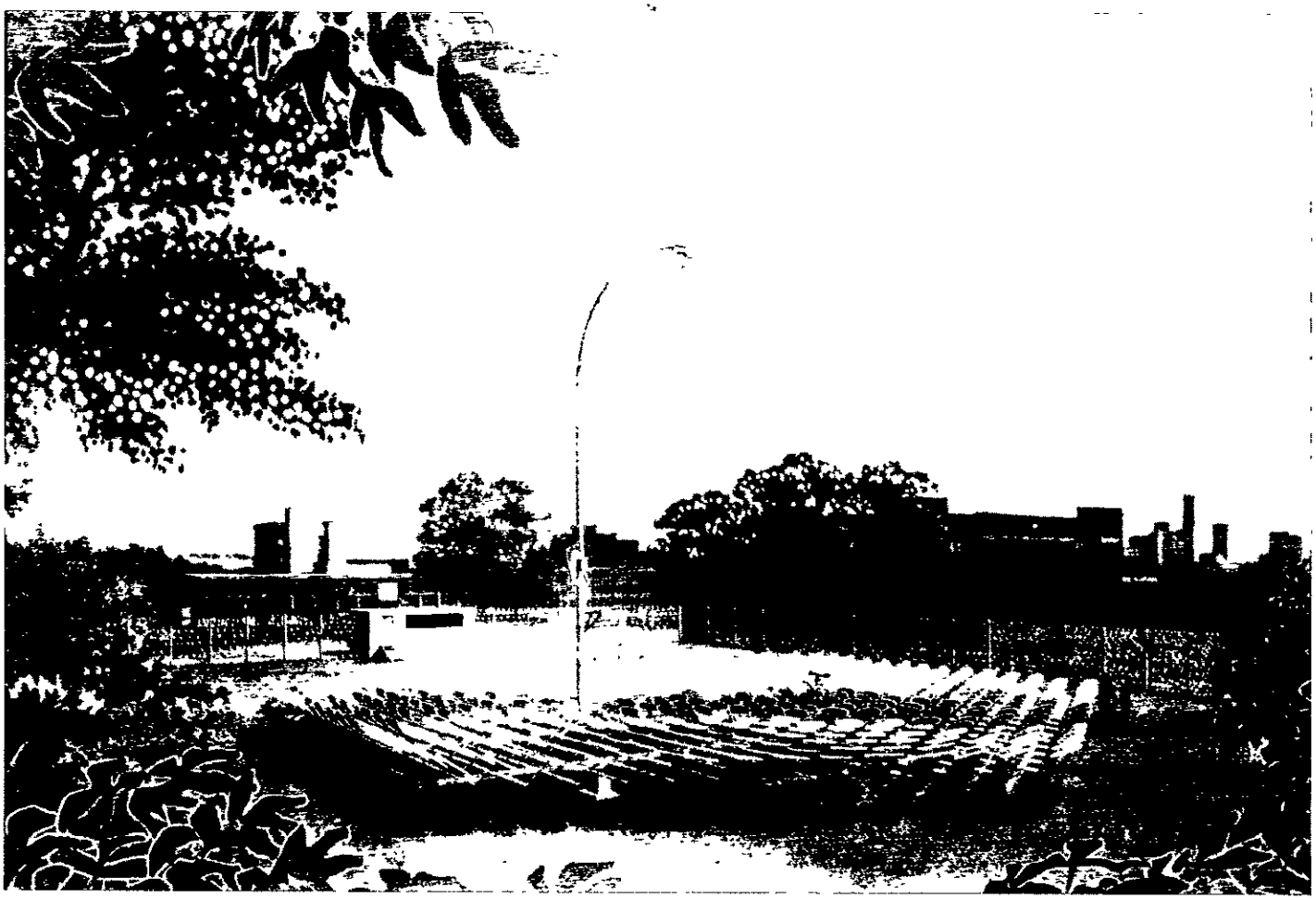
PN-AAK-910

EMPLOYMENT GENERATION THROUGH THE STIMULATION OF SMALL-SCALE INDUSTRY

Pictorial Monograph No. 2
Appropriate Technology Aspects of Solar Energy



Developed from the files of the Georgia Institute of Technology,
Atlanta, Georgia

Pictorial Monograph No. 2

APPROPRIATE TECHNOLOGY ASPECTS OF SOLAR ENERGY

Compiled by

Ross W. Hammond

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Engineering Experiment Station
GEORGIA INSTITUTE OF TECHNOLOGY
Atlanta, Georgia 30332
February 1977

FOREWORD

This is the second of a series of pictorial monographs on aspects of appropriate (or intermediate) technology. This monograph deals with examples drawn from the alternative energy source field, including various aspects of solar energy. This contrasts with the subject covered in Monograph No. 1, which dealt with appropriate technology in the small industry field. The two monographs are related, however, because many solar energy components lend themselves to manufacture by the small industry sector.

The examples cited herein are from both developed and developing countries. The interest in solar energy as an alternative source of energy is widespread and research is being conducted in many countries. It appears that a number of solar energy applications are now or will shortly be competitive with conventional energy sources. This is especially true in those countries where conventional energy costs are presently high.

This monograph has been made possible by a 211(d) grant to Georgia Tech and small industry grants to a number of counterpart organizations by the Agency for International Development.

Ross W. Hammond, Director
Economic Development Laboratory
Engineering Experiment Station
GEORGIA INSTITUTE OF TECHNOLOGY

APPROPRIATE TECHNOLOGY ASPECTS OF SOLAR ENERGY

For 21 years, the Economic Development Laboratory (formerly the Industrial Development Division) at Georgia Tech has been involved in appropriate technology, first in Georgia, then in the southeastern United States, and since 1964, internationally.

The increase of worldwide interest in what is variously called appropriate, intermediate, or adaptive technology is manifest in the proliferation of literature on the subject, and in recent programs established by a number of national governments and privately funded organizations.

There are several varying definitions of appropriate technology in existence. For the purposes of this monograph, however, appropriate technology is defined as " . . . that level of applied technology which is best suited to the specific cultural, social, economic and political climates found in the various countries of the world."

The characteristics of appropriate technology as perceived by various practitioners in the field vary considerably as well. However, a number of generally accepted characteristics recur in most such compilations. These include the following:

1. Technology is seldom directly transferable. More often than not it must be adapted to different environmental conditions.

2. The various cultural, political, economic, and infrastructure conditions must be considered in suggesting the appropriate technology.

3. To the maximum extent possible, local materials and natural, manpower, and man-made resources should be utilized.

4. Appropriate technology should encourage and foster indigenous initiative and innovation. It is not sufficient to buy technology and know-how and transfer and install it without encouraging in the productive system flexibility and a willingness to change with changing markets and other factors.

5. Appropriate technologies must have or develop logistical support systems, such as maintenance services and spare parts availability.

6. Basic to appropriate technology is the concept of cost effectiveness. Hence, most considerations are concerned with labor-intensive, low-cost elements.

It obviously is desirable that appropriate technologies (which embody all or most of these characteristics) have widespread applicability. In this way, the cost effectiveness and other advantages associated with such developments may be widely distributed.

In the examples that follow, it will be apparent that not all solar technologies are universally applicable. They are frequently location specific, and would require considerable modification or adaption to be transferred from one milieu to another.

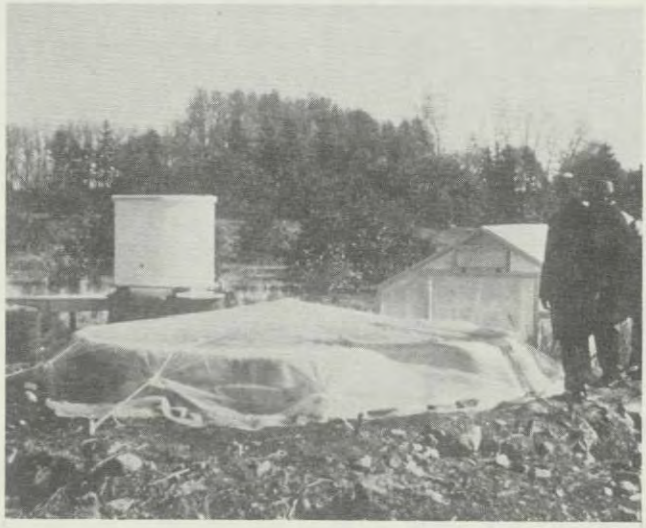
APPROPRIATE TECHNOLOGY ASPECTS OF SOLAR ENERGY

Impending shortages of nonrenewable fuels and escalating energy costs have created worldwide problems and accelerated research on alternative energy sources. Georgia Tech has conducted solar energy applications research and development since 1972, and the involved scientists believe solar energy can compete with traditional sources of energy in various applications.

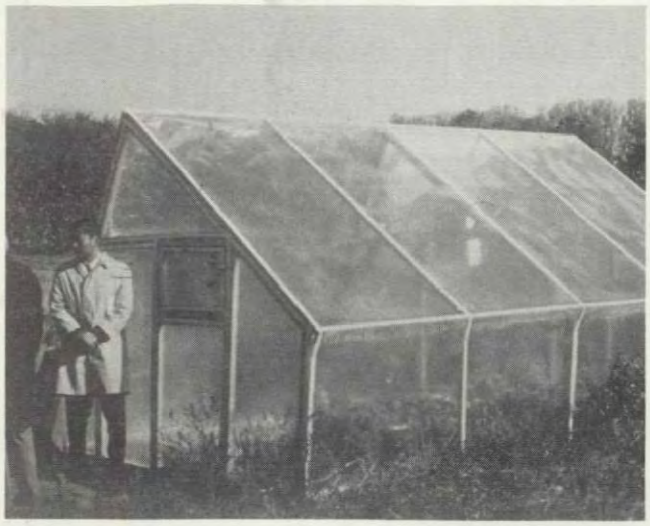
SOLAR ENERGY APPLICATIONS

DRAWN FROM THE ECONOMIC DEVELOPMENT LABORATORY FILES

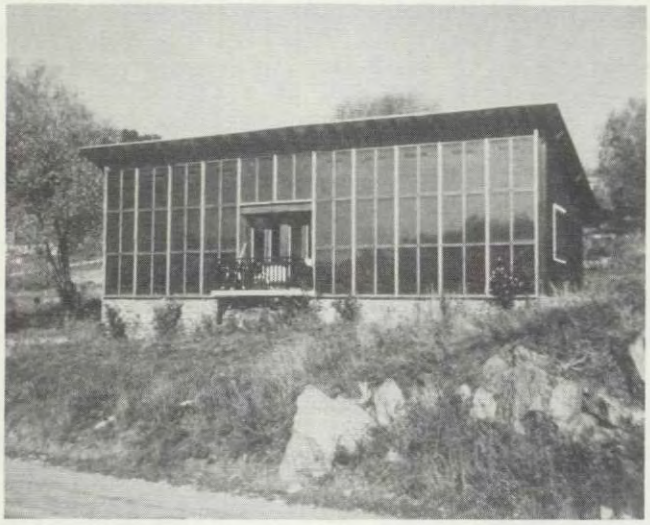
Examples of solar energy research conducted by various organizations around the world and at Georgia Tech illustrate some of the applications which have promise.



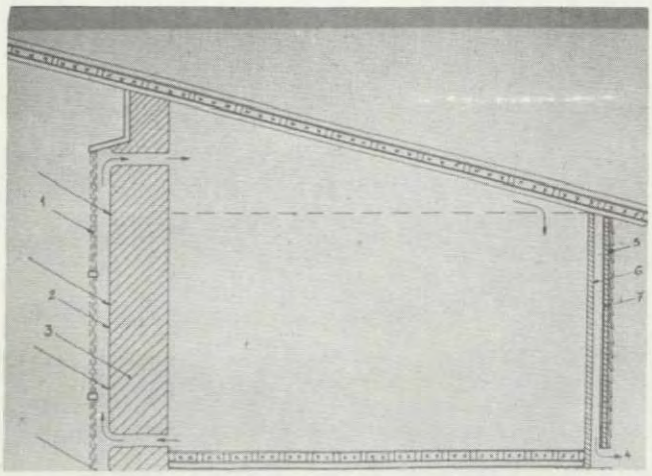
At Brace Research Institute in Canada, a solar pond with a plastic cover provides a source of water at 160°F, even though the ambient temperature was near freezing when this picture was taken.



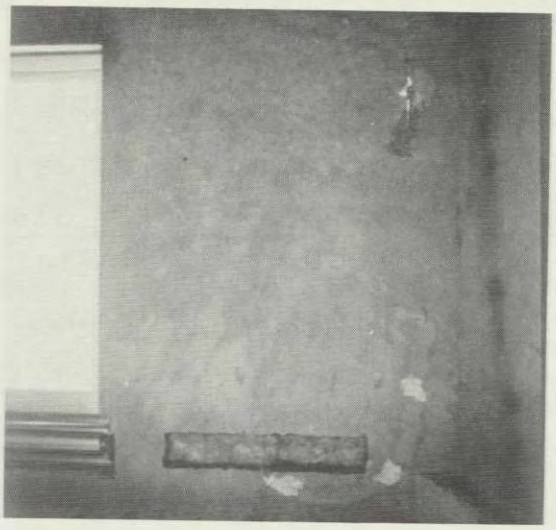
A high-efficiency greenhouse at Brace with an aluminized back wall which reflects solar radiation to a heat storage medium -- rocks. The rocks release the stored heat slowly after sundown.



In France, solar heating of residences is accomplished in various ways. This house utilizes a passive heating system.

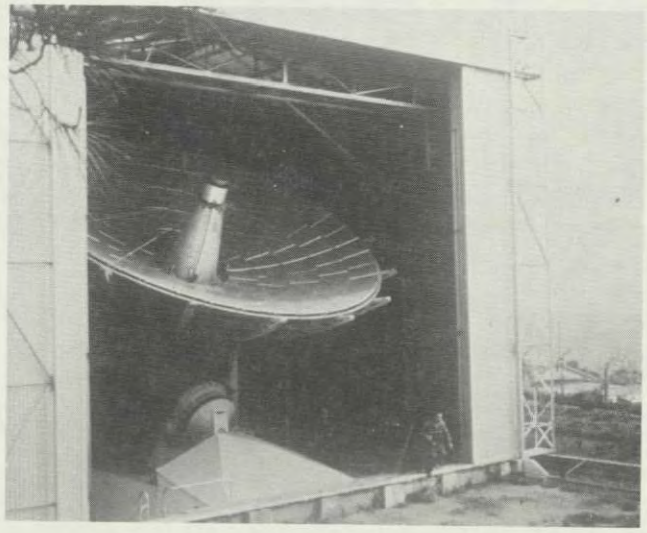


A double glass window admits solar radiation which heats a black painted stone wall. The wall absorbs the heat. When vents near the floor and ceiling are opened, cool air enters near the floor and is heated in its passage between the exterior glass and the stone wall.

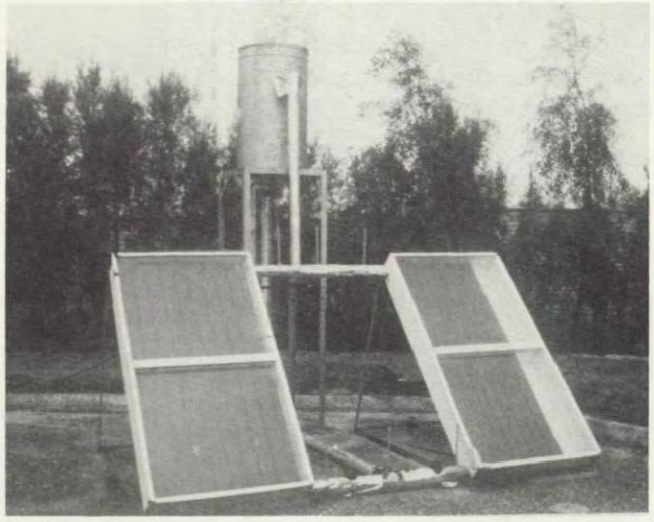


Natural convection forces the air to rise and be released into the house through the top vent.

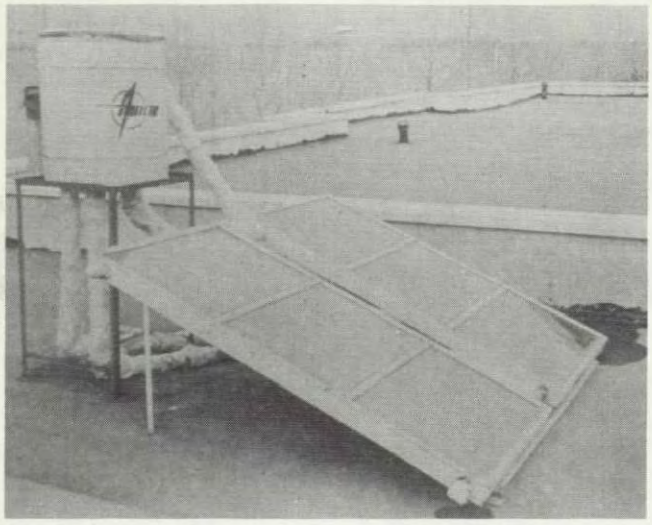
Here is an apartment complex in the south of France heated by solar energy.



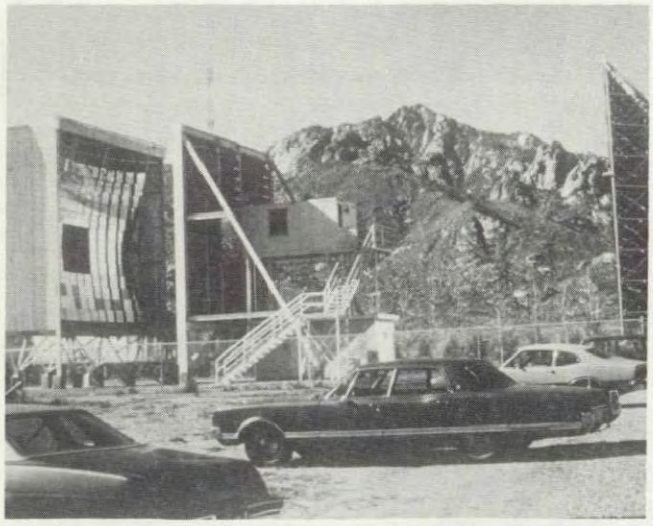
In Algeria, a parabolic solar concentrator is used for solar energy research at relatively high temperatures.



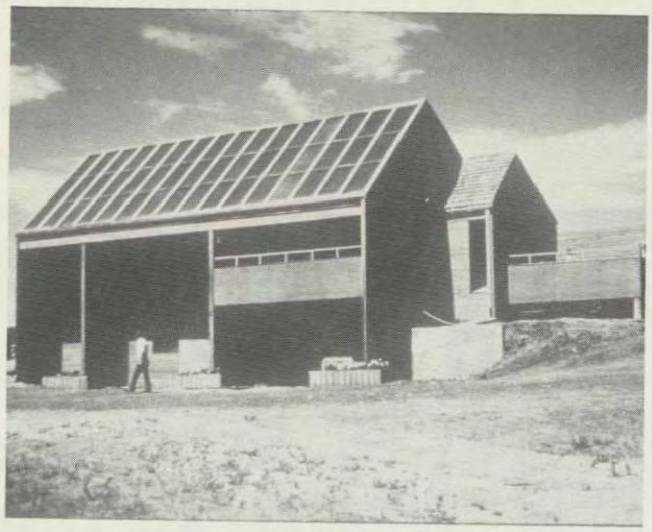
In Kuwait, a solar water heater works effectively and is practical even in this oil-rich country.



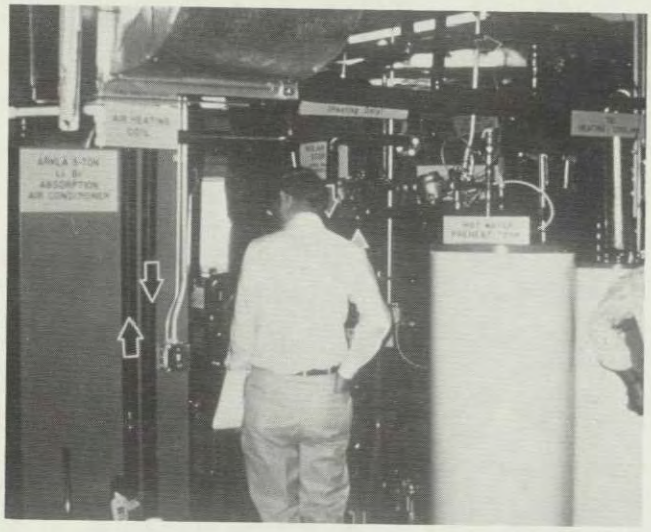
The Israeli water heater is simple, unsophisticated, and widely used in the Middle East.



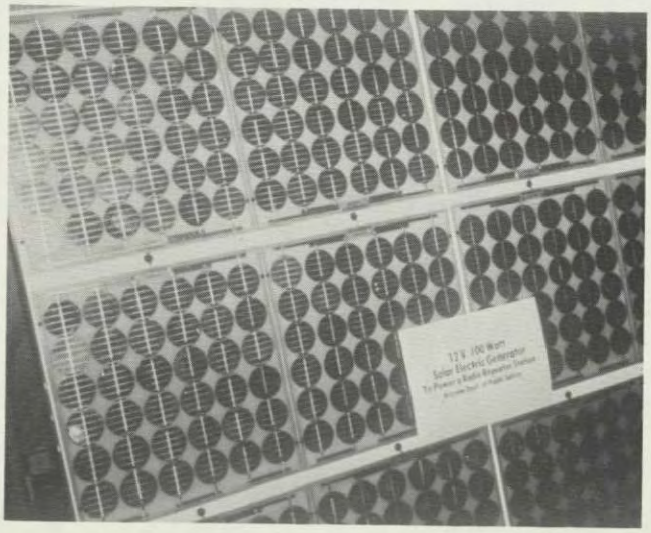
This 35-kilowatt U. S. Army solar furnace at White Sands, New Mexico, involved Georgia Tech in several projects, including measurements, test methods, and instrumentation.



Colorado State University's solar-powered residence is heated and air conditioned.

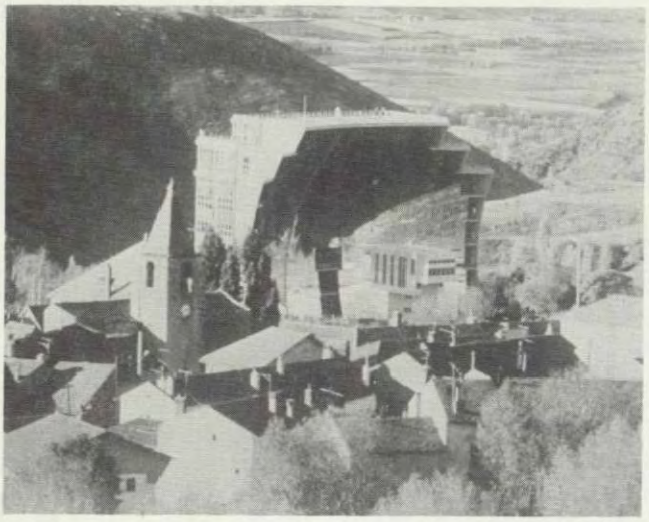


Some of the residence equipment is shown here.

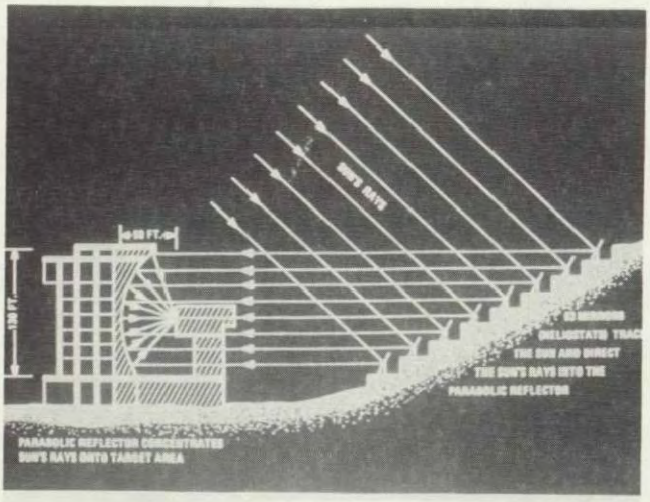


Direct conversion of sunlight to electricity is technically possible, using photovoltaic cells, but it is still not competitive with conventional means of generating electricity.

In Genoa, Italy, a field of mirrors produces 100 KWTH of superheated steam at 1100°F and 2200 PSI in the solar boiler on the pole.

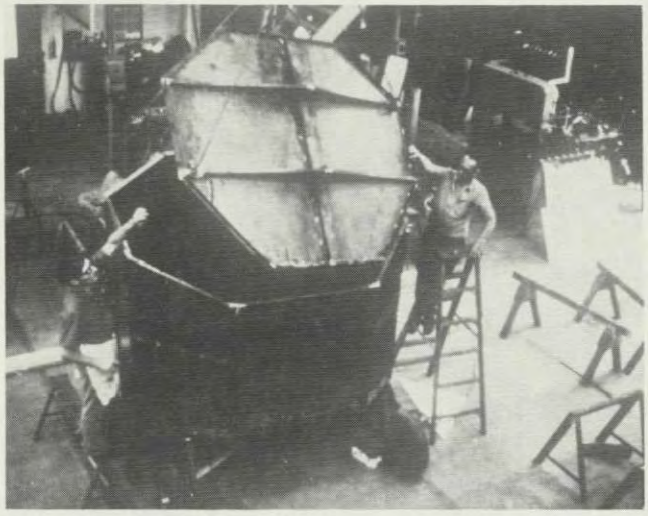


The Centre National de Recherche Scientifique in France operates a 1000-KW solar furnace. This eight-story parabolic mirror concentrates the solar radiation in a receiver. A temperature of 4000°F can be achieved.

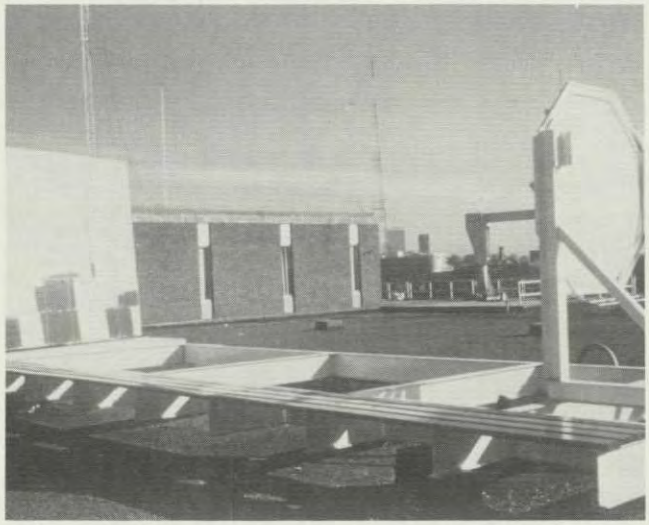


This schematic shows the sun's rays impacting on mirrors on a hill near the furnace which transmit the radiation to the parabolic mirror.

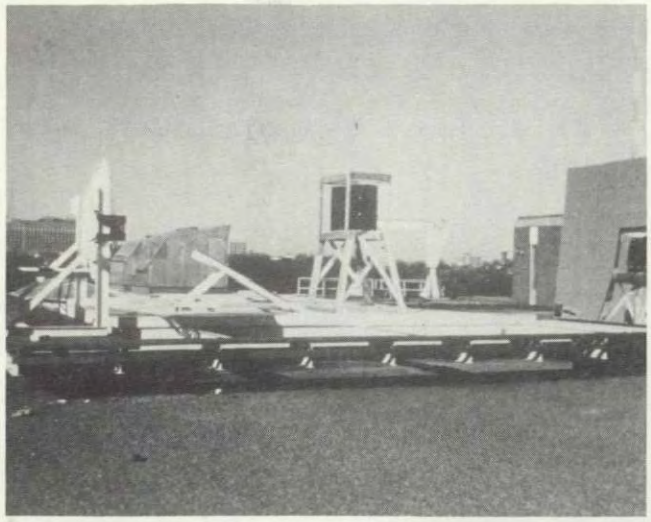
Georgia Tech has been using this test facility for five years, first for high-temperature ceramics testing and later for solar boiler testing and evaluation.



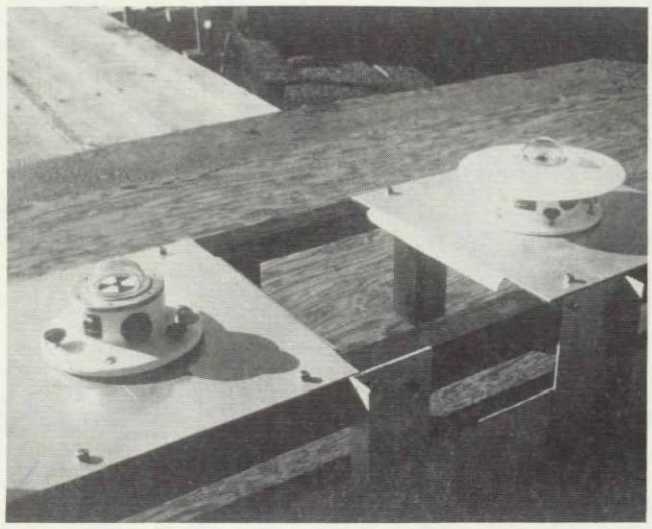
Jointly with Martin Marietta Corporation, Georgia Tech designed and constructed a bench model solar steam generator. Tested at the French solar furnace, the unit produces 1 megawatt thermal with a steam rate flow of 2600 pounds per hour at 1250 PSI, equal to 300 KW of electrical energy output.



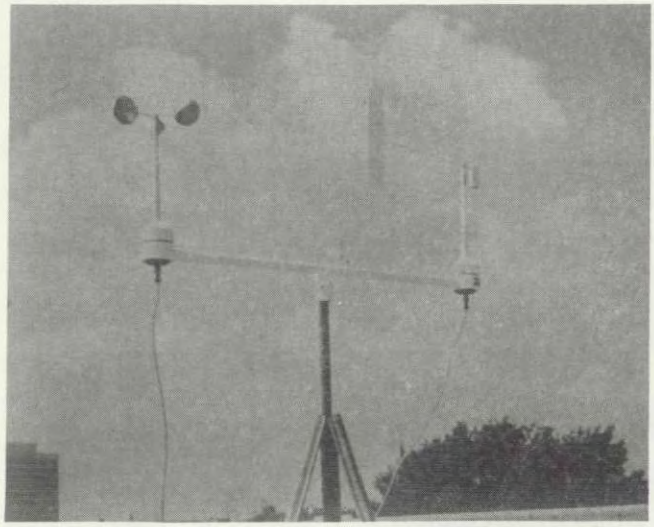
A model solar furnace on the Tech campus consists of reflecting mirrors and a 62-inch-wide parabolic concentrator which produces 2000 watts of energy in a one-inch focal point.



An optical guidance system designed at Georgia Tech controls electric motors which rotate the mirrors to follow the sun.

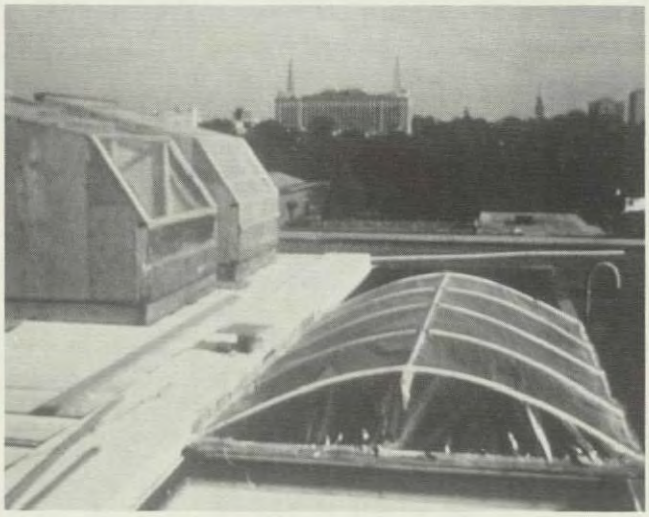


Used for research, the solar furnace is highly instrumented. Radiation, wind, and other readings are continuously recorded in a mini-computer installation.

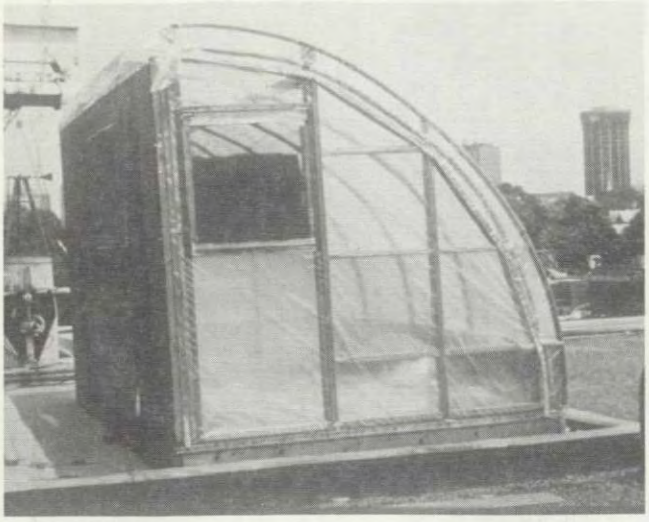


An experimental fixed segment mirror at Tech focuses radiation on a focal line.

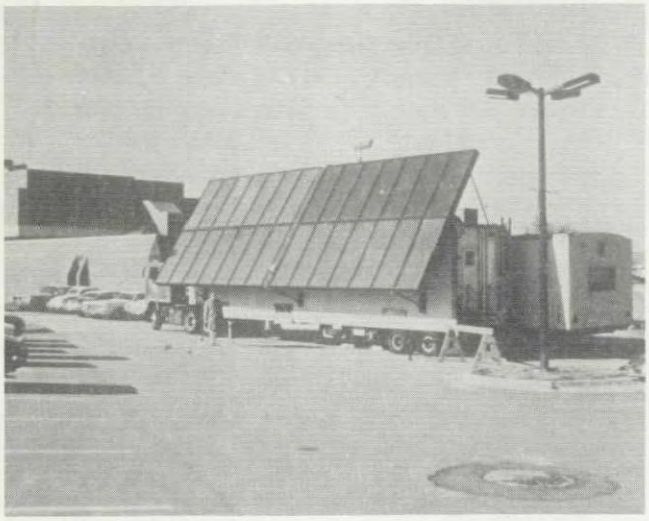
A larger unit with 540 square feet of mirror concentrator, utilizing either air or liquid in the pipe located in the focal line, produces large quantities of 500°F process heat, usable for air conditioning or electric power generation.



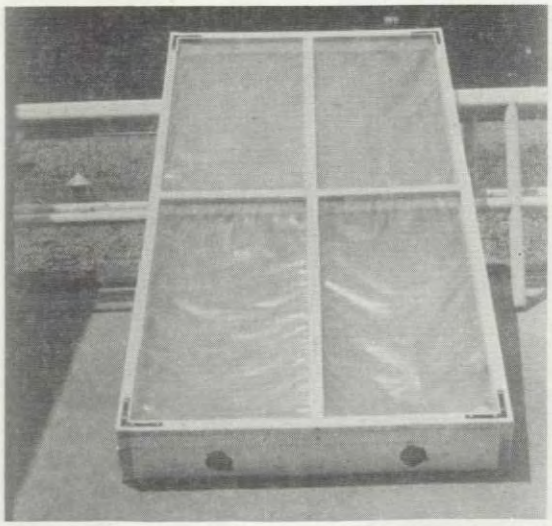
Research is being conducted at Georgia Tech on the use of solar ponds and materials for use in greenhouses.



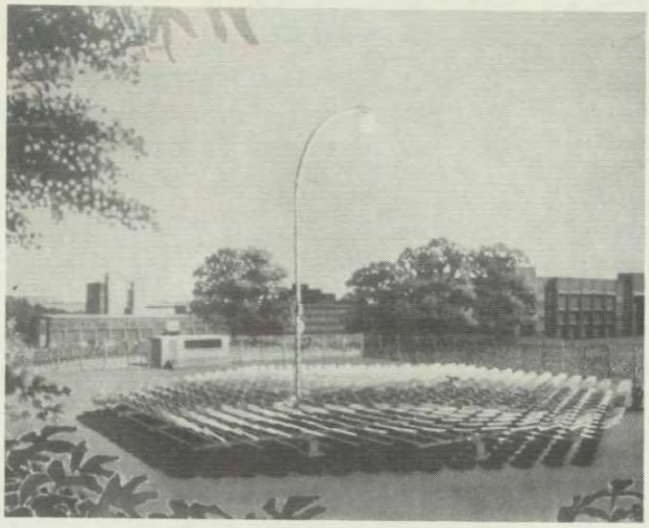
A high-efficiency greenhouse at the institution with an aluminized back wall for reflecting radiation to rock storage. The growing season can be lengthened with this type of design.



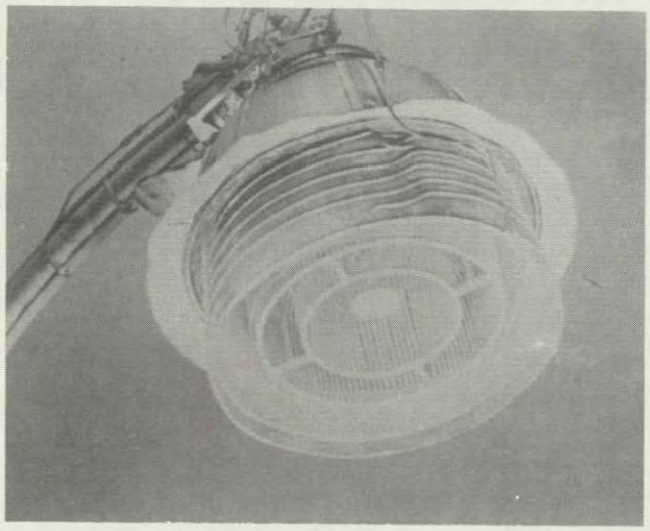
A flat-plate collector mobile test unit being exhibited on the campus.



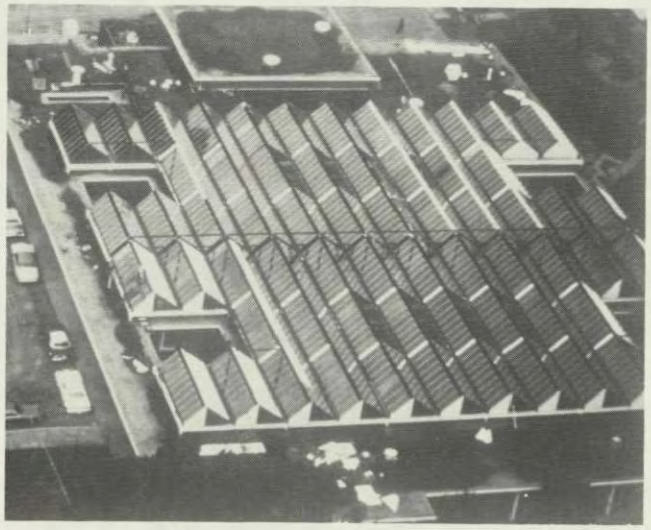
Research is being conducted on low-cost flat-plate collectors, testing various materials. Locally available materials should be utilized where possible to reduce costs of such units. Solar energy components such as this lend themselves to manufacture by small industries.



A large solar thermal generator being constructed on the Georgia Tech Campus. The 550 mirrors focused on a solar boiler will produce steam at 1100°F and 220 PSI.



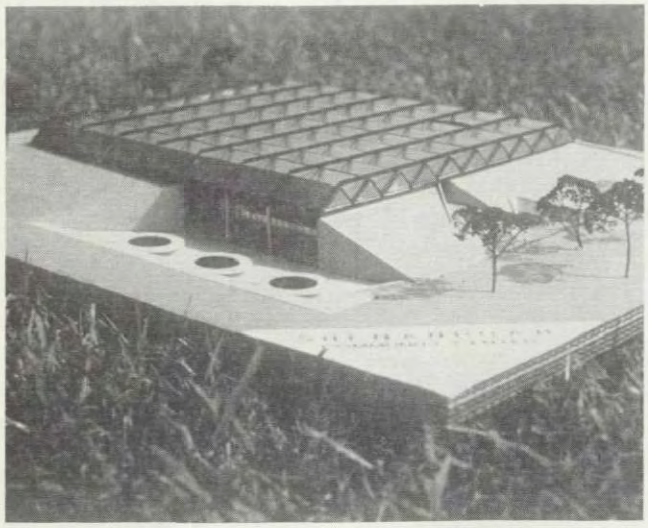
The radiation intensity focused on the black boiler makes it appear white.



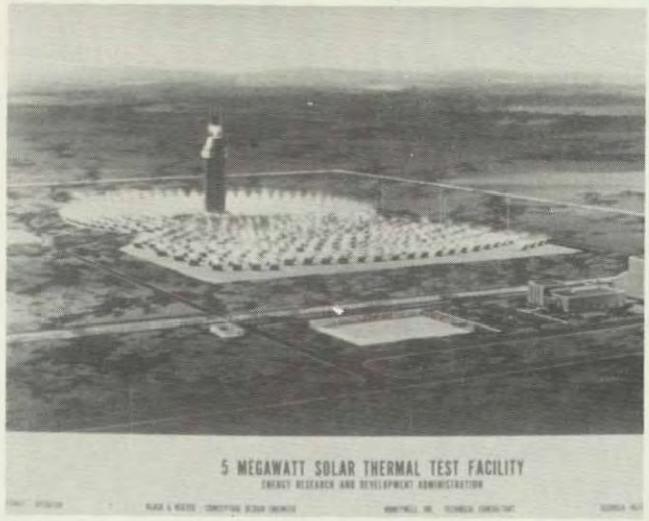
Westinghouse and Georgia Tech combined efforts on a retrofit solar energy system which has been installed at the 32,000-square foot George A. Towns Elementary school in Atlanta. This shows the flat-plate collectors on the roof of the building.

Alternate sides of the collector units are aluminized to reflect additional radiation on the collector plates during the summer months when the sun is high. This accommodates the additional energy requirements of the air-conditioning system.

Underground water tanks store hot water in the winter for building heating and chilled water in the summer for air conditioning.

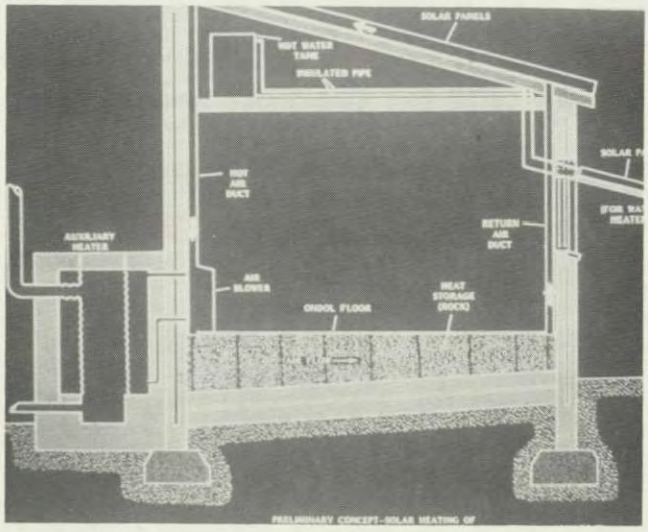


This model is of a 54,000-square foot community center nearing completion in Georgia. The solar system, designed and engineered by Georgia Tech, will provide 90% of winter heating energy and 60% of summer cooling. This is believed to be the largest solar-powered building in the United States.



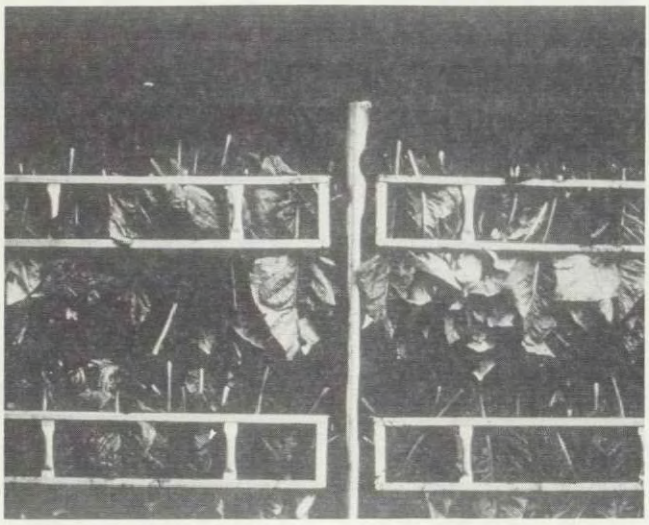
Tech is contributing to the design and development of a 5-megawatt solar thermal test facility near Albuquerque, New Mexico.

This solar-powered residence in Atlanta is one of a growing number of such homes in the area.

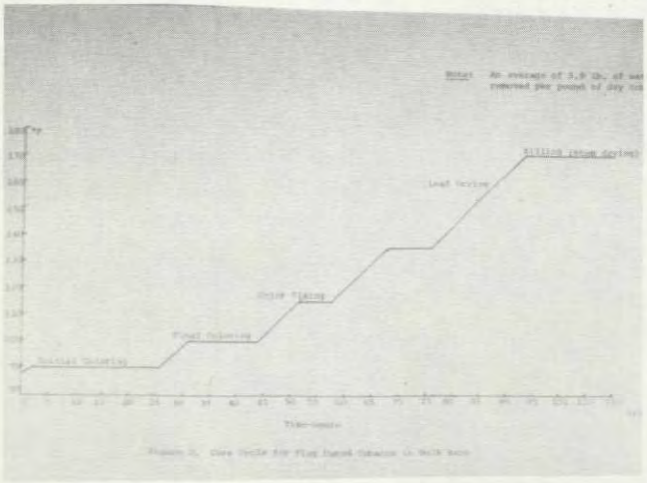


A recent cooperative program between Tech and the Korea Institute of Science and Technology resulted in the design of a solar-heated Korean residence which retains the traditional pattern of heating the floors of homes through a hot-air system.

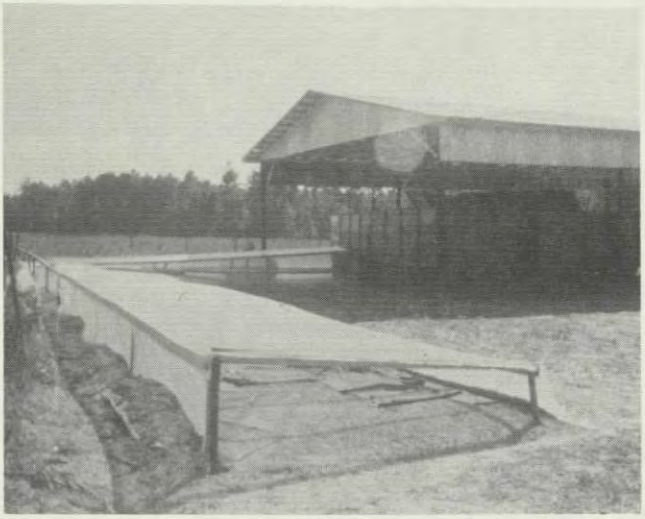
Solar crop drying for such crops as tobacco, shown here, represents an appropriate use of solar energy which can reduce crop loss and improve product quality.



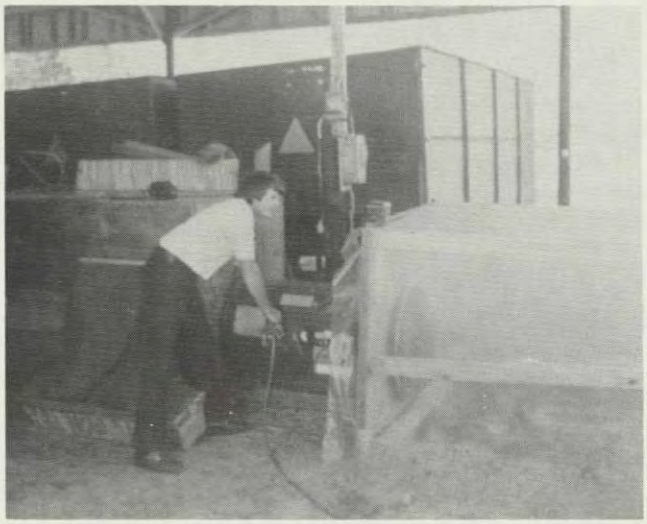
Tobacco is a particularly interesting crop for solar drying. In the U.S., it is frequently dried in carts such as this.



The optimum drying cycle for tobacco occurs at different temperatures for varying lengths of time. Controlled solar heating presents a low-cost way of tobacco drying.

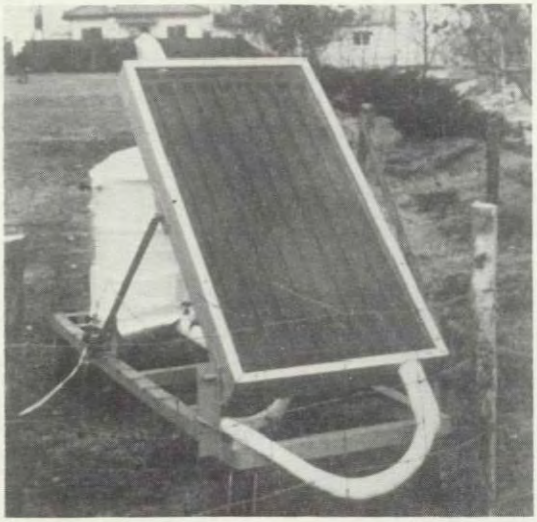


Peanut drying is accomplished with the simple solar tunnel shown here. Black tar paper on the ground is the heat-absorbing medium. A wood frame supports a single layer of plastic to provide the tunnel. Air is drawn in at this end at about 75°F and . . .

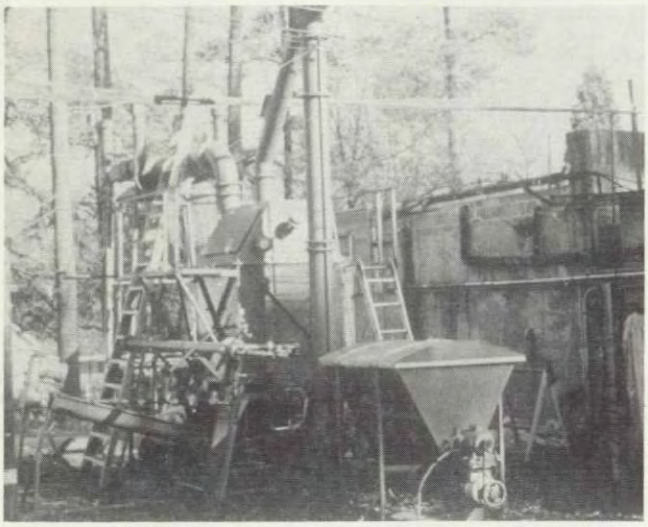


By the time it reaches this blower, it has been heated to 115°. It is blown into the peanut drying carts. The farmer utilizing this installation, designed by Tech, regained the cost of the solar installation several times over in the first year because of the reduction in fuel costs.

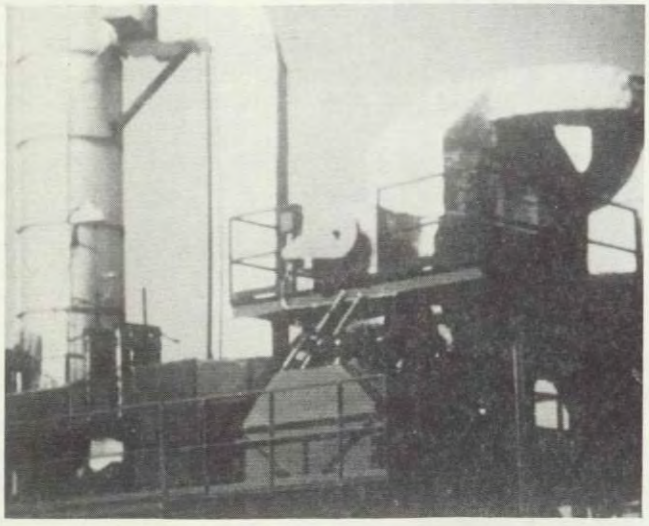
A solar water heater designed and built by Tech and Soong Jun University in Seoul, Korea.



Made of locally available materials, it is used by students for research and class projects.

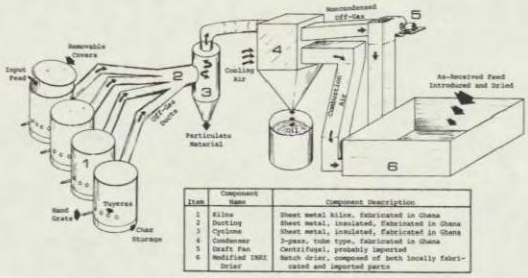


Peanut shells from the large Georgia crop traditionally have been burned in open incinerators, adding to air pollution. This pyrolytic convertor was built at Tech to convert peanut shells and other agricultural waste into alternative sources of energy -- charcoal, oil, and gas.



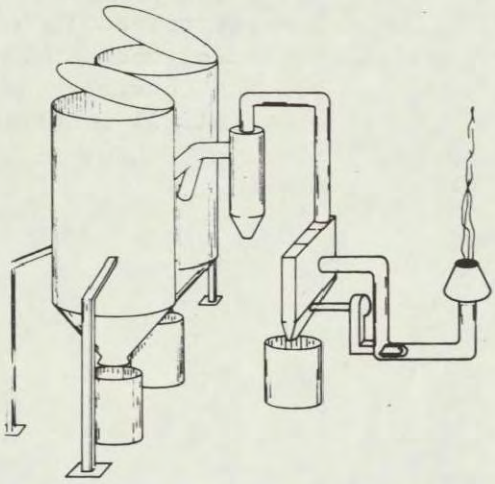
This 50-ton-a-day automated commercial unit in Georgia uses the process to convert sawdust into charcoal and oil. This unit can be converted to a more labor-intensive, less capital-intensive unit for use in developing countries.

SIX-TONS-PER-DAY PYROLYTIC CONVERSION SYSTEM FOR GHANA



Item	Component Name	Component Description
1	Kilns	Sheet metal kilns, fabricated in Ghana
2	Ducting	Sheet metal, insulated, fabricated in Ghana
3	Cyclone	Sheet metal, insulated, fabricated in Ghana
4	Condenser	3-pass, tube type, fabricated in Ghana
5	Draft Fan	Centrifugal, probably imported
6	Modified INEI Drier	Batch drier, composed of both locally fabricated and imported parts

This is a preliminary design for a six-ton-a-day pyrolytic convertor for use in Ghana. It will convert sawdust to charcoal and oil, which are needed to fuel brick kilns.



This one-ton-a-day convertor for Indonesia will burn rice hulls in a controlled combustion process to produce charcoal, oil and gas fuels.

The energy/food plantation concept is an exciting idea which addresses both the food and energy problems.

THE ENERGY-FOOD PLANTATION

FOR THE

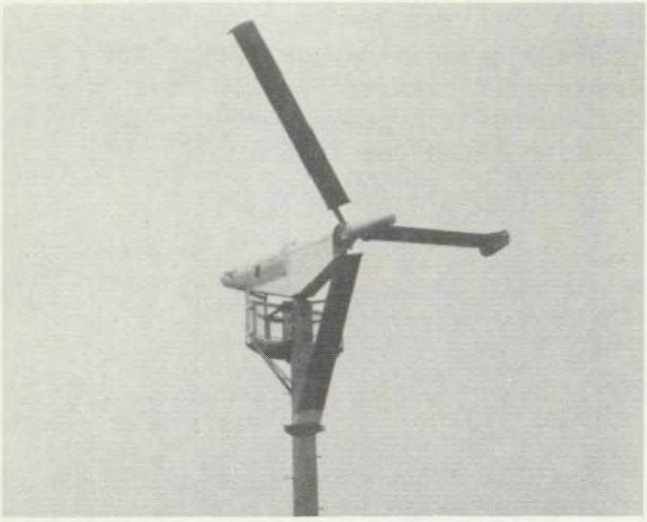
THIRD WORLD

(A RENEWABLE SOURCE OF ENERGY, FOOD & FIBER)

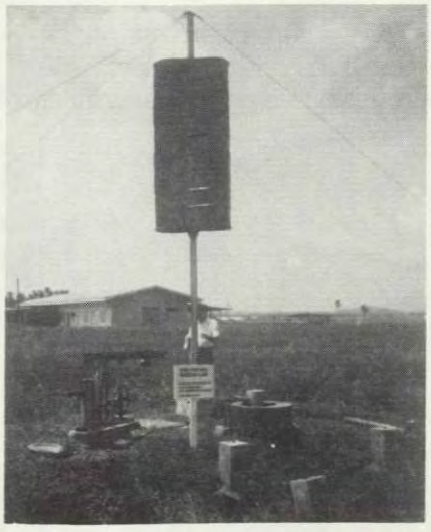
ADVANTAGES OF THE ENERGY-FOOD PLANTATION

- AN ETERNALLY RENEWABLE SUPPLY OF ENERGY
- AN ETERNALLY RENEWABLE SUPPLY OF FOOD
- EMPLOYMENT GENERATION
- IMPROVED BALANCE OF PAYMENTS
- INTERNATIONAL POLITICAL INDEPENDENCE

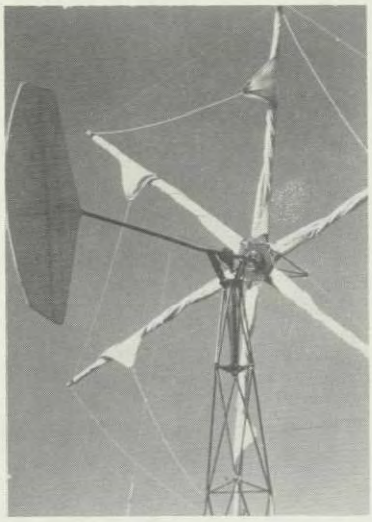
In this approach, a large area would be intensively farmed in food crops and rapidly growing trees. The agricultural crop wastes and renewable timber resources then would be converted to alternative energy sources, such as char, oil and biogas.



Wind energy is another facet of solar energy in which research is being conducted around the world. At Tech, earlier feasibility analyses in the wind energy field for NSA and ERDA have led to research utilizing this 15 KW Grumman windstream machine.

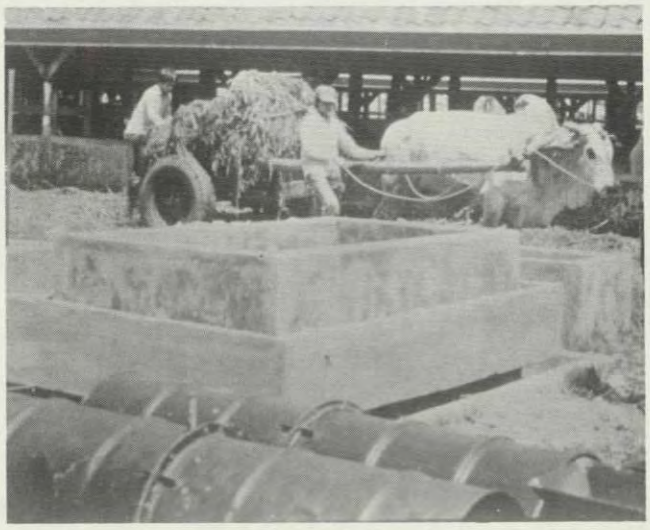


Experimentation with windmills which utilize vanes made from oil drums is being conducted in a number of places. This unit built at the International Rice Research Institute in the Philippines is effective for pumping water.

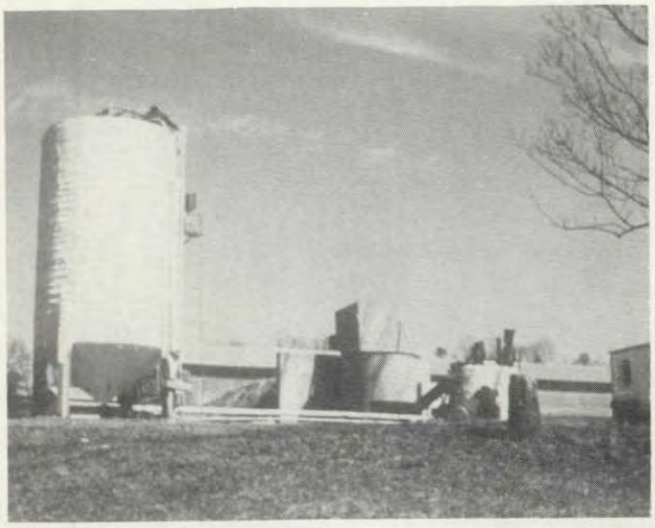


Brace Research is experimenting with windmills utilizing sails which can be furled during heavy winds. This unit develops 5 horsepower.

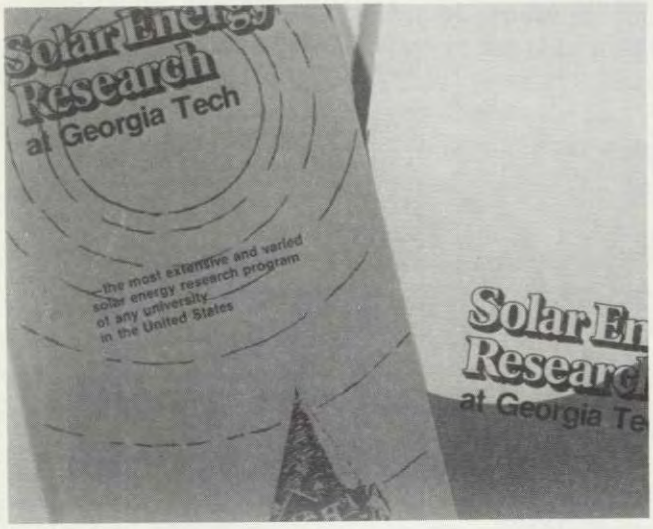
The production of biogas from agricultural and animal wastes is being conducted in many places. Here is a simple oil-drum biogas generator in Indonesia which uses a cow dung slurry.



A larger unit under construction in the same location is capable of supplying cooking gas to several families.



An 8000-gallon methane generator designed and built by Georgia Tech utilizes chicken manure slurry and a 21-day cycle.



A recent U. S. Government report indicates that solar heating presently is competitive with conventional methods of heating in the United States. Most of the developing countries have higher energy costs than those found in the United States, indicating that heating as well as other specific solar energy applications are competitive now and are likely to present a considerable cost savings to users in the future.

Researchers in the field believe that solar energy has good potential application as an alternative energy source which will help relieve the demand on conventional energy sources.

The contents of this monograph also are available as a color slide presentation with taped commentary which may be borrowed upon request to:

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Georgia Institute of Technology
Atlanta, Georgia 30332, U. S. A.

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