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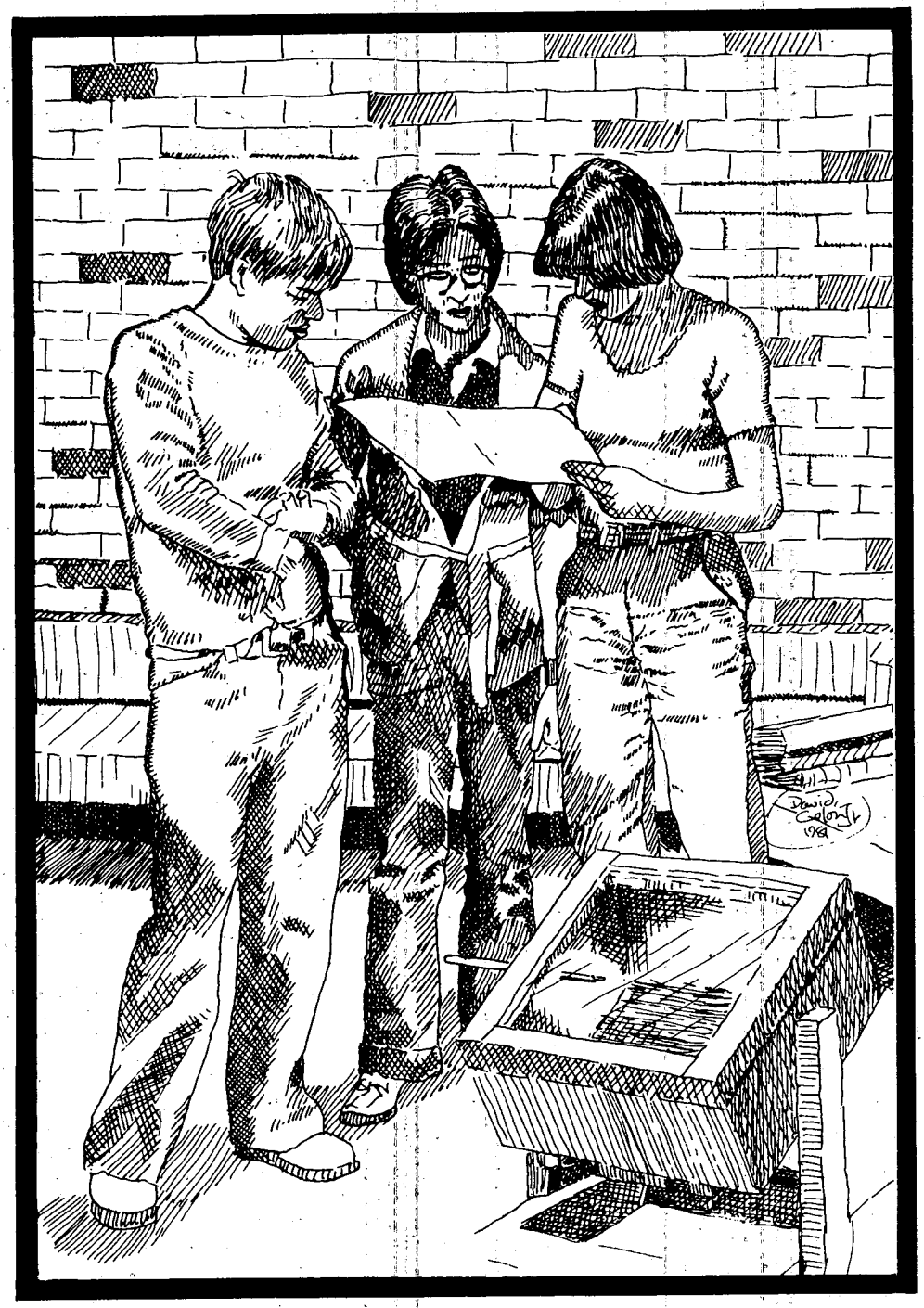
U.S. Department of Energy

May 1981

# Solar Energy Education



MASTER

# Sun Schooling

# READER Part IV

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# The Solar Energy Education Curriculum

The booklet in your hands is just one part of a series. The Solar Energy Education materials include

*a Solar Energy Text*

*a Solar Energy Reader* in four parts:

Energy, Society, and the Sun (general),

Sun Story (history and literature),

Solar Solutions (practical applications), and

Sun Schooling (classroom-oriented readings),

*Solar Energy Education Activities* for

Science,

Industrial Arts,

Home Economics,

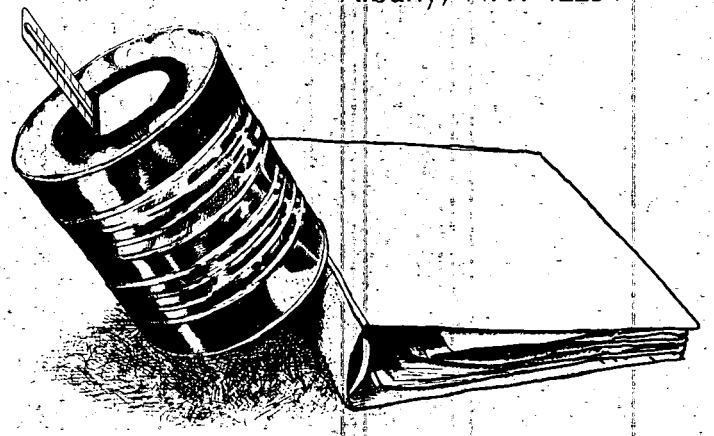
Social Studies, and

Humanities (Art, Music, and English), and

*Solar Energy Education Teacher's Guides* to accompany the above activity booklets.

For more information on the Solar Energy Education curriculum, contact

Solar Energy Project
c/o Curriculum Services
New York State Education Department
Albany, N.Y. 12234



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# Solar Energy Education

# READER
## Part IV
# Sun Schooling


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# Introduction

The energy picture is changing too fast to be captured in books. Before the ink is dry new experiments, technologies, and legislation make some of a new book's information obsolete. Magazines and newspapers are better able to keep pace with rapid change, and it is on these media that the well-informed energy consumer depends.

In your hands is a collection of magazine articles selected to help you focus on an important part of the changing energy picture: solar energy. This booklet is Part IV of the Solar Energy Reader, a series of four booklets:

*I. Energy, Society, and the Sun*

(General readings on philosophical, political, and legal topics)

*II. Sun Story*

(Solar history, mythology, and poetry)

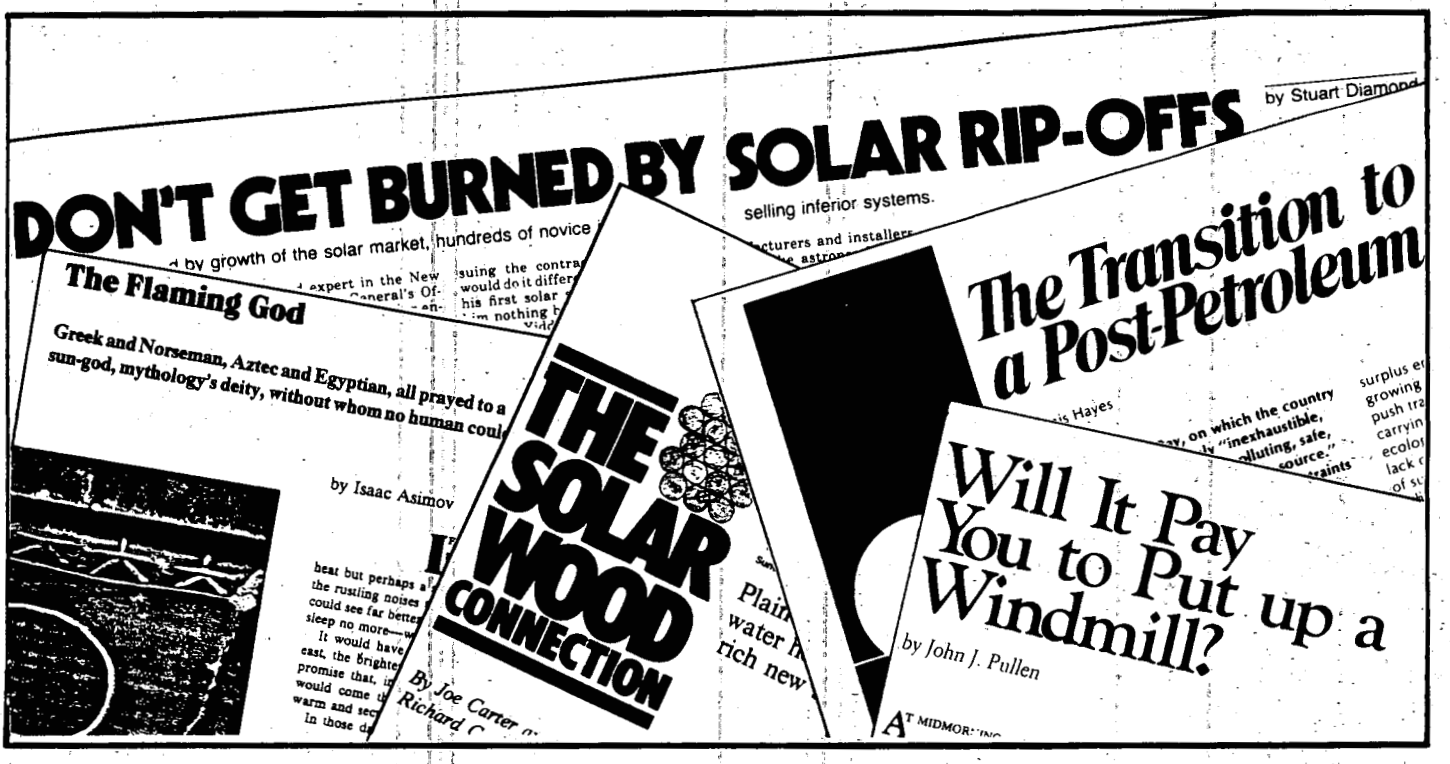
*III. Solar Solutions*

(Articles on the many applications of solar energy: heat, photovoltaics, wind, hydro, biomass, etc.)

*IV. Sun Schooling*

(Easy readings on energy and articles about teaching solar)

The bibliography at the end of this booklet will guide you to articles that time and space would not allow us to include here. But the magazines represented in the bibliography and the reader are continually publishing new reports on recent developments. The person who wants to be well-informed about the changing energy picture will follow these publications regularly.



# The Readings For the Student

# The Energy of the Sun

Did you know that the sun is the source of all the energy on earth? Oil, coal, wood, grain, ocean currents, winds, waterfalls, or simple heat -- it all comes originally from the same place. Get to know the sun!

# THE ENERGY OF THE SUN

The world is not short of energy. More than enough energy exists to run all the activities upon which modern life depends, for some 10 billion years or more. What is the source of this boundless energy? It's no secret. Every day each of us sees it for himself or herself. The source of that truly limitless energy is the sun.

Scientists believe that the sun produces more energy in one second than all the energy people have used so far in the course of human history. Only a tiny fraction of the sun's total energy output actually reaches the Earth, but that is more than enough to supply all human energy needs. The problem is that scientists and

The Sun, the source of all energy for our planet, has several different regions.

**corona** — the outer atmosphere, seen as a silvery halo during an eclipse. Made up of thin, electrified gases.

**chromosphere** — the 6000 mile thick inner atmosphere seen as a rose-colored fire during eclipse. Several thousand mile long "flames" called prominences rise from it. Tremendous winds and storms rage in this region.

**photosphere** — the restless surface of the sun. Bubbles of gases 300 to 900 miles across rise from the interior. Earth telescopes show whirlpools of gases that are darker and cooler than the rest. These are called sunspots.

**gaseous interior** — tremendous heat from the interior is transfered by the gases in this layer.

**inner region** — billions of hydrogen nuclei are constantly being fused into helium in this gigantic nuclear furnace. Temperature thought to be around 20,000,000 degrees F.

Every second, 4,000,000 tons of the Sun's mass converts to radiated energy. Possibly one-third of the Sun's supply of hydrogen has already been converted by fusion into helium. That leaves enough hydrogen for about 6000 million more years of energy.

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engineers have not yet developed ways to use the sun's energy on a large scale.

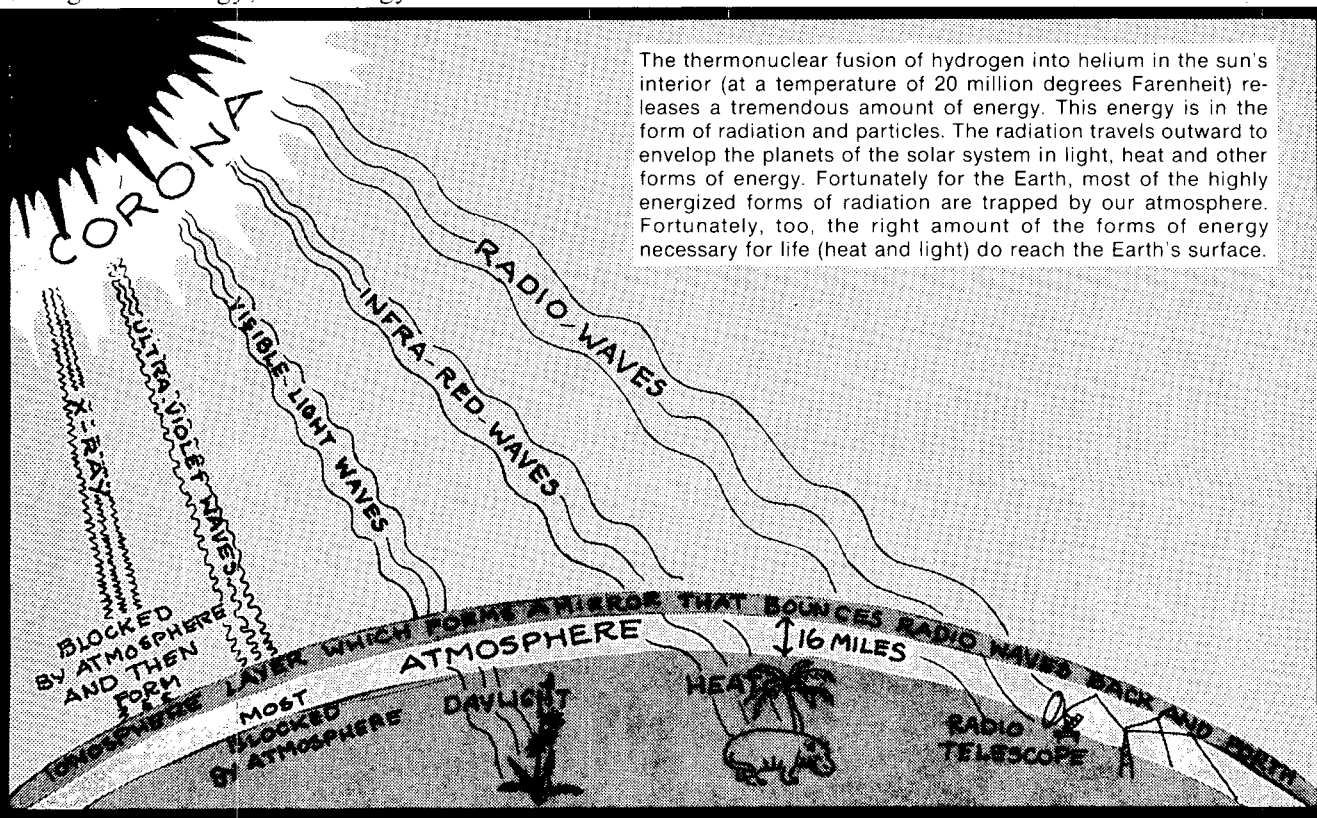
The sun really is not so unusual. It is just another middle-size star. What *is* special is the location of the Earth with regard to the sun. The Earth's place in the solar system is just right — not too far and not too near the sun. Just enough of the sun's energy — *solar* energy reaches the Earth to make it hospitable for life as we know it. Think of that next time you walk in the sunshine.

Like other stars, the sun acts as a gigantic hydrogen bomb. Its surface has a temperature of 10,000 degrees F. and its center, or core, more than 20 million degrees F. The core of the sun is where all the action is. Like the rest of the sun, it is composed of hydrogen gas. But the gas is under so much pressure it is more dense than steel. In that unbelievably hot core, the atoms of hydrogen come apart. The electrons fly away from the nuclei of the atoms. Under the great pressure and heat in the core of the sun, the nuclei of the hydrogen atoms combine, or fuse. Four hydrogen nuclei fuse into one of helium. However, the helium particle weighs slightly less than the four particles that fused to form it. Some matter has been lost during the joining, or "fusion" of the hydrogen nuclei. That matter changes to energy, the energy of the sun. The sun has enough hydrogen fuel to continue to burn for about 10 billion years, twice the time it already has existed.

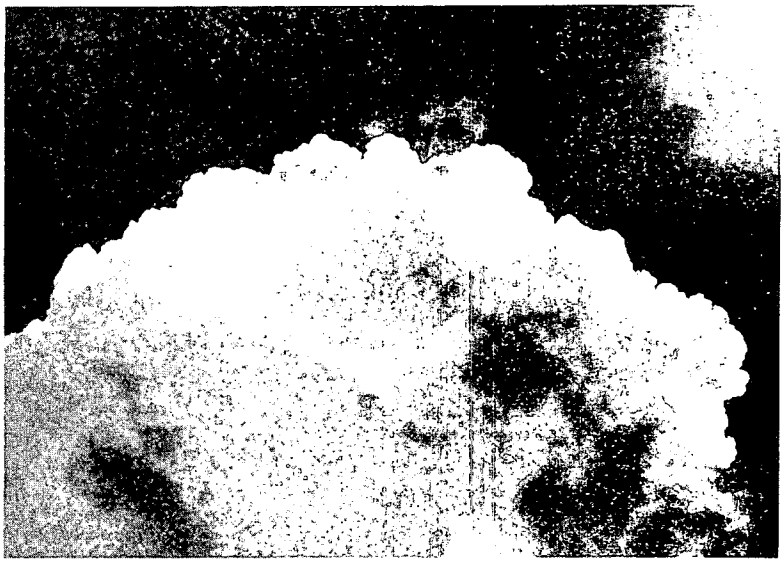
The tremendous energy produced by the sun radiates out into space as several forms of rays or waves, and also in the form of particles. Scientists measure the energy that the sun radiates in terms of *wavelength*. Those kinds of radiation with long wavelengths — visible light, heat, radio waves — are able to pass through the Earth's atmosphere. Much of the short wavelength radiation — ultra-violet light, X-rays — plus the high energy particles, are blocked by the Earth's atmosphere. Thus visible light is only one part of the energy that comes from the sun. Much solar radiation cannot be seen by the human eye. Some ultra-violet rays, for example, do pass through the atmosphere and cause sunburn even on a cloudy day when the light from the sun seems weak.

The sunlight we see is yellow-white in color. But it really is a mixture of colors. You can prove this for yourself by noticing what happens when a beam of sunlight passes through a prism, an aquarium, a crystal chandelier, or even a drinking goblet full of water. A prism breaks up so-called "white light" into violet, blue, green, yellow, orange and red.

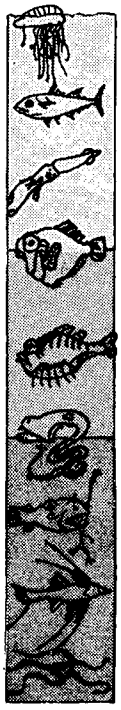
*Edward R. Ricciuti*




The thermonuclear fusion of hydrogen into helium in the sun's interior (at a temperature of 20 million degrees Farenheit) releases a tremendous amount of energy. This energy is in the form of radiation and particles. The radiation travels outward to envelop the planets of the solar system in light, heat and other forms of energy. Fortunately for the Earth, most of the highly energized forms of radiation are trapped by our atmosphere. Fortunately, too, the right amount of the forms of energy necessary for life (heat and light) do reach the Earth's surface.



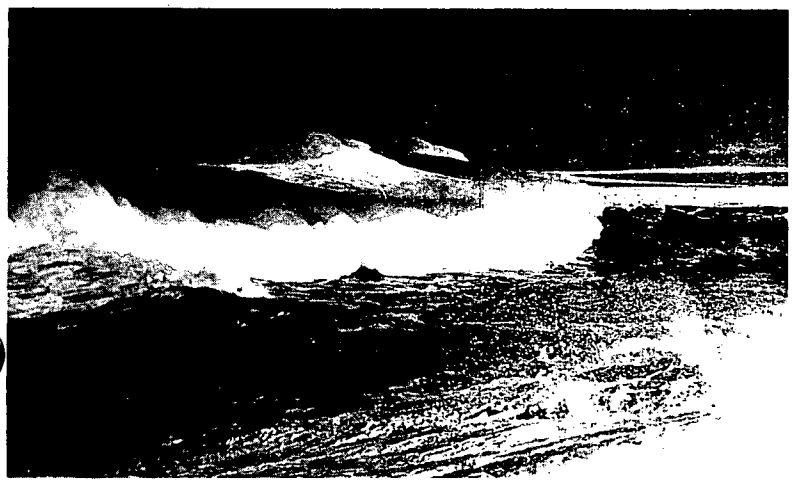
## LIGHT AND LIFE



Every night as darkness falls and light retreats from the upper zones of the sea, vast numbers of creatures from the depths rise towards the surface. They belong to a zone of the sea that is forever dark. The sea is lit by the sun to a depth of about 650 feet. Below that, the water dims and then blackens. Some creatures of the dark depths carry their own lights, like fireflies. The lights are used as identification, to lure prey, and to attract mates. At night, as the light ebbs from the surface waters, many deep sea animals rise to feed.

Although light may shine to a depth of more than 600 feet, there is enough light for green plants to grow only to 350 feet. In the sea, as on land, green plants are the base of the food pyramid. Plants gather the energy from sunlight and convert it into chemical energy, which animals can use.

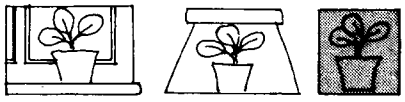
Plants accomplish the conversion of energy through the process called "photosynthesis."



Without photosynthesis neither plants nor animals could live. See the September, 1974, *Curious Naturalist* for a diagram on photosynthesis. Photosynthesis generally takes place in leaves, which are light traps. Leaves have a large surface exposed to the sun. They absorb sunlight easily. The light is absorbed in the leaves by the substance that gives them their green color — chlorophyll. Meanwhile the plant has taken in carbon dioxide from the air, through its leaves, and water and minerals from the soil, through its roots. In the leaves, the chlorophyll triggers a chemical process, which with the energy of sunlight makes sugars from carbon dioxide and water. As this process takes place, the plant gives off oxygen. Without plants, not only would we have no energy for our bodies, we could not breathe. The sugars are the basic food of the plant. Plants provide food for many animals, which in turn provide food for other animals. In the long run, the energy that powers our living processes originally came from the sun, and was processed through plants.

Photosynthesis is not the only way in which sunlight affects living things. Light has a variety of effects upon life. The length of daylight — called the "photoperiod" — triggers many natural activities. Deciduous trees sprout leaves in the spring because the period of daylight has increased. Many animals begin reproduction in the spring for the same reason. Biologists who have tried to breed certain wild animals in captivity have found that they must duplicate the

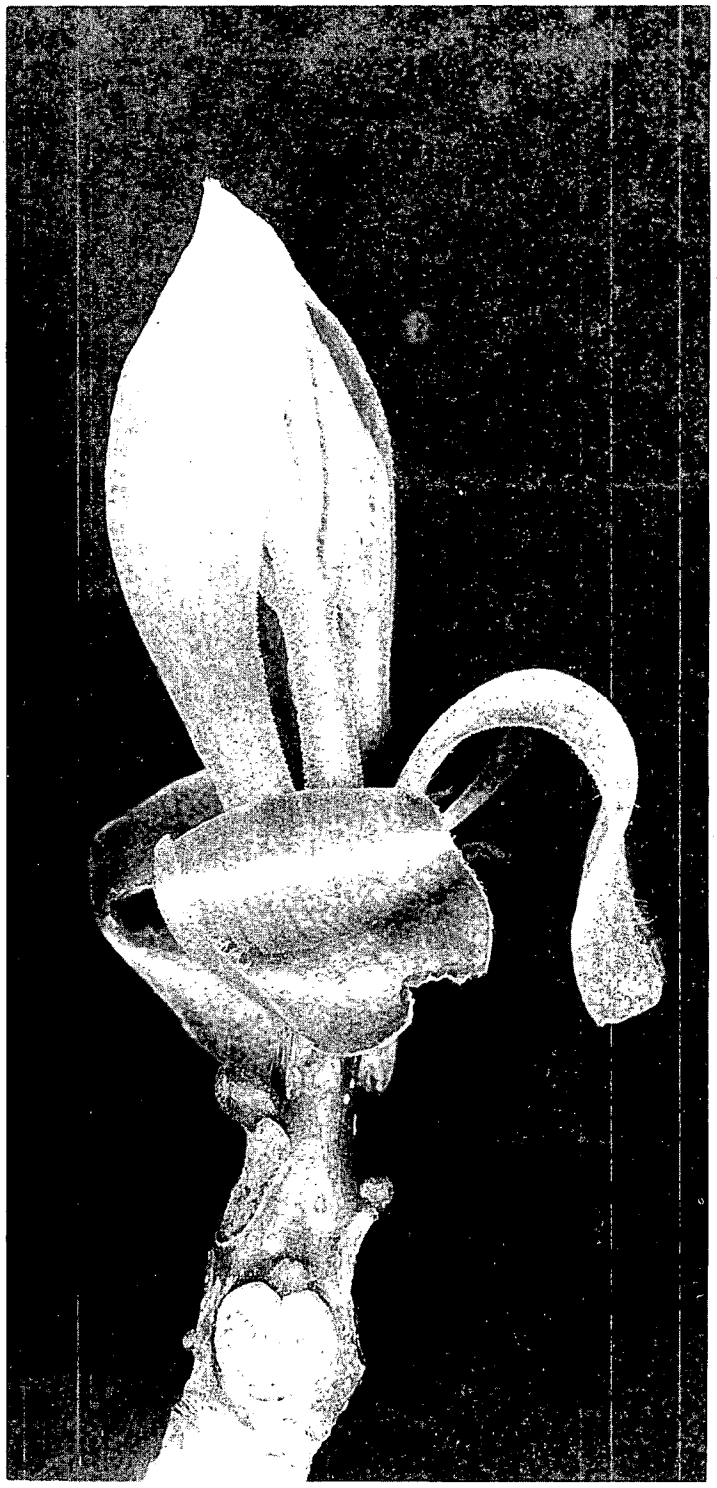
### TRY THIS



You can find for yourself how sunlight affects plant growth.

Pot three plants (beans or peas are a good choice) in potting soil. Place one of the plants in a window where it will receive light throughout the day. Each day turn the pot around so the plant gets equal light on all sides. Keep another plant under a fluorescent lamp that is on 24 hours a day. Place the third plant in a box that is light-tight. Remove the box for only five hours daily and during that time place the plant under the lamp. Give each plant enough water to keep the soil lightly moist.

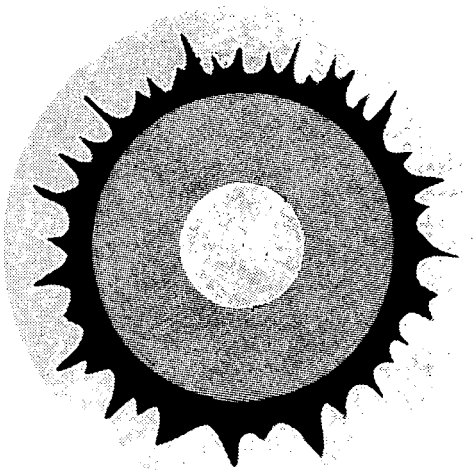
Compare the growth of the plants.

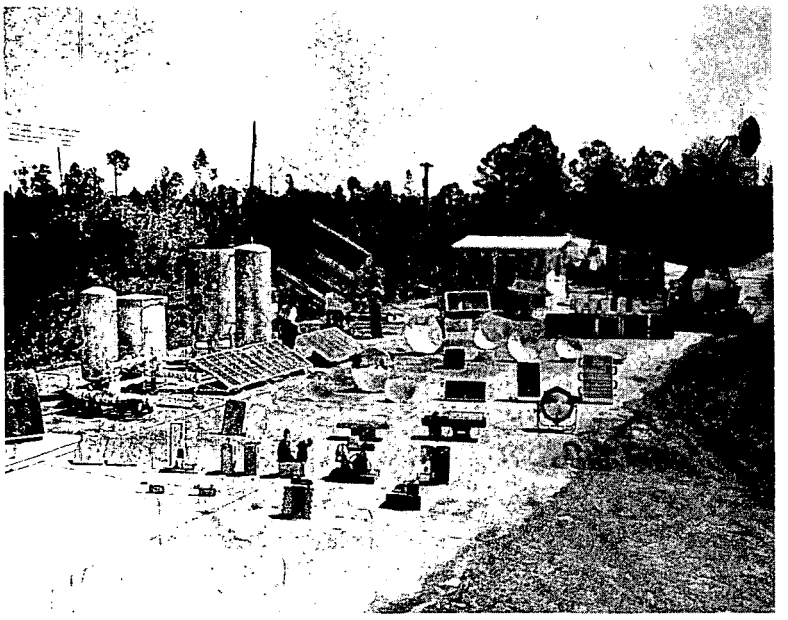


All the Earth's living things depend on the sun for the light energy needed for photosynthesis and for the heat energy that warms the atmosphere.

natural photoperiod with artificial light to have success. The length of day also helps trigger the migration of birds.

*Edward R. Ricciuti*





Solar engines, furnaces, ovens, water heaters, space heaters, refrigerators, air conditioners, and swimming pool heaters are some of the kinds of solar energy equipment being tested in this Florida laboratory.

## SUN POWER

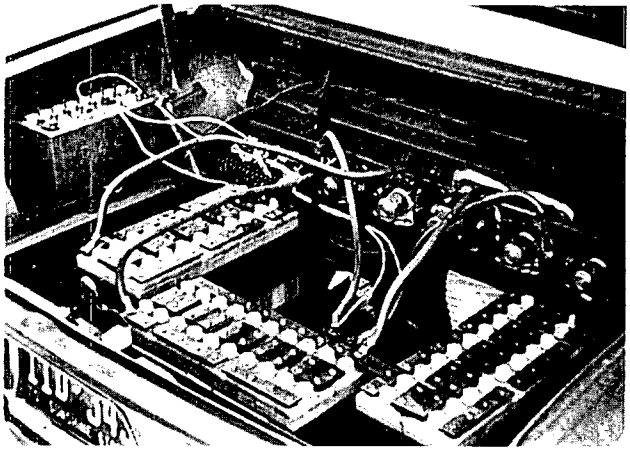
Anyone who has walked with bare feet over pavement on a hot summer day knows that the sun can be used to heat objects here on Earth. "Sun power" appears to be the solution to finding energy for not only heating but all other needs. During the day, the energy of the sun is no person's property. It is available to anybody on Earth as long as the sun is shining. Of course, the amount of sun power varies according to the season, weather, and the part of the Earth where it is used. But with proper scientific know-how, there would be enough sun power for everybody.

Unfortunately, it may be many years before scientists and engineers can develop inexpensive ways of using sun power on a wide scale. Many imaginative ideas have been put forth. Most of these make use of mirrors or glass to collect and concentrate solar energy. Although a tremendous amount of solar energy reaches the Earth, it is diffused, or spread out, and must be concentrated if it is to be used to produce power. The idea is not new. Heat from a solar collector was used to make steam to drive a steam engine in France a century ago. Some people have proposed setting up solar collectors over more than a hundred square miles of desert. Such a solar power plant would use the sun's heat to make steam just as coal, oil and nuclear fuels are used to make steam in power plants today. The steam could generate more than enough electricity to power the nation.

Another idea is to launch a satellite more than 20,000 miles into space to collect solar energy. The satellite would beam the energy to an antenna on Earth, which would convert it to electricity. The electricity could then be distributed through the power lines we already use. Unfortunately, the cost of such projects still is very high.

Meanwhile, however, sun power is heating homes and hot water for homes in several parts of the world. A solar home costs more to build than a regular home but in the long run, it is cheaper. The home has its own energy supply. The heat source does not have to be distributed to the home from a distant power plant or oil terminal. There is no delivery charge for solar heat, although in very cold places a home may have to have an emergency heater that runs on fossil fuel. Most solar homes, however, have to operate the emergency heating system only rarely.

Providing electricity for a solar home is more difficult than heating it. Normal sunlight must be concentrated many times to generate enough heat to provide a household electrical supply. Researchers are experimenting with many approaches to designing equipment for this purpose. One promising idea is a bowl-shaped device that gathers sunlight and focuses it in a narrow beam. It might be suitable for the roof-



An electric car that uses batteries charged by the sun. The car of the future?

top of a home, and may produce enough heat to make electricity. Some researchers have even designed experimental solar powered automobiles.

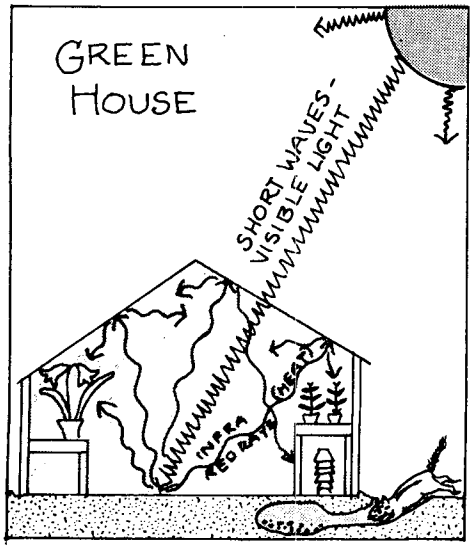
It remains to be seen how soon we will harness sun power effectively. Recently, however, some experts offered a hopeful estimate. Perhaps, before the end of the century, so many homes will be solar heated that it will total 10 per cent of the country's energy need.

*E.R.R.*

## THE GREENHOUSE EFFECT-- KEY TO SOLAR HEATING

Solar energy is used as the source of heat in greenhouses. Most of us know what a greenhouse looks like, but what about how it works? Simply, the greenhouse is built so that solar energy can enter it but heat cannot escape to the outside. It is a heat trap.

The greenhouse works on the principle that not all wavelengths of energy can pass through glass. Visible light rays can go through the glass of a greenhouse. The light heats up the interior of the greenhouse, which then radiates energy as heat, rather than light. The heat energy is in the form of infrared radiation, which has a longer wavelength than visible light. Infrared does not pass through glass, so the heat is locked within the greenhouse. As more and more light enters the greenhouse, the inside gets hotter and hotter.



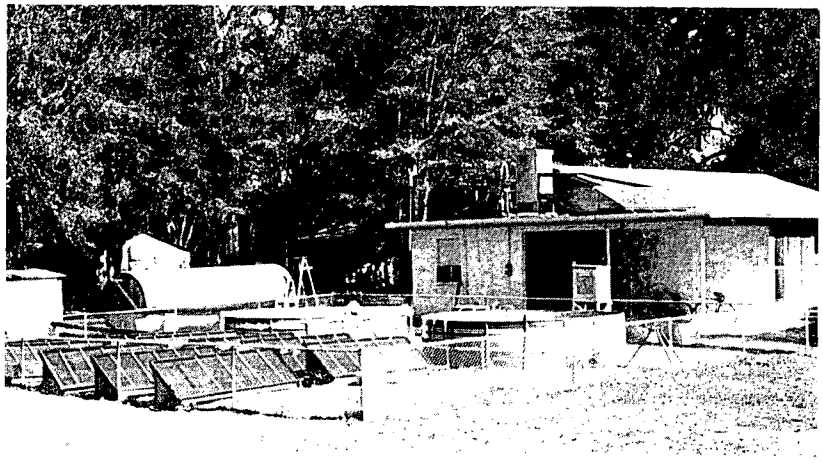

## FROM GREENHOUSE TO SOLAR HOME

A solar home is heated through the greenhouse effect. This does not mean that a solar home is all glass. Rather, part of the roof of a solar home is designed as a greenhouse. Heat builds up inside the greenhouse and is transferred through the rest of the home just like heat from fuel-powered furnaces — through water pipes or hot air.

Some solar homes have huge tanks of water or gravel in their "greenhouse" to absorb large amounts of heat during the day. The heat is thus stored for use at night when the greenhouse is not operating.

In summer, the heat gathered from the sun also can be used to power a refrigeration unit to cool a solar home.

A demonstration solar home. Space heating in winter, air conditioning in summer, hot water, a stove and oven, a heated swimming pool, some electricity and even some liquid waste recycling are all done by the sun.



The force of wind from the Pacific Ocean has bent these trees permanently.

**TRY THIS**
Clap a couple of dusty blackboard erasers or shake a cloth dusted with talcum powder over an *unlit* light bulb. What happens to the dust? Now, light the bulb and wait for it to heat. Shake the dust over the bulb again. What happens to the dust? Why? Do you see why the wind is said to be "a child of the sun"?

# WIND, CHILD OF THE SUN

Perhaps no other natural force affects us in so many different ways as the wind. A gentle breeze can cool us on a hot day. A north wind in winter can chill to the bone. Wind can bring rain to areas parched by drought. It also can bring swirling dust storms. Wind can sweep away clouds, revealing the sunshine. And at its worst, as storms such as hurricanes and tornadoes, wind can be among the most dangerous forces on Earth. Whether breeze or hurricane, however, wind is basically a movement of the Earth's atmosphere.

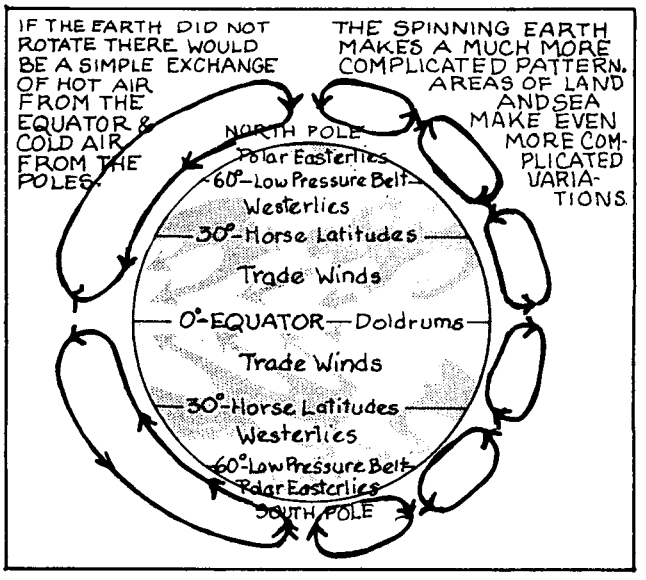
Weathermen measure wind according to a scale that runs from calm to hurricane force. When the wind blows at less than a mile per hour, it is calm. A strong breeze is a wind of between 25 miles per hour and 31 miles per hour. Hurricane force starts above 74 miles an hour, but the wind can blow much harder than that.

The strongest wind ever recorded, outside of a tornado, blew over the top of Mt. Washington, New Hampshire, one April day in 1934. It swept the peak at a speed of 231 miles per hour.

Most of us experience wind every day. Have you ever wondered, however, what makes the wind? In a word, the answer is the sun. Many other things contribute to the real winds, but basically the wind is a child of the sun. The movement of the atmosphere, or air, that is the wind happens because the sun heats the Earth's surface unevenly.

Near the equator, the Earth receives the direct rays of the sun and thus receives more heat than northern and southern regions, where the sun's rays strike at an angle. The air near the equator is warmer than temperate air because of this fact. Moreover, the surface of the Earth acts like a radiator. It radiates, or gives off some of the heat from the sun, further heating the air.

The warm air from the equatorial region is pushed upward by the cooler, denser air flowing in from the polar regions. The warm air then moves in the direction of the polar regions, cooling as it moves. As it cools it settles and pushes any warmer air toward the equator in a kind of cycle. Because of the Earth's rotation the winds blowing to north or south seem to veer to the east, while those heading for the equator veer west. The great masses of air that move between poles and the equator make up the Earth's overall wind pattern. There are local winds, also, which affect smaller areas. A sea breeze on a hot day is a local wind. It occurs when the denser, cool air over the ocean rushes in and pushes up the lighter, warm air over the land.



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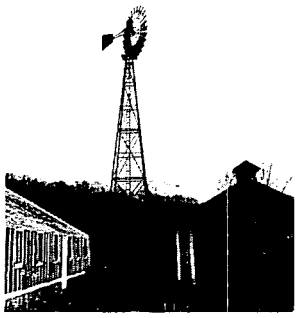

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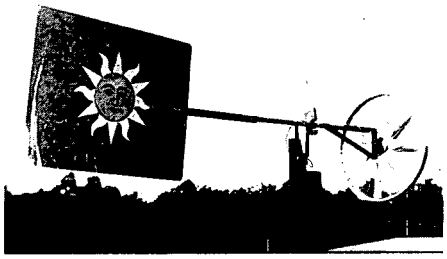

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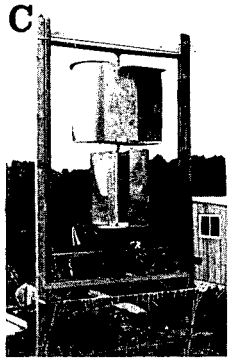

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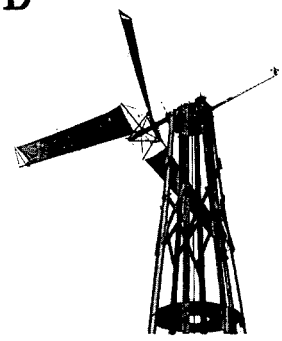
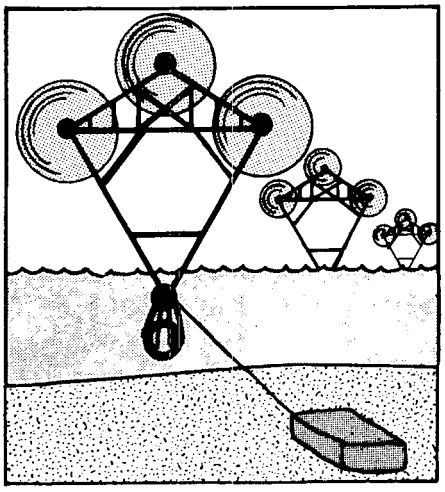


On farms there are still some old windmills (A) being used to pump water. Recently, new windmills of many different designs have appeared on homesteads and experimental farms. Windmill (B) uses a bicycle wheel and a small generator to produce small amounts of electricity to run a radio. Windmill (C) is made from sheet metal and mechanically pumps water. Windmill (D) is a turbine-generator that operates power tools.

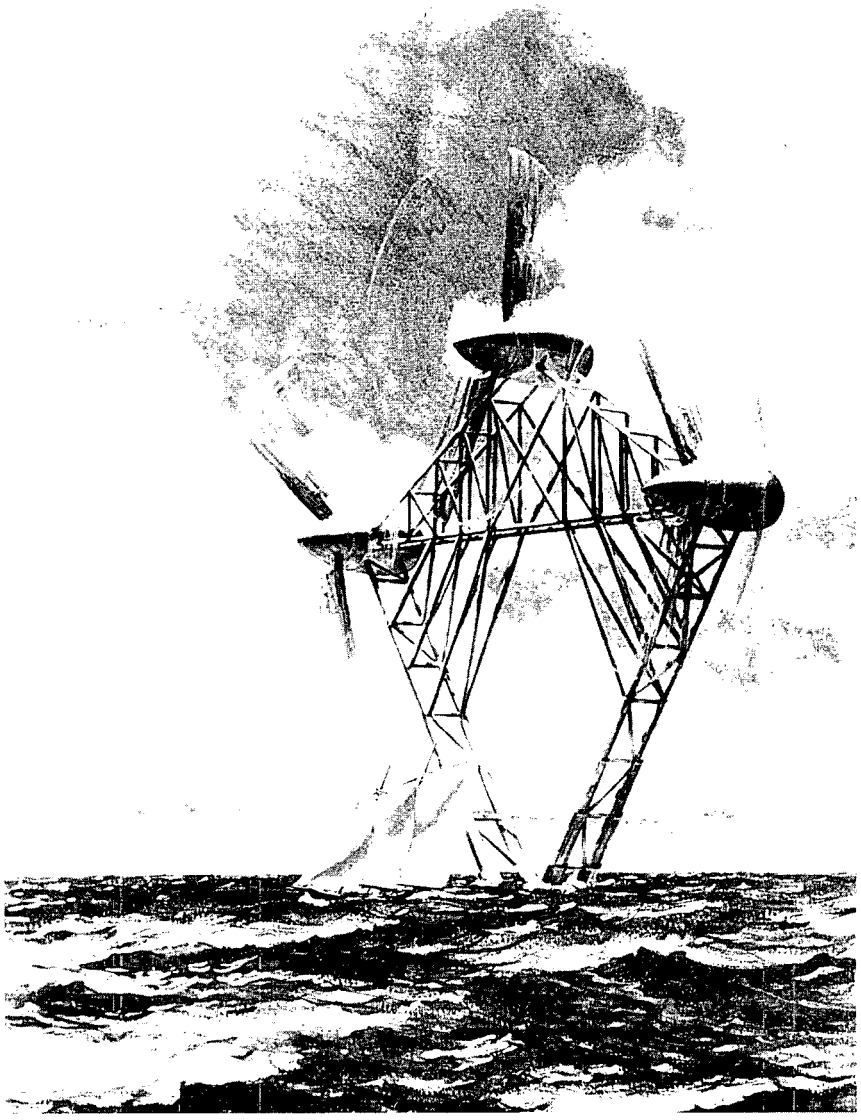
## RETURN OF THE WINDMILL

Imagine a million giant windmills stretched for 1500 miles across the Great Plains. Or imagine an even bigger line of windmills towering over the landscape from the Gulf of Mexico to the Canadian border. Imagine windmills 600 feet high along New Jersey's coastline, and a chain of windmills whirling atop platforms at sea, off New England. Within a few years, perhaps it may not be imaginary, but real, for the windmill may return as a major source of energy.

This year the National Science Foundation will spend $7 million to study how to make a better windmill. The windmill has been in use for a few



Wind power is a more concentrated form of solar energy. Some day, windmills such as this may float offshore and provide power for New England's cities and towns.



thousand years. Some people credit the Chinese with inventing it. Others say the Persians are responsible. Chinese, Persian, Dutch or American — all windmills work on the same pattern. A windmill consists of blades — or sails — which are attached to a shaft. When the blades catch the wind they spin the shaft. The shaft may be attached to other shafts, or directly to an engine, pump or turbine. Basically, however, wind energy spins a set of blades, which spin a shaft that drives whatever device is attached to it. Some scientists and engineers believe that blades spun by the wind may supply a large portion of electrical power in the United States by the end of the century. That may be too much to expect but it appears as if the windmill will be one tool to help meet energy problems in the years to come.

The wind, of course, does not blow all the time, so a windmill cannot be expected to operate continuously. This is a problem researchers are trying to solve. First of all, windmills probably will be concentrated in "wind corridors", where it is windy much of the time. Electrical power from windmills also can be stored for use when the blades are not spinning.

Actually, small windmills were commonly used for power on farms in the United States until only a few years ago, and some are still in use. But the windmills of the future will be much larger and much more complex. And, rather than supplying just one household, the new windmills will be linked to power networks stretching across the country. Among the experimental windmills to be built in the near future is one that NASA plans to construct at Sandusky, Ohio. It will have a single pair of blades, 125 feet from one tip to the other, and will perch atop a tower 125 feet high.

A pair of windmills almost as large have been proposed to generate electricity on Block Island, Rhode Island and researchers are studying a plan to produce electricity for New Jersey from wind power. According to the plan, windmills 600 feet high would be constructed along a parkway that runs close to New Jersey's coastline. Another plan proposed by engineers in the Southwest suggests setting up a million windmills along a 1500-mile stretch of the Great Plains. The engineers who propose it say the windmills could produce a fourth of the electricity needed by the nation.

E.R.R.

## THINGS TO NOTICE ABOUT THE SUN

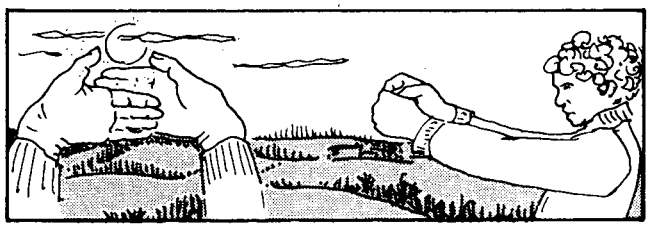
How many of us pay much attention to the sun? We miss its warmth and brightness after several days of rain. And some of us notice it during a solar eclipse such as the one last month. However, for the most part, people in today's world pretty much ignore the star that gives us life. *You should never look directly at the bright sun* even with dark or smoked glass. However, there are a lot of things you can safely notice about the sun. Here are a few:

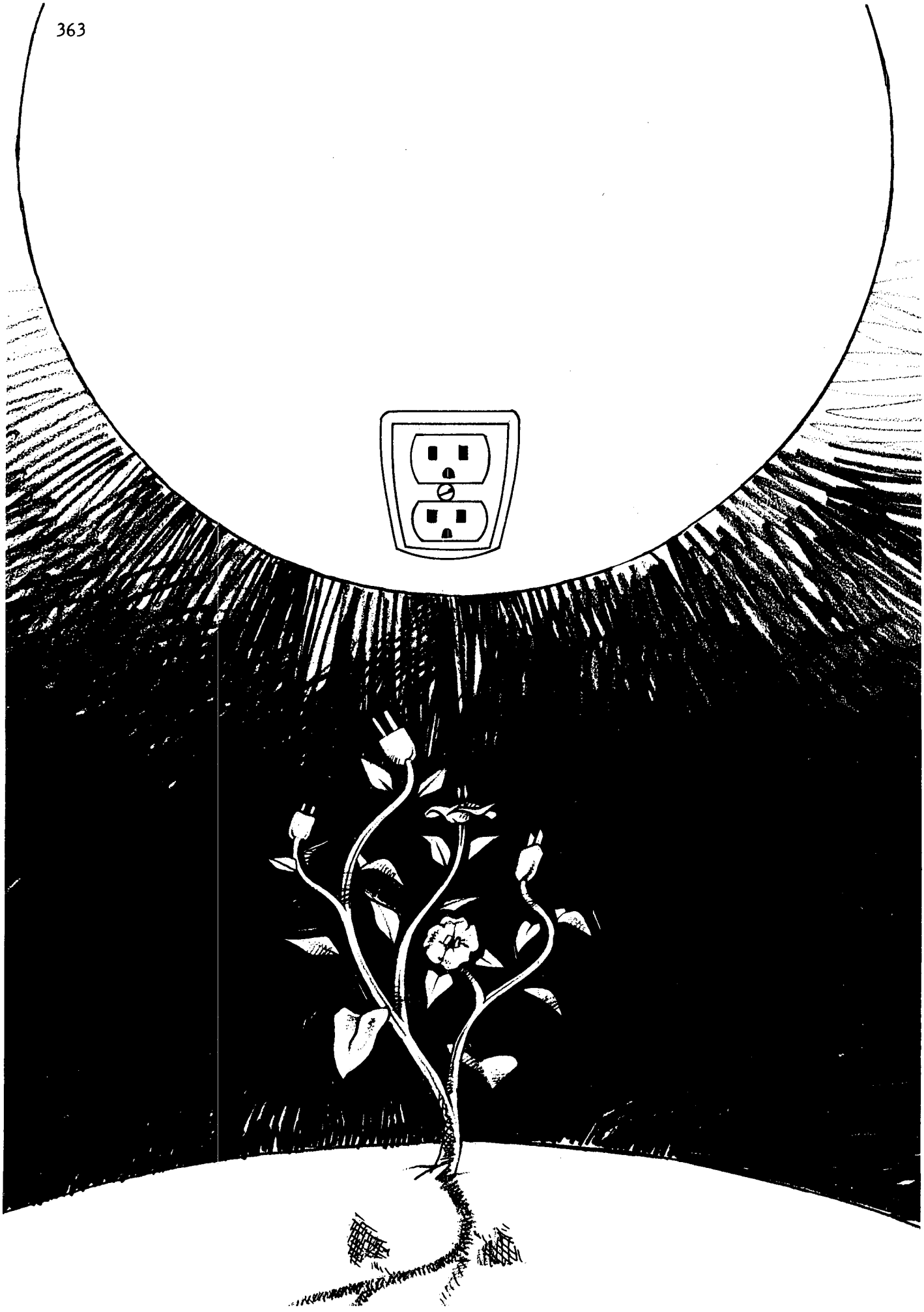
### USING THE SUN AND A WATCH INSTEAD OF A COMPASS

We all know that the sun appears to cross the southern sky each day. If you want an *accurate* way to find true south at any time of the day, without a compass, you can use a wrist watch. Point the hour hand of a correctly set watch at the sun. In the northern hemisphere, *south* will always be halfway between the hour hand and number 12 on the face of the watch. Of course, once you know south you can find north, east and west.

### USING YOUR FINGERS TO ESTIMATE THE TIME TO SUNSET

If you have no watch but are concerned about how many hours of daylight are left, here is a helpful tip. Face the setting sun with both arms out straight in front of you. With your fingers estimate the distance between the base of the sun and the horizon. That is, each finger equals about fifteen minutes. Four fingers means one hour until sunset. Four fingers on one hand and two on the other means one and a half hours until sunset, and so forth. If the sun is more than your eight fingers above the horizon, you can still figure the time to sunset by using a stick at arm's length. Hold the stick vertically so that its base comes at the horizon. Mark the place on the stick with your fingernail where you see the base of the sun. Then measure how many fingers fill the space on the stick.





# The Star That Controls Our Lives

Our sun may be an average star -- as stars go. But for us, it's the big clock, the super-cooker, the eye of the universe.

ILLUSTRATIONS BY BILL ERSLAND

BY LILLIAN BORGESON

ONE year out of every eleven, the mysterious star that controls our lives does something even more baffling than usual. For reasons imperfectly understood, its magnetic forces build to a peak and discharge in a pyrotechnic display. Great tongues of flame leap hundreds of thousands of miles into space and violent, erratic flashes of energy stream out from its surface to cause all sorts of weird happenings on earth. As it happens, 1980 is one of those years, and all over the world scientists will be monitoring the spectacle with the most sophisticated instruments they can find.

Which just goes to show, there's still not much new under the sun. As long as humans have lived on earth, we've been monitoring the sun and its effects, even when the most sophisticated instruments available were only our eyes and our wits. We've watched it and worshiped it and wondered about it. Along the way, we've collected a vast array of facts and fables about it. Here are just a few of them.

## Great ball of fire

The sun has more than 99 percent of all the matter in the solar system, most of it packed into its dense core. Its diameter is more than *three times* the distance between the earth and the moon. Like most cosmic balls, the sun has an axis and turns on it, but not very neatly. Because most of the sun is gassy rather than rigid, its surface doesn't turn all-of-a-piece. At its equator, it does one lap in 25 earth days; at its poles it takes approximately 37 days to do a full turn.

## Star light, star bright, star I wish upon tonight . . .

Of the dozen or so stars in the sun's near neighborhood — say, within a radius of 60,000,000,000,000 miles — only one is a lot bigger and brighter. That's brilliant blue-white Sirius, the brightest night-star we see. Alpha Centauri, which is visible from the southern hemisphere, is a yellow star much like our sun in size and brightness. All the others in the neighborhood are redder, smaller and dimmer than the sun, mostly too dim to be seen with the naked eye in spite of their closeness. The smaller orange-and-red stars burn their fuel much more slowly than the yellow intermediates and the blue-white superstars. So they will probably still be chugging along when our sun is nothing more than an old, used-up hunk of helium ash.

## THAT way is up

Most wildlife lovers know that birds use the sun to help them navigate . . . but fishes?

Sure. Not much sunlight penetrates the murky depths, but apparently enough gets through to tell the fish which way is up. Prove it by putting a fish in a small aquarium with a bright light at the top: the fish will maintain a vertical position. But put the light along one side of the aquarium and the fish will tilt in that direction.

# The star that controls our lives

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## Twisters

Even when you know the earth's day and night are caused by its own 24-hour spin on its axis, rather than sun-"rise" or sun-"set," it's not always easy to keep things straight.

Consider the sunflower, for instance. In the morning, it faces east to catch the morning sun, at noon it's straight up, and it looks west for the afternoon sun. So between dawn and dusk the flower has made a 180-degree change in directions, right?

Wrong. It's the land around the sunflower that faces in a constantly changing direction. The sunflower always faces in the same direction — the direction of the sun.

On the other hand, the lowly mallow weed is a *real* twister. Like many plants it keeps its leaves turned to the sun all day. But right after sunset (or earthrise, to be accurate), it turns its leaves from west to east, in anticipation of the dawn that's still hours away.

How does it "know" where the sun will reappear? It's not telling.

## The sun also sets

Or seems to. And its daily disappearance in the west caused much nervousness among prescientific humans, who suspected that it might never come back. Nobody was more anxious than the Aztecs, who saw themselves as the people chosen to protect the sun from extinction. To keep it strong enough to rise every morning, they nourished it with blood — the hearts taken from vast numbers of sacrificed humans, at least 20,000 a year and probably many more.

Meanwhile, peoples whose beliefs were based on the Bible were spared that worry by the Lord's post-flood promise that "while the Earth remaineth ... summer and winter and day and night shall not cease."

## No flare warning

Sunspots, prominences and flares all multiply when the sun hits the top of its 11-year magnetic cycle. But it is flares — the sudden, intense bursts of electromagnetic energy and highly-charged gas particles — that have the most effect on the earth. They batter and penetrate our magnetic shield and spark weird happenings.

On the plus side, increased flare activity this year should make the "northern lights" brilliant and beautiful. These auroras are caused by electromagnetic energy, magnified by flares.

On the minus side, flares can cause powerline surges and blackouts, increase radiation danger in high-flying jetliners and mess up radio-TV communications. Not long ago, flare interference jammed emergency radio channels so badly that a California fire department dispatcher was getting emergency calls from an airplane crash in West Virginia. And flare activity is what caused Skylab to fall years before it was supposed to.

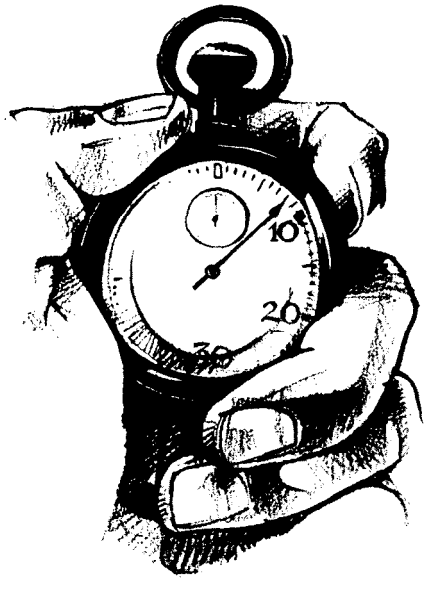
"We do a lousy job of predicting flares," U.S. solar scientist David Rust told a reporter recently. Not surprising. Nobody knows exactly what causes them, and their speed gives earthlings very little time to react. The electromagnetic energy of a flare covers the distance from the sun to the earth at the speed of light and its high-charged gas particles can get here in just 20 minutes.

## Higher noon

About 2,300 years ago, a vacationing Greek named Eratosthenes noted that the noon sun at Alexandria, Egypt, was a little closer to "straight up" than at his home town in Greece. With that observation, plus the new game of logic called geometry, he calculated the circumference of the earth. Correctly.

## Time lag

Well, actually, we never really see the sun at all. We see what it looked like a little while ago. That's because its light, traveling at 186,000 miles per second, takes eight minutes to get to the earth. But that's practically nothing, as stellar distances go: the light of the next-closest star takes more than four years to get here, and our view of most other night-stars is dozens, hundreds or even thousands of years old.



## Paeans

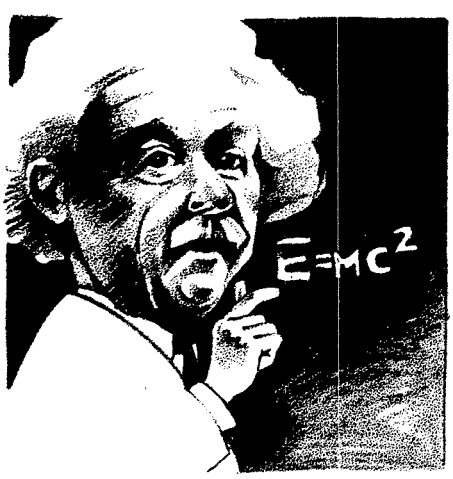
*Oh, thou whose dawn is life, whose setting, death,*
*In the great dawn, then lift up me, thy son.*
— King Ikhnaton of Egypt, thirteenth century B.C.

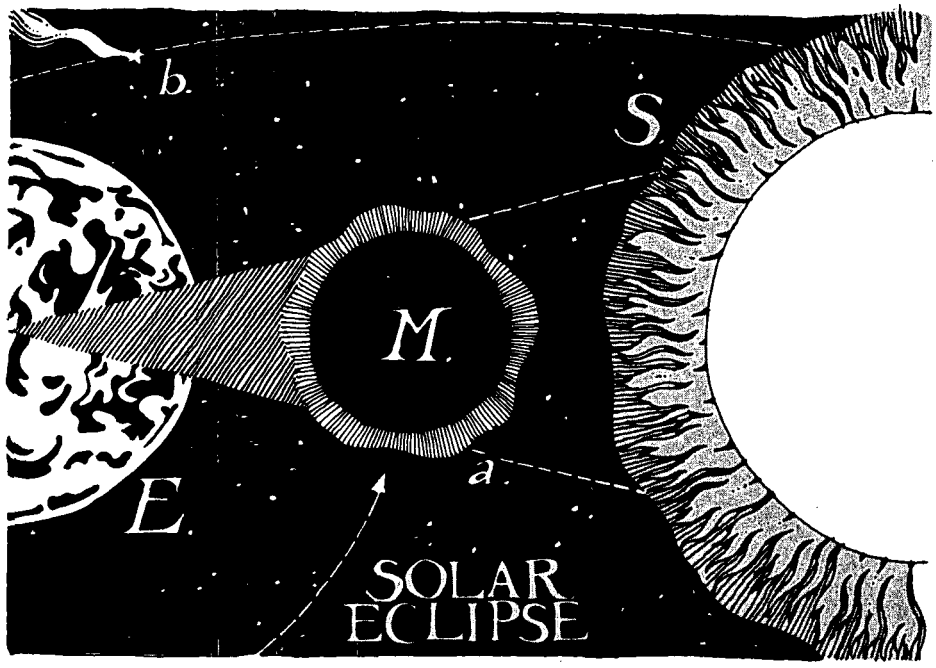
*Thou Sun, of this world both eye and soul.*
— John Milton, seventeenth century A.D.

(**paean,** pe-an, *n*: originally a song of praise to Apollo, a.k.a. Helios, god of light and the sun.)

## The fourth dimension? Oh dear . . .

If you have a hard time grasping Einstein's contention that space and time are different aspects of the same thing, here's a close-to-home solar illustration. Any earth date — say, August 31, 1980 — isn't just a "time." It's also a place in space, a specific section on the earth's track around the sun. So instead of saying, "next August 31," you could say, "the next time earth is at the place in solar orbit that we call August 31." Right? Of course. Or as Dr. Einstein put it: "There is no more commonplace statement than that the world in which we live is a four-dimensional space-time continuum."




## Sundance

Eclipses are an intricate three-part ballet in which the sun has the star role. An eclipse of the moon happens when the earth moves directly between the sun and the moon, so that the earth's shadow, cast by the sun, obscures the moon. An eclipse of the sun happens when the moon moves between the earth and the sun at exactly the right angle to obscure the sun.

If the earth's orbit around the sun were in exactly the same plane as the moon's orbit around the earth, there would be two total eclipses every month: an eclipse of the sun at new moon, an eclipse of the moon during every full moon. But it's not, so there aren't. Instead, eclipses happen two or more times a year at irregular intervals, but in a pattern that repeats every 18 years.

## Waste not, want not

Mull this one over: In just *one second,* the sun puts out more energy than humanity has used in its whole history.

The sun radiates its energy impartially in all directions, and only about 1/2,000,000,000 of it reaches the earth. But that's a bunch: 170,000,000,000 megawatts every second (one "mega" is a million watts). Of that, 40 percent is reflected back into space, 15 percent is absorbed by the earth's atmosphere, 14 percent powers the evaporation/rainfall cycle that nourishes the dry land, and 2 percent maintains the earth's wind and ocean currents. Only about 7,000,000 megawatts per second, .004 of one percent, are absorbed by the earth's plants, and less than half of one percent of that is made into food.

Enter humanity, to play its so far tiny role in the solar-energy economy. People use only about 2 percent of the earth's plants for food, feeding another 1½ percent to domestic animals. Solar energy stored as fossil fuels and firewood is converted to 200,000 megawatts of usable energy each second. This is a mere 1/800,000,000,000 of the sun power we receive each second.

## Oddball

On Venus, every day would seem longer than a year — because it is. Venus orbits the sun once every 225 earth days: that's how long its year is. It turns on its axis only once every 250 earth days: that's how long its day is. The combination of those two motions makes "sunrise" happen on Venus once in about 118 earth days.

## Spotting the spots

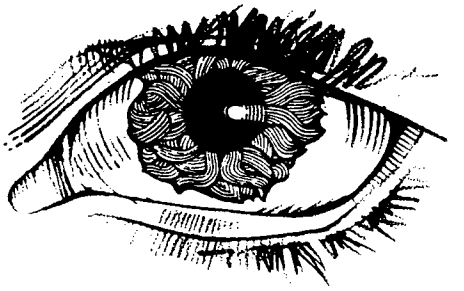
In order to be visible to the naked eye, a sunspot — one of those pyrotechnic displays referred to at the outset — has to cover at least 500,000,000 square miles of the sun's surface. The biggest recorded to date: 7,000,000,000 square miles.

Sunspots were seen and noted by the ancient Greeks and "rediscovered" by Europeans in 1611, after Galileo started scanning the skies with a telescope. In between, the leading thinkers of the Dark Ages maintained that the sun was a perfect, unblemished sphere, so sunspots obviously "couldn't be."

Note: Sunspots only *look* black against the dazzling radiance of the sun's surface. Against a dimmer background, a big spot would look as bright as the full moon.

## Fire and ice

Studies of the earth and its fossil records show that great sheets of ice have advanced and receded through most of its history, and the intervals — an Ice Age lasting a few million years every 150,000,000 years — correspond roughly to the path the sun takes on its great orbit around the hub of the Milky Way. Some scientists theorize the Ice Ages happen when the sun and its family pass through the dust clouds of the galaxy's two spiral arms.



## The eyes don't have it

The intense radiation of the sun can damage human eyes quickly and permanently. Never look at it directly when it's high and bright in the sky. Never look at it through binoculars or nonsolar telescopes. Look at it with the naked eye only when it's a big red ball, hazy on the horizon at sea level . . . and even then, do it briefly.

The safe way to view the sun is indirectly, by projecting its image through an eyepiece onto some other surface. This is done in a big way by the instrument called the heliostat. Heliostats are used mostly in conjunction with the great solar telescopes (the largest, at Kitt Peak Observatory in Arizona, produces a 33-inch-diameter image of the sun), and mainly by researchers. One of the few heliostats always available for public viewing is at the Space Museum in Hong Kong.

## The prodigal sun

The sun cooks up energy deep in its core, where super-high temperatures and pressures trigger nuclear reactions in which lighter elements combine to form heavier elements. Some free energy gets away as a kind of by-product. As a result of this conversion, the sun is losing about 4,500,000 tons of its mass every second. At that rate, it will probably start burning itself out in about 5,000,000,000 years.

## Children of the sun

For some of the racial differences that have caused human disharmony, blame the sun . . . or our ability to adapt to the sun's different effects at different parts of the earth's surface. In general, scientists say, the shape, size and color of mammals (including humans) tend to follow these patterns: The average size of individuals is smaller in warm climates, larger in cold climates. Protruding body parts like noses and legs are longer in warm climates, shorter in cold climates. Colors are darker in warm climates, lighter in cold climates.

The dark-skinned peoples who developed near the earth's equator, where the sun's rays are most direct and most intense, have more of the protective pigment melanin, which absorbs the ultraviolet rays of the sun and helps resist both sunburn and skin cancer.

## When dinosaurs stopped dining

About 65,000,000 years ago, a six-mile-wide asteroid crashed into the earth. The impact kicked up so much dust that sunlight was screened out all over the world for several years. Without it, all the plants stopped growing, and creatures that ate fresh plants or plant-eating animals starved to death — vanished, literally, in a cloud of dust. By the time the dust settled and sunlight returned to revive dormant plants, the only critters that survived were those that could get by on nuts, seeds and decaying vegetation. Life and evolution took off on a new tangent.

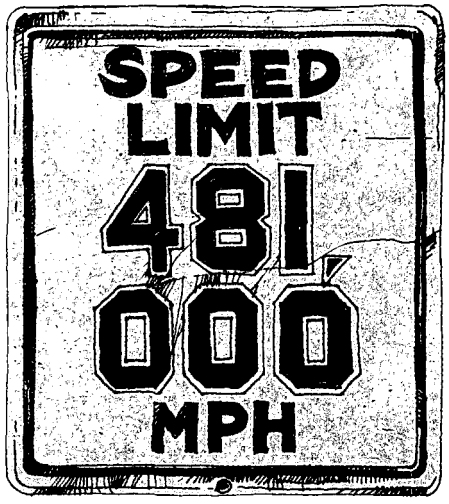
So goes a brand-new theory proposed by Nobel Prize winner Luis Alvarez and a team of University of California scientists. It's only a hypothesis, they grant, but one that explains an otherwise puzzling part of the fossil record: the fact that 65,000,000 years ago more than half the species then living, including dinosaurs, suddenly died out.

## Early but right

Nearly 6,000 years ago, the sun-watching Chaldeans of Asia Minor made accurate sundials, divided the day into the hours we still use and figured out the recurring cycle of eclipses. The ancient Egyptians, Chinese, Celts and Aztecs all made accurate predictions about the movements of the sun. And in a burst of solar insight more than 2,000 years ago, Greek astronomers figured that the sun might be a big, burning hunk of metal, larger than the southern half of Greece and maybe even 300 times larger than the earth — instead of 27 inches or "the size of a foot," as scholars elsewhere maintained. The Greeks also surmised that the earth rotated on an axis and orbited around the sun. They even took a fair shot at estimating the distance between the earth and the sun, using the math methods still in use today.

## This place has such a nice atmosphere . . .

. . . For which we should all be grateful. On our neighbor the moon, which has no atmosphere to reflect, diffuse, retain and generally soften the radiance of the sun, the temperature gets to 243 degrees Fahrenheit at noon, drops to 260 degrees Fahrenheit below zero after nightfall.




## Moving right along . . .

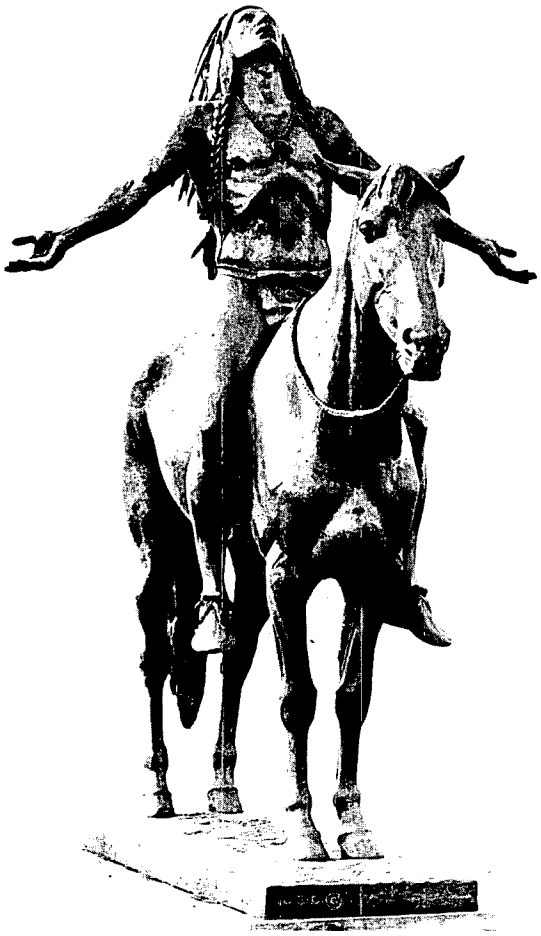
Right now the earth is spinning on its axis at the rate of about 700 miles per hour, and carrying you with it. It's also barreling along at about 66,000 miles per hour on its annual 584,000,000-mile track around the sun, and carrying you with it. Meanwhile, like everything else in the solar system, the earth is accompanying the sun on *its* 225,000,000-year orbit around the far-distant center of our home star system, the Milky Way galaxy — and carrying you with it at about 481,000 miles an hour.

And you thought you were just sitting in one spot, reading a magazine. ■

*Free-lance writer Lillian Borgeson has had a lifelong interest in astronomy, lives in sunny California and claims a generally sunny disposition.*

## Behold, My Brothers

Energy is just one of the gifts of our earth. We need energy, but we also need other things: clean air and water, food and land that will grow it, and space for living. We have to weigh each against the others.



The Appeal to the Great Spirit
Cyrus E. Dallin

# Behold my brothers,

*the Spring has come; the Earth has received the embraces of the sun and we shall soon see the results of that love!*

*Every seed is awakened and so has all animal life. It is through this mysterious power that we too have our being and we therefore yield to our neighbors, even our animal neighbors, the same right as ourselves, to inhabit this land.*

*Yet, hear me, people, we have now to deal with another race – small and feeble when our fathers first met them but now great and overbearing. Strangely enough they have a mind to till the soil and the love of possessions is a disease with them. These people have made many rules that the rich may break but the poor may not. They take tithes [taxes] from the poor and weak to support the rich who rule. They claim this mother of ours, the earth, for their own and fence their neighbors away; they deface her with buildings and their refuse. That nation is like a spring freshet [stream] that overruns its banks and destroys all who are in its path.*

These words were spoken by the Sioux chief, Sitting Bull, nearly one hundred years ago.

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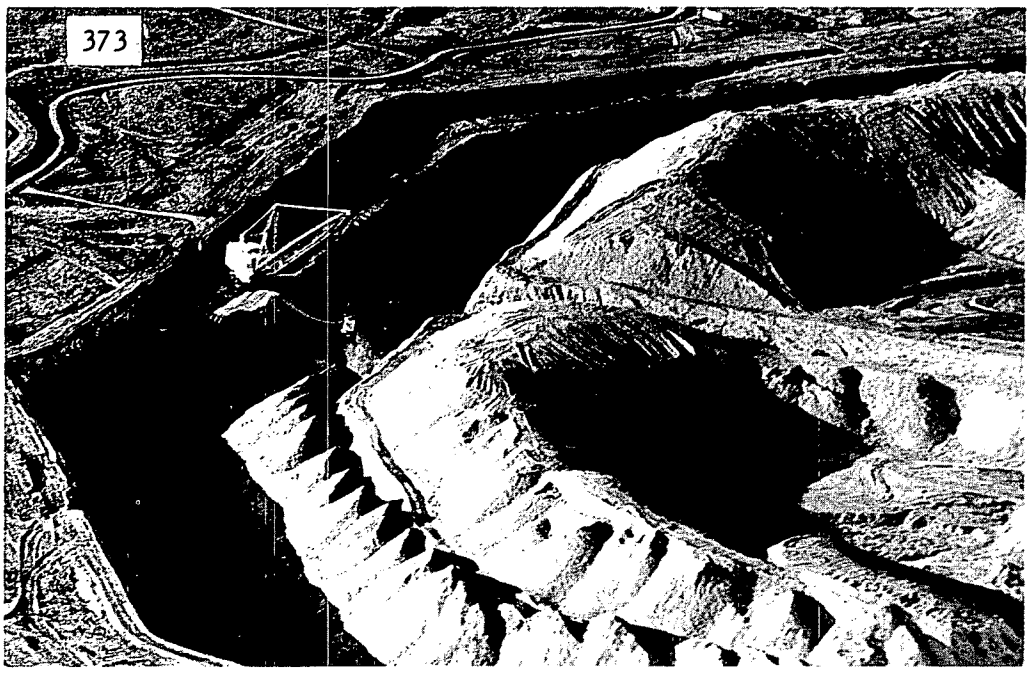
Also one hundred years ago, Herman Melville, the author of *Moby Dick*, said,

*My eyes rolled over the wide rolling country and over the village and over a farmhouse here and there and over woods, groves, rocks and falls – and I thought to myself what a slight mark does man make over this huge green earth.*

Who was right, the Indian or the white man? In a sense, they were both right. Even though much of "this huge green earth" is now covered with the white man's possessions and refuse — parking lots, dumps, hot-dog stands, highways, power lines — there is still a lot of scenery that is pleasing to the eye. There are still a few places where humans have respect for the land that supports them. But are there enough places left? When the human population doubles in about 35 years, will the Indian's words alone be true?

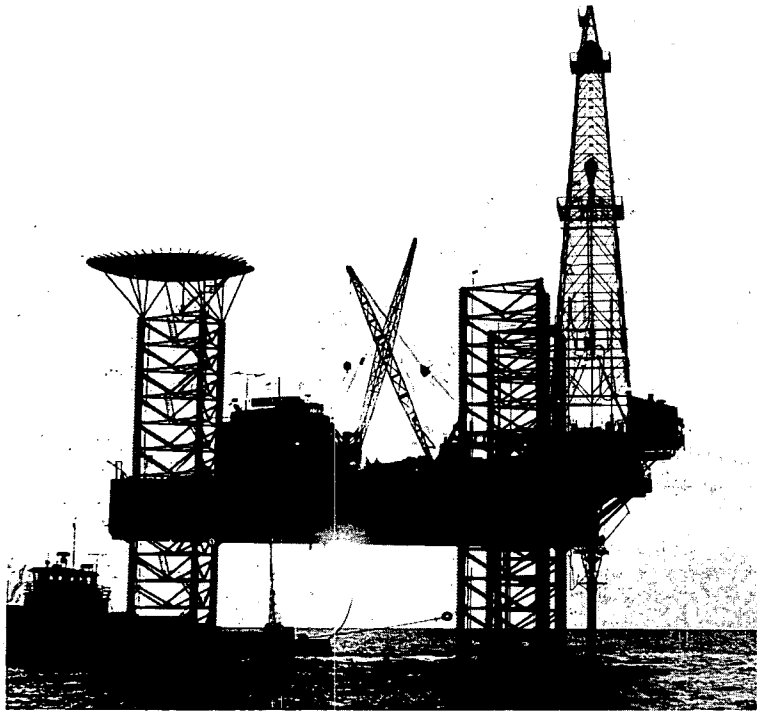
Much of the mistreatment of the land, the water and the air is caused by our use of tremendous amounts of energy. On the next few pages we have outlined some of the energy problems we are facing now. There are no easy solutions. Energy problems will be even more difficult to solve in the future.



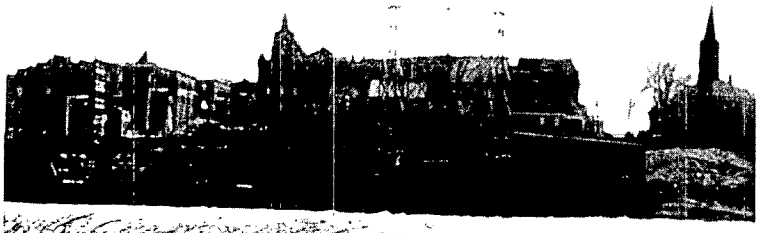
# SOURCES OF ENERGY

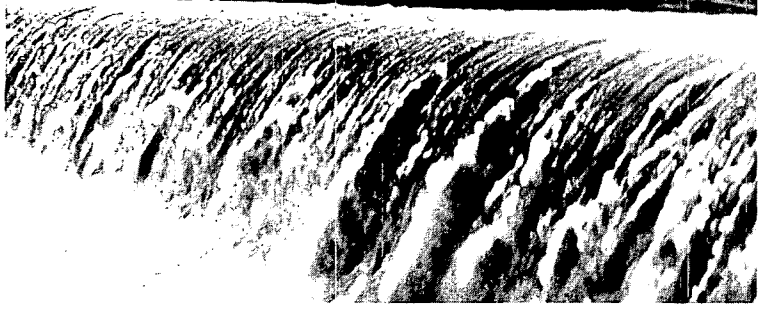
The strip-mining of coal just below the surface of the land (left) provides a relatively inexpensive source of fuel for making electricity. Some day, economical ways of making gas or synthetic oil from coal may be found. As petroleum becomes more expensive and scarce, the search for coal both underground and at the surface will increase.

However, strip-mining results in a ravaged landscape. Gigantic holes and piles of waste are left behind. The waste materials often erode and wash into rivers and streams. In most cases the strip-mine can be filled in, covered with soil and planted with grasses. This is an expensive process that adds to the cost of coal. In the past, mining companies as well as some government leaders have resisted the added cost of restoring the land. Hopefully, new laws will require that strip-mines be restored.

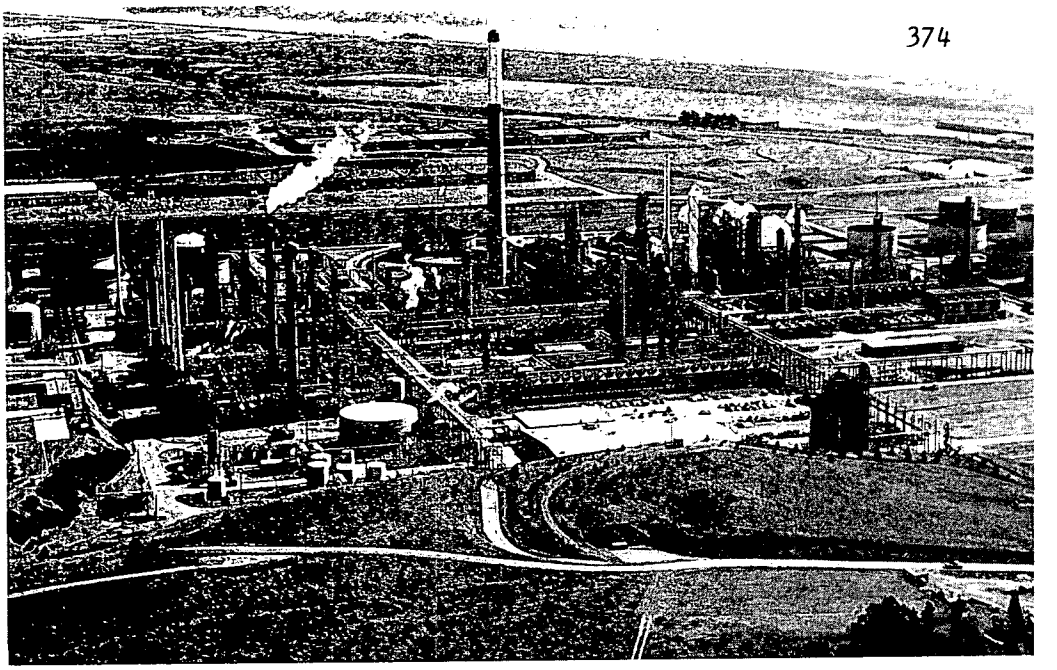


Drilling platforms (center) up to one hundred miles offshore search for natural gas and petroleum for electricity, gasoline and heating fuel. This drilling in the oceans is increasing as sources of oil and gas under the soil become scarce. Most coastal wells are operated without oil leaks or "blow outs" that cause oil pollution. But occasionally accidents happen. As more wells are drilled in the oceans, the chances of oil damage to our beaches and salt marshes and to the wildlife and food sources will increase.





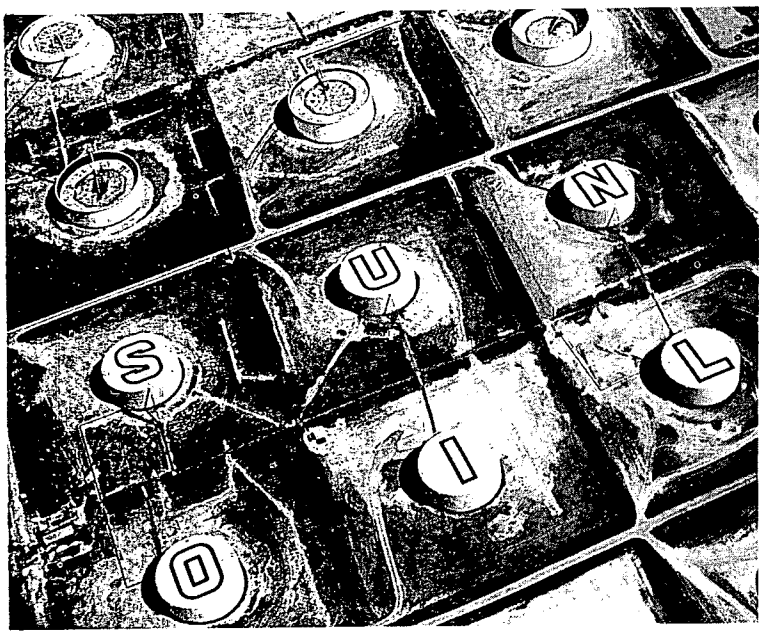
Hydroelectric power (lower left) is considered to be a relatively pollution free source of electricity. No fossil fuels are burned. Water falling over a dam in a river turns a turbine and generates electricity. The electricity is then transmitted on power lines to urban centers. However, this process causes disruption of the river. Dams alter the flow of the river and thus the life in the river. They flood large areas of land and cause the reservoirs that are created to fill up with silt. Fish migrating upstream must be helped over the dams with specially constructed "ladders." These are expensive and are often omitted.



## REFINING AND STORAGE

After petroleum is extracted from the land or sea, it must be processed or refined into different products and then stored. This requires a large amount of land and results in a certain amount of air and water pollution.

In recent years, refinery operations have improved and storage areas are carefully controlled to prevent pollution. However, as our demands for more and more oil, gasoline, plastics and other petroleum products grow, we must expect more refineries and "tank farms" on our landscapes.




## POWER GENERATION

The largest use of both oil and coal is for generating electrical power. As new plants have been added and air pollution laws strengthened, the process is becoming somewhat cleaner. However, the burning of fossil fuels that have large amounts of sulphur in them continues to be a threat to health.

Because of the need for cooling water, generating plants are often built on wetlands, rivers, seacoast and other scenic sites. While most of us use the electricity they produce, no one wants a power plant in his backyard!

## GOOD READING

**Man's Mark on the Land; The Changing Environment,** Arthur S. Gregor, Scribner's, 1974. (e,j)

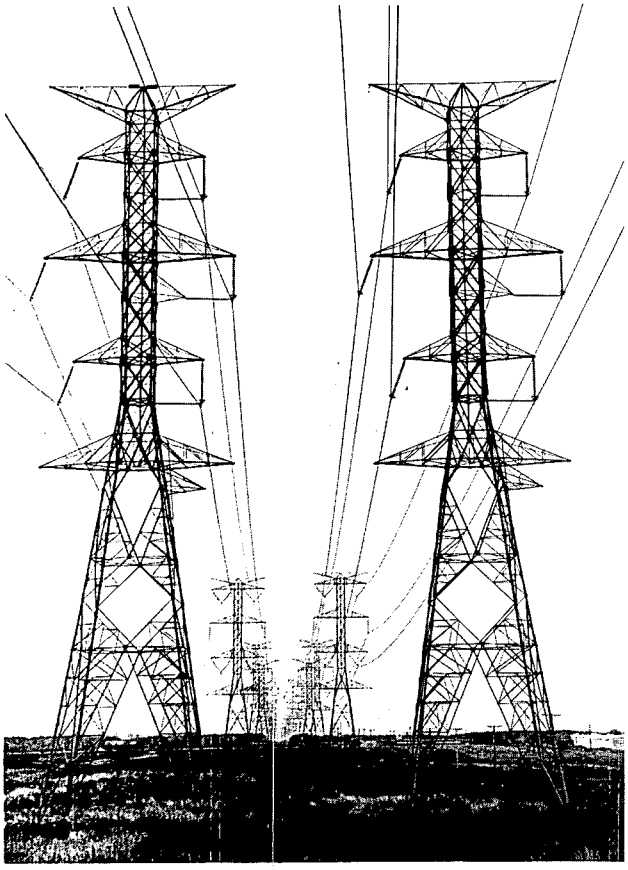
**Man, Nature and History: Controlling the Environment,** (Nature and Science Library) Natural History Press, 1969. (j,a)

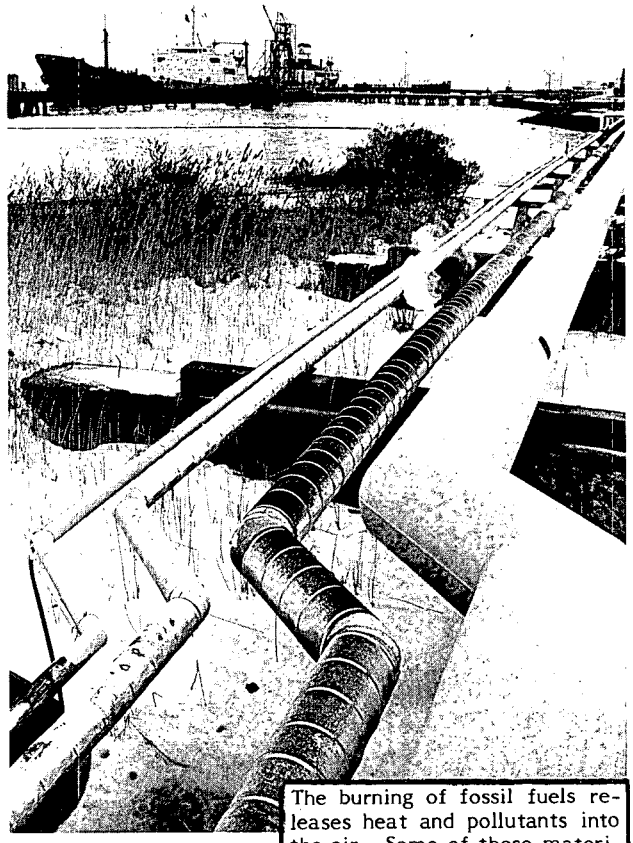
**Energy, Power For People,** Laurence Pringle, Macmillan, 1975. (j,h)

**The Flow of Energy in Nature,** Laurence Pringle, Crowell, 1975. (e)

**TEACHERS** and **YOUTH LEADERS** — could you use extra projects, discussion topics, games, book and film lists for your class or youth group? *The Curious Naturalist* now provides a bimonthly teachers' guide leaflet. For a sample copy send a *stamped*, self-addressed envelope to The Curious Naturalist, Lincoln, Mass. 01773.

'p = primary, e = elementary, j = junior high, h = high school, a = adult





The burning of fossil fuels releases heat and pollutants into the air. Some of these materials are in the air naturally. In natural systems, the amounts of these materials seem to be in balance. However, as man burns more fossil fuels there is concern about the increasing amounts of these materials in the air.

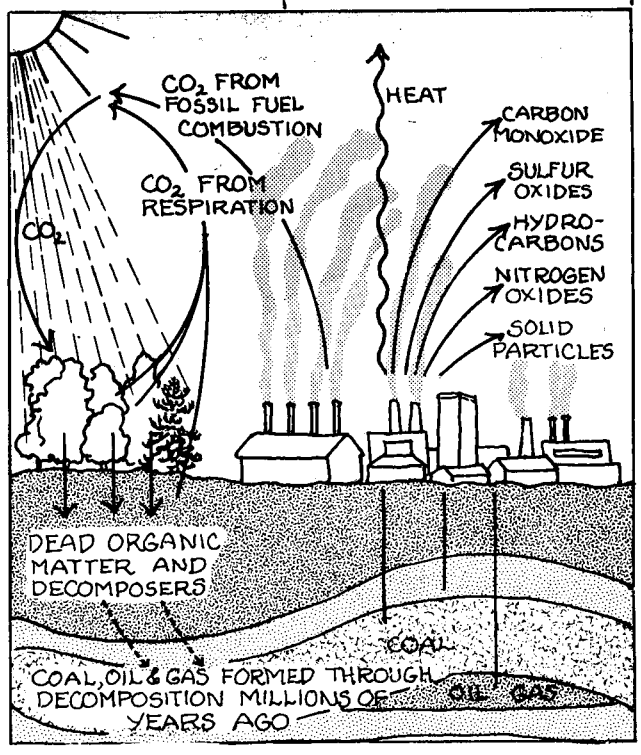
## TRANSMISSION

Both before and after a fuel is consumed, it must be transported. Oil and gas travel across land by pipelines or across oceans by tanker ships. Electricity is transmitted on power lines strung on towers that seem to march across much of the landscape. Pipelines and power lines use large amounts of land.

There has been some progress in placing these transport systems underground where they at least cannot be seen. In some cases, such as the Alaskan tundra, oil pipelines cannot be buried. This presents problems for migrating animals.

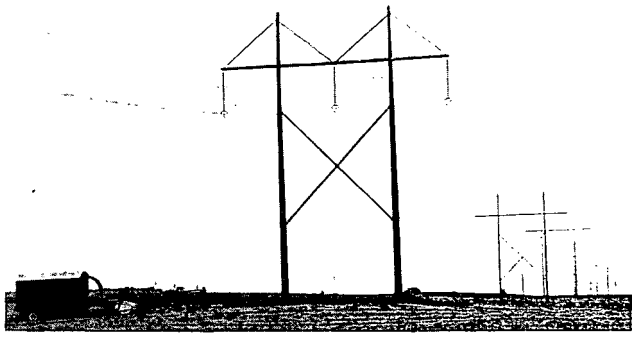
High voltage lines produce heat so they cannot always be buried. New research is in progress now on specially cooled power lines that allow for underground systems. However, it is unlikely that many existing power lines will be removed from the scene.

Tankers that carry oil on the oceans have grown to super sizes. When accidents occur in the future, the oil spills will be more serious and harder to control. Seabirds, sea mammals, fish, plankton and shellfish are sure to be threatened by future oil spills.

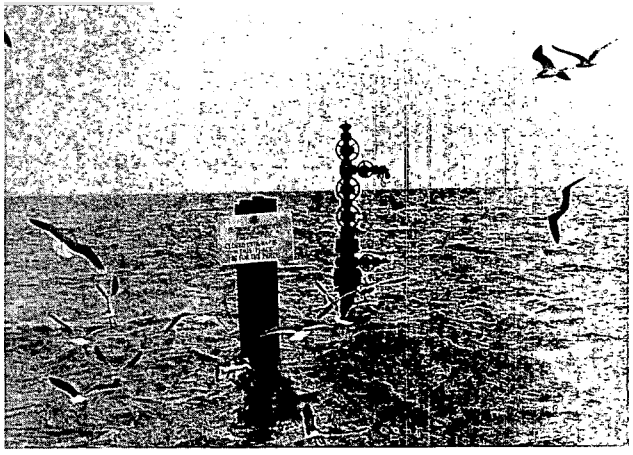


## AN ENVIRONMENTAL PRICE TO BE PAID

We all enjoy an easier life because of the tremendous amount of energy our nation obtains. We pay an environmental price for this energy in the form of disturbed land, poor water quality and air pollution. Some of the intrusions on our landscape and waterways are relatively minor. Plants, animals and people can live with

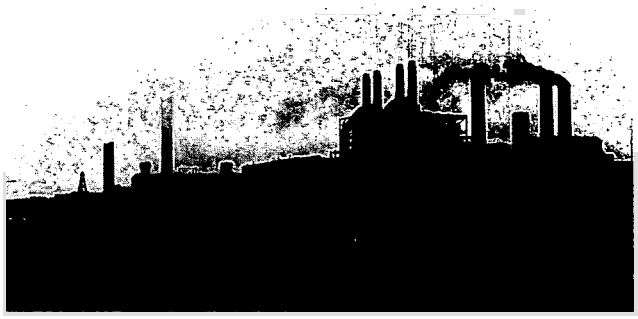


some power lines. We can live with some oil and gas rigs off our coasts.

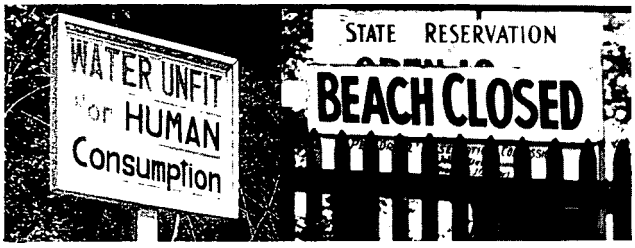


We will have to live with even more energy related intrusions on our land and water if our numbers and our energy demands continue to rise.

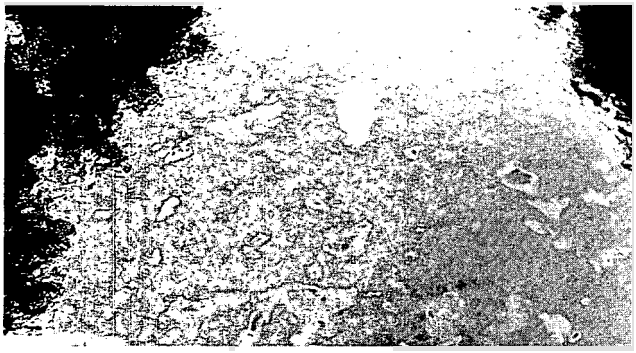
Extra care will be needed in the future to control the environmental cost of our energy-rich life. People, animals and plants cannot live with air that is dangerous to breathe, with water



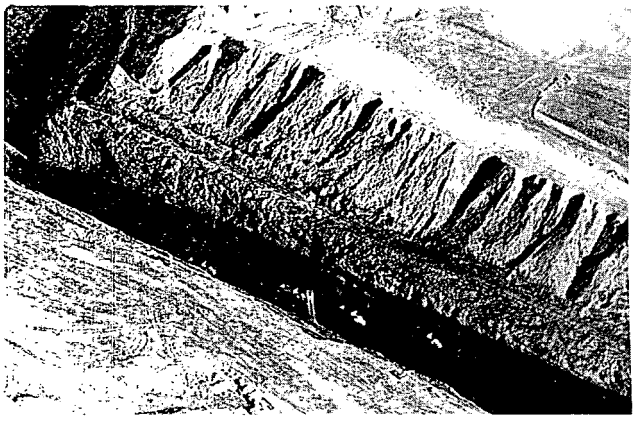
that is unfit for drinking, or with very many dis-




astrous oil spills on our oceans. And as our



population grows we will not be able to feed ourselves unless we learn to take special care of our land.

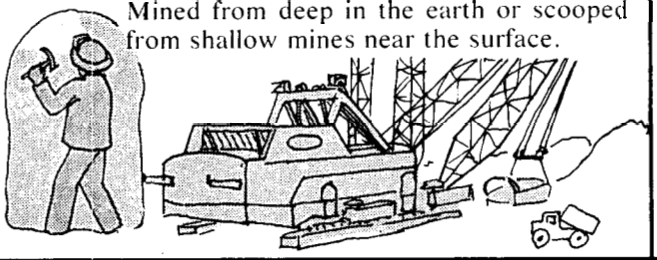
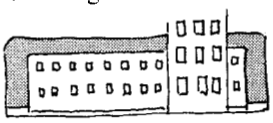
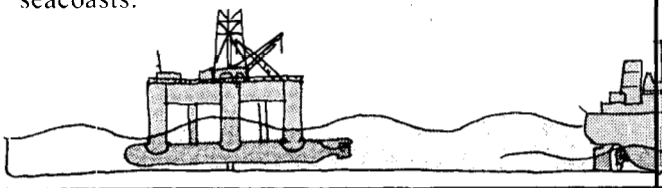
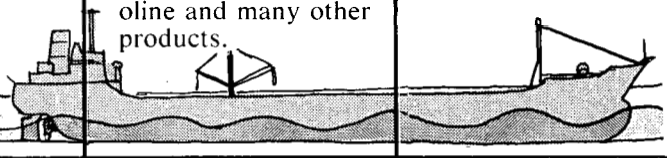
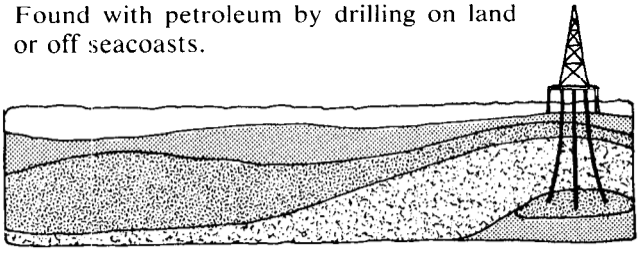
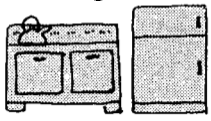
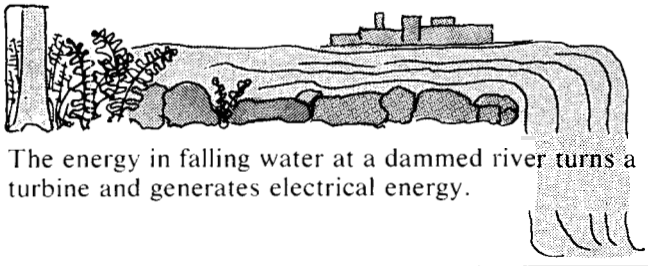
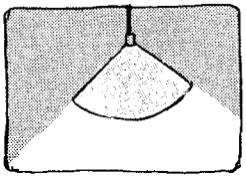
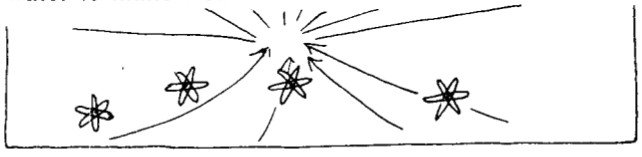
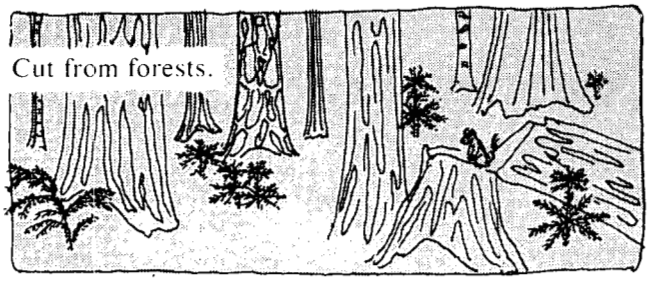
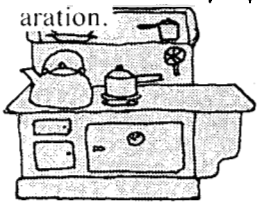


The alternative energy sources we have explored in *The Curious Naturalist,* such as solar, wind, geothermal and methane energy, hold some of the answers to our future energy needs. There are other experimental energy sources that may also help. But no one energy source is the perfect answer. Some combination of many energy sources, including the fossil fuels that remain, will probably be the best solution for the future.

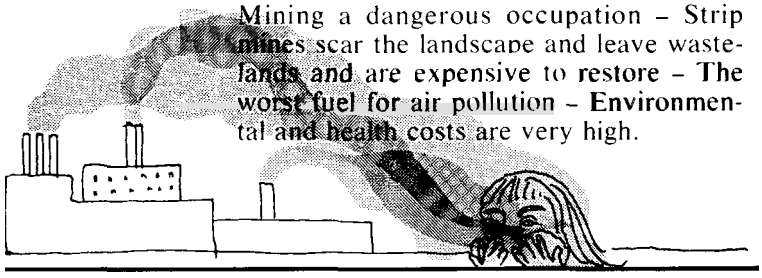
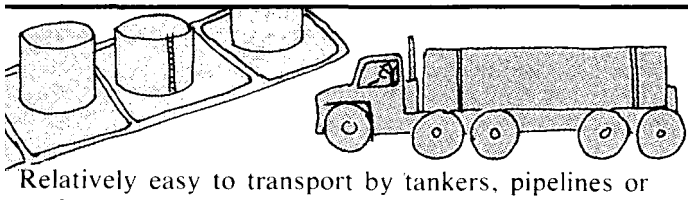
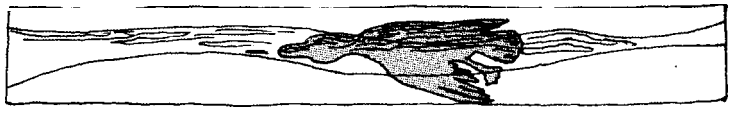
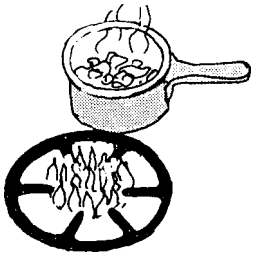
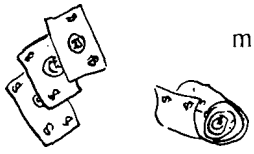
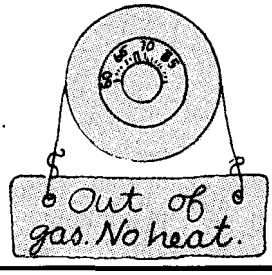
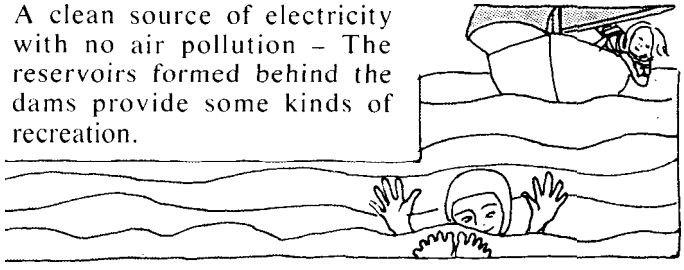
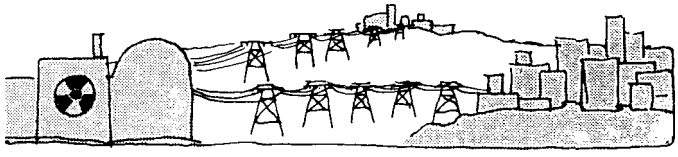
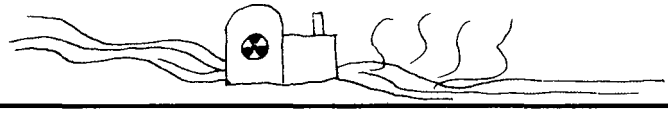
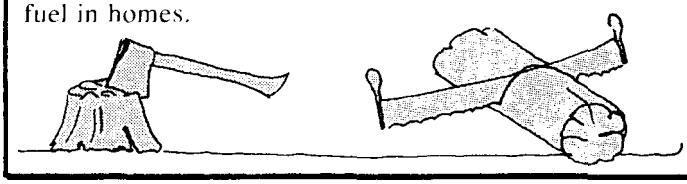
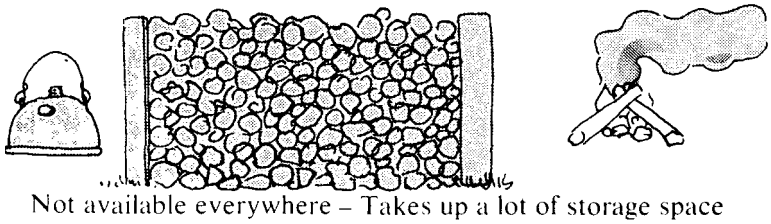
Whatever the solutions may be; we must make sure they are rooted in good conservation practices. Just as with other of the earth's resources — the soil, the forest, the air, the water, the wildlife — we must make wise and careful use of energy.

What are you doing today to conserve our energy resources? What will you do tomorrow?

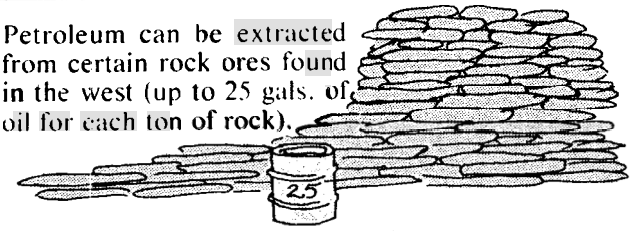
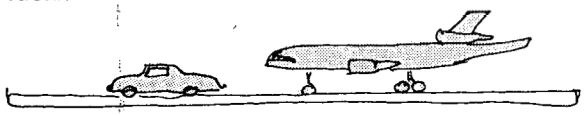
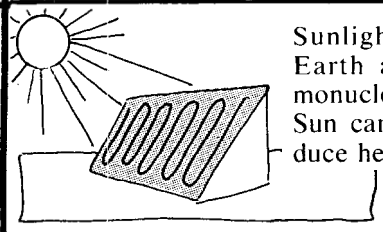
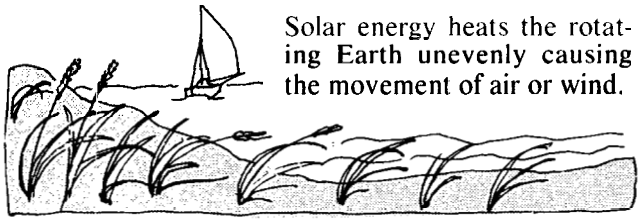
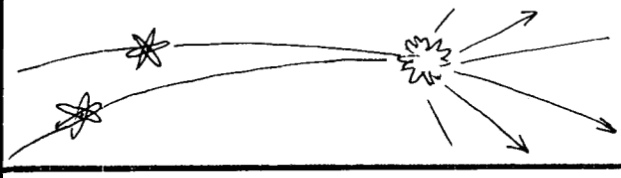
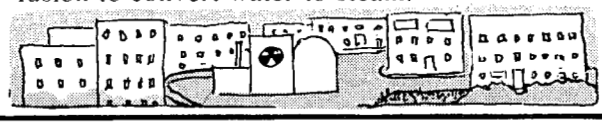
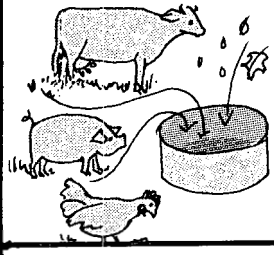
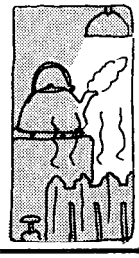
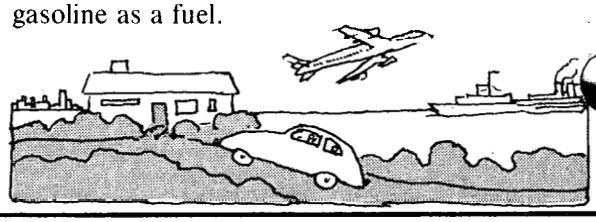
## CHART OF PRESENT ENERGY SOURCES

| ENERGY SOURCES | HOW IS IT PRODUCED? | USE | RENEWABLE? |
|---|---|---|---|
| COAL | Mined from deep in the earth or scooped from shallow mines near the surface.  | Burned in power plants for electricity or burned for heat in buildings.  | No, will run out someday. |
| PETROLEUM | Pumped from deep wells on land or off the seacoasts.  | Transported to refineries to be made into fuel oil for heat or electricity, gasoline and many other products.  | No, will run out sooner than coal. |
| NATURAL GAS | Found with petroleum by drilling on land or off seacoasts.  | Burned as a heating and cooling fuel and for drying food products and other manufacturing.  | No, will run out with petroleum. |
| HYDRO-ELECTRIC |  The energy in falling water at a dammed river turns a turbine and generates electrical energy. |  To make electricity. | Not really, because suitable sites are becoming scarce. |
| NUCLEAR FUEL | The nuclei of atoms of uranium are split apart by fission in a nuclear reactor. The heat produced boils water to make steam and drive a turbine.  | Electricity is produced from the steam driven turbine. | Yes, although uranium is scarce, other fuels will be used in the future. |
| WOOD |  Cut from forests. | Burned in stoves for heat and food preparation.  | Yes |

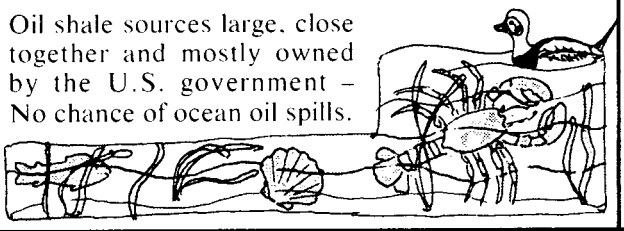
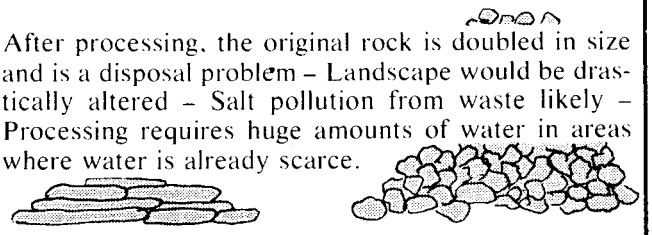
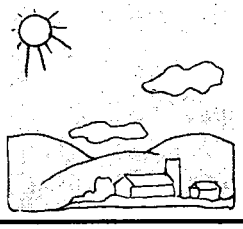
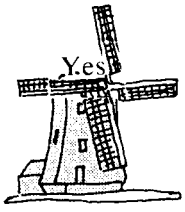
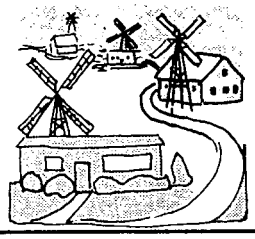
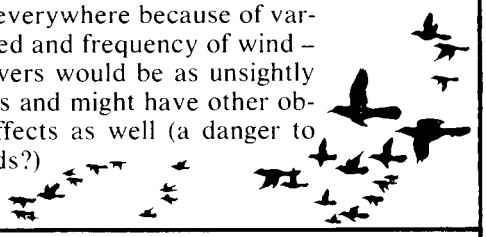
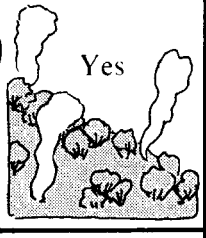
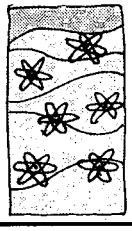
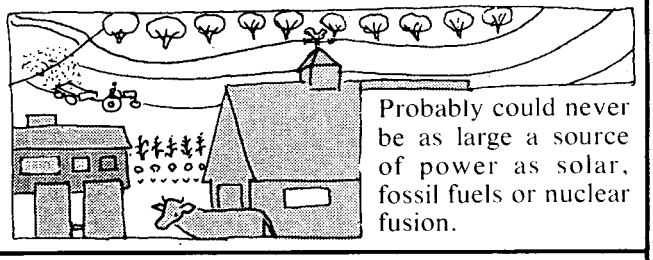
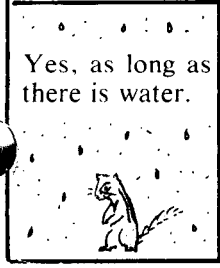
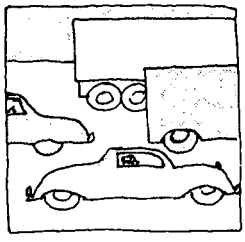
Most of the energy we use today for transportation, heating, manufacturing, lighting, and household uses involves the fuels and processes described on this chart.

| ADVANTAGES | DISADVANTAGES |
|---|---|
| Still abundant especially in strip mines – Requires relatively little refining – Less expensive to mine or buy. | Mining a dangerous occupation – Strip mines scar the landscape and leave wastelands and are expensive to restore – The worst fuel for air pollution – Environmental and health costs are very high.  |
|  Relatively easy to transport by tankers, pipelines or surface vehicles – Conveniently stored – Until recently, very abundant and relatively inexpensive to produce. | Becoming more expensive and supplies running short – Refineries often pollute water, air and land – High sulphur content causes air pollution when burned — Oil spills at sea damage seacoasts and endanger food chains that supply food for animals and humans — More spills inevitable.  |
|  Easily transported by pipeline – The cleanest burning of the fossil fuels | Becoming scarce and therefore more expensive.    |
| A clean source of electricity with no air pollution – The reservoirs formed behind the dams provide some kinds of recreation.  | The sites are often far from cities and electricity must be transmitted over long power lines – Much energy lost as heat from the power lines – Dams destroy the environment of many river organisms including migrating fish – Reservoirs flood much land, destroy some kinds of recreation and fill up with silt. |
| A small amount of fuel produces a tremendous amount of heat energy – No gaseous or particle pollution in the air – Cost of electricity may be kept low.  | Nuclear wastes are extremely dangerous and difficult to handle and contain – Leaks of radioactive fuels or wastes or other accidents could endanger many lives and contaminate land – Large amounts of water needed for cooling thus causing heat pollution of waterways or fog in the air – The fuels could be stolen and made into nuclear weapons.  |
| Where available it is easily obtained and prepared for use by individuals – A major source of fuel in this country a hundred years ago and still used in many country homes and farms – A good back-up source of fuel in homes.  |  Not available everywhere – Takes up a lot of storage space – A rather low amount of heat available – Pollutes the air. JH/MSS |

# CHART OF ALTERNATIVE ENERGY SOURCES

| ENERGY SOURCES | HOW IS IT PRODUCED? | USE |
|---|---|---|
| OIL SHALE | Petroleum can be extracted from certain rock ores found in the west (up to 25 gals. of oil for each ton of rock).   | As a substitute for petroleum from wells – A stop-gap measure to tide us over until better sources can substitute for diminishing fossil fuels.  |
| SOLAR |  Sunlight that reaches the Earth as a result of thermonuclear fusion within the Sun can be gathered to produce heat and electricity. | Individual buildings have glass collectors on roofs, or large collector "power station" units could be built in deserts, or orbiting satellites could transmit solar generated electricity to Earth. |
| WIND |  Solar energy heats the rotating Earth unevenly causing the movement of air or wind. | The wind will turn blades attached to a shaft and connected to a generator to make electricity. Power can be produced by windmills on individual buildings or a series of large windmills on plains or seacoasts could make electricity for whole cities or regions. |
| GEO-THERMAL | The slow decay of radioactive rock deep within the core of the Earth produces heat that turns subterranean water to steam. | In certain areas heated steam comes near or to the surface. It can be used to heat buildings directly or to turn a turbine and generator to make electricity for cities. |
| NUCLEAR FUSION | The joining or fusing of atomic particles to release energy about the same way that the sun works.  | Nuclear fusion power plants would be located near or in cities and produce large amounts of electrical power by using the heat of the nuclear fusion to convert water to steam.  |
| METHANE |  Large amounts of a burnable gas, methane, can be produced by the breakdown of organic wastes such as manure, garbage or leaves. | The methane can be burned as a cooking or heating fuel or used to power a generator to make electricity in individual homes or on a larger scale. The gas can also operate vehicles.  |
| HYDROGEN | The gaseous element hydrogen can be burned as a fuel. Hydrogen together with oxygen form water. Therefore, one very abundant source of hydrogen is water. Before the hydrogen in water can be used it must be separated from the oxygen by devices called electrolyzers. The hydrogen can then be stored and used to power vehicles or for industrial processes. | It might some day replace natural gas and gasoline as a fuel.  |

Because of high costs, environmental problems, and decreasing supplies, our present energy sources are gradually giving way to new sources or up-dated versions of old sources. Here are some energy sources that may be part of your future.

| RENEW-ABLE? | ADVANTAGES | DISADVANTAGES |
|---|---|---|
| No | Oil shale sources large, close together and mostly owned by the U.S. government – No chance of ocean oil spills.  | After processing, the original rock is doubled in size and is a disposal problem – Landscape would be drastically altered – Salt pollution from waste likely – Processing requires huge amounts of water in areas where water is already scarce.  |
| Yes |  No air or water pollution or strip mining – No charge for sunlight – Buildings could be powered individually or large collectors used. | Sunlight varies according to season, weather and location so must be stored or a substitute source provided – If large collectors used they would use much land. |
|  Yes | No air or water pollution or strip mining – Unlimited supply – No charge for use – Buildings could be powered individually.  | Not suitable everywhere because of variations in speed and frequency of wind – The large towers would be as unsightly as power lines and might have other objectionable effects as well (a danger to migrating birds?)  |
|  Yes | An unlimited supply of heat in the Earth – No mining or transport of dangerous fuels required – Already being used in some parts of world – Pollution would be less than with fossil fuels. | Some destruction of land (often scenic areas) would occur – Large amounts of cooling water needed – Salt pollution of surface water a problem – Also some air and noise pollution from the released steam. |
| Yes |  An almost unlimited source of fuel, the deuterium and tritium found in sea water – Would produce large amounts of power – Fewer environmental problems than with nuclear fission plants. | Would use large amounts of cooling water – some heat pollution of waterways likely – Radioactivity within plants would be high although not as much or as dangerous as in present nuclear plants – some leaks of radioactive tritium likely – Disposal of the plant after no longer usable would be a problem. |
| Yes | A good use of materials that are often discarded to cause pollution – An abundant supply of plant wastes available – The gas is easily compressed for use in vehicles – A plant fertilizer is left over after processing – Could be most effectively used on farms. |  Probably could never be as large a source of power as solar, fossil fuels or nuclear fusion. |
|  Yes, as long as there is water. |  Burns very cleanly, so might make pollution control devices for vehicles and power plants unnecessary — Can be stored and transported safely. | The separation of large amounts of hydrogen and oxygen from water requires large amounts of electricity. Some other kind of power (fossil fuel, solar or nuclear) would be needed in large amounts to make the electricity to process the hydrogen to make fuel for other uses. JH/MSS |

There are many other sources of power that we have not discussed. See what you can find out about tidal power, ocean thermal power, heat pumps, fuel cells, or the fairly simple process with the long name, magnetohydrodynamics, MHD for short.

*Our land is more valuable than your money. It will last forever. It will not even perish by the flames of fire. As long as the sun shines and the waters flow, this land will be here to give life to men and animals. We cannot sell the lives of man and animals; therefore we cannot sell this land. It was put here for us by the Great Spirit and we cannot sell it because it does not belong to us. You can count your money and burn it within the nod of a buffalo's head, but only the Great Spirit can count the grains of sand and the blades of grass of these plains. As a present to you, we will give you anything we have that you can take with you; but the land, never.*

A chief of a northern tribe of Blackfeet Indians.

PROJECTS

## SOME TOUGH DECISIONS

Your class, nature club or scout group can do some experimental problem-solving that may help in real-life situations. Here's the problem:

An electric power company wants to build a new generating plant in your town. The most suitable land for the plant is next to the river in an area used as a refuge by many forms of wildlife. A school and playground are located a short distance away, and the hospital is downwind of the proposed site. The power company must present its case for the site before the town council which will make the final decision. Many local conservationists object to the project and are prepared to address the council with their reasons.

- Divide your group* into three categories; the power company officials, the conservationists and the town council members. Decide what kind of fuel the plant will be using (coal, oil, nuclear). Make a map of the site area and surrounding community.
- The "company officials" group can write or talk to a local power company to find out how it chooses sites and how it feels about providing its services.
- The "conservationists" can write or talk to local conservation organizations to determine how they protect natural areas and speak out on environmental issues.
- The "town council" can write or talk to local government officials to determine how they weigh the many sides of an issue in order to make the best decisions for the town.
- The "company officials" and the "conservationists" prepare and give their arguments before the "town council." The "council" questions both groups about their arguments. Consider the pros and cons below.
- The "council" votes and tells why it made its decision.

If this problem-solving works well, you could try several variations. You might develop a similar problem for a town council thirty to fifty years into the future. The council might be considering the siting of a huge solar collecting complex, a series of giant windmills, a nuclear fusion plant or a geothermal drilling area. Energy problems will not go away in the future.

* If you have no group available, you could present the problem and its solution in the form of a story or a play.

| PRO | CON |
|---|---|
| 1. The community needs more electrical power as it grows. | 1. Alternative forms of energy and strict conservation of energy might make the destruction of this area unnecessary. |
| 2. The new plant would provide jobs for people in the town. | 2. People need places to relax in their leisure time. |
| 3. The fuel that could be used at this site would make the town's electricity less expensive. | 3. The fuel would cause increased air pollution in the town. |
| 4. The company promises to make its plant grounds attractive and some wildlife would continue to live nearby. | 4. The natural environment and the recreation use of the area would be destroyed. |

# Ocean Energy: Scratching the Surface

The oceans cover much of the earth. So most of the solar energy that falls on the earth falls on water. What happens to it -- and how can we use that energy?

# OCEAN ENERGY: Scratching The Surface

The oceans cover two-thirds of the earth's surface and receive about two-thirds of the sunlight striking the earth. In an energy-short world, it would be logical to find a way to use such a large and powerful resource. How could this be done? A look at the oceans' characteristics provides some ideas. They're water, they're deep, and the currents, waves, and tides show they have lots of latent (stored) energy.

Maybe the first idea to come to mind would involve the waves and water flow. After all, water power from rivers and streams was one of the earliest energy sources, used to turn grindstones for milling grain. And water flowing through large-scale dams turns turbines to generate electricity.

Ocean tides are actually being harnessed this same way in France, providing power for a city the size of St. Paul, Minnesota. And other projects have been proposed for places where the tides are very high. Such a project, with multiple dams, has been on the drawing boards since the late 1930s for the Bay of Fundy, between Maine and Nova Scotia. But its high cost—each dam could cost as much as $9 billion—has prevented action. Recently, though, with the changing world energy picture, the Canadian government has begun to study the idea again.

Another, farther-out idea (literally) involves anchoring turbines at sea and using the currents to generate electricity to be transmitted back to shore. Big—from 1 to 80 megawatt (MW, million watt)—designs have been drawn up. The plants would be huge, and the 80 MW unit would need a hull four-fifths the size of the New Orleans Superdome. At least one small unit, to charge storage batteries in scientific and navigational buoys, may be built soon.

The ocean water itself is being considered as a source for energy fuel. Since water is composed of hydrogen and oxygen, and there's so much of it, it's a natural as a raw material to be processed into hydrogen, which is being considered as a fuel in future energy systems.

These "ocean energy" projects are mostly far-in-the-future oriented. But one project is in the here-and-now. It's called OTEC (not to be confused with OPEC), which stands for Ocean Thermal Energy Conversion. It's really a watery kind of solar energy, since it depends on the higher temperature of the surface waters warmed by the sun.

It may be a bit of a surprise, but the first OTEC plant was actually operated off the coast of Cuba in 1930 by a Frenchman named Georges Claude. His principle and process are still valid: The surface temperature of tropical water is about 29.5°C (85°F), 13°-18°C (20° to 30°F) warmer than the deeper water beneath it. Imagine an oval-shaped tube going from the surface to the depths and back up. The tube is filled with a fluid—Claude used ammonia—that boils or vaporizes at the temperature of the surface water. The vapor is used to run a turbine, which generates electricity. The vapor is then pumped below, where the cold water brings it back to the liquid state. It is then ready to make its next trip to the surface, where the cycle begins again.

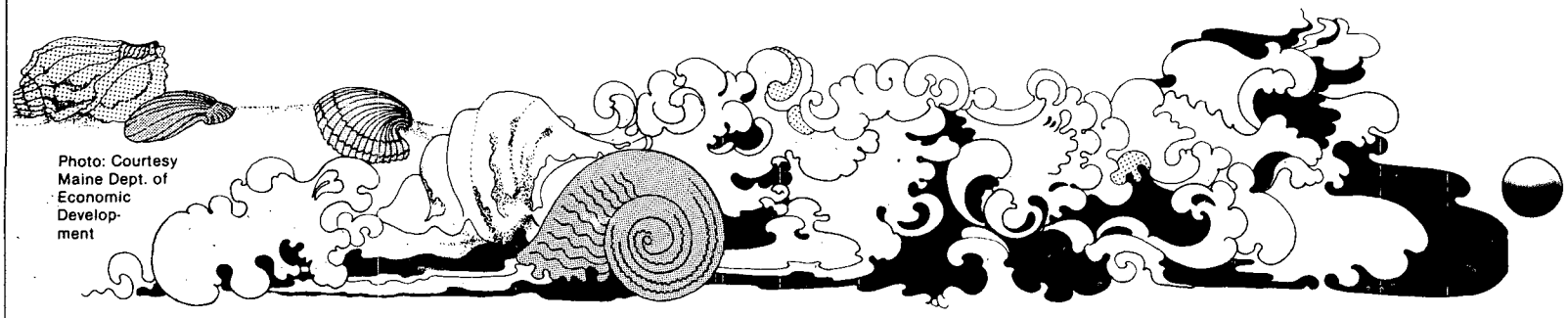


Photo: Courtesy Maine Dept. of Economic Development

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Claude's OTEC system used all the power it produced to run its pumps. But now, 50 years later, the first stage of an improved system is being tested off the coast of Hawaii. The test unit, operated by the University of Hawaii, is producing only 10 kilowatts (10,000 watts) more energy than is needed to run the pumps.

The full-scale unit is another matter. A $50 million Department of Energy project called OTEC-1 will generate 1 megawatt of electric power. (A nuclear power plant generates about 500 MW.) In a variation on the original design, the ammonia will be cooled close to the surface with 5.5°C (41°F) water brought up from a depth of 2,100 feet. OTEC-1 will be located on a converted Navy ship to be anchored off the west coast of the island of Hawaii. Construction and testing are scheduled to begin this year.

Besides providing power, OTEC may be a big boost to two other future-oriented projects—fish farming and mariculture (growing crops at sea). The cold water brought from the ocean bottom to cool the ammonia vapor will be loaded with small plants, animals, and minerals. This high-powered fertilizer could be used with a sea-going farm located nearby. In this way, one project could provide both power and food, important items in restricted land areas with growing populations, which is the case in Hawaii. The island nation of Japan is interested in OTEC for the same reason, and studies are also under way in Europe.

As people use up more and more of our land-based fuel resources, it seems likely we will turn to what seem now to be the unlimited, renewable energy sources that are the earth's oceans. Finding ways to effectively tap that energy without harming the environment is a challenge for your generation.

## For More Information

U.S. Department of Energy
Technical Information Center
P.O. Box 62
Oak Ridge, TN 37830

*Pamphlets: NSTA Fact Sheet #6 "Solar Sea Power; Ocean Thermal Energy Conversion," #OPA-007 (11-77) "Ocean Thermal Energy Conversion," #F-78-013 Fact Sheet: "Ocean Thermal Energy Conversion (OTEC)," "Ocean Energy Fact Sheet" presents information on OTEC as well as energy from wave power and ocean currents; single copy of each free.*
*Booklet: "Ocean System Program Survey," $3 single copy.*

Edison Electric Institute
1111 19th Street
Washington, DC 20036

*Booklet: "Emerging Energy Technologies; Energy Research, Answers to Your Questions," single copy free.*

**Model platform which would use temperature differences in the ocean to drive a heat engine**

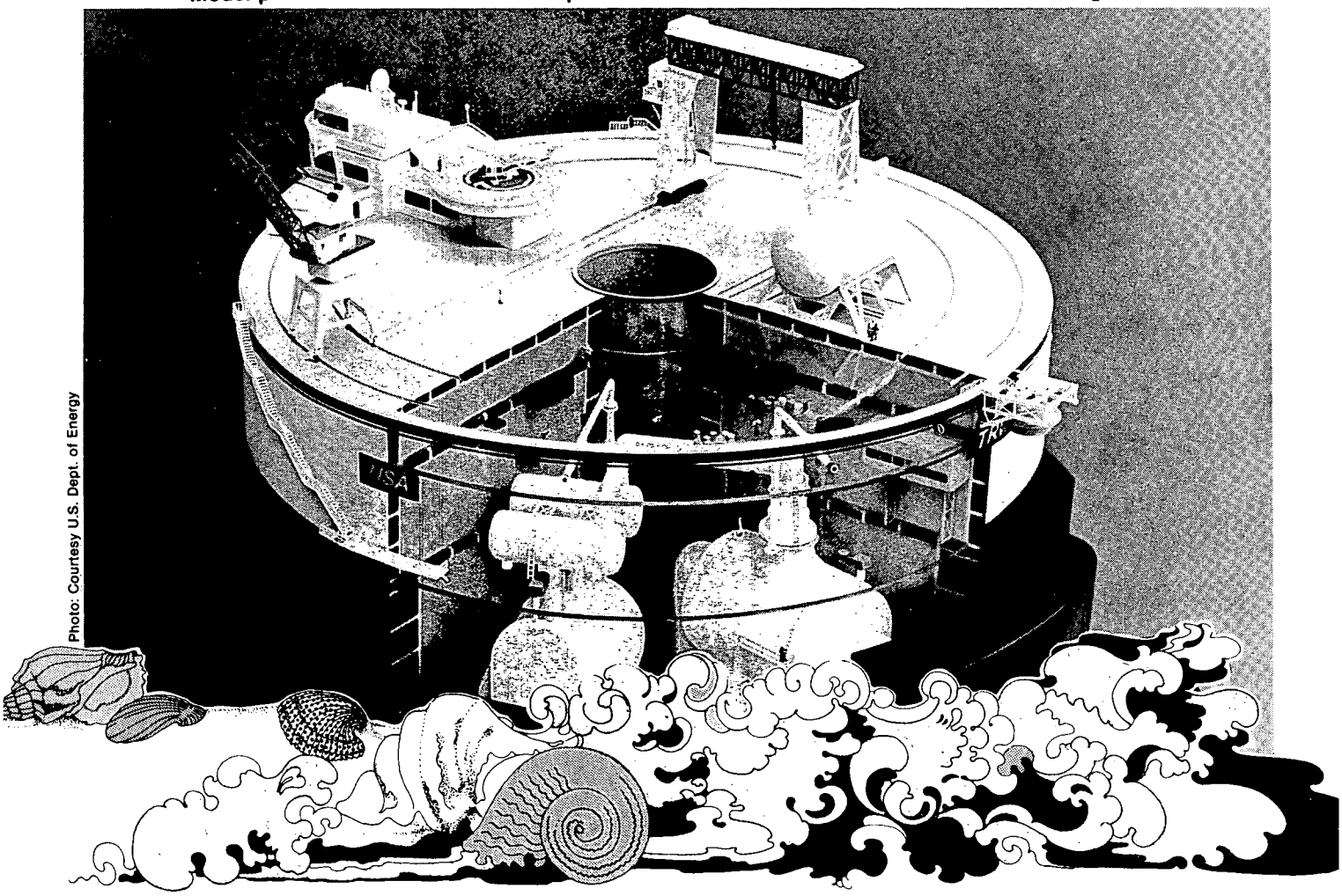
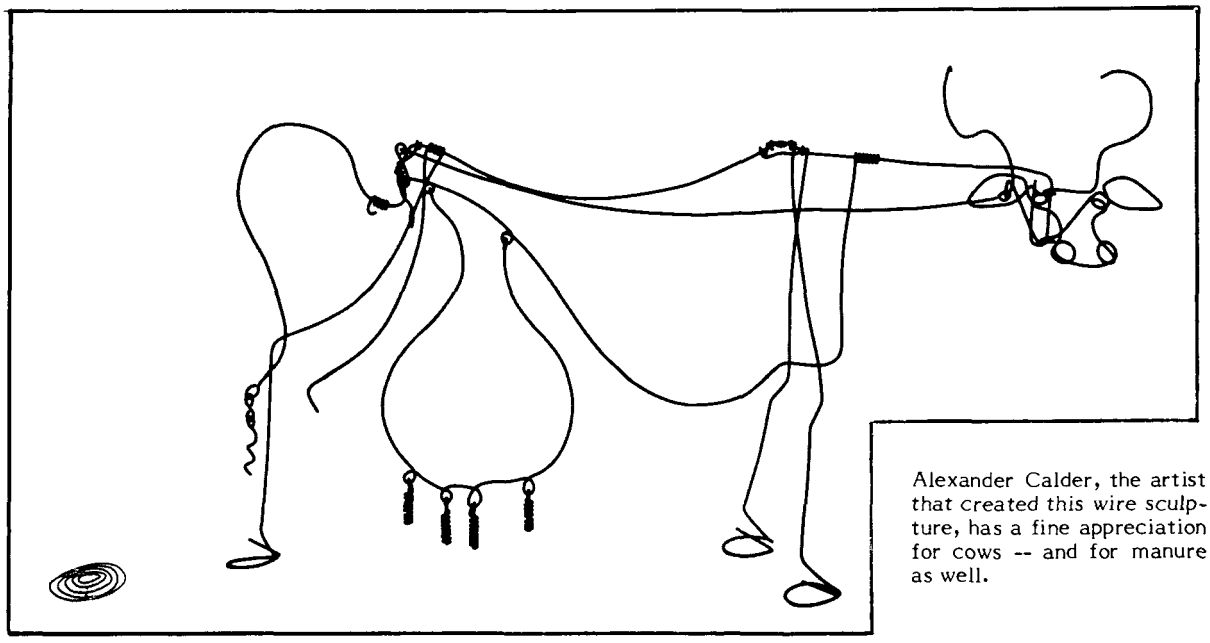



Photo: Courtesy U.S. Dept. of Energy

# Mighty Methane

Living bodies use a lot of energy, but a lot of energy goes right through them. What can you do with what's left? Would you believe -- heat your house and drive your car?



Alexander Calder, the artist that created this wire sculpture, has a fine appreciation for cows -- and for manure as well.

# Mighty Methane

Some people say that we may be just the burp of a cow away from solving our energy problems. That may sound like a joke, but it is at least partly based on fact. When a cow burps, methane gas is released into the atmosphere. Scientists estimate that cattle and other large plant-eating creatures release about 45 million tons of this colorless, odorless gas into the atmosphere each year. Also called marsh gas because it is a by-product of the decaying plant tissues in wetlands, methane is an excellent fuel. Pure methane gas has a heat value of about 1000 British Thermal Units (Btu) per cubic foot — and five cubic feet of methane provides enough heat energy to boil a half gallon of water and keep it bubbling for 20 minutes.

While no one goes around collecting cow burps, people have used methane for fuel on a limited basis for a long time. One way they obtain methane is from manure, which contains rotting vegetable matter.

Using manure to produce fuel may seem odd, but it is a very sound idea, endorsed by many well-known scientists. A century ago, Louis Pasteur, the French chemist who among other important discoveries developed a vaccine for rabies, called for production of methane from manure. Facing a fuel shortage in World War II, German researchers developed methane plants in farming areas to make fuel for tractors from manure. Today manure is used in some parts of Europe to produce methane; and the by-product is a fertilizer for enriching the soil.

India has used the manure itself, not the gas methane, for fuel — cows in that country produce more than 800 million tons of manure annually — for heat and light. Half of the manure produced by India's cows is burned by people for fuel. This can be wasteful, however, for once burned the manure is useless as fertilizer. However, when methane is made from manure, fertilizer is left over as a bonus.

During the 1950s Indian scientists began using methane gas, produced from manure, to heat and light homes on a small scale. Today more than 2,500 digester plants produce methane from organic wastes in India.

Methane is produced by the use of a device called a digester. A digester is an air-tight container in which the natural processes that result in methane production are copied and speeded up considerably. In the absence of air, bacteria are fed a mixture of waste and water called slurry which contains large amounts of nitrogen and carbon. The bacteria act on the slurry and produce methane, carbon dioxide and some hydrogen sulfide gas. The gases rise within the digester and are collected in a drum for storage or for immediate use. The liquid slurry that remains is drained off for fertilizer.

Indian researchers have tested several different kinds of manure in digesters. Manure from horses and pigs produces more methane than cow manure, and chicken manure makes less. The best methane production occurs when dry vegetable matter such as leaves, are proces-

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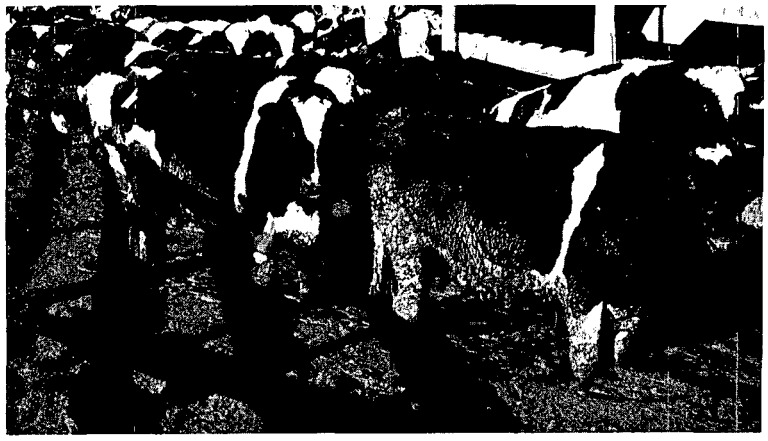
sed in the digester.

Animal waste materials rarely are used to produce methane in the United States, where disposal of these wastes is one of the worst of all ecological problems. However, a few sewage treatment plants in California are using methane made from sewage to power their own generators.

Unfortunately, manure is rarely used for methane where it could be processed most efficiently — on the farm. Not only could the gas be used to fuel farm equipment, but the manufacture of methane also would produce fertilizer, saving the farmer expense in both areas.

Two farmers in Benson, Vermont, are trying to pioneer the use of digesters to make methane for the farm. Ralph Hurd and his nephew, James Whitehurst, have built a digester on their 300-acre dairy farm. Their digester, which was built with the help of an expert from India, holds 3000 gallons of waste and can produce 200 cubic feet of mixed methane and carbon dioxide daily. This gas mixture is equal to about as much energy as in one gallon of gasoline. Built for a cost of $800, the digester on the Vermont farm can handle the manure of only four cows a day. Why don't Mr. Whitehurst and Mr. Hurd build a larger digester? The problem is cost. They would need a digester with a 65,000-gallon capacity to handle the manure from their herd of 100 cows. Thus far the two farmers say they cannot find a bank to lend them the money to build the device, although they believe it would cut a farmer's costs so much he could pay off the cost of a large digester in a few years. Many scientists and engineers question whether the digester plan is as good as it looks, and the Vermont farmers have not been able to find institutions willing to pay the costs of building a larger digester.

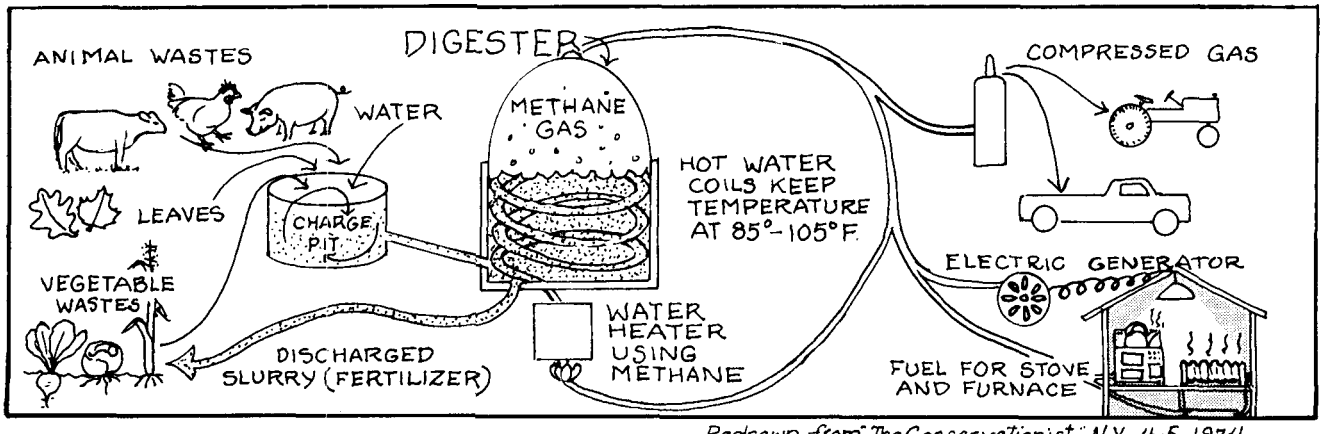


When cattle are confined to feed lots rather than to large pastures, their wastes become a problem. Imagine how much fuel for light, heat, machinery, and transportation this feed lot could produce.

Digesters work in other countries, say Whitehurst and Hurd, why can't they work in the United States?

If they could, the ecological benefits might be considerable. Farmers often dispose of their manure by spreading it on their fields to decompose and gradually fertilize their crop. If the manure washes into streams before it decomposes it can pollute the water. Using liquid slurry as fertilizer would lessen that problem, because the liquid quickly soaks into the soil and goes right to work to nourish the crop. Commercial fertilizer, which could be largely replaced with slurry, is a product of petroleum, and so is in short supply. Moreover, a farmer's petroleum demand could be cut further if he converted his farm equipment to run on methane instead of gasoline.

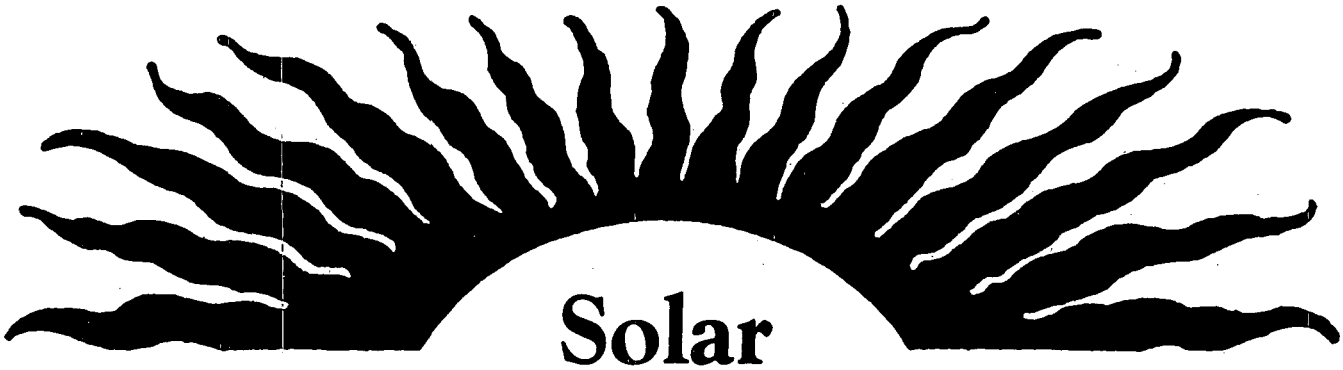
So far, however, there is little sign that making methane from manure will be conducted on a large scale in the United States. Should the United States move ahead in this area? What do you think? *E.R.R.*




Redrawn from "The Conservationist", N.Y., 4-5, 1974.

# Solar Jobs With Sunny Futures

Find out about some of the jobs for technicians and tradespeople that new energy technologies are already creating.



# Solar Jobs With Sunny Futures

By Lester David

AS a power-short nation looks to the sun for a major source of its energy, prospects for a sound, steady —not to mention lucrative—career are becoming shiny bright.

Already hundreds of small, medium-size and large firms are creating the hardware—photovoltaic cells, solar collectors, reflectors, valves, heat-storage units and other components. And already hundreds of thousands are working in the field.

Openings are expected to skyrocket, too, reports the Solar Energy Institute in Washington. In just five years, the Institute forecasts that fully *3,000,000 persons* will be collecting paychecks in the industry, some upwards of $40,000 a year. Professionals, yes, but many good-paying jobs require only one to two years of training.

In general, jobs in the solar field simmer down to five main categories: salesman, designer, installer, electrician and service technician.

A *salesman* must understand all solar heating and cooling systems, including domestic hot-water applications. He must also know about conventional heating, ventilating and cooling methods and how solar technology can be used with them.

A salesman explains the details of the finished system and answers all questions on maintenance operations. In addition, he must know how to estimate installation costs, anticipated savings and how long it might take to earn back the investment. Knowledge of local, state and federal solar incentive programs for tax credits and an understanding of local building codes and insurance laws are also essential.

The expert who selects the system that will work best in a big building, plant or even a small home is the *solar designer*. There are dozens of different solar heating and cooling methods already in existence, and more are being developed all the time. The designer works with these, changing and adapting as he sees fit, often combining the best parts of several systems.

In making his selection, he must study the amount of annual sunshine in a particular region, the architecture of the building, its heating and load requirements and a number of other key factors. Then he lays out all details, preparing drawings and charts that describe everything needed to make the system work efficiently. Everything must be set down clearly so that installers, electricians and maintenance men can follow up.

A designer must also make sure buildings can withstand the extra stress placed upon them by solar collectors and the supporting structures that must be added. Sometimes, a systems designer also is an architect with special solar training who designs an entire structure.

The *installer* mounts the collectors that trap the sun's warmth and attaches all the necessary hardware. He must understand not only how the system on which he's working operates but local building codes and the special complexities of solar hardware and plumbing. He also must know if the collectors and necessary support structures will stand up to the wind, hail, snow and rain of a local climate. He tests the collectors for leakage, knows all about storage systems, containers and tanks, reads designer blueprints to connect pipes and air ducts and puts into place the hardware that affects the operation of the system. Finally, he must also be trained to connect the solar system with a standard backup heating unit.

A *solar electrician* installs the solar controls. While detailed knowledge of how the system operates isn't needed, he must be able to follow blueprints and other specs that tell him how to install the wiring that provides power to the main control unit and hook up key mechanisms. Solar electricians work almost exclusively on large systems in commercial and industrial buildings. They're not required in residential installations because in small systems there's no need to connect wiring to the main service box or to work directly with the 110-volt lines.

Solar systems, like cars, must be serviced on a regular basis to function

*(Continued on page 111)*

**FOR MORE INFORMATION . . .**

Training for a career in solar energy is now being offered in schools and colleges all across the country.

•

For a free 36-page directory of courses that equip you for practical technical work in the field, write to:

**The National Solar Heating and Cooling Information Center**
P.O. Box 1607
Rockville, Md. 20850
**OR**
The Solar Energy Research Institute
1617 Cole Blvd.
Golden, Colo. 80401

One- and two-year programs and courses offered in community and junior colleges and technical and vocational schools are listed alphabetically by state.

•

A more extensive 279-page directory aimed at those who want to equip themselves for advanced scientific and engineering jobs is available from:

**The Superintendent of Documents**
**U.S. Government Printing Office**
**Washington, D.C. 20402**

The National Solar Education Directory costs $4.75 and includes every course, program and curriculum offered by all post-secondary schools in the country.

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well. And like cars, they develop bugs that must be spotted and eliminated. The *service* and *maintenance technician* must keep pumps, motors, blowers and other components working smoothly by following a maintenance schedule laid out by the system designer. He must also be an ace troubleshooter who can locate problems.

In addition to these, more and more highly trained professionals will be needed in research and development as the industry continues to expand.

These scientists and engineers will be working not only on systems for small homes and large buildings but in the vast solar utility plants that, experts forecast, will supply sun power for entire cities.

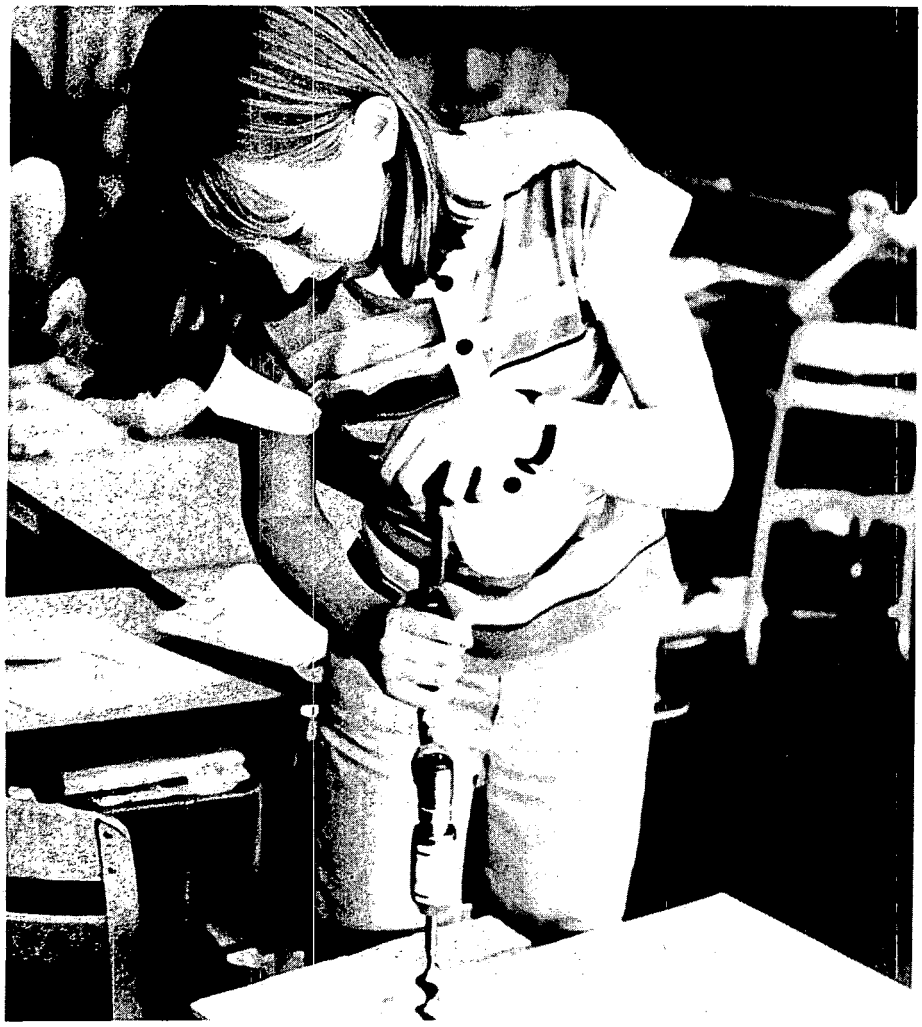
Pay varies widely, depending on the job, company, experience and location. Installers earn between $5 and $8 an hour in smaller companies but can get up to a hefty $20 hourly in larger firms. Solar electricians make about $17 an hour, sometimes more, while designers earn $25,000 and up. Service and maintenance technicians earn about the same as skilled technical workers in other fields, namely hourly rates that bring annual income into and above the $15,000 range. Helpers who assist technicians while they are learning their craft generally make about $5 an hour.

Naturally, pros earn the most. Beginning salaries for R&D specialists with masters degrees in chemistry or engineering range between $20,000 and $30,000. Earnings, including commissions, for top sales personnel can hit $22,000 annually and up.●

# The Readings For the Teacher

# Solar Energy: Classroom Reality

Demonstrating solar energy doesn't have to be expensive or complicated. You can start with cardboard and move up to plywood. Students will enjoy seeing what works.



# Solar Energy: Classroom Reality

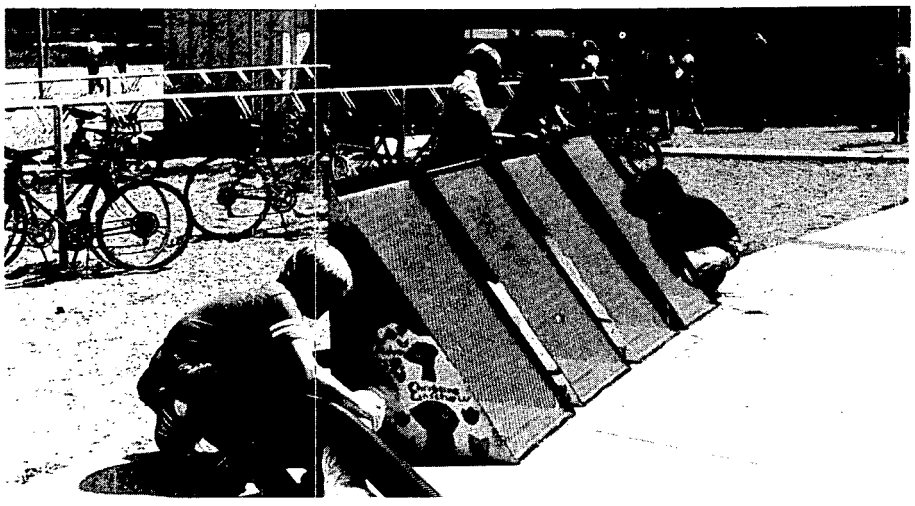
Thomas Geier
James R. Wailes

Solar projects described in various magazines and books sound impressive, but you may have wondered about a full-sized, working solar apparatus in your classroom. Is the project too expensive? Is it beyond the students' understanding and capabilities? For anyone with a budget-minded principal and a few simple carpentry tools, this article describes a solar heating system that works, and is practical and inexpensive.

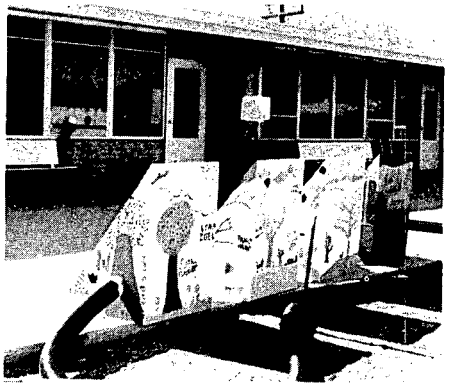
Burke School's sixth graders enthusiastically accepted the challenge of the energy crunch by agreeing to build solar collectors to supply heat to their classroom. The girls and boys went to work with hammers, saws, and metric measures, soon becoming carpenters and engineers, making suggestions and changes, and turning mistakes into an unforgettable learning experience.

The class first constructed a cardboard prototype to test the project's design feasibility. A small group was selected to build the prototype. A clear

*A sixth-grade girl (above) uses a hand drill in building a solar collector. Students later assemble the collectors, which are placed on the edge of the playground. Wire glass was used for safety reasons. The finished system (below right) shows how the collectors were hooked up to the classroom.*



*Thomas Geier is a Teacher at Burke Elementary School, Boulder, Colorado. James R. Wailes is Professor of Science Education, University of Colorado, Boulder. Photographs by Thomas Geier.*



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plastic sheet was used in the mock-up. The original temperature was 12 °C when the apparatus was placed in the sun. Ten minutes later the temperature had soared to 50 °C. The class was convinced the system would work. They used the model to explain the purpose of the classroom activity to the principal and the maintenance department.

More detailed plans were formulated. A list of materials was prepared. (All materials had to be bought in standard feet and inches, but the students did all their work in metric units.)

- 4 sheets of ½-inch plywood, 4 x 8 feet
- 8 sheets of ½-inch foam insulation, 2 x 4 feet
- 4 pieces of sheet metal, 1 x 3½ feet
- 50 feet of flexible plastic construction tubing, 4-inch diameter
- 4 sheets of wire glass, 24 x 41 inches
- 1 tube of silicon rubber caulking
- 1 roll of furnace tape
- 1 bottle of wood glue
- 2 pounds of finishing nails
- 1 gallon of flat black paint

The total cost of materials, exclusive of the plywood panels which were donated, was $174. If the solar collectors can be put where there is no safety factor involved, much money can be saved by substituting plate glass for wire glass. Thermopane glass works best, but is expensive. Tools we needed for the project included: saws (jig, crosscut, circular, and coping), hammers, metric tape measures, brace and bit, wood files, carpenter's square, and clamps.

We divided the class into four groups, each of which would be responsible for working on one collector. Each group had an unofficial leader who helped members get started. The teacher's role was more that of project supervisor, giving suggestions, checking measurements, and doing tasks (such as using the power saw) that may have had some risk. Many students gave up recess time to work on their collectors.

Students were required to follow directions carefully and make all measurements precise. Each collector was 91.5 cm tall and 62.5 cm wide. Each triangular side was 71 cm at the base, 91.5 cm at the back, and 116 cm on the hypotenuse. Measurements allowed for a 53° angle for the collector's surface. This angle was determined to be the best for the latitude of 40° N.* The corners were nailed as well as glued for maximum strength, since the collectors had to be portable. Wire glass was used on the collecting surface since the collectors were designed to sit on the edge of the playground.

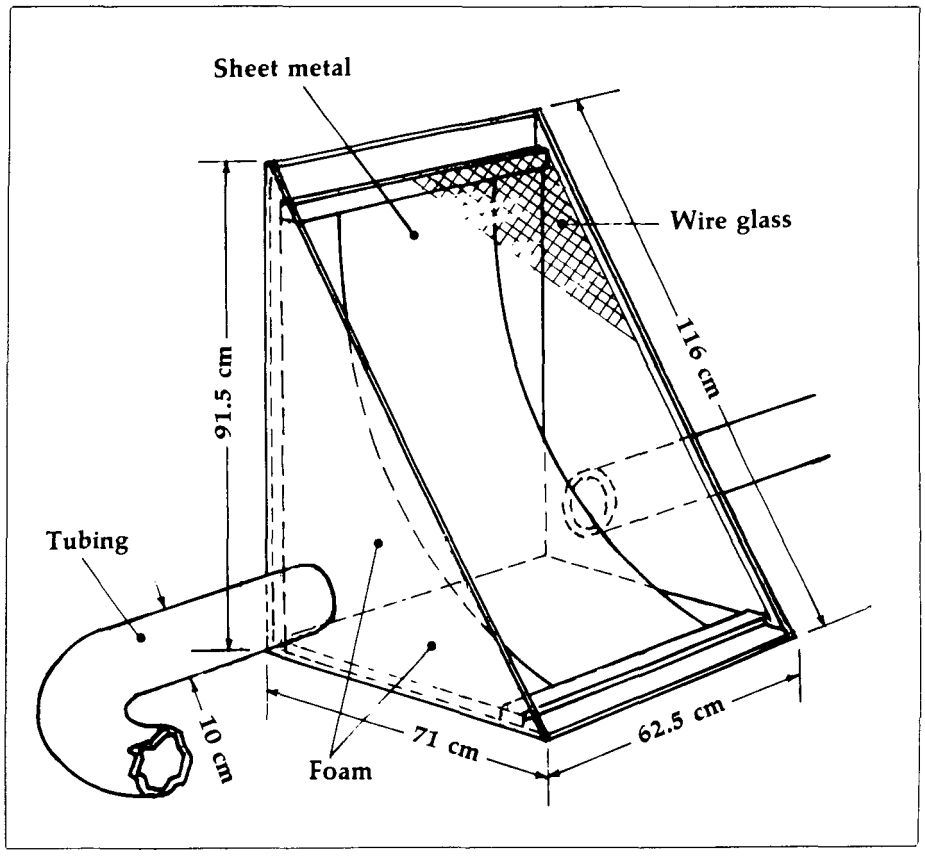


*Diagram of one of the solar collectors.*

Students lined the inside of each collector with foam and painted it flat black for maximum heat absorption. (See diagram.) Sheet metal was also painted flat black and nailed near the inside top and bottom to act as a heat absorber and radiator for the air flowing through the flexible pipe into the classroom. The sheet metal touches the inside of the collector only at the top and bottom so that air can flow freely around it. The flexible tubing connected each of the four collectors together, and led into the building. The flexible pipe was insulated with plastic foam packing material, recycled from a shipment the school had received. Furnace tape sealed the joints and prevented air leaks, and the caulking compound sealed the units to make them airtight.

Moving the heated air from the collectors into the classroom was a challenge the students faced by constructing a rectangular box to fit over the wall heating unit which blew air into the classroom. The flexible pipe was fitted into the box, and the blower then forced the air outside and into the collectors and then back into the classroom through a window fitted with an access for the pipe coming from the collectors.

Since the collectors sit on the ground they are easy to examine and available to future classes. Students did not attempt to design a heat storage system because of the money and space problems. On sunny days the collectors reached temperatures as high as 70 °C. With this much free heat, the class eyed the cold hallway just outside the lunchroom.

At the start, the teacher had misgivings about the project working at all. However, the children were not surprised that everything went according to plan and the infrared rays of the sun helped to heat their classroom.

*For other latitudes, contact a local solar equipment supply company.

# Solar Homes: the Shape of Things to Come

Every student dreams of his own private place -- so let him design his own (solar) home and, in the process, learn the basics of solar design and energy conservation.

# Solar homes: the shape of things to come?

To design a solar house you need to know about solar energy. It also helps, students found, to know about geology, architecture, landscaping, and interior decorating. Their successes are outlined here.

Patricia A. Kovacs and William W. Rasor

Letting the sunshine in . . . or keeping it out . . . became the preoccupation of students in five ninth-grade earth science classes at Madison Junior High School (Trumbull, Conn.). The students, who spent two months designing and building model solar homes, discovered the enormous amount of science on which solar technology depends, and became involved as well in English, art, and social studies.

We initiated the project by constructing a large bulletin board, illustrating in seven major sections numerous considerations about constructing solar houses. Among the seven sections were included our aim (to design efficient solar homes) and numerous inquiry questions relating to materials, orientation, insulation, seasonal effects, and so on. We discussed the necessity of collecting specific types of information in a methodical fashion, but youngsters were then free to select their own approach to the project.

Students in each class were divided into four major groups, and then grouped further into two's and three's. The students were already used to working in groups, so they knew the give-and-take necessary in sharing ideas, making decisions, and so on.

Library research was our first task, with all important information being presented to the entire class. But students soon decided that field studies would be needed to better understand the sun.

Our first field trip was to the local planetarium, where students learned about Earth's movement around the sun. Students then used an astrolabe[1] to determine the sun's altitude, and measured the shadow cast by a stick—just as was done by ancient peoples. Some also constructed geometric sundials.[2]

Using information on the sun's daily positions during the year at Trumbull, students could then construct diagrams and charts to help determine such things as home orientation, window placement, and the necessity for overhangs.

Choosing a building site led immediately to more "earthy" topics. What land is available? What land formations and soil types are desirable for home sites? What ordinances govern cite location? How would utilities be supplied and at what cost?

*Figure 1.* **Even miniature light sockets and small electric motors were installed in the houses.**

Students visited and collected information in areas where construction was in progress. They learned much about soils, and did percolation tests on samples collected during the field trip. They also invited outside experts—from civic leaders to contractors—to advise them on proper site selection.

Next, they settled down to the business of designing their homes. Solar buildings can be "active" or "passive" or a combination of the two. In so-called active houses, energy is collected by a system of solar collectors, typically placed on the roof. Fans and pumps then move heated air or liquid from the collector to a storage area, from which it can be circulated when needed—for example at night or on cloudy days. In the passive system, there is no circulation to storage; such homes store energy right where sunlight impinges; thus they are designed to shield the structure from summer sun but to capture warmth in the winter.

Architectural considerations included construction materials (for example, frame *vs.* brick), roof angle, placement of solar panels, placement of windows, relative advantages of single, double, and triple-paned windows, and various types of insulation.

Room placement and furnishings came next in importance. Where, for example, are the best locations for the kitchen, living room, and bedrooms? Where would insulated drapes be most ef-

[1] See "Measuring with a Quadrant" by Jon K. Wooley, *The Science Teacher*, March 1978.

[2] See "We Made It and It Works! The Classroom Construction of Sundials" by M. Stoessel Wahl, *The Arithmetic Teacher*, April 1970.

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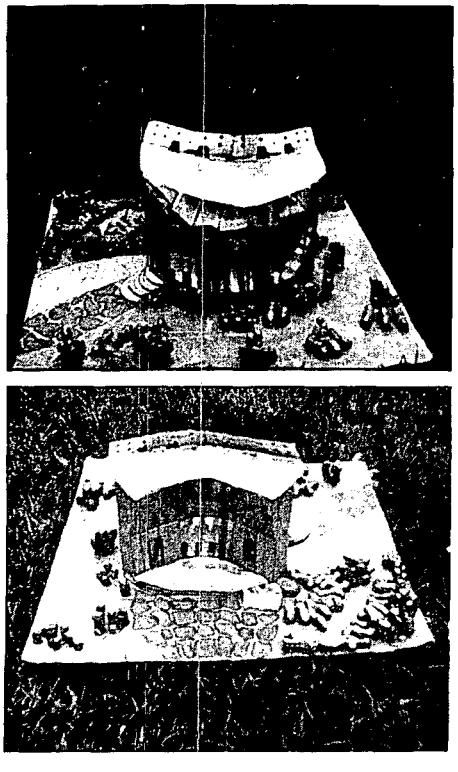
**"Choosing a building site led immediately to more 'earthy' topics. What land formations and soil types are desirable for home placement? What ordinances govern site location?"**

fective? How about different kinds of flooring? Decorating became an area of keen interest. What are the psychological effects of different colors and materials?

Landscaping, too, was given careful thought, for proper placement of trees and shrubs can do much to provide shade in summer and break prevailing winds in winter.

Once students had arrived at a design, they were ready to formulate their blueprints. A good starting point was to let students make measurements at home and in class of room dimensions, windows, and door sizes, and translate these into scaled blueprints. Students also enjoyed looking at professionally-made blueprints, readily available from various magazines.

*Figure 2.* **The winning home featured a broad sloping roof on its front (top photo) for the placement of solar collectors, and a large area of convex windows. The back of the house (bottom) had a protective overhang.**



We assumed the total floor area of an average home to be about 200 $m^2$. In making blueprints we let each centimeter represent 1 meter. In determining proper relationships between length, width, and height, we found builders and contractors to be most helpful.

All of the accumulated information on site location, interior design, and so on was available to guide students in drawing their blueprints. In designing exterior features (including roof, windows, architectural projections, and so on), the students had to consider the sun's altitude throughout the year.

To build their model homes, students used a variety of scrap materials. Basically, the houses were made of cardboard, with sides either pinned or glued together. Windows were made from clear or tinted plastic, and interior walls decorated with wall paper, construction paper, or water paint.

Features such as rain gutters and air circulation ducts were made from soda straws. Even miniature light sockets and small six-volt electric motors (constructed by the students) were installed in the houses. And thermal air circulators were simulated with brass paper fasteners.

Students then developed criteria to use in judging the solar homes, based on goals identified at the beginning of the project. These included: site location (as described by the student), demonstration of basic scientific information, exterior and interior design and decoration, calculated energy savings, landscaping, and overall aesthetic appearance.

The winning model home (see Figure 2), for example, featured:

- A broad sloping roof on the front (facing south)—both to prevent snow accumulation and for the placement of solar panels.
- A large area of convex windows facing south.
- A vertical metal plate (containing numerous 15-cm holes) along the roof to block the sun's rays, reduce the Bernoulli effect of wind on the roof, and provide places for many small wind-driven generators.
- The back of the house (facing north) had a large protective overhang.

The culminating activity for all classes was to plan a solar village composed of four neighborhoods, with homes designed and situated so that each could capture the maximum amount of sun energy. ■

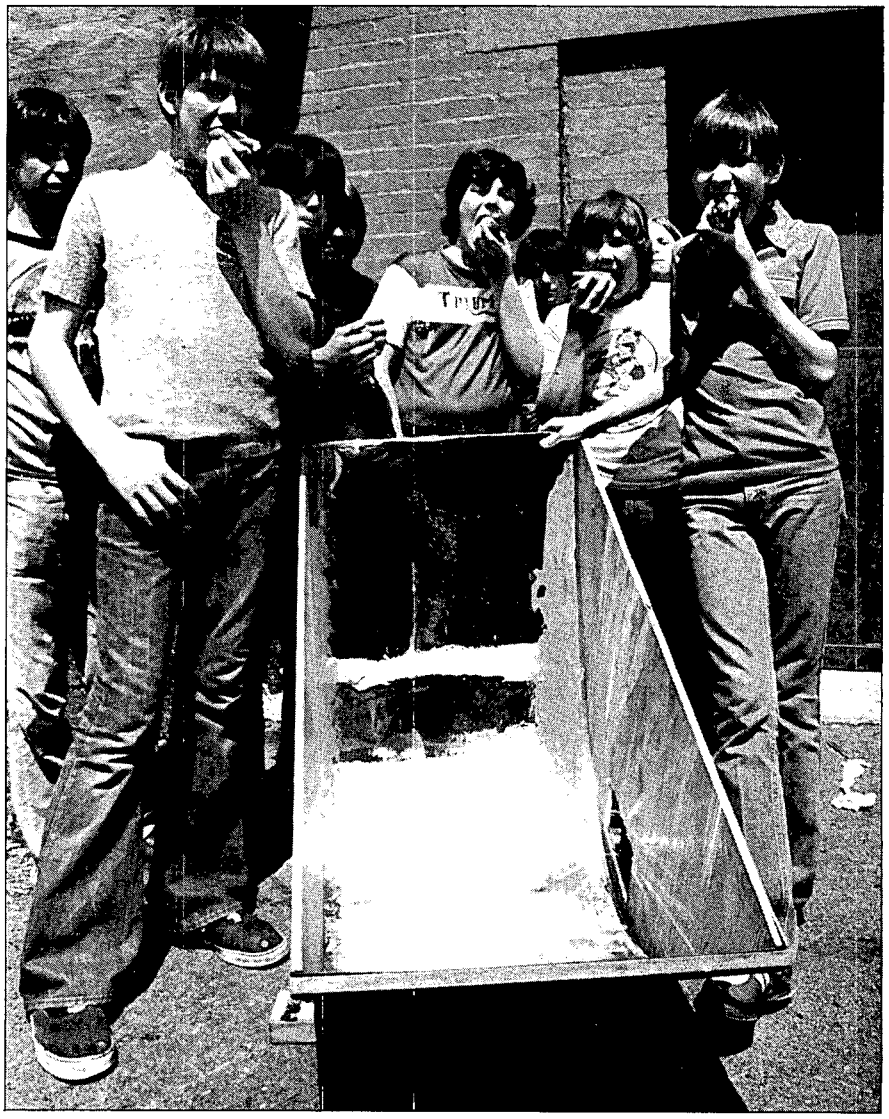
# Solar Stoves Teach Energy Awareness

Eating is close to students' hearts and a solar collector that cooks real food will give them food for thought. The article includes designs for two solar cookers.

# Solar Stoves Teach Energy Awareness

## Details about how even junior high students can build their own solar stove

By Debra Korhone Kildahl



Students enjoy fruits of their labor, or rather, the hot dogs of their labor.

Take a piece of sheet metal . . . bend it and nail it to two parabolic shaped pieces of plywood . . . glue special non-wrinkling reflective sheeting to the metal . . . add a spit and, except for a hot dog to cook, your solar stove is ready to go. Solar stoves may be the technology of the future for most of us, but for students at the United States Air Force dependent's middle school at RAF Upper Heyford in Oxfordshire, England, they are cooking today's lunches.

The solar stoves were built by 8th-grade students with the help of industrial arts teacher Carl Gross. The inspiration for the stoves came from a five-day power and energy workshop (sponsored by Department of Defense Schools Europe) which Carl attended in Wiesbaden, Germany, in March, 1978. At the conference, Carl was introduced to the basic plans for constructing and designing a solar stove.

The main objective behind the stove project was to make students aware of alternative energy sources like solar energy. Carl comments that the solar stove is a "device that demonstrates to students how solar energy can be captured and utilized." That the stoves can actually be used for cooking lends special appeal to the project. Sizzling hot dogs, chicken, or hamburgers (in foil) provide tangible and tasty proof of the existence and power of solar energy.

Solar stoves not only harness sun power, but they capture a student's curiosity and interest as well. Carl's students questioned him about his week's absence when he returned from the workshop. After hearing his enthusiastic descriptions and seeing the plans for the solar stoves, they were eager to construct their own. With class time taken up by another project, Carl opened up the industrial arts shop for solar stove building during lunch time for those students who were interested. Originally 15 students chose to become involved, although many more later joined in.

The industrial arts skills and techniques used in building a solar stove are basic ones. No special or complicated procedures are required. Under Carl's direction and by following plans similar to those given here, students were able to build the stoves in three to four hours.

### Introduction

Most solar stoves are mirrors shaped like a parabola. (A parabola is the theoretical curve taken by an object thrown in a gravitational field). A parabola is used because of its ability to focus sunlight accurately. (See Figure 1.) If enough sunlight is caught, this concentration of light energy focused on a small area will produce heat of a sufficient intensity to cook food. (Carl's students measured the focal temperature of their large stove at 190°F).

A trough-shaped solar stove will concentrate heat on a band along its entire length, creating perfect conditions for cooking with a spit. (Figure 2.) A bowl-shaped stove (Figure 3) would produce more intense heat, but it is harder to construct and the smaller spot of concentrated energy makes it less suitable for cooking.

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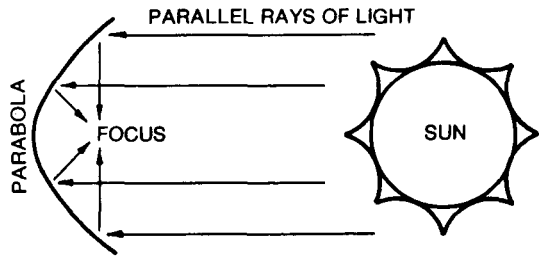



FIGURE 1

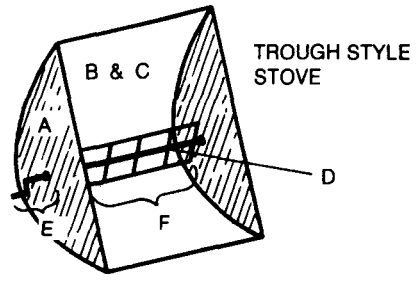
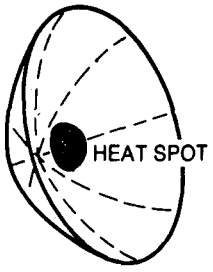



FIGURE 2




BOWL STYLE STOVE

FIGURE 3

A. PARABOLIC PLYWOOD SIDES

B. SHEET METAL TO FORM TROUGH

C. CHROME METALIZED POLYESTER SHEETING GLUED TO SHEET METAL

D. STRAIGHTENED COAT HANGER SPIT

E. COAT HANGER BENT TO FORM SPIT HANDLE

F. HEAT BAND

The reflective surface on the inside of the trough must be smooth and mirror-like. A sheet of chrome metalized polyester is excellent for this purpose. Aluminum foil may be substituted, but only in southern areas where the sun is more direct. Extreme care must be taken to avoid creating wrinkles when gluing the foil to the sheet metal. Wrinkles cause erratic reflection of the sun and will reduce the stove's efficiency. Results will be less satisfactory when foil is used in place of the chrome metalized polyester.

**Materials for stove**

The materials listed below will produce a large stove. Vary dimensions proportionally to produce a smaller stove. Try to utilize recycled materials, where possible, in support of the energy theme.

1 125 cm x 125 cm sheet of paper or cardboard.
2 125 mm or 200 mm thick x 125 cm x 125 cm plywood.
1 61 cm x 150 cm sheet metal, 24 or 26 gauge.
14 wood screws R.H. #6, 2.5 cm long.
1 60 cm x 150 cm sheet chrome metalized polyester (available in rolls from art supply companies).

To begin making the stove, follow the directions below to make a parabolic pattern to be used in cutting out the plywood sides.

**Drawing the pattern**

Place a large sheet of heavy paper or cardboard 125 cm x 125 cm on an old table or workbench. Secure the sheet with tape.

Using a carpenter's square (Figure 4) draw a line down the center of the paper, perpendicular to one edge.

Select the focal length of the parabola. This is the point where light will be concentrated when the reflector is built. An 8 cm focal length is suitable for hot dog cooking. (A longer focal length would be required for larger foods, like chicken, to keep them from touching the back of the stove.)

Measure the focal length from bottom edge and drive a small nail at point F (see Figure 5).

The parabola will be drawn by making a great number of tangents to the curve (Figure 6). There are two rules for drawing a parabolic tangent: (1) Keep one side of the carpenter's square firmly against the small nail at point F; (2) Keep the apex of the carpenter's square flush with the back edge at all times.

Continue moving the square, being sure to always check (1) and (2) before drawing the tangent. Create as many tangents as possible with a fine, hard pencil.

Flip the square around and draw tangents on the opposite side of the sheet of paper or cardboard. Eventually, one will have a neat, accurate parabola (Figure 7).

Cut along the curve with a sharp knife or scissors and separate the two pieces (Figure 8). Use the template with the focal point F marked on it to trace the parabolic curve in the next step below. Note: The remaining pattern piece (without the marked focal point) may be used to create a second trough style stove to be used with a free-standing spit (Figure 9). This type of stove can be used most effectively in southern areas with a more direct sun angle.

**Constructing the stove**

1. Trace the pattern made above on to one sheet of 125 cm x 125 cm plywood, marking the focal point on the wood.
2. Nail the two pieces of plywood together. (Three nails are sufficient.)
3. Accurately cut along the curve line with a band saw or power saber saw. (Accuracy in cutting will insure an efficient stove.)
4. Drill a hole the diameter of a coat hanger at the focal point F (Figure 8).
5. Separate plywood sheets. Punch seven holes in each side of 61 cm x 150 cm piece of sheet metal and attach to the curved plywood sides with wood screws to form a trough.
6. Glue 60 cm x 150 cm sheet chrome metalized polyester to the inside of curved sheet metal trough with contact cement.
7. Straighten a coat hanger to use as a spit. Bend at one end to make a handle (Figure 2). Insert the coat hanger into drilled focal point holes.

**Using the stove**

The trough opening must be aimed directly at the sun. (A simple aiming device may be made to aid in tracking the sun's position.) To avoid dripping, foil may be wrapped around cooking foods. But seeing food sizzle and spit is part of the fun! Grease may be wiped off of the sheeting.

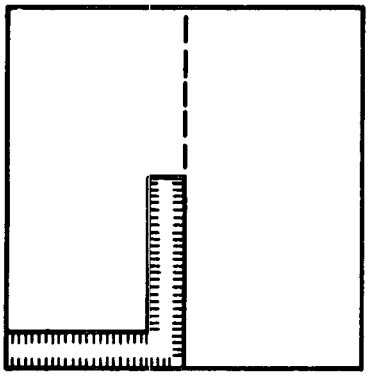


FIGURE 4

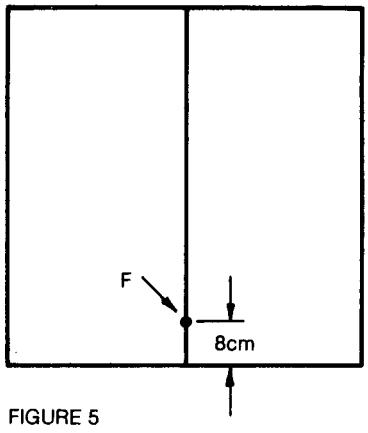



FIGURE 5

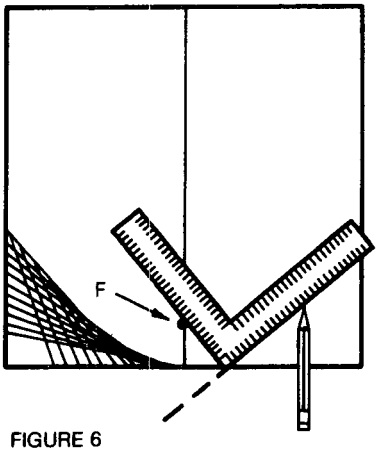



FIGURE 6

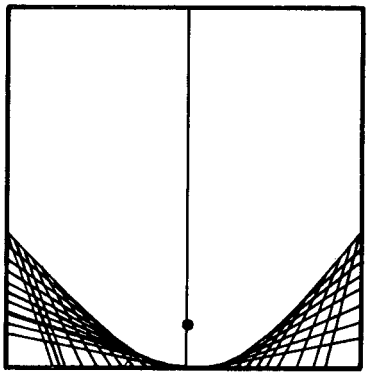


FIGURE 7

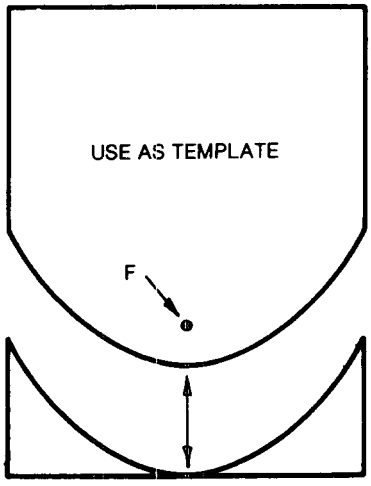
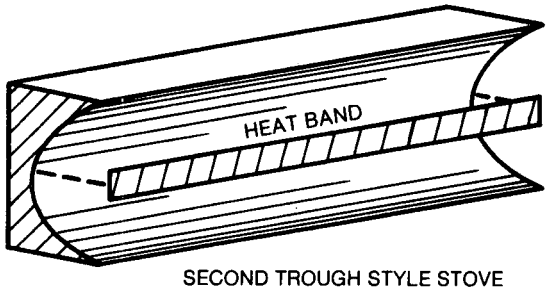



FIGURE 8




SECOND TROUGH STYLE STOVE

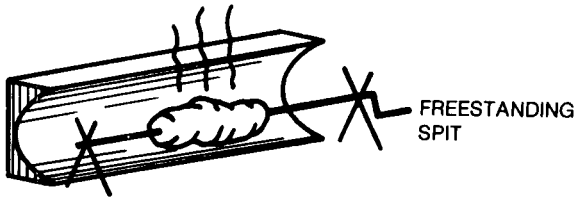
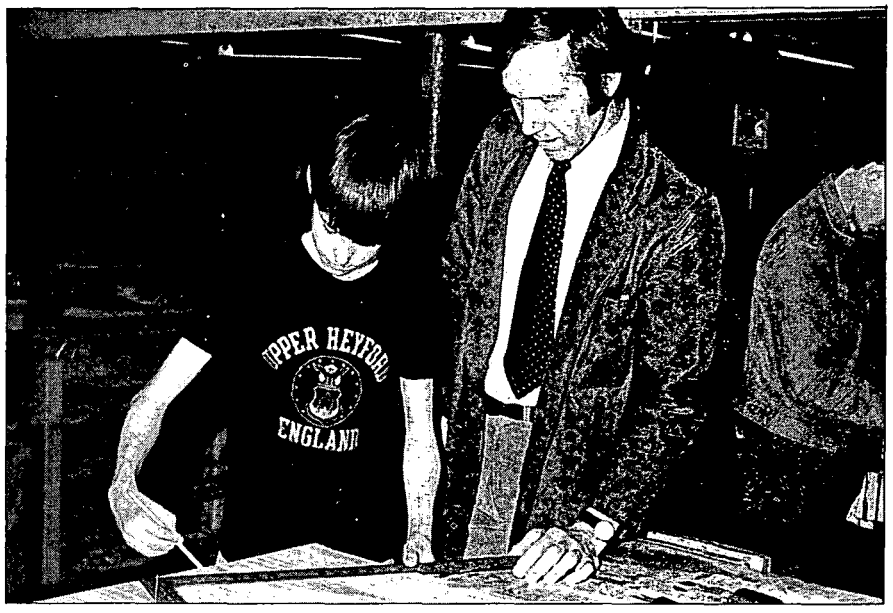



FIGURE 9




Carl Gross checks student's drawing of the parabolic pattern.

**Adaptations**

Let your students' imaginations go to work. How could heat be trapped to create an oven effect? (Carl's students came up with a clear plastic cover placed over the trough opening.) Could a portable, collapsible stove be made for camping? (Except to make a very small stove, probably not, because a folding model would create wrinkles in the reflective sheeting. However, you might come up with an answer.)

Move the project from the school shop to the home or club workshop. For a simpler, though less durable, version use tri-wall cardboard instead of plywood and thin, flexible cardboard in place of the sheet metal. Use paper tape over masking tape in place of wood screws for assembly of the stove.

The solar stove project was only a beginning at the Upper Heyford middle school. It served as an energy appetizer. The students' administration's enthusiasm was stirred to the point where a full "menu" is now being offered at the school in the form of an 18-week energy and industrial arts class which Carl Gross is teaching.

The solar stove ties together several disciplines: science, math, industrial arts, and even nutrition. But more important, it creates energy awareness among young people who will soon confront the problems of a world suffering from depleted traditional energy reserves. ■

*Ms. Kildahl is assigned to the Air Force Public Information Office at Upper Heyford, Oxfordshire, England.*

Door cut in plywood at right makes it easier to spear and remove food.

# Making a Sundial

Designing a sundial helps students to focus on the orientation of the sun to their location. The activity also gives lots of room for creativity.

# Making a Sundial

by John Horst

THE SUN CLOCK began life as an important scientific tool 3,500 years ago in Egypt. The sundial as we know it was developed in the early Christian era, but now it is obsolete as a timepiece and rarely seen. Still it is an easy and practical way to brighten your garden. In today's split-second age there is something satisfying about glancing up from weeding the vegetable patch and noting on your homemade solar clock that it is about half-past ten and time for a coffee break.

Making a sundial is easy. It has only two parts, the style (also known as the gnomon), which casts the shadow, and the clock face, which has the time markings. With a little care you can produce a curio that will tell time reasonably accurately, within ten minutes, all year long.

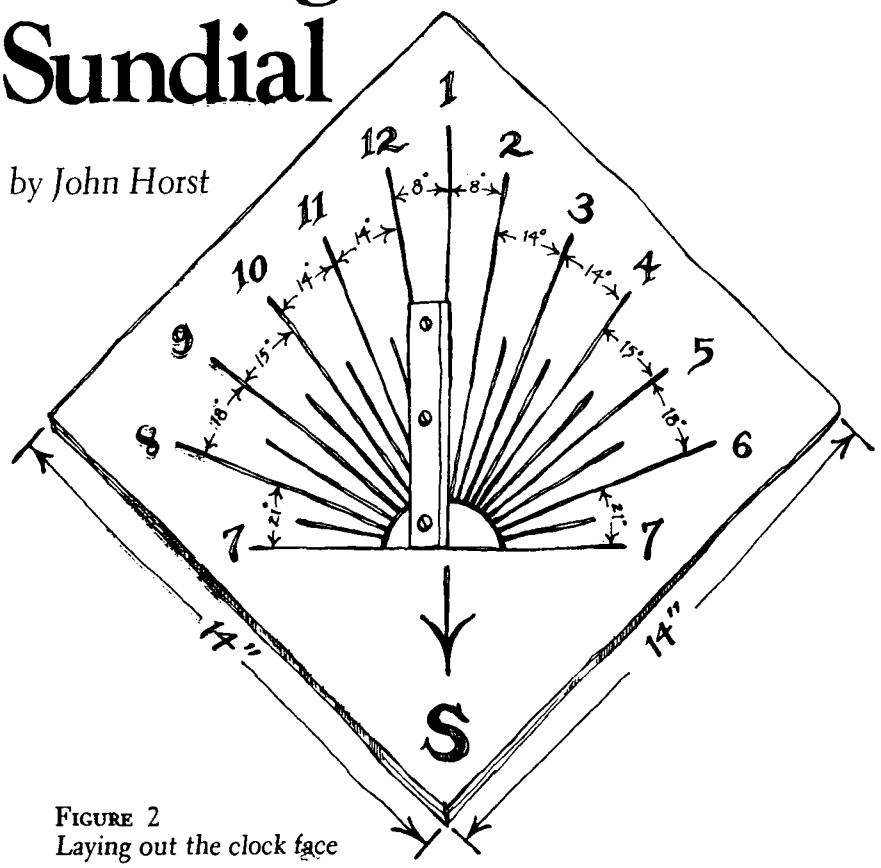



FIGURE 2
*Laying out the clock face*

### The Style

Make the style from a piece of sheet metal thick enough to resist bending by curious little hands, yet flexible enough to permit bending to form the base that attaches to the clock face. I used a piece of aluminum sheet 1/16 inch thick with good results.

The important things to remember about the style are: First, the shadow-line edge should be at 45 degrees to the clock face in the north-south direction and at 90 degrees to the clock face in the east-west direction (*see* Figure 1). Ideally, the north-south shadow-line edge should always be at a right angle to the sun at noon, standard time. Thus, its angle to Earth should vary slightly every day as our "tilted" Earth moves around the sun. Also, this angle varies depending on where you are on the globe in relation to the equator. For our purposes, 45 degrees is a good compromise angle for any location in the continental United States. If you live in Alaska the angle should be 60 degrees.

Second, the shadow-line cast by the style should be thin enough to make a readable line, yet the edge should be sturdy enough to resist bending by wind and the weather. I made mine 3/8 inch wide (*see* Figure 1) and got good results.

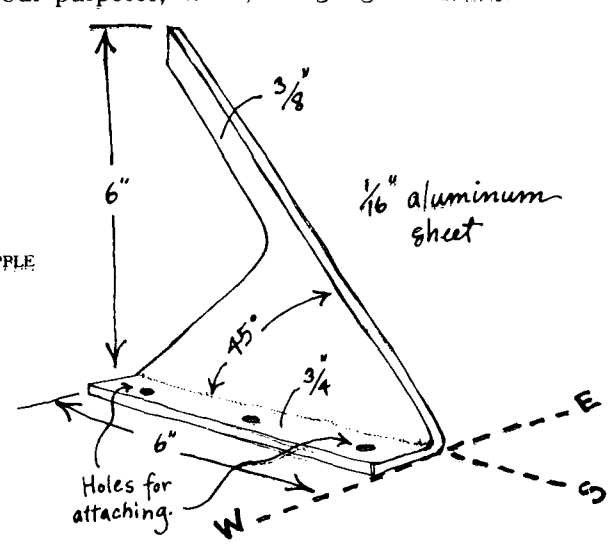



FIGURE 1
*Making the style*

DRAWINGS BY MARGOT APPLE

### The Clock Face

The clock face can be any flat surface. I used two square pieces of 5/8 inch exterior-grade plywood glued together to make one solid piece 1¼ inches thick and 14 inches on a side. The double thickness made for a sturdy face that had enough weight to set firmly on the stand even in windy weather. You can just as easily make it round or any shape that strikes your fancy. A friend made one using a slice from a maple log he was cutting up for firewood.

The important things about the face are the spacing of the time marks and their orientation to the sun.

Start by laying out two lines at right angles, crossing where the 45-degree shadow-line edge of the style will meet the clock face when the style is installed. These two lines will be your north-south and east-west orientation lines.

Now divide the space between east, north, and west into wedge-shaped segments using the angle measurements shown in Figure 2.

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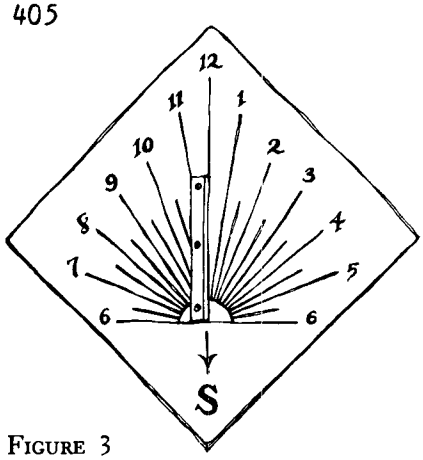



FIGURE 3
*Aligning the face and style*

The line dividing each segment will stand for an hour. Divide the space between each pair of hour lines in half, and you have the half-hour lines. A simple protractor will be accurate enough to establish the degree angles at the "point" of each segment. To set your solar clock for daylight saving time (Figure 2), label the line pointing west "7", the next hour line "8", and so forth. The 1 P.M. line will also be the north indicating line. The 7 P.M. line will coincide with the east indicator.

For standard time (Figure 3), start with 6 on the west line. Noon will be on the north line and east will be 6 P.M.

A good way to have a clock that is good all year is to paint standard-time markings on one side and daylight-saving-time markings on the other. When the time to set the clock forward or back arrives, you simply remove the style, flip the clock face over, replace the style, and realign the face with the sun.

### Setting up Your Solar Clock

After the clock-face markings are painted on and dry, you are almost finished.

Attach the style as shown in Figure 2. The 45-degree shadow-line edge should slope down toward and meet the clock face exactly where the east-west and north-south lines intersect. The rest of the style should be perpendicular to the face along the north line.

Now set the clock face on a suitable base in a sunny spot. I used an old bird-bath pedestal. Anything that provides steady support will do. Level the face in all directions using a carpenter's level or a pan of water.

The next step requires a little preliminary explanation. The sun is always due south at midday (noon, standard time or 1 P.M., daylight saving time) if you live precisely on the eastern edge of a time zone, any time zone. If you live on the western edge of a time zone, midday by the sun comes at 11 A.M., standard time (noon, daylight saving time). If you live in the middle of a time zone it comes at 11:30 A.M.

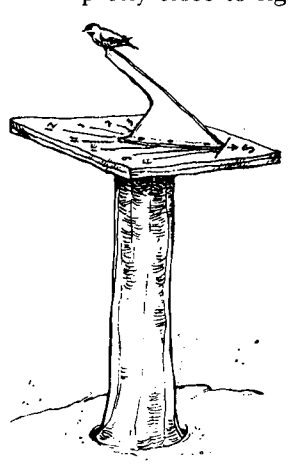
Now, back to our sundial. To obtain the most accurate reading, set your sun clock at midday, sun time. Here is what to do.

If you live in the eastern quarter of a time zone, Boston, Chicago, or Spokane, for example, at the stroke of noon standard time (1 P.M. daylight saving) on a sunny day, rotate the sundial on its base so the style shadow-line indicates 12 o'clock (or 1 P.M. daylight saving time).

If you live in the middle of a time zone, say Pittsburgh or Denver, follow exactly the same procedure, but set it at 11:30 A.M., standard time. If you live in the western quarter of your time zone, set it at 11 A.M. standard time (or noon, daylight saving time).

You can set the clock at any other time of day, but the approximations used to compute the style angle will complicate things. I don't recommend it unless you are willing to tinker around making adjustments.

That should do it. You now have your very own energy-saving, perpetual, solar-powered clock. Enjoy it, but don't expect it to match the accuracy of your new digital wrist watch. And if you live in Vermont, as I do, don't be upset on those cloudy days when your clock goes off duty, or in winter when it is covered with snow. It will soon be back on the job and pretty close to right on time. ◇



JOHN HORST is a retired engineer and management consultant, a glider pilot, and a habitual tinkerer.

# To Teachers

WHO PLAN TO USE THE READER WITH STUDENTS

Whether you are teaching young people or adults, whether you use this reader for classroom reading or for student assignments, there are a few facts that you should be aware of.

1. You have certain rights to and restrictions on your use of the material in this reader under the copyright law.

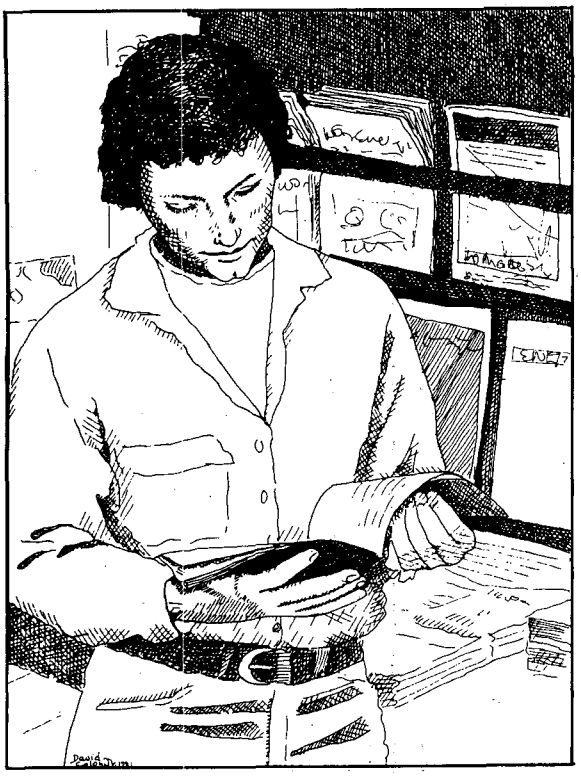
2. The statements and opinions contained in this material should be weighed and evaluated carefully.

3. In using readings with students, preparation and follow-up are as important as the reading itself.

Let's look at each of these points more closely.

## Your Right to Use the Reader

The articles included in this reader are reprinted here by the generosity of a number of writers, artists, editors, and publishers. Where the material is copyrighted (and most of it is), the copyright appears with the article, poem, or story. The copyright law does allow teachers to reproduce such material; however, there are limitations on that right. To make your rights as an educator clear, and to encourage you to use the reader, we have included the Congressional Guidelines for Classroom Copying. These guidelines appear on pages 411-413.



## Point of View

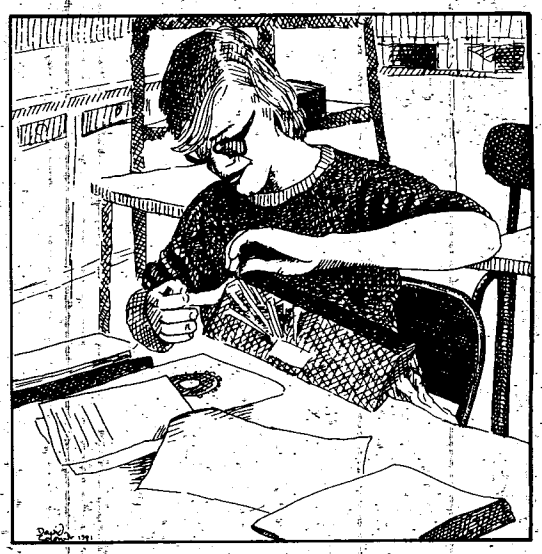
No magazine article can give you the full energy story; writers and publishers, like everyone else, have points of view. We can't guarantee that the articles included here are completely objective or all-inclusive. What this reader does attempt to do is to give a broad sampling. For suggestions on how to read thoughtfully and how to help students do the same, read on.

## Reading: Preparation and Follow-Up

To profit from a reading, the person doing the reading must begin with

motivation,
background,
reading ability and vocabulary, and
critical skills

How can you be sure that you and your students get the most from your energy reading? Below are some suggestions for preparation and follow-up on reading assignments.



### *Motivation*

Students today know that their future literally depends on energy. It's not hard to motivate them to read about energy, if you remind them that energy knowledge gives them more control over that future. To motivate,

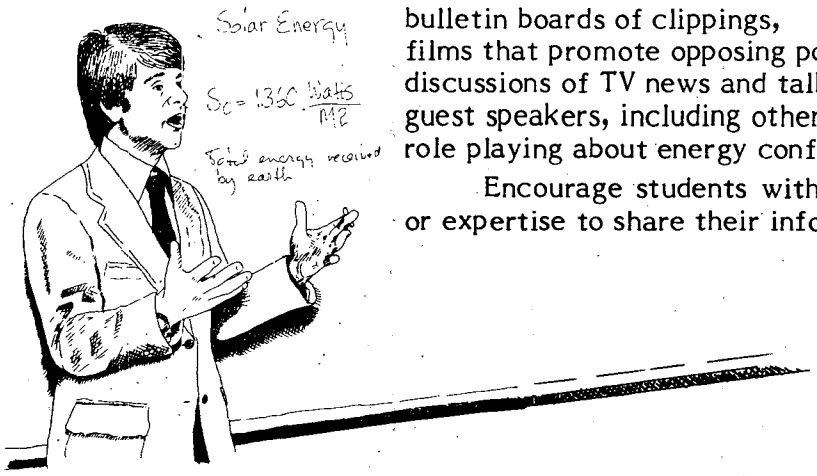
discuss sources of anxiety for them and their families, such as:
- rising costs,
- blackouts and shortages,
- political and strategic barriers to energy supply, and
- daily necessities and comforts that depend on energy;

use questions to encourage imagining and sharing, like:
- "Have you ever been in a greenhouse? What was it like?"
- "What would happen to utility companies if everyone used solar energy?"
- "Do you remember how you felt when you first became aware of an energy crisis?"
- "How do you think a person in a developing country might feel about energy use in the United States?"
- "How would you design a completely self-sufficient house?"

or do a pre-reading activity, for example:
- try a simple experiment or demonstration related to the article's subject,
- take a poll or survey,
- plan a debate or writing assignment based on the article's information, or
- consider various energy futures and raise questions about the probable outcomes.

## *Background*

Students care about the energy future, but they often lack specific information. They tend to get their opinions by hearsay, and talk in generalities and slogans. They need more context for their reading. You can break through oversimplified thinking with




bulletin boards of clippings,
films that promote opposing points of view,
discussions of TV news and talk shows,
guest speakers, including other faculty members, or
role playing about energy conflicts.

Encourage students with special knowledge or expertise to share their information.

## *Reading Ability and Vocabulary*

Not every reading is intended for every student. In fact, some of the articles in the reader are only appropriate for teachers and advanced students. Stack the deck for reading success:

1. Select articles at the appropriate reading level. (They are keyed in the table of contents with color tabs; one for easy, two for intermediate, and three for difficult.)

2. Introduce new words before beginning the reading. Students can use the glossary (page 415) or they can try to figure out the meanings of the words from their context.

3. Attack the reading at the easiest (informational) level first, and then lead students to the more difficult levels:
   First, search for and recall facts.
   Second, consider what the writer is trying to communicate.
   Third, apply what the writer says to one's own experience.
   Fourth, analyze how the writer presents his/her ideas.
   Fifth, suggest new ways of presenting or adding to these ideas.
   Last, evaluate and express opinions on the material.

## *Critical Skills*

Students like magazine readings because they perceive magazines as "adult" reading. But reading like an adult requires 1) desire for objectivity and 2) tolerance for ambiguity.

Desire for Objectivity

Help students to generate questions about the reading that encourage objectivity:

Who is the author?
Is he/she associated with some special interest group?
What are his/her claims to expertise?
Where does he/she use facts and where, opinions?
What is the quality of the evidence?
How can the assertions be verified or compared with opposing views?
Is the information up-to-date?
Is the style objective and balanced?
Does the author use propaganda techniques and emotional appeals?
Does the article leave out or gloss over certain points?

Tolerance for Ambiguity

Encourage students to be aware of ambiguities in their reading and discuss them:

Are there things the author has left out (intentionally or unintentionally)?
Are there other possible points of view on the subject?
May time and events alter the validity of what the author says?
Is the real situation more complex than the author suggests?
Does the author admit to uncertainty on some points?

With this kind of thoughtful preparation and follow-up, a reading becomes more than just another assignment. It becomes an opportunity to expand vocabulary, sharpen thinking, and develop more mature skills in evaluating ideas.

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# Agreement on Guidelines for Classroom Copying

## in Not-for-Profit Educational Institutions with Respect to Books and Periodicals

The purpose of the following guidelines is to state the minimum and not the maximum standards of educational fair use under Section 107 of H.R. 2223. The parties agree that the conditions determining the extent of permissible copying for educational purposes may change in the future; that certain types of copying permitted under these guidelines may not be permissible in the future; and conversely that in the future other types of copying not permitted under these guidelines may be permissible under revised guidelines.

Moreover, the following statement of guidelines is not intended to limit the types of copying permitted under the standards of fair use under judicial decision and which are stated in Section 107 of the Copyright Revision Bill. There may be instances in which copying which does not fall within the guidelines stated below may nonetheless be permitted under the criteria of fair use.

### Guidelines

I. Single Copying for Teachers

A single copy may be made of any of the following by or for a teacher at his or her individual request for his or her scholarly research or use in teaching or preparation to teach a class:

A. A chapter from a book;
B. An article from a periodical or newspaper;
C. A short story, short essay or short poem, whether or not from a collective work;
D. A chart, graph, diagram, drawing, cartoon or picture from a book, periodical, or newspaper.

II. Multiple Copies for Classroom Use

Multiple copies (not to exceed in any event more than one copy per pupil in a course) may be made by or for the teacher giving the course for classroom use or discussion; provided that:

A. The copying meets the tests of brevity and spontaneity as defined below; and,
B. Meets the cumulative effect test as defined below; and,
C. Each copy includes a notice of copyright.

Definitions

Brevity

(i) Poetry: (a) A complete poem if less than 250 words and if printed on not more than two pages or, (b) from a longer poem, an excerpt of not more than 250 words.

(ii) Prose: (a) Either a complete article, story or essay of less than 2,500 words, or (b) an excerpt from any prose work of not more than 1,000 words or 10% of the work, whichever is less, but in any event a minimum of 500 words.

Each of the numerical limits stated in "i" and "ii" above may be expanded to permit the completion of an unfinished line of a poem or of an unfinished prose paragraph.

(iii) Illustration: One chart, graph, diagram, drawing, cartoon or picture per book or per periodical issue.

(iv) "Special" works: Certain works in poetry, prose or in "poetic prose" which often combine language with illustrations and which are intended sometimes for children and at other times for a more general audience fall short of 2,500 words in their entirety. Paragraph "ii" above notwithstanding such "special works" may not be reproduced in their entirety; however, an excerpt comprising not more than two of the published pages of such special work and containing not more than 10% of the words found in the text thereof, may be reproduced.

Spontaneity

(i) The copying is at the instance and inspiration of the individual teacher, and,

(ii) The inspiration and decision to use the work and the moment of its use for maximum teaching effectiveness are so close in time that it would be unreasonable to expect a timely reply to a request for permission.

Cumulative Effect

(i) The copying of the material is for only one course in the school in which the copies are made.

(ii) Not more than one short poem, article, story, essay or two excerpts may be copied from the same author, nor more than three from the same collective work or periodical volume during one class term.

(iii) There shall not be more than nine instances of such multiple copying for one course during one class term.

The limitations stated in "ii" and "iii" above shall not apply to current news periodicals and newspapers and current news sections of other periodicals.

III. Prohibitions as to I and II Above

Notwithstanding any of the above, the following shall be prohibited:

A. Copying shall not be used to create or to replace or substitute for anthologies, compilations or collective works. Such replacement or substitution may occur whether copies of various works or excerpts therefrom are accumulated or reproduced and used separately.

B. There shall be no copying of or from works intended to be "consumable" in the course of study or of teaching. These include workbooks, exercises, standardized tests and test booklets and answer sheets and like consumable material.

C. Copying shall not:

(a) substitute for the purchase of books, publishers' reprints or periodicals;
(b) be directed by higher authority;
(c) be repeated with respect to the same item by the same teacher from term to term.

D. No charge shall be made to the student beyond the actual cost of the photocopying.

# Publications Address List

BLAIR & KETCHUM'S COUNTRY JOURNAL
205 Main Street
Brattleboro, Vermont 05301

THE CURIOUS NATURALIST
Massachusetts Audubon Society
Lincoln, Massachusetts 01773

CURRENT ENERGY AND ECOLOGY
Curriculum Innovations, Inc.
3500 Western Avenue
Highland Park, Illinois 60035

INDUSTRIAL EDUCATION
77 Bedford Street
Stamford, Connecticut 06901

INTERNATIONAL WILDLIFE
225 East Michigan
Milwaukee, Wisconsin 53202

MECHANIX ILLUSTRATED
CBS Publications
1515 Broadway
New York, New York 10036

SCIENCE AND CHILDREN
National Science Teachers Association
1742 Connecticut Avenue, N.W.
Washington, D.C. 20009

THE SCIENCE TEACHER
National Science Teachers Association
1742 Connecticut Avenue, N.W.
Washington, D.C. 20009

# Glossary

## a

active solar energy system
a system which requires external mechanical power (motors, pumps, valves, etc.) to operate the system and to transfer the collected solar energy from the collector to storage or to distribute it throughout the living units. Active systems can provide space heating and cooling, domestic hot water, and/or steam for industrial use.

## b

## c

coal
solid fuel formed by the decomposition of plants buried deep under the earth's surface. A group of naturally occurring, carbon and hydrogen-rich substances are called "coal". Various types are ranked by the percentage of carbon in dried samples or by the caloric value of moist ones. From least to most carbon-rich, the coal group includes peat, lignite, sub-bituminous and bituminous coals, and anthracite.

collector
any of a wide variety of devices (flat-plate, concentrating, vacuum tube, greenhouse, etc.) which collect solar radiation and convert it to heat.

conservation
making the best use of natural resources by reducing waste, improving efficiency, and slowing the rate of consumption.

## d

## e

energy
the ability to do work or make things move; the application of a force through a distance. Energy exists in a variety of forms (electrical, kinetic or motion, gravitational, light, atomic, chemical, heat) and can be converted from one to another. Common units are calories, joules, Btu, and kilowatt-hours.

environment
the sum of all external conditions and influences affecting the life, development, and ultimately the survival of an organism.

## f

fission
a nuclear reaction in which large atoms are split in two with the release of large amounts of energy. Heat produced by fission of a particular kind of uranium, $U_{235}$, is used to generate electricity in Western Europe, the U.S., and Japan.

force
the action on a body which tends to change its relative condition as to rest or motion.

fossil fuels
coal, petroleum, and natural gas; this term applies to any fuels formed from the fossil remains of organic materials (plants and animals) that have been buried for millions of years. The ultimate source of energy for those plants and animals was the sun.

fusion (nuclear)
a nuclear reaction involving combinations of small atomic nuclei into larger ones with a tremendous release of energy. Experimental fusion reactors are being developed in Europe and the U.S. The fuel for fusion is deuterium, a form of hydrogen which occurs naturally in sea water in a ratio of one atom to 6,500 atoms of normal hydrogen. Deuterium fuel is abundant, but technical and economic feasibility of fusion processes as the bases for electrical power is problematic.

# g

geothermal energy
heat trapped in the interior of the earth is called geothermal energy. Boreholes into the crust show an average temperature increase of $1^{\circ}$ C for every 30 meters of depth, or about $100^{\circ}$ F per mile. Geothermal heat is believed to come from the decay of radioactive materials deep in the earth as well as from friction of rock movements, tidal forces, and perhaps other sources. This heat keeps great quantities of buried rock molten and hot. Some of this energy escapes at the surface as hot water. Geothermal energy is available in four forms: dry steam, wet steam, hot rocks, and hot water.

greenhouse effect
a phenomenon which converts solar radiation to heat. Sunlight penetrates glazing quite easily but, when absorbed by objects behind the glazing, is reradiated as heat which does not penetrate the glazing as easily. Heat is thereby trapped and can be used. Also: the warming effect of carbon dioxide and water in the atmosphere acting as a "lid" to slow the escape of heat from the earth's surface. Molecules of water and carbon dioxide absorb and reradiate back to earth much of the heat radiated from it.

# h

heat
energy that flows between a system and its surroundings because of a temperature difference between them. Heat results from the motion of molecules of matter. Also, the word heat is often used to refer to the energy contained in a sample of matter (for example, kilocalories per unit of food).

heliostat
an instrument consisting of a mirror mounted on an axis moved by clockwork; used to reflect the sun's rays into a solar collector or furnace.

hydroelectric plant
an electric power plant in which the energy of falling water is converted into electrical energy by a turbine generator.

# i

infrared radiation
the invisible rays just beyond the red of the visible spectrum; their wavelengths are longer than those of the spectrum colors and they have a penetrating heating effect.

insulation
material with high resistance (R-value) to heat flow. Some commonly used materials for home insulation are fiberglass, cellulose, rock wool, and styrofoam.

# j k l

# m

methane gas
a colorless, flammable, gaseous hydrocarbon, emitted by marshes and by dumps undergoing decomposition; can also be manufactured from crude petroleum or other organic materials.

# n

natural gas
a mixture of gaseous hydrocarbons occurring naturally in certain rocks. There are several kinds of gas trapped in porous rocks underground. One of these "natural gases" is methane, used as a commercial fuel. Petroleum deposits always include some methane, but natural gas deposits are not always accompanied by petroleum. Natural gas is commonly sold to individuals in hundreds of cubic feet (CCF), the unit appearing on household utility bills. One CCF of commercial methane has about 25,000 kilocalories, the equivalent of 8 pounds of coal or 0.7 gallons of crude oil. (See also: methane.)

nonrenewable resources
energy resources that are not being replaced during the time span of human history. Examples are coal, oil, natural gas, and uranium.

nuclear energy
energy from radioactive decay or from fission or fusion reactions. In a controlled situation it can be used to produce electricity.

nuclear power plant
a generating station where heat for creating steam comes from nuclear fission instead of from combustion of fossil fuels.

# o

ocean-thermal energy conversion (OTEC)
an energy technology in which the temperature difference (between cold deep water and the warm surface water 2,000 feet above it) in tropical oceans is used to generate electricity.

oil shale
a sedimentary rock containing solid organic matter (kerogen) that yields substantial amounts of oil when heated to high temperatures.

overhang
a solid horizontal or angled projection on the exterior of a building placed (ideally) so that it shades southern windows in summer only. An overhang may be fixed or movable, part of the original construction or a retrofit. Several designs are possible. An upward-tilted overhang can also serve as a reflector in winter.

# p

passive solar energy system
an assembly of natural and architectural components which converts solar energy into usable or storable thermal energy (heat) without mechanical power. Current passive solar energy systems often include fans, however.

petroleum
an oily, flammable liquid that may vary from almost colorless to black and that occurs in many places in the upper strata of the earth. It is a complex mixture of hydrocarbons and is the raw material for many products including gasoline, kerosene, lubricants, and waxes.

photosynthesis
green plants' process of using solar energy to convert simple molecules into complex ones with high potential energy. Carbon dioxide and water are combined, in the presence of sunlight and chlorophyll, into carbohydrates such as sugars, starches, oils and cellulose.

photovoltaic cell
a device which converts solar energy directly into electricity. Sunlight striking certain materials (silicon is most common) causes the release of electrons. The migration of these released electrons produces an electrical current. The conversion process is called the photovoltaic effect.

pollutant
an impurity or contaminant emitted to the ambient air. It may be a solid (particulate matter), liquid (mist), or gas (such as carbon monoxide).

power
the rate at which work is performed. It is measured as units of energy per unit of time, for example: calories per second, watts (joules per second), or horsepower (foot-pounds per second).

## q

## r

radiation
the method by which heat is transferred through open space. About 60% of the heat transferred to a room from a wood stove is by radiation. Sunlight travels to us by radiation through space at "the speed of light", 299,728 kilometers per second.

renewable resources
materials that are recycled by natural processes within a relatively brief span of time (a human lifetime). Fresh water, wind, sunshine, and trees are some examples of resources that replace or recycle themselves within human time frames.

## s

solar energy
the electromagnetic radiation emitted by the sun. The earth receives about 4,200 x $10^{15}$ kilowatt-hours of solar radiation per day.

solar greenhouse
a sunspace containing thermal mass and used to grow plants.

storage
the device or medium that absorbs collected heat and stores it for later use.

strip mining
mining for coal or useful ores by removing the soil and rock found above them, rather than by tunneling underground.

synthetic fuel
liquid, solid, or gaseous fuels produced from carbon-rich materials by human technology. Examples are coal gasification, coal liquefaction, oil shale extraction, and trash-to-energy conversions.

# t

temperature
a measure of the energy of motion of the atoms and molecules of a substance. Thermometers and thermistors are used to measure an object's temperature. Temperature is not the same as heat. The tip of a burning match has a high temperature, but the object as a whole might contain very little heat due to its size.

# u v

# w

wastes, radioactive
by-products of producing power by splitting atoms in a nuclear power plant; some of these materials are highly radioactive and remain radioactive for long periods of time.

windmill
a machine run on energy generated by wind blowing against blades or slats.

work
energy transferred from one object to another, that is, a force acting against resistance to produce motion in a body; measured by the product of the force acting and the distance moved through, against the resistance.

# x y z

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