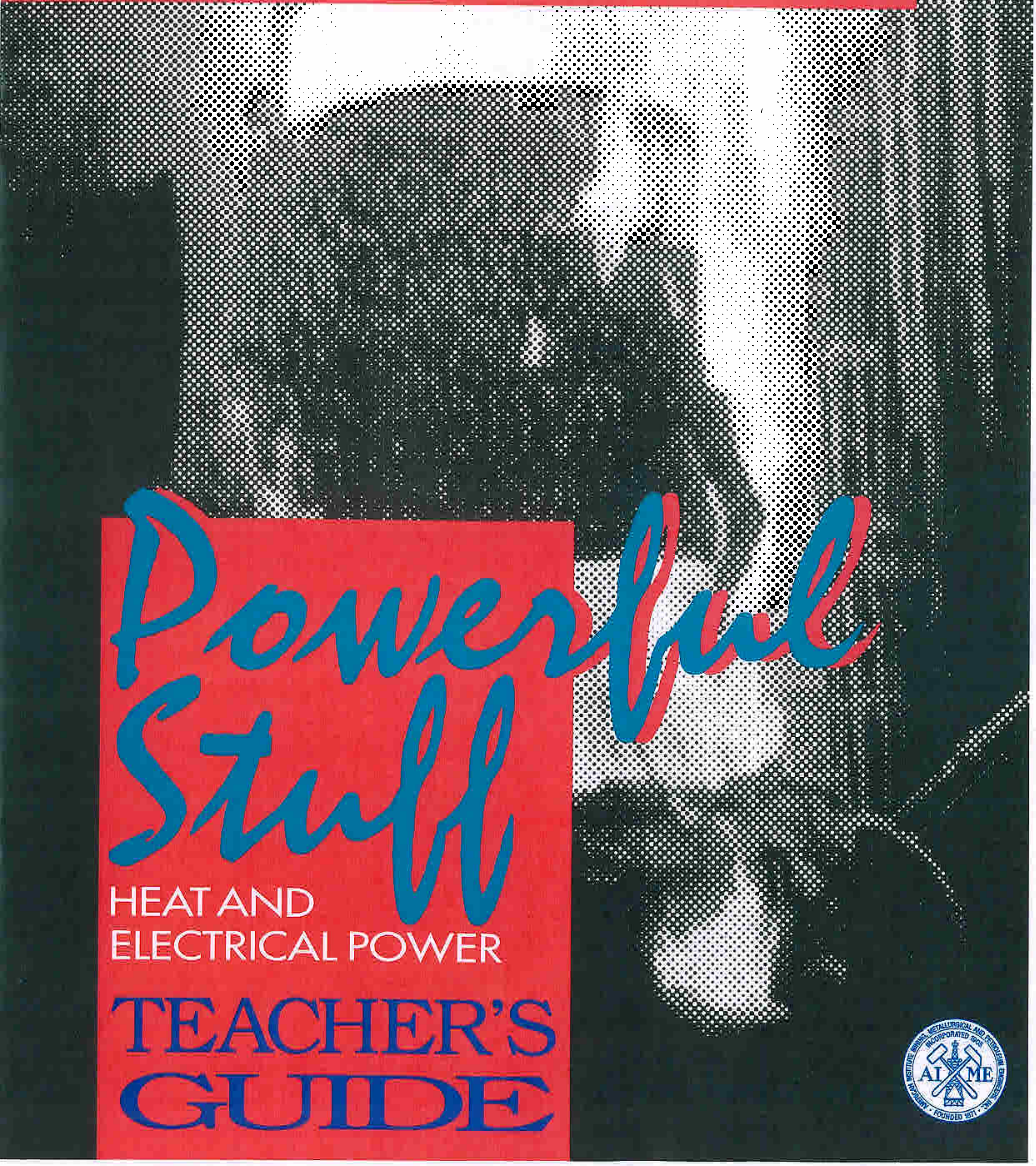
E

TRANSFORMATIONS
SCIENCE, TECHNOLOGY & SOCIETY



Powerful Stuff

HEAT AND ELECTRICAL POWER

TEACHER'S GUIDE

TRANSFORMATIONS: Science, Technology & Society

Program Goals

- ▲ to enhance and enrich science instruction in Middle School classrooms
- ▲ to explore ways that technology takes scientific knowledge and applies it to meeting society's needs and solving society's problems
- ▲ to foster among students a spirit of inquiry, encouraging and developing their problem-solving skills
- ▲ to help create citizens who are cricital thinkers, prepared to make informed decisions about complex social/technological issues that will confront them in decades to come

POWERFUL STUFF

Heat and Electrical Power

The centerpiece of this unit is a video visit to a steel mill in Texas, Chaparral Steel Company, which recycles this popular alloy from junkyard cars. In order to produce steel to certain specifications, intensely high levels of heat must be generated by massive amounts of electricity. The topics treated in this Guide are listed below.

- ▲ Heat
- ▲ Electrical Power
- ▲ Metals

Curriculum Connections: General Science, Physical Science; a social-studies unit on the Bronze or Iron Age, the Industrial Revolution, or the discovery of electricity

Summary of the Video

While Billy is working on his car, a "mystery" part falls out of the engine. Billy's muttering of "you're headed for the car crusher" leads to his visiting a steel mill that recycles steel from old cars and to Richard Williams, the steelworker who is his guide.

Back in the studio, Laurie, using the toaster, and Billy, turning on his amplifier, overload the circuit. As they deal with the resulting blackout, they realize that they are "electricity hogs."

The scene shifts to the melt room, where huge amounts of electricity are used to generate enough heat to melt the steel. Billy finds out about the various stages of "cooking the steel to order" and sees how the mill uses "continuous casting" to conserve energy.

Just after the band finishes their song "Powerful Stuff," Billy learns that, for better or worse, his car has been saved from the crusher: he has found a replacement part.

Below are the lyrics to "Powerful Stuff."

A hundred kilowatts of electric
soul
I'm talking 'bout the power of
rock 'n'roll
So if your heart is heavy and
your mind is sour
Come get a heavy hit of that
rock 'n' roll power
Powerful stuff,
Powerful, powerful, powerful,
powerful stuff!

This rockin' power gonna make
things hot
Gonna show you every single
thing that you got
So kick off your shoes, open up
like a flower
And dance to the music with
that rock 'n' roll power.
Powerful stuff,
Powerful, powerful, powerful,
powerful stuff!

Suggestion for Using Unit E: "Powerful Stuff"

Page 3
Introduction to the Teacher

Here you will find additional background information on the science and technology presented in "Powerful Stuff"

Page 4
Introduction to the Students

This section gives you material for introducing "Powerful Stuff" to your students, including a statement of the purpose of the unit; suggestions for connecting the unit to students' experience; definitions of key concepts and terms; and directions for the Video Study Guide (see below).

Page 5 — **Topic 1**
Page 6 — **Topic 2**
Page 7 — **Topic 3**

These pages focus on the three topics in "Powerful Stuff": Heat, Electrical Power, and Metals. Each page furnishes options for introducing the topic to students and a wide array of ways for students to respond to the topic, including labs that are carried out through the Activity Masters.

Choose any of the topics as your focus, depending on where you are in the curriculum.

Video Study Guide

You can use the video guide (Activity Master 1) to focus students' attention on and check their comprehension of the video.

Video

Running time for the video is 13 ½ minutes. You may want to preview the video and choose a Stop Point for conducting a discussion, carrying out an activity, or making a comprehension check. The video may also be show straight through.

Pages 8-13
Activity Masters

The first blackline master is the Video Study Guide for "Powerful Stuff". The other masters give students hands-on opportunities in the form or activities and labs.

Page 14
Extension

This final section includes suggestions for science fair projects and research topics, ones that build on concepts explored in "Powerful Stuff". Also listed are related resources for interested students to pursue, including book titles and organizations to contact.

POWERFUL STUFF: An Introduction for the Teacher

In "Powerful Stuff," students explore the industrial and everyday uses of electricity, the relationship between electrical and thermal energy, and the properties and uses of metals and alloys, especially steel.

Below is a fuller explanation of concepts presented in the video and developed in this Guide.

How is thermal energy measured?

The conversion of mechanical to thermal energy is measured in **joules**, named for English scientist James Prescott Joule, who concluded that 4190 joules of energy are needed to raise the temperature of 1 kilogram of water one Celsius degree. This amount of energy is the **specific heat** of a material; so the specific heat of water is 4190 J/kg • C° (joules per kilogram per Celsius degree). It takes an enormous amount of energy to raise the temperature of water compared with other common substances, such as clay (130 J/kg • C°), iron (450 J/kg • C°), sand (664 J/kg • C°), and carbon (710 J/kg • C°).

Changes in thermal energy can be measured. If a 0.10kg block of metal, heated to 100°C, is placed into 0.20kg of water (temperature 20°), the water will warm and the block cool until both are the same temperature. The amount of heat lost from the metal can be calculated from the change in water temperature, its mass, and specific heat. In the example given, the change is 3400J.

Though not accepted by the International System of Units, the **calorie** is widely used in discussing food (1calorie = 4.18J). Food packages use the kilocalorie (Kcal) when listing foods (1 Kcal=4180J). The **BTU**, British thermal unit, is used to measure the amount of thermal energy in fuel. A BTU is the amount of energy needed to raise the temperature of one pound of water one degree Fahrenheit. One BTU=252 calories=1053.36J.

How is thermal energy transferred?

Conduction: The energy is transferred through matter from particle to particle. Conduction happens when two objects at different temperatures are in direct contact. The higher the temperature, the more kinetic energy is present in the particles, causing them to vibrate and collide with cooler, slower moving particles. Thus the energy moves through the material. Metals such as iron, copper, and silver are good conductors; plastic, wood, and glass are poor conductors.

Convection: The energy is transferred by the movement of matter. This is the main method of transfer in a fluid. When fluids are heated, convection currents are set up, circulating heat through the fluid. Winds and ocean currents are convection currents that transfer heat on the earth.

Radiation: The energy is transferred without the need for matter, via electromagnetic waves, as with sunlight. Dark-colored objects absorb radiant energy while light-colored or shiny objects reflect it.

What is the relation between electricity and heat?

The electric field in a circuit imparts kinetic energy to electrons, which pass most of this energy on to the atoms they strike, causing them to vibrate faster. This means more heat, since heat is energy of motion. However, heat in metals slightly reduces conductivity (increases resistance), thus cutting down the current slightly. Heat can also generate electricity by acting upon the joined ends of two different kinds of metals (whose unheated ends are also joined—to complete the circuit).

What is the composition of steel and how does its composition affect its performance?

Steel, produced in greater amounts than other metals, is made from iron and carbon. The percentage of carbon—from 0.1% to 1.7%—affects steel's strength and ductility. Low-carbon steels (<0.2%) are soft; medium steels contain 0.2%-0.6%C; and high-carbon steels (0.75%-1.7%C) are hardest.

High-carbon steels are used in products such as car axles, engine parts, and the landing gear for the space shuttle. Low-carbon steel is used in car bodies. Steel may contain other elements—such as sulfur, phorphorus, manganese, and silicon. Popular steel alloys include manganese (very strong), nickel (tough and corrosion resistant), "permalloy" (magnetic), "invar" (does not contract or expand when heated), stainless (strong and corrosion resistant), and high speed (stays hard at high temperatures).

POWERFUL STUFF: An Introduction for Students

Introducing the Unit

Present students with the goals for "Powerful Stuff":

- ▲ to see that there is a relationship between electricity and heat;
- ▲ to explore some industrial and everyday uses of electricity and metals;
- ▲ to find out the effects of heat and electricity on various metals and alloys;
- ▲ to realize how reliant we are on electricity and to consider ways to conserve.

They should **not** feel that they must fully learn the process discussed in the video.

Connecting the Unit to Students' Experiences

Ask students if they were ever in a situation where the electricity went out. What daily activities were affected? Do any of their homes have electric heat and/or ranges? How would a winter blackout affect "all-electric" homes? Stress that while homes may have diferent kinds of heating and appliances, **everyone** has electricity.

Key Concepts and Terms

Students will be exploring and extending their understanding of the words listed below (in bold face) by topic area. You might write these words on the board and briefly discuss them to determine which are familiar to your students.

Topic: Heat

- ▲ A force that imparts kinetic energy to the atoms in matter, causing them to vibrate, generates **thermal energy—heat**.
- ▲ The change from mechanical to thermal energy is measured in **joules** (J). The **calorie** is used to discuss thermal energy in food (1 calorie=4.18J). The **kilocalorie** ((kcal) is often used on food packages (1 kcal=4180J). The **BTU**, British thermal unit, is used to measure the thermal energy in fuel (1 BTU=252 calories=1053.36J).
- ▲ **Specific heat** is the amount of energy needed to raise the temperature of 1 kilogram of a particular substance one Celsius degree. It takes an enormous amount of energy to raise the temperature of water compared with other substances.
- ▲ Heat **transfer** occurs in three ways:

  Conduction happens when two objects at different temperatures are in direct contact; the energy is transferred from particle to particle.

  Convection is the main method of transfer in a fluid; heating the matter creates convection currents that circulate heat, as in boiling water.

  Radiation transfers heat without matter; the sun is 150 million kilometers away with mostly empty space between it and Earth, yet it continuously heats our planet.

Topic: Electrical Power

- ▲ **Electrical power** is the rate at which electrical energy is changed into another form of energy, such as thermal energy.
- ▲ The power is measured in **watts**. Light bulbs in lamps are usually between 40 and 150 watts, while a toaster may use energy at a rate of 1000 watts.
- ▲ The amount of energy an electrical device uses depends on the level of power it delivers and the length of time it is used. Electrical energy use is measured in **kilowatt hours** (kWh). One kilowatt hour equals 1000 watts of power used for one hour. The average house uses 500 kWh of electrical energy each month.
- ▲ An electric **current** is the flow of electrons through a **conductor**. Good conductors have low **resistance** (electrons flow easily). Conductors with high resistance can be used to control current flow.
- ▲ An electric **arc** is formed as a strong current jumps across space from one conductor to another; it produces a lot of heat.

Topic: Metals

- ▲ Most chemical elements are **metals,** which are usually hard and shiny, **conduct** heat and electric current, are **malleable** (can be rolled or beaten into sheets), are **ductile** (can be pulled into wires).
- ▲ An **alloy** contains more than one element and has metallic properties.
- ▲ **Steel** is an alloy made of iron and carbon (1.7% or less) that may contain other elements, such as silicon or nickel. The greater the **percentage of carbon**, the harder and less flexible the steel.
- ▲ In steelmaking, impurities called **slag** float to the top of the molten steel.

VIDEO STUDY GUIDE

To focus or direct students' viewing of the video, distribute Activity Master 1, the Video Study Guide. You might have your students work individually, or small groups could each be responsible for a particular section of the Study Guide. Allow time—stopping the video at various points or after the video is over—for students to discuss their responses.

POWERFUL STUFF: Heat

Introducing the Topic: Options

▲ Write this statement on the board: **Heat is energy of motion**. Have students rub their hands back and forth on the side of their desks to produce friction and generate heat. Help them see the connection between the mechanical energy of rubbing; the fact that this energy causes the molecules in the surface of the desk and their hands to vibrate and move apart; and that this creates heat, converting mechanical energy into thermal energy.

▲ Have students brainstorm in groups to come up with 3 lists: 1) how we use heat; 2) what heats up quickly/burns well; and 3) what heats up slowly/does not burn. Bring groups together to create a master list.

Sample answers: 1) for comfort or survival in the cold, for cleaning, for drying and ironing, for cooking, for sterilizing; in industry—to make power and process metal; 2) wood, coal, paper, oil, gas (*i.e.*, fuel substances made from living matter); 3) water, sand (*i.e.*, substances that can control heat).

▲ Materials needed: **ball and ring device (available from hardware stores), heating source, water.** Demonstrate how heat affects volume. Pass the ball through the ring, so students can see the movement. Ask them what will happen when you heat the ball. Do so, and show that the ball no longer fits through the ring. Ask students what will happen when the ball is cooled with water. Demonstrate the results (it fits again). If time permits, heat the ball **and** ring, having students predict the results

Both expand.

STUDENT INVOLVEMENT: OPTIONS
▲ Indicates an activity that would take less than a class period.
▲ Indicates an activity that could take most of a class period.
⧗ Indicates an activity that would go beyond the class period.

Discuss the Video.

Video Guide notes can be used to help students answer these and other straightforward questions:

▲ Why does the steel mill use a lot of electricity?

To create heat to melt the steel.

▲ What has the mill done to be more efficient and to conserve heat and electricity?

Made electric arc longer; used slag to insulate furnace; continuously cast, so steel doesn't lose as much heat as it is processed—saves time.

▲ How hot does the steel get? When is it allowed to cool down?

3000°F or 1650°C; not until the process is over.

Group Discussion: Comparing Heating Systems– Machine and Human.

Point out that in the video, the steelworker tells how the mill must deal with heating and cooling the electric arc furnace to maintain heat at the proper level to melt steel and not the furnace. Have students compare/contrast this with our bodies: How do we maintain our 98.6°F internal temperature to keep things running efficiently?

Possible answers: external heat and clothing (insulation), our fuel intake (oxygen, food, fluid), and various built-in controls, such as skin pigment, sweat.

Lab: Specific Heat.

Materials per lab group: **quarter, aluminum foil, scales, hammer, wood block, pot filled with water, heat source, tongs, paper towels, parafin wax.** Review the concept of specific heat, using Guide page 2 (first question) as needed. Have students use scales to get an amount of foil equal to the weight of the quarter. They then compress the foil and hammer it into a cylinder with a base similar to the size of the quarter. They place both in boiling water for five minutes; meanwhile, they set two cakes of parafin on the wood block. Using tongs, they remove the quarter, dry it, and lay it on the parafin; they do the same with the foil. Observation: Which melted more parafin? Which parafin cavity is deeper? Conclusion: Which, aluminum or silver/copper, has a greater heat capacity (higher specific heat)?

Activity: Heat Transfer (Activity Master 2-2 pages).

NOTE: Supervise students conducting Part 2. Materials needed: See Master. Use the information on master and on Guide page 2 to review methods of heat transfer with students. Depending on available time and materials, students could work in lab groups that conduct all three parts or only on one part, coming together to pool results.

Answers: Part 1—temperature goes up 1-2°; heat transferred by radiation. Part 2—spoon heats up; heat transferred by conduction. Part 3—temperature gets progressively higher; heat distributed by convection, or hot air rises. Discuss students' examples.

POWERFUL STUFF: Electrical Power

Introducing the Topic: Options

▲ Have a student investigative team provide historical background on the discovery of electricity. Ask the team to find out the pioneering work done by Luigi Galvani, Alessandro Volta, Hans Christian Oersted, and Michael Faraday. Students could use classroom or school encyclopedias or visit the library. Give them time to prepare before having them present to the class.

▲ Materials needed: **one small electrical appliance per student group. Create a wallchart: appliance name, number of watts, required voltage, number of amperes. Nearby, write the equation power (watts) = voltage (volts) x current (amperes).** Review the equation, and point out that students may have to calculate amperes (a=w/v). Student groups should find and interpret the electrical information printed on their appliance. Have them fill in and discuss the chart: Which appliance uses the most electrical power? the least? How much would you predict it costs per year to use each appliance?

▲ Materials needed: **1.5-volt dry cell; length of bell wire; 1.5 volt, #222 flashlight bulb with matching socket.** Demonstrate a simple electrical circuit. Use two 12-inch lengths of wire to hook up the circuit. Connect only **one** wire to the cell, leaving the other wire with an unconnected end. Tell why the bulb is not lit, and then connect the wire to complete the circuit. To demonstrate conductivity and insulation, cut apart a length of wire, and place different materials—glass, plastic, wood, rubber, various metals—between the two wires. Ask students to make predictions before and conclusions after each material is tried.

STUDENT INVOLVEMENT: OPTIONS

- Indicates an activity that would take less than a class period.
- Indicates an activity that could take most of a class period.
- Indicates an activity that would go beyond the class period.

Discuss the Video.

Video Guide notes can be used to help students answer these and other straightforward questions:

▲ What causes the blackout? Why does AJ say they are "electricity hogs"?

Using Billy's amp at the same time as toaster overloads the circuit; they use a lot of electrical appliances.

▲ Why does the mill use a lot of electricity? How much does Richard say they need?

To create enough heat to melt the steel; 60,000 kWh to melt "all that steel".

▲ What has the mill done to be more efficient and conserve heat and electricity?

Used longer arc; used slag to insulate furnace; continuously cast, so steel doesn't lose as much heat as it's processed—saves time.

Group Discussion: Electricity Hogs.

In the video, AJ decides the band members are electricity hogs. Have students consider what this means and decide if they, too, are hogs. Have them break into small groups to come up with recommendations for conserving electricity: Healthy Diets for Electricity Hogs.

Home Electrical Survey (Activity Master 3).

Review with students how to figure out kilowatt hours (explained on sheet). Make sure they understand how to do the calculation and how to figure out yearly costs. Have them fill in their charts at home and discuss them in class. Ask students to volunteer their suggestions for reducing family electric bills. Can any suggestions be applied to reducing the school's electric consumption?

Lab: Circuits and Resistance.

Materials needed for each lab group: **copper and nichrome wire of equal length and diameter; 1.5-volt dry cell; 1.5 volt, #222 flashlight bulb with socket.** Review **resistance** with students (see Guide page 3). Have each group compare the two wires by creating a circuit with the dry cell and bulb. Students' observations should be based on the amount of light generated. Use these questions to draw out conclusions: Which wire has the most resistance? (nichrome) Which would you use for a coil in a toaster or heater? Why? (nichrome—more heat) Students could conduct additional experiments to see how wire length, diameter, and temperature affect resistance.

Resistance decreases with increased thickness; resistance increases with temperature.

This could lead to a discussion of superconductors, which have little or no resistance and produce no heat.

POWERFUL STUFF: Metals

Introducing the Topic: Options

- ▲ Ask students if they are familiar with these historical designations: Stone Age, Bronze Age, Iron Age. Tell them that metals are so important to humans that we have used them as a way of tracing our development—by referring to the type of metal (iron) or alloy (bronze) that was the major material human cultures used for tools and weapons, among other things.

  You might display objects of copper (*e.g.*, wire) and aluminum (*e.g.*, can) alongside a bronze object. Ask students to compare the properties of the two metals contained in bronze with the properties of the alloy. Why would a society with bronze tools and weapons have an advantage over other societies? (Focus should be on bronze's strength.)

- ▲ Divide students into brainstorming groups, and direct them to come up with lists of earth materials found in the home or classroom. They should categorize each material as metal or nonmetal. While still in groups or as a whole class, students can use the lists to generate some properties of metals vs. nonmetals.

  Sample list items: graphite, steel, iron, aluminum, copper, gold, silver; glass concrete brick, clay, plaster, tile, plastic, synthetics. Metals vs. nonmetals could be compared by color, shininess, ability to conduct heat/electricity, malleability, ductility.

- ▲ Materials needed: **items that display steel's strength and flexibility, e.g., a wrench, screwdriver, coffee can, and safety pin.** Tell students that these objects are made of the same metal alloy. Ask them to identify it and to compare its properties as seen in the objects. Explain that low-carbon steel is flexible (ductile), while high-carbon steel is stronger and more rigid. Have them rate the steel objects as low- or high-carbon steel. Ask which type of steel would be used in creating girders for skyscrapers.

STUDENT INVOLVEMENT: OPTIONS

⚠	Indicates an activity that would take less than a class period.
▲	Indicates an activity that could take most of a class period.
⧗	Indicates an activity that would go beyond the class period.

Discuss the Video.

Video Guide notes can be used to help students answer these and other straightforward questions:

- ▲ Where does the mill get the steel from? Why is this a good source?

  Old cars; people throw away about 10 million cars a year.

- ▲ What has the mill done to be more efficient and conserve heat and electricity?

  Used longer arc; used slag to insulate furnace; continuously cast, so steel doesn't lose as much heat as it's processed—saves time.

- ▲ How hot is the steel as it is being shaped and rolled? When is it allowed to cool down?

  3000°F or 1650°C; at end of process.

Group Discussion: The Age of Steel.

Have students respond to the following: Although we are still technically in the Iron Age, the 20th century has been called the Age of Steel. Do you think this name fits? Why or why not? Can you think of another name that you feel better suits the late 20th century?

Demonstration: Bimetallic Bars.

Materials needed: **bimetallic strip or bar (can be found in hardware store or made: connect two equal strips of, say, zinc and brass binding; or, rivet together two bars of, say, steel and brass).** Demonstrate how heat is conducted at different rates in different metals. Have students guess what will happen to the bar/strip before you heat it over a flame. Heat it, and have them hypothesize why the bar/strip curves in one direction (forced by more rapidly expanding metal). Have students predict what will happen as you cool the bar with water (the same side contracts more rapidly). Elicit a conclusion about variable conduction rates in metal.

Activity: Properties of Different Metals (Activity Master 5).

Have students work in cooperative pairs. Provide time to discuss answers.

Answers: chart, top to bottom—invar, wood's metal, manganese, mercury, nichrome, tungsten, copper; 1. invar, wood's metal, strength vs. ductility; 2. high resistance; 3. too expensive.

Homework: Steel Mill Math.

A steel mill has made a 500,000-pound batch of molten steel that contains .05% carbon. Adding a bag of carbon (each bag is 50 lbs.) raises the carbon level of the steel .01%. The mill adds 75 bags of carbon. What is the new percentage of carbon in the molten steel?

.01 x 75=.75 + .05=.8%

VIDEO STUDY GUIDE

This guide is designed to help you get the most out of the video for "Powerful Stuff." Look over the questions below before you watch the video. Use the space under the questions to take notes. What does the video tell you in answer to each question?

1. Some steel mills recycle steel. Where does the steel come from at the mill shown in the video? Why is this a good source?

2. What causes the band's blackout? Why does AJ say the band members are "electricity hogs"?

3. Why does the mill use a lot of electricity? How much does Richard, the steel mill guide, say the mill needs?

name: ______________________________ **class:** ________ **date:** ___________

VIDEO STUDY GUIDE, continued

4. What has the mill done to be more efficient and to conserve heat and electricity?

5. About how hot is the steel as it is being shaped and rolled? When is the steel allowed to cool down?

6. What parts of the video did you like best? Why?

name: ______________________ **class:** ________ **date:** __________

HEAT TRANSFER

The energy from heat can be transferred in three ways:

CONDUCTION: The heat travels from one form of matter to another, from particle to particle.
CONVECTION: The heat travels within matter by means of convection currents, with heated particles rising and cooler particles sinking.
RADIATION: The heat is transferred to a form of matter even though it is not in direct contact with the source of heat.

Each of the three parts of this activity (on two sheets) demonstrates one of the three methods of heat transfer. Which is which? After you conduct a procedure, fill in your observations and conclusions.

PART 1

PROCEDURE:

Fill the bottle or glass with cold water. Place it in the sunlight (in a window or outside), after measuring the water temperature. Wait 30-45 minutes, and measure the water temperature again.

MATERIALS NEEDED
▲ Water
▲ Soda bottle or glass jar
▲ Thermometer

OBSERVATIONS:

First temperature reading is ______________

Second temperature reading is ____________

CONCLUSION: ______________________________

FOLLOW-UP:

Give other examples from your experience of this kind of heat transfer: ______________________________

____

____

name: ______________________ class: ________ date: __________

HEAT TRANSFER , continued

PART 2

Caution: Do this procedure under a teacher's supervision.

PROCEDURE:

Place the spoon in a saucepan filled with water. As the water heats, hold the spoon handle until a change begins to occur in the spoon. Let go of the handle, and turn off the heat.

MATERIALS NEEDED

- ▲ Water
- ▲ Small saucepan or pan
- ▲ Metal spoon
- ▲ Heat source (bunsen burner,hotplate)

OBSERVATIONS: ____________________

CONCLUSIONS: ____________________

FOLLOW-UP:

Give other examples from your experience of this kind of heat transfer: ____________________

____

____

PART 3

PROCEDURE:

Place the thermometer on the classroom floor. Wait for the reading to stay steady; record it. Place the thermometer on top of a desk. Wait for the reading to say steady; record it. Place the thermometer on the top of the ladder. Wait for the reading to stay steady; record it.

MATERIALS NEEDED

- ▲ Thermometer
- ▲ Ladder

OBSERVATIONS:

Temperature on the floor is ____________

Temperature on the desk is ____________

Temperature on the ladder is ____________

CONCLUSIONS: ____________________

FOLLOW-UP:

Suggest a way in which heat is distributed in the classroom: ______

____

name: ____________ **class:** ______ **date:** ______

HOME ELECTRICAL SURVEY

Electric bills are calculated in kilowatt hours (kWh) using the equation E = P x t. **E** stands for **energy** (kWh); **P** is for **power** (kilowatts, with each kilowatt equally 1000 watts); and **t** is **time**, the number of hours electricity is used.

The chart below is partially filled in. It shows sample figures for common appliances. Change any figures that don't match your appliances (number of watts; your estimate of the amount of time used in a year). Cross out appliances you don't have, and add those you do have and turn on frequently. Use the back of the sheet if you need to.

Calculate cost per year, using your family's last electric bill to find cost per kWh. Add these figures to the chart.

APPLIANCE	WATTAGE HRS	USED/YEAR	COST ($)	YEARLY
toaster	1,200	35	42	
range	12,200	100	1,220	
refrigerator (12 cubic feet)	240	3000	720	
washer	500	200	100	
iron	1,000	140	140	
air conditioner	900	1000	900	
window fan	200	850	170	
TV (color)	200	2200	440	
radio	70	1200	84	
vacuum cleaner	630	75	47	

1. Suggest ways to reduce your family's electric bill: ______________
____
____
____

2. How much money would your family save each year if they followed your suggestions? ______________________________
____

name: ______________________ **class:** __________ **date:** __________

PROPERTIES OF DIFFERENT METALS

Different metals and alloys have properties that make them more suitable for different purposes. The chart below lists special properties of eight metals and alloys.

METALS	SPECIAL PROPERTIES
Copper	good conductor of electricity; low resistance
Invar (steel alloy)	minimal expansion/contraction with heat change (much less than other metals)
Magnesium	strong, but has low density (lightweight)
Manganese	creates a very hard, durable steel alloy
Mercury	only metal liquid at room temperature-low freezing point
Wood's metal (lead alloy)	very low melting point (below boiling water)
Nichrome (alloy of nickel, iron, chromium)	very high resistance to electrical flow
Tungsten	can be drawn into fine wire; does not melt at white-hot temperatures

Match the special properties of these metals and alloys to the uses in the chart below. Fill in what you think would be the best metal or alloy to use. (Be prepared to support your choice.) Then answer the questions below the chart.

USES	METAL/ALLOY
Measuring tapes	
Automatic sprinkler (fire-safety device)	
Railroad rails	
To make lightweight alloys for aircraft	
Thermometer	
Hairdryer and toaster coils	
Filament in incandescent light bulbs	
Home electrical wiring	

1. Of the steel alloys listed, which would be a high-carbon steel? ____
   ______________ A low-carbon steel? ______________
   Why do you think so? ______________
   ____

2. Why is nichrome not a good choice for home wiring? ______________
   ____

3. Gold and silver are better conductors than any of those listed in the chart. They are used in high-tech electronics. Why aren't they used in home wiring? ______________
   ____

name: ______________ **class:** ________ **date:** ________

POWERFUL STUFF: Extension

Interested students may wish to pursue ideas and concepts raised by this unit. You could direct them to the suggestions and resources listed on this page.

Possible Research Topics

- ▲ Visit a major auto parts center, and survey the items that are rebuilt or reconditioned. Interview an employee to ask questions about your results and to find out about the processes used.
- ▲ Visit a "junkyard," and list what is saved and discarded. Can you find this information on a computer?
- ▲ Learn more about the "hot" issue of superconductors, using recent newspaper, magazine, and journal articles as well as books to make sure your information is as current as possible.
- ▲ Call your local electrical power company, and ask if they provide an energy audit. If so, will your parents or school participate in one?
- ▲ The terms "Bronze Age" and Iron Age" are imprecise—various cultures experienced these ages at different times, while some "skipped" an age altogether. Find out more about humans' developing relationship with metals and about metallurgy (a comparatively recent field).

Suggested Science Fair Projects

- ▲ What are the effects of various kinds of insulation on maintaining the temperature of a substance?
- ▲ Is the elasticity of a rubber ball affected by temperature?
- ▲ What is the effect of insulation on the melting rate of ice?
- ▲ What is the effect on the voltage of a dry cell when used intermittently?

Resource Center

Books to recommend:

Easy-to-make Electric Gadgets by Leon Stanley (Harvey House, 1980)

Energy: The New Look by Margaret O. Hyde (McGraw, 1981)

Experiments with Heat by Harry Sootin (Norton, 1964)

Heat by Lawrence Santrey (Troll, 1985)

How Did We Find Out About Superconductivity? by Isaac Asimov (Walker, 1988)

In Came the Darkness: The Story of Blackouts by Peter Z. Grossman (Four Winds, 1981)

Looking at Metals by Don Radford (David & Charles, 1985)

More Wires and Watts: Understanding and Using Electricity by Irwin Math (Scribner's, 1988)

Thomas Alva Edison by Christopher Lampton (Watts, 1988)

Yellowstone Fires: Flames and Rebirth by Dorothy Hinshaw Patent (Holiday, 1990)

Organizations to contact:

Chaparral Steel Company
Route 1, Box 1100
Midlothian, TX 76065

Energy Learning Center
Edison Electric Institute
1111 19th Street NW
Washington, DC 20036-3691

Futurism Technology
P.O. Box 7544
Murray, UT 84107
(scientific equipment: superconducting ceramic material)

USX Corporation (U.S. Steel)
USS Division
600 Grant Street
Pittsburgh, PA 15219

To order additional sets of TRANSFORMATIONS

The set of eight videotapes and matching Teacher's Guides is available for $75.00 plus $5.00 postage and handling. Checks or money orders payable to TRANSFORMATIONS should be sent to TRANSFORMATIONS, PO Box 1205, Boston, MA 02130. Purchase orders can be sent to the same address or faxed to 617-323-8687. For more information, call 1-800-433-AIME.

CREDITS

TRANSFORMATIONS is sponsored by **AIME**, the **American Institute of Mining, Metallurgical and Petroleum Engineers Inc.,** a national professional society dedicated to advancing the knowledge of engineering in the fields of minerals, metals, materials and manufacturing and energy resources, and to undertaking programs addressing significant national needs, including education.

TRANSFORMATIONS is a project of the AIME Public Issues Committee.

Frank Nolfi, Chairman
David Donohue
John Hammes
John Healey
Richard Klimpel
Ravindra Nadkarni
Arthur Nedom
Louis Kuchinic, Sr.
Gerald Roe
John Stubbles

PROJECT TEAM:

Project Director .... **Lee Richmond**
Senior Consultant .... **Jerry Murphy**
Marketing Director ..... **Joanne Van Voorhis**
Project Coordinator .... **Etienne Martine**
Teacher Consultants .... **Bill Jones**
Ron Barndt
Joe Pignatiello
Bill Rockwell
Evaluator .... **Barbara Flagg**
Project Managers .... **Judy Downes**
Mark Irwin
Teachers Guide Editor .. **Joanne Fedorocko**

AIME STAFF SUPPORT:

Robert Marcrum, Executive Director
Melissa Leggieri

B "POWERFUL STUFF"

Producer/Director......Lee Richmond
Scriptwriter...............Lee Richmond
Composer ....Mark Spencer
Lyrics:
"Transformations" .....Lee Richmond
"Powerful Stuff" ....Lee Richmond
Line Producer...Polly van den Honert
Casting.................Collinge/Pickman

CAST

A.J. ....**Anthony Ruivivar**
Billy...............................**Jonathan Deily**
Laurie...................................**Eisa Davis**
Simone ....**Linda Balaban**
Chaparral Steel
Steelworker.................**Richard Williams**

LOCATION CREW

Director of Photography .....**Dean Gaskill**
Sound Engineer.................**Mike Pfeiffer**
Script Supervisor..........**Etienne Martine**

STUDIO CREW

Director of Photography......**Bestor Cram**
Sound Engineer............**Chris O'Donnell**
Video Engineer................**Eliat Goldman**
Gaffer ....**Ken Perham**
Key Grip............................**Jack McPhee**

Set Designer ....**Frank Gaide**
Wardrobe ....**Carlene Lee**
Props ....**Fairlie Myers, Carlene Lee**
Makeup ....**Marleen Alter**
Script Supervisor ....**Eve Wrigley**
Instrument Mix ....**Rob Scott**
Audio Playback ....**Tim Lay**
2nd Camera (film) ....**Mike Majoris**
Assistant Camera.......**Mary Anne Jenke**
Grips ....**John Maliscewski, Arnold Brown**
Carpenters ....**Larry Batherwitch, Terrance Gaide**
Electric ....**Mark Bialas, Jeff Hanel**
Production Assistants ...**Sharon Hibbert, Jimmy Frieden**

POST-PRODUCTION & PRINT

Editor ....**Mark Fish**
Paintbox ....**Joanne Kaliontzis**
Sound Mixer........................**Ken French**
Teacher's Guide ....**Joanne Fedorocko, Ellie Schottman**
Designer ....**David White**
DesktopPublisher **SullivanCreativeServices**

TRANSFORMATIONS was created and produced by
Galileo Studios, 50 Hunt Street, Watertown, MA 02172 (617) 923-0912

TRANSFORMATIONS: Science, Technology and Society © 1991 was produced under the auspices of the American Institute of Mining, Metallurgical and Petroleum Engineers, Inc.

345 East 47th Street
New York, NY 10017
1-212-705-7677