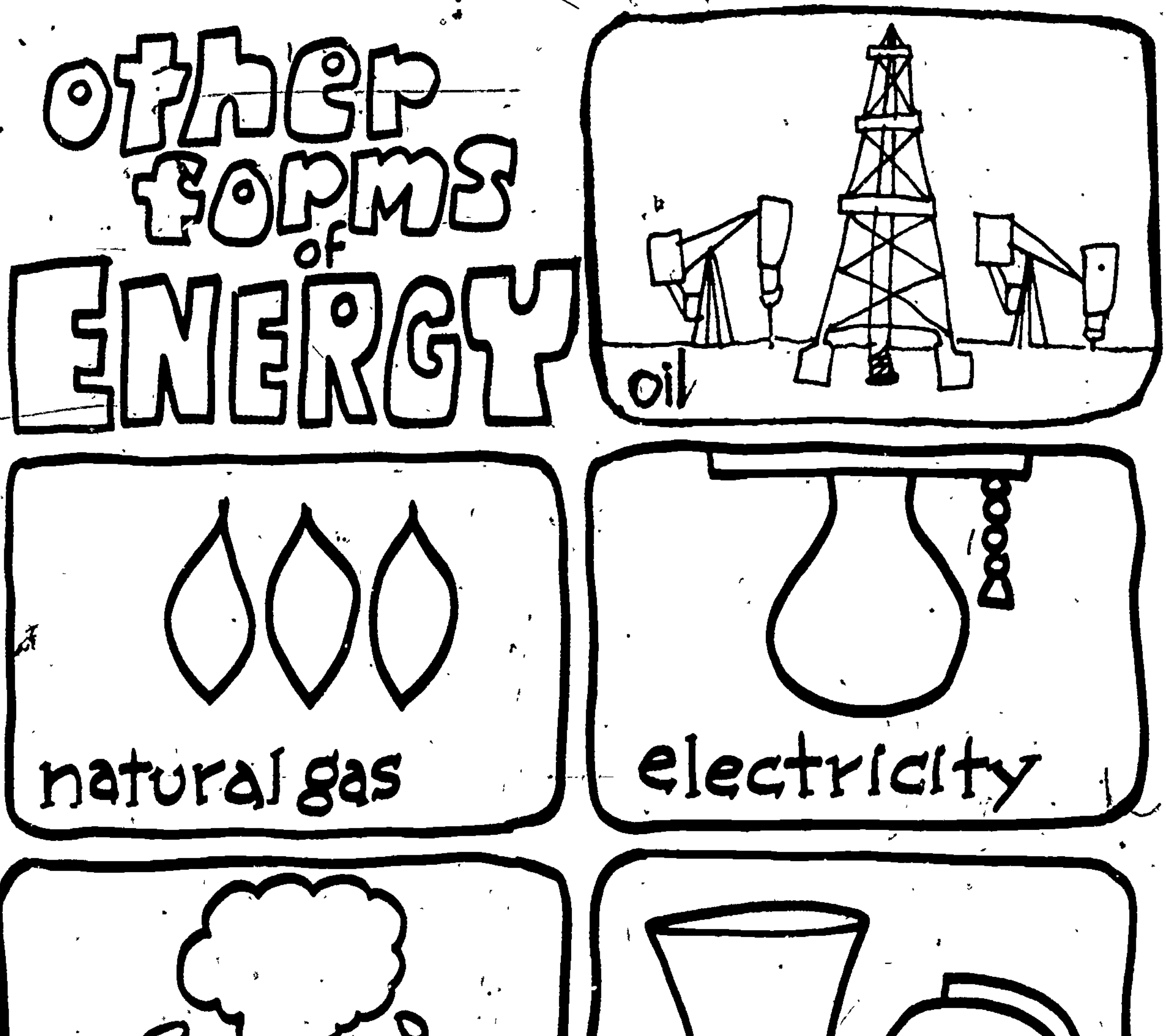


SMOKE STACKS

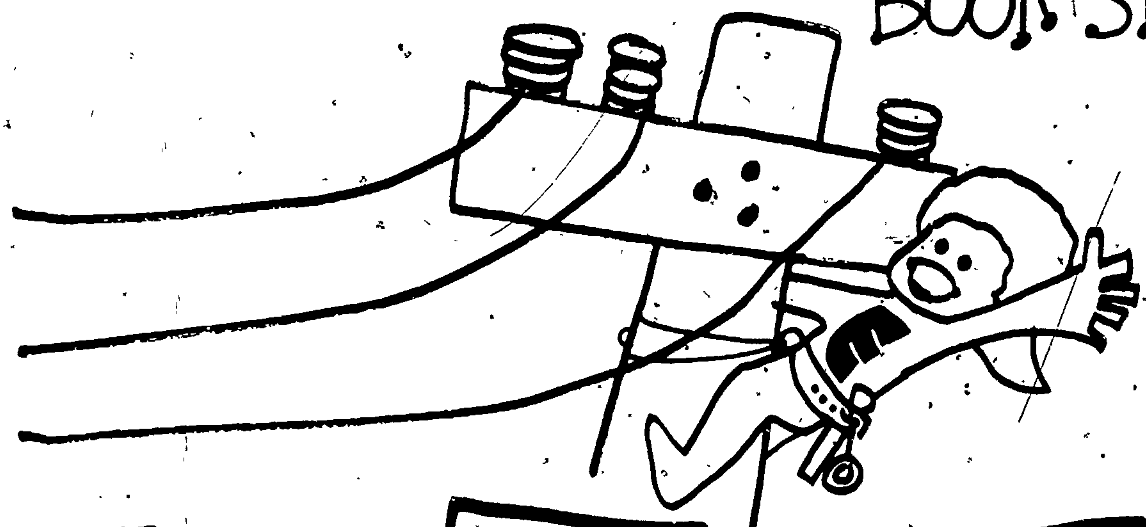


SOME COAL USES



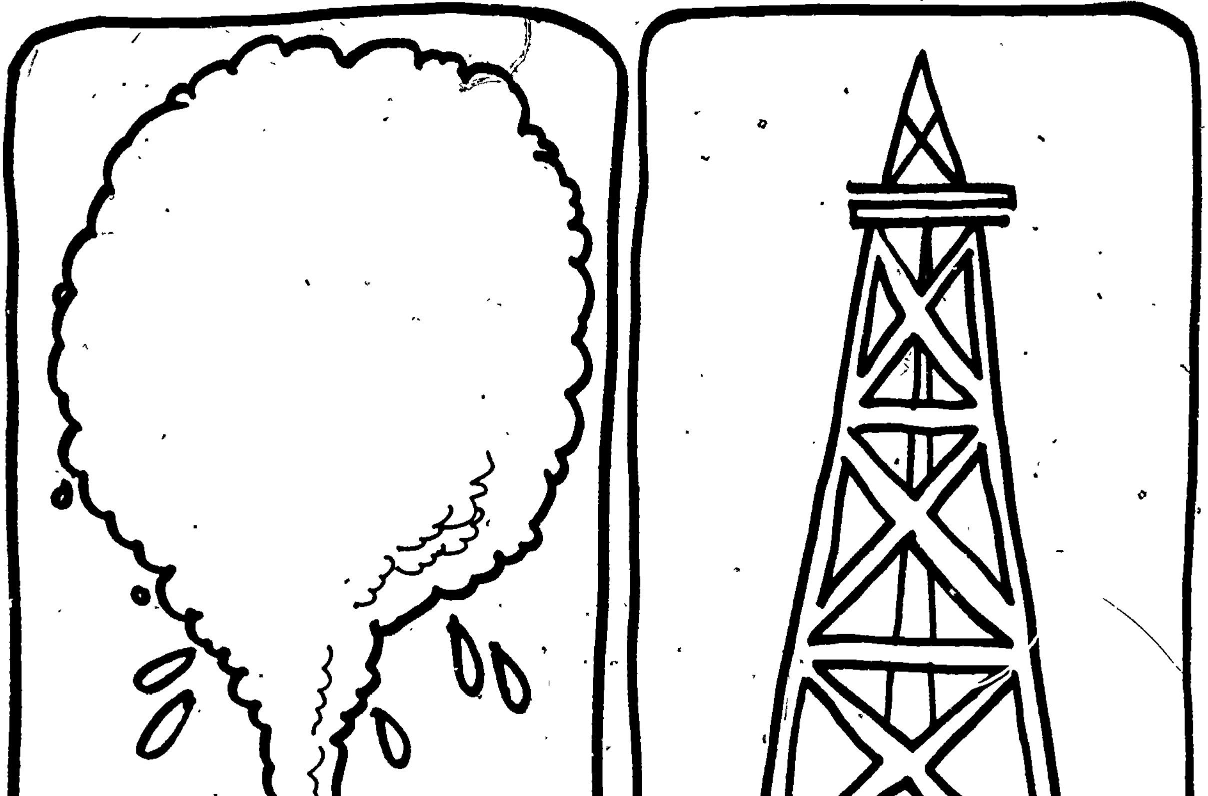

other forms of ENERGY
oil
natural gas
electricity
geo·thermal
nuclear
solar
food

BOOK SIX

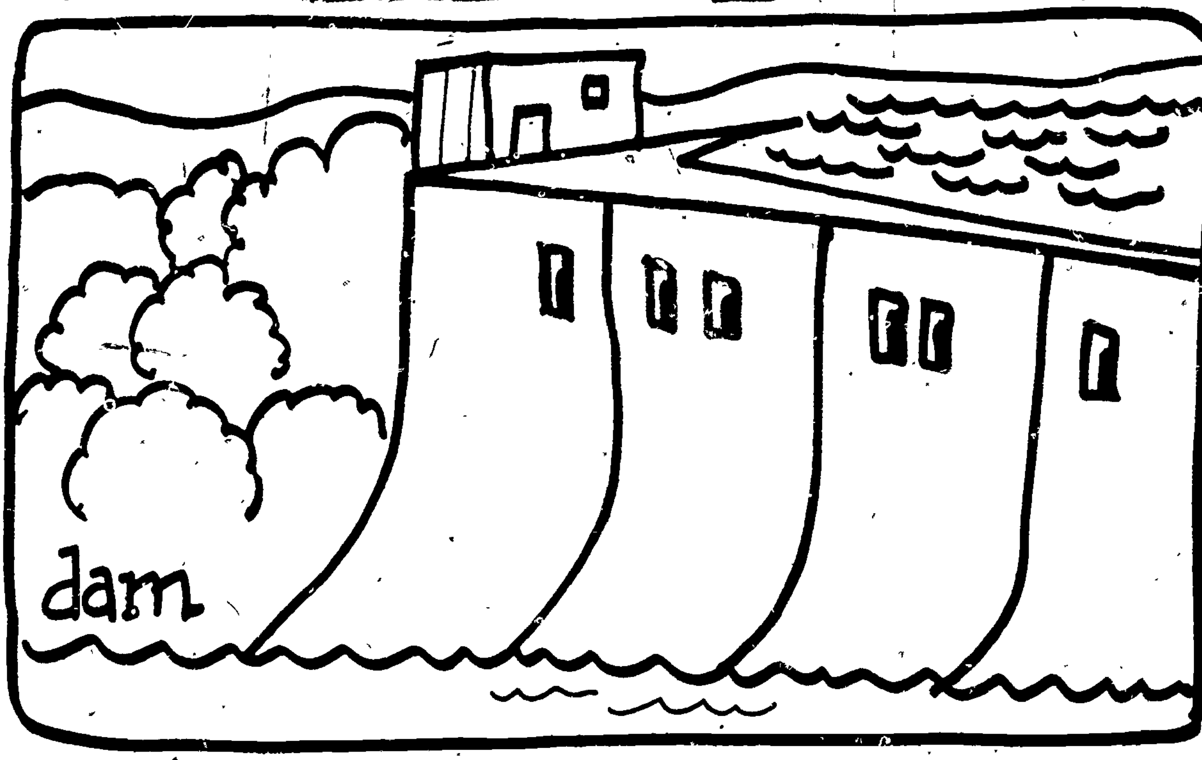


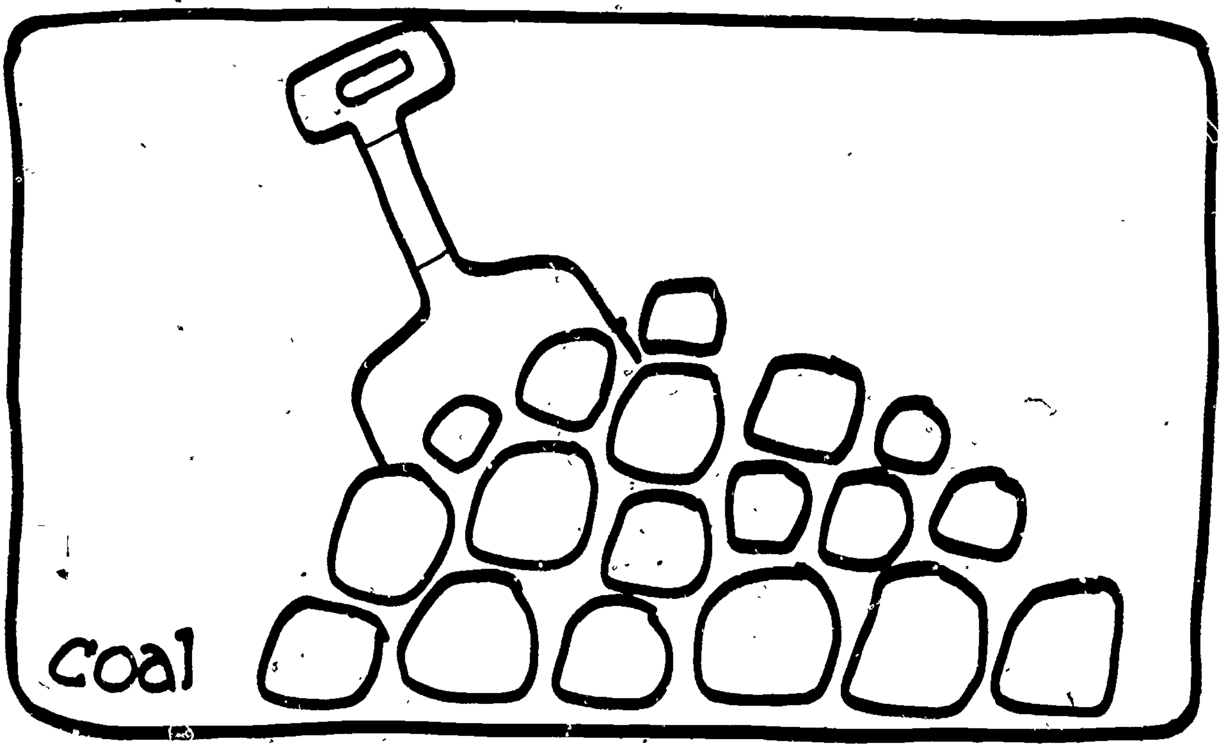
ELECTRICITY AND ENERGY

Sources of

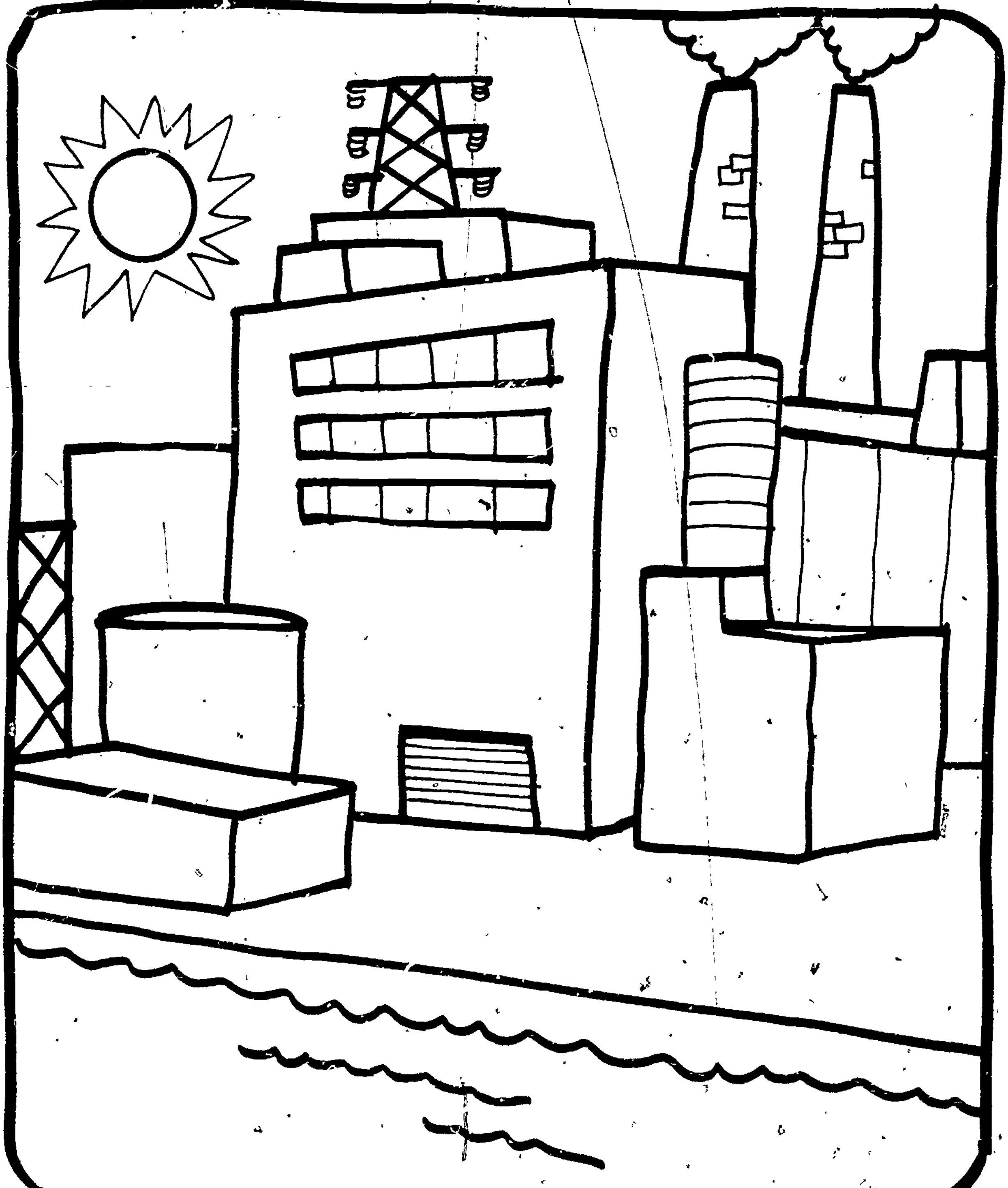


electric power

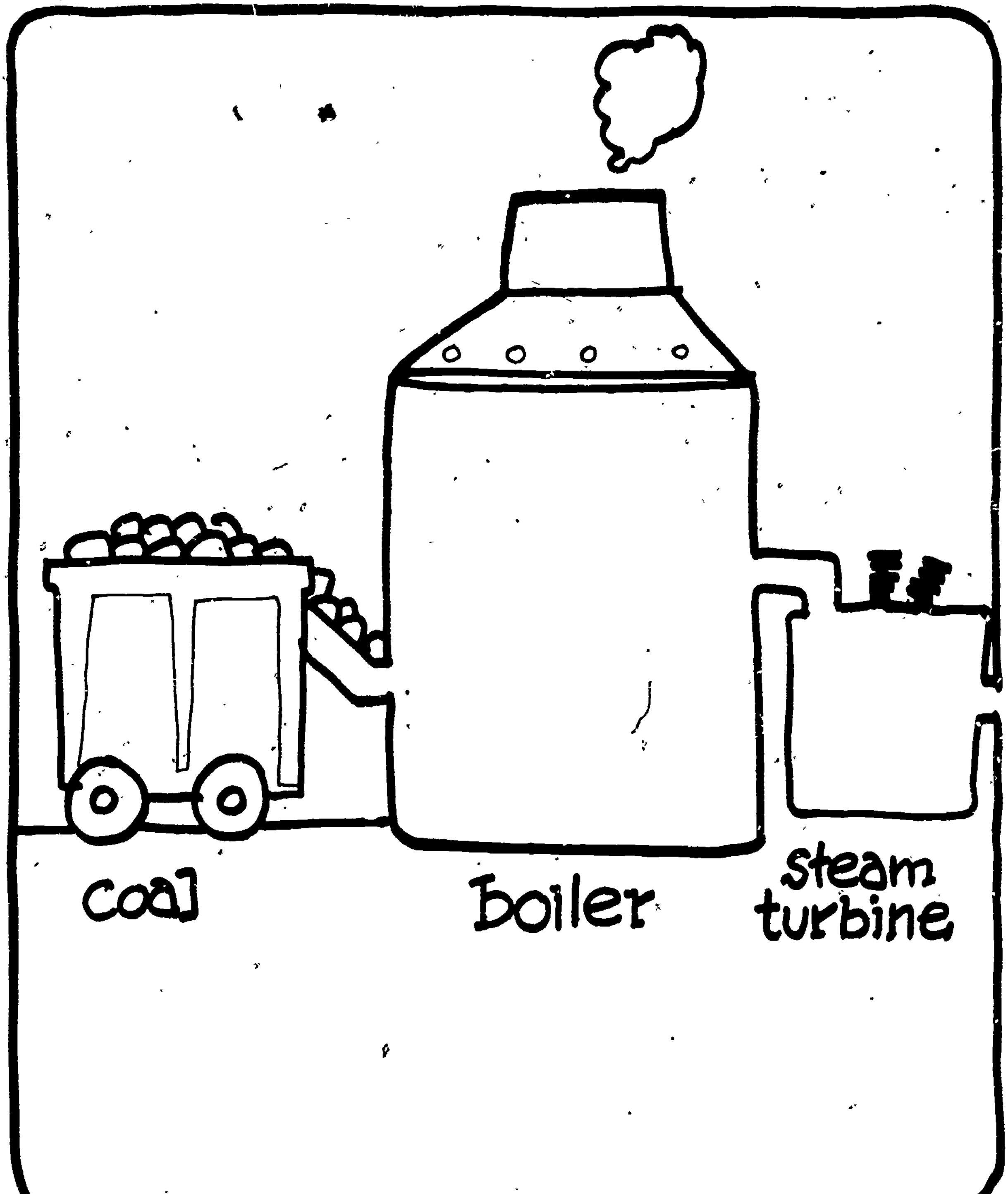


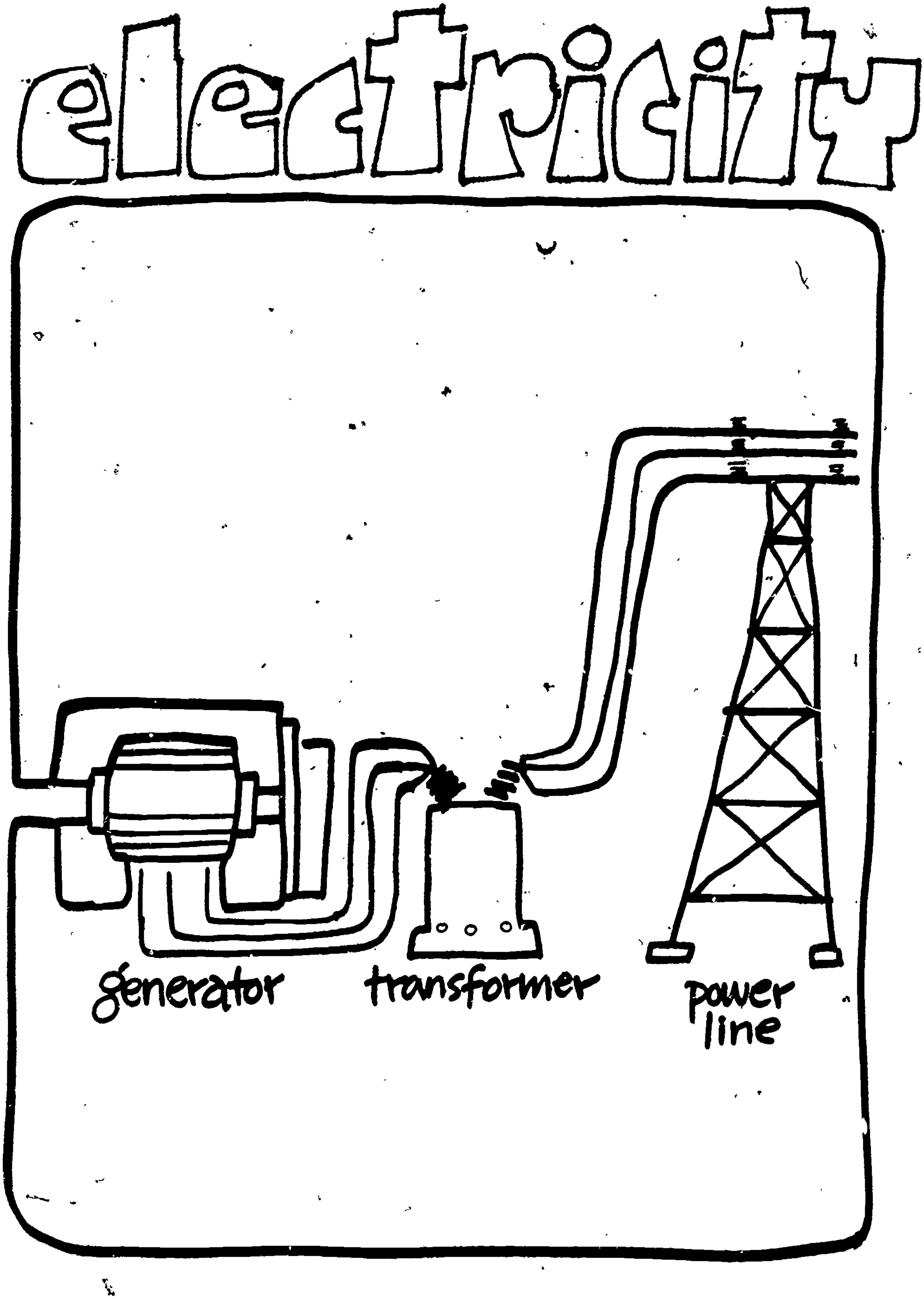


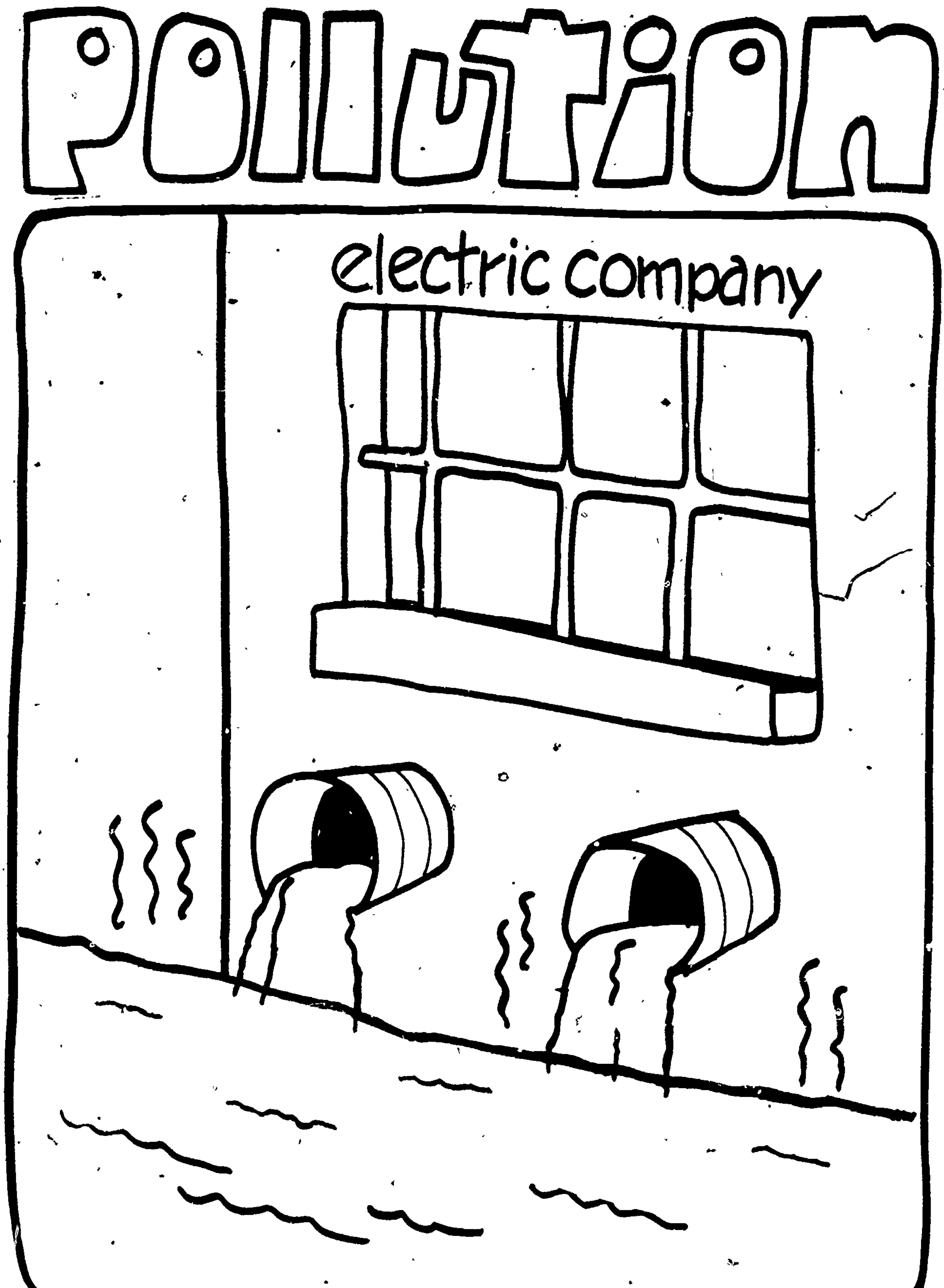
Power Plant



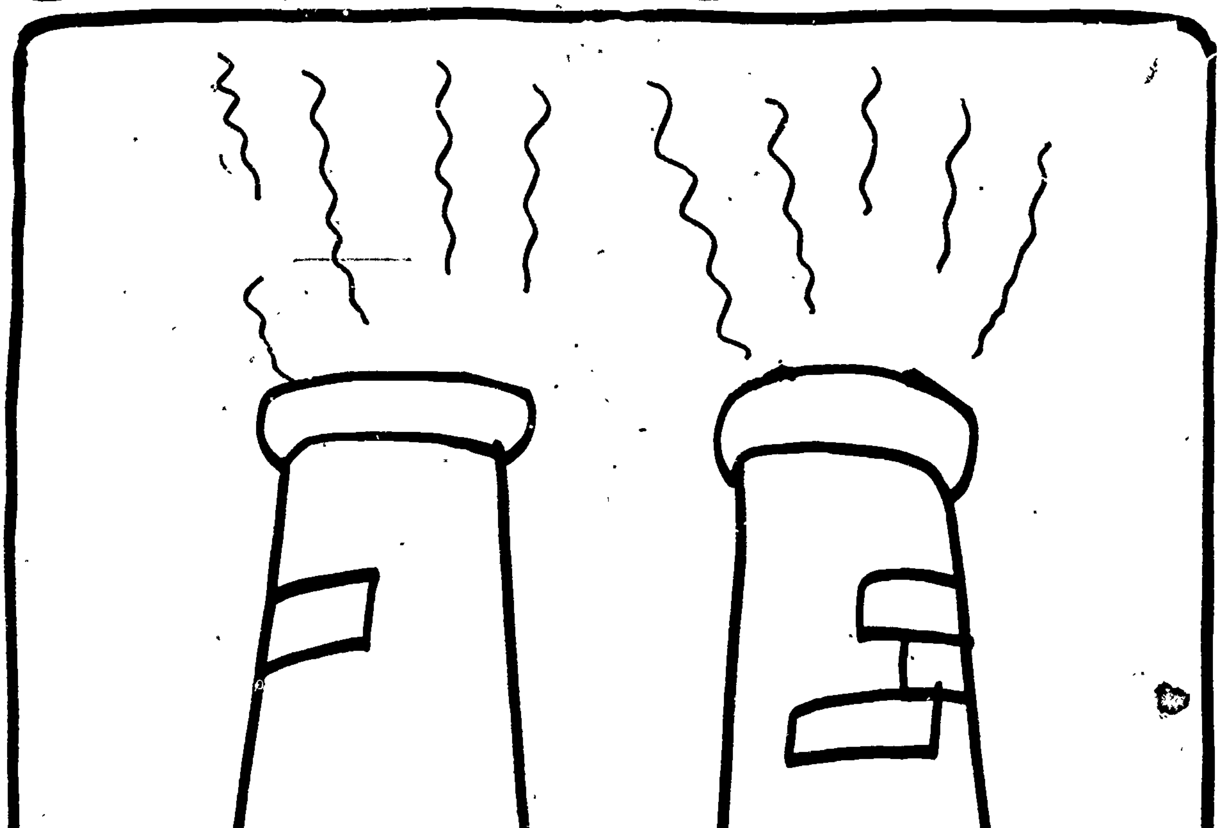
MAKING



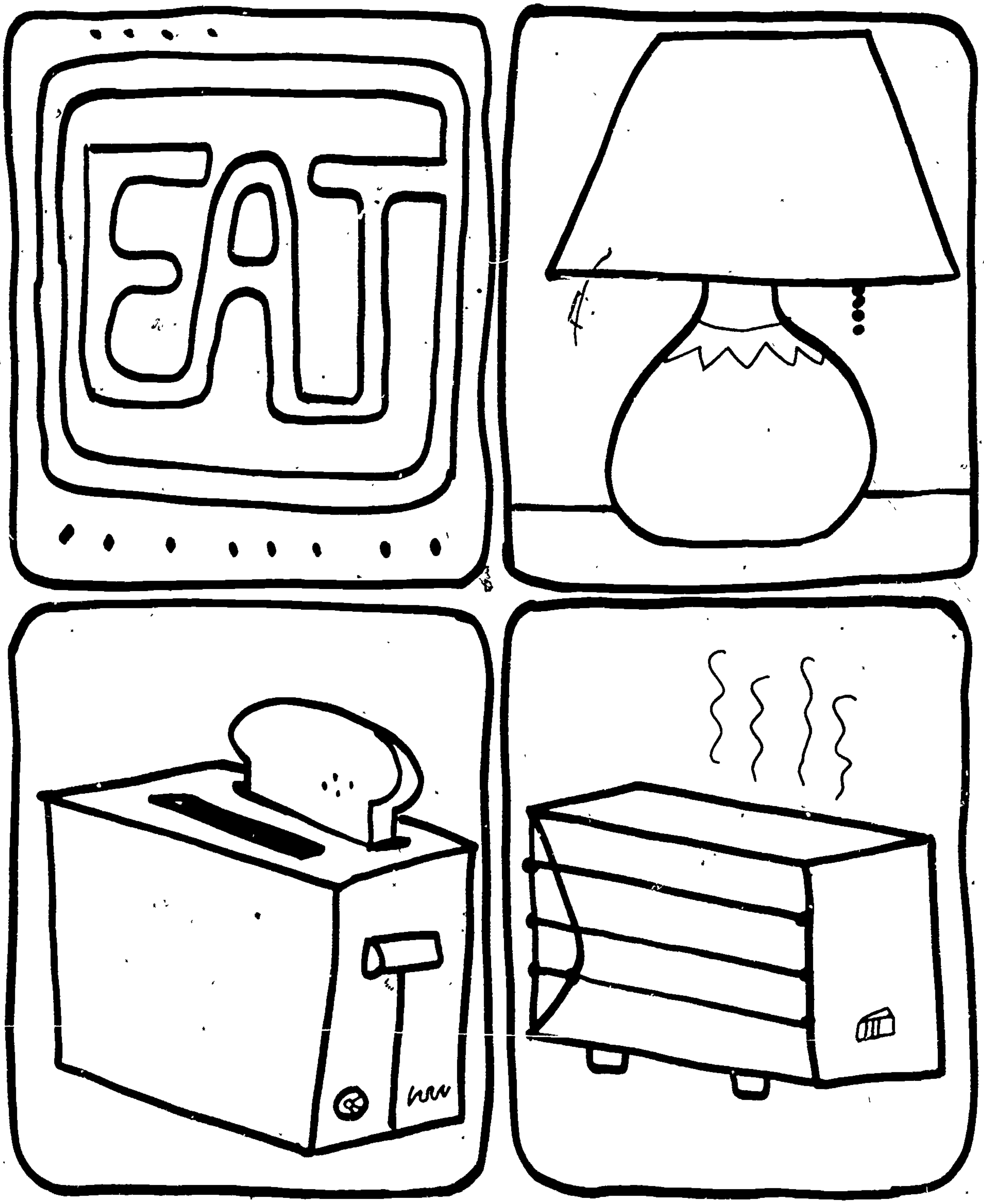

electricity
generator
transformer
power line

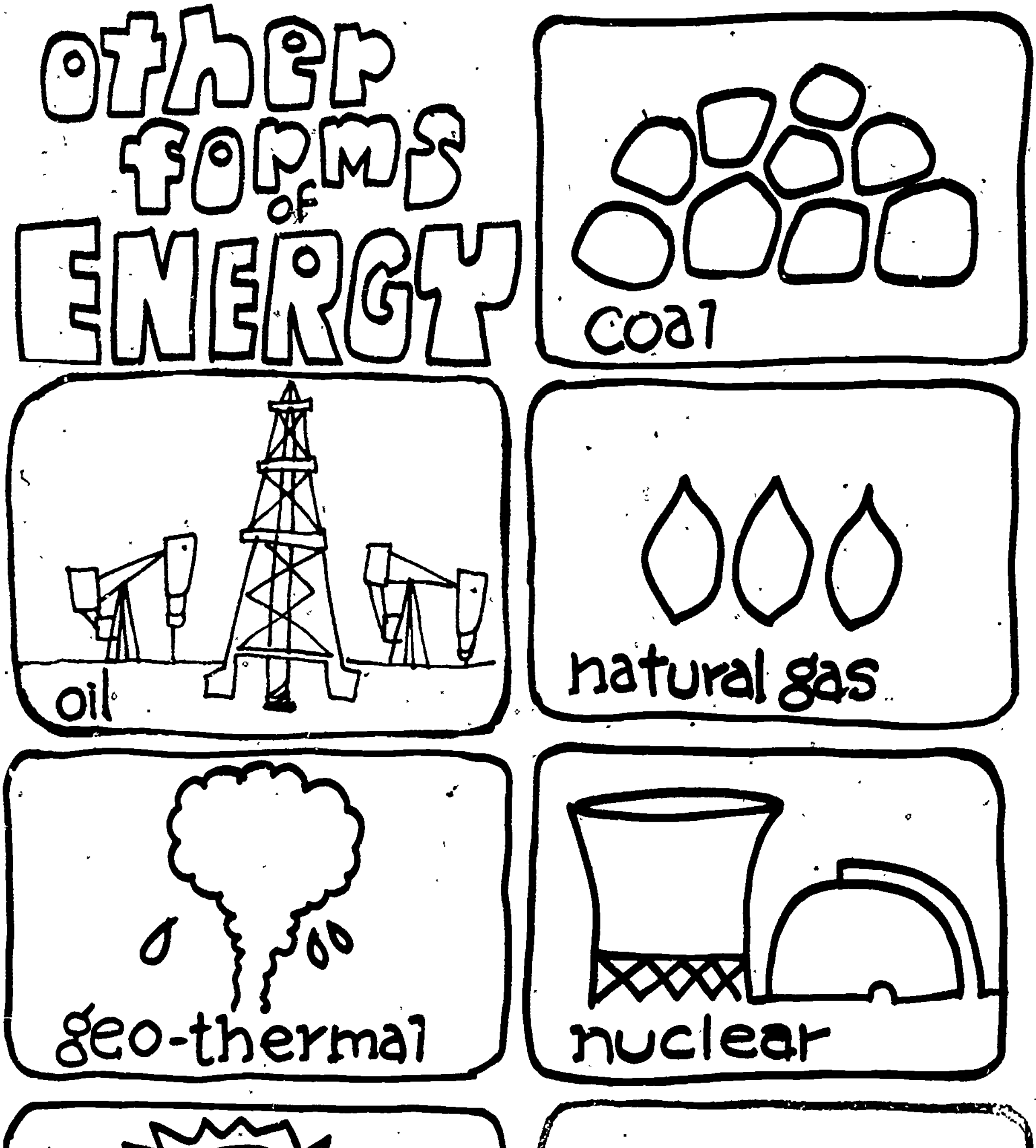

POLLUTION
electric company

Smoke Stacks

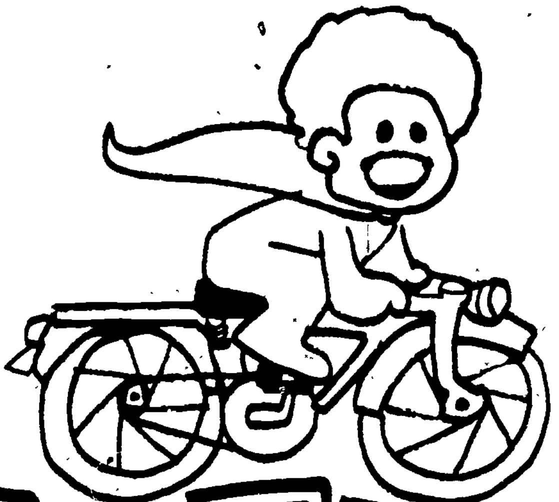


Some electricity uses

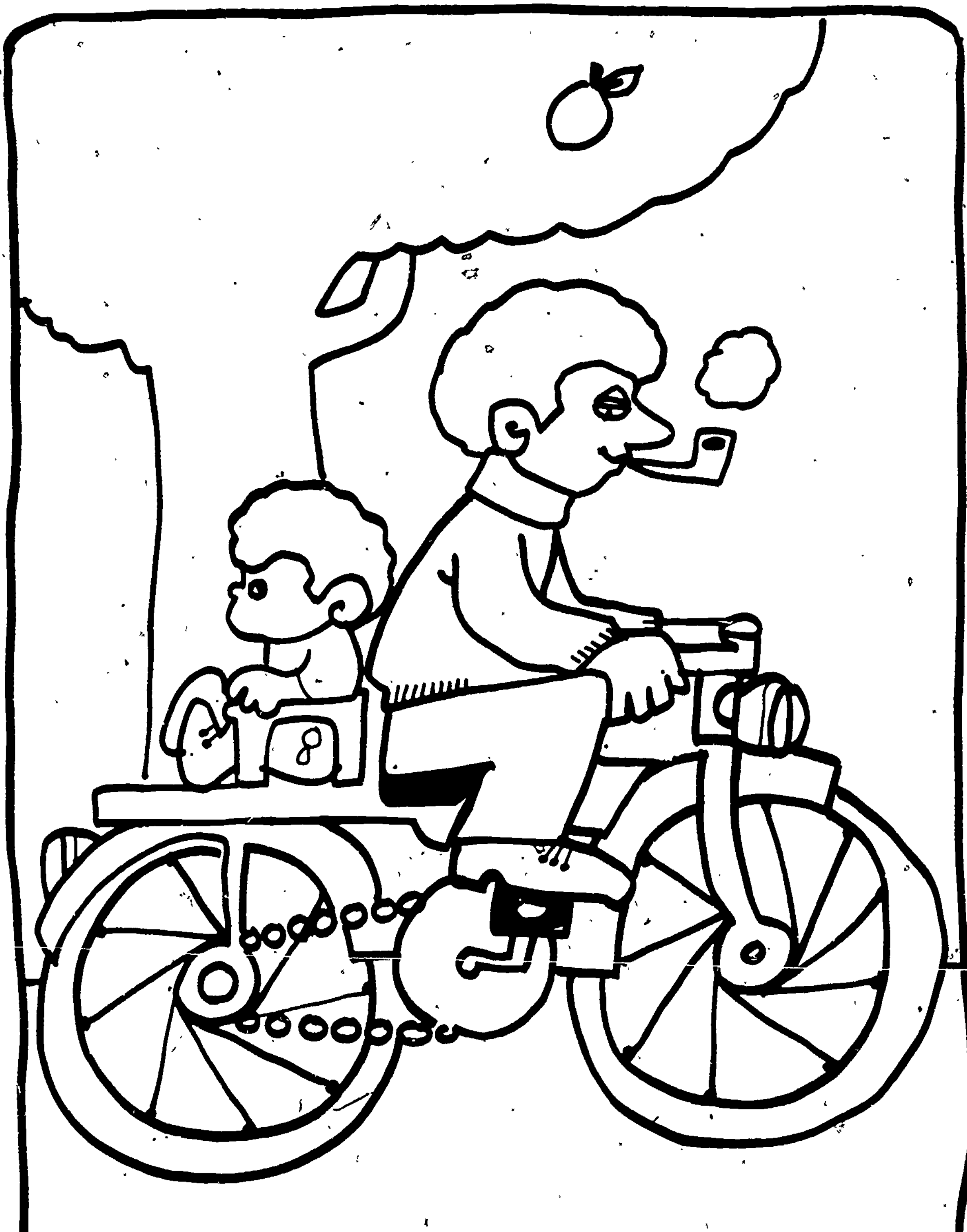



other forms of ENERGY
coal
oil
natural gas
geo-thermal
nuclear
solar
food

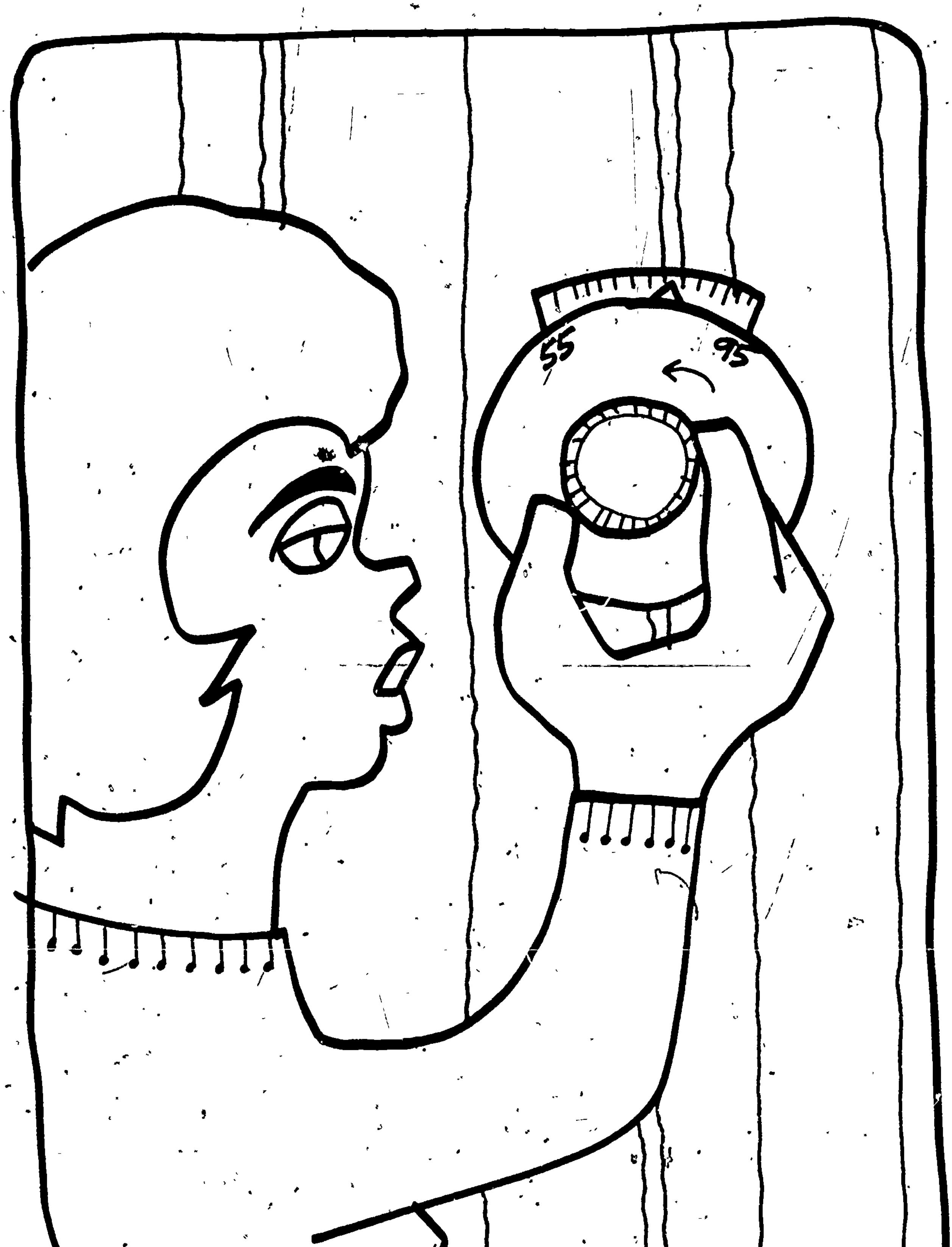
BOOK SEVEN

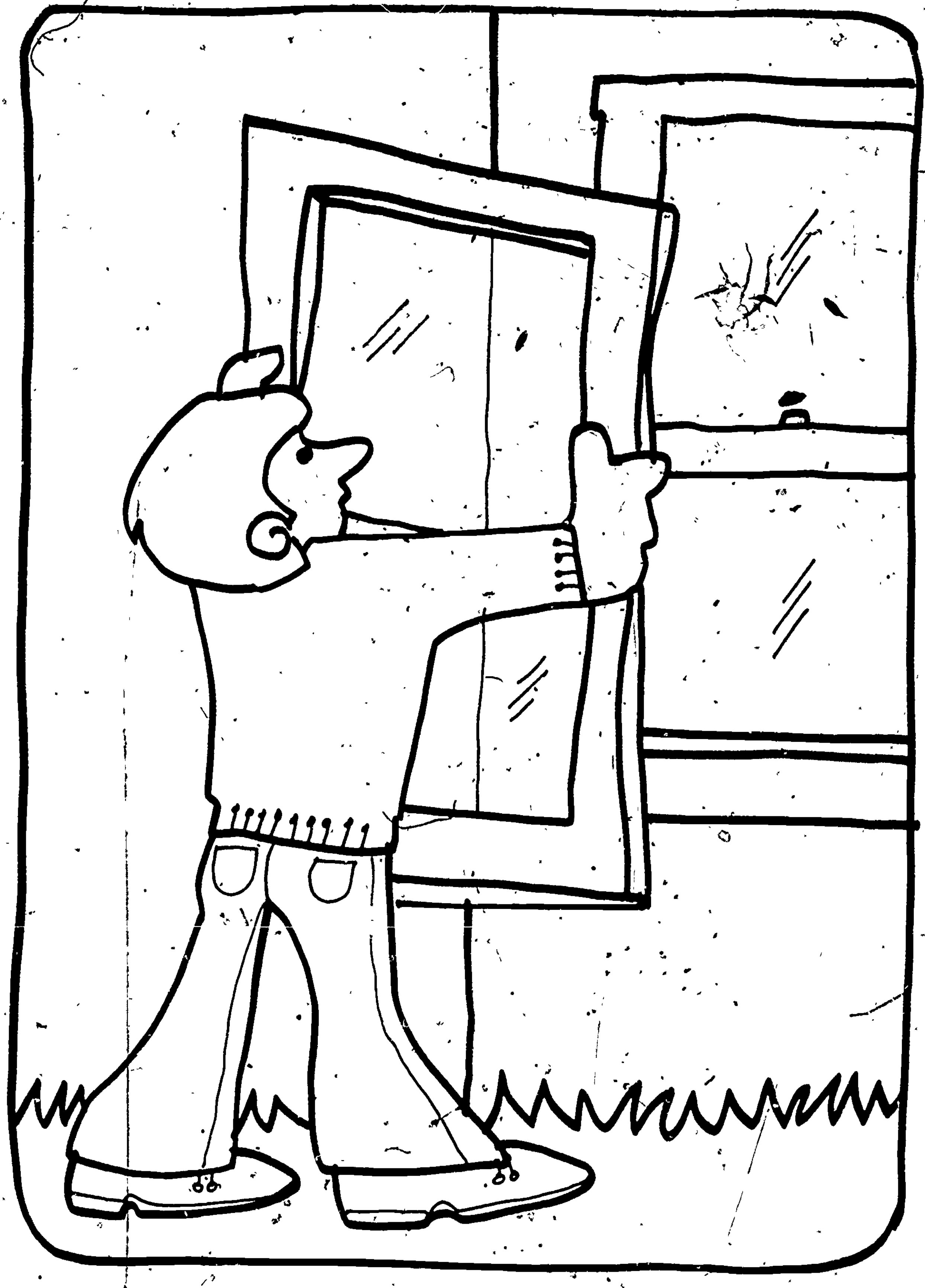


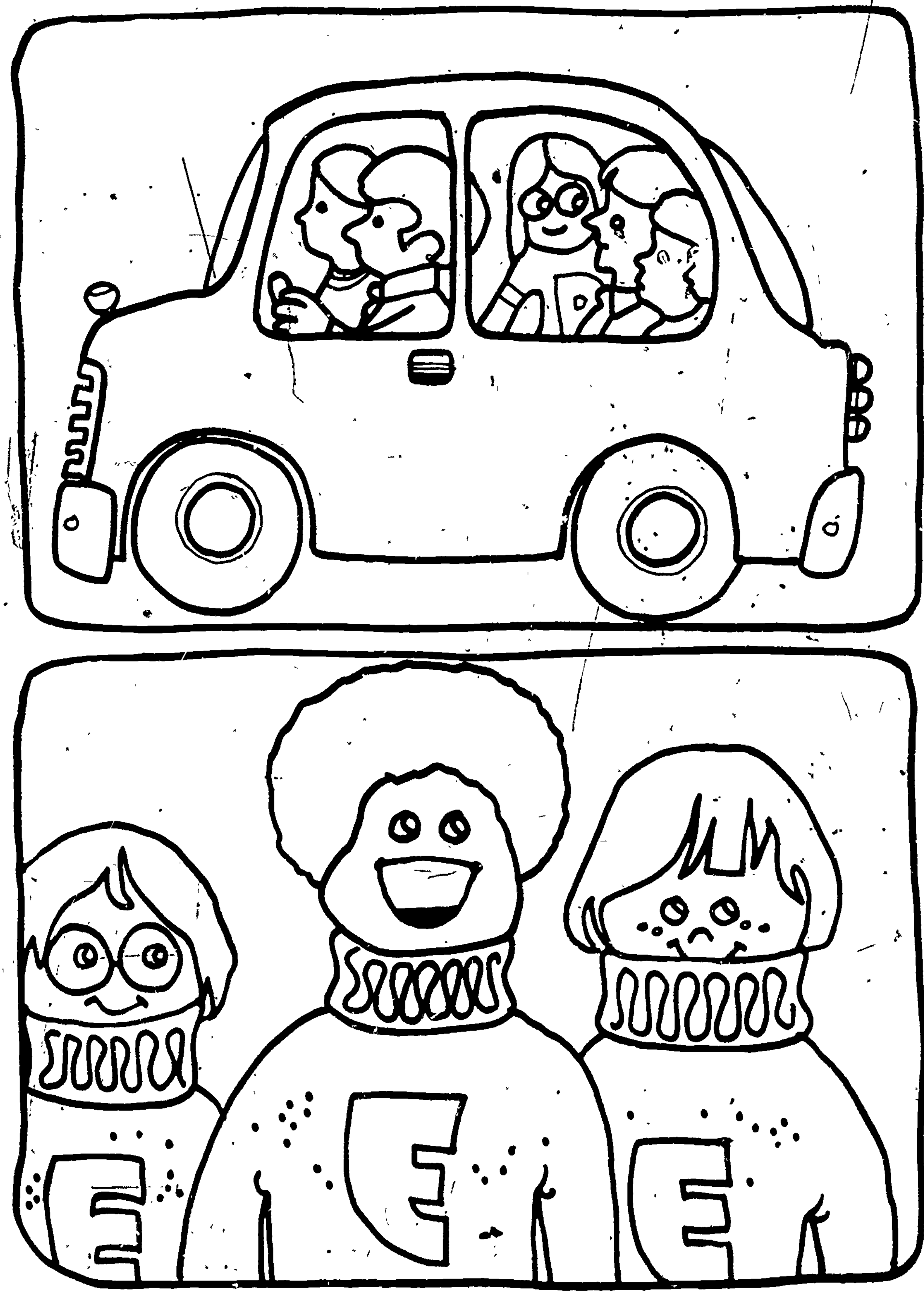
ENERGY can be CONSERVED


8


ON
OFF

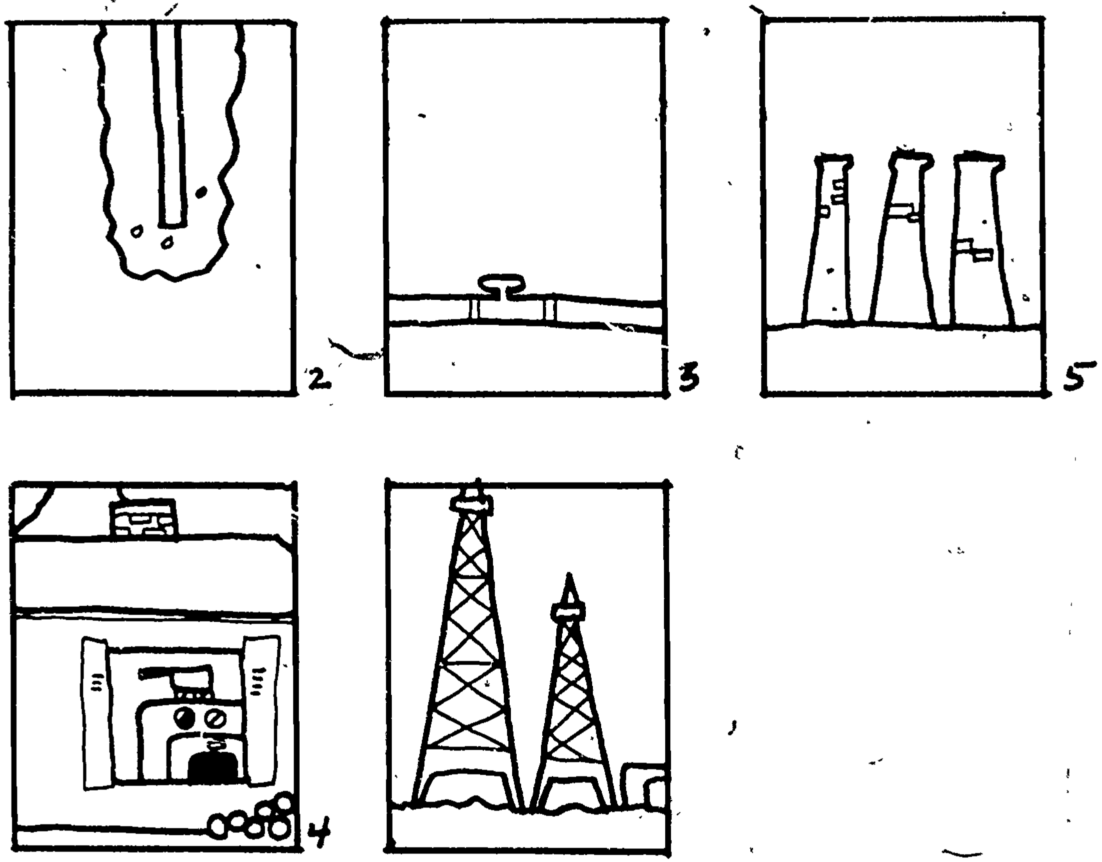

55
95



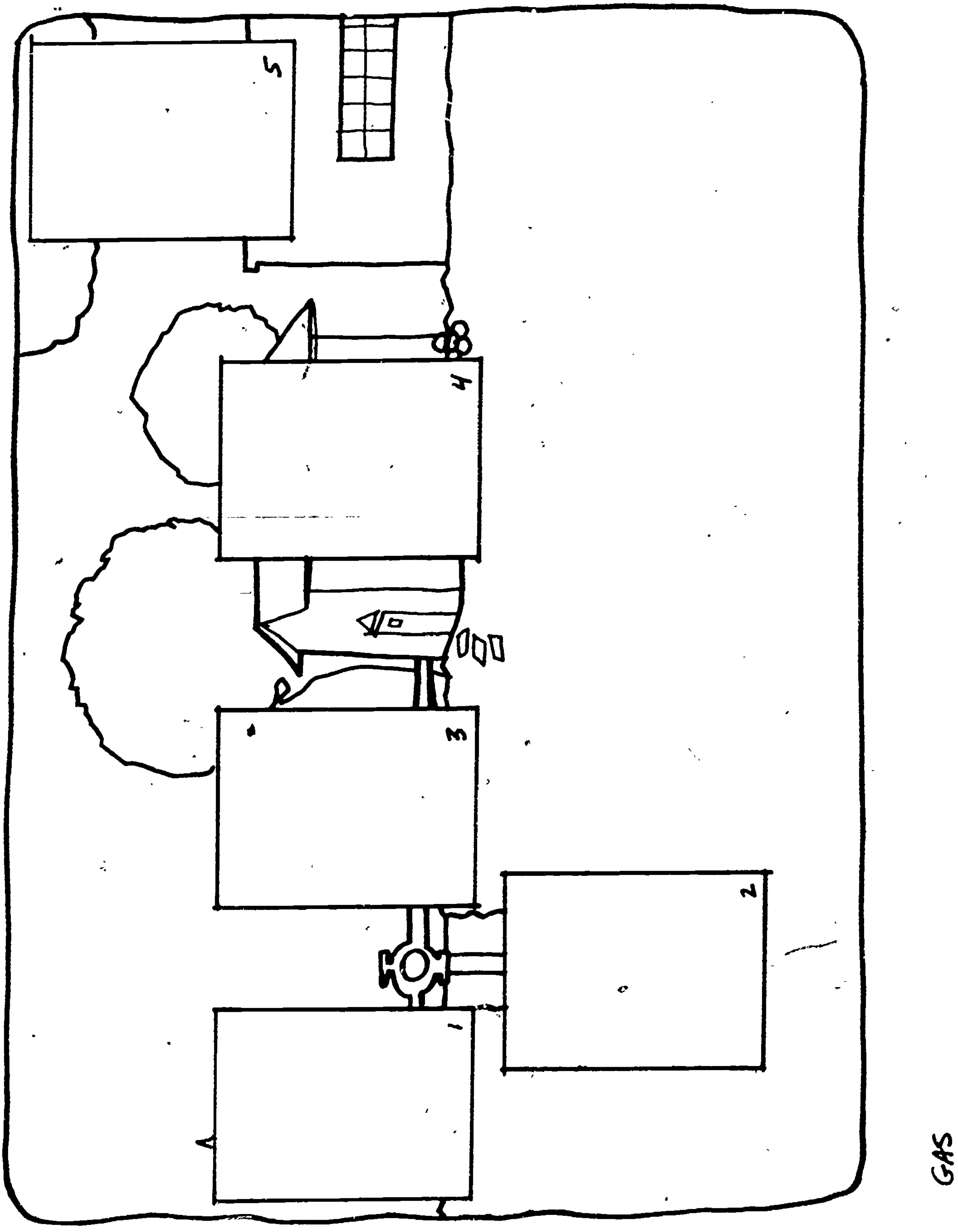


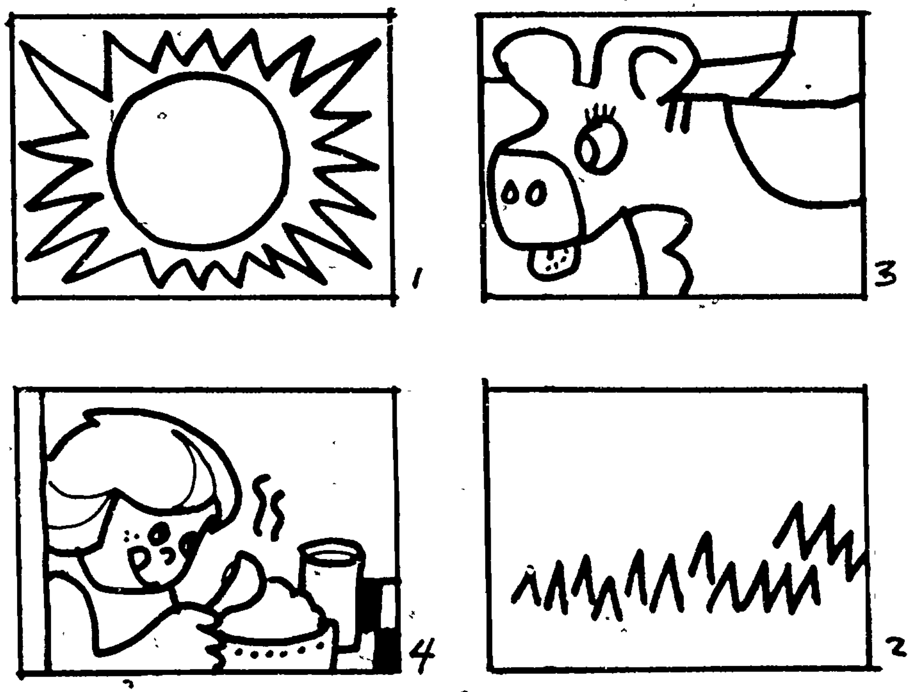
ENERGY STAMPS

ENERGY STAMPS

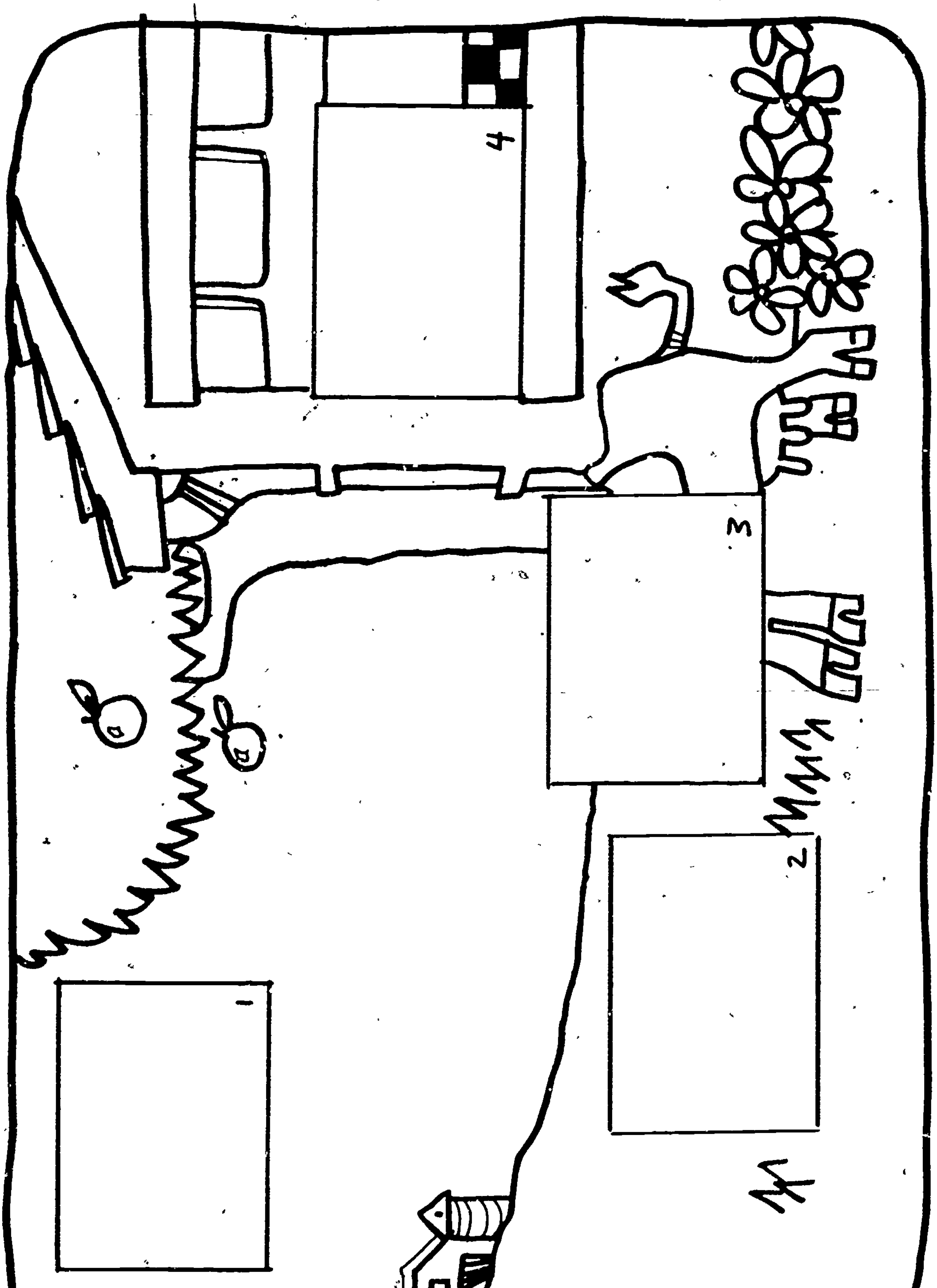


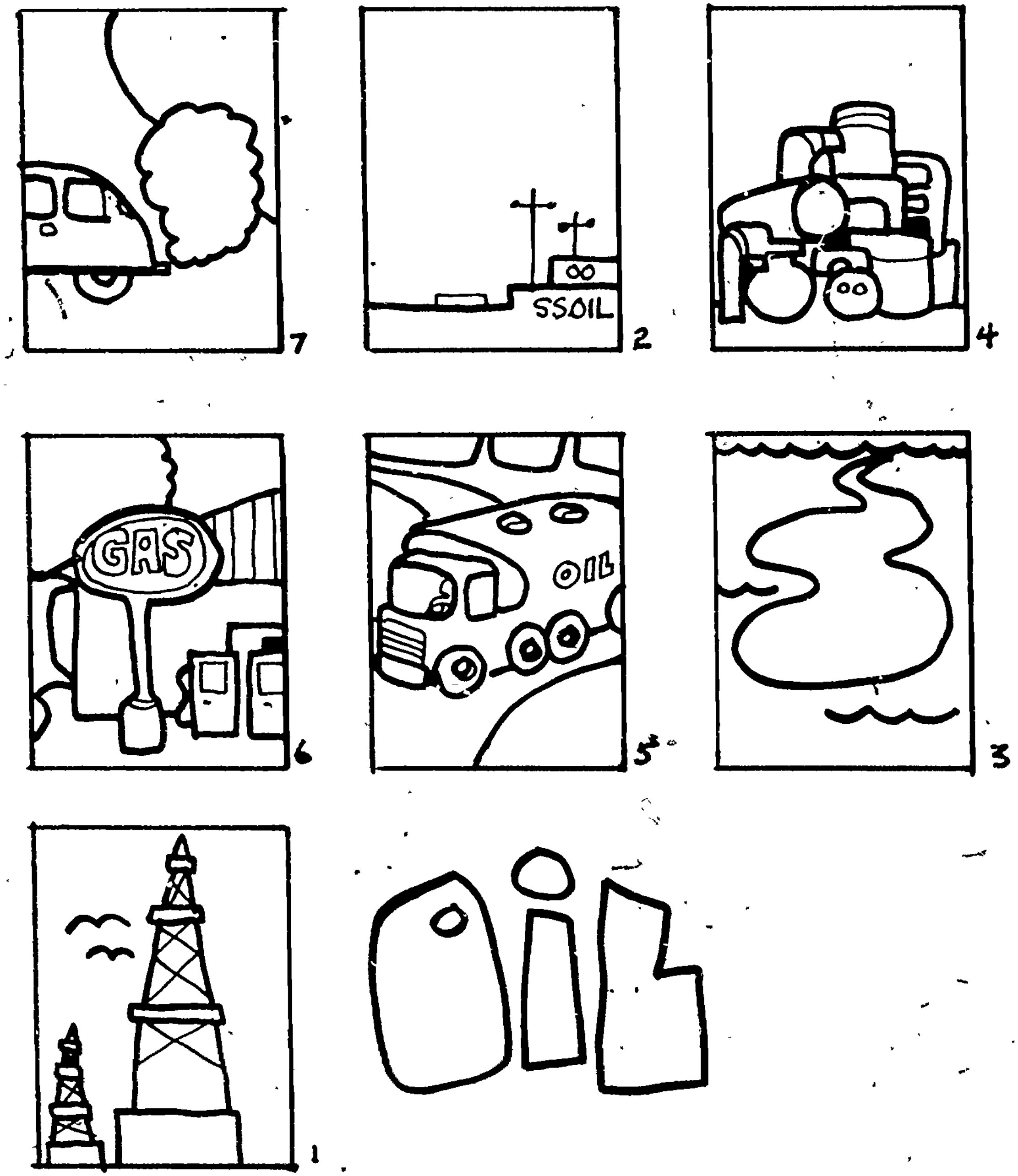
natural GAS

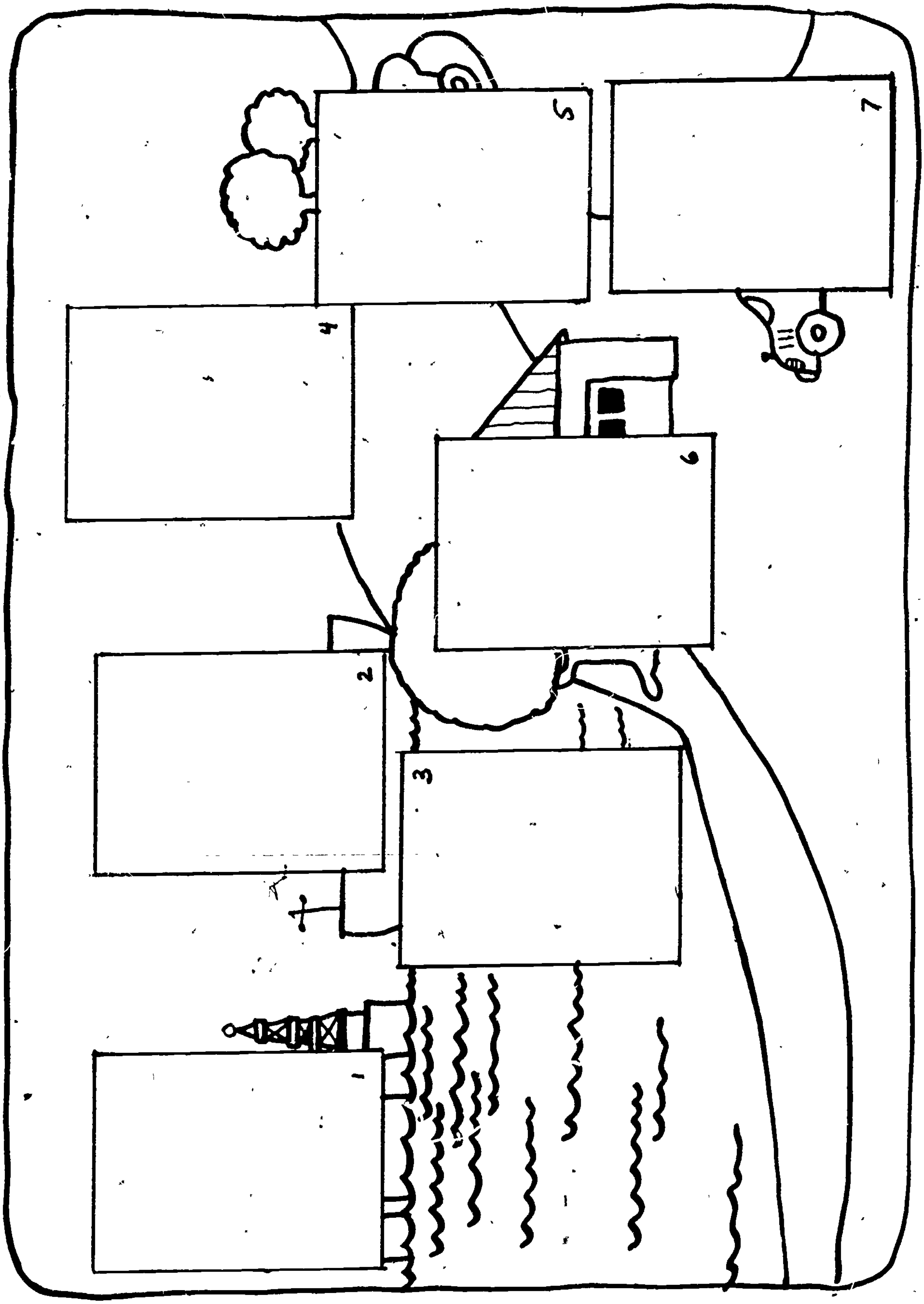

1
2
3
4
5
GAS

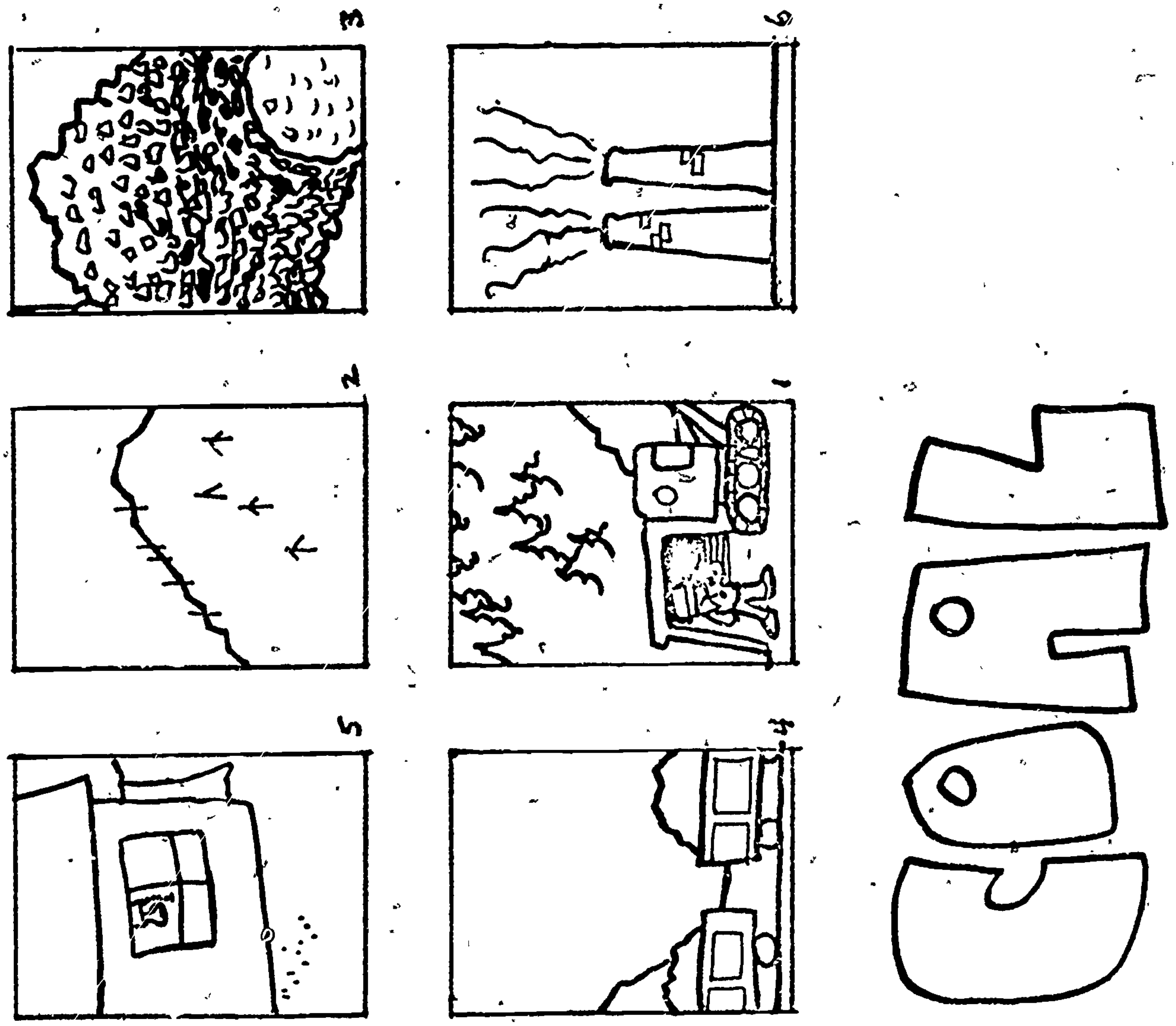


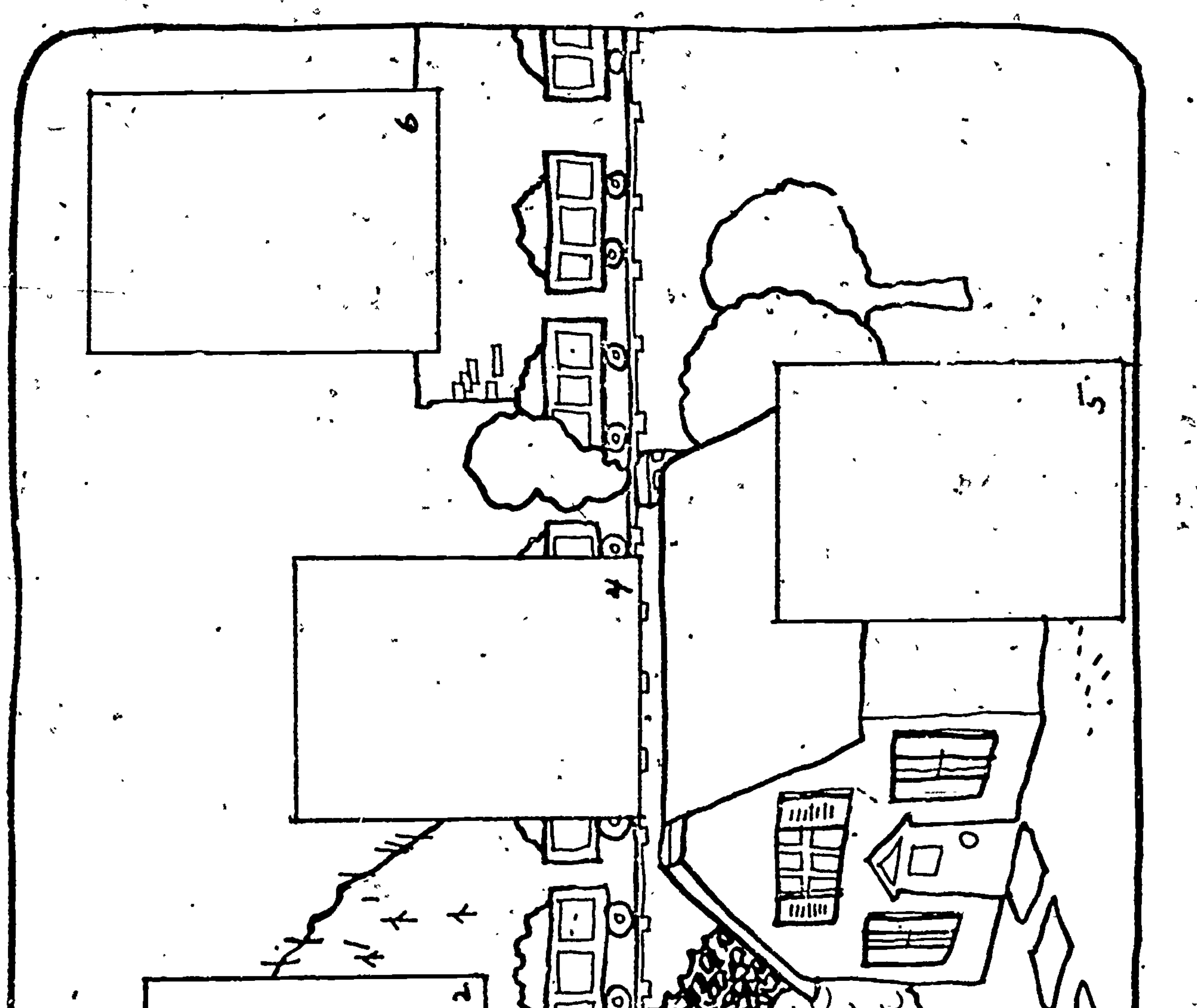
the FOOD CHAIN

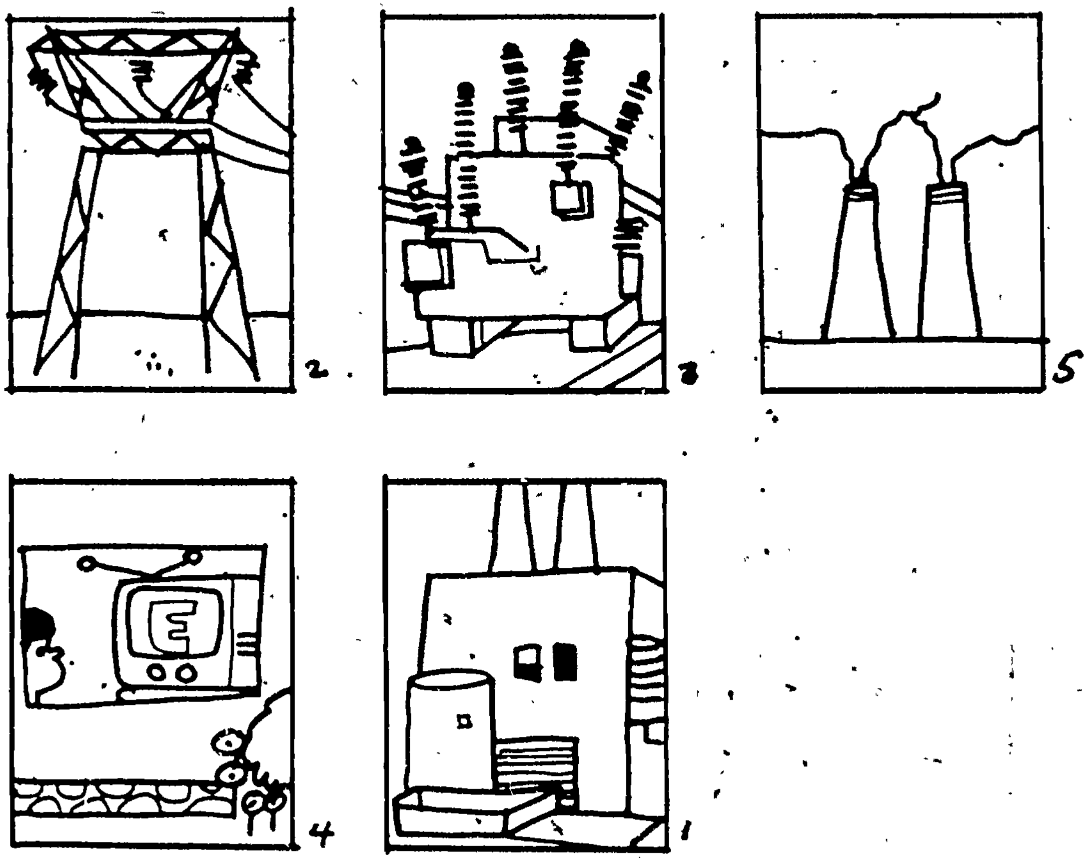

1
2
3
4


7
SSOIL
2
4
GAS
6
OIL
5
3
1
oil

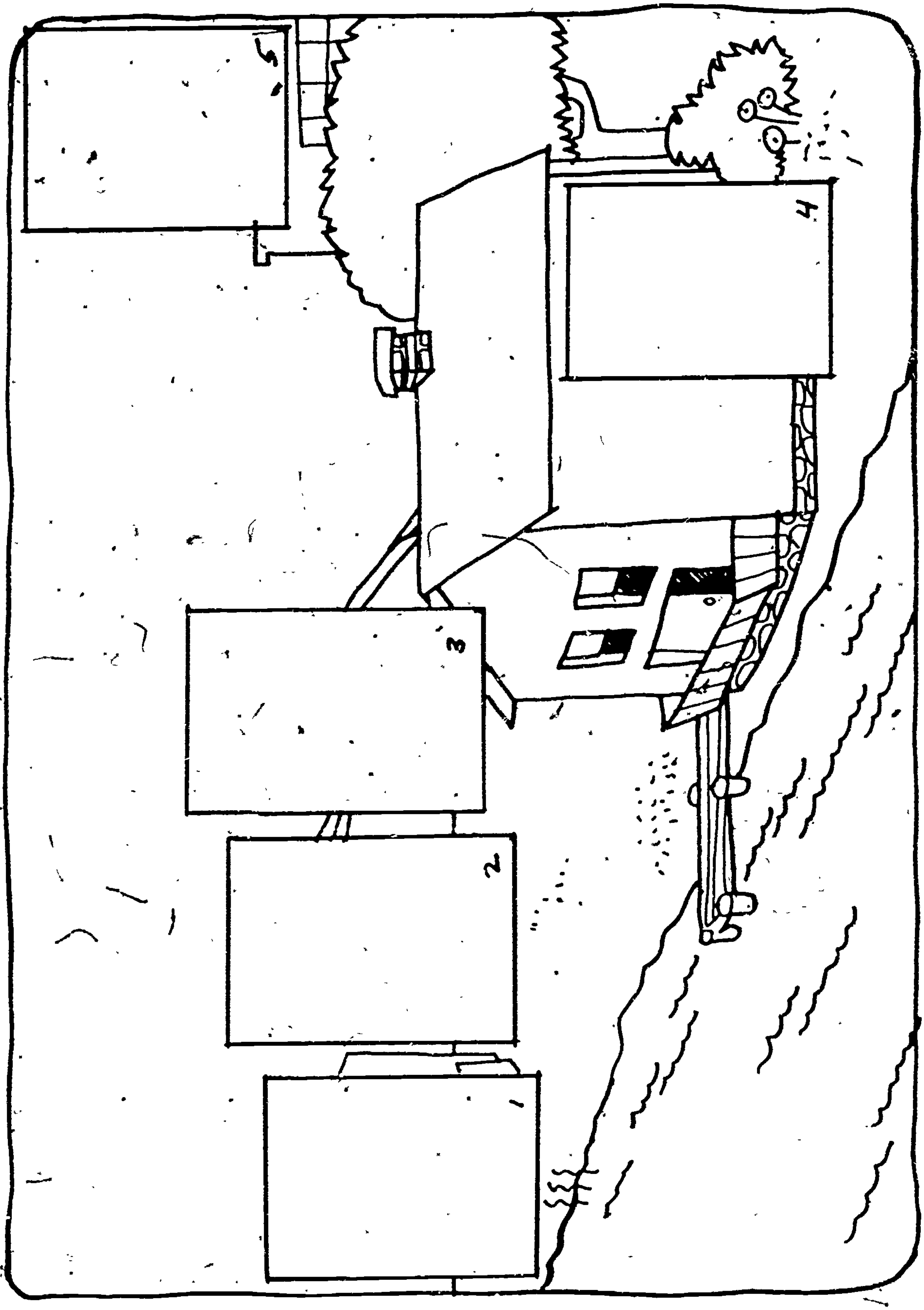

1
2
3
4
5
6
7


COAL


2
3
4
5
6



ELECTRICITY



ELECTRICITY

MINI-UNIT 2
Keep It Cool!

Keep It Cool!

ABSTRACT

Thirty percent of the national use of electricity during the summer consists of air-conditioning for homes and apartments. Power system overloads with brownouts and blackouts during very hot weather are increasingly likely. The relationship between keeping things cool and insulation is investigated in activities in which students try to prevent the melting of ice cubes. The desirability of insulating homes to use less electricity is examined through student experiments and classroom discussion.

Recommended level: grades 3-6.

Time required: Three to four 45-minute periods. To allow time for ice cubes to melt, first and third lessons require a 5-15 minute period roughly two hours after the initial activity period of 30-40 minutes in which the ice cube melting game begins.

Major teaching strategies: Individual experiments and classroom discussion.

Advance preparation: Collect ice cubes and insulating materials (see materials list).

Key Ideas

1. Heat energy is transferred *from* hot *to* cold environments.
2. Insulating materials slow down heat energy transfer and thus help to maintain either cool or warm environments, as in Thermos bottles, houses or apartments, and inside winter clothing.
3. Some materials are better insulators than others.
4. Consumption of electricity and other energy sources for cooling and heating homes is reduced when insulation is used.

Objectives

At the completion of this mini-unit the student should be able to:

1. *Identify* the direction of heat energy transfer between hot and cold environments.
2. *Classify* a variety of common materials as either good or poor insulation materials.
3. *Describe* the difference in coolness (or warmth) of a house or apartment with poor insulation versus one with good insulation during the summer (and during the winter).
4. *Relate* the use of insulation to the increased or decreased use of electricity for cooling (and perhaps heating) homes and apartments.

Teaching Suggestions

Lesson 1 — Preserve That Ice Cube!

By participating in a game to preserve an ice cube, students become aware of the capabilities of different materials to insulate. This lesson should be performed early in the day, since ice cubes may take about two hours to melt.

1. Introduce game and organize teams.
   - ☐ As a suggested lead-in, tell students that you have collected some materials together for an interesting game that everyone can play. Inform them that you have a bag of ice cubes, enough to give one ice cube to every two or three students. The goal of the game is to prevent the ice cube from melting for the longest time possible — they must keep it cool!
   - ☐ Divide the class into groups of two or three persons. Display the materials (see materials list) that can be used by students to wrap or enclose ice cubes to preserve them. Ask each group to propose ways to do this and to perhaps write down their best idea. Encourage groups to choose different materials and means of construction, such as thickness of wrapping.
2. Proceed with game.
   - ☐ When all groups have proposed a plan to preserve their ice cubes, let them proceed with their plans. Give each group an ice cube (they should be nearly equivalent in size) in a small plastic sandwich bag taped shut (this will keep the water from the melted cubes confined) or use Ziploc bags.
   - ☐ You may find students wrapping their ice cubes in paper or foil or burying them in some material where they will not be visible. Therefore, in order to keep track of the melting process place one ice cube in a plastic bag and suspend it by a string someplace in the classroom where it will be visible to the students (not in the sunlight near a window). This ice cube will be used as a timer: when it is almost completely melted the game will end. It will take about one and three-quarters hours for a typical ice cube from a refrigerator tray to melt. However, this lesson can effectively end when all groups have finished wrapping their ice cube and the timing begins. You may want to go on to some other unrelated classroom activity during the period while the ice cubes are melting. Occasionally, have students check the ice cube that is serving as the timer to see if it is completely melted.
3. Conclude the game.
   - ☐ When the ice cube suspended in the plastic bag is melted or nearly melted, have students obtain the ice cube bags from their environments and compare the results. Identify with students the materials which preserved the ice cube the longest.* Did

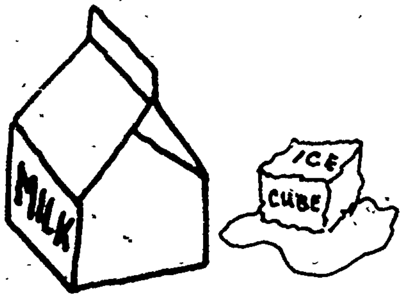
*If there is difficulty in distinguishing by sight which ice cubes are larger (and therefore preserved the best), one might employ a more quantitative technique for comparison, such as:

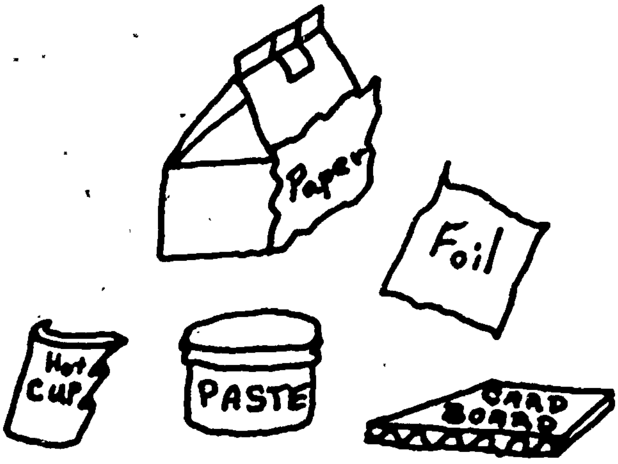
1. weighing each ice cube, or
2. drain off all water in plastic bag and allow remainder of ice cubes to completely melt; then compare the amount of water remaining either by volume or weight measurements.

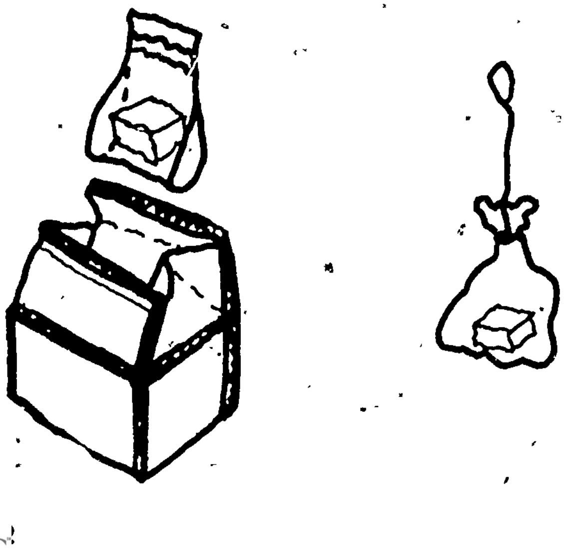
In a similar manner, if there is not enough time to complete the activity (melting the cube) as outlined, the following procedure could be used: At the conclusion of the period have students put the remainder of their ice cube in a baby food jar or other container. At the next meeting they then could measure the amount of water to determine who had the largest or most preserved ice cube.

the thickness of the material make any difference? Ask them to think about what materials they would use if they played the game again.

☐ Ask students to save milk cartons for Lesson 3.







Lesson 2 — Insulation and Heat Flow

Students develop concepts of insulation and heat energy transfer (or heat flow) through classroom discussion.

1. Lead students to the concept of heat energy transfer.
   ☐ Review results of game. How long did it take for the unwrapped ice cube to melt? Were any ice cubes still unmelted? Which materials preserved the ice cube the most at the end of the game and what materials were used to preserve it?
   Ask students:
   "Why did the ice cubes melt?"
   Provide clues to answer:
   "Would you say the ice cube is cold? Is the room warmer than the ice cube?"
   ☐ Inform students that one of the laws of nature is that warm things have more *heat energy* than cold things, and when a warm thing is placed near or around a cold thing, some of that heat energy is transferred or flows to the cold thing. By wrapping or enclosing the ice cube, students were slowing down the transfer of some of the heat energy in the room to the ice cube. The results of the game indicate that some materials can slow down the transfer of heat energy more than others.

2. Develop with students a definition of *insulator*.
   ☐ Ask:
   "Which materials did we find slowed down the transfer of the heat toward the ice cube more than others? Can we give these materials a name that tells us they are good materials to slow down the motion of heat? Let's call them *insulation* materials or *insulators*.
   ☐ Discuss with students what materials might be called good insulators and what materials might be called poor insulators. Have students classify materials they used in game as good or poor insulators based on the results of their game.

3. Generalize experience by providing other examples of heat energy transfer and insulation.
   ☐ Discuss with students several examples in which insulation is used to keep things *cold*; for example, Ask students:
   a) "Can you think of other situations where we try to keep things cold by using insulation? How about a refrigerator? Where is it cold? Where is it warm? (Draw a sketch or display a picture of a refrigerator.) Which area has more heat energy? Which has less? How is the transfer of the heat slowed down?"
   b) "Suppose you bought some ice cream at the supermarket to take home. Is the ice cream put in a special bag to prevent it from melting? Where is it warm, where is it cold? What kinds of materials are used to slow down the transfer of the heat energy to the cold area?"

☐ Discuss with students several examples in which insulation is used to keep things *warm;* for example:

Ask students:

a) "Do you wear heavier clothes (coats, etc.) in the winter than you do in the summer? Why? Is it colder? What kinds of clothes does an Eskimo wear? A Hawaiian? Could we call the clothes an Eskimo wears insulators? Which area has more heat energy? Which less energy? Can clothes slow down the transfer of heat energy from one area to another?"

b) "Are there other examples you can think of where we use insulation to keep things warm? That is, examples where we slow down the transfer of heat and try to prevent it from leaving something so it will stay hot? How about coffee cups? How are they made? Are good or poor insulators used?"

4. Relate discussion to home insulation in preparation for next lesson.

☐ Ask students:

"Are the walls and ceilings of our houses or apartments insulators? Why? What happens in winter? Where is it cold? Where is it warm? In what direction is the heat transferred? (Inside to outside.) Is it slowed down in any way?"

"What happens in summer? Suppose you have an air-conditioner. Where is it cool? Where is it hot? (Cool is inside, hot outside.) In what direction is heat transferred? (Outside to inside.) Is it slowed down in any way?"

☐ As an assignment, ask students to investigate at home the kinds of materials that are used to keep things cold or hot. Perhaps they can arrange with their parents to view some area in their house or building where the insulation is exposed, such as in an attic. What kinds of materials are sold in hardware stores and lumber yards to insulate homes?

☐ Request that students think about how they would insulate a house — what materials they would use and where they would put them, and how these would slow down the transfer of the heat energy.

Remind students to bring in milk cartons for tomorrow's lesson.

Lesson 3,— Insulation and Homes

The relationship between the increased use of insulation in homes and the decreased use of electricity and the cost for cooling and heating homes is developed

☐ Special preparation: Collect milk cartons

1. Review assignments with students. Discuss with students their examples of situations where insulators are used to keep something hot or cold, and of how their homes are insulated.

2. Organize and proceed with second "Keep It Cool!" game with model houses.

Conduct same type of game as in first lesson, except this time have students construct small model houses using pint or one-half pint milk or cream containers (see drawing). Have students "insulate" house by wrapping or gluing different materials on outside of container. Have students place ice cube in plastic bag inside container. Time game as before with a separate ice cube which is uninsulated.

3. After game has started, discuss with students the role of an air-conditioner.

"How many students have an air-conditioner in their homes? Have you been in stores or other places with air-conditioners? Is it colder inside or outside?"

Ask students if they know what powers most air-conditioners.

"What would happen if they were unplugged? What do the air-conditioners obtain through the wires from the plug to the unit?"

Bring out the point that most air-conditioners run on electricity.

"What would happen if there was a power failure and they didn't work? Would the rooms warm up and 'melt?' Could the air be kept cold for a longer period of time if there were more insulation? Would it be as necessary to run the air-conditioner for as long a time if a house or store had more insulation? If we use an air-conditioner less, is less electricity used?"

4. Compare insulated and uninsulated homes.

☐ Show Transparency 1 and ask students to describe the differences between the two homes in the summer. Which one has more insulation? Which one is cooler? Hotter? Which one is using more electricity?

Tell students that we must pay for the electricity we use, usually each month, when the bill from the electric power company comes in the mail. Ask them:

"Which house uses more electricity and thus would cost more to keep cool with air-conditioning?"

Inform them that in an average size house each year they could save between $35 and $60 if their house had insulation in the ceiling and walls.*

☐ Ask students to describe the differences between the two homes shown in Transparency 2 in the winter. Which one has more insulation? Which one is warmer? Cooler? Which one would use more electricity or some other fuel to keep the house warm?

Inform students that each year a family could save $425 to $712 by having an insulated house compared to an *un*insulated house.**

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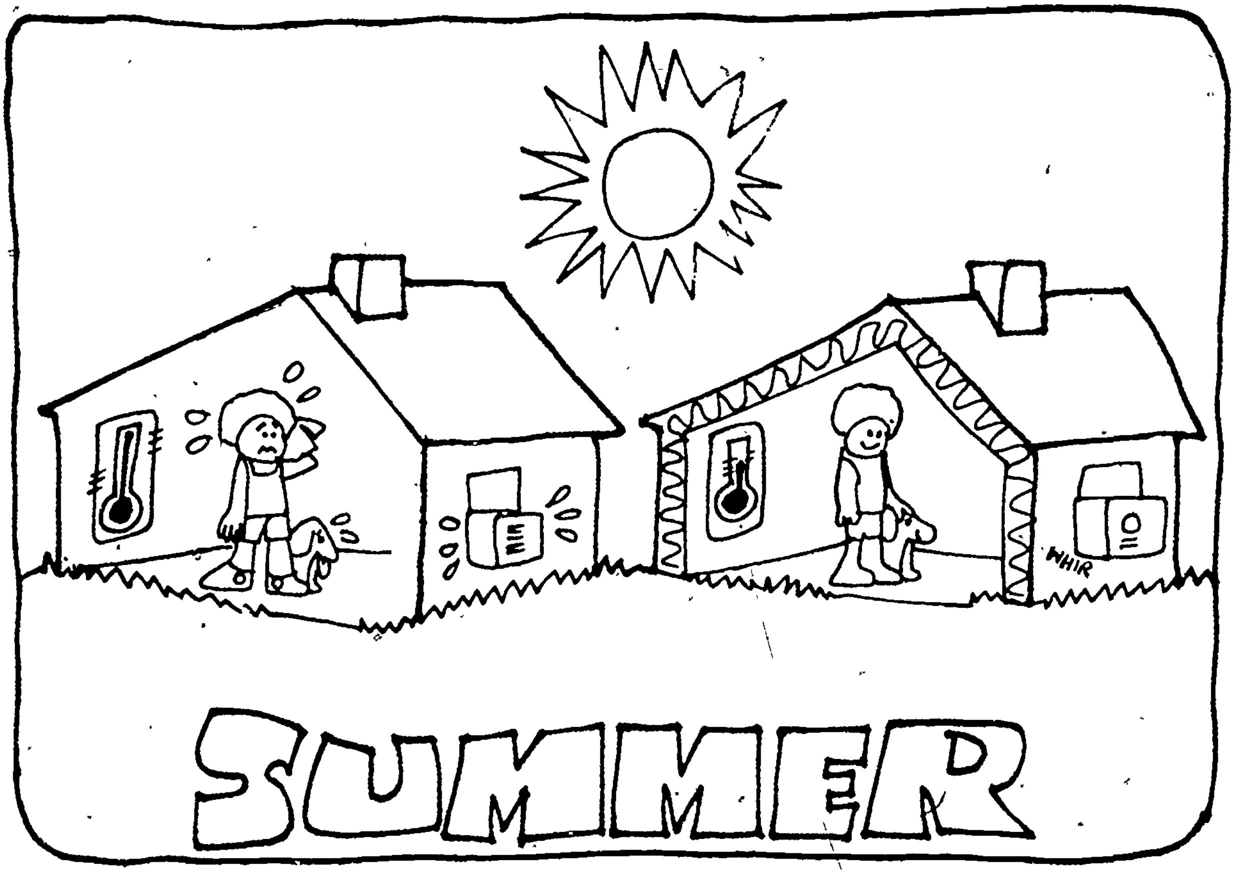
*Based on a 1,500 square foot home, 2,333 kilowatt-hours of electricity saved, and a price of 1.5 to 2.5 cents per kw-hr (depending on region).

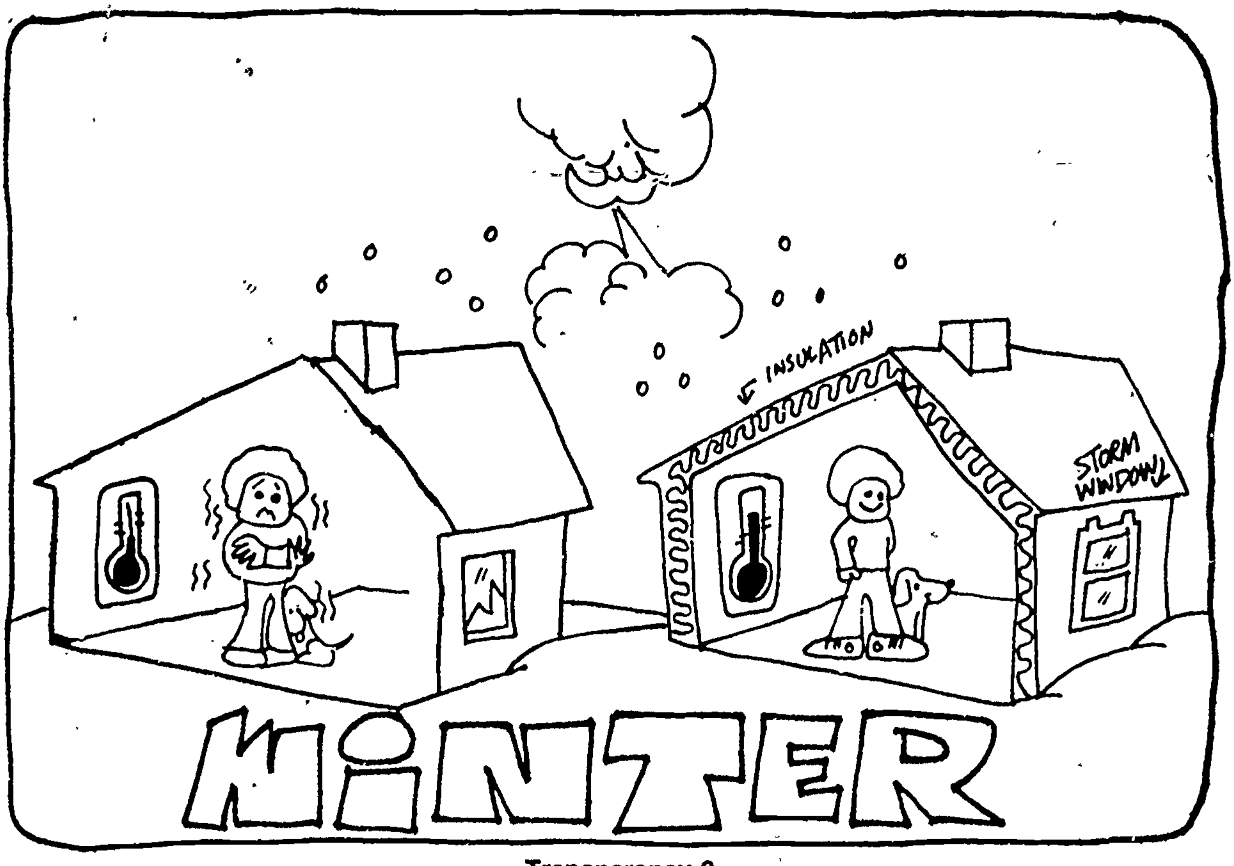
**Based on a 1,500 square foot home, 28,500 kilowatt-hours of electricity saved, and a price of 1.5 to 2 5 cents per kw-hr

† See footnote Lesson 2.

5. Have students choose their preferred home. Conclude discussion by asking students to choose the home they would rather live in and to describe their reasons. Proceed to other classroom activities if ice cubes still have not melted.
6. Conclude mini-unit at conclusion of game. When uninsulated ice cube has melted, have students remove their ice cubes from their model houses. Determine which houses preserved the ice cubes the best.† Discuss the results with students.
7. (Optional) Electricity is the major energy source for home air-conditioning; however, it is not the major energy source for home heating. The effect of insulating students' homes on the use of oil, natural gas, and coal in the winter, therefore, might be similarly discussed.



Transparency 1



Transparency 2

Evaluation Suggestions

1. Display, draw, or describe a variety of situations in which warm or hot items or environments are near, around, or in contact with cool or cold items or environments. For example: a house in the summer; a refrigerator; a styrofoam cup filled with hot coffee; a pot of water on a stove; a person inside a sleeping bag outdoors. Ask students to identify the warm areas, the cold areas and the direction of the heat energy transfer.
   Acceptable responses. The heat energy is transferred from the warm or hot areas to the cool or cold areas. In the examples above, heat energy is transferred from the outside of the house to the inside, from the stove to the water, from the person inside the sleeping bag to the environment outside.
2. Display the following collection of insulation materials for individuals or groups of students:

styrofoam	empty cans
wood	metal cans
paper	transparent food wrap
cardboard	glass container

   Have students select those materials that are good (poor) insulators.
   Acceptable responses: Good insulators — styrofoam, wood, cardboard, poor insulators — cans, metal, food wrap.
3. Ask students to describe (written or orally) an *insulator*.
   Acceptable response: An insulator is a material used to slow down the transfer of heat from a warm area or thing to a cooler area or thing.
4. At the conclusion of the unit, show students two milk container houses, one wrapped with foil or metal and the other with styrofoam and/or wood. Ask them to identify the house or container that would be coolest in summer and warmest in winter; which one, if air-conditioned, would use less electricity?
   Acceptable response: The styrofoam and/or wood container would be coolest in summer ano warmest in winter since styrofoam and wood are better insulators than metal. The styrofoam-insulated house would use less electricity for air-conditioning.

Bibliography

Free or Inexpensive Materials:

"A Consumers Guide to Effective Energy Use in the Home." American Petroleum Institute, 1801 K Street, N.W., Washington, D.C. 20006. Free.

"Thirty Ways to Cut the Cost of Heating Your Home," "How To Conserve Energy at Home," "How to Cut the Cost of Cooling Your Home" from Channing L. Bete, 45 Federal Street, Greenfield, Massachusetts 01301. (25 cents each for 1-99 copies.)

"Electricity: How to Get the Most for the Least." Potomac Electric Power Company, 1900 Pennsylvania Avenue, N.W., Washington, D.C. 20006. Free.

"Seven Ways to Reduce Fuel Consumption in Household Heating." U.S. Government Printing Office

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

Materials List

- ☐ Approximately equal-size ice cubes (approximately three per student, save one-third for third lesson)
- ☐ Plastic bags (small sandwich bags to hold ice cubes and water when taped shut).
- ☐ Empty pint, or one-half pint, milk cartons.
- ☐ Suggestions for insulating materials (collect as many as possible):

paper — various thicknesses
cardboard — various types and thicknesses
styrofoam coffee cups
aluminum foil
glass tumblers or cups (be careful of breakage)
metal tumblers or cups
plastic food containers
transparent food wrap
wax paper
newspaper
foam rubber
vermiculite (available at plant and garden stores)
sand (to surround ice cube bag in any container)
small wooden containers
home insulating materials obtainable from hardware stores (Note: fiberglass batts may cause skin irritation and should only be handled with gloves by teacher.)
different kinds of cloth material — wool, cotton, nylon, fake fur, etc.
cotton balls

MINI-UNIT 3
Which Source of Energy Is Best for Heating My Community?

Which Source of Energy is Best For Heating My Community?

ABSTRACT

A significant fraction (more than 60 percent) of our residential and commercial use of energy is devoted to the heating and cooling of homes and offices. This use of energy influences and is influenced by personal, local, and national policy decisions related to the wise or unwise use of our energy resources and our environment. In order to investigate the trade-offs that result from a particular energy-related decision, students are asked to pretend they are citizens of a model community and to choose the energy source they consider the best to heat and cool their homes and offices. Students research each source (fossil fuels, solar, geothermal, etc.) and compare in a mock community meeting their cost, availability, environmental effects, and other characteristics. Students are given opportunities to use their critical thinking skills in doing research and evaluating sources, and also to engage in group decision-making processes.

Recommended level: Social studies and general science classes grades 5-8.

Time required: Five to eight 45-minute class periods, depending on student research time allocated.

Major teaching strategies: Classroom discussion, individual and group research, simulation of community meeting, student charting, notetaking, and reporting.

Advance preparation:

- ☐ Collect cartoons, headlines, newspaper articles, brochures on energy-environment problems and on the seven sources of energy (coal, electricity, geothermal, natural gas, nuclear, oil, and solar) examined in this mini-unit, and prepare a bulletin board using these materials. (See bibliography for a list of available materials.)
- ☐ Duplicate enough copies of each of the seven Data Sheets on energy sources so each student in the corresponding research group has a copy

Key Ideas

1. We presently use, either directly or indirectly, seven sources of energy to heat and cool our homes. oil, natural gas, coal, electricity, nuclear, solar, and geothermal.
2. Sources of energy for heating and cooling homes differ in their availability, their costs, and their environmental effects.
3. Energy-environment decisions require making value judgments of the trade-offs involved, a decision involves the acceptance of the possible disadvantages of the choice along with its advantages.

Objectives

At the completion of this activity the student should be able to:

1. *Name* several energy sources we use to heat and cool our homes and offices.
2. *Identify* several factors that might influence the choice of an energy source for heating and cooling our homes and offices.
3. *Choose* and *justify* his/her individual choice of energy source for heating and cooling homes in his/her community.
4. *Research* and *report* to the group information that might influence a group decision (e.g., information on the availability and cost of natural gas for heating homes).
5. *List* several components of a group's decision-making process.

Teaching Suggestions

Lesson 1 — Students as Citizens of a Model Community

In order to set the stage for energy-related decision-making, present students with the opportunity to determine, through their roles as citizens of a totally new community, how they might change their community if they could start anew. Lead them to discuss whether some of our energy-environment problems might be solved by new community designs. In particular, have students begin examining possible sources of energy for heating and cooling homes and offices of their new community.

1. Have students identify what they consider the most important problems in their community.
   - ☐ Begin lesson by having students brainstorm about what they consider to be problems in their community. For example, is there inadequate housing or inadequate park and recreation facilities, poor siting of factories and highways, too much pollution, too much crime, not enough theaters? Alternatively, they might be asked to collect, for several days prior to this lesson, articles and news displays concerned with what they consider to be problems in their community.
   - ☐ Have students share their opinions about which problems they believe are the most serious. Poll their opinions and list on the blackboard the problems in order of their seriousness to the class.
2. Present students with the hypothetical situation of being members of a new model community.
   "Suppose that everyone in our class could be citizens of a future, totally new community. In what ways would you want this new community to differ from our present community? Which of our community problems could we solve if we built our new community differently? Which might still occur?"
   "What should we name our community?" (Students may want more time to think about this and decide later.)
3. Relate discussion of new community to energy use and to home heating.
   "We have been collecting for several days articles and news clippings on various energy-environment problems. Would we be able to solve some of these

problems if we built our new community differently?" "For example, one of the opportunities we would have in completely designing or redesigning our new community is to decide what kinds of houses we want and which source of energy would be best for heating and cooling our homes and offices. If we choose the 'right' source, could we eliminate some of our energy shortage problems or environmental problems due to energy production and use?"

4. Initially examine the sources of energy which are available for heating and cooling homes and offices. "Let's suppose that we are all home owners in our new community. As home owners we must decide which source we want to use to heat and cool our homes and offices. For now we will pretend that all of the sources of energy are available to us and that all of us will use the same one. What sources of energy are available to heat and cool homes? What sources of energy are now used to heat your home or apartment?" (List responses.)

   Students at this point may not be aware of all of the energy sources that are available and may not know the advantages and disadvantages of each. The bulletin board should provide some ideas for discussion. After student ideas have been listed, refer to the bulletin board. Ask students to go to the board and select any article they wish. Then ask them to skim the article, cartoon, etc. and answer the following:
   a. Which source of energy is described in your article? (electric, oil, coal, geothermal, etc.)
   b. Would you prefer this source for our community?
   c. What are your reasons for preferring or not preferring this source as opposed to others?

   These questions may be written on the board for easy referral. Allow 10-15 minutes for students to read and summarize their reactions to the materials (This may be continued into the next period.)

   Continue the lesson by having the students share their reactions.

   List each different type of energy on the board as it is discussed. (Keep the summaries brief — one to two minutes per topic, for instance.) The students will end with a fairly complete summary of the sources of energy available.

5. End lesson by asking each student as an assignment to identify his/her personal preferences for home heating energy sources.

   Ask each student to rank his/her first, second, and third choice of home energy sources from the list on the board.

   "My choices for a source of energy for my community are":
   1st ______
   2nd ______
   3rd ______

   Have students keep this list for future reference.

Lesson 2 — Factors for Judging Energy Sources

Through classroom discussion, several factors which might be important in making a choice among energy sources should be identified. These help guide the students' research. Form the research groups and begin the research.

Advance preparation:
Assemble as many textbooks and references on energy and its sources as possible or have a group of students do this. Make student copies of Data Sheets which are provided in this unit. Four or five copies of each Sheet should be sufficient for average-size class — 30-35 students.

1. Review energy sources identified in previous lesson.

   Introduce the lesson by asking students to review the sources of energy that are available to a community. Sample lead-in questions might be:

   "Yesterday we started to explore some of the sources of energy which are available to a community. Which sources did we identify?" (List these.) "Does anyone know any other sources of energy?" (Students may suggest tidal, wind, organic waste, etc. These are presently used only in isolated circumstances.)

2. Have students identify their needs for further information about energy sources. Have each student list the sources he/she needs to know more about:

   "The sources of energy that I would need to know more about are:
   ______, ______, and ______."

3. Have students choose topics and form research groups.

   Using the list of energy sources, allow students to choose an energy source for investigation. Try to establish groups for all seven energy sources discussed in the Data Sheets: solar, coal, oil, natural gas, geothermal, electricity, and nuclear.

4. Develop with the class the important factors on which to compare the sources of energy used for home heating and cooling. Begin discussion with:

   "What would we need to know about a source of energy so that we could judge whether or not it would be good for our community?"

   Depending upon student responses, several of the following questions might additionally be asked to promote discussion:
   - ☐ "How does it heat and cool a home?"
   - ☐ "What does it cost to install the equipment, etc. for home heating and cooling?"
   - ☐ "How much does it cost to heat and cool a home per month or per year by this method?"
   - ☐ "How much of this energy source is available?"
   - ☐ "Are there any problems with using this source of energy?"

☐ "How does it affect people? The environment?" Have students decide on four or five criteria to guide their research.

5. Introduce available reference resources. Include Data Sheets.

   Have students mention and/or review the references available to them (textbooks, almanac, atlas, encyclopedias, etc.). Introduce and distribute Data Sheets to the appropriate groups.

   "One resource that we have about sources of energy are these Data Sheets. There is one for each: solar, geothermal, coal, oil, natural gas, nuclear, and electricity. They will help you answer some of the questions that we have listed to guide our research. Use these as you would other written references."

   A Data Sheet is a brief summary of current factual information related to a specific form of energy.

   Have resources available in a central location.

6. Have research groups meet and begin research.

   Use the remaining time for small group meetings and student research. Teacher can circulate among the groups and act as a resource. Ask each group to assess its progress at the end of the research time and determine its needs.

7. (Optional) Encourage use of non-text references in research.

   a. Invite representatives of oil, gas, coal, and electric industries in your community to visit and talk with the class and give specific information to the corresponding research group.
   b. Have class or individual research group visit a local mine, refinery, generating or processing plant of a particular energy industry.
   c. Invite parents to visit the class to describe how their homes or apartments are heated or cooled.
   d. Invite plumbers or heating contractors to the class to describe home and office heating systems and installation costs.

Lesson 3 — Investigating Energy Sources

Groups suggest ways of sharing their new learnings with other members of the class and continue to research their topics. Additional research periods might be inserted here if necessary or if desired for optional activities.

1. Have the class suggest ways that they could summarize their new learnings for other members of the class.

   Class can brainstorm in ways of sharing information so that one source of energy can be chosen for their new community. Sample lead-in question might be:

   "We have listed the kinds of information that we want to obtain for each source of energy. How can we share our information so that we as a class can decide on the source we prefer for our community?"

   List ideas. Possible suggestions include: preparing outlines, making a summary chart, writing a report, preparing posters, drawings, and other graphics, etc.

   The class may agree on one form for all groups — a summary chart, for instance — or each group may choose its own method. (Note: only the summary chart will be explained in this mini-unit.)

   Help students acquire any special materials needed for the method they have chosen — poster paper, Magic Markers, etc.

2. Have groups meet and continue research.

   Use the remainder of the time for group meetings and research. Teacher may circulate among the groups and assess progress and special needs. Individual students needing help may be paired with more capable students or may be grouped with other students and work with the teacher on reading and interpreting information.

   At the end of the lesson ask each group to assess its progress and set a group goal for the next lesson.

3. (Optional) Have students investigate how decisions are made in the local community. Are public hearings held to obtain citizen input? Is there a City Council or Legislature? Is there a Public Service Commission or Zoning Board which regulates siting of generating plants, refineries, and location of transmission lines?

Lesson 4 — Planning a Community Meeting

Groups finish research and the class plans the agenda for the community meeting.

1. Have the class set the agenda for the community meeting.

   Ask students to decide on an agenda for the community meeting. Sample agenda might be:
   a. Call meeting to order
   b. Set purpose of meeting (to decide on one source of energy to use for heating and cooling homes)
   c. Group reports (list order)
   d. Discussion (note advantages and disadvantages of each energy source)
   e. Voting (use hand vote or secret ballot)
   f. Evaluation of decision (what is important to us?)

   Have group decide if a Chairperson and Secretary will be needed. If so, allow them time to think about their choices and to be prepared to vote on this at the end of the lesson.

2. Have groups complete research and prepare any necessary materials for their summary report.

   Remind the class that this will be their final work period. Circulate among the groups checking progress and needs. Help students prepare charts, posters, outlines, etc. as needed. Ask each group to give a brief progress report and to plan their presentation for the meeting.

3. (Optional) Have class select Chairperson and Secretary for the community meeting.

End the lesson by allowing students to nominate and vote for Chairperson and Secretary for the community meeting. Groups may also determine the order of group reports by drawing numbers, using alphabetical order, volunteering, etc.

Lesson 5 — Which Is Best For My Community?

Students conduct a community (class) meeting in order to practice group decision-making skills. They also evaluate the decision made.

Advance preparation:

Make copies of attached Energy Summary Chart for distribution to entire class. Arrange desks in a circle to facilitate discussion. Meet with Chairperson and Secretary and review the agenda and use of the summary chart.

1. Begin meeting by establishing the procedures.

   Have Chairperson call meeting to order and post a chart listing the agenda for the meeting. Be sure to include the order of group presentations. Have the Secretary pass out the Energy Summary Chart (change to headings conforming with group's criteria) and briefly explain how it can be used for note-taking. For example, the students may jot figures, examples, notes, pluses (+) or minuses (−), etc. in the appropriate columns. They should record whatever they feel will help them compare the advantages and disadvantages of the sources of energy and be prepared to make a decision on the source of their choice.

2. Have groups give reports.

   Set a time limit for each, such as three minutes. Allow a brief question period at the end of each presentation.

3. Review and discuss reports. After the last committee report, allow the students to review their notes and have a brief general discussion of the energy sources. Encourage discussion of advantages and disadvantages of each energy source. Group may wish to identify which is best in terms of other uses, costs, lifespan, environmental effects, etc. Allow time for each person to think about his decision.

4. Allow students to vote on their preferred source.

   Students may use hand vote or secret ballot for voting. Students will select their preferred source of energy for heating and cooling homes.

5. Guide evaluation of the decision.

   Announce the results. The group may want to rank its second and third choice also. Briefly discuss the decision made. Ask:

   "What influenced your decision most?" (Listen to several responses.)

   "What are the advantages and disadvantages of the source of energy chosen?" (Have students refer to notes on summary chart.)

   "What does this decision indicate about the factors that are important to us as a group? (Is cost important? Availability? Environmental effects?) What were we willing to trade off?"

   "Why can't a real community decide as we have? What problems does it face that we have not considered?"

   (Possible considerations:
   - ☐ All sources of energy are not equally available to all communities.
   - ☐ Homes and businesses already have some source of heat and cooling which would have to be converted if a change was made. This change would be costly.
   - ☐ Some sources of energy need improved technology before they can be useful for large communities.)

   Have students compare their original choice (on the first day) with their individual final choice and the group's choice. Did their choice change as a result of new information?

6. Have students review the process they have used in making this decision.

   Focus attention on the decision-making process that has been used in this mini-unit. Ask such questions as:

   a. What was the problem that we wished to resolve in this unit? (Define the problem.)
   b. What method did we use to solve the problem? (Divided into groups, did research, gathered information, established factual base for decision making.) Why did we divide into seven groups? (We identified seven alternative choices.)
   c. How did the group reach its decision? (Held meeting, shared information, summarized, discussed, voted.)
   d. How did we evaluate our decision? (Reviewed advantages and disadvantages of chosen source, inferred our priorities from such a choice, related choice to practical limitations which exist in real communities.)

   After this review, students may want to record the steps of the decision-making process:

   1. *Define* the problem.
   2. *Plan* a method for investigating the problem. Identify alternative choices.
   3. *Gather* and evaluate information.
   4. *Decide* and act.
   5. *Evaluate* the decision made.

7. (Optional) Have students compare their choice for their new model community with the sources used in their present community. What are the trade-offs in their present community?

ENERGY SOURCE SUMMARY CHART

Energy Source \ Factor	Availability Now	Availability Later	Cost	Environmental Effects		
1. Oil						
2. Natural Gas						
3. Coal						
4. Electricity						
5. Nuclear						
6. Solar						
7. Geothermal						

DATA SHEET
Where Does the Energy We Use Come From?

Where Does the Energy We Use Come From?

Primary Energy Sources

There are five *primary* sources of energy that are naturally available to us on earth: solar, chemical, nuclear, geothermal, and tidal energy. Two of these, the chemical energy of fossil fuels and nuclear energy are *stored or potential* forms of energy. The other three — solar, geothermal, and tidal energy — are *kinetic* forms of energy; that is forms which are active and always in motion. While we can use the energy in the stored sources of energy whenever we choose, we can use the kinetic forms only when nature makes them available to us; for example, sunlight is only available during daylight hours. In the sections that follow we will briefly discuss each of the primary sources.

Solar energy: Solar energy is a kinetic form of energy. It is more precisely called radiant energy, much of which is observable as visible light. A major portion of the sunlight which approaches earth is reflected by the atmosphere back into space. Although only roughly half of the solar energy reaches the ground, half is still a tremendous amount. If all the solar energy reaching the ground could be stored for 48 minutes, it could provide as much energy as used worldwide in 1970.

A very small part (1/5000) of this energy interacts with plants and fuels the photosynthesis process. Solar energy, thus, is indirectly the source of the food energy on which we depend. It is also the source of the chemical energy which was stored hundreds of millions of years ago in the plant life of the swampy jungles of earth. We are using stored solar energy when we burn the fossil fuels: coal, oil, and natural gas.

The sun's radiant energy also heats the land and the oceans and thus provides the energy for the great air and ocean currents — the winds and waves. Historically, wind and water currents were early sources of energy and were harnessed by windmills, sailboats, and waterwheels. With increases in the world's population and the rise of cities, however, these sources became inadequate. Today we get some of our energy from these wind and water currents in a different manner. Some of the sun's energy evaporates water from lakes and oceans. The water rises and is carried in the winds. If the water falls on the mountains, we get some of the energy for our use by letting the mountain-fed streams and rivers turn the turbines of hydroelectric plants to produce electricity.

Most of the solar energy reaching the ground is unused by man. It is available during the daylight hours throughout the world in varying amounts. However, since it is a kinetic form of energy, it must be used immediately or it must be converted into some potential form of energy for later use. Presently, sunlight is being used as the sole source of heat for a few homes. However, collection and storage of solar energy for later transportation and use is still difficult. In particular, we have not perfected practical and economical methods of collecting solar energy and converting it into electricity. Since the lifetime of the sun is many billions of years, for all practical purposes this energy source will always be with us. It is a *continuous* source of energy which does not need to be renewed.

Fossil fuels: The most important form of stored energy is the chemical potential energy of the fossil fuels: coal, oil, and natural gas. As we have said, this energy was originally solar energy hundreds of millions of years ago. Coal began to be formed when the huge mosses and ferns of the Paleozoic swamps died and fell into the mud. They were acted on by anaerobic bacteria (bacteria which don't need oxygen) and then by pressure and heat as they were buried under tons of sediment and converted to the almost pure carbon of coal. When the carbon atom is burned (oxidized), it releases this stored energy.

Petroleum and natural gas were formed in a similar manner. Some of the plant and animal life sank to the bottom of the great sea beds and went through a different chemical transformation under pressure and heat to form the "hydrocarbons," the complicated molecules of hydrogen and carbon characteristic of petroleum. Their stored energy is also released by burning.

Fossil fuels are used extensively because they are relatively easy to find, collect, store, and transport. Coal, oil, and natural gas resources can be located through geological surveys. Once discovered, the fuels can be removed from the ground by mining or drilling and transported by pipes, truck, rail, etc. to any destination. Although the formation of fossil fuels is continuing, the process is very slow. It would take another 300 million years or so to produce an amount equal to that which has been built up so far. Since our energy use is much more rapid than this, we are likely to use up all of our fossil fuels. For this reason, fossil fuels are called *non-renewable* sources of energy.

Nuclear energy: A form of potential energy which is of growing importance is that stored in nuclei, the tiny, dense cores of atoms. Nuclei are made up of the elementary particles — protons and neutrons. It is by rearranging these particles that nuclear energy is stored and released. There are two important examples of this. the fission reaction and the fusion reaction. In the fission reaction, the heavy nucleus, or center, of an atom such as uranium is split into two lighter ones. In this process, mass is converted into energy and it is this energy we obtain from the hot interior of a nuclear reactor.

The fusion reaction involves very light nuclei, It is the same reaction which is the source of the sun's energy. In a typical example, four hydrogen nuclei, by a complicated series of reactions, combine to form the heavier helium nucleus (two protons and two neutrons). Again, some of the mass has been converted to energy.

Nuclear energy becomes available to us in the nuclear reactor of an electric power plant. The energy of the nuclear reaction heats water, for example, and converts it to steam. This turns a turbine which produces electricity much as a river is used in a hydroelectric power plant.

The electricity is then transmitted to our homes through wires. The major fuel for the fission reaction in nuclear reactors is Uranium 235; it is available in limited quantities throughout the world.

Like the fossil fuels, the nuclear fuels are also presently *non-renewable*. However, if all of the many technical and safety problems of a new type of reactor called the breeder reactor can be overcome, nuclear fuels will be much more plentiful. The breeder reactor, while it uses up some nuclear fuel to produce electricity, produces a by-product which can be reused as a nuclear fuel to produce more electricity.

Geothermal energy: The earth's interior is molten rock, or "magma" as the geologists call it. There is a tremendous amount of energy in the earth. Although heat energy is an active or kinetic form of energy, the heat of the earth is effectively stored and insulated by the solid, thin crust on which we live.

We are not sure how the energy got there. It may have been stored in the molten blob of original earth, or it may have come from the impact of countless chunks of matter pulled to it by the earth's gravity. We are fairly certain that the radioactivity of some of the material in the earth keeps it hot. There seems to be enough uranium, radium, and other naturally radioactive material in the earth's interior to produce that relatively small amount of heat needed to make up for that lost through the surface. In this sense, geothermal energy does not need to be renewed and is essentially a *continuous* source.

The geological conditions which produce geothermal energy restrict this energy source to a few geographic areas. Where available, it is inexpensive, clean, and has few adverse environmental effects, It is available to us in those regions where the magma is close to the surface and the energy can leak out from the core through cracks in the crust. Volcanoes, geysers and hot springs are visible evidence of geothermal reservoirs, but more sophisticated techniques will soon allow us to find others not evident on the earth's surface. If available as hot water or steam, geothermal energy can be used to heat buildings. Some 500 homes and offices in Klamath Falls, Oregon, are heated by hot water drawn from a hot spring running under the town. The only large-scale use of it is in The Geysers in California where dry steam — steam so hot there are no water droplets in it — is piped to steam turbines and used to generate electricity.

Tidal energy: The last of the big five, tidal energy, is probably of least importance for our use. The source of this energy is the kinetic energy stored in the rotation of the earth-moon system. Like geothermal energy, it is another example of the successful temporary storage of energy in the kinetic form. It is *continuous* and does not need to be renewed. This energy is converted to motion of the oceans through the gravitational attraction of the moon on the oceans' contents. Ocean water is pulled toward the moon on the near side (and bulges in the other direction on the far side). To use this tidal energy, the up and down (in and out) motion of the water must be used to turn a turbine and produce electricity. This electricity can then be carried by wires to homes and offices.

Tidal generation of electricity is only practical where geologic peculiarities cause high tides. The first tidal dam and generator were built in the Rance estuary on France's Brittany coast where tides rise and fall an average of 26 feet.

There has also been some interest in building a tidal conversion facility at Passamaquoddy Bay on the far northern coast of Maine, but it does not yet appear commercially usable. We do not expect much contribution to our total supply of energy from this form.

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Concern Inc., 2233 Wisconsin Avenue, N.W., Washington, D.C. 20007, "Eco-Tips #7 — Energy Alternatives."

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- Nuclear energy — $12.50 per hundred.
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Our Minerals and Energy Resources, filmstrip, 1970. $10.00. Coronet Films, Division of Esquire, Inc., 65E South Water Street, Chicago, Illinois 60601.

The World of Energy, filmstrip. National Geographic Society, Department 1037, Washington, D.C. 20036.

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

Materials List

- ☐ Duplicate Data Sheets for class: "Where Does the Energy We Use Come From? Primary Energy Sources."
- ☐ Fan, turntable, or other electric appliance that moves
- ☐ Incandescent bulb and socket
- ☐ Candle or alcohol lamp
- ☐ Radiometer (available from, for example, Welch Scientific Company, #1733, $6.75)
- ☐ Obtain books, articles or non-text materials on primary energy sources. (See Bibliography.)

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MINI-UNIT 4
Energy and Its Natural Sources

Energy and Its Natural Sources

ABSTRACT

What is energy? How do we know we are using energy? What are the sources of energy naturally available to us? These questions are investigated in this mini-unit, which might serve as a first introduction to other discussions related to energy. Students develop criteria for identifying when energy is being used, and identify energy sources. The five primary sources of energy (solar, fossil fuel, nuclear, geothermal, and tidal) are investigated. Students increase their awareness of the origin of our energy dilemma by associating the most frequently used primary sources with their non-renewability.

Recommended level: Science and social studies classes, grades 6-8, depending on reading and vocabulary skills.

Key Ideas

1. When energy is being used we observe or sense heat, light*, or motion; an energy source is a source of heat, light, or motion.
2. There are five primary energy sources naturally available for use on earth: fossil fuels, nuclear fuels, solar energy, tidal energy, and geothermal energy.
3. Fossil fuels and nuclear fuels are stored, or potential, forms of energy and are non-renewable. Solar, tidal, and geothermal are kinetic forms of energy. They are also continuous sources of energy which do not need to be renewed.
4. Almost all of our present energy use is derived from the non-renewable, stored primary sources that are easily transported; the large-scale use of the continuous sources is limited by present technology.

*Includes non-visible radiant energy, such as x-rays.

Objectives

At the completion of this activity the student should be able to:

1. *Distinguish* activities or items that use energy from those that don't.
2. *Identify* the immediate source of energy in an activity where energy is being used.
3. *Identify,* in an activity where energy is being used, the primary source of energy.
4. *Distinguish* the most-used primary sources from the least-used, and the non-renewable from the continuous sources.
5. *Describe* one or more of the problems that might result from increased use of fossil fuels.

Teaching Suggestions

Lesson 1 — Energy in Use

Students are led to develop a criterion for identifying when energy is being used (see Key Idea #1, this section) by classifying their observations from several activities.

1. Perform several activities that involve the production of light, heat, and/or motion.
   - ☐ Begin class by doing a few physical exercises with students (e.g., side-bends, toe-touching, running-in-place, etc.). While exercising, ask students:

     "What is happening as we exercise?" (Possible responses: getting tired, *moving* parts of our bodies, getting *warmer*.)

     Record responses on blackboard or overhead projector transparency in table similar in format to the following:

Activity	*Observations*
people exercising	(moving, getting warmer)

Responses to note involve ideas of *moving* and getting *warmer*.

   - ☐ Turn on record player, fan, or other electric device that moves. Ask students:

     "What happens when I turn the fan switch on?" or "How can we describe to someone that the fan is ON?" (Fan blades *rotate* or move.)

     Add "fan ON" under *Activity* and "blades moving" under *Observations* to table written on blackboard.
   - ☐ Next, turn on incandescent light bulb. Ask students:

     "What do we observe when we turn on the light bulb?" (See light, feel warmth or heat.)

     Add "light bulb ON" under *Activity* and "light, heat" under *Observations*.
   - ☐ Light a candle or alcohol burner. Ask:

     "What do you observe when the candle (or alcohol burner) is lit?" (Light and heat.)

     Add "candle burning" under *Activity* and "light, heat" under *Observations*.

     Place radiometer (see materials list) on a table. When the vanes are moving very slowly, bring a flame (alcohol or candle) close to the radiometer or place it in the sun. Ask:

     "What happens when we bring the candle close to the radiometer (or place it in the sun)?"

     Similarly, on table:

Activity	*Observations*
people exercising	(moving, getting warmer)
fan ON	(blades moving)
light bulb ON	(light, heat)
candle burning	(light, heat)
radiometer near candle	(motion)

2. Summarize activities and develop criterion for energy in use.

Ask students if they are familiar with the word *energy*. How can they determine when energy is being used? Was energy being used in any of the listed activities?

Introduce the concept of energy-in-use by informing students that in each of the activities they performed or observed, *energy* was being used. Ask students:

"If we performed other activities, how would we know that energy was being used?"

To answer this question review the table of activities and observations with students and ask:

"What observations do most of these activities have in common?" (moving, getting warmer, light)

Have students summarize observations by completing a chart similar to the following:

Activity	*How Do I Know Energy Was Being Used?*	*(Leave room here for two more columns to be used later)*
people exercising	(motion, getting warmer)	
fan ON	(motion)	
light bulb ON	(light, warmth)	
candle burning	(light, warmth)	
radiometer near candle	(motion)	

Ask students:

"How do we know that in each of the following activities energy is being used?" (Acceptable responses in parentheses.)

car running at 30 mph	(moving)
hamburger cooking on charcoal grill	(getting warm)
clothes being washed in washing machine	(moving)

Have students add these activities and responses to their charts.

3. End lesson by formulating description of energy in use. Ask students to complete the following sentence after completing their charts:

"I know energy is being used in an activity if I observe ________." (heat, light, or motion)

4. (Optional)
   a. Activity 1 in Lesson 2 might be used as a conclusion to Lesson 1 or as a home assignment, depending on time constraints and student abilities at independent work.
   b. Students may wish to summarize their new learnings by developing a bulletin board entitled. "Energy in Use—Heat, Light, and Motion." Have them collect pictures that show some activity where heat, light, or motion is produced.

Lesson 2 — Energy Sources

Students identify several sources of energy and the general characteristics of a source of energy.

1. Review and apply criteria for energy in use.
   - ☐ Ask students to share their reactions to the incomplete sentence:

     "I know energy is being used in an activity if I observe ________."

     List key criteria on the board. (Possible responses include: heat, warmth, motion, light, etc.)
   - ☐ After a brief discussion, divide the class into three groups and assign the topic of Heat, Light, or Motion to each group. Allow 10 minutes for students to brainstorm and list as many energy users as possible under each topic.
   - ☐ Make a summary chart of responses:

     Energy is being used because I observe:

Light	*Motion*	*Heat*
sun	car	home furnace
lamp	elevator	sun
	electric mixer	electric heater
	windmill	person running

Note items that appear under more than one heading. Point out that there are many cases where we know that energy is being used to produce not only heat, or light, or motion, but heat *and* light, or heat *and* motion, or light *and* motion, etc.

2. Identify the immediate source of energy for each activity listed.
   - ☐ Refer to the list of activities in which energy was being used and select one; for example, the light bulb, and ask:

     "Where do we get the energy that enables the light bulb to produce light and heat?" (Electricity from wall or ceiling outlet.)

☐ Summarize the responses by adding a third column to the table from the first lesson:

Activity	How Do I Know Energy Was Being Used?	Immediate Energy Source
people exercising	motion, warmth	(food)
fan ON	motion	(electricity)
light bulb ON	light, warmth	(electricity)
candle burning	light, warmth	(candle wax)
radiometer near candle	motion	(heat of candle flame or sun)
car running at 30 mph	motion	(gasoline)
hamburger cooking on charcoal grill	getting warm	(charcoal)
clothes being washed in washing machine	motion	(electricity)

☐ Complete with students the third-column entries of several activities until the concept of an immediate energy source appears understood.

3. Conclude lesson by having students identify the general characteristics of a source of energy.

   After several examples, ask students to identify the general characteristics of a *source* of energy. (A source of energy is something capable of producing light, heat, or motion.)

   Students may be assigned to complete table and also identify the source of energy for each energy use activity listed in (1) above.

Lesson 3 — Primary Energy Sources

Students obtain information on the five primary sources of energy — solar, geothermal, chemical, tidal, and nuclear through reading and discussion. They identify the primary sources of energy for their examples of energy in use.

1. Review the general characteristics of a source of energy.

   (A source of energy is something capable of producing light, heat, or motion.) Elicit one or more examples of a source of light, heat, or motion.

2. Introduce students to the five primary energy sources by having them read the enclosed handout, *Where Does the Energy We Use Come From? Primary Energy Sources.*

   ☐ Ask students:

   "What are our basic or primary sources of heat, light, or motion?"

   List ideas. Continue by adding:

   "Today we will read the handout *Where Does the Energy We Use Come From? Primary Energy Sources* to answer the following:

   What are the primary energy sources that are naturally available to us? Which sources of energy are *continuous* and which are *non-renewable*?"

   These are likely to be new vocabulary words. Have students research their meaning in dictionaries and discuss the difference between renewable and non-renewable, and the difference between continuous and non-continuous. (There may be some confusion since the primary sources are not divided into non-renewable and renewable, and continuous and non-continuous. The sun, for example, is considered a continuous source, but it is not a renewable source like the supply of wood.)

   ☐ Distribute copies of handout and write purpose for reading on the board. Allow 10-15 minutes for reading. You may want to circulate among students or form a small group of students who would need teacher guidance to read material with understanding.

   Students might also be assigned other reading materials (see bibliography) or be shown films or slides relating to primary energy sources.

3. Discuss the handout and other materials. Review and discuss general purposes for reading.

   Other follow-up questions *might* include:

   a. "What is the difference between *potential* and *kinetic* energy? Which of the five primary sources are *potential*? Which are *kinetic*?" (These concepts might be further emphasized if presented in context of a science class.)
   b. "Name some of the indirect forms of solar energy." (Food, coal, oil, natural gas, winds, watercycle.) "Why aren't we using direct solar energy to supply us with the energy we need?"
   c. "What do coal, oil, and natural gas have in common?" (All are fossil fuels, formed millions of years ago, are types of chemical energy, must be burned to release energy, are easily stored and transported, can be totally consumed, etc.)
   d. "Explain a fission reaction." (A heavy nucleus is split into two lighter ones.) "Explain a fusion reaction." (Two or more light nuclei fuse, or come together, to make one heavier nucleus.) "What is

necessary to make nuclear energy nearly a renewable source?" (The breeder reactor.)

e. "Why can't geothermal energy be used to a greater degree?" (The geysers and hot springs that produce it are restricted to certain geographical areas.)

f. "What conditions are necessary for the use of tidal energy?" (There must be high tides so that the rise and fall of the tide can generate electricity.)

g. "Rank the natural sources of energy in terms of importance to our life." (This is meant to be students' personal reactions.)

4. Associate the examples of energy in use with the five primary sources. Have students refer to their charts on energy in use and add another heading entitled *Primary Energy Source*. Select one or more examples from the *Activity* list and identify the primary source. For example, for *people exericising,* ask:

"If food is the source of energy for people, which of the primary sources of energy contributes to food? (Solar energy.)

Ask students to complete the list and be prepared to discuss the results tomorrow. Completed chart would resemble the example below:

"Are there some primary sources that seem to be used more than others? Which primary sources appear not to be used for any activity in which energy is being used?" (Tidal energy, geothermal energy, and solar energy may be identified; however, all plants in the food chain utilize sunlight and hydroelectric power has its origins in the radiant energy from the sun; nuclear energy sources are being used in some areas to generate electricity.)

"Do you know what percentage of the energy we use in this country is derived from the fossil fuels? What percentage from the nuclear fuels?"

☐ Display or distribute copies of Transparency 1. Discuss with students:

"Which sources shown are called fossil fuels?" (Coal, oil, natural gas.)

"From which primary source do we get most of our energy?" (Oil.)

"Which primary sources are not included on the graph? Why?" (Geothermal and tidal contribute much less than 1 percent to the total use.)

"What percentage of our energy is obtained from solar energy?" (4 percent.) "How?" (Energy is from hydroelectric sources — solar energy turns water precipitation-evaporation cycle.)

Activity	*How Do I Know Energy Was Being Used*	*Immediate Energy Source*	*Primary Energy Source*
people exercising	motion, warmth	food	(solar energy)
fan ON	motion	electricity	(fossil fuel)
light bulb ON	light, warmth	electricity	(fossil fuel)
candle burning	light, warmth	candle wax	(fossil fuel)
radiometer near candle	motion	candle or sun	(fossil fuel or solar energy)
car at 30 mph	motion	gasoline	(fossil fuel)
hamburger cooking on grill	getting warm	charcoal	(solar)
clothes being washed in washing machine	motion	electricity	(fossil fuel)
(Other)			

Lesson 4 — Conflicts Between Energy Use and Limited Sources

The most-used energy sources are re-examined to determine why they are the most-used. Students are made aware of the origin of our energy dilemma: our most-used sources are non-renewable sources.

1. Determine which primary sources are used the most.

☐ Review with students information from previous lesson associating an activity where energy is being used and the primary source of that energy. Ask students:

"What percentage of our energy is obtained from fossil fuels?" (95 percent.)

Ask students to make a list of the primary energy sources listing the most frequently used first, the next most frequently used second, etc.:

Fossil Fuels	95%
Solar Energy (hydroelectric)	4%
Nuclear Energy	1%
Geothermal Energy	less than 1%
Tidal Energy	0%

(Note: No detailed information is provided students on the last two entries, so these items may be reversed by them. The correct order, however, is that above (since no tidal energy sources are presently being used in the United States).

2. Investigate with students reasons why some sources are used more than others.

   Ask students why they think fossil fuels, particularly oil and gas, are used more than the other sources. Through discussion bring out such factors as:

   Availability within different areas of the United States or the world
   Ease of storing
   Ease of transporting
   Ease of extraction

   All of which might determine cost.

   Information concerning these factors is presented in the student reading sheets.

   You might suggest that students construct ordered lists of the primary sources on each of these factors or answer questions such as:

   "Which source is most easily stored? Why?"

   "Which source is most easily transported? Why?"

3. Relate most used primary sources to non-renewable sources.

   Refer students back to ordered list of most frequently used sources. Ask students:

   "Which sources are non-renewable, that is, which sources are being used up faster than they are being made?" (Fossil fuels, nuclear fuels.)

   "Which sources are continuous sources, sources which do not need to be renewed?" (Solar, tidal, geothermal.)

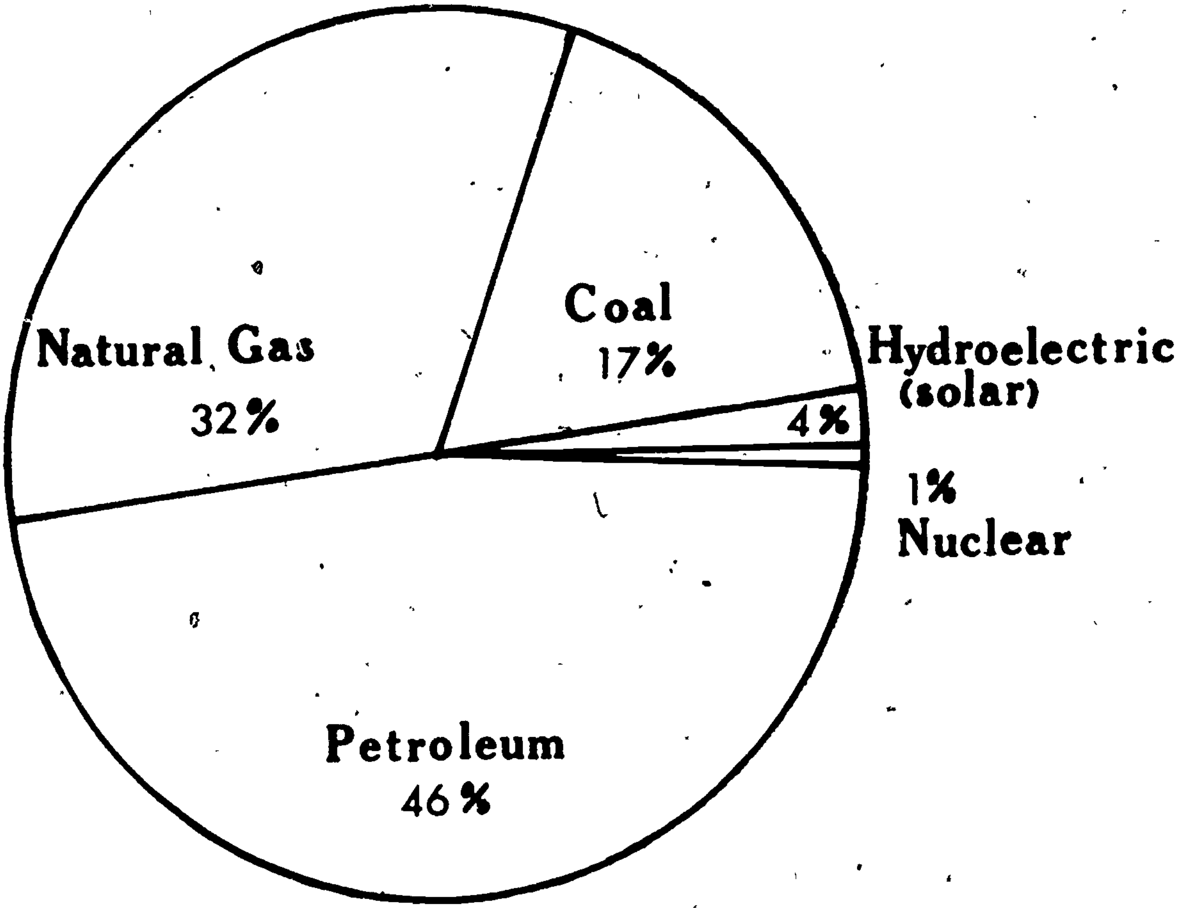
   If these have been answered correctly, ask:

   "Do you see any problems that might arise because the sources that are used the most are non-renewable sources that can be used up?"

   Bring out obvious problem: continued reliance on fossil fuels, particularly oil and natural gas, will soon use up this source of energy. Other problems might be listed from newspaper and magazine sources.

4. In this or another lesson conclude mini-unit with discussion of possible alternative solutions to this problem.

   Ask students to suggest solutions to the problem of declining supply of fossil fuels and increased demand for them as energy sources. Discussion should at least include possibilities of conserving non-renewable sources by not using as much energy as we do now and developing continuous sources to supply more of our energy needs.


Natural Gas
32%
Coal
17%
Hydroelectric
(solar)
4%
1%
Nuclear
Petroleum
46%

Evaluation Suggestions

1. Using the following list, ask students to identify which items or activities use energy. Also, for each item or activity identify the characteristic (clue) that indicates energy is being used.

Item or Activity	*Is Energy Being Used?* Acceptable response
Table	No
Radio playing	Yes; light (dial), motion (sound is motion of air)
Electric clock running	Yes; motion
Overcoat	No
Food cooking	Yes; heat, light, motion (bubbling)
Car parked	No

2. Have students list the immediate and primary sources of energy for each activity below.

Item or Activity	*Immediate Source*	*Primary Source*
Stove or oven heating	gas or electricity	fossil fuel
Television playing	electricity	fossil fuel or solar hydroelectric or nuclear
Geyser erupting	geothermal	geothermal
Person riding bicycle	food	solar

3. a) Ask students to explain what is meant by a non-renewable energy source.
   b) Have students list the five primary energy sources in descending order of present energy use.
   c) Ask the students to label non-renewable sources (N) and continuous sources (C).
   Acceptable responses:
   a) Non-renewable energy source is one which is being consumed faster than it is being produced.

b. and c.)		
	fossil fuels	N
	solar energy (hydroelectric)	C
	nuclear energy	N
	geothermal	C
	tidal	C

4. Ask students a) to describe one or more of the problems that might arise if we continue to obtain 95 percent of our energy from fossil fuels, and b) to list some steps to help solve the problem.
   Acceptable responses:
   a) Since fossil fuels are non-renewable, our continued and increased use will deplete our supplies, particularly of oil and natural gas. We will not be able to engage in many of our energy-using activities (heating homes and offices, cooking, lighting, and transporting people).
   b) Conservation of energy — decrease demand and develop renewable sources of energy, such as solar energy.

DATA SHEETS
Natural Gas, Oil, Coal, Electricity, Nuclear Energy, Solar Energy, Geothermal Energy

Natural Gas

What Is It?

Natural gas, like coal and oil, is a fossil fuel. A mixture of gases, it is composed mostly of methane, an odorless, colorless, and tasteless gas that is lighter than air. A distinctive odorant is added to natural gas so that people recognize its presence. Conditions similar to those which produce oil also produce natural gas, and they are often, but not always, found together.

Natural gas and oil were formed, it is believed, out of the tiny plants and animals that existed on the land and in the water that covered much of the earth hundreds of millions of years ago. Gradually, the remains of these plants and animals were buried in layer upon layer of sand, mud, and other sediment. Time passed and the pressure, heat, and, perhaps, the action of bacteria and radioactivity changed these remains into oil and natural gas, which collected in layers of porous rock (see Diagram 1). Gas can move more easily through the porous rock than can oil and, as a result, there are many areas of natural gas not associated with oil.

Extracting Gas

Gas is extracted, or removed from the ground, by drilling wells. Geologists (scientists who study the earth and its outer layer) investigate land formations, looking for the kind of rock formations in which oil and gas have been discovered in the past. When a favorable location is found, a gas producing company will lease the mineral rights and proceed to drill a well (see Diagram 2). Drilling equipment is moved to the site and a derrick is erected. The drill bit, or cutting tool, begins to break up the rock and dirt between ground level and the area thought to contain the natural gas. After the dirt and rock are removed, a pipe is lowered into the hole. The average depth of natural gas wells drilled on land in the United States in 1972 was 5,679 feet. (The average depth for offshore natural gas wells was 10,698 feet.) There is never a guarantee that gas and oil will actually be located. Of the 28,449 oil and gas wells drilled from January to November 1974, 10,656 were "dry holes." If gas is found, it rises through the pipe to the surface where it is cleaned. After cleaning, it enters the transmission pipeline. Pumping stations along the way help maintain the pressure necessary to move the gas. It may travel thousands of miles to distribution systems and from there to individual homes or its many other points of use. By 1973, 967,667 miles of pipeline stretched across the United States. Of this total, 265,000 miles were transmission pipelines.

Natural Gas as Heat

Natural gas can heat a home directly or indirectly A gas furnace can provide the heat that can be used to heat water or air (see Diagram 3). The hot water can be moved via pipes to radiators throughout the house, or the hot air can circulate heat throughout the house via air ducts. Natural gas can also be used to air-condition homes. As with other fossil fuels, it can be changed into electric power and be used to heat or to air-condition homes.

How Much Natural Gas Is Available?

In 1973 natural gas supplied about one-third (30 percent actually) of the nation's total energy. Its percentage share of total energy is expected to decline as new sources become harder to find. One prediction is that by 1990, natural gas will provide only one-quarter of our total energy. This smaller percentage, however, will correspond to more than half again as much gas as was consumed in 1973. It is, therefore, important to know how much gas we have left.

DIAGRAM 1

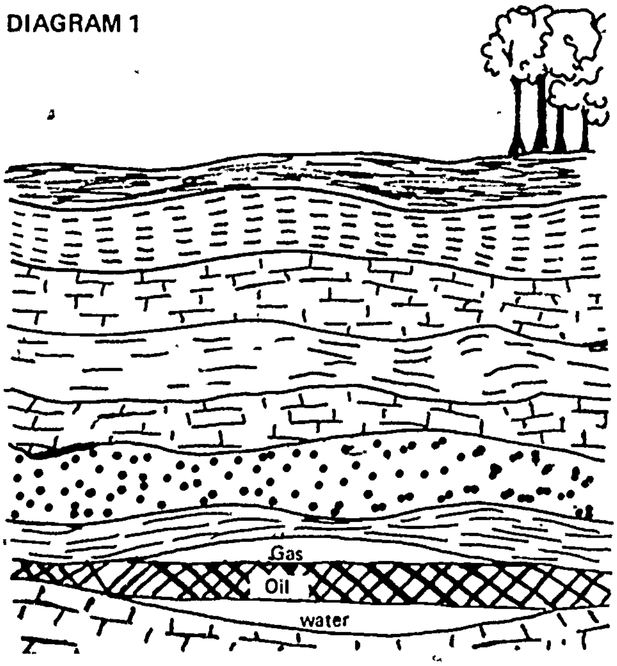
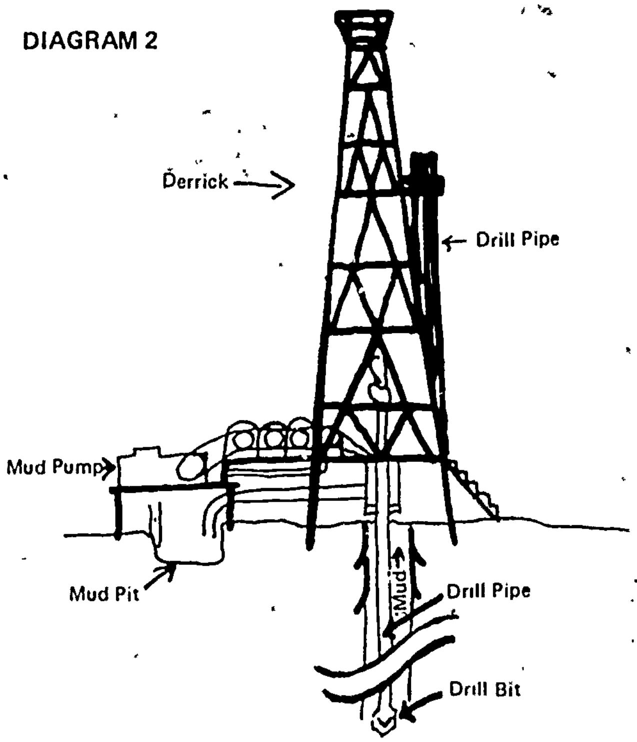


DIAGRAM 2



Some of our natural gas resources were wasted before it was learned how to store and transport the gas found during oil exploration. In the early 1900s, such gas was burned or lost — the know-how and equipment for transporting and using the gas supply were lacking. Between 1935 and 1955, however, a number of pipelines were built from the gas fields of the Southwest and other producing areas throughout the United States. It is now possible to extract and transport 80 percent of the natural gas found. (Coal is recovered at a 50 percent rate and oil at a 33 percent rate.)

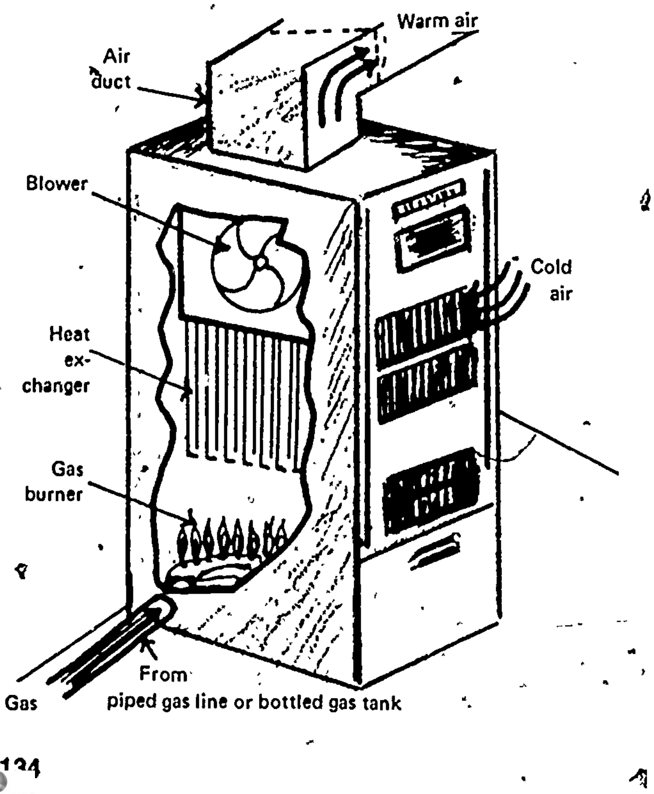
Natural gas has been a preferred fuel during the last 50 years. It is clean, efficient, and causes only a small amount of pollution of the environment. In addition, the Federal Government, which regulates the price of interstate natural gas, has kept gas prices low. We have been using our natural gas supply at an increasing rate. In 1973, the people in the United States used 22.6 trillion cubic feet of gas. (A cubic foot is a block that measures one foot in length, one foot in height, and one foot in depth.) Until the 1970s, gas companies were seeking new customers and building new pipelines. By 1972, however, some gas companies began to refuse new customers and to occasionally interrupt the supply to their larger customers, such as schools and industries.

There is presently no way of knowing exactly how much natural gas, oil, and coal is buried in the earth. Geologists and other scientists concerned with such problems make estimates based upon their knowledge of geological formations that may contain these fossil fuels. These estimates are called "ultimately recoverable resources." For instance, the estimated "ultimately recoverable resources" of natural gas in the lower 48 states and Alaska at the end of 1973 were figured at 2,560 trillion cubic feet*.

When drilling actually produces natural gas in an area previously designated as containing resources, and additional exploratory drilling reveals the size of the gas field, then data are available for a much better estimate of the quantity of natural gas in a given area. Such an estimate is then called a "reserve." Total reserves of natural gas in the lower 48 states and Alaska at the end of 1973 were estimated at 290 trillion cubic feet.

How long these supplies will last depends on how large they actually turn out to be, and on how much we use each year. If we were to continue to use natural gas at the 1973 rate of 22.6 trillion cubic feet per year, the ultimately recoverable resources would last 112 years and the reserves 13 years. If, however, our use of natural gas were to increase each year as fast as it did in the 1960s, even the ultimately recoverable resources would last only 45 years. To make sure that some natural gas is around for the next generation to use we must continue both to look for new supplies and to make sure that we use our present supplies efficiently — primarily for purposes demanding this clean fuel.

DIAGRAM 3



How Much Does It Cost?

As mentioned earlier, the United States Government regulates the price of interstate natural gas at the well. This has kept the price of natural gas low. The cost of heating using natural gas depends upon the size of the house, its geographic location, and the commercial cost of gas. In 1972, the average cost of heating a home with natural gas in our country was about $150.00 (see Table, Regional Annual Average Residential Consumption and Cost of Natural Gas).

In addition a gas furnace can cost from $250 to $500 plus installation charges. It is likely that gas prices will increase in the near future.

*Estimates differ from source to source. These estimates come from Chapter 2, Volume II, of the NSTA *Energy-Environment Source Book.*

Regional Annual Average Residential Consumption and Cost of Natural Gas

Region	Gas Consumption (in Million British Thermal Units*)	Cost
New England	89	$202
Middle Atlantic	104	170
East North Central	164	197
West North Central	154	171
South Atlantic	102	147
East South Central	112	124
West South Central	101	89
Mountain	138	122
Pacific	111	121

Source: American Gas Association, 1972.

* BTU = 0.252 Calories of energy or 1 Calorie equals about 4 BTUs.

What Are the Environmental Effects of Producing and Using Natural Gas?

Natural gas in general has few harmful effects on people or the environment. It is basically a clean fuel, with practically no sulfur impurity and, therefore, contributes little to sulfurous smog. Like any fuel, when it is burned it will produce some of the nitrogen oxides that are part of the "photochemical" smog present in places like Los Angeles.

While safe for household use, natural gas does have explosive potential as the occasional leak-caused home explosion attests. It is not poisonous but can cause death by carbon monoxide poisoning if burned in a poorly ventilated room. About 100 people per year lose their lives from gas explosions and another 230 suffer from carbon monoxide poisoning due to gas fires.

Although many people prefer natural gas because it is clean and environmentally safe, it is presently our most limited fossil fuel resource and cannot be considered the answer to our long-term energy problem.

Oil

What Is Oil?

Oil is one of our most important fuels. In appearance it is a bluish-brown liquid about the consistency of table cream. It is called a fossil fuel because it was formed hundreds of millions of years ago when the seas were filled with tiny, one-celled animals called protozoans. Each protozoan lived in the sea inside a tiny shell and fed on very small sea plants. The unused food was stored in liquid form inside the shells. As these tiny animals died, they dropped to the sea bottom and layers of their remains were built up. With the passage of time, mud, sand, and other sediments buried these layers deep within the earth. Pressure and heat eventually changed the remains into what we now call "oil." It is sometimes found in a "pool" (as shown in Diagram 1), trapped along with gas and salt water under an impenetrable dome of rock. At other times it is not in a definable pool but is absorbed into the cracks and crevices of a porous rock formation.

Extracting Oil

Oil is found by exploratory drilling in an area where geologists (scientists who study the earth and its outer layer) determine that conditions are right for its existence. Equipment and men move onto the site, a derrick (see Diagram 2) is constructed, and well digging begins. There are three major parts of a well. The derrick is a steel structure about 100 feet high that helps raise, lower, and position the pipe. The rotary drill bits are huge, pipe-like steel cones covered with sharp teeth that cut up the rock and dirt so that it can be removed. The drill pipe is a steel pipe about four to six inches in diameter and about 30 feet in length. The drill pipe is rotated, or turned, into the ground by powerful engines. A mixture of water, clay, and chemicals known simply as "mud" is forced through the pipe. This mud cleans and cools the bit and carries the cuttings to the surface. A drill bit can cut into the earth at a rate of about 40 feet per hour before the bit wears out. As the well gets deeper and deeper, additional sections of pipe are added. When a bit does break or wear out, the entire length of pipe must be pulled up and stored and the bit replaced, then the entire pipe is reassembled and lowered. The depth of the average oil well in the United States is about 4,500 feet. The complete job of replacing a drilling bit can take six men at least 10 hours — if all goes well.

Oil as a Source of Heat

Like any fossil fuel, oil must be burned to obtain energy. A sketch of a home oil furnace is shown in Diagram 3. Heat energy released in the burning of oil can be used in two ways: It can be used to heat water and then the water or steam moves into radiators throughout the house; or it can heat air, which circulates through air ducts located throughout the house. The heat from burning oil can also be changed into electricity in large power plants. This electric power can then be sent to homes to run air-conditioners or room electric heaters.

How Much Oil Is Available?

Oil supplied 46 percent of our total energy in 1974 and about half of this was used in transportation. Second only to natural gas in home heating, oil use is expected to increase. It is, therefore, important to know how much is left.

Because we imported so much of our oil, 40 percent in 1974, we have to distinguish between domestic resources — those in the continental United States — and world resources. With imported oil, it is the price

DIAGRAM 1

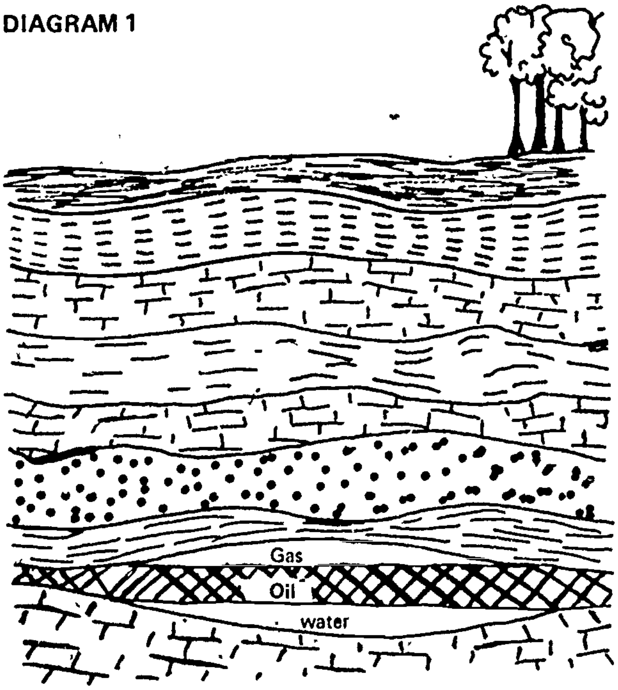
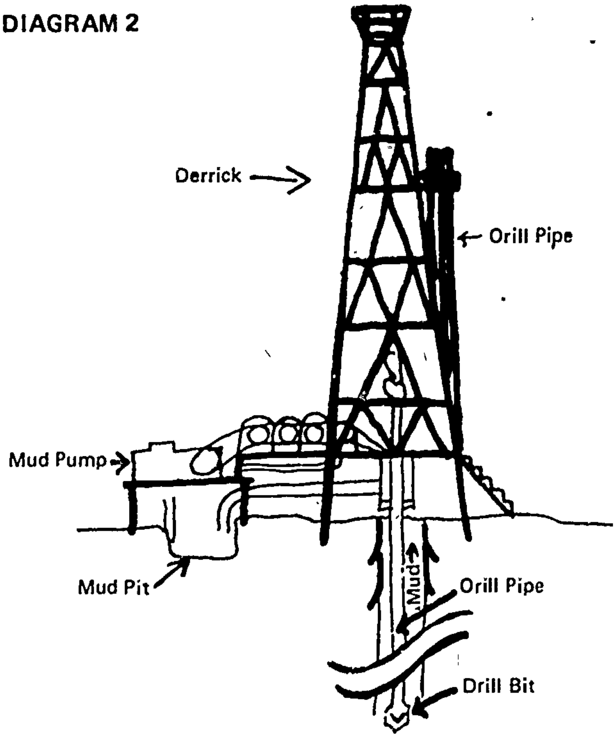


DIAGRAM 2



rather than the amount in the ground that will be important.

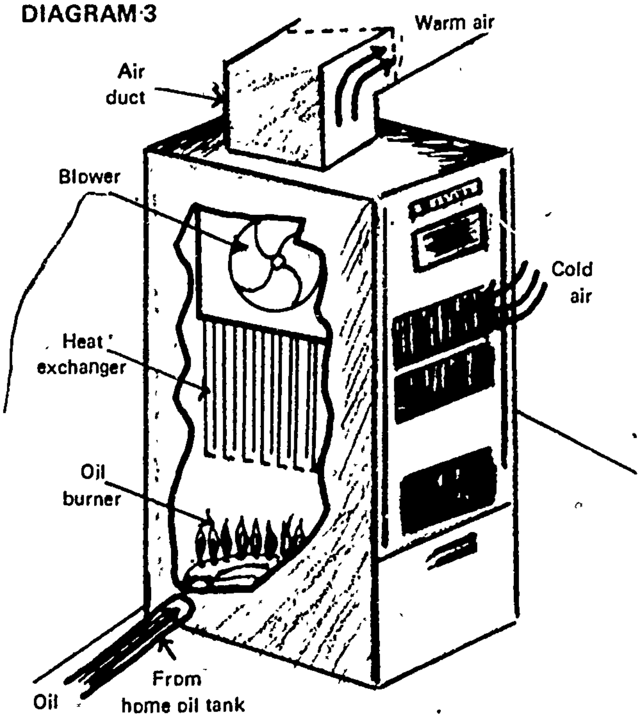
As for our domestic resources, it is difficult to estimate them. We do not really know how much there is until we pump it from the ground. We not only need to discover oil, by exploratory wells such as we have described, but we need to be able to get it out of the ground. Present techniques allow us to get only one barrel out for every three that are in an oil deposit.

We will make the same distinction here that we made in discussing natural gas. We will talk about "ultimately recoverable resources," which are estimates, based on geological studies and the like, of the total amount of oil economically worthwhile and technically possible to recover, and "reserves," which is oil that is found and its extent measured. A present estimate is that there are 52 billion barrels of oil (one barrel is 42 gallons) in the reserve category and 502 billion barrels in the ultimately recoverable resources* category. In 1973 we used 6.3 billion barrels of oil in this country. If we obtained all of that oil from domestic resources and continued using it at the same rate each year, our domestic reserves would last eight years and the ultimately recoverable resources would last 80 years. If we got only half of the supply from United States sources, these numbers would be doubled.

Our use of oil has, of course, been increasing each year, and if this trend continues the supplies will not last as long as current estimates. If our rate of use were to increase as fast as it did in the 1960s and we were to rely on domestic sources alone, even the ultimately recoverable resources would last only 35 or 40 years.

*Estimates differ from source to source. These estimates come from Chapter 2, Volume II, of the NSTA *Energy-Environment Source Book*.

DIAGRAM 3



How Much Does It Cost?

The cost of oil is rising. The cost of an average oil well ranges from $100,000 to $3 million. Most of the oil that was easy to find has been discovered and wells constructed. Offshore and Alaskan sites are likely to be the major sources of oil in the future, as they will be in much harder places to work, their oil will be more expensive.

In 1964 fuel oil cost the consumer about 16 cents per gallon. By 1974 the price had doubled to 35 cents per gallon. Only a small part of the environmental cost of correcting pollution problems is included in the 35-cent price. As these environmental costs are added, we can expect the price of oil to increase some more.

The cost of heating a home with oil varies according to the size of the home, the geographic region, and the current price of oil. The average cost of heating a home with oil is about $300 per year (estimate based on $2.50 per million BTUs* at 1974 Washington, D.C., prices).

What Are the Environmental Effects of Producing and Using Oil?

Oil can harm the environment when it is produced, shipped, or burned. Although land-based wells and land transportation of oil can be messy, offshore or Arctic drilling for oil and its shipment by sea causes most of the environmental worries. Wells leak oil into the ocean or spill it in the occasional blowout. Tankers cleaning out their holds dump oil into the sea or spill it in an accident. In the Arctic, oil spills on the ice take a long time to disappear and pipes, such as the one being built across Alaska, can cause many changes in the land they cross.

Oil refineries, which process the oil to produce gasoline, heating oil, asphalt, and other products, create air and noise pollution as well as waste products, such as sludge and brine, that can create land and water pollution unless controlled.

Air pollution is a major problem. The burning of oil in furnaces adds harmful gases to the environment unless emission controls are added to the system. The Clean

*A BTU is a unit of heat energy equal to about one-fourth a Calorie. It takes about a 100 million BTUs to heat a home for one year.

Regional Costs of Oil Heat

Region	Amount (in Million British Thermal Units)	Heating Cost*
New England	89	$365
Middle Atlantic	104	328
East North Central	164	384
West North Central	154	294
South Atlantic	102	255
East South Central	112	216
West South Central	101	165
Mountain	138	269
Pacific	111	210

* $2.50 per 1,000,000 BTU 1974, Washington, D.C.

Air Act of 1970 has set standards for oil refineries and other manufacturing plants in an attempt to control the emission of harmful gases into the atmosphere. Plants may be fined or closed if they do not comply with state regulations. At present no legislation has been passed to regulate air pollution from individual home furnaces. These harmful gases contribute to a variety of respiratory problems in people and animals.

The Water Quality Act of 1970 was passed to help regulate water pollution caused by oil spills and offshore oil drilling. The Federal Government has authority to conduct water clean-up operations and bill the responsible party later.

Coal

What Is Coal?

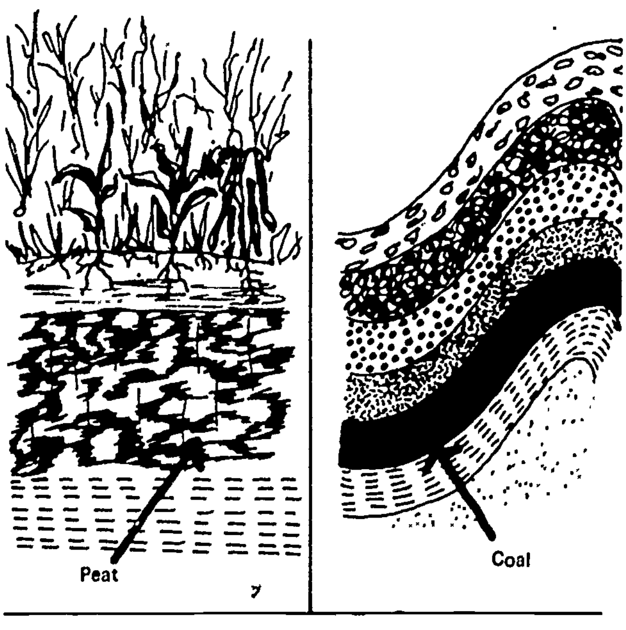
Coal, like oil and natural gas, is a fossil fuel formed from the remains of vegetation. Half a billion years ago, the earth was warmer and wetter than it is now. Fern trees, huge mosses, and other tropical plants grew profusely in earth's swampy surface. They died and fell into the shallow water, building up layer upon layer. Cut off from oxygen by the water, much of the plant matter remained undecayed. As time passed this undecayed organic matter built up into the spongy substance we call peat (see Diagram 1). Dirt and sand washed down from the mountains and gradually buried the peat deeper and deeper. As the pressure compacted it and the heat increased much of the gaseous part, the hydrogen and oxygen were driven off and almost pure carbon was left behind — the hard, shiny black mineral we call coal. Now found in *coal beds*, seams usually 3 to 8 feet deep (although seams up to 100-feet thick are known), twisted by the folding of the earth's crust, coal is sandwiched between layers of shale, sandstone, or other kinds of rock as shown in Diagram 1.

Mining Coal

Coal is mined either on the surface or underground. In underground mining, a hole is dug to the coal bed and gradually a tunnel large enough for men and machines to enter is cleared. Miners then begin the task of drilling and removing the coal. Coal is cut from the seams with automatic equipment. Shuttle cars or conveyor belts carry the coal to the surface, where it is processed and loaded on trucks or directly on railroad cars and sent to its destination. About half of all the coal produced in the United States is mined underground.

Surface mining, or *strip* mining as it is called, is used when the coal is located near the surface. Large power shovels and bulldozers remove the earth, rock, and vegetation above the coal seam, sometimes to a depth of 100 feet. Then smaller power shovels are used to remove the coal. Strip mining has become more important during the past decade and now about half of all domestic coal is produced in this way.

DIAGRAM 1



Coal as Heat Energy

When coal is burned, the sun's energy that was stored in the plants hundreds of millions of years ago is released. Coal was once an important source of home heat, but now only a few coal-burning heating systems remain and most of these are in large buildings. When it is used to heat a building, the furnace system is similar to the one shown for oil, heat can be transported around the building by hot air, hot water, or steam.

The more important use of coal for heat is indirect. About half (46 percent in 1973) of the electricity we use is generated at coal-burning utility plants. This electricity can then be used to heat or cool houses and commercial buildings.

How Much Coal Is Available?

In 1974 coal accounted for only 18 percent of our total energy. We produced about 600 million tons of this fuel and exported 54 million tons to foreign countries. Since coal is our most abundant fossil fuel resource, its use is expected to increase; some experts predict that we will mine almost a billion tons of coal per year by 1980. It is thus important to know how much coal we have.

Coal deposits are much easier to find and map than are deposits of oil and natural gas. They are nearer the surface and are usually found where the geologists predict that they should be. The total coal which can be mined from known seams is given as 390 billion tons.* This is coal that is economically feasible to mine and counts only that 50 percent which will be extracted. (Present techniques leave about half the coal in the ground.) If we use coal at the rate we did in 1974, these reserves will last about 650 years. If our use increases 5 percent per year (this means our consumption will double every 14 years), the coal reserves will only last 70 years—not even coal can last forever.

How Much Does It Cost To Heat with Coal?

As we said earlier, coal is no longer used to any great extent in home furnaces. Still, some idea of the cost is helpful and is given in the table below, using 1974 coal prices in Washington, D.C. On the average it would cost $244 per year to heat a home by coal.

The cost of coal will no doubt rise. Not only are labor, machinery, and other production costs rising, but environmental and miner health costs must also be added. Mine safety is being improved, payments to miners with

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*Estimates differ from source to source. These estimates come from Chapter 2, Volume II, of the NSTA *Energy-Environment Source Book*.

"black lung" (a respiratory disease caused by inhaling coal dust) are now being made by coal companies, and stricter land reclamation laws may add several thousand dollars per acre to production costs. All these increases, however, will add only a dollar or so to the price of a ton of coal, and it will probably remain our cheapest fossil fuel.

What Are the Environmental Effects of Producing and Consuming Coal?

Coal mining is harmful to the environment in a number of ways. When strip or surface mining is used, huge shovels — 200 feet tall, weighing millions of pounds — and other equipment move trees, shrubs, grass, and topsoil to get at the coal underneath. This is a cheaper way to harvest coal than underground mining and usually yields a higher percentage of the coal in the seam, 80 to 90 percent, than the 50 percent yield from underground mining.

Strip mining leaves the ground turned up and desolate. The exposed, bare ground, if it is on a hillside, is easily eroded and the silt and acid (formed when water combines with sulfur impurities) damage vegetation and stream life. On arid land it may take years for any vegetation at all to return.

The strip-mining picture is improving in this country. All states now have laws that require the restoration of mined lands, and the enforcement of these laws is becoming more vigorous.

Coal mining has also been costly in terms of human life. It is considered the most hazardous occupation in this country, 152 miners were killed in 1973. New coal mine health and safety regulations are being enforced, making the mines safer. The 152 miners killed in 1973 was a much better record than the 250 killed in 1970.

In addition to the mine accidents, many miners have been afflicted with black lung disease. It is estimated that as many as 125,000 miners may have this life-shortening illness and that it contributes to some 3,000 to 4,000 deaths per year. The new health and safety laws call for regulation in this area and measurement of dust levels in mines already show that coal dust is below the designated maximum level.

Coal also causes problems when it is burned. Most coal contains a chemical called sulfur that, when it is burned, creates a gas which escapes up the smokestack and contributes to the smog we sometimes see over cities in the winter. This smog can be harmful to people and other living things. And soot from burning coal is one of the causes of the dirt and grime that cover our cities. The new clean air laws cause utility companies to employ emission control devices. Most electric power plants now have equipment that removes 99 percent of the soot from the smokestack fumes and equipment is coming into use that can take out most of the sulfur also.

Since our supplies of coal are much greater than the supplies of the other fossil fuels, oil and natural gas, scientists and engineers have developed means for creating synthetic or manufactured gas from coal. While the environmental effects of mining coal would not be reduced, the "gasification" of coal could add to our supplies of natural gas and decrease the contribution coal makes to our air pollution.

Regional Costs of Heating with Coal

Region	Amount (in Million British Thermal Units)	Cost
New England	89	$175
Middle Atlantic	104	204
East North Central	164	322
West North Central	154	302
South Atlantic	102	201
East South Central	112	219
West South Central	101	198
Mountain	138	271
Pacific	111	218

Figures based on $51 per ton, 1974 price, Washington, D.C.

1 ton coal = 26 M BTUs

Electricity

What Is Electricity?

We call electricity an intermediate form of energy. It is not stored energy, such as the fossil fuels or uranium, and it is not in the form in which it finally appears as work or heat. Stored, or potential, energy is converted to electric energy by the processes described below. Electric energy then must be converted by a motor or a heater in order to be used.

Electric energy comes out of the following processes:

1) A fuel such as coal, oil, or natural gas is burned and heat energy is released. (Nuclear energy is also converted to heat energy.)
2) Heat energy is used to produce very hot steam.
3) The steam turns a steam turbine, converting heat energy to mechanical energy.
4) The turbine turns an electric generator, converting mechanical energy to electric energy.
5) Electric energy is transformed to very high voltages in a transformer and transmitted to substations and around the country on high-voltage transmission lines.
6) From the substations, the electric energy is transformed to appropriate low voltages and distributed by wire to offices, industrial plants, homes, and the like, where it is converted to heat, light, or mechanical energy by a variety of electrical devices.

The entire process is shown schematically in Diagram 1, below.

Electric power for heating and cooling: Homes are wired to carry electric current throughout the house. This electric power can then be used to heat and cool the home, to power appliances such as washers, dryers, TVs, and toasters, or to provide light. To heat a home electrically, baseboard heaters containing electric coils can be placed in each room, or larger space heaters can be used to heat a room (see Diagram 2). To cool a home, a centrally-located air-conditioner can be used to circulate cool air through air ducts or individual air-conditioning units can be placed in various windows to cool rooms.

How Much Electric Power Is Available?

The amount of electric power that can be produced depends upon two factors: available fuels and available generators. In 1973, 81 percent of our electric power was produced by burning fossil fuels (see Graph 1). This poses a problem. Our domestic supply of natural gas and oil is diminishing and imports of these fuels are becoming more expensive. The estimated lifetimes of our various fossil fuels is summarized in Table 1. This

TABLE 1
Predicted Lifetimes of Fossil Fuels[a]

Coal	650 years
Oil[b]	180 years
Natural Gas	110 years

[a] Lifetime calculations assume consumption continues at 1973 rate and are based on "ultimately recoverable resources" rather than known "reserves."

[b] Based on continued importing of 45 percent of oil consumed. If only domestic oil is consumed, the lifetime would be 80 years.

DIAGRAM 1

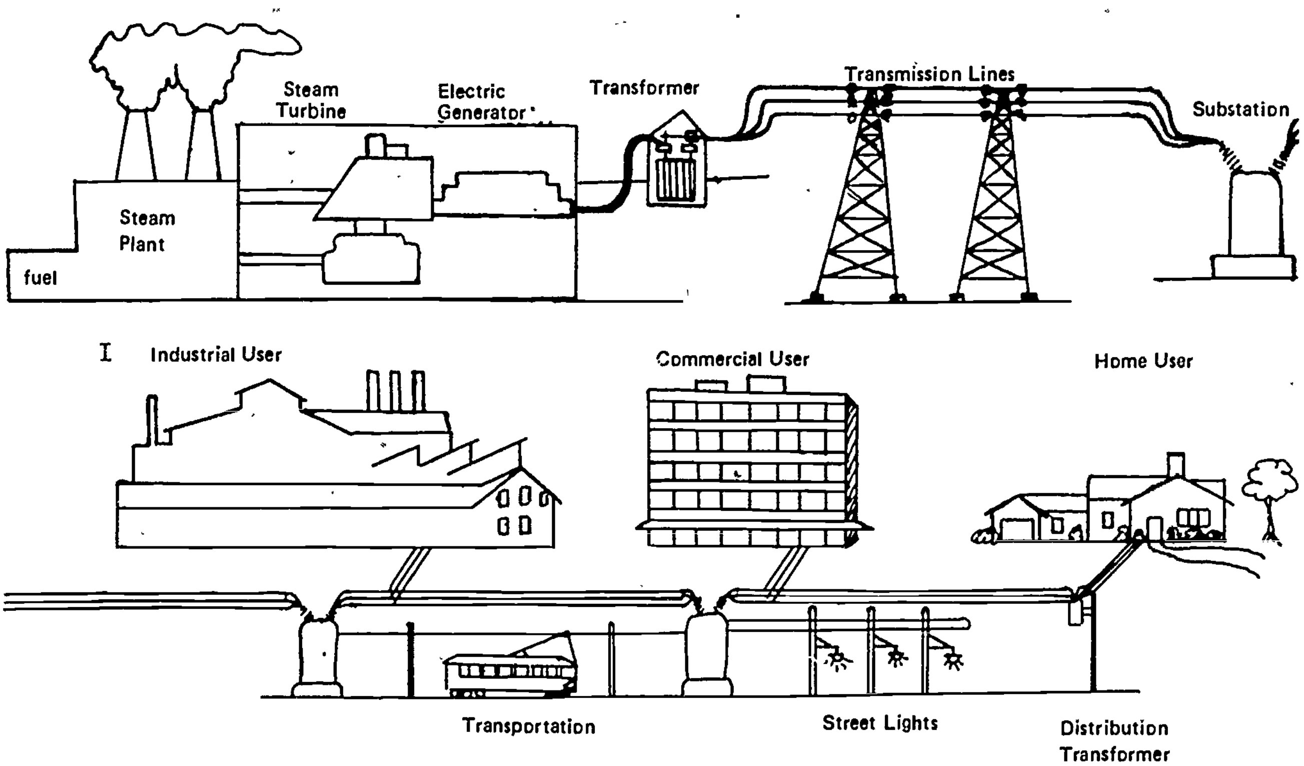


table tells us how long they will last *if each year we use the amount we used in 1973.* Since we are actually using them faster than this, they will probably not last this long. The Federal Power Commission predicts that nuclear power will be providing 40 percent of all electric energy by 1990. In addition, methods of converting solar energy into electric power are being investigated. Only coal can be considered a possible long-range energy resource, and increased use of coal will reduce the supply more quickly than we presently predict.

In addition to the need for an adequate fuel supply, electric energy is limited by the number of power plants which can generate electricity. There are presently about 3,000 power plants in the United States. A generator consists of many coils of wire placed between the north and south poles of a magnet. Steam moves the turbine, which spins the coils of wire and causes electric current to flow. It requires four to seven years to build a typical large generating plant. Each generator has a peak capacity (upper limit) for producing electric power. In 1974 the total generating capacity of all electric plants was about 500,000 megawatts* of electric power. By 1990 this figure is expected to be 1,260,000 megawatts — almost three times as much. Modern generator capacity ranges from 1,000 to 3,000 megawatts. (A 3,000-megawatt generator could power Washington, D.C.) We will need at least another 300 generating plants by 1990.

What Does Electric Energy Cost?

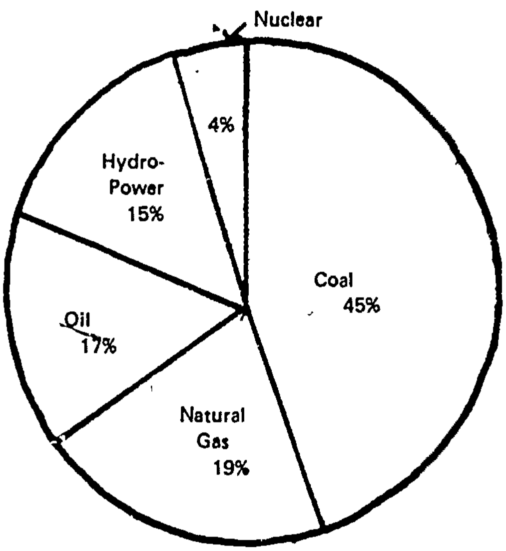
Electric energy use has grown because the price for electricity has actually decreased over the years. In 1940 the average electric energy cost was 2.2 cents per kilowatt-hour. (A kilowatt-hour can power a 100-watt lightbulb for 10 hours.) In 1968 it cost, on the average, 1.5 cents per kilowatt-hour. Since 1971, however, the price of electricity has been increasing. The average cost of heating an electrically-powered home in 1972 was estimated to be between $500 and $600 for the year (see Table 2).

The cost of building an average electric power plant is now more than $500 million. Many experts believe that the days of declining costs are over. As fossil fuel costs rise, electricity costs are also likely to rise. We can expect electric power to be available if we are willing to pay the price for it.

What Are the Environmental Effects of Producing and Consuming Electricity?

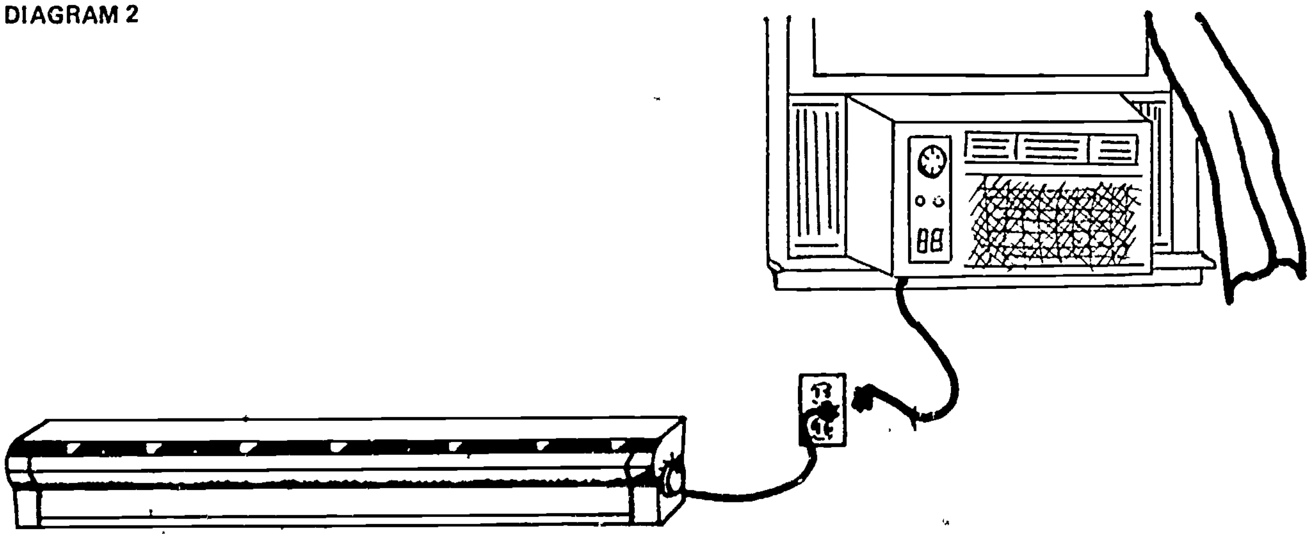
Electric energy today depends largely upon the fossil fuels — coal, oil, and gas. Whenever a fuel is burned to create the steam which produces electricity, much of the heat created by burning the fuel is lost. The best electric

GRAPH 1
Fuels Which Produce Electric Power



*A watt is a measure of electric power; i.e., the rate at which electric energy is produced. A megawatt is one million watts. For reference, a typical football or baseball stadium uses about a megawatt of electric power for night lighting.

DIAGRAM 2



plants convert 40 percent of the fuel's energy into electric energy, allowing 60 percent to become wasted heat. About 10 percent of this heat loss leaves the plant as hot gas while the rest is discharged into the cooling water and enters nearby rivers or lakes. This increase in water temperature does not directly affect the health of people, but it can affect the marine life in the body of water it enters. Some of these effects are considered beneficial for the marine life, but most are considered harmful. At a certain stage of development, an increase in water temperature can help eggs and young fish grow faster. However, increased temperature often results in a loss of the more desirable species of fish and stimulates the less desirable. Higher temperatures can also affect the migratory habits of fish.

In addition, higher temperatures increase water evaporation and help concentrate the minerals already present in water. In cold areas, the warmer waters would stimulate recreational use; while in already warm waters, they would make the waters' use undesirable.

The Water Quality Act sets the standards for water quality. This includes temperature regulation of our rivers, streams, and lakes. Each state specifies the allowable rate-of-change of water temperature. Most states set the maximum water temperature change at less than 5°F.

Utilities are seeking practical ways of using their waste heat for such things as heating commercial buildings or in industrial processes. It may also be employed in desalting water and in agriculture. They are also turning away from direct use of river or lake water to cooling towers. In these towers a smaller amount of cooling water is recirculated and cooled either by evaporation (the "wet cooling towers") or by cooling fins in contact with air (the "dry cooling towers"). The use of such towers might increase the cost of electric power 5 to 10 percent.

Besides increasing water temperatures, power plants burning fossil fuels add sulfur dioxide and other gases to the air, forming smog that is harmful to man, materials, and crops. It contributes to diseases such as bronchitis and emphysema. The Clean Air Act establishes and maintains regional, state, and local air pollution control programs and enforcement of its provisions is bringing about more control over utility emissions.

In addition to gases and heat, fly ash enters the air and deposits dirt on surrounding homes and factories. This can also affect health and possibly even the climate of a given region. Gases and fly ash are controlled by equipment capable of removing 99 percent of the particles from the air.

In transmitting electricity from generating stations to local customers, towers, utility poles, and miles of cable are needed. High-voltage transmission lines require 200-foot-wide rights-of-way and now occupy about four million acres in the United States. Lesser effects include above-ground interference with radio and TV reception and underground electric currents which may corrode sewer and water pipes.

In addition to the environmental problems caused by creating electricity itself, the effects produced by obtaining the fossil or other fuels for its generation must also be considered.

Electric power does, however, make many positive contributions to our society. It creates jobs for the people who extract and transport the fossil fuels, as well as other jobs in the power plant and along the transmission lines. It provides the power for industry, for most of our home appliances, and for most of our forms of entertainment — radio, TV, and movies, for instance. Electric power is largely responsible for the high standard of living and many of the luxuries we enjoy today.

TABLE 2
Regional Cost of Electric Power for Home Heating

Region	Amount (in Million British Thermal Units)	Cost*
New England	89	$731
Middle Atlantic	104	656
East North Central	164	769
West North Central	154	589
South Atlantic	102	511
East South Central	112	432
West South Central	101	330
Mountain	138	539
Pacific	111	420

Source: Potomac Electric Power Company, Washington, D.C., 1974.

* $5.00 per 1,000,000 BTU.

Nuclear Energy

What Is Nuclear Energy?

Many people believe that nuclear energy is the answer to our energy problems. Others feel that it is a threat to public safety. It has already begun to play a large role in our energy future.

Nuclear energy is created by a process called fission. In fission the atoms of Uranium 235 are bombarded inside a nuclear reactor by neutrons (see Diagram 1). This bombardment results in the splitting of the uranium atom into two smaller atoms. When the uranium splits, heat is released along with more neutrons to continue the process. Since nuclear reactors are very complex and require many safety precautions, they can not be used as direct sources of heat for individual homes. The heat produced in a large reactor, however, can be used to heat water which creates steam and generates electric power. In 1974 nuclear-electric power accounted for about 6 percent of our total electric power. The Federal Power Commission predicts that by 1990, 40 percent of all electricity will be powered by nuclear energy.

Nuclear reactors: The nuclear reactor provides the environment in which fission occurs and is controlled. It also recovers the heat that is used to produce the electricity. The major parts (see Diagram 2) of the reactor are:

- ☐ fuel, which is used in the fission reaction and produces the energy
- ☐ control elements, which set the rate of energy released
- ☐ cooling fluid, which removes the heat generated in the reactors

The nuclear plant: Today there are 50 licensed nuclear plants located in 26 states. The average plant costs $600 million to construct, requires 4 to 6 years to build, and produces 1,000 megawatts* of electric power. The plant design is determined by the kind of nuclear reactor used (see Diagram 3). Besides uranium, one of the important resources necessary for a nuclear plant is water. It is estimated that 330,000 gallons of water flow through a reactor *per minute*. A nuclear plant functions much like a fossil fuel electric plant. Both use steam to drive a turbine generator that produces electricity. The main difference is the way the steam is produced. In fossil fuel plants, coal, oil, or gas is burned to boil water to make steam. In nuclear power plants, nuclear fission produces heat which creates the steam.

Home use: Nuclear energy can be used indirectly to heat and cool homes. It is first used to produce electric energy, and then this electric power is sent to homes. In the home, electric baseboard heat or space heaters are used to provide heat, and electrically powered air-conditioners can be used for cooling the home.

*A watt is a measure of electric power: the rate at which electric energy is produced. A megawatt is one million watts. For reference, a typical football or baseball stadium uses about a megawatt of electric power for night lighting.

DIAGRAM 1

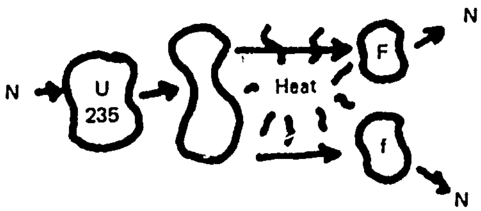


DIAGRAM 2

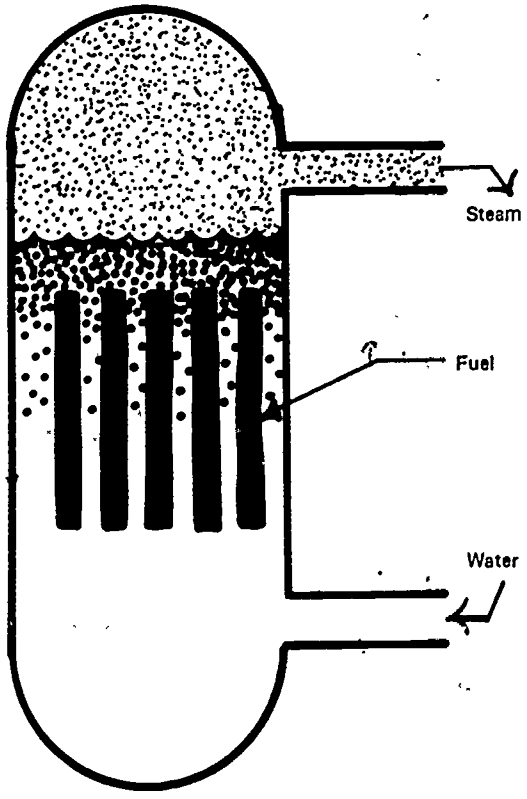
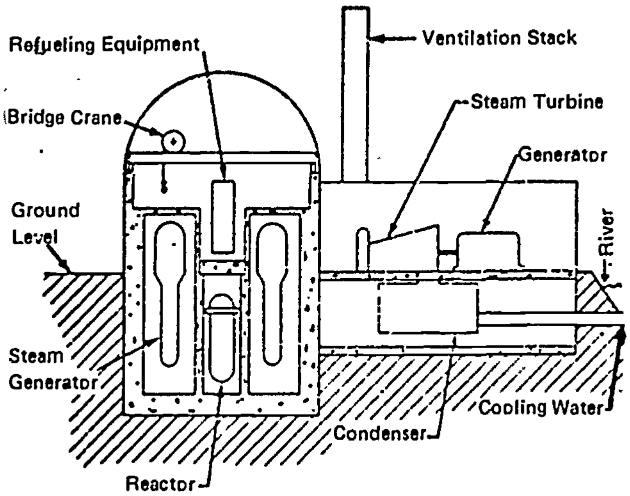


DIAGRAM 3



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How Much Nuclear Energy Is Available?

The basic fuel for nuclear energy is uranium, a somewhat rare mineral. As with other fuels, the amount of uranium available depends to a large extent on the price we are willing to pay for it (see Table 1). It is estimated that a typical nuclear power plant uses 130 tons of uranium to produce 1,000 megawatts of electricity. (A 1,000-megawatt plant could power one-third of the city of Washington, D.C.) The 50 plants in operation today produce 33,000 megawatts of electricity and use approximately 4,290 tons of uranium per year. At this rate, using the $10-estimate figures from Table 1, the lifespan of our domestic uranium reserves would be about 220 years. Since we are using more and more each year, they will not last that long. In fact, if the growth of nuclear-generated electricity were to continue at its present rate, the consumption of electricity doubling every three years, the supply of under-$10-per-ton uranium would only last about 30 years.

Scientists are working on a new reactor known as the breeder reactor. Breeder reactors are so named because they are able to produce a by-product, plutonium, which is itself a fuel. It is estimated that the breeder reactor can increase the lifetime and supply of nuclear fuels fifty-fold. Although breeder reactors are not being used today, they are likely to be developed and used in the near future.

How Much Does Nuclear Energy Cost?

Today the cost of producing electricity using nuclear power is similar to fossil fuel costs. The cost of heating and cooling with nuclear-electric power depends upon the size of the house, its geographic location, and the price of uranium. The average annual cost of nuclear-electric power to heat a home is about $550 to $600 (see Table 2 for regional costs).

How Does Nuclear Energy Affect the Environment?

Nuclear energy affects the environment in two main ways. On the one hand, there are environmental effects of mining and processing uranium. On the other hand, there are dangers to the environment and to people from the reactors themselves.

Effects of mining uranium: Uranium mining problems are similar to those of other types of mining. The miners are exposed to dust, accidents, fumes, and intense noise. The major concern, however, is the added presence of radioactive gas. Uranium is slightly radioactive and the U.S. Public Health Service has connected the relationship between exposure to radioactivity and lung cancer in humans. Uranium miners have higher rates of lung cancer than the general population. Controls for reducing the amount of radioactivity in the mines are being investigated. The waste materials from uranium mining are also dangerous and must be kept out of contact with living things.

Effects of nuclear reactors: There are two dangers from the reactors themselves. The leftover fuel material is highly radioactive and must be kept out of contact with living materials. There are about 45,000 gallons of radioactive waste produced for every 1,000 megawatts of electricity produced, and this must be stored somewhere for hundreds of years.

Large doses of radiation can seriously injure or kill human beings. Much less is known about the effects of the very small doses associated with the discharge from nuclear plants. Scientific opinion is, however, that even small doses do some amount of genetic damage and carry a low cancer-causing probability. Radiation levels from nuclear plant discharge are considerably smaller, at present, than are the levels we are exposed to from other man-made and natural sources.

The radioactivity associated with nuclear waste is potentially much more dangerous than that from plant discharge and for that reason it must be safely and securely stored. The final disposition of this material has not yet been decided, and more and more accumulates as the number of operating reactors increases.

The major concern about nuclear reactors is the possibility of an accident. While present-day reactors cannot explode like a nuclear bomb, there are possible malfunctions that can result in a small explosion. The spread of radioactive debris over the countryside would be a catastrophe.

In a recent study funded by the Atomic Energy Commission (this agency no longer exists and most of its functions are absorbed in the Energy Research and Development Agency, ERDA), the probabilities of such accidents were estimated. The conclusion was that

TABLE 1
U.S. Uranium Resources

Price Per Pound	Reasonably Assured Reserves (in tons)	Estimated Additional Resources (in tons)	Total (in tons)
$ 8.00	277,000	450,000	727,000
10.00	340,000	700,000	1,040,000
15.00	520,000	1,000,000	1,520,000

Atomic Energy Commission, 1974

TABLE 2
Regional Costs of Nuclear-Electric Energy

Region	Heating Cost
New England	$409
Middle Atlantic	476
East North Central	751
West North Central	705
South Atlantic	469
East South Central	511
West South Central	462
Mountain	632
Pacific	510
Average	$569

(Based on 1973 figures, 1,000 megawatt nuclear power plant—light water reactor, $4.57 per 1,000,000 BTUs.)

serious accidents are not very likely — only one chance in one billion of an accident causing some 2,000 deaths. Such an accident, however, could do as much as $2 billion in property damage. These are risks which must be weighed into the cost of nuclear power.

Solar Energy

What Is Solar Energy?

Solar energy, sunlight or radiant energy, falls on the earth, providing both heat and light for plant and animal life. Scientists and engineers are just beginning to find practical ways to use solar energy to heat and cool individual homes. The United States Government is sponsoring several experimental projects which are investigating methods of collecting solar energy and converting it to electric energy. This solar-electric energy could then be used to heat and light entire communities.

Solar energy as a heat source: The present method of using solar energy to heat a home requires some type of collector which absorbs and traps the sun's energy. One side of the roof of a house might be converted into a solar collector similar to a very large "glass sandwich" (see Diagram 1). The "sandwich" has an outside layer of glass, a half-inch air space, a second layer of glass, and a layer of aluminum painted black. The glass allows the sunlight to pass through to the black surface, which absorbs the light and is heated. This absorbed energy then heats water which flows over the black surface or flows through pipes directly behind the black surface. This hot water can then be piped to hot water radiators throughout the house or it can be used to heat air which is circulated through ducts throughout the house.

Using solar energy: A solar heating and cooling system is expensive to install now, but the rising costs of other fuels make solar energy one of our best hopes for the future.

A solar-heated home: Harry Thomason of Washington, D.C. has designed a workable solar heating system for an individual home (see Diagram 2). He made a solar collector by covering one side of the roof of his house with two layers of glass followed by a third layer of corrugated (∩∩∩∩) aluminum. He placed a 1,600-gallon water tank in his basement. This tank is insulated and surrounded on three sides by fist-sized stones. Pipes lead from the tank, across the basement, up the side of the house to the top of the roof. Water moving through a pipe trickles down the hot corrugated aluminum and becomes warm. This warm water flows into the tank, heats the surrounding stones which in turn heat the air. This warm air is then circulated by a fan throughout the house.

Mr. Thomason's storage system can provide heat for five sunless days. Average daytime temperature in the house is 72°F and the nighttime average is 68°F. A small furnace is kept in the basement for use during prolonged sunless periods. With certain changes this system can also be used to cool a house.

How Much Solar Energy Is Available?

Solar energy is the most abundant and continuous form of energy available to man. Much of the sunlight that approaches earth is reflected by the atmosphere back into space. It is estimated that only half of the solar energy from the sun actually reaches the ground. This is still a great amount of energy — roughly 810 kilowatts per acre. Only a small part of this is actually used by man. Sunlight not only provides light and heat but is indirectly the source of our food, winds, water power, and the fossil fuels. When scientists learn to successfully collect, store, and transport solar energy, they will have tapped the greatest energy source available to us.

What Does It Cost?

Solar heating and cooling systems are expensive to install but very inexpensive to operate. The Thomason system costs about $2,500 to install but only $6.30 a year to use. Local governments (the Washington area is one) and private companies are sponsoring research projects in hopes of finding less expensive systems for using solar energy. There are also research teams investigating practical methods for converting solar

DIAGRAM 1

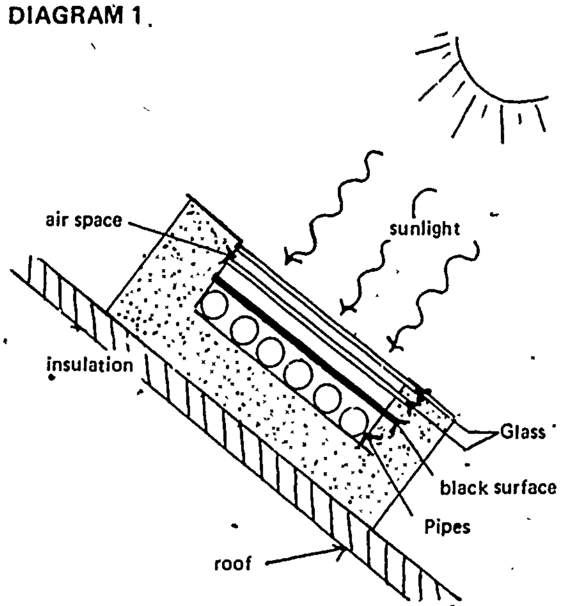
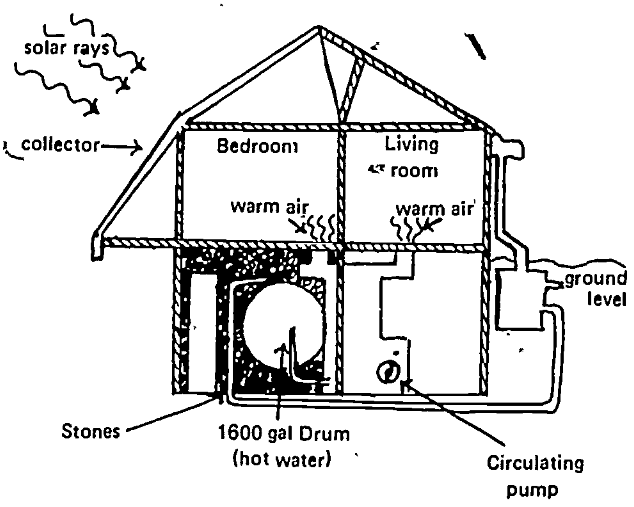


DIAGRAM 2



energy into electric energy which can be used to power entire communities.

The basic cost of operating a solar-heated home will vary according to the size of the house and the general climate of the region in which it is located. Colder regions would require greater use of the auxiliary heating system to maintain a 70-72°F house temperature.

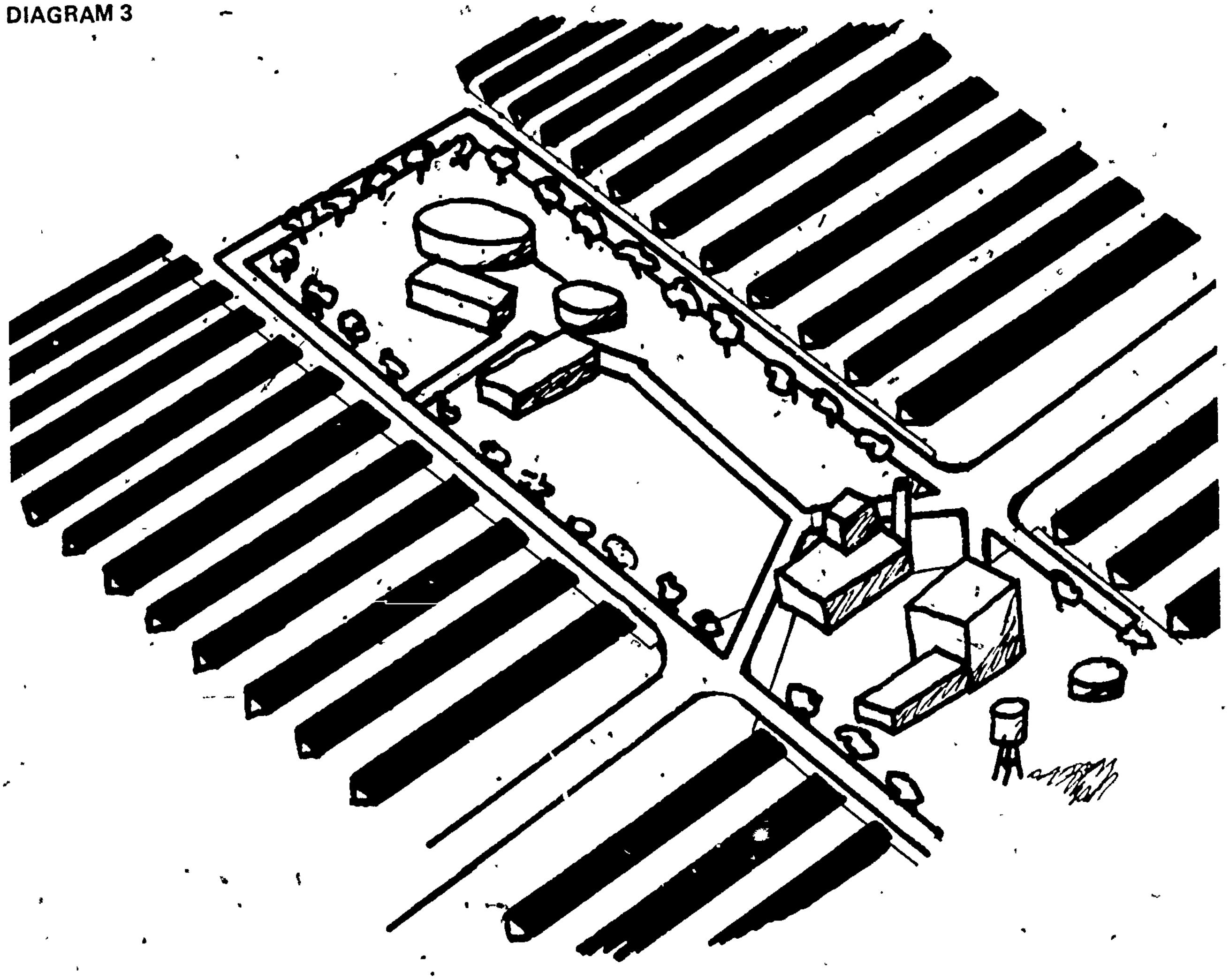
What Are the Effects on the Environment?

Solar heating and cooling have no known harmful effects on man or plant life. If used in an individual home, the system can provide a clean form of heat without adding pollution to the surrounding air, land, or water. In order for solar heating to be widely used, however, we will need to find a way to make electric energy from solar energy. At our present level of technology, large tracts of land would be needed for solar collectors. Two physicists, Drs. Aden Meinel and Marjorie Meinel, have designed a model of a solar "farm" which could be used to collect solar energy and convert it into electric energy (see Diagram 3). They estimate that these solar farms would require 10,000 square miles of land to produce enough electricity for the entire United States. This would mean that about 25 square miles of land, or an area roughly equal to 1,000 football fields, would be needed to power Washington, D.C. (based on the 3,000-megawatt* 1970 consumption rate).

If cheaper, more compact systems can be designed, solar energy is likely to be an increasingly popular form of energy in the future. It is probably one of the best alternatives to the long-term energy problem, but we are just beginning to understand its potential.

*A watt is a measure of electric power; the rate at which electric energy is produced. A megawatt is one million watts. For reference, a typical footba.. or baseball stadium uses about a megawatt of electric power for night lighting.

DIAGRAM 3



Geothermal Energy

What Is Geothermal Energy?

Geothermal energy is created by the natural heat of the earth. When the heat from the molten inner core of the earth meets the underground water, hot water or steam results. When this water or steam pushes through the surface of the earth, it creates either a hot water spring or a geyser (see Diagram 1).

People have used hot water springs as health baths for centuries, but only in the 1900s have natural steam and hot water been used for heating homes. In 1904 geothermal energy was first used in Italy to provide electricity. Hungary and Iceland started piping natural steam and hot water directly into homes in the 1930s. Finally, by the 1960s, New Zealand, Japan, and the United States started to build small power plants that used geothermal steam to generate electricity. Presently geothermal energy accounts for 0.1 percent of the world's electric power. The largest United States field, California's The Geysers, provides about 500 megawatts* of electric power.

Tapping and Using Geothermal Energy

Geysers indicate that in the surrounding area hot underground water and steam are near the earth's surface. Once the geysers have been located, a geologist, a scientist who studies the earth and its outer layer, investigates the size, volume, and temperature of the geothermal system. If conditions are favorable, a well is dug near a geyser and the steam is channeled through large pipes to its destination (see Diagram 2). This natural steam may be piped directly to homes or to a nearby electric plant.

When natural steam is piped directly to a home, it fills hot water radiators and provides heat. More often today it is piped to an electric plant and is used directly to turn the turbines and generate electric power. Then this electric power is transmitted through wires into individual homes. Inside a home, electric power can heat either by using an electric hot-air furnace or by using electric space heaters. Electric power can cool by using individual air-conditioners or a centrally located forced cool air system.

How Much Geothermal Energy Is There?

At the present time geothermal energy provides 0.1 percent of our electric power and only isolated examples of direct steam power for homes. It is limited to those areas where geysers exist. In the United States, most of these areas are located in the Western states. Geothermal springs are located in Idaho, Nevada, Colorado, New Mexico, Oregon, Wyoming, Utah, and Montana (see map of Geothermal Regions). The more

*A watt is a measure of electric power: the rate at which electric energy is produced. A megawatt is one million watts. For reference, a typical football or baseball stadium uses about a megawatt of electric power for night lighting.

DIAGRAM 1

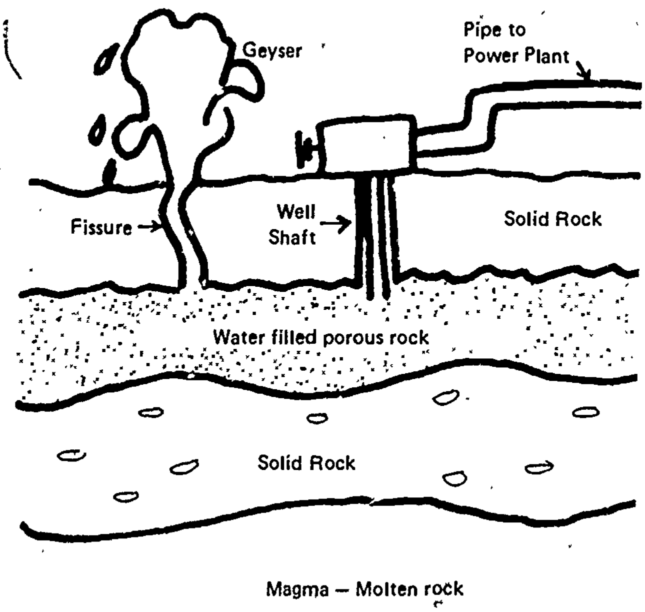
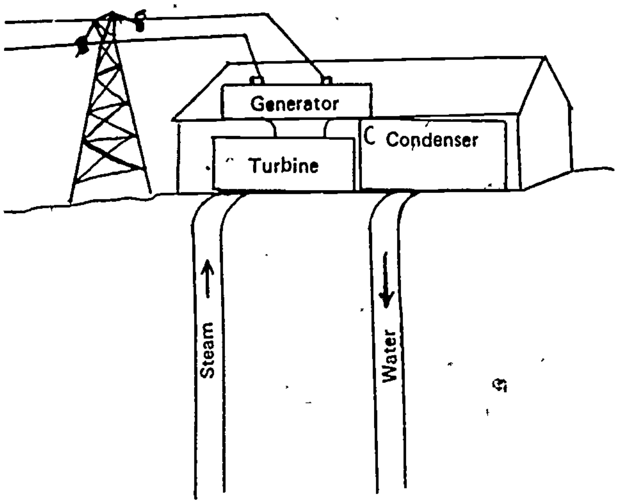
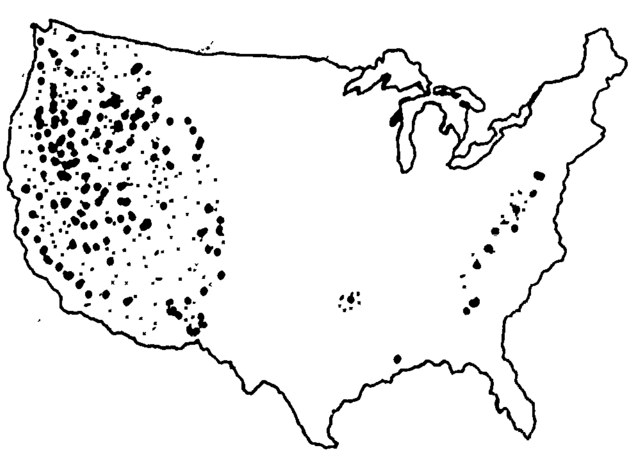


DIAGRAM 2



Map of Geothermal Regions



thorough survey now under way will, no doubt, locate many more sources not visible on the land's surface.

Steam is not easily transported long distances, therefore, geothermal-electric power plants are located on the geothermal sites. Relatively small, they service only the local area. The Geysers Plant in California provides half of San Francisco's electricity.

How Much Does It Cost?

One of the most attractive qualities of geothermal energy is its low cost. The initial costs of locating reservoirs of natural steam are fairly expensive, but natural steam itself is very inexpensive when compared to nuclear and fossil fuels. Natural dry steam (steam without any water droplets) is available at about $0.70 per million British Thermal Units (BTU)*. If steam is piped directly to individual homes, the average cost of heating with dry natural steam would be about $92 per year.

When dry natural steam is used to create electric power, it is also less expensive than nuclear or fossil fuels. An estimated cost for geothermal electric heat for the average American home would be about $200 per year (see Table, Regional Cost of Geothermal Electric Energy).

This is about one-third the cost of oil-generated electric heat and one-half the cost of nuclear-electric heat. So the relatively low cost of geothermal-electric heat makes it a desirable alternative for heating and cooling homes where it is available.

How Does It Affect Our Environment?

The use of geothermal energy can have adverse effects on the surrounding land area and on the people and animals who live there. Most geysers and hot water springs are present in scenic areas with unique landscapes. Yellowstone National Park is one area where geysers, such as Old Faithful, are located. People often object to "spoiling" these landscapes with geothermal wells. Tapping geothermal energy would require the construction of roads, ponds, wells, large aboveground pipes, and an electric power plant. In addition, geothermal wells require a ventilating system to prevent the loss of the well due to condensation. Noise from an unmuffled well has been compared to a jet plane on takeoff. When the steam and fluids of a geothermal reservoir are removed, the ground may subside, or sink, a little. In residential areas this would create problems. One solution to this is to pump the used water and fluids back into the earth after they have been used.

Geothermal energy also affects the water and air. Poisonous or highly salty geothermal fluids can pollute streams, ponds, and ground water. In addition, the heat added to the water can be fatal to marine life. Certain gases, such as ammonia and carbon dioxide, which are released from the wells, can cause serious air pollution in the local areas. These pollutants will have to be controlled at the well.

Although people, wildlife, and marine life are affected in various ways by geothermal energy, it does not create as many problems as fossil and nuclear fuels. Geothermal energy can be used directly and does not require processing plants for fuels. It does not require major land disturbances, such as mining, when extracting the fuel. It also does not create as many problems with waste disposal as do the fossil fuels. It produces a basically clean heat. For these reasons it is considered a desirable source of energy where it is available.

*1 BTU = one-fourth of a Calorie.

Regional Cost of Geothermal Generated Electric Energy (Estimated)

Region	Regional Use (in Million British Thermal Units)	Regional Cost
New England	89	$138
Middle Atlantic	104	162
East North Central	164	254
West North Central	154	239
South Atlantic	102	158
East South Central	112	174
West South Central	101	157
Mountain	138	214
Pacific	111	172

Source: Bureau of Mines, U.S. Department of the Interior, 1974.

Evaluation Suggestions

1. Ask the student to name three* or more energy sources that we could use to heat and cool our homes and offices.

   Acceptable response:

   Three or more of the following — coal, oil, natural gas, nuclear, solar, geothermal, electricity.

2. Ask the student to identify two* or more factors which might influence his/her choice of an energy source for heating or cooling homes in his/her community.

   Acceptable response:

   Two or more of the following -- cost, availability, environmental effects, and others which differentiate sources.

3. Ask students to write an essay entitled, for example, "My Choice of an Energy Source to Heat and Cool My Community." The student may be judged as having achieved the objective if in the essay—
   (a) one of the seven sources described in the mini-unit is chosen
   (b) several factors are mentioned which the student regards as important
   (c) the energy source chosen ranks among those which have the most advantages and fewest disadvantages of the factors mentioned.

4. Pose an additional decision problem to students and ask the students to research and report on one of the alternatives. The problem may be as simple as. "Which movie, book, or magazine should the class see or read?" In this case the student might review and report on one of the alternatives after the class determined the factors in which it was interested.

   The problem may also be more involved. For example, you might pose as another mini-unit investigation: "Which form of transportation should we use in our model community?"

   The student may be judged as having accomplished objective 4 if, in additional problems such as these, the student presents pertinent information to the group with less aid from the teacher in researching and reporting than in previous group decision-making activities.

5. Ask the student to list three or more components of a group's decision-making process.

   Acceptable responses:

   Three or more of the following should be mentioned in their correct order. (1) define the problem; (2) plan a method for approaching the problem and identify alternative choices, (3) gather and evaluate information, (4) decide and act, (5) evaluate the decision made.

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*Achievement criterion which may be varied by the teacher.

Bibliography

Books:

Let's Go to An Atomic Energy Town, Kirk Polking (New York: Putnam) 1968.

Power and Energy, Frank Ross (New York: Lothrop, Lee & Shepard) 1967.

The Whole Earth Energy Crisis (New York. Putnam) 1973.

Articles:

"The Fascinating Story of Fossil Fuel," Isaac Asimov, **National Wildlife 38** (4), August-September 1973.

"Geothermal—the Devil's Own Breath," **Conservation News 38** (23), December 1973.

"The Search for Tomorrow's Power," **National Geographic,** November 1972.

"Coal Is Cheap, Hated, Abundant, Filthy, Needed," Jane Stein, **Smithsonian,** February 1973.

Free or inexpensive materials:

American Gas Association, Educational Services, 1515 Wilson Boulevard, Arlington, Virginia 22209.
Booklets #N00160 and N00165:
"Natural Gas Serves Our Community," 28 bulletin board pictures and descriptive booklet.
"The Story of Natural Gas Energy," 48 pp., 50 illust.

Channing L. Bete Co., 45 Federal Street, Greenfield, Massachusetts 01301, 25¢ each 1-99 copies, may be available from your local power company. Sample titles.
"ABC's of Electric Power from the Atom"
"Electric Power"
"About Coal Gasification"

Concern Inc., 2233 Wisconsin Avenue, N.W., Washington, D.C. 20007, "Eco-Tips #7 Energy Alternatives"
Data cards on:
Fossil fuels — $10.00 per hundred
Nuclear energy — $12.50 per hundred
Solar energy — $12.50 per hundred
Geothermal energy — $7.50 per hundred

Interstate Oil Compact Commission, Educational Department, P.O. Box 53127, Oklahoma City, Oklahoma 73105, "Oil for Today and for Tomorrow."

National Coal Association, 1130 17th Street, N.W., Washington, D.C. 20036, "Coal," 24-page reprint from *World Book* article and "Coal in Today's World."

U.S. Department of the Interior, "Indivisably One," "Conservation Yearbook Series, #8, USGPO $2.00 (SN2400-0751) section on energy.

U.S. Department of the Interior, Bureau of Mines, Publications Distribution, 4800 Forbes Street, Pittsburgh, Pennsylvania 15213. One copy of up to 10 chapters in booklet form from book *Mineral Facts & Problems* (must be requested on official stationery). Sample topics: anthracite, energy resources, natural gas, petroleum, shale oil.

U.S. Department of the Interior, Geological Survey Information Office, Reston, Virginia 22092, "Natural Steam for Power."

Films:

The American Dream is Running Out of Fuel, 18 minutes, color, $230 or $19 rent. Films Inc., 1144 Wilmette Avenue, Wilmette, Illinois 60091.

Atomic Power Production, 14 minutes, color. Handel Film Corporation, 8730 Sunset Boulevard, Los Angeles, California 90069.

Flames & Energy, 37-frame filmstrip, free. Educational Services. American Gas Association, 1515 Wilson Boulevard, Arlington, Virginia 22209.

Natural Gas — Energy in the Home, 16 mm, sound 13½ minutes, free. American Gas Association, 1515 Wilson Boulevard, Arlington, Virginia 22209.

Our Minerals & Energy Resources, 1970 filmstrips, sound, $10. Coronet Films, Division of Esquire, Inc. 65 East South Water Street, Chicago, Illinois 60601.

Our Mr. Sun Parts I & II, 60 minutes, color. Pacific Northwest Bell.
Part I, Sun as Ancient Man Saw It.
Part II, Efforts to Harness the Sun's Energy.

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

Materials List

- ☐ Collect, or have students collect, cartoons, headlines, newspaper articles, brochures, etc. on energy-environmental problems and on the seven sources of energy discussed in the mini-unit (coal, oil, natural gas, electricity, geothermal, solar, nuclear).
- ☐ Prepare a bulletin board of these materials.
- ☐ Duplicate enough copies of each of the seven enclosed data cards on energy sources so that each student in the corresponding research group has a copy. (about 4 to 5 copies of each for a class of 30)
- ☐ Duplicate a copy of the Energy Summary Chart for each student.
- ☐ Have available materials to aid presentation of student reports such as poster paper, magic markers, etc.

MINI-UNIT 5
No Gas Today. Tomorrow?

No Gas Today. Tomorrow?

ABSTRACT

The gasoline shortages in many regions of our country in 1973 indicated that our nation's supplies of petroleum products, such as gasoline and heating fuel oil, are falling behind demand. This situation is studied to introduce students to the concepts of shortages, supply, demand, and consumption. Classroom discussions and group activities are suggested to enhance skills of interpreting graphs while developing the following concepts: that the supplies of fossil fuels are finite, that their lifetimes can be estimated, and that some estimated lifetimes of the United States supplies of oil and natural gas are comparable to the students' expected lifetimes.

Recommended level: Social studies, science, and math classes, grades 6-9, depending on mathematical ability. Student familiarity with large numbers, such as billions, is assumed. Joint math-science or math-social studies classes may be appropriate, given the emphasis on developing pictograph interpretation skills.

Time required: About seven to eight 45-minute periods.

Major teaching strategies: Classroom discussion, graph interpretation.

Advance preparation: Make transparencies of several figures and duplicate copies of figures and task sheets for each student.

Key Ideas

1. Shortages of a material or resource — such as gasoline (oil) and natural gas — occur when, at a given price, the demand exceeds the supply.
2. Consumption of fossil fuels has been increasing faster than the rise in population over the past 30 years. and the demand is likely to increase in the future.
3. The exact amounts of future supplies of fossil fuels are difficult to determine. Estimates of these supplies depend on (1) whether their geological existence has been verified, (2) whether technically feasible methods to mine or recover them are known, and (3) the cost of mining or recovery.
4. Fossil fuels are non-renewable energy sources and thus have a finite lifetime.
5. Shortages of oil and natural gas are likely to occur in the student's lifetime. Estimated United States supplies of these fossil fuels might be totally consumed in about 100 years, even if there is no increase in consumption over present rates.

Objectives

At the conclusion of this activity, students should be able to:

1. *Apply* definitions of the terms shortage, supply, demand, and consumption to different buy-and-sell situations.
2. *Translate* and *interpret* pictographs (of past and future consumption of fossil fuels).
3. *Determine* the lifetime of fossil fuels at different projected rates of consumption (given supply estimates).
4. *Distinguish* between reserves (low) and ultimately recoverable (high) estimates of fossil fuel supplies.
5. *Describe* the past patterns of fossil fuel consumption in the United States (whether it has increased or decreased) and the likelihood of future shortages of oil, natural gas, and coal.

Teaching Suggestions

Lesson 1 — Shortages

Through classroom discussion of the effects of the 1973-1974 energy crisis in many regions of our country — the long lines of cars at gasoline service stations — and subsequent group problem-solving activities, the concept of shortage is introduced and developed.

Note: In some areas of the country there were no lines of cars at gasoline stations during, or since, 1973. Some of the following suggested classroom discussion would, therefore, be inappropriate. The teacher should, therefore, adapt the activities to his/her area. This might be accomplished by discussing the shortages experienced in his/her region of the country and what the likelihood of similar shortages are in his/her area.

1. Introduce lesson by discussing lines of cars at gas stations.

   Ask students:

   "How many of you 'spent time' in line? How long did you (or your parents) wait? Describe your experience — what did you do while you waited? — what time of the day did you join the lines?"

   After students have had an opportunity to relate their experiences, lead discussion to immediate cause of lines.

   "Why do you think there were lines of cars at stations? Did stations have enough gasoline for everyone? Could drivers buy all they wanted?"

2. Have students develop concept of shortage.

   Introduce the word *shortage*.

   "Would you say there was a shortage of gasoline? What do we mean by *shortage*? When does a shortage occur?"

   You might pose the following problems:

   a. "Suppose a station has 100 gallons of gasoline to sell, but there are only two customers and each wants 10 gallons of gasoline. Is there enough gasoline for each customer? Is there a shortage?" (No)
   b. "Suppose there are now 20 customers who each want 10 gallons. Is there enough gasoline for each customer? Is there a shortage?" (Yes)
   c. "If the station receives an additional 100 gallons to sell, is there a shortage?" (No)

3. Have students apply concept of shortage to buy-and-sell situations.

Divide the class into several groups. Ask each group to construct similar problems for other members of the class. Each group should choose:

a. A buy-and-sell situation; e.g., a supermarket, candy store, football ticket office, etc.
b. The items to be bought and sold; e.g., apples, cereal, licorice sticks, tickets.
c. The number of customers and the quantity of the item available.

Each group's problem might start with the questions:
Is there enough for each customer? Explain.
Is there a shortage? Explain.

The problem sheets might then pose situations in which the number of customers and/or the available quantity of the item changes.

Each group could also provide a separate answer sheet to be given to you.

When all groups have constructed problem sheets. interchange them and have other groups answer the questions.

After all groups have answered the questions, have them pass both problem sheets and their answer sheets to still another group to mark the answers right or wrong according to the student-constructed answer sheets *or* to determine if the answer sheets and problems incorrectly apply the concept of *shortage*.

In other words, if there are three groups A, B and C:

sell and two customers who each wanted to buy 10 gallons. What was the total amount available, or the *supply*, of gasoline? (100 gallons) What was the total amount wanted by customers, or the *demand*?" (20 gallons)

Continue with other cases, B and C.

☐ Inform students of definitions:

Supply: at a given price, the total amount of a resource or a material *available for purchase*.

Demand: at a given price, the total amount of a resource or a material that people are willing to *buy*.

☐ Ask students:

"In which of these cases (A-C, number 2, lesson 1) was supply greater than the demand? In which case was demand greater than supply? Is there a shortage when demand is greater than supply or vice versa? (The former) Did the long lines at gasoline stations last year result from supply being greater than demand or demand greater than supply?" (The latter)

3. Introduce the relationships between price and supply and demand.

☐ Pose the following situation to students:

"Suppose a station has a supply of 100 gallons of gasoline to sell and, as in a previous example, there are 20 customers each of whom is willing to pay the 30 cents a gallon price to buy 10 gallons each. What is the total *demand* at 30 cents a gallon? (200 gallons) If the owner doubles the price of gasoline to 60 cents, so each customer is now only willing or able to buy five gallons, what is the total demand at 60 cents? (100 gallons) How does this compare with the demand when the price was 30 cents a gallon? (It is less) Is there a shortage at 30 cents a gallon? (Yes) At 60 cents a gallon? (No) What is the price of gasoline per gallon today? Do you remember what the price was a year ago?"

☐ Display Table 1, "Recent Gasoline Prices," as an overhead transparency. (Note: Table 1 displays wholesale prices of gasoline, taxes are included.

Group A	*Group B*	*Group C*
1. Constructs *problem sheet A* and *answer sheet A*	1. Constructs *problem sheet B* and *answer sheet B*	1. Constructs *problem sheet C* with *answer sheet C*
2. Answers *problem sheet B*	2. Answers *problem sheet C*	2. Answers *problem sheet A*
3. Corrects *problem sheet C* with *answer sheet C*	3. Corrects *problem sheet A* with *answer sheet A*	3. Corrects *problem sheet B* with *answer sheet B*

Lesson 2 — Supply and Demand

As in Lesson 1, employ classroom discussion and group activities to develop concepts of *supply* and *demand*. (Depending on ability of students, this lesson might be combined with Lesson 1.)

1. Review briefly with students concept of shortage and its relation to lines at gasoline service stations.
2. Introduce definitions of supply and demand.

☐ Use examples given in first lesson to introduce supply and demand. For example:

"In our last lesson, we discussed the case of a service station that had 100 gallons of gasoline to

Retail prices may run 5 to 15 cents higher. If students are not familiar with decimals, round off numbers prior to presentation; e.g., 29.8 → 30 cents.)

"Do you think the increase in price has resulted in an increased or decreased demand for gasoline? How do you think the increase in gasoline price will affect people's vacation plans? Do you think more smaller cars with better mileage are being sold?"

4. Have students apply concepts of price and of supply and demand by formulating problems using these concepts.

Again divide the class into groups and ask them to construct problems to test other groups on their ability to apply the words *supply* and *demand* and their dependency on price.

Each group should construct buy-and-sell situations as before, but this time ask them to attach a price to the items to be sold and then pose questions such as:

a. What is the supply at this price?
b. What is the demand at this price?
c. Is there a shortage? Explain.

Then a change in the price, or supply, or demand might be imposed in the problem, and again ask the above three questions.

Rotate the problem sheets for answering and correcting as on the first day.

TABLE 1

Recent Gasoline Prices*

Year and Month		Wholesale Price of Regular Gasoline
1972	January	29.8¢
	March	29.8
	June	31.8
	September	31.8
1973	January	31.8
	March	31.8
	June	31.8
	September	32.6
1974	January	37.3
	March	40.8
	June	45.4
	September	43.2

*Wholesale prices are shown (tax included). Retail prices are 5 to 15 cents higher.

Lesson 3 — Gasoline and Oil

By interpreting graph material, students determine the origin of gasoline (oil wells) and the pattern of United States consumption of gasoline.

1. Review application of concepts of *shortage, supply,* and *demand,* particularly as relates to gasoline.
2. Relate supply and demand of gasoline to supply and demand of oil.

   "Do you think there will be other, future occasions when there will be long gas lines?" (If there are lines in your area when this activity is implemented, rephrase to: "How long do you think these lines will continue?")

   "Is the demand for gasoline increasing? Are there enough supplies to meet the demand? Where do the gasoline station owners obtain their *supply* of gasoline to sell?"

   ☐ Determine whether students can identify the ultimate source of gasoline at service stations as crude oil from oil wells.

   Display and briefly discuss Figure 1 to help students visualize the drilling, refining, and transportation processes that are necessary to ultimately pump gasoline into a car. Use transparency follow-up:

   Have students fill in the story of the route of the oil from the oil well to the corner gasoline station.

   Sample sequence:

   a. An oil man obtains a lease on the oil rights to a given plot of ground where he has reason to believe oil is located. This particular land is located in Texas.
   b. If oil is found, it is removed from the ground, along with natural gases, by drilling and pumping. In the same week, the crude oil is pumped to a storage tank and later loaded onto an oil tanker for shipment. The tanker is located in a port on the Gulf of Mexico.
   c. In the second week after the oil is pumped from the ground, the tanker travels through the Gulf of Mexico to a port (such as Linden, New Jersey) where it is temporarily stored again until it is processed.
   d. In the third week, the oil is transported through pipelines to a refinery where it is processed and converted into gasoline and other products such as butane, propane, and asphalt. The gasoline is next stored in a pumping station.
   e. The gasoline is then transported through pipes to a terminal tank in the fourth week after the oil is pumped from the ground. It is then transported to the corner gasoline service station by truck. Finally, it is pumped into our cars.

   "Did you think the time span from well to gas station would be longer or shorter than our transparency shows?"

   "What four important steps occur in the process of oil→ gasoline?" (Drilling, storing, refining, transporting.)

   ☐ Inform students that nowadays for every two gallons of oil obtained from the ground, refineries are operated to produce roughly one gallon of gasoline. Thus, for every one gallon required by motorists, two gallons of oil need to be extracted and refined. The other gallon of oil is refined into other products such as heating oil and kerosene.

3. Introduce and interpret pictograph of oil consumption in the United States (past, present, and projected). Introduce barrel as unit of measuring oil supplies.

   ☐ Inform students that in the early history of oil drilling, crude oil was transported in barrels. Each barrel contained roughly 42 gallons — about the capacity of two gasoline tanks in cars. Today crude oil supply and demand is still discussed in terms of barrels — abbreviated bbl.

   ☐ Distribute copies of Figure 2 to students and also display figure as transparency. Cover the lower part of the transparency (from 1975-2029) to concentrate attention on years 1945-1974.

   "Let's look at a graph which shows the amount of oil we have used in the United States since 1945."

   a. "What is the scale on the top?"
   b. "What does consume and consumption mean? Does consume and use mean the same?"
   c. "How much does each symbol represent?" (Each stands for 10 billion barrels.)
   d. "What is the scale at the left?"
   e. "How many years are in each division?" (Five)
   f. "How many barrels of oil were consumed in the years 1965-1969?" (Demonstrate how, by adding two full pictured barrels plus three-tenths of a third picture, the graph shows that 23 billion barrels of oil were consumed in the five-year period 1965-1969. It may be helpful to suggest to students that two symbols are full of oil and a third is only three-tenths filled.)

   ☐ Have students draw symbols which represent 4 billion barrels, 12 billion barrels and 25 billion barrels. By examining their drawings, determine if they have grasped the meaning of the pictorial representation; that is, one picture of a barrel equals 10 billion barrels. Demonstrate other examples if necessary.

   Note: Some additional discussion might be directed at the meaning of large numbers such as a billion, 10 billion, etc., if manipulation of these numbers is unfamiliar to students.

4. Conclude lesson by having students obtain tabular data from graph. (This might also be a home assignment.)

   Ask students to construct a table, using the information on the graph, of the number of barrels consumed in each five-year period shown. (The amount displayed for 1970-1974 was obtained from the known amounts consumed for 1970-1973 and estimated amount for 1974.)

The table might look like this:

(Instruct students to leave room for three additional columns.)

Five year period	Oil consumed in United States (billions of barrels)			
1945-1949	(9 1/2)			
1950-1954	(13)			
1955-1959	(16)			
1960-1964	(18)			
1965-1969	(23)			
1970-1974	(28)			

(The numbers in parentheses are the answers which have been obtained from the figure. They are rounded values of the actual numbers. Source: Bureau of Mines, U.S. Department of the Interior.

☐ In order to relate the time periods being discussed to each student, ask them to also note their age next to the years 1965 and 1970.

Figure 1

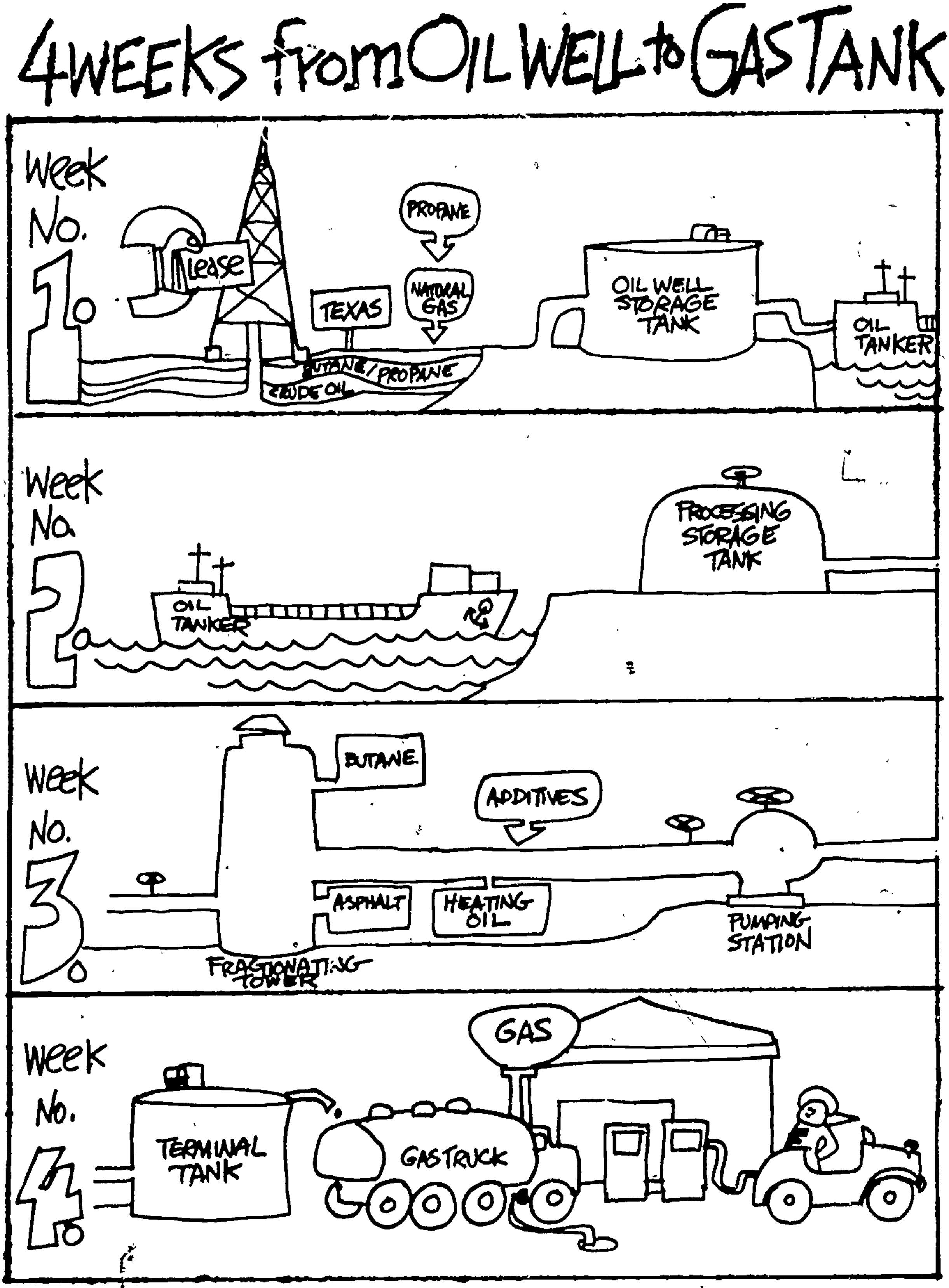
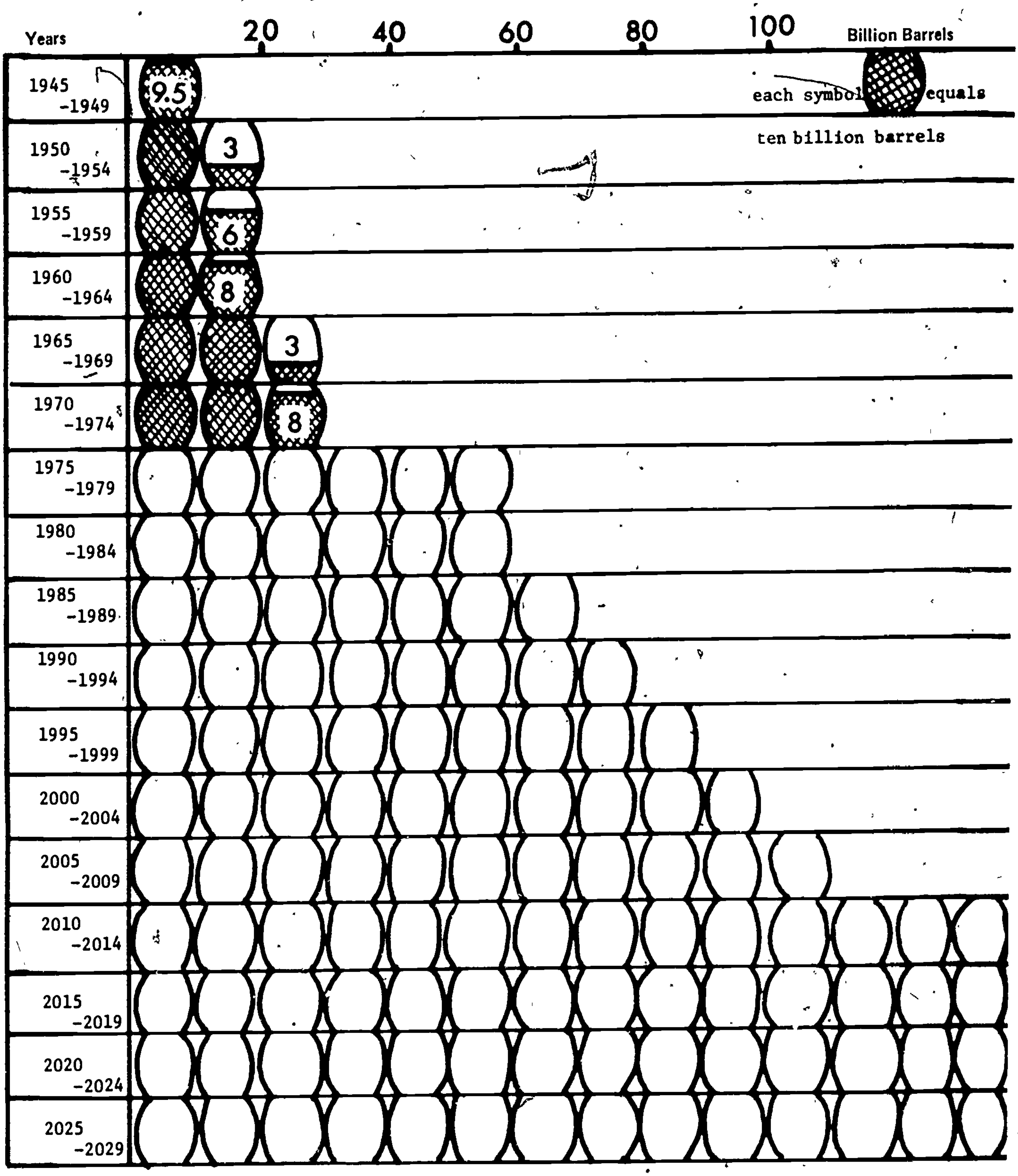

4 WEEKS from OIL WELL to GAS TANK
Week No. 1
Lease
TEXAS
PROPANE
NATURAL GAS
BUTANE/PROPANE
CRUDE OIL
OIL WELL STORAGE TANK
OIL TANKER
Week No. 2
OIL TANKER
PROCESSING STORAGE TANK
Week No. 3
BUTANE
ADDITIVES
ASPHALT
HEATING OIL
PUMPING STATION
FRACTIONATING TOWER
Week No. 4
TERMINAL TANK
GAS TRUCK
GAS

FIGURE 2
U.S. Consumption of Oil



Lesson 4 — Oil Consumption and Future Supplies

Different estimates of the future supplies of natural resources are introduced through discussion and interpretation of graph materials.

1. Review interpretation of oil pictograph with students.

   Discuss with students the tables they have constructed from Figure 2. By examining their answers, determine if they are able to translate the graph data into tabular data. Review procedures if necessary.

2. Discuss increasing demand for oil with students.

   "From an examination of your graphs or tables, has demand for oil increased since 1945? How much was consumed in 1970-1974? (28 billion barrels.) How much in 1950-1954? (13 billion barrels.) How many times greater was our consumption in 1970-1974 than in 1950-1954? (About two.) How can we describe this result in words?" (One way: The consumption of oil in the United States has more than doubled in the 20 years since 1950.)

3. Discuss possible reasons for the increase in oil consumption. In particular, examine whether it can be accounted for by the rise in population.

   "What do you think might be a reason for the increase in oil consumption? Do you think we are consuming more oil because there are more people in the United States or because people and industry are using more?"

   Present the following data and ask students to record in third column of their table the population of the United States in 1950, 1960, and 1970: (Alternatively, this may be part of a research exercise.)

   1950 150,697,361 or 151 million
   1960 179,323,175 or 179 million
   1970 203,235,298 or 203 million

   (Source: *1973 World Almanac*, pg. 135.)

   "About how many times greater was the population in 1970 than in 1950? (About one and one-third times. 200/150 = 1.33.) How can this be phrased in other words?" (One way. In the 20-year period 1950-1970, the United States population has increased by a third.)

   Compare the increase in the population (one and one-third) to the increase in oil consumption ratio (about two) and discuss with students possible reasons why the increase in oil consumption exceeds the growth in population. Let students brainstorm for awhile to develop their own answers. Some direction might be provided later by asking.

   "Do families today have more cars than families in 1950? How many cars does your family have now?"

4. Relate past consumption to future consumption.

   Ask students to determine the *total* number of barrels of oil consumed or used in the United States in the 30-year period 1945-1974 (by adding number of barrels pictured or by adding numbers in table). Answer: 107½ billion barrels.)

   Emphasize that the result may be obtained by *counting* the symbols.

   "Do you think we will consume more or less oil in the next 30 years, from 1975 to 2004? Why?" ("How old will each of you be in the year 2004? Will you still be in school?" etc.)

5. Introduce problems of estimating future supply.

   "Suppose we attempted to consume the same amount of oil in the next 30 years, do you think there is a large enough supply of oil? How can future supplies be estimated? Do we know how much oil there is in the ground? Can it all be extracted?"

   ☐ Inform students that the oil industry and government use several different methods for estimating the future supplies of natural resources such as oil, since *supply* depends not only on what ultimately exists geologically in the earth's crust, but also whether the technology or methods exist to locate and extract the resource, and whether it is economical (profitable) to do so.

6. Present two kinds of estimates of future supply.

   ☐ Display Figure 3 as a transparency.

   Inform students that in order to discuss the supplies of natural resource, two specific estimates are often discussed: a low estimate called *reserves*, and a high estimate called the *ultimately recoverable resources*.

   Ask students to examine Figure 3 and determine the differences between these two amounts for oil. Use discussion questions such as:

   a. Which row describes the low estimate? Which row the high estimate? What are they called?
   b. In what ways do these two estimates differ? (Refer students to headings at top)
   c. Which estimate of oil supply includes only the oil that is already known to exist? (Reserves) (Ultimately recoverable includes both known *and* unknown supplies.)
   d. Which supply of oil can be obtained now with current methods of extraction or drilling? (Reserves.)
   e. Which supply of oil will cost more to extract and use? (Ultimately recoverable.)

   ☐ Provide students with definitions of *reserves* and *ultimately recoverable* amounts of a resource:

   Reserves (low): The amount of a resource (1) already discovered and known, (2) which can be extracted with present methods, and (3) at prices people are presently willing to pay.

   Ultimately recoverable (high). The amount of a resource (1) believed to be discoverable and already discovered, (2) which may or may not need new undeveloped methods of extraction, and (3) that can be sold at any price.

☐ Inform students that reserves are part of the amount of ultimately recoverable oil. Provide examples of estimates for oil in the United States (see NSTA *Energy-Environment Source Book*, Volume II, Chapter 2).

	Reserves	*Ultimately recoverable*
Oil (billion barrels)	52	502

To determine if students understand differences in estimates, ask students:

"How much of the 502 billion barrels of the ultimately recoverable, or high estimate, of our supplies of oil was known to exist and could be extracted with current methods at present costs?" (52 billion, or the amount of reserves.)

7. Conclude lesson by relating estimated future supply of oil to past consumption.

"How do these numbers compare with the amount we have consumed in the past 30 years; i.e., 108 billion barrels? Suppose we attempted to consume the same amount in the next 30 years. If we had to rely on the oil supply that we could presently obtain at current prices (i.e., reserves), would we have a shortage? (Yes.) If we located new sources and paid higher prices (ultimately recoverable), would we have enough for the next 30 years?" (Yes.)

In the next lesson we will see if we can answer this question:

"Can you determine how long our supply of oil will last?"

Figure 3

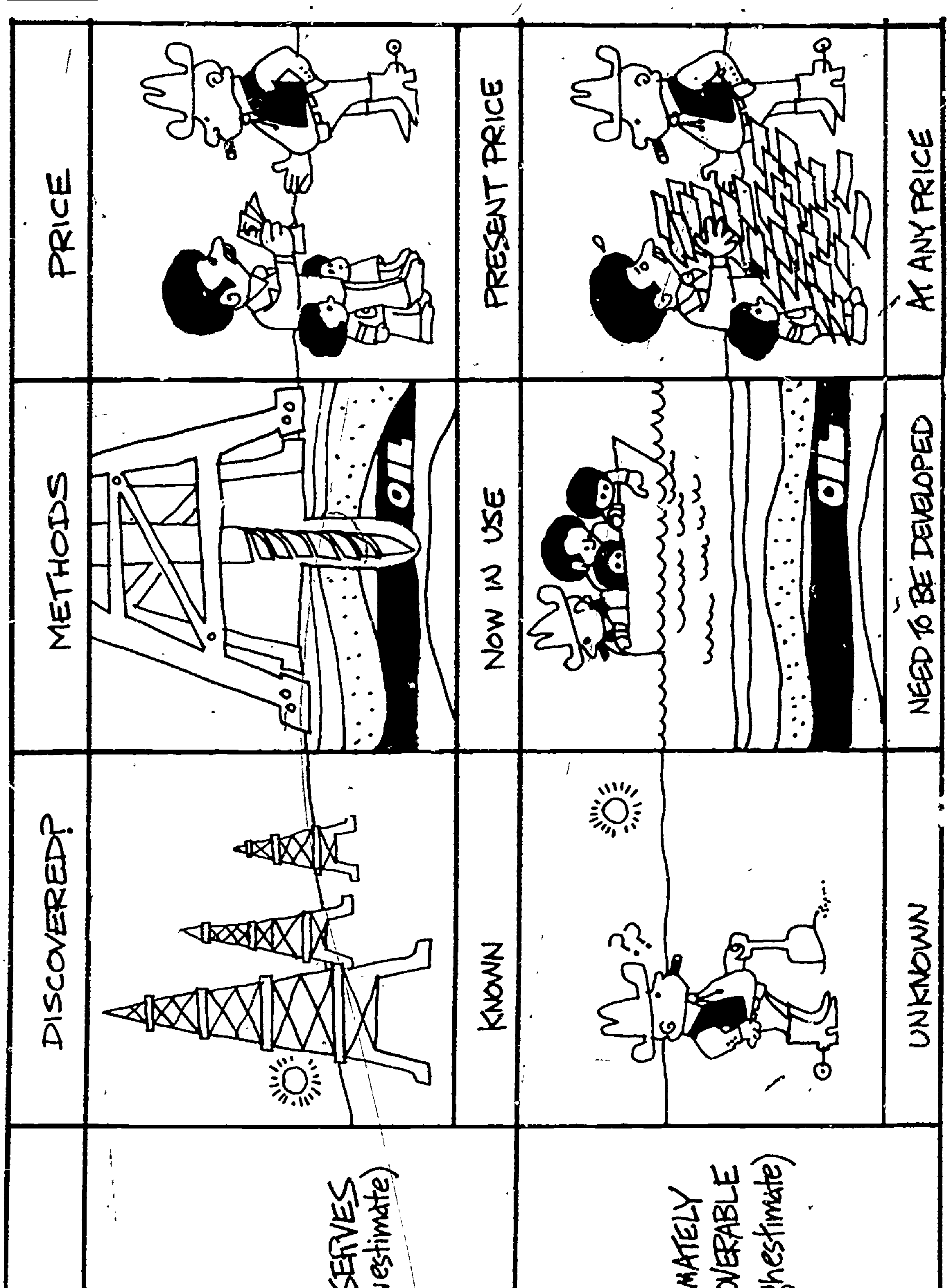
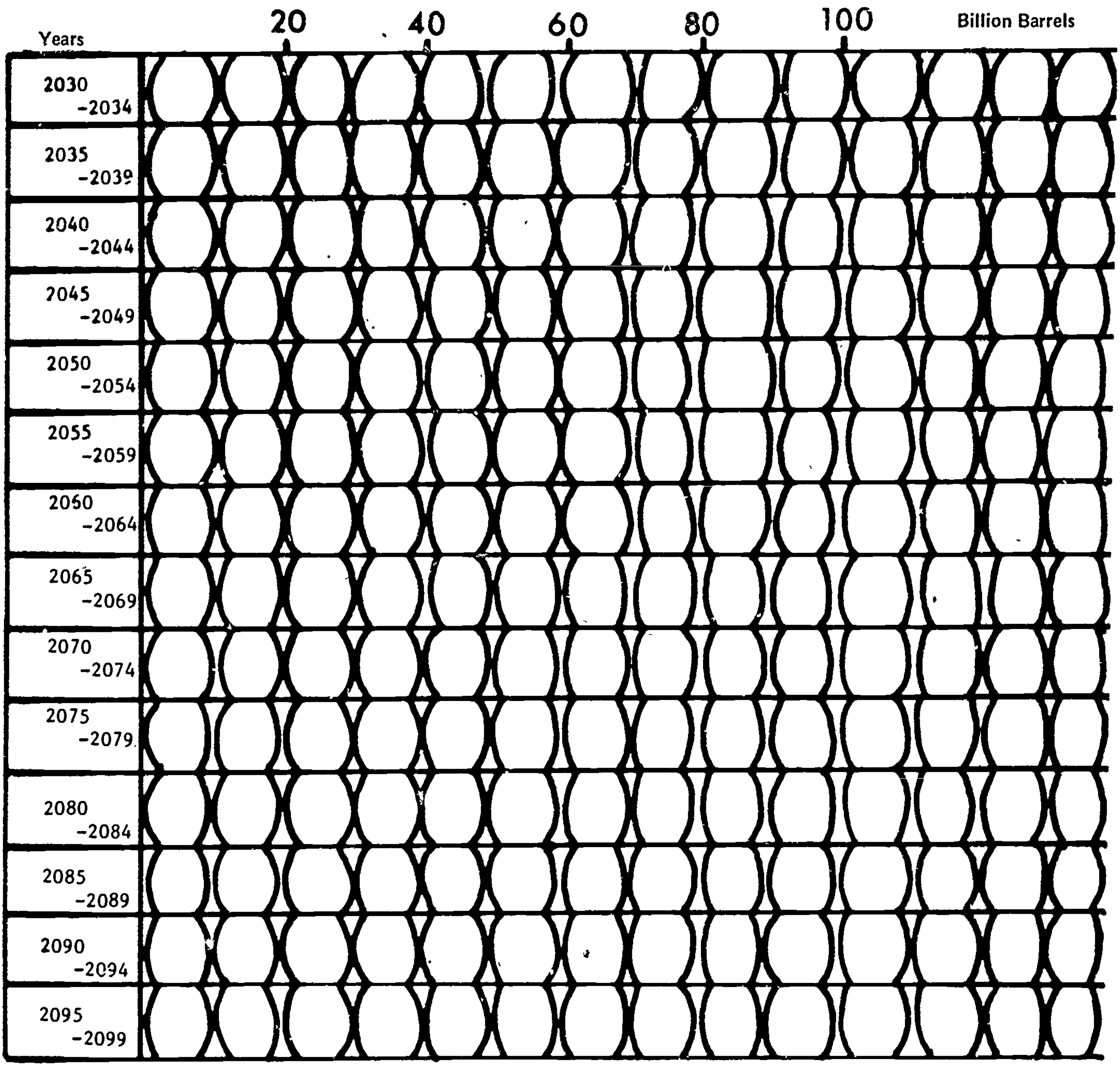

DISCOVERED?
METHODS
PRICE
RESERVES (low estimate)
KNOWN
NOW IN USE
PRESENT PRICE
ULTIMATELY RECOVERABLE (high estimate)
UNKNOWN
NEED TO BE DEVELOPED
AT ANY PRICE
OIL
OIL

FIGURE 2a


20
40
60
80
100
Billion Barrels
Years
2030 -2034
2035 -2039
2040 -2044
2045 -2049
2050 -2054
2055 -2059
2060 -2064
2065 -2069
2070 -2074
2075 -2079
2080 -2084
2085 -2089
2090 -2094
2095 -2099

Lesson 5 — Resource Lifetimes

Students are led to determine the lifetimes of the different estimates of our oil supplies at different future consumption rates using graph analysis.

1. Review relationship of oil supply estimates and past consumption.

   Ask students:

   "How much oil is estimated to be ultimately recoverable in the United States? (502 billion barrels) How much of this is reserves? (52 billion barrels.) How much oil did we consume in the past 30 years? (108 billion barrels.) If we consume the same amount of oil in the next 30 years as we did in the past 30 years, would we use up all of our present reserves? (Yes.) All of our ultimately recoverable supply?" (No.)

2. Relate future supply with possible future demand; determine supply lifetime.

   ☐ Display Figure 2 again. Ask:

   "Now suppose in the next 30 years we consumed oil at the same rate that we have for the last five years. That is, in 1970-1975 we used 28 billion barrels, so in 1975-1979 we might use 28 billion barrels. (Lightly shade two and eight-tenths barrel symbols on line for 1975-1979, and the same in 1980-1984.) How long would it take us to run out of oil reserves?"

   Demonstrate that you have shaded through 1984, (2 + 0.8) + (2 + 0.8) figures which represents 28 + 28 = 56 billion barrels and that this is larger than the reserve supply of oil, 52 billion barrels.

   "How long would it take us to run out of all the oil estimated to be ultimately recoverable? How many symbols are required to represent the ultimately recoverable supply?" (502 billion barrels ÷ 10 billion barrels per symbol = 50 symbols.)

   Distribute and display Figure 2a, which adds rows for years 2030-2100 to Figure 2. Have students tape or paste bottom of Figure 2 and top of Figure 2a together. Demonstrate that by coloring in two and eight-tenths figures or billion barrels in each five-year period, by the period 2060-2064 all ultimately recoverable oil will be consumed if demand remains constant at present rates. *Emphasize that you can obtain this result by counting the shaded figures until you reach 50.*

   ☐ Ask students to add rows to their tables constructed in Lesson 3 to correspond to the periods 1975-1979, 1980-1984, etc. through year 2069. In the fourth column record 28 billion for all lines and

Years	Barrels Consumed	Population	Future Consumption: Constant	Future Consumption: Increasing
1970-74				
1975-79			28 billion	37
1980-84			28 billion*	44
1985-89			28 billion	51
1990-94			28 billion	60
1995-99			28 billion	71
2000-04			28 billion	85
2005-09			28 billion	102
2010-14			28 billion	122
.			.	.
.			.	.
2060-64			28 billion**	.
2065-69			28 billion	

* Reserves totally consumed.
** Ultimately recoverable resources totally consumed.

note years at which reserves and ultimately recoverable oil are each totally consumed.

☐ Introduce concept of lifetime:

"How many years from now is 1984, the year all present reserves might be consumed? How old will you be then? How many years from now is 2064, the year the United States ultimately recoverable supply of oil might be totally consumed? How old will you be then?"

Point out that the people in the United States, on the *average,* live to an age of 70 years. Some live longer, some less, but on the *average* a *lifetime* is 70 years.

"Can we attach to our supply of oil a number for its lifetime? If we only consider reserves, what would be the lifetime? (10 years.) If we consider ultimately recoverable supplies, what would be the lifetime?" (90 years.)

3. Determine resource lifetime with more realistic future demand.
   ☐ After students grasp techniques for determining lifetime of estimated supplies of oil with this admittedly artificial projection of consumption, give students projections listed in column five of the previous table, which are more realistic (i.e., they increase with time as did consumption in the 1945-1974 period). Ask students to record information in column five of their tables. Then ask students to color in barrel symbols until reserves (52 billion barrels = 5.2 pictures) have been consumed to find out how long reserves will last with more realistic estimates of demand. (Answer: less than 10 years.)
   ☐ Similarly, ask students to determine how long ultimately recoverable resources of oil (502 B bbls = 50 symbols) will last with these projections of demand. (Answer: 40 years.) Again, emphasize result can be obtained by *counting*.

4. End lesson by having students construct a summary table (see below).

Year Oil Supply Will Run Out

Future Demand / Oil Supply	At Same Consumption Rate as 1970-1974 (28 B bbls every five years)	At Increasing Consumption Rate—More Realistic Estimate
Reserves 52 B bbls	(Ans: in 1980-1984, 10 years from now)	(Ans: in 1980-1984, less than 10 years from now)
Ultimately Recoverable 502 B bbls	(Ans: in 2060-2064, 90 years from now)	(Ans: in 2010-2014, 40 years from now)

B bbls = billion barrels of oil

Discuss with students the lifetimes of the supplies. Relate them to their age at the time the supply is totally consumed.

Lesson 6 — Coal and Natural Gas Supply Lifetimes

Students apply the graph methods of analysis employed in determining the lifetime of United States supplies of oil to determine the lifetimes of two other fossil fuels: natural gas and coal.

1. Relate oil to other fossil fuels.

   Begin with a discussion of why oil is called a fossil fuel.

   "Are there other fossil fuels, those materials formed thousands of years ago by the decay of plants and animals and the pressure of subsequent layers of rock and earth, which release their stored energy when burned?"

   Identify natural gas and coal as the other fossil fuels.

2. Organize student investigation of lifetimes of other fossil fuels.

   "Are the United States supplies of natural gas and coal also running out? Will we have enough of these fuels to meet future demand? Let's find out."

   □ Divide the class into three groups. Assign two groups the task of determining estimates of the lifetime of our supplies of natural gas and one group the task for coal. One of the two groups for natural gas will examine future supplies with a future consumption rate equal to the rate for 1970-1974, the other will study the supply lifetime with a more realistic consumption rate.

   Note: The lifetime estimates for coal greatly exceed those for oil and natural gas. The demand for coal has not increased in the past 30 years due to the increased use of the oil and natural gas alternatives. Thus, an increasing consumption situation has not been presented, since projections so far into the future might be misleading.

   Distribute copies of the task sheets and graphs (enclosed) to each student in these respective groups. Answer sheets are also enclosed.

   Allow approximately one period for students to complete the tasks specified on the sheets. Circulate through the classroom to determine if students are able to proceed through the tasks by examining their responses to tasks 1-3. These tasks cover the more elementary graph interpretation skills. An answer sheet is enclosed.

   The long lifetimes for coal may require students to attach additional sheets to their graphs, if the same graph procedures are employed. An alternative arithmetic method is suggested on the task sheet for the constant consumption projection.

Lesson 7 — Fossil Fuel Lifetimes

The objectives of this day's activities are to summarize the results of the students' investigations of the lifetimes of natural gas, coal, and oil and draw conclusions concerning the finite nature of our fossil fuel resources as well as the likelihood of future shortages.

1. Record summary statement of fossil fuel lifetimes on a chart. Construct on the blackboard a table similar to the following:

United States Oil Supplies

Future Consumption	1. Low Estimate (reserves) 52 billion barrels	2. High Estimate (ultimately recoverable) 502 billion barrels
A. Constant (does not increase)		
B. Increases (as in past 30 years)		

United States Natural Gas Supplies

Future Consumption	1. Low Estimate (reserves) 290 trillion cubic feet	2. High Estimate (ultimately recoverable) 2,390 trillion cubic feet
A. Constant (does not increase)		
B. Increases (as in past 30 years)		

United States Coal Supplies

Future Consumption	1. Low Estimate (reserves) 150 billion tons	2. High Estimate (ultimately recoverable) 1,500 billion tons
Same as in past 25 years		

Ask students to fill in the lifetime determined for each situation and the span of years in which the supply will be totally consumed.

The answers are:

	1.	2.
Oil A	5-10 years, 1980-1984	90 years, 2060-2064
Oil B	5-10 years, 1980-1984	40 years, 2010-2014
Gas A	10 15 years, 1985 1989	110 years, 2080-2085
Gas B	10-15 years, 1985-1989	65-70 years, 2040-2045
Coal	375-400 years, 2350-2374	4,000 years, 5950-5975

(Technical Note: The estimates of fossil fuel supplies were obtained, with one exception, from the U.S. Geological Survey — see NSTA *Energy-Environment Source Book*, Chapter 2, Volume 2. The estimate of coal reserves, 150 billion tons, was obtained from the "U.S. Energy Outlook, A Summary Report of the National Petroleum Council," December 1972. A higher estimate, 390 billion tons, is given by the U.S. Geological Survey. The lower number was chosen to facilitate the students' graph analysis.)

2. Discuss with students the implications of this summary.
   - ☐ Note that although it is realistic to assume that the demand for fossil fuels is likely to increase, the lifetimes for oil and natural gas are still short even *when it is assumed that demand will not increase*.
   - ☐ Compare the lifetimes of the fossil fuels with the lifetimes of the students. Are the expected lifetimes of the fuels longer or shorter than the students? If demand will exceed future supplies, what is the likelihood of future shortages of the fossil fuels?
   - ☐ You might also discuss the implications of the differences in the lifetimes estimated for *reserves* versus those for *ultimately recoverable* supplies. Ask students to recall the differences between these two types of estimates. If new, more costly methods of mining and recovery need to be developed to extract oil and gas from new types of wells, will the price of these fuels increase? Is more exploration required?

   (One aspect of the future supply-and-demand situation for fossil fuels that has been purposefully overlooked in this mini-unit is the effect of imports. Our domestic supplies for oil, even in the past 30 years, have not met domestic demand, since our production capability, i.e., drilling and refining activity, falls short of demand. Thus, today we import close to 50 percent of the crude oil that we consume. Our imports are expected to increase in the future as it becomes more costly to extract our domestic supplies. These facts may be brought into a more general discussion outlined below.)

3. As a concluding discussion, explore with the students the possible consequences of oil and gas shortages.

   "Are there other alternatives to fossil fuels? Can coal be employed to replace oil and gas? How will shortages of gas and oil affect consumption of coal? Do other nations have enough supplies of oil and gas for themselves as well as for us?" (It is often noted that the United States has 6 percent of the world's population but consumes 25 percent of the world's energy.)

Several of these points are examined in other mini-units.

Evaluation Suggestions

1. To evaluate student understanding of the concepts of supply, demand, and shortage and their ability to apply them, employ questions of the following type:

   "A soda machine at a beach contains 100 cans of soda. On a hot day, each person consumes an average of two cans at 25 cents each. If there are 60 people at the beach on a hot day, will there be a *shortage* of soda? If so, how much? Explain." (Answer: Yes, 60 × 2 = 120 cans = Demand. Supply = 100 cans. Shortage = 20 cans.)

2. Present, via overhead projector and/or duplicated copies, the mini-unit pictograph that shows United States consumption of oil (or natural gas or coal). Ask students to interpret the pictograph as follows:

   A. "How many barrels of oil (cubic feet of natural gas or tons of coal) were consumed from 1960-1964?" (18 billion barrels.)

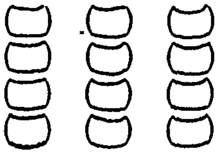
   B. "How many barrels of oil were consumed from 1945-1964?" (56.5 billion barrels.)

   C. "Indicate the number of barrel symbols to be shaded to show a consumption of 35 billion barrels of oil." (three and one-half symbols or

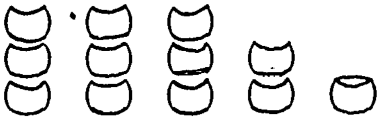
   D. (Assuming students have a copy of the pictograph) Shade barrels in the pictograph to show the number of years necessary to exhaust a reserve of 120 billion barrels, starting in 1975 with consumption a *constant* 30 billion barrels a year.

   Answer: 1975-1979
   1980-1984
   1985-1989
   1990-1994

   E. Shade barrels in the pictograph to show the number of years necessary to exhaust a reserve of 120 billion barrels, starting in 1975 with consumption at 30 billion barrels for 1975-1979, increasing to 40 billion barrels in 1980-1984, to 50 billion barrels in 1985-1989, and to 60 billion barrels in 1990-1994, etc.

   Answer:
   1975-1979
   1980-1984
   1985-1989

   F. Ask students if they would predict a *shortage* of oil in the future and, if so, why. (Yes, supply becomes exhausted but demand continues.)

   G. "How can a shortage be prevented?" (Increase supply and/or decrease demand, or find alternatives.)

Natural Gas Consumption—Past and Future
Constant Future Demand
GROUP A TASKS

Are there sufficient United States supplies of natural gas to meet future demand? What are the lifetimes of United States supplies of natural gas? Complete the following tasks to find out.

1. Examine the accompanying graph.

   A. What are the units of the scale at the top?

   ____

   B. How much natural gas does each symbol represent?

   ______

   C. Draw the number of symbols which would represent:

   20 trillion cubic feet ____________

   13 trillion cubic feet ____________

   5 trillion cubic feet ____________

   The abbreviation for trillion cubic feet is TCF.

2. Construct a table with the following headings:

Years	Amount of Natural Gas Consumed (in trillion cubic feet)
1945-1949	
1950-1954	
1955-1959	
1960-1964	
1965-1969	
1970-1974	

   A. Read the graph and enter into the table the amount of natural gas consumed in *each* five-year period from 1945 to 1974.

   B. Did demand increase or decrease? How many times greater was the amount consumed in 1970-1974 than the amount consumed in 1950-1954?

   C. How many times greater was the United States population in 1970 than in 1950? (Refer to work on oil or see 1973 Almanac.) Is your answer to 2B, the increase in the consumption of natural gas, greater than, equal to, or less than the increase in the United States population?

   ____

3. Estimates of the supply of natural gas in the United States are:

	Reserves	*Ultimately recoverable*
Natural Gas (in trillion cubic feet)	290	2,390

   A. Calculate from your table or graph the total amount of natural gas consumed in the past 30 years (1945-1974).

   ____

   B. Is this amount greater than, equal to, or less than the reserves of natural gas?

   ____

   C. Is it greater than, equal to, or less than the amount ultimately recoverable?

   ____

   D. If in the next 30 years we attempt to consume the same amount used in the past 30 years, will we run out of reserves? ______ Out of ultimately recoverable resources of natural gas? ______ Explain your answers.

4. A. How many symbols would be required to represent the amount of natural gas *reserves*?

   ____

   B. How many symbols would be required to represent the amount of *ultimately recoverable* natural gas?

   ____

5. A. How much natural gas was consumed in 1970-1974?

   ____

   How many symbols are used to represent this quantity?

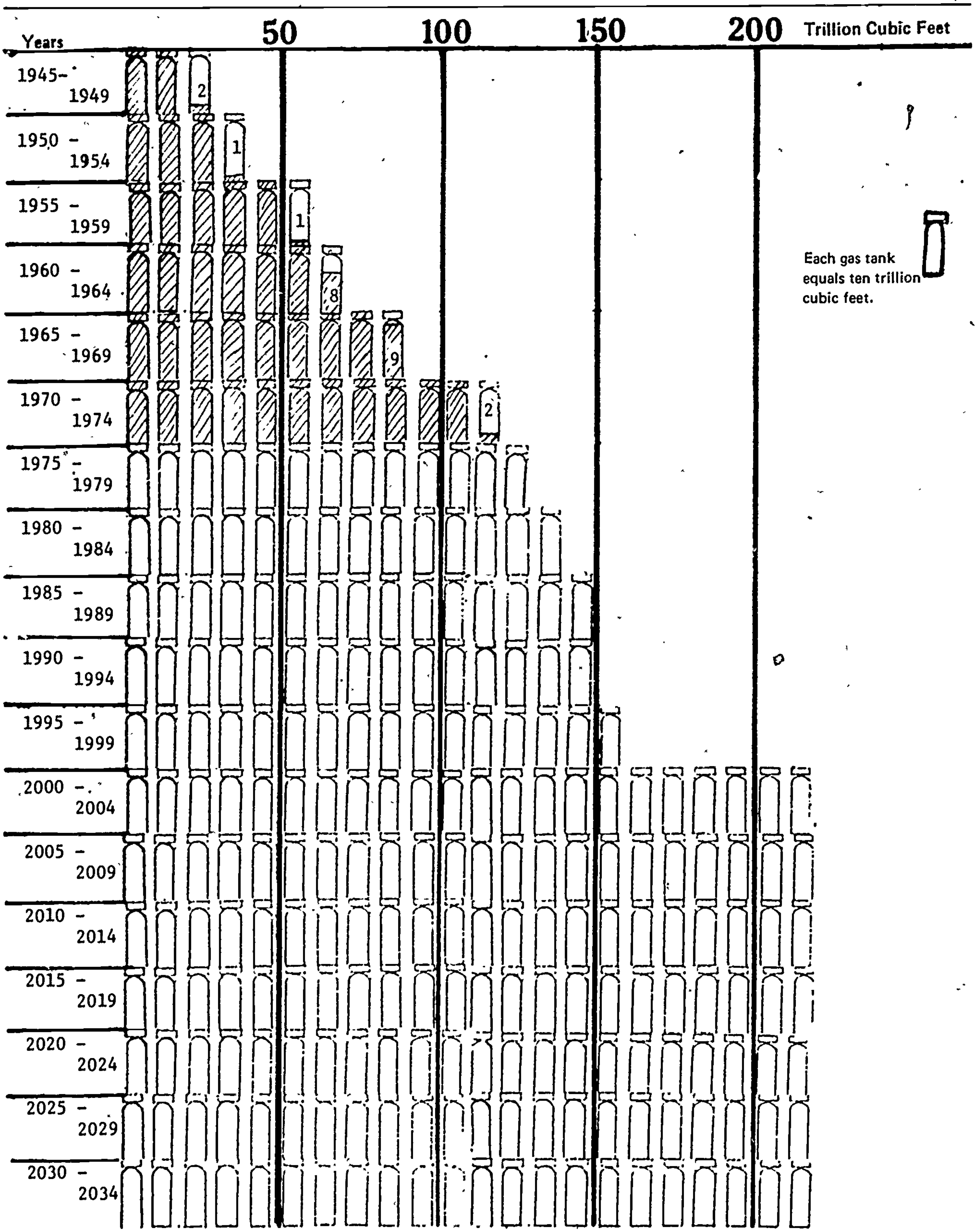
   ____

   B. Color this many symbols in each row after 1970-1974 until the total number of symbols equals the *reserves* of natural gas. In what five-year period would the *reserves* be totally consumed? __________ What is the lifetime of the United States reserves of natural gas at a constant consumption rate? __________

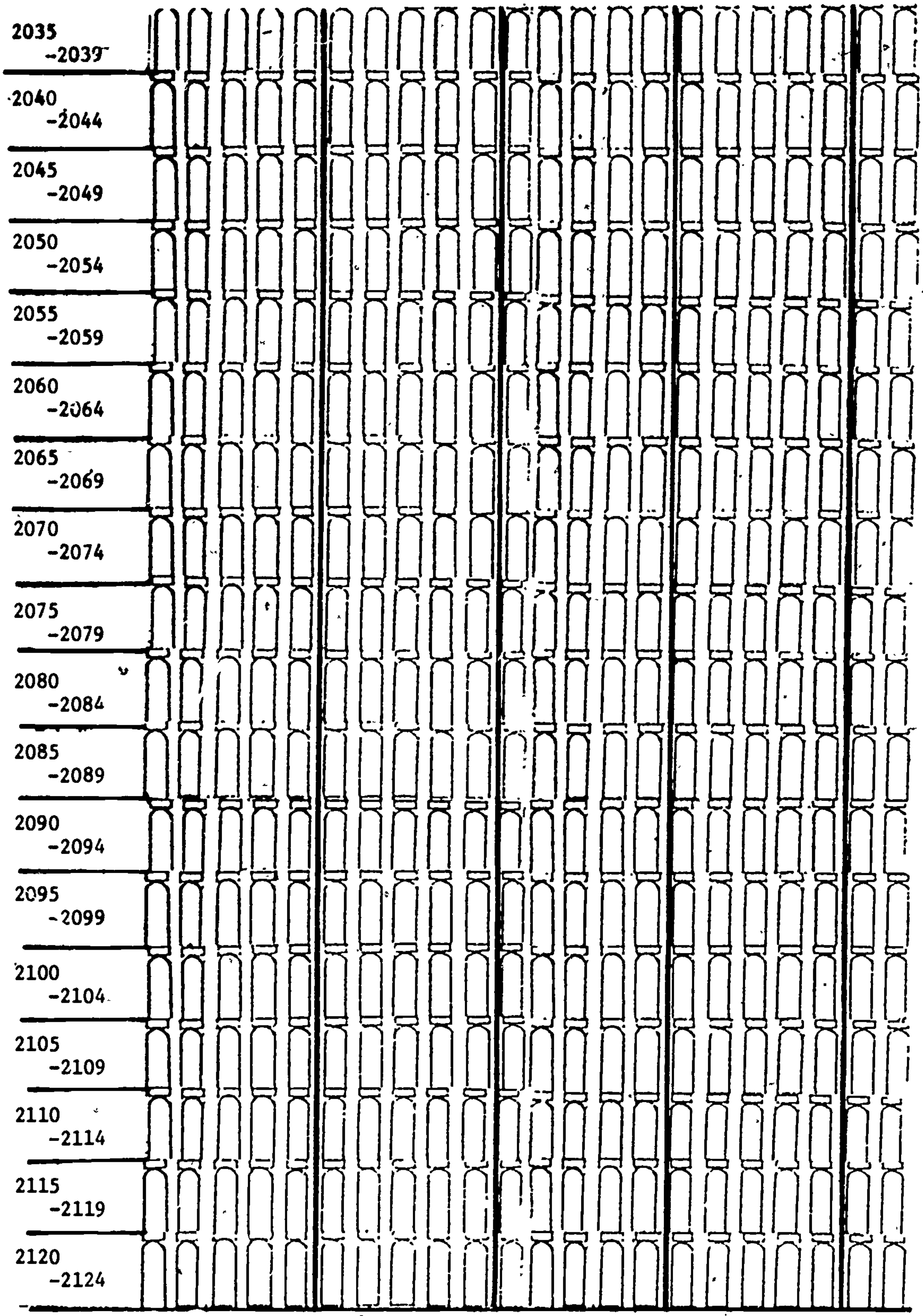
   C. Similarly, color the number of symbols in your answer to 5A in each row until the *ultimately recoverable* resources of natural gas are totally consumed. In what five-year period does this occur? __________ What is the lifetime of the *ultimately recoverable* United States supplies of natural gas at a constant consumption rate?

   ____

U.S. Consumption of Natural Gas



(paste top of next graph here)


2035 -2039
2040 -2044
2045 -2049
2050 -2054
2055 -2059
2060 -2064
2065 -2069
2070 -2074
2075 -2079
2080 -2084
2085 -2089
2090 -2094
2095 -2099
2100 -2104
2105 -2109
2110 -2114
2115 -2119
2120 -2124

Natural Gas Consumption— Past and Future Increasing Future Demand

GROUP B TASKS

Are there sufficient United States supplies of natural gas to meet future demand? What are the lifetimes of United States supplies of natural gas? Complete the following tasks to find out.

1. Examine the accompanying graph.

   A. What are the units of the scale at the top?

   ____

   B. How much natural gas does each symbol represent?

   ______ ______

   C. Draw the number of symbols which would represent:

   20 trillion cubic feet ______________

   13 trillion cubic feet ______________

   5 trillion cubic feet ______________

   The abbreviation for trillion cubic feet is TCF.

2. Construct a table with the following headings:

Years	Amount of Natural Gas Consumed (in trillion cubic feet)
1945-1949	
1950-1954	
1955-1959	
1960-1964	
1965-1969	
1970-1974	

   A. Read the graph and enter into the table the amount of natural gas consumed in *each* five-year period from 1945 to 1974.

   B. Did demand increase or decrease? How many times greater was the amount consumed in 1970-1974 than the amount consumed in 1950-1954?

   C. How many times greater was the United States population in 1970 than in 1950? (Refer to work on oil or see 1973 Almanac.) Is your answer to 2B, the increase in the consumption of natural gas, greater than, equal to, or less than the increase in the United States population?

   ____

3. Estimates of the supply of natural gas in the United States are:

	Reserves	*Ultimately recoverable*
Natural Gas (in trillion cubic feet)	290	2,390

   A. Calculate from your table or graph the total amount of natural gas consumed in the past 30 years (1945-1974).

   ____

   B. Is this amount greater than, equal to, or less than the reserves of natural gas?

   ____

   C. Is it greater than, equal to, or less than the amount ultimately recoverable?

   ____

   D. If in the next 30 years we attempt to consume the same amount used in the past 30 years, will we run out of reserves? ______ Out of ultimately recoverable resources of natural gas? ______ Explain your answers.

4. A. How many sumbols would be required to represent the amount of natural gas *reserves*?

   ____

   B. How many symbols would be required to represent the amount of *ultimately recoverable* natural gas?

   ____

5. A realistic projection of future consumption of natural gas is given by the following set of numbers:

Year	Demand (in trillion cubic feet)	Year	Demand (in trillion cubic feet)	Year	Demand (in trillion cubic feet)
1975-1979	126	2000-2004	168	2025-2029	221
1980-1984	134	2005-2009	177	2030-2034	234
1985-1989	141	2010-2014	188	2035-2039	247
1990-1994	150	2015-2019	199	2040-2044	261
1995-1999	158	2020-2024	210	2045-2049	276

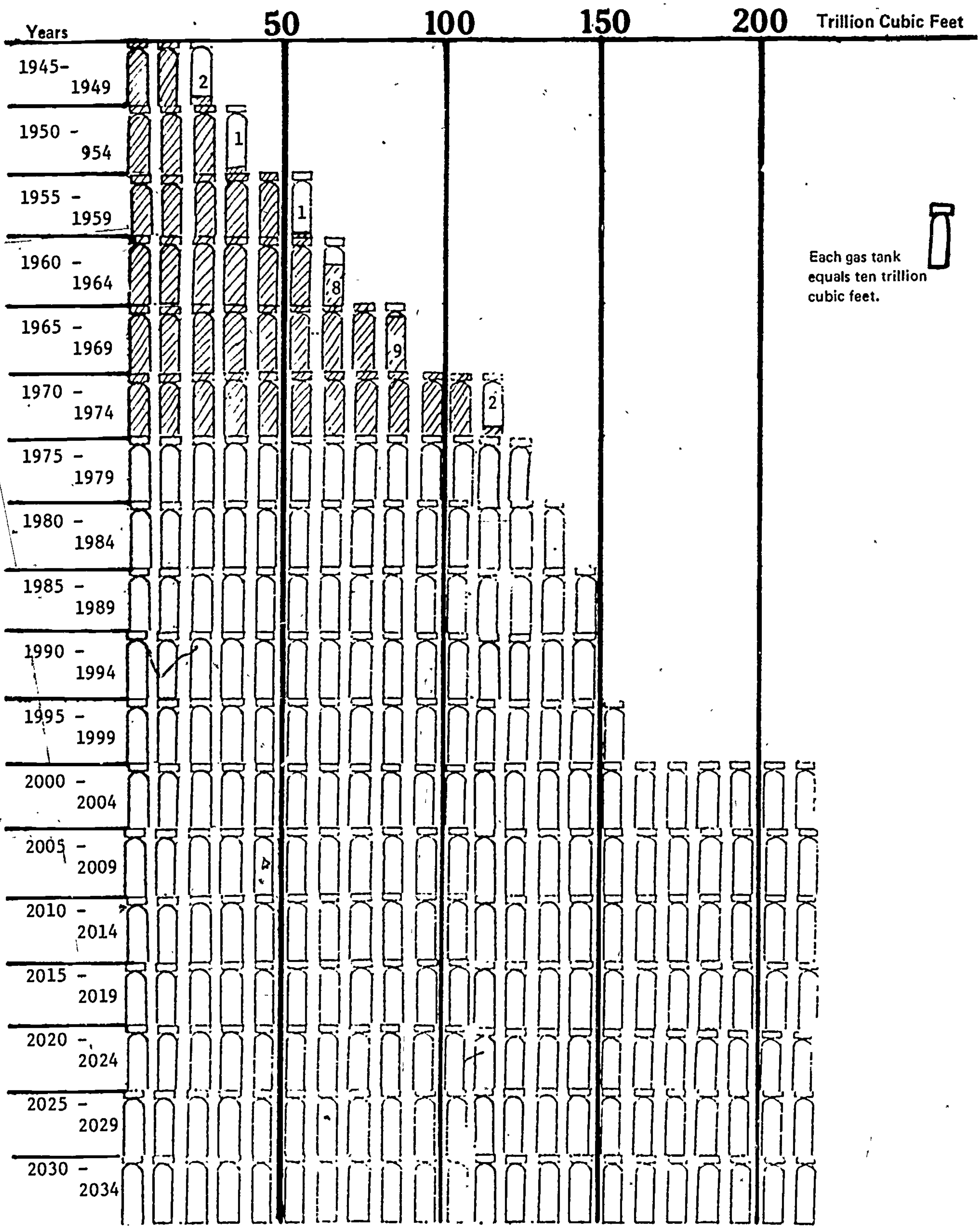
   A. How many symbols are required for each of these numbers? 126 TCF ______, 134 TCF ______, 141 TCF ______, 150 TCF ______, 158 TCF ______.

   B. Color the symbols in each row up to these respective maximum amounts until the *reserves* of natural gas are totally consumed. In which five-year period does this occur? __________ What is the lifetime of the United States *reserves* of natural gas at an increasing consumption rate?

   ____

   C. Similarly, color in each row up to the maximum amounts until the *ultimately recoverable* natural gas resources are totally consumed. In which five-year period does this occur? __________ What is the lifetime of the *ultimately recoverable United States supply of natural gas?* ______

U.S. Consumption of Natural Gas



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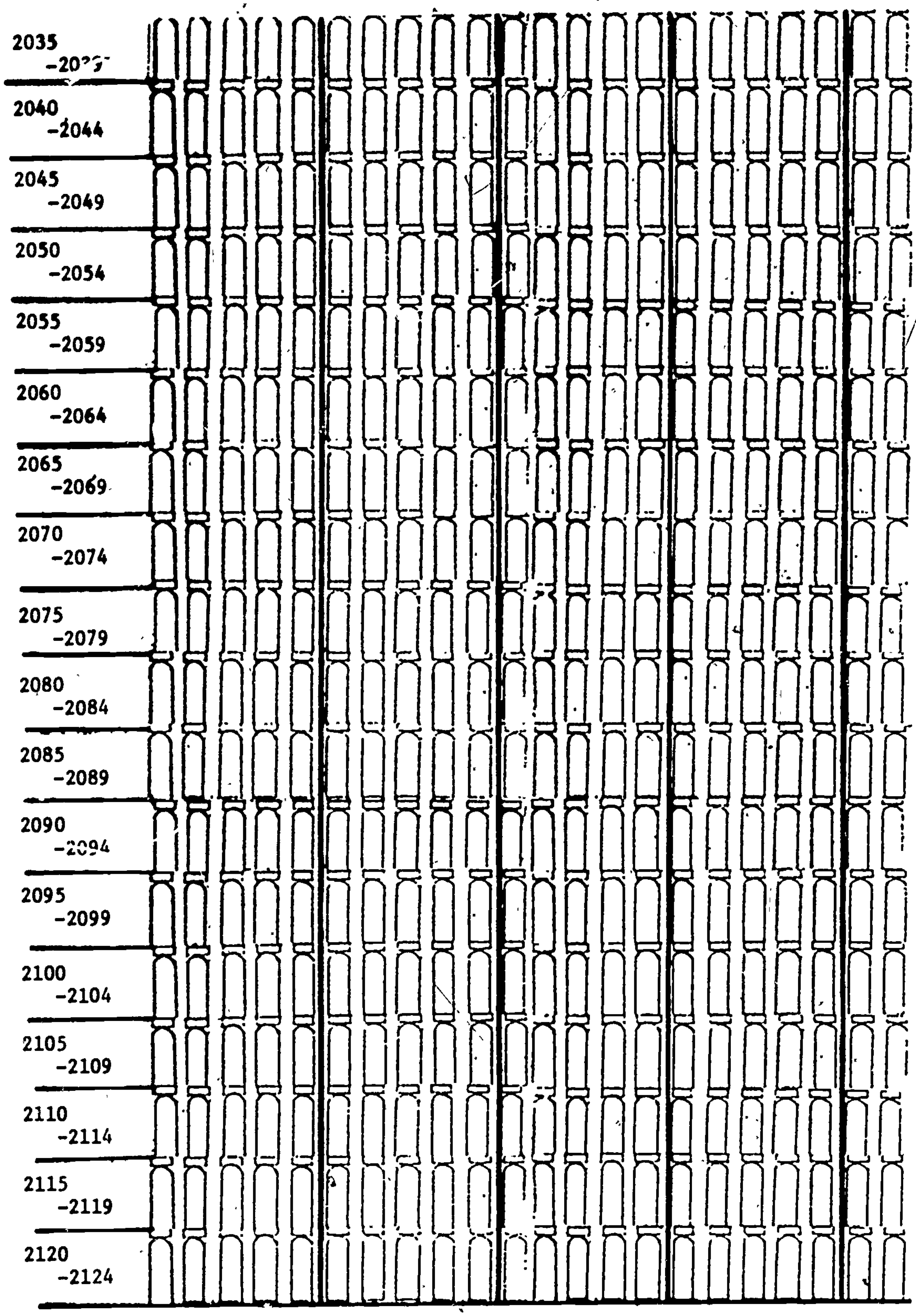

2035
2040 -2044
2045 -2049
2050 -2054
2055 -2059
2060 -2064
2065 -2069
2070 -2074
2075 -2079
2080 -2084
2085 -2089
2090 -2094
2095 -2099
2100 -2104
2105 -2109
2110 -2114
2115 -2119
2120 -2124

Coal Consumption—Past and Future
Constant Future Demand

GROUP C TASKS

Are there sufficient United States supplies of coal to meet future demand? What is the lifetime of United States supplies of coal? Complete the following tasks to find out.

1. Examine Graph 1.
   A. What are the units of the scale at the top?

   ____

   B. How much coal does each pile of coal, or symbol, in the figure represent?

   ____

   C. Draw the number of symbols which would represent:

   2 billion tons of coal ____________________

   1 1/3 billion tons of coal ____________________

   2 1/10 billion tons of coal ____________________

   The abbreviation for a billion tons of coal is B tons.

2. Construct a table with the following headings.

Years	Coal Consumed
1945-1949	
1950-1954	
1955-1959	
1960-1964	
1965-1969	
1970-1974	

   A. Read the graph and enter into the table the amount of coal consumed in each five-year period from 1945 through 1974.

   B. Did the demand increase, decrease, or remain the same in the last 20 years? __________ How many times greater was the amount consumed in 1970-1974 than in 1950-1954? __________

   C. How much did the United States population increase from 1950 to 1970? (Refer to your work on oil or see 1973 World Almanac.) __________ Is your answer to 2B, the change in consumption of coal, greater than, equal to, or less than the increase in United States population?

   ____

3. Estimates of the supply of coal in the United States are:

	Reserves	Ultimately recoverable
Coal (in billion tons)	150	1,500

   A. Calculate from your table or Graph 1 the total amount of coal consumed in the past 30 years (1945-1974).

   ____

   B. Is this amount greater than, equal to, or less than the United States *reserves* of coal? ____________________ Is it greater than, equal to, or less than the amount *ultimately recoverable*?

   ____

   C. If in the next 30 years we attempt to consume the same amount used in the past 30 years, will we run out of reserves? __________ Will we run out of ultimately recoverable resources of United States coal? __________ Explain your answers.

4. A. How many symbols would be required to represent the amount of United States coal *reserves*?

   ____

   B. How many symbols would be required to represent the amount of *ultimately recoverable* United States resources of coal?

   ____

   C. How many symbols would represent the total amount of coal consumed in the 25-year period *1950-1974*?

   ____

   Enter this number of symbols on the first row of Graph 2 and in every succeeding row until the United States reserves of coal are totally consumed.
   During what 25-year period will the United States reserves be totally consumed? ____________________
   What is the lifetime of coal *reserves*?

   ____

5. A. How many future 25-year periods are there; i.e., how many rows did it take to totally consume all of the coal reserves?

   ____

   B. Is this approximately the same number you would obtain by dividing the amount of the reserves (150 billion tons) by the consumption in the 25-year period 1950-1974 (see your answer to 4C)?

   ____

   C. If you took your answer to 5A, the number of 25-year periods, and multiplied it by 25 years, do you obtain the same answer as in 4C for the reserve lifetime?

   ____

   Explain ____________________

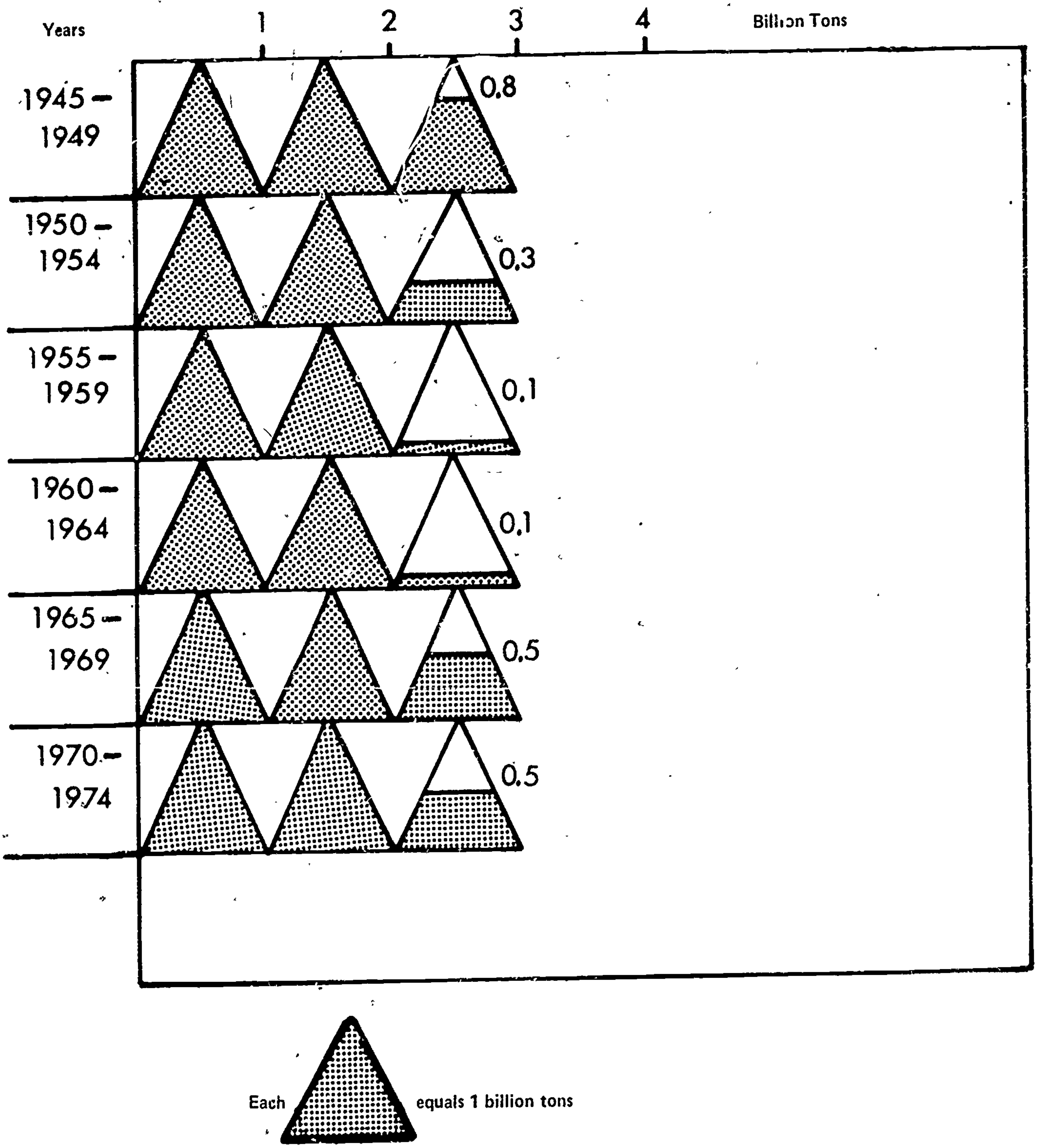
6. Your answers to 5B and C suggest an alternative method for calculating resource lifetime when the consumption remains *constant*.
   Using the estimate of 1,500 billion tons for ultimately recoverable supply of United States coal, calculate, using this alternative method, the lifetime of this supply.

   ____

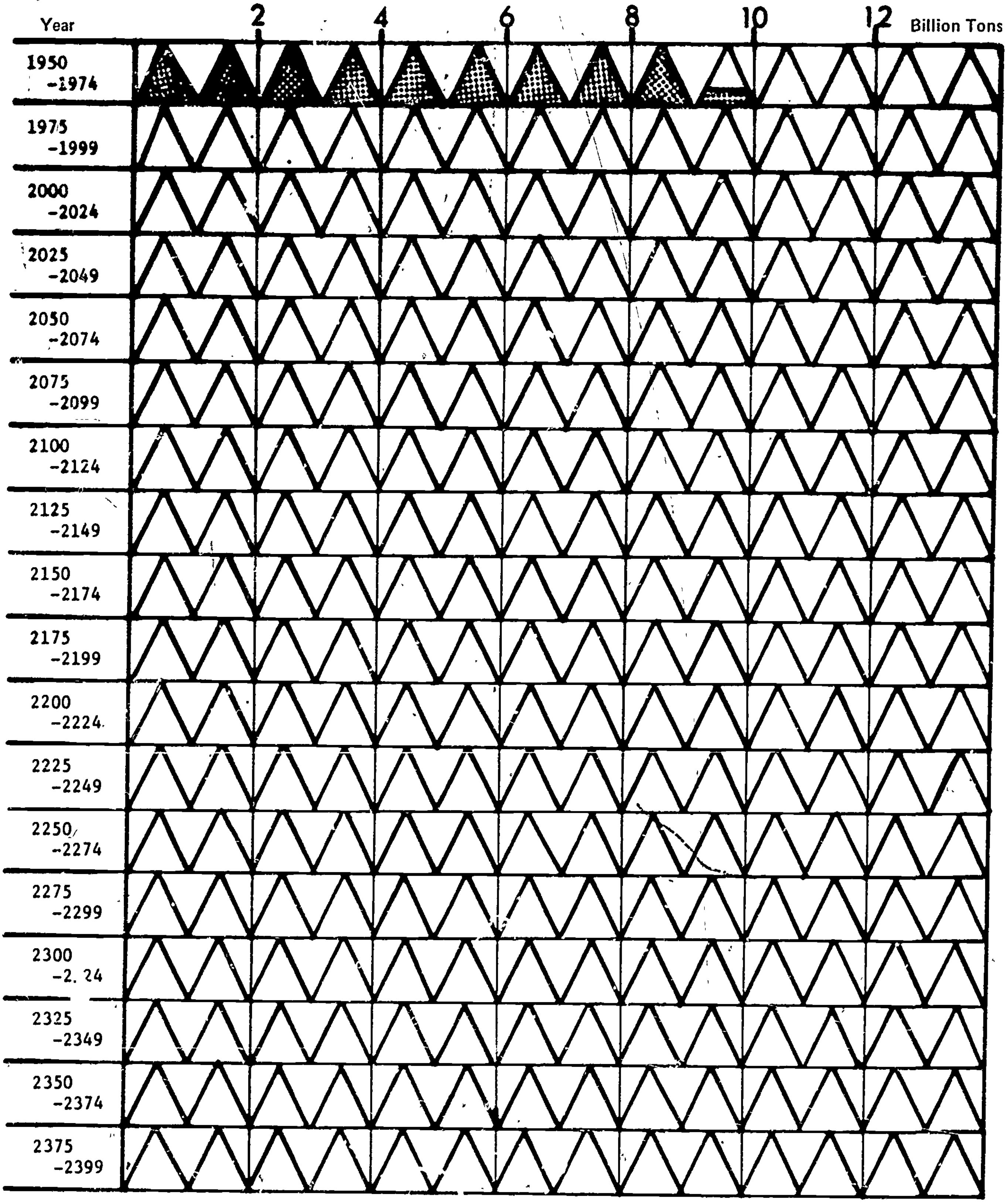
   During what period would this supply be totally consumed?

   ____

GRAPH 1
U.S. Consumption of Coal; 1945-1974

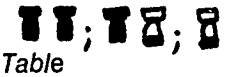


GRAPH 2
U.S. Consumption of Coal



Answer Sheet For Task Sheets

Group A: Natural Gas, Constant Consumption

1. A. Trillion cubic feet
   B. 10 trillion cubic feet
   C. 
2. A. *Table*

Years	Amount of Natural Gas Consumed
1945-1949	22 trillion cubic feet
1950-1954	31 trillion cubic feet
1955-1959	51 trillion cubic feet
1960-1964	68 trillion cubic feet
1965-1969	89 trillion cubic feet
1970-1974	112 trillion cubic feet

   B. Increase. The consumption in 1970-1974 was about 3½ times greater.
   C. About 1 1/3 times. The increase in natural gas consumption is *greater* than the population increase.

3. A. 373 trillion cubic feet
   B. Greater than
   C. Less than
   D. Yes. No. The amount consumed in the past 30 years (373 trillion cubic feet) is greater than the reserves, so they would be totally consumed. They are less than the ultimately recoverable amount, however, so they would not be totally consumed.
4. A. 29 symbols
   B. 239 symbols
5. A. 112 trillion cubic feet; 11 2/10 symbols
   B. 1985-1989; 10-15 years
   C. 2080-2085; about 110 years

Group B: Natural Gas, Increasing Consumption

Answers to all questions 1-4 in Group B (i.e., 1 A, B, C; 2 A, B, C, D; 3 A, B, C, D and 4 A, B) are the same as those in Group A task sheet.

5. A. 12 6/10, 13 4/10, 14 1/10, 15, 15 8/10
   B. 1985-1989, 10-15 years
   C. 2040-2045, 65-70 years

Group C: Coal Consumption

1. A. Billion tons
   B. Each symbol represents 1 billion tons
   C. 
2. A.

Years	Amount of Coal Consumed
1945-1949	2.8 billion tons
1950-1954	2.3 billion tons
1955-1959	2.1 billion tons
1960-1964	2.1 billion tons
1965-1969	2.5 billion tons
1970-1974	2.5 billion tons

   B. Increase slightly; (2.5 ÷ 2.3) = 1.1 or about the same
   C. 1 1/3 times. Less than
3. A. 12.2 billion tons
   B. Less than. Less than
   C. No. No. The amount of coal consumed in the past 30 years is much less than the reserves or ultimately recoverable supplies.
4. A. 390
   B. 1,500
   C. 9 4/10. 2350-2374. About 400 years
5. A. Nearly 16 rows
   B. [(150 billion tons) ÷ (9.4 billion tons per 25-year period)] = 15.9. Yes
   C. Yes. (16 rows) × (25 years per row) = 400 years
6. Calculate:
   (1) (1,500 billion tons) ÷ (9.4 billion tons per 25-year period) = 159 periods
   (2) (159 periods) × (25 years per period) = 3,975 years

   The lifetime could be 3,975 years, or close to 4,000 years. Alternatively, students might note that the ultimately recoverable amount is 10 times the reserves. Thus, the lifetime of the ultimately recoverable supply which is consumed at a constant rate is 10 times the lifetime of the reserves.

   The ultimately recoverable supply would be totally consumed 4,000 years from now.

Bibliography

Books:

Energy in the World of the Future, Harold Hellman (New York: M. Evans) 1973.

The Whole Earth Energy Crisis, John H. Woodburn (New York: Putnam) 1973 ($4.98).

Natural Resources: Will We Have Enough for Tomorrow's World? Reed Millard (New York: Messner) 1972.

Energy Resources of the U.S. (Skokie, Illinois: Rand McNally) 1969 (an atlas, 48 pp, $1.00).

Articles:

"Are We Running Out of Fuel?" Irving Bengelsdorf, **National Wildlife** 9 (2) February-March 1971 (includes chart).

"Over the Mideast Oil Barrel," **Newsweek** 82 (4) July 23, 1973 (includes chart of estimated oil reserves).

"The Search for Tomorrow's Power," Kenneth Weaver and Kristof Weaver, **National Geographic** 142 (5) November 1972.

Films:

Earth: The Years of Decision, 35 mm filmstrip with phonodisc and teacher guide. Lyceum Productions, Box 1226, Laguna Beach, California 92652.

Energy and the Earth, 1973, filmstrips plus cassettes or records and teacher guide. Lyceum Productions, Box 1226, Laguna Beach, California 92652.

Part I — Earth, the Early Years to 1900.

Part II — Earth, Years of Decision

The Fuel Crisis, Scott Education Division, 104 Lower Westfield Road, Holyoke, Massachusetts 01040.

Science, Energy, Environment-Ark (1970), 20 minutes, color film. Barr Films, Box 7-C, Pasadena, California 91104.

World's Energy Supply, filmstrip, color, 37 frames, $8.50, McGraw-Hill Films, 1220 Avenue of the Americas, New York, New York 10020.

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

Materials List

- ☐ Overhead projector for displaying transparencies.
- ☐ Duplicate task sheets and figures for each student.
- ☐ (Optional) Photographs or clippings from magazines or newspapers showing long lines of cars at gasoline service stations.

MINI-UNIT 6
Going Places
(Transportation Choices and Oil Supplies)

Going Places
(Transportation Choices and Oil Supplies)

ABSTRACT

Our industrial and mobile society relies heavily on the use of oil — a nonrenewable resource. Transportation in various forms — private and public — is the major consumer of the available oil supply. Domestic oil production has not been sufficient to meet our nation's demand for oil, our need to import oil has been increasing each year. This demand has affected domestic prices of oil products, international relations between oil importing and exporting countries, and the intensiveness of searches for new domestic sources of oil. In this mini-unit students express their initial preference for a mode of personal transportation and for a type of car. They then examine the impact of their personal transportation choices on our nation's need for oil and oil products by exploring our domestic supply of oil, our major uses of oil, and our need to import oil. Students then have an opportunity to re-evaluate their choice of a form of personal transportation. Critical thinking skills in interpreting graphs and written materials, and math computation skills of finding percentages and multiplying and dividing 6 to 9-place numbers are utilized.

Recommended level: Social studies classes, grades 6-9.

Time required: Five to 10 45-minute class periods, depending on optional activities chosen.

Major teaching strategies: Classroom discussion, group research.

Advance preparation: Make copies of the transparencies which accompany the lessons (see materials list). Assemble current periodicals and references which address themselves to United States oil policy and decisions, both domestic and foreign (see bibliography for suggestions).

Key Ideas

1. Gasoline and oil are a significant part of the cost of car ownership and operation.
2. Transportation by car is the major consumer of our nation's oil and oil products.
3. The domestic production of oil and oil products does not meet our nation's present need for oil. The percentage of oil and oil products imported by the United States is increasing.
4. The necessity to import oil influences our domestic oil policies and our relations with other countries.
5. Other forms of transportation than cars use less gasoline (oil) per passenger mile.

Objectives

At the completion of this activity, the students will be able to:

1. *Name* or *list* several factors which influence the cost of operating a car.
2. *Rank* several types of cars (e.g., compact, standard) according to gasoline consumption per mile.
3. *Interpret* appropriate graph and tabular information *in order to determine* the amount of gasoline consumed and the amount of oil consumed, produced, and imported in a specified year.
4. *Compare* the effects of a significant number of persons choosing differing forms of personal transportation (such as standard car, subcompact car, or bus) on total United States consumption of oil and our need to import oil.
5. *Choose* a personal form of transportation consistent with his/her personal priorities.

Teaching Suggestions

Lesson 1 — Initial Preferences for Different Transportation Modes and Car Models

Students are asked to consider their preferences for various forms of transportation, and then for cars, in particular. Cost is introduced as a possible factor in their decisions.

Advance preparation: Arrange a group of transportation and automobile pictures on a bulletin board with an interesting title, such as. "My Dream Machine," "Is There a Right Car for Me?," or "Cars. Right On?" If possible arrange a display of model toy cars with catchy labels attached. Also acquire a folder (construction paper, tagboard, etc.) for each student.

1. Begin lesson by having a brief discussion on the form of transportation they presently use and their activities which require transportation.
   - ☐ For example, ask students:

     "How did you get to school this morning?"

     "How did members of your family get to work?" (List responses.)

     "Name some of the activities in your daily family life which require the use of some form of transportation." (Possible responses: shopping for clothing, groceries, other household needs; visiting friends; taking trips; going to sporting events, theater, or some other form of entertainment, etc.)
   - ☐ Have students list five things they really like to do. (They do not have to share this information unless they choose to do so.) Then have them write a *T* beside the items which require some form of transportation. Tally the number of items that require transportation. For example.

     "How many of you needed transportation for all five items? Four? Etc."

     Briefly discuss the implications of our need for transportation to maintain our present lifestyles.
2. Brainstorm with students in order to identify the various forms of transportation available, and to group these into public versus private forms. Have students identify their preferred form.
   - ☐ Continue discussion by asking.

     "Can you think of other types of transportation available to us besides the ones we have listed?" (Refer to original list developed in 1 above.)

"Which of these examples are public forms of transportation, and which are private forms of transportation?" (Public = buses, cabs, trains, metros, subways, etc.; private = cars, bicycles, motorcycles, motorbikes, motor scooters, etc.)

If necessary discuss the difference between public forms, which are business or tax-supported systems, and private forms, which are personally financed. Have students copy the list of suggestions made.

☐ Ask students:

"Which form of transportation would you choose if you were an adult?"

Allow time for several students to respond and then tally the number of students choosing each type. Have one student record this list and keep for future reference. Have each student place an * near his/her first choice on the list. Discuss their reasons for their choices.

3. Have each student and the class as a whole indicate their preferred choice for a car, and identify and rank the factors they consider important in their choice of a car.

☐ Begin discussion by asking:

"Most American families own at least one car. Let's assume that each of us planned to purchase a car. Which one would you choose? Do you know much about the makes, models, and options that are available today?"

☐ Continue by asking:

"What kinds of things would be important to you when buying a car?" (Possible answers. initial cost, cost of operating, color, power, appearance, environmental effects — pollution.)

List these responses on board or chart. Ask each student to rank these factors in terms of importance to him/her. Then ask the class to identify their priorities as a group. Tally the number identifying cost as most important, appearance, and so forth, until three priorities of the class have been identified. Have one student record this list for future reference. Have each student record his/her car choice and his/her personal priorities on paper.

4. End lesson by assigning students the task of determining the cost for their car choice.

Ask students:

"How many of you listed cost as your first priority?"

Then:

"How much do you think each of these (pictured) cars costs?"

Write these on a piece of paper and attach to pictures. Ask each student to try to find out the actual price range of the car of his/her choice, using newspaper and magazine advertisements, or by calling local car dealers.

5. Have students set up folders for collecting information during this unit.

Distribute construction paper, tagboard, etc. and have students place the following papers in the folder:

"Forms of Public and Private Transportation"

"My Car Choice and Reasons For It"

6. (Optional) Each student may design his/her favorite car and describe its characteristics.

Lesson 2 — Oil-Related Costs of Operating Various Cars

Students compare costs of purchasing and operating various cars in order to focus attention on the operating costs related to oil and gasoline consumption.

1. Have students briefly review their favorite car choices and the group's priorities for car buying.

"According to our discussion yesterday, which cars were our favorites?" (Refer to the class list of popular choices and priority rankings.)

"Which items were important to the class when buying a car?"

"Yesterday we guessed the prices of the cars shown here on the bulletin board, was anyone able to find out the actual cost of his/her favorite car?" (List these on board and compare with "students' prices.")

Ask students to give the source of price information — called dealer, newspaper, brochure, etc. Allow students to share picture, price, and any other information they choose about their car choices.

Discuss briefly the range of purchase prices and have students speculate as to why they vary.

2. Have students analyze the cost of operating a car using Figure 1.

☐ Begin discussion of car operating costs by asking.

"Besides the initial cost, or purchase price, of the car, what other costs are there in owning and operating a car?" (Possible responses: maintenance, repairs, tires, insurance, parking, tolls, taxes, gasoline, and oil, etc.)

"How much do you think a car owner spends on all this in one year?" (List responses on board.)

"Let's look at some information the Department of Transportation has put together about the cost of operating a car."

☐ Show Figure 1 and guide the discussion by referring to the transparency and asking:

"What is the main idea of this information?" (It tells some of the costs of operating a car.)

"Who would like to write $27 billion on the board? How many zeros does it have? (Nine.) Is a billion more or less than a million?" (More.)

"If you drive a car 100,000 miles over a 10-year period, how many miles did you drive each year, on the average?" (10,000 miles.)

"What is meant by 'depreciation'?" (Depreciation refers to the amount of money the car decreases in value each year. By subtracting the depreciation from the purchase price, you determine the present value of a car — its trade-in value. Bring out the fact that the $425-figure is average depreciation for each of 10 years — *not* first-year depreciation. Annual depreciation is calculated by taking the purchase price and dividing it by the assumed lifetime of the car — here 10 years.)

"Does a car's value increase or decrease as it gets older?" (Decreases.)

"Why?" (Wear-and-tear through use reduce the remaining lifetime of the car. As it is used, it decreases in value.)

"In the transparency, what is the total cost of operating a car for each year?" ($1,594.)

"Which of the costs shown would probably increase as the car gets older?" (Repairs and maintenance.)

"Are the costs shown higher or lower than you expected?"

"Using these figures, how much does it cost to operate a standard size car per day?" (Using rounded figures — $1,600 ÷ 360 = $4.44 per day.)

(Optional) Send for free copies of *Cost of Operating an Automobile* which are available to students and their families by writing to:

U.S. Department of Transportation
Federal Highway Administration
Office of Highway Planning
Highway Statistics Division
Washington, D.C. 20590

Have students relate the costs of gasoline and oil.

☐ Begin a discussion of the gasoline and oil-related costs of operating a car. Sample questions might be:

"What affects how much gasoline a car uses?" (Car size, engine size, equipment, etc.)

"Which of our favorite cars do you think uses the most gasoline and oil?" (Larger cars, cars with more equipment, etc.)

☐ Have each student rate his choice according to gasoline useage by establishing a simple ranking system, such as:

1 — uses least amount
2 — uses average amount
3 — uses most gasoline

Have different members of the class rate the examples on the bulletin board.

☐ Show and discuss Figure 2.

"Let's look at some more information about the difference in operating various size cars."

"Which three types of cars are described?" (Standard, compact, and subcompact.) "Which is the largest car?" (Standard.) "Which kinds are not mentioned?" (Luxury cars — Cadillac, etc. — foreign cars, and sports cars.)

"Which car used the most gasoline?" (Standard size.) "If each car went 10,000 miles, how many gallons of gasoline would it use?" (Answers. Standard — 769, compact — 625, subcompact — 476) "How much would it cost?" (Cost: Standard — $400; compact — $325, subcompact — $247)

"How much oil would each car use in 10,000 miles?" "How much would it cost?" (Answers: 1 gallon of oil = $4.00. Using rounded figures: standard uses 5 gallons of oil = $20.00; compact uses 4 gallons of oil = $16.00; subcompact uses 3 gallons of oil = $12.00.)

"Which category (or group) describes your favorite car?" (If group does not exist, add it to the Figure under *Other Types*.) "How many miles per gallon does your car get?"

4. End lesson by asking students to research the number of miles per gallon that the car of their choice gets.

   Students may contact owners of certain cars, car dealers, *Consumer Reports* and other references to find approximate figures on gasoline mileage for their cars. They will also want to check the current gasoline prices in their area and then calculate the yearly cost of driving their car 10,000 miles.

5. (Optional) Free copies of "Gas Mileage Guide for New Car Buyers" are available for students by writing:

   Fuel Economy
   Federal Energy Administration
   Washington, D.C. 20461

Related Activity

Use the figures below to determine the effects of emission controls and various accessories, etc., on the consumption of gasoline. The mileage, or number of miles that can be driven on one gallon of gas, decreases by 7 percent with emission control devices; by 9 to 20 percent with air-conditioners; by 6 percent with automatic transmission; and decreases with the weight of the automobile (a 5,000-pound car uses twice as much gasoline as a 2,000-pound car).

Example: If a 2,000-pound car with a standard transmission was able to travel 14 miles per gallon, then this car with:

1) Emission control devices would travel (.07 × 14) = .98 or 1 mile less per gallon.
2) Air-conditioning would travel (.10 × 14) = 1.4 to 2.8 miles less per gallon.
3) Automatic transmission would travel (.06 × 14) = .84 or .8 miles less per gallon.

A 5,000-pound car would travel (.50 × 14) = 7 miles less per gallon.

FIGURE 1
What an Automobile Really Costs

The average cost* of operating a standard size car for one year is:

	Cost
1) Gasoline and Oil	$322.00
2) Repairs and Maintenance	338.00
3) Garage, Parking, Tolls, etc.	196.00
4) Depreciation	425.00
5) Insurance	162.00
6) State and Federal Taxes	151.00
TOTAL	$1,590.00

Most motorists do not know that as a group they spent a total of $27 billion in 1973 on automobiles. The average life span of a car is considered to be 10 years — 100,000 miles.

*Costs are figured on a fully-equipped, four-door sedan purchased for $4,251 and averaged over the 10-year life span of the automobile. Gasoline cost is figured at 52 cents a gallon and mileage of 13 miles per gallon.

Source: U.S. Department of Transportation, 1974.

FIGURE 2
Costs of Owning and Operating Different Automobile Models

TYPE OF AUTOMOBILE	Standard Size Automobile	Compact Size Automobile	Subcompact Size Automobile	Other Types (Sportscars, Vans, etc.)
BASIC DESCRIPTION (1974 MODELS)	4-door sedan, with V-8 engine, automatic transmission, power steering and brakes, air-conditioning, radio, white walls	2-door sedan, with 6-cylinder engine, automatic transmission, power steering, radio, vinyl top	2-door sedan, with standard equipment, radio, wheel covers	
PURCHASE PRICE	$4,251.00	$2,910.00	$2,410.00	
CAR MODELS	Newport Torino Impala	Cutlass Mustang Tempest	Vega Gremlin Pinto	
GASOLINE COST	52¢ a gallon	52¢ a gallon	52¢ a gallon	
MILES PER GALLON	13 m.p.g.	16 m.p.g.	21 m.p.g.	
OIL COST	$1.00 a quart	$1.00 a quart	$1.00 a quart	
QUARTS PER GALLONS OF GASOLINE	1 quart per 40 gallons gasoline	1 quart per 38 gallons gasoline	1 quart per 34 gallons gasoline	

Lesson 3 — Domestic Supply and Demand for Oil

In order to develop the relationship between car use and our oil supply, students estimate the amount of gasoline used by United States passenger cars in one year. Then students research the major users of oil and the amount of oil produced by the United States.

Advance preparation: make transparencies, or copies for each student, of Figures 3-5. Assemble for research activity textbooks and reference materials which deal with oil production and consumption. encyclopedias, almanac, atlas, etc. Have available large wall maps of United States and the world.

1. Have students begin to determine our domestic demand for oil by calculating the amount of gasoline that would be used by the cars chosen or owned by the class.
   - ☐ List, or have students develop, a classification system for the automobiles that have been selected. (Possible categories include. luxury cars, standard size, compact size, subcompact size, and sports cars). Write these class headings on a chalkboard or bulletin board. Then ask each student to write his/her chosen car type and its miles per gallon of gasoline on a piece of paper. Affix tape to the backs of these and place them under the proper heading.
   - ☐ Divide the class into small groups — one for each major car class they have listed. Then have them select one class of cars and determine the amount of gasoline used by all of the cars in that particular class. This may be calculated by:
     a. Determining the number of gallons used by each car.
     b. Dividing by a standard yearly mileage figure; i.e., 10,000 miles. (Example: 10,000 ÷ 16 mph = 555 gallons.)
     c. Adding the gallons used by each car, or, if the same amount for each, by multiplying. (Example: 6 cars × 555 = 3,330 gallons.)
   - ☐ When each student group has completed this assignment, post the results and total the amount used by *all* of the cars selected by the class. Interpret the results by asking:

     "Does this amount surprise you? Is it a greater or lesser amount than you imagined?"

     "If our supply of gasoline were unlimited, would it matter how much gasoline our cars used? Is our supply limited or unlimited?"

2. Extend student awareness of the amount of motor fuel oil used in the United States by estimating the amount of gasoline used by all United States passenger cars.

   Continue discussion by asking:

   "How many passenger cars are there in the United States?" (List guesses.) "Where could we find out about this?" (1973 Almanac, p. 447. In 1972 there were 96 million registered passenger cars in the United States) "What is the estimate of the number of miles Americans drive in one year?" (980 billion miles — same source.) "Using these figures, let's estimate the amount of gasoline used by passenger cars in one year." (Choose a standard size car, figure for miles per gallon; i.e., 13 mpg and then divide the total mileage by it. Example: 980 billion ÷ 13 mpg = 75 billion gallons of gasoline.)

   "How does this estimate compare with the number of gallons known to have been consumed in 1971, i e., 98 billion gallons (1973 Almanac, p 448)?" (The estimate is smaller, indicating that the estimate of the number of miles traveled was too low, or the mileage too high.)

   Interpret the results by asking:

   "Does the amount surprise you? Do we have enough gasoline for all car owners to drive 10,000 miles a year? How could we find out? Which of our natural resources is used to make gasoline? (Oil) Do we have enough oil?" (List responses.)

3. Have students list 3 to 5 questions to guide their re- of United States oil production and the major users of the United States oil supply using Figures 2-4 and their follow-up activities.

   "Let's use our references and other resources and find out about the United States production of oil. What exactly would we want to know?"

   Have students list 3-5 questions to guide their research. Sample questions include:

   "How much oil does the United States produce in one year?
   Is the amount of oil produced increasing or decreasing?
   Do we have enough oil for our motor fuel needs?
   Where are these oil deposits located?
   What are some of the other major users of our oil supply?"

   In order to perform the research, the class may be divided into groups, each taking one or two questions to answer, or the teacher may use the transparencies and associated follow-up activities with small groups or the entire class and assign other questions for individual research.

4. End this lesson by having students add their notes to their folders and set research goals for next lesson.

Follow-Up Activity: Figure 3 — U.S. Domestic Oil Production 1965-1975

1. What is the unit of measure for determining the amount of oil? (Barrel.) How many gallons equal one barrel? (42 gallons = 1 barrel.) Write one billion on the board (1,000,000,000.) How many zeros are there in one billion? (Nine.)
2. What was the United States oil production in 1965? (3.4 billion barrels.) In which year did the production peak? (1971.) How much oil was produced that year? (4.2 billion barrels.)

3. How many gallons of gasoline did passenger cars use in 1971? (98 million gallons.) How many barrels would this be? (98 ÷ 42 = 2.3 billion barrels.) Let us mark this on our graph for the year 1971. Is there enough oil for our motor fuel needs? (Yes.)

   Are there other forms of transportation besides passenger cars? What else is there? (Trucks, buses, trains, ships, airplanes, motorcycles, boats.) How much oil is used by these forms? Where could we find out? (Besides references see Figure 5 entitled "Major Users of Oil Supplies." From this Figure we find that 55 percent × 5.5 billion barrels equals about 3.0 billion barrels. Thus, 3.0 - 2.3 = 0.7 billion barrels of oil were used for other forms of transportation altogether.)

Follow-Up Activity: Figure 4.— Oil Deposits in the United States

1. Which parts of the United States contain the major oil deposits? (Midwest, Southwest.)
2. Which three states appear to have the greatest oil reserves? (Texas, Louisiana, Oklahoma.) Are there any states with no oil reserves? (Iowa, Minnesota, Wisconsin, Georgia, North and South Carolina, Virginia, etc.) How could they obtain gasoline and oil? (Oil could be piped or shipped to these states.)
3. Where could you find information regarding the actual amounts of oil produced by states. (Almanac, textbooks.)
4. Have students research the amount of domestic oil supply by states and total production.

   Total United States domestic production, 1971: 4,071,729 barrels (1971 figures stated in thousands of barrels — 42 gallons per barrel — Source: 1973 Almanac. Includes crude oil and natural gas liquids.)

Follow-Up Activity: Figure 5 — Major Users of Oil Supplies

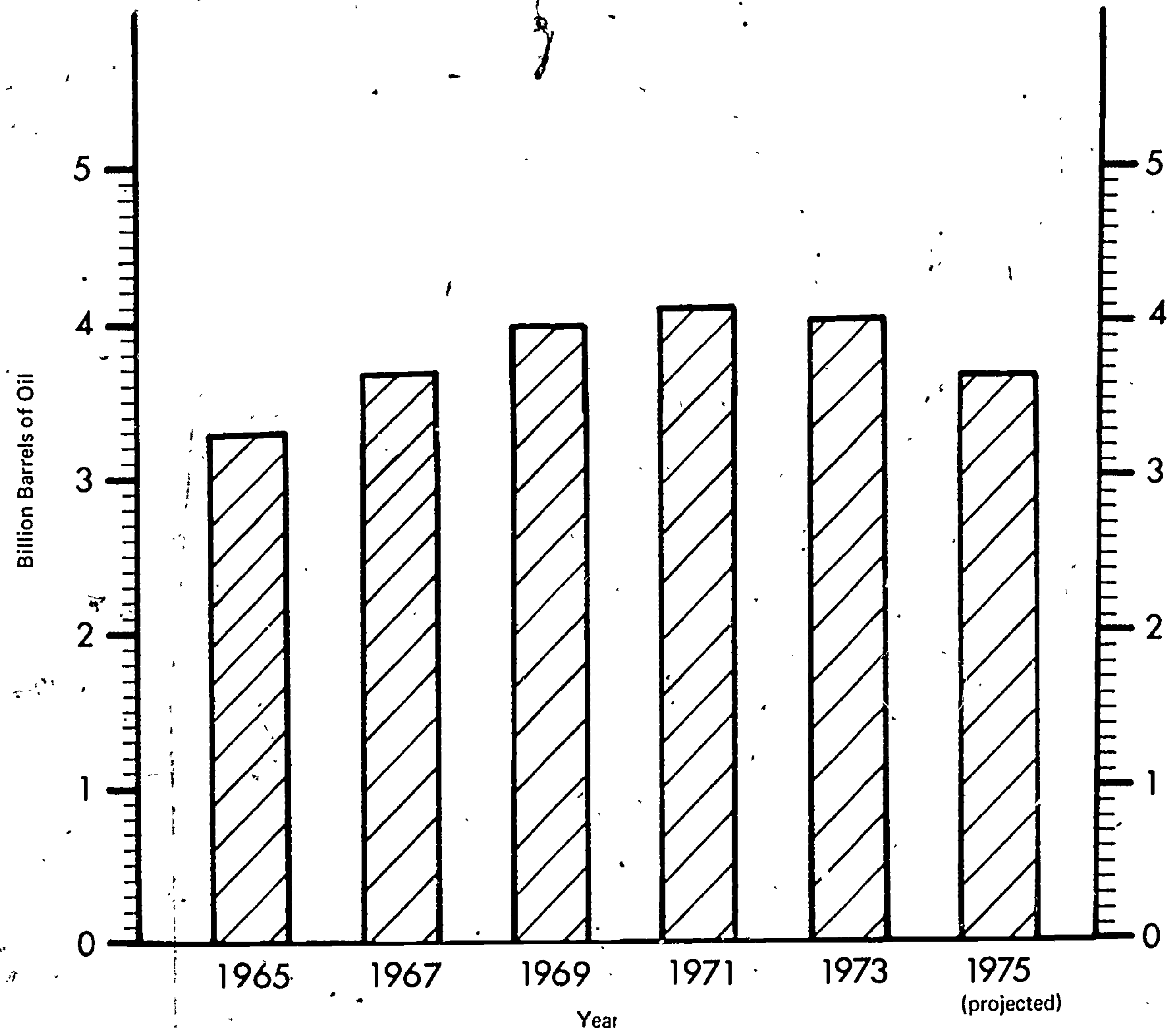
1. What is our major user of oil? (Transportation.)
2. What is meant by:

   Transportation? (All means of private and public travel.)
   Residential and commercial? (Homes and businesses.)
   Industrial? (Manufacturing plants of all kinds.)
   Electricity? (Electric power for heating, appliances, and air-conditioners.)
3. What percent of the total oil supply is used by industrial plants? (18 percent.) Electricity? (8 percent.) Residential and commercial? (19 percent.)
4. Name two to three ways that oil could be used by:

   Industry (Lubricate machinery and heat buildings.)
   Homes (Heat, electricity, appliances, air-conditioning.)
   Businesses (Heat, cool, machinery, electricity.)
   Electricity (Space heating, appliances, machines.)
   Transportation (Fuels and lubricants.)
5. In 1972 we consumed roughly 6 billion barrels of oil, how many barrels were used in:

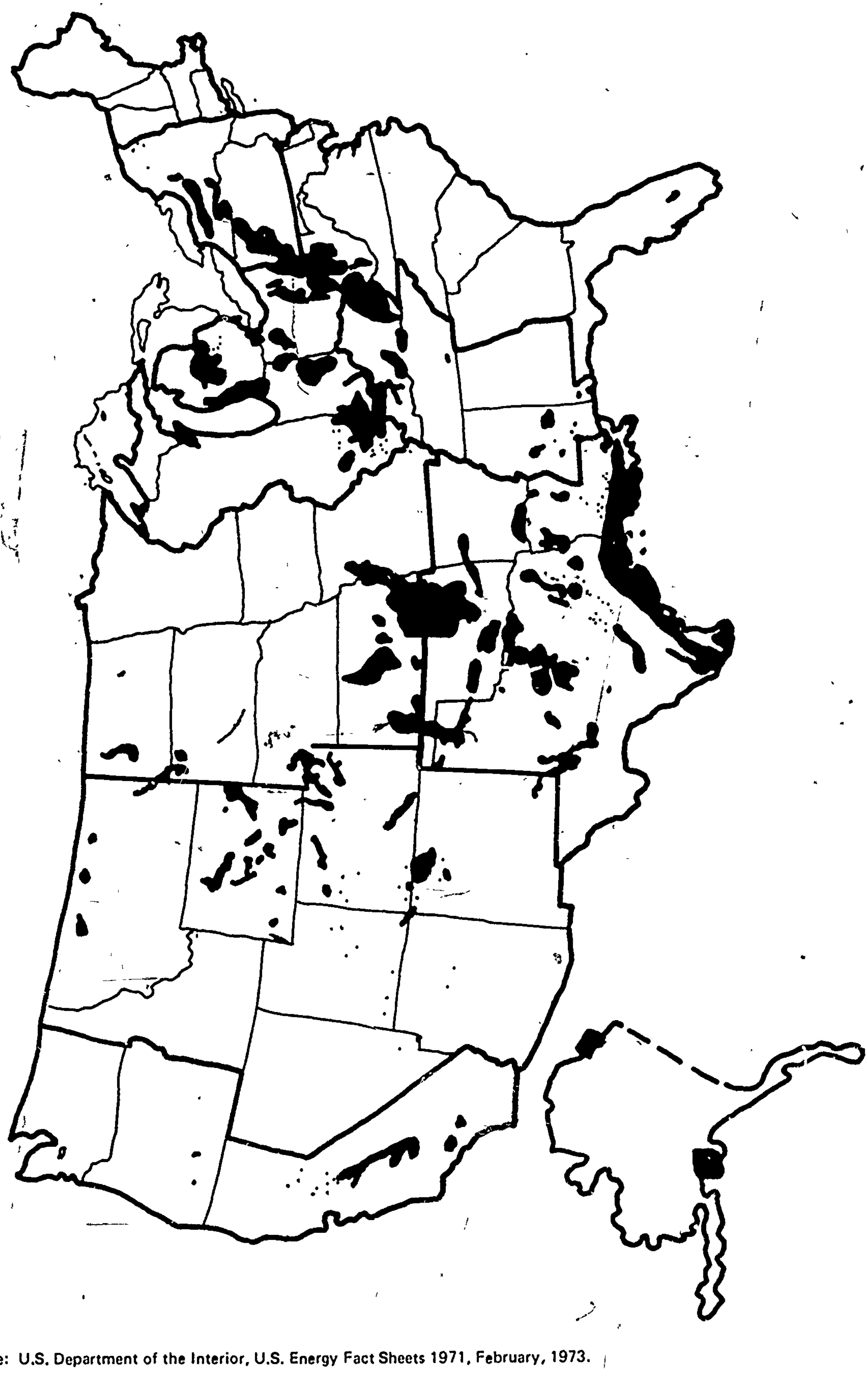
   Transportation? (0.54 × 6 = 3.2 bbl.)
   Residential-commercial? (0.19 × 6 = 1.2 bbl.)
   Industrial? (0.18 × 6 = 1.1 bbl.)
   Electricity? (0.8 × 6 = 0.5 bbl.)
6. Are there alternatives to oil for any of these users? (Yes. Heating could use other fuels; other fuels could be used to produce electricity which powers appliances, refrigeration, air-conditioning, etc.)
7. Which user probably has the greatest dependency on oil? (Transportation.) Can anything be done to reduce the amount of oil needed by transportation? (Use more public transportation, plan shopping areas close to residential areas, produce cars that get better gas mileage, use car pools whenever possible.

FIGURE 3
Domestic Oil Production, 1965-1975



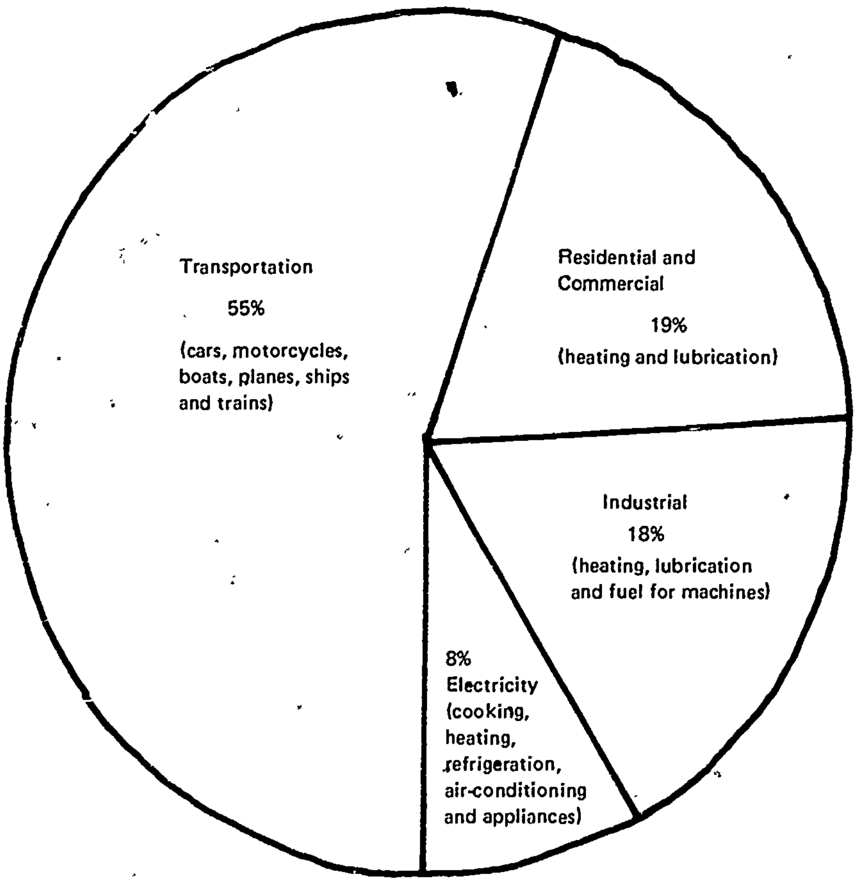
Source: Bureau of Mines, U.S. Department of the Interior

FIGURE 4
Oil and Gas Fields in the United States



Source: U.S. Department of the Interior, U.S. Energy Fact Sheets 1971, February, 1973.

FIGURE 5
Major Users of Oil Supplies, 1971
Total Supply = 5.5 Billion Barrels



Lesson 4 — Oil Imports

Students investigate the amount and general trend of United States imports 1965-1975 and determine our major sources of oil imports.

Advance preparation: Make copies or transparencies of Figures 6 and 7.

1. Have students summarize the information related to the domestic production and the uses of oil.

   Continue research of previous lesson until it is complete. This may require an additional class period. After research is complete, interpret and summarize the information related to the production and use of oil in the United States. Suggestions:

   Distribute desk-size United States maps and have students locate and label deposits. List amounts by states.

   Have students construct a table which begins to show the trends in United States oil supply and demand. Data on oil production are obtained from Figure 3.

U.S. Oil Supply and Demand
(in billions of barrels)

Year	Domestic Production	Consumption	Imports	Imports as Percentage of Consumption
1965	3.3 B bbls			
1967	3.7			
1969	4.0			
1971	4.1			
1973	4.0			
1975	3.7			

2. Have students investigate the need for oil imports.

   Begin discussion by comparing our domestic production with the amount actually consumed each year.

   "Our Major Users of Oil Supplies graph indicated that in 1971 we used 5.6 billion barrels of oil, but Figure 3, Domestic Oil and Oil Products Production, indicated that in 1971 we only produced 4.2 billion barrels. Where did we get the rest of our oil?" (Imported it. Discuss meaning of *import* and *export* if necessary.) "How much oil does the United States import each year?" (List ideas.) "Do you think that this amount is increasing or decreasing?" (List ideas.)

   - ☐ Distribute or display Figure 6, U.S. Oil Consumption, 1965-1975. Have students determine the amount imported each year.

     Looking at Figure 3, how much did the United States produce in 1965? (3.3 billion barrels.) How much was imported? (4.2 − 3.3 = 0.9 billion barrels.) Continue to determine the amount of oil imported in 1967 (4.6 − 3.7 = 0.9); 1969 (5.2 − 4.0 = 1.2); 1971 (5.5 − 4.1 = 1.4); 1973 (6.3 − 4.0 = 2.3); and 1975 (6.8 − 3.7 = 3.1 billion barrels.) Add this information to the table, *U.S.* Oil Supply and Demand; subheading may be entitled *Imports*. Is the amount of imported oil increasing or decreasing? (Increasing.)

     Ask students to calculate the percent of the total supply we were importing in each year and to add the results to the table.

U.S. Oil Supply and Demand
(in billions of barrels)

Year	Domestic Production	Consumption	Imports	Imports as Percentage of Consumption
1965	3.3	4.2	0.9	21%
1967	3.7	4.6	0.9	20
1969	4.0	5.2	1.2	23
1971	4.1	5.5	1.4	24
1973	4.0	6.3	2.3	36
1975 (projected)	3.7	6.8	3.1	46

"Where do we get the oil we are importing? (List ideas.) Where can we find out?" (List references including Figure 7, Sources of U.S. Oil Imports.)

3. Have students identify the countries exporting oil to the United States using Figure 7, Sources of U.S. Oil Imports. Interpret Figure 7 with students by asking:

   "Which country provides us with the greatest amount of oil?" (Canada.)

   "Do we have friendly international relations with Canada?" (As of this writing, yes.)

   "How much oil is imported from the Mideast? (19 percent.) Africa? (20 percent.) Locate the countries in these two groups on a world map. Where are they located? (Along the Suez Canal and Indian Ocean.) These nations are known as the Arab bloc. Does anyone know what kind of international relations our country has with this group?" (Group is part of oil cartel, Organization of Petroleum Exporting Countries, OPEC, which controls oil prices. Check magazines and newspapers for current status of United States - Arab relations.)

   Distribute desk maps of the world and have students trace the route of oil imports from points of origin to the United States.

4. Have students add information related to United States oil imports to their folders.

   Have students complete follow-up activities and add their summaries, charts, graphs, etc., to their folders.

   At this point in the mini-unit, several activities related to oil policy and current events might be appropriately inserted.

Related Activities

Have students research and discuss the current United States oil policy. Have them consider the possibilities of increasing domestic production and assess the international political implications and economic factors related to our importing policy.

1. Have students identify sub-topics that would provide a background for assessing United States oil policy and practices.

   Introduce the discussion of United States oil policy by asking:

   "What problems exist for the United States as the result of our need to import oil in large amounts? What are our alternatives?" Have students briefly discuss this topic and identify related sub-topics that would offer insight to United States practices and policies related to oil. Related topics include:

   OPEC
   Alaskan pipeline
   Domestic oil resources
   Offshore drilling
   Supertankers
   Deep-water ports
   Environmental effects of oil production and use
   Balance of payments, etc.

   Students may survey periodicals, newspapers, and other references to determine the current status of United States oil policy.

2. Allow students to form groups and develop questions to guide their investigations.

   Have students select a topic of interest and form small groups to investigate one aspect of the present United States oil policy. Allow groups to meet and have each group write a few questions to guide their research. Sample questions related to environment topic are:

   "How do the production and transportation of oil affect land, air, water, and people?"

   "How does the consumption of oil affect land, air, water, and people?"

   "What is being done to correct or prevent these problems?"

   "What kind of legislation exists to regulate the environmental consequences of oil use?"

   Have each group decide on a method of summarizing their findings. They may use reports, charts, graphs, pictures, tables, or any combination of these.

3. Allow sufficient time for research.

   Students may need one or two periods to complete their investigation. Teacher may circulate among the groups helping individuals, locating materials, and serving as a general resource.

4. Determine with the class how they could share their information on United States oil policy and practices.

   Students may decide to have a general discussion and have one representative from each group report on their findings. Then the general topic could be opened for discussion. Sample discussion topics could be:

   "What should the United States do: Increase domestic production? Decrease our demand for oil? Continue to import? From whom?"

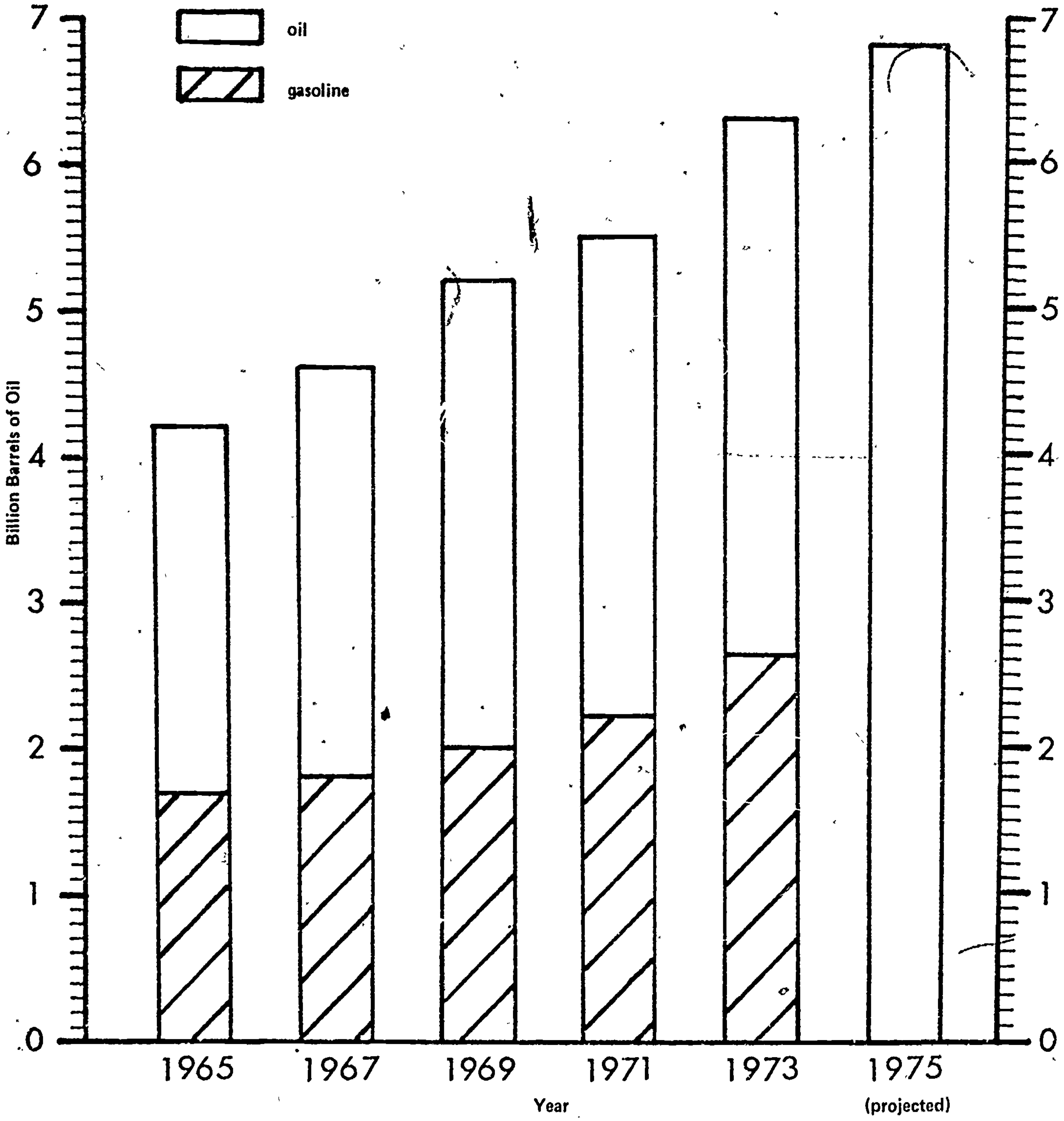
   or

   "What problems face the United States as the result of our need for oil?"

5. Have students formulate a sample oil policy for the United States.

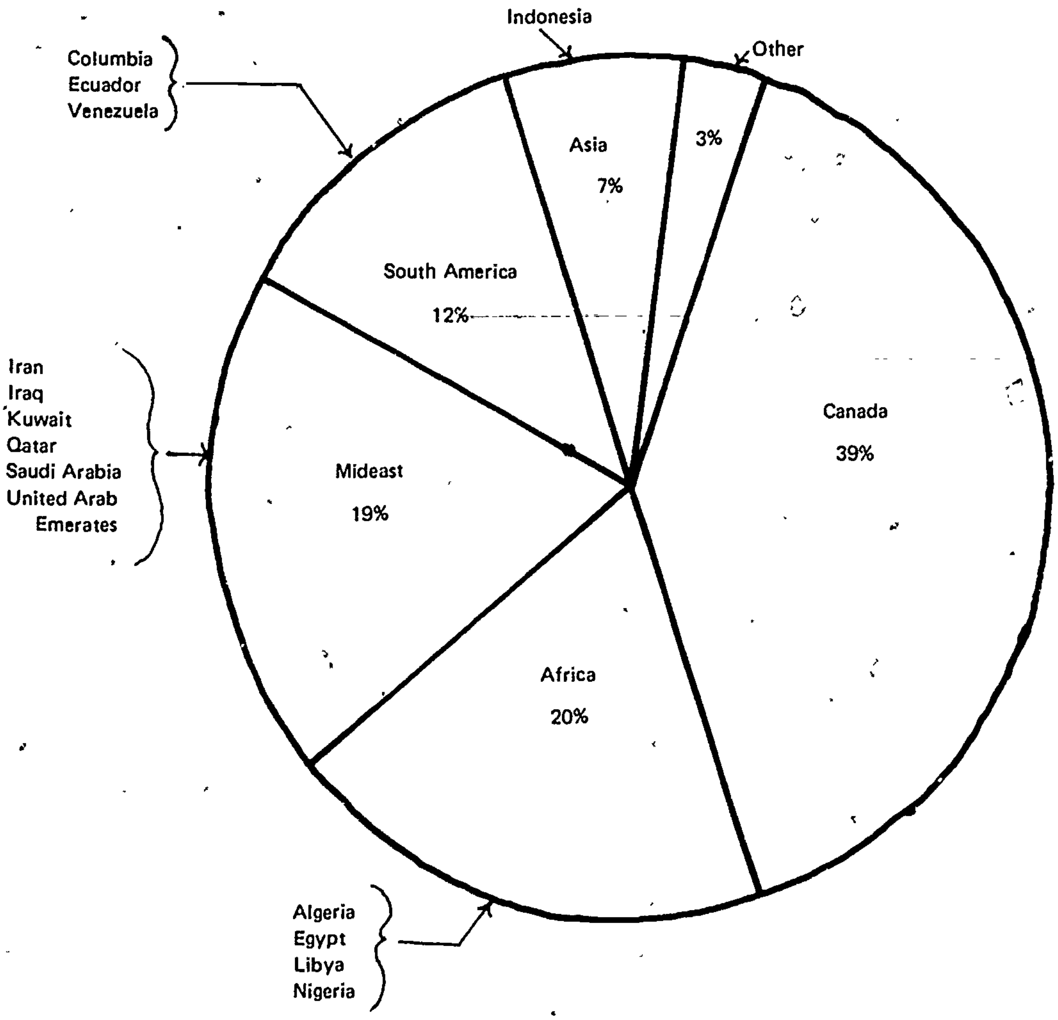
   End this research-discussion series of lessons by having students summarize what they think the United States oil policy should be. Have students add a written copy of this to their folder.

FIGURE 6
U.S. Consumption of Oil and Gasoline (domestic and imported)



Source: Bureau of Mines, U.S. Department of the Interior and American Petroleum Institute

FIGURE 7
Sources of U.S. Oil Imports



Lesson 5 — Reevaluating Initial Preferences for Personal Transportation

Have students relate their new learnings about the United States oil situation to their personal selection of a form of transportation.

1. Ask students to explore the potential savings of changing transportation habits.

   Begin discussion by having students identify how often in a given week or month they use various means of transportation — car, bus, subway, etc. Show Figure 8, Gasoline Consumption with Various Kinds of Transportation, and ask:

   "Which form of transportation uses the most gasoline?" (Car — luxury size.)

   "Which uses the least?" (Urban bus or monorail.)

   "How many gallons a year did the car of your choice use?" (Check figures in Lesson 2. Standard automobiles used 769 gallons per year.)

   "If a person changed from a standard size auto to a subcompact auto, how many gallons could be saved?" (Subcompact cars get 21 passenger miles per gallon, standard size cars get 13 miles per gallon, approximately one-third less the amount of gasoline. one-third of 769 = 256 gallons per year saved)

   "If half of the drivers in the United States used subcompact cars instead of standard size cars, how much could be saved in one year? (Use earlier figure of 96 million cars. Half of 96 million = 48 million. 48 million × 256 gallons = 11,776 million gallons of gasoline, or 11.8 billion gallons saved. For the number of barrels, divide by 42, i.e., 11,776 million ÷ 42 = 280 million barrels saved, or 0.28 billion.)

   "What percent of our total oil supply is this?" (Using 1973 figures of 6.3 billion barrels, 0.4 ÷ 6.3 = .04, or 4 percent savings per year.)

   "Is this amount significant?" Allow students to offer ideas.

   "What percent of our total imports in 1973 is 4 percent?" (Imports in 1973 were 34 percent. 41 percent is roughly 12 percent of 34 percent. So we could have reduced our imports by 12 percent.)

2. Ask students to review their original decisions and priorities related to a choice of personal transportation. Sample lead-in question would be.

   "When we started this unit each of you decided which form of transportation you would use. Check your folder and reexamine the choice you made. You also chose a particular type of car that you would buy — assuming that each of you wanted to buy a car. Would you make the same choices today? Why or why not?"

   Allow several students to respond. Note the amount of influence the new information on the problems related to our use of gasoline and oil has on their current decisions.

   Tally the forms of transportation chosen and their new car choices. Compare these to original class preferences made in Lesson 1. Discuss any reasons students suggest for keeping or changing their original choice.

3. Have students examine their transportation preferences and desires for private versus public means. End this unit by having students identify when they would use private and when public transportation.

   "Times when I would use my private car would be ____________________"

   (Emergencies, no other form available, etc.)

   "Times when I would use public transportation ____________________"

   (Shopping, commuting, general travel, etc.)

   "My suggestion for reducing the demand for oil in the area of transportation is ____________________"

   Have students share these ideas.

   Teacher may wish to collect and evaluate folders. Students may wish to share their findings with parents, P.T.A., or other adults in their community.

Evaluation Suggestions

1. Have student list at least three factors that contribute to the cost of operating a car.

   Acceptable response. three or more of the following — depreciation, repairs and maintenance, gasoline and oil, insurance, parking and tolls, and taxes.

2. Give student a list of cars similar to the following in which makes and models and sizes are given.

   For example:

   Chrysler Newport (standard)
   Oldsmobile Cutlass (compact)
   Chevrolet Impala (standard)
   Lincoln Continental (luxury)
   Chevrolet Vega (subcompact)
   Ford Mustang (compact)
   AMC Gremlin (subcompact)
   Cadillac (luxury)

   Ask student to list the cars in order of gasoline consumption per mile, lowest gasoline users first.

   Acceptable response. As a general rule, cars in subcompact class should be ranked first, followed by those in the compact class, those in the standard class, and finally, those in the luxury class. Cars within a class that have less accessories should be ranked higher than those with accessories, such as air-conditioning. If copies of the "1975 Gas Mileage Guide for New Car Buyers" (from the Environmental Protection Agency, Washington, D.C. 20460) are available, student should rank models in order of exact mileage.

3. Give the student the following information.

   a) An average standard size car achieves a gas mileage of 13 miles per gallon, a subcompact achieves 21 miles per gallon.

b) Copies of Figure 3, Domestic Oil Production, 1965-1975, and Figure 6, U.S. Consumption of Oil and Gasoline, 1965-1975.

Choose one of the years for which information is displayed in Figures 3 and 6 and ask the student to identify 1) the amount of oil consumed in that year, 2) the amount consumed as gasoline, and 3) the amount of oil imported.

Acceptable response. If 1973 were chosen, for example, Figure 6 indicates 6.3 billion barrels were consumed that year of which 2.6 billion barrels were used in the form of gasoline. From Figure 3, the domestic oil production was 4.0 billion barrels. Thus, the amount of oil imported was 6.3 − 4.0 = 2.3 billion barrels.

4. Give the student the following information:

☐ A table showing the difference between the oil produced in the United States and the oil consumed in the United States for all purposes *except* gasoline in the years 1965-1975.

Year	Oil Produced (in billion barrels)	Oil Consumed Except Gasoline (in billion barrels)	U.S. Oil Remaining for Use as Gasoline (in billion barrels)
1965	3.3 B bbls	2.5 B bbls	0.8 B bbls
1967	3.7	2.8	0.9
1969	4.0	3.2	0.8
1971	4.1	3.3	0.8
1973	4.0	3.7	0.3

The abbreviation for billion barrels is B bbls

☐ The gasoline mileage for several forms of personal transportation from Figure 8 is:

Standard Size Car — 13 passenger miles per gallon (mpg)

Subcompact Car — 21 passenger miles per gallon (mpg)

Urban Bus — 40 passenger miles per gallon (mpg)

☐ An estimate of the total number of miles traveled in one of the above years by all persons in the United States; for example, a number between 800 billion and 1 trillion miles. One trillion is 1,000,000,000,000.

a) Ask the student to calculate the number of gallons and then the number of barrels of gasoline that would have been consumed by each of the forms of personal transportation suggested for the total number of miles traveled. For example, How many gallons of gasoline would have been used to travel this number of miles if everyone used a standard size car?"

Acceptable response: Approximate values are:

Standard Size Car:

1,000,000,000,000 miles ÷ 13 miles per gallon
≃ 77,000,000,000 gallons = 77 billion gallons
= 1.8 billion barrels

Subcompact Car:

1,000 billion miles ÷ 21 miles per gallon
≃ 48 billion gallons
= 1.1 billion barrels

Urban Bus

1,000 billion miles ÷ 40 miles per gallon
≃ 25 billion gallons
= 0.6 billion barrels

b) Ask the student to determine whether United States oil remaining for use as gasoline is sufficient to meet the needs for the different personal forms of transportation suggested in the indicated year. For example, "In 1973 the amount of United States oil remaining for use as gasoline was 0.3 billion barrels. Is this amount less than, equal to, or greater than the amount that would be necessary if everyone used a standard size car?"

Acceptable response: 0.3 billion barrels is less than the amount (1.8 billion barrels) needed for standard size cars. It is also less than the amount available for subcompacts and buses.

c) Ask the student to determine and compare, from the data in the table and their results from a, the amount of oil that would have to be imported by the suggested personal transportation modes.

Acceptable response:

For standard size cars:
1.8 − 0.3 = 1.5 billion barrels of oil would need to be imported

For subcompact cars:
1.1 − 0.3 = 0.8 billion barrels of oil would need to be imported

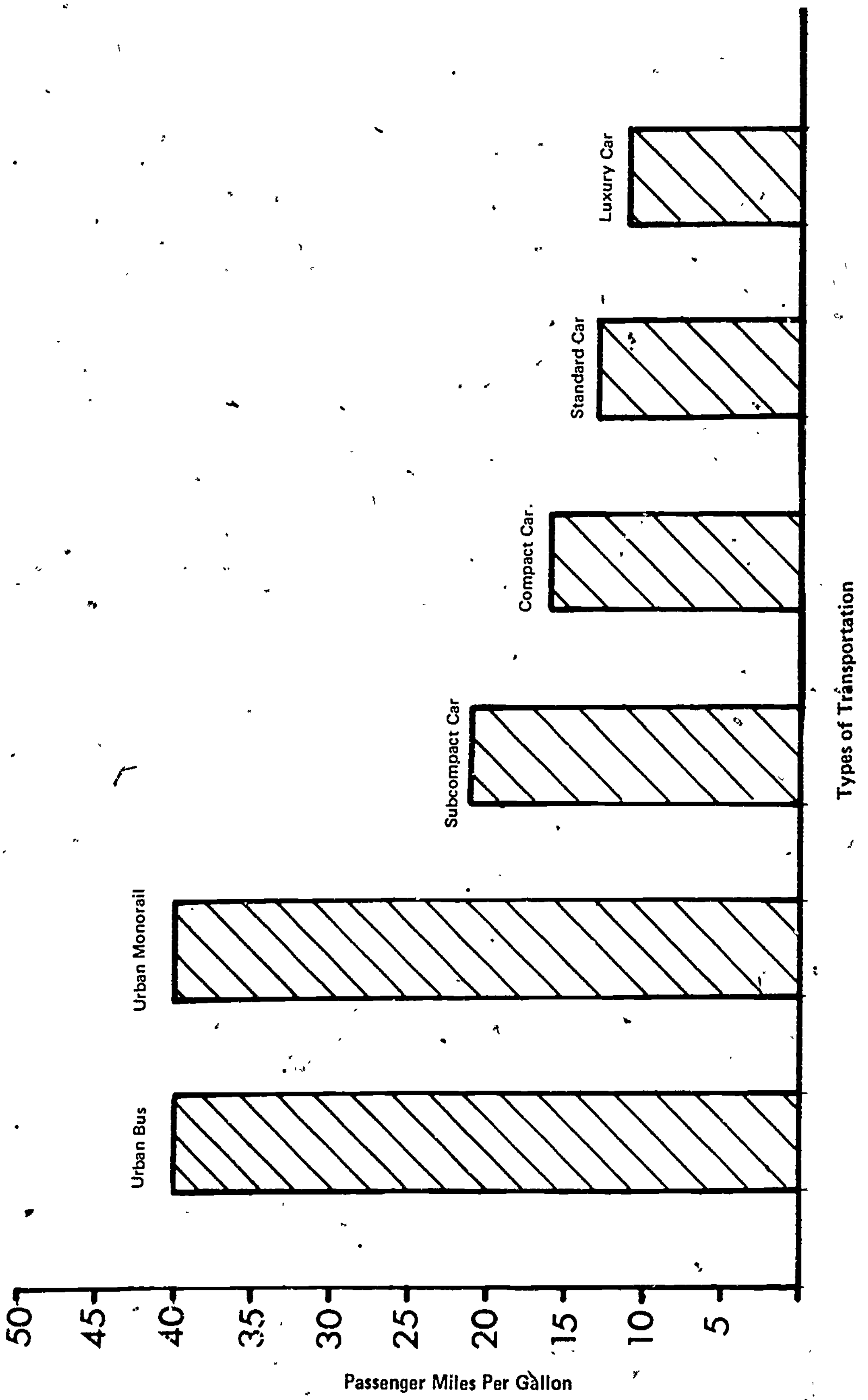
For urban buses:
0.6 − 0.3 = 0.3 billion barrels of oil would need to be imported

Thus, if all persons used subcompact cars as personal forms of transportation, we would need to import one-half the amount that would be needed if everyone used a standard size car. If everyone used buses, this need would drop by an additional factor of three.

5. Ask the student to write an essay entitled "My Preferred Forms of Personal Transportation and My Reasons for Choosing Them."

The student shall be judged as having successfully achieved objective 5 if in the essay. 1) at least three factors are identified by the student as important to him/her in choosing a form of personal transportation, 2) at least one preferred form of transportation is identified, and 3) the preferred form ranks high on the factors identified as important to the student.

FIGURE 8
Gasoline Consumption of Various Kinds of Transportation (local)



Source: "Energy Efficiencies of the Transport Systems," Richard A. Rice, a paper presented before the Society of Automotive Engineers at the International Automotive Engineering Congress, Detroit, January 1973.

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The New World of Petroleum, Alfred Lewis. (New York: Dodd-Mead) 1966.

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Rock Oil to Rockets: The Story of Petroleum in America, Dirk Ginghuis. (New York: Macmillan) 1960.

Sixteen Easy Ways to Cut Your Transportation Costs, free. Environment Center Institute for Public Service, University of Tennessee, Knoxville, Tennessee 37916.

Articles:

"Man on the Move" and "Keeping a Transportation Energy Journal," in **Curious Naturalist,** October 1974. Massachusetts Audubon Society, Lincoln, Massachusetts.

"The Search for Tomorrow's Power," Kenneth Weaver. **National Geographic 142 (5),** November 1972.

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

Materials List

- ☐ Make transparencies, or copies for each student, of the following Tables and Figures:
  1. What an Automobile Really Costs.
  2. Costs of Purchasing and Operating Different Types of Automobiles.
  3. U.S. Domestic Oil Production, 1965-1975.
  4. Oil Deposits in the United States.
  5. Major Users of Oil Supplies.
  6. U.S. Oil and Gasoline Consumption, 1965-1975.
  7. Sources of U.S. Oil Imports.
  8. Gasoline Consumption of Various Kinds of Transportation.
- ☐ Acquire from magazines, newspapers, or auto dealers pictures of a variety of cars.
- ☐ Select construction paper or any suitable material for student folders. Have one folder for each student.
- ☐ Assemble resource materials textbooks, reference books, and periodicals related to oil-automobile topic.
- ☐ Optional:

  Write for free copies of "Gas Mileage Guide for New Car Buyers," Federal Energy Administration, Washington, D.C. 20461, and "Cost of Operating an Automobile," U.S. Department of Transportation, Federal Highway Administration, Office of Highway Planning, Washington, D.C. 20590.

  Desk copies of United States map and world map for each student.

MINI-UNIT 7
Calories for Heating Our Homes

Calories for Heating Our Homes

ABSTRACT

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 mini-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. This mini-unit can best be employed in the context of other studies of heat and energy.

Recommended level: General science, chemistry, and physics classes, grades 9-12.

Time required: Five 45-minute periods.

Teaching strategies: Classroom discussion, demonstrations and student experiments (if equipment supply permits).

Advance preparation: Assemble materials on materials list.

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).

Objectives

At the completion of this mini-unit the student should be able to:

1. *Define* the common units for measuring heat energy (Calorie, BTU) and *convert* measurements from one set of units to another, given the conversion formulas.
2. *Calculate* the heat transferred to water by different heat sources, given its mass and change in temperature.
3. *Calculate* the cost per unit of heat energy that could be produced by an energy source, given appropriate data (such as price per unit of measure and BTU per unit of measure).
4. *Compare* the relative cost of different energy sources using their costs per unit of heat energy and *identify* the most economical one.

Teaching Suggestions

Pre-unit Preparation

This mini-unit can best be employed in the context of other studies of heat and energy. In particular, students should have acquired 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.

Lesson 1 — The Cost of Heating

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 had caught was larger. Each friend, however, was interested in the heat source 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. Brainstorm with students to obtain a list of current and past 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 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.

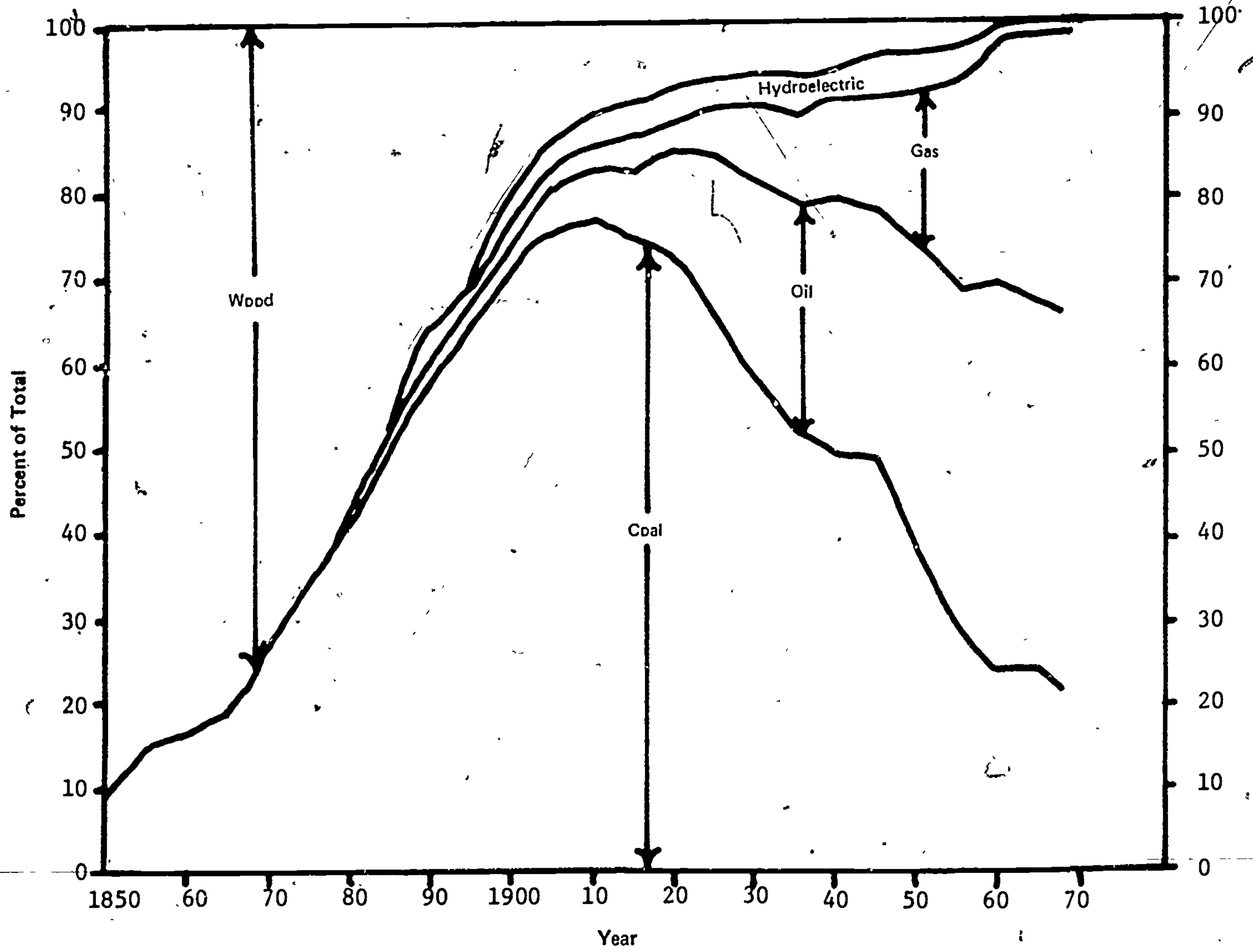
5. End lesson by assigning students the task of determining "price per unit of measure" for all heat sources in table.

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.

(1) Heat Source	(2)	(3)	(4)	(5)	(6)	(7)
Heating Oil #2 Natural Gas Electricity Coal Hardwood Gasoline Other						

(1) Heat Source	(2) Unit of Measure	(3) Price Per Unit	(4)	(5)	(6)	(7)
Heating Oil Natural Gas Electricity Coal Hardwood Gasoline Other						

FIGURE 1
The Changing Fuel Mix



Lesson 2 — Do We Know the Heat Produced Per Unit of Measure?

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.

Advanced preparation: 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, and a pile of wood splints on an asbestos pad for another. (At minimum, set up two tripods with the first two heat sources.)

1. Review results of student assignment, and complete the table of heat sources and their price per unit of measure.

   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 money? For example, can you tell me which gives you more nutrition: a gallon of milk or a pound of cheese? Why not? Are the units the same? (No.) Can we compare the cost per gallon and the cost per pound? (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.)

(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.

"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.)

(The above discussion would not be needed if in the previous discussion some students already indicated that it would be inappropriate to compare the costs of the various energy sources as they are given in the table. What you want to buy is not coal, wood, or oil for itself but for 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:

$$\text{price per gallon divided by ?} = \text{price of heat produced}$$

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

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

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

☐ 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), or point out that in all cases demonstrated the temperature of the water increases 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 the 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 3 — Measuring Heat Transfer: the Calorie

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) 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 describe 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. Explain that since it is difficult to measure the 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 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 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.)
   - ☐ 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:

     "Was the measured temperature change the same or different for each trial? (Different.) Was the volume of gas burned the same or different? (Same, since the time of heating was the same.) If the same amount of gas was burned, was the same amount of heat transferred? (Yes.) 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 of heated water 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.

3. Introduce the MKS 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

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

— kilocalorie — equals 1,000 calories. The Calorie is the unit most commonly applied to food.)

4. 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 transferred 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 1°C 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) × mass (kg) × change in temperature (°C)

   Heat transferred = 1 (Calorie/kg/°C) × 0.398 kg × 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.)

5. 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.

Lesson 4 — Kilowatt-hours, Calories, and BTUs

By performing a simple experiment, students determine the number of Calories that are equivalent to one kilowatt-hour. The BTU is introduced and compared to the Calorie and kilowatt-hour.

Advance preparation: Set up apparatus as in Lesson 3, 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 headings 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. The water was stirred continually with the thermometer during the time the immersion heater was on.

3. 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)

4. 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°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 °C to °F with the conversion equation °F = 9/5 (°C + 32).

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

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

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 3,412 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 ≃ 4 BTU

(Literature value for 1 BTU is 0.25 Calories.)

5. 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 should be suggested. Also, some students should make calls to local energy suppliers for information regarding their particular product.

Lesson 5 — The Most Economical Home Heat Source

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

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

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 their notebooks 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 mini-unit 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.

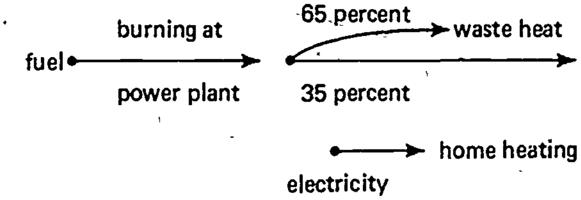
Ask:

"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?"

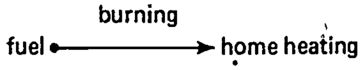
Take a survey in the class of the number of families who use each of the energy sources (excluding gasoline) to heat their homes.

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 35 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:



as compared to direct heating of fuel in home furnaces:



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 are to replace these.

Evaluation Suggestions

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°C.

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

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 = 3,412 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 100ft^3)	= $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 data for the Washington area given in this mini-unit as problem data. If the Washington, D.C. data were employed in the lessons, use the local price data for problem data.

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Books:

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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

Lesson 1:

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

Lesson 2:

- ☐ 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 3:

From the materials in Lesson 2, 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 4:

Same materials as in Lesson 3 except substitute the electric immersion heater(s) for the Bunsen burner(s) and three 250 milliliter beakers instead of the 500 milliliter beakers.

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