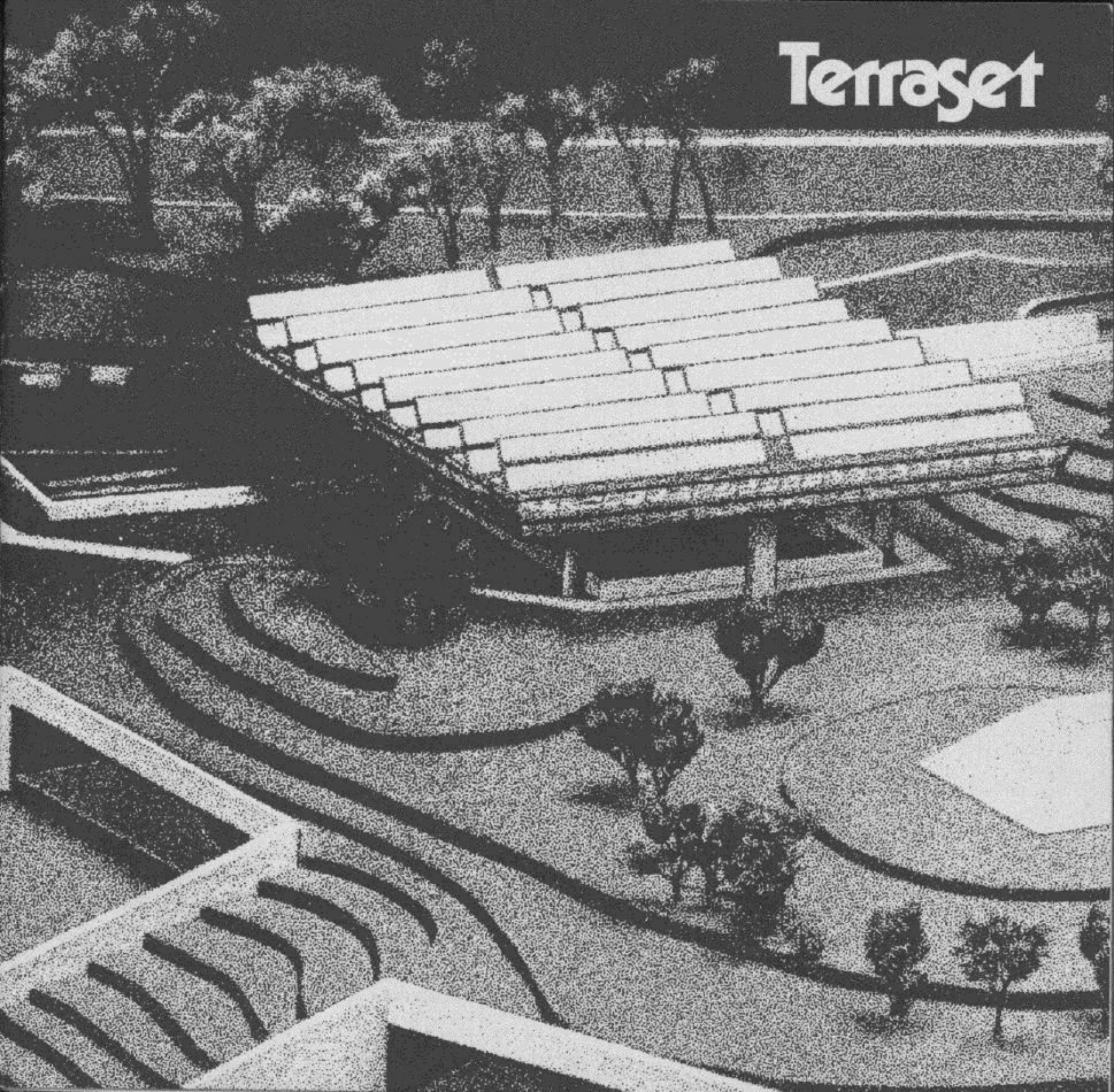
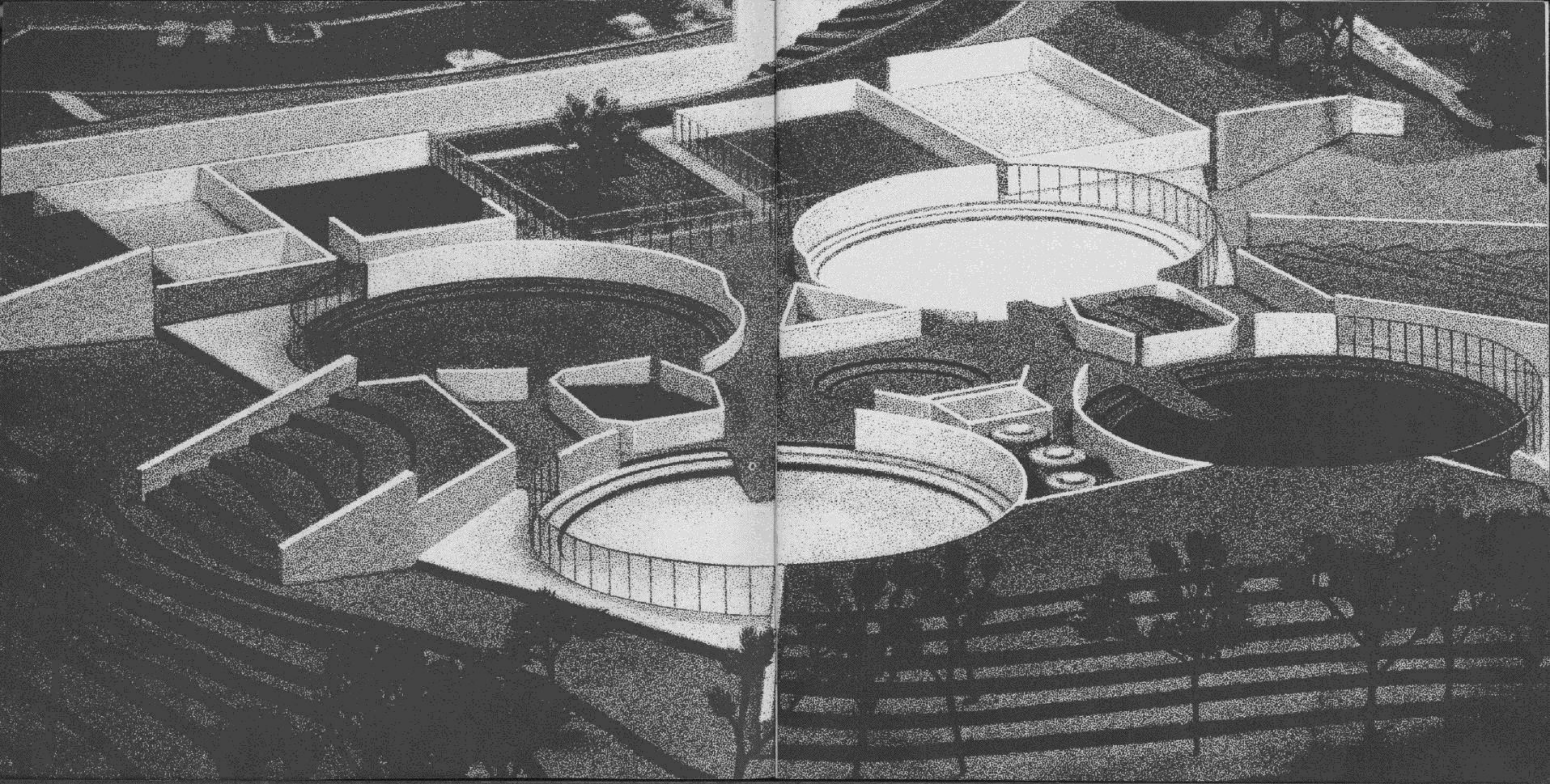
Terraset

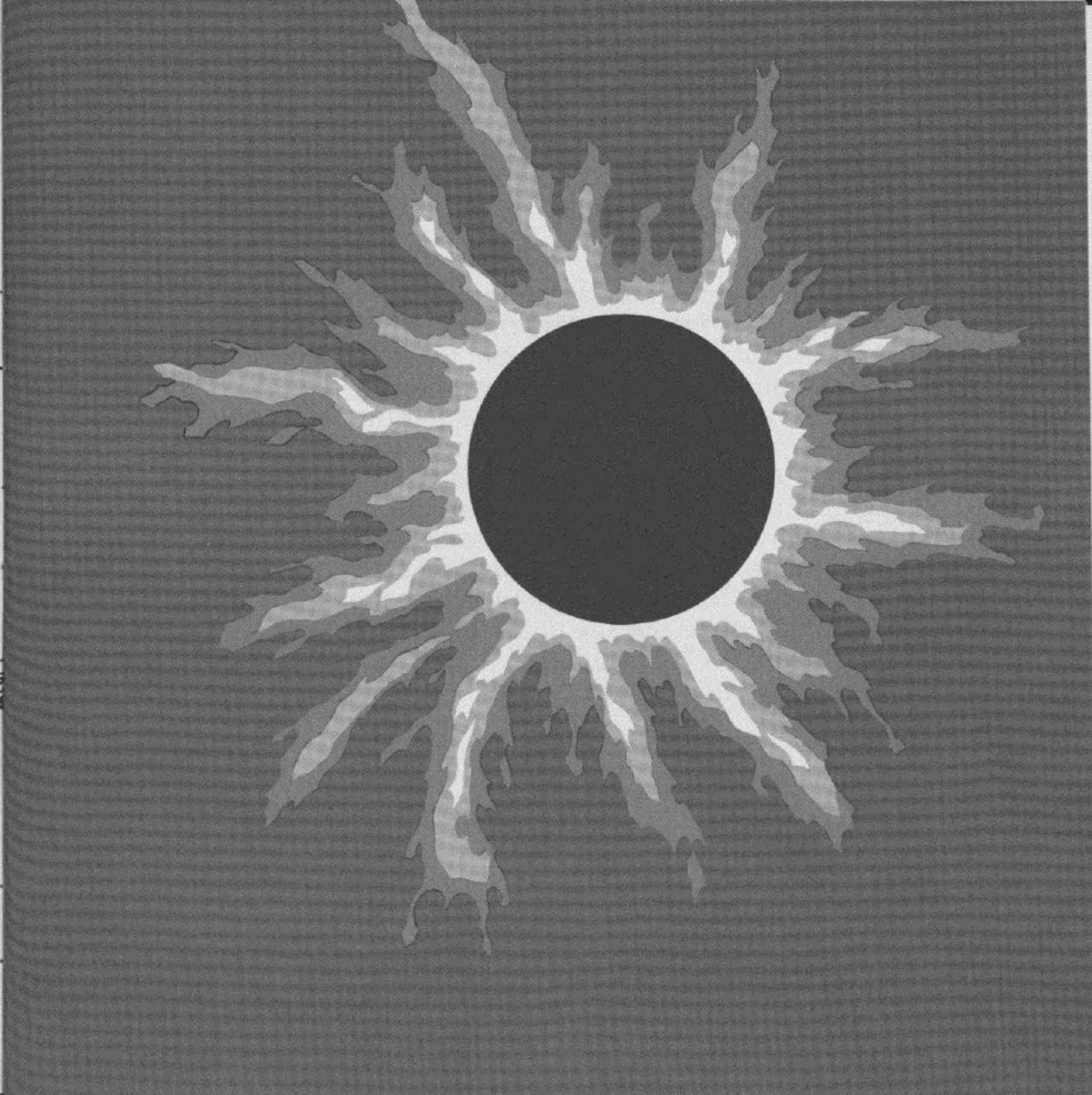




Terraset is a hill with a school inside it.

We built it that way to save energy. The Arab oil embargo made us all aware that we can no longer take cheap fuels for granted. In fact, they are no longer cheap. Geologists tell us that cheap or dear, Arabs or no—we are running out of oil and gas. We have about thirty years to find alternatives. At the time of the energy crisis in 1973, Fairfax County, Virginia was planning a new school. Our engineers and architects sat down and asked themselves, "What are all the things we can possibly do to save energy in this school?"

The first thing they decided was to bury it. And they gave us a hill—with windows, a skylight and a courtyard. The way they did this was to shave off the top of a hill, pour the concrete shell, and then put the hill back on.



. . . Dirt insulation

The dirt protects from the extremes of heat and cold in two ways. First, it makes good insulation. And second, it has high thermal mass. That means the earthen mass acts like an energy reservoir, storing warmth or coldness and delaying the impact of outside temperature changes. As long as the building is occupied, it is kept fairly warm by people, lights and machinery, so that heat gains are the rule, and year round cooling a necessity. On school days in the winter, only the window areas need warmth. Of course, at night and on weekends, the people are gone and the entire building may require heat. The alternating needs for heating and cooling are an advantage to the design of the building's systems.

. . . Integrated Heating and Cooling

The heating and cooling system combines heat reclaim, solar energy and electricity.

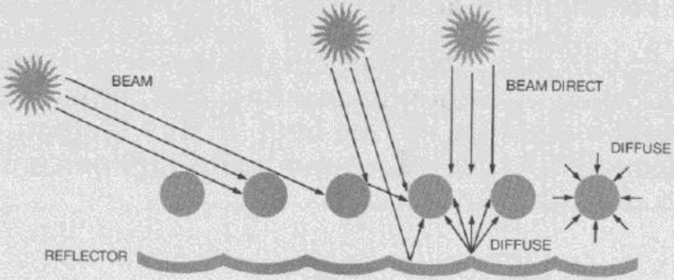
Waste heat reclaim. The excess heat from people, machines and lights is extracted by any cooling system along with whatever heat has filtered in from the outside. Terraset's electrically run reciprocal chiller does just this in the process of producing conventional cooling. The waste heat is a normal bi-product. But, instead of rejecting the wasted heat, Terraset recycles it.

Up to this point, Terraset cost little more to construct than a conventional building. But through the earth insulation and the heat reclaim system, our designers expected to save about fifty percent of standard fuel costs.

Evacuated tubular collectors. Then a grant of $625,000 made it possible for us to install solar heating and cooling as well and save around 25 percent in further fuel costs.

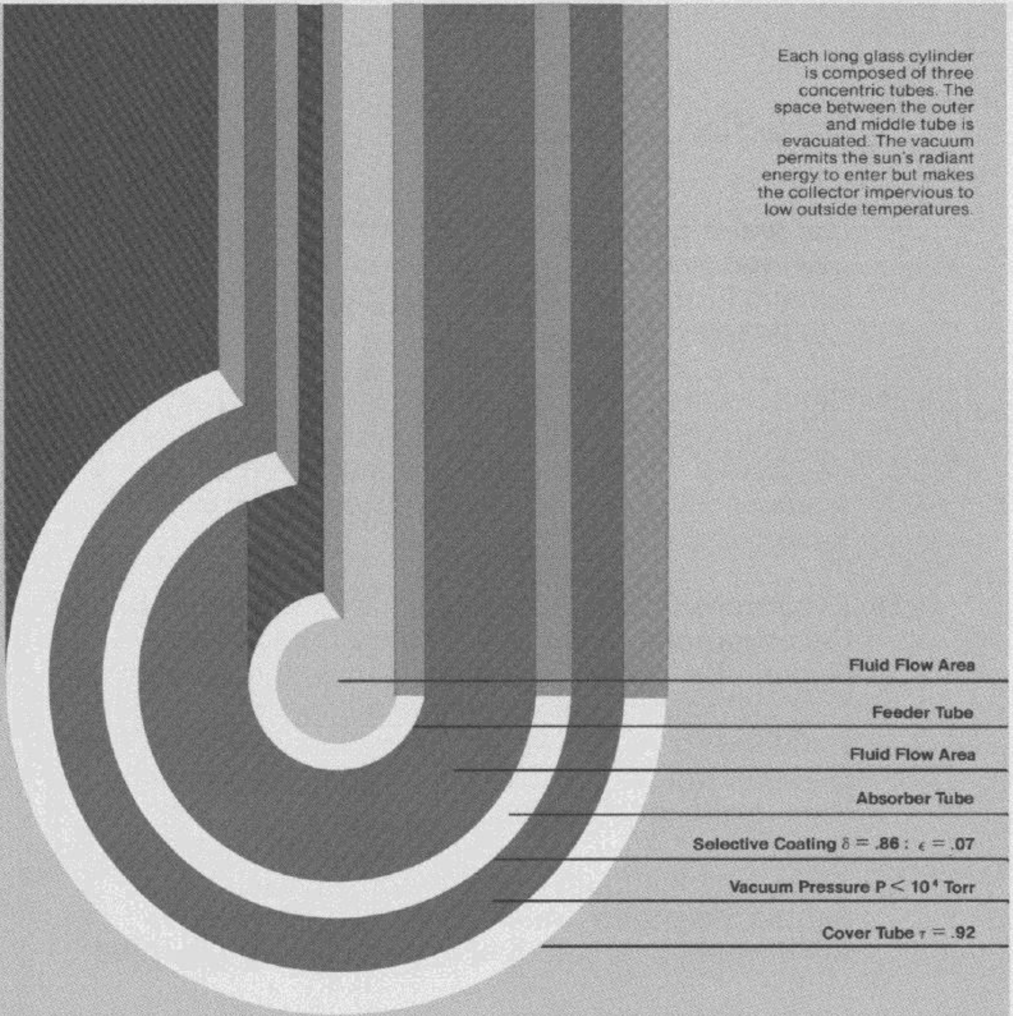
The solar panels collect the sun's energy. Water circulates through 4822 effective square feet of tubing, absorbing enough energy to heat and cool ten homes. The water temperature goes as high as 240°F in the cooling season. But in the heating season, the collector outlet temperature will be limited to 180°F to improve collector efficiency.

The tubes in these panels are made of glass, a material we have in abundance. But they are strong. Each square foot can support well over ten feet of dry snow.



Since the tubes are round instead of flat, they can efficiently collect the sun's energy from any direction, just as if they were physically tracking the sun's path. And reflectors help collect the energy that does not fall directly on the tubes.

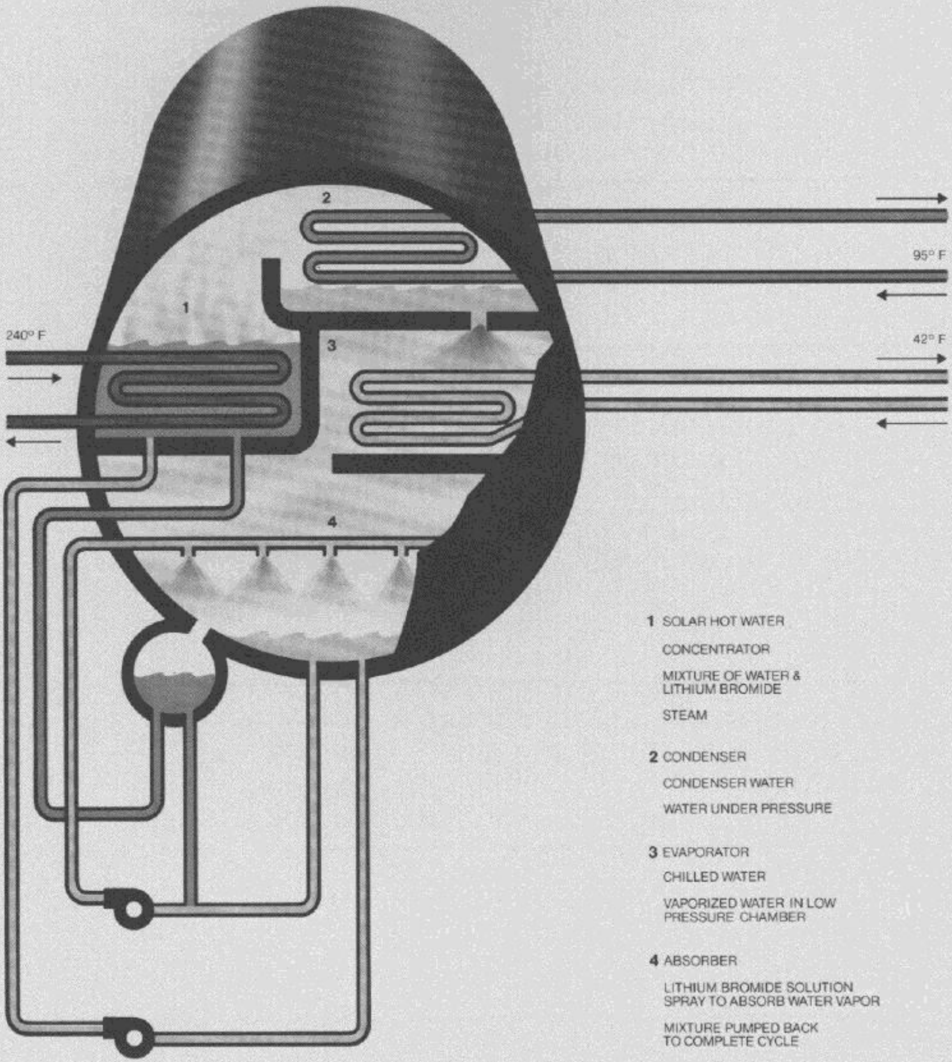
Each long glass cylinder is composed of three concentric tubes. The space between the outer and middle tube is evacuated. The vacuum permits the sun's radiant energy to enter but makes the collector impervious to low outside temperatures.



Transfer of energy to building water. The water circulating through the solar collector panels is not used directly in the building. Instead the heat is transferred to the school's hot water system by means of heat exchangers. Having received heat, the building hot water can flow into the baseboards of the school rooms to provide warmth. Or the solar water can pass through a refrigeration unit and its heat energy can be used to create cooling.

Air conditioning from the sun. Solar energy for heating and hot water is easy to understand. But how do we get cooling from the sun? Think of an aerosol can. Ever notice that the spray is colder than the can itself? When you release the pressure by spraying, the can's pressurized liquid is converted to a gas.

The conversion from liquid to gas also requires heat, and in this case the heat for conversion comes from everything in contact with the spray—the air, your skin—hence, the cool feeling. This principle is put to work in Terraset's chiller. On the overleaf is an explanation of how the chiller operates.



1 SOLAR HOT WATER

CONCENTRATOR

MIXTURE OF WATER & LITHIUM BROMIDE

STEAM

2 CONDENSER

CONDENSER WATER

WATER UNDER PRESSURE

3 EVAPORATOR

CHILLED WATER

VAPORIZED WATER IN LOW PRESSURE CHAMBER

4 ABSORBER

LITHIUM BROMIDE SOLUTION SPRAY TO ABSORB WATER VAPOR

MIXTURE PUMPED BACK TO COMPLETE CYCLE

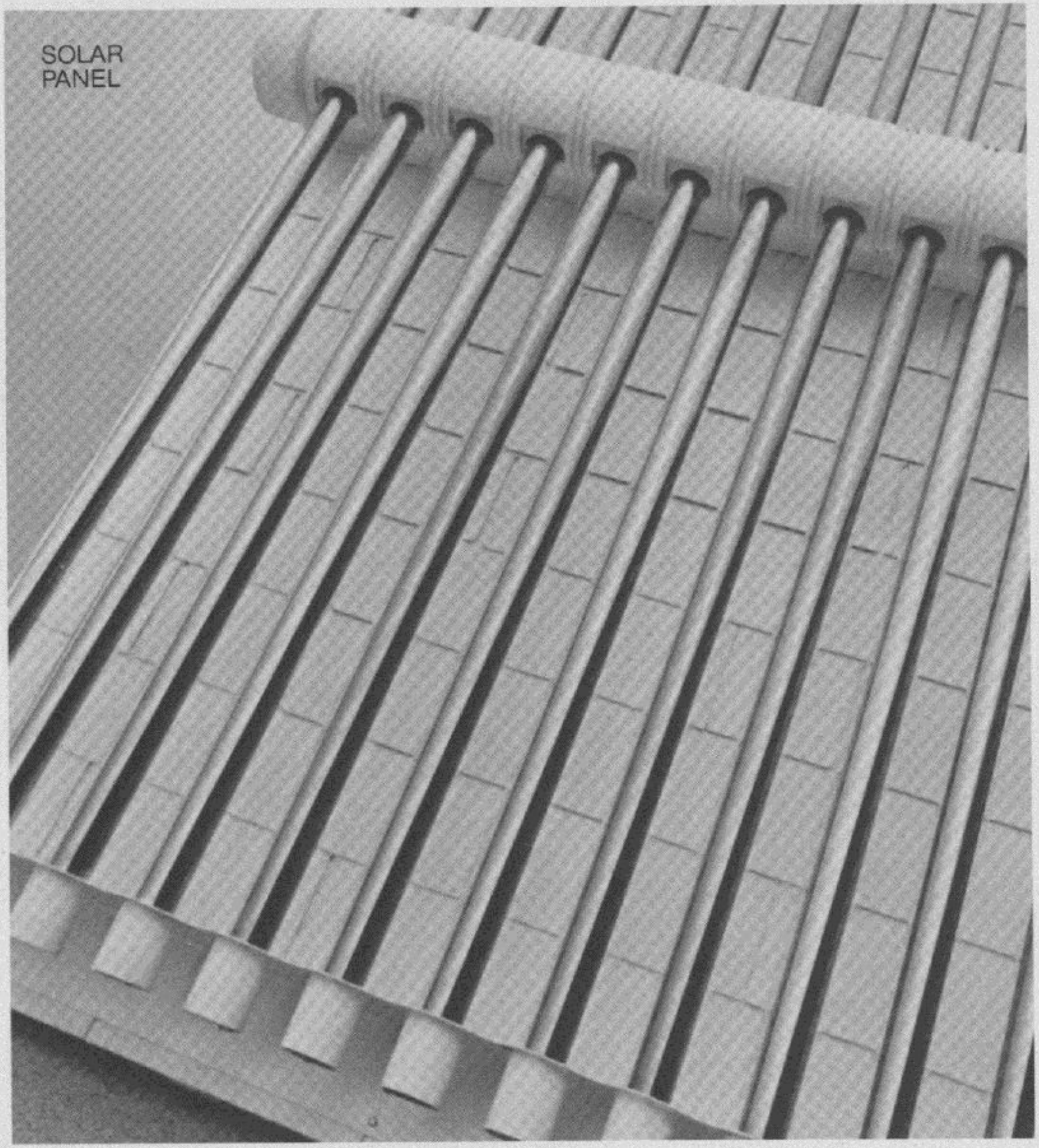
Simplified Absorption Cycle . . . Solar Cooling

1) **Hot water input.** In the concentrator, the chiller uses the sun's heat to boil off water vapor from a lithium bromide and water mixture and compresses it, just like a pressure cooker.

2) **Condensation chamber.** In a separate but connecting chamber, this compressed water vapor condenses on a heat exchanger surface maintained at about 95°F. It is now in the form of a pressurized liquid.

3) **Evaporator.** The pressurized liquid is sprayed into the evaporator, a low pressure chamber. Like an aerosol, the spray cools water circulating through a heat exchanger, maintaining its temperature as low as 42°F. This 42°F water flows into coils. Fans blow the building air over the coils—and there you have it. Air conditioning.

4) **Absorber.** A lithium bromide spray, which has a natural affinity for water, absorbs the spent water vapor into solution, and the cycle is repeated.


SOLAR
PANEL

How the mechanical systems interconnect

Solar panel heats water to 240° F in summer and 180° F in winter.

Hot water absorption chiller. Uses the solar heat to produce up to 50 tons of cooling. This is free energy.

Auxiliary electric boiler. Backup in case the solar and waste heat systems fall short in supplying heat.

Electric chiller. A double bundle reciprocating chiller. 145 ton. Electrically driven.

Provides conventional auxiliary cooling. Produces 42° F chilled water, as backup to the absorption chiller.

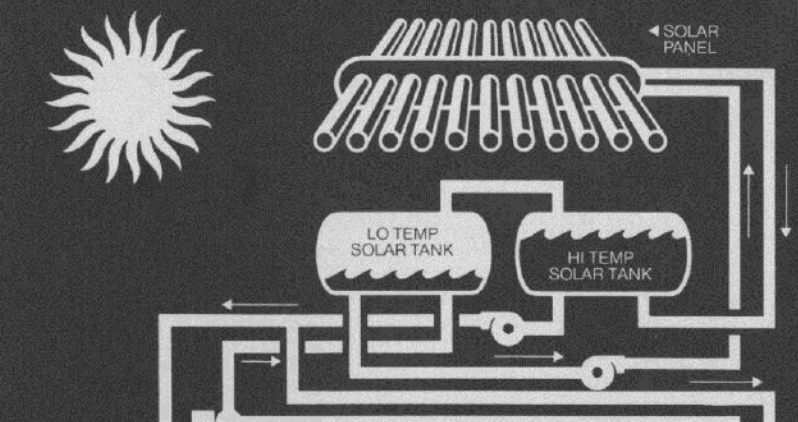
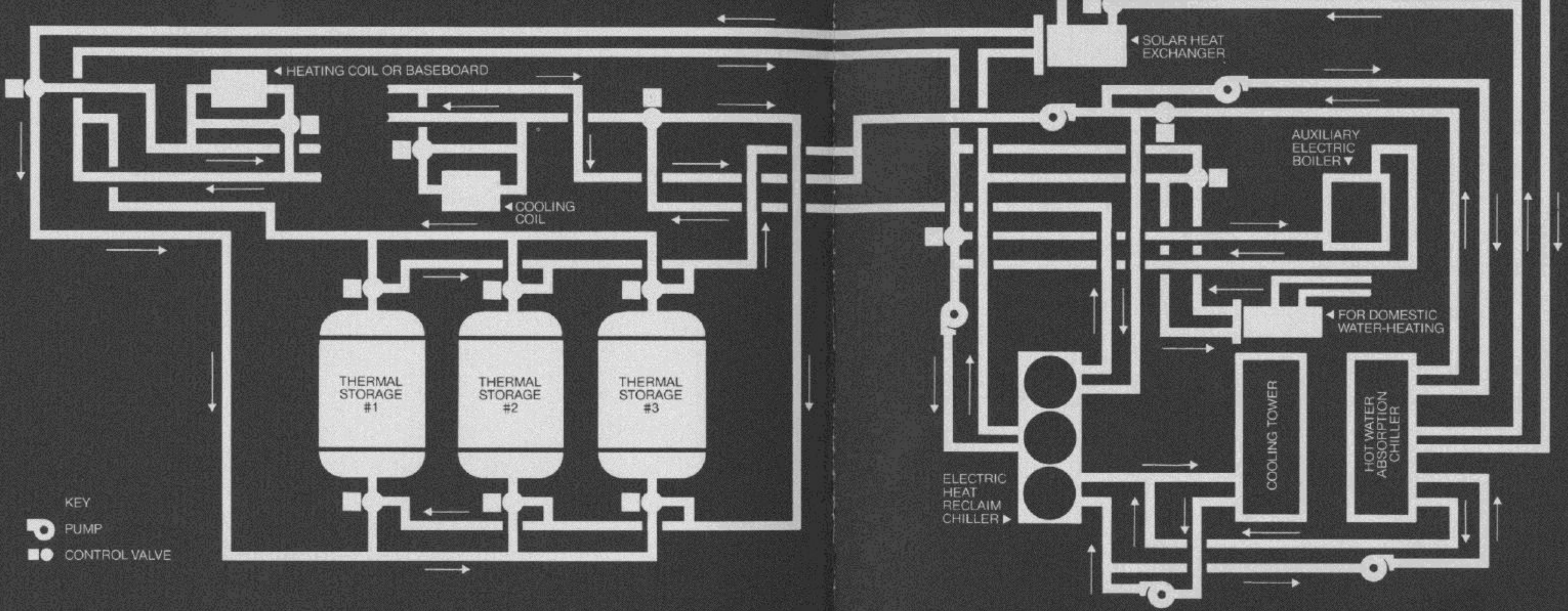
Recycles waste heat. Reclaims heat in the form of condenser water at 125° F and stores the rejected heat for use at night and on weekends.

Cooling tower and condenser water loop reject excess heat to the outside.

Thermal storage tanks hold hot or cold water in reserve for time-phased use.

Solar hot water tanks. Water from the solar panels is collected in the high temperature solar tank. It then flows through the system, gives up its energy and flows into the low temperature solar tank. From there, it is pumped back into the panels to continue the cycle.

TERRASET'S HYDRONIC SYSTEM

Dual temperature storage tanks. Of course, the trouble with the sun and with people is that they aren't around all the time producing heat. For this reason, we have three 10,000 gallon dual purpose storage tanks at Terraset. They hold hot or cold water, but what they store is energy to be used when it is needed.

Role of electricity. Terraset wouldn't run without electricity. Electricity operates the machines that help convert solar heat into useful energy. It also runs the air conditioning which re-cycles the waste heat. And it powers a boiler for heating when unusually long periods of cloud cover may combine with vacation times so that there is no solar or waste heat available. But the cost of that electricity is small compared to the cost of heating and cooling conventionally. In fact, the engineers expect to save about thirty thousand dollars a year in fuel bills. This is a reduction of 75%.

Computer controls. A computer controls Terraset's heating and cooling. It is programmed to make maximum use of free energy before turning to auxiliary sources.

While the computer is installed in the school, it could just as well be located elsewhere. In fact, one central computer could operate several buildings.

The computer can monitor its own activities and minimize human error.

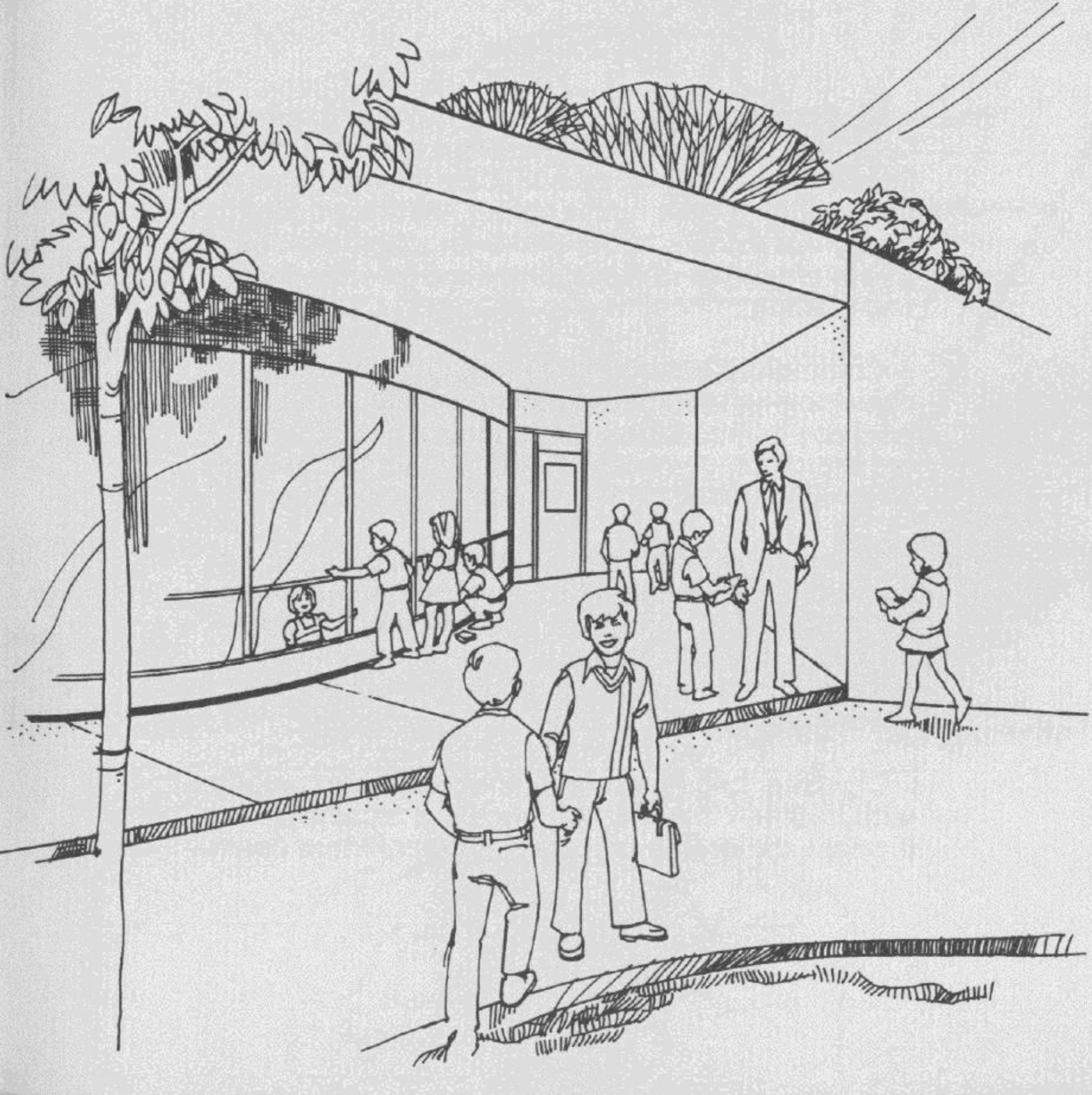
Economics of the project. Our initial economic analysis indicates the immediate feasibility of the heat reclaim system, enhanced by the energy conservative design, particularly the earth cover.

The return on the solar system appears to be much longer. To become economical, solar system costs must be reduced. As we use our computers to measure the concrete effects of our design decisions, we will be able to identify those areas with a potential for cost reduction. We hope the project will help to create a downward trend in costs.

. . . Integration of Design and Function

Recessed windows. Of course, the sun can be useful or a nuisance, depending on the season. In Terraset the overhangs help shade from direct summer beams, but when the sun is lower in the winter sky, its rays can shine in for welcomed warmth.

Circular rooms. Each of the four learning circles is home base for 250 children. The spaces are huge, with only one central supporting column. Relocatable partitions divide them, so that teachers and students can change the spaces as they wish. Steps around the edge lead to the sunken circles and form natural small group teaching areas.

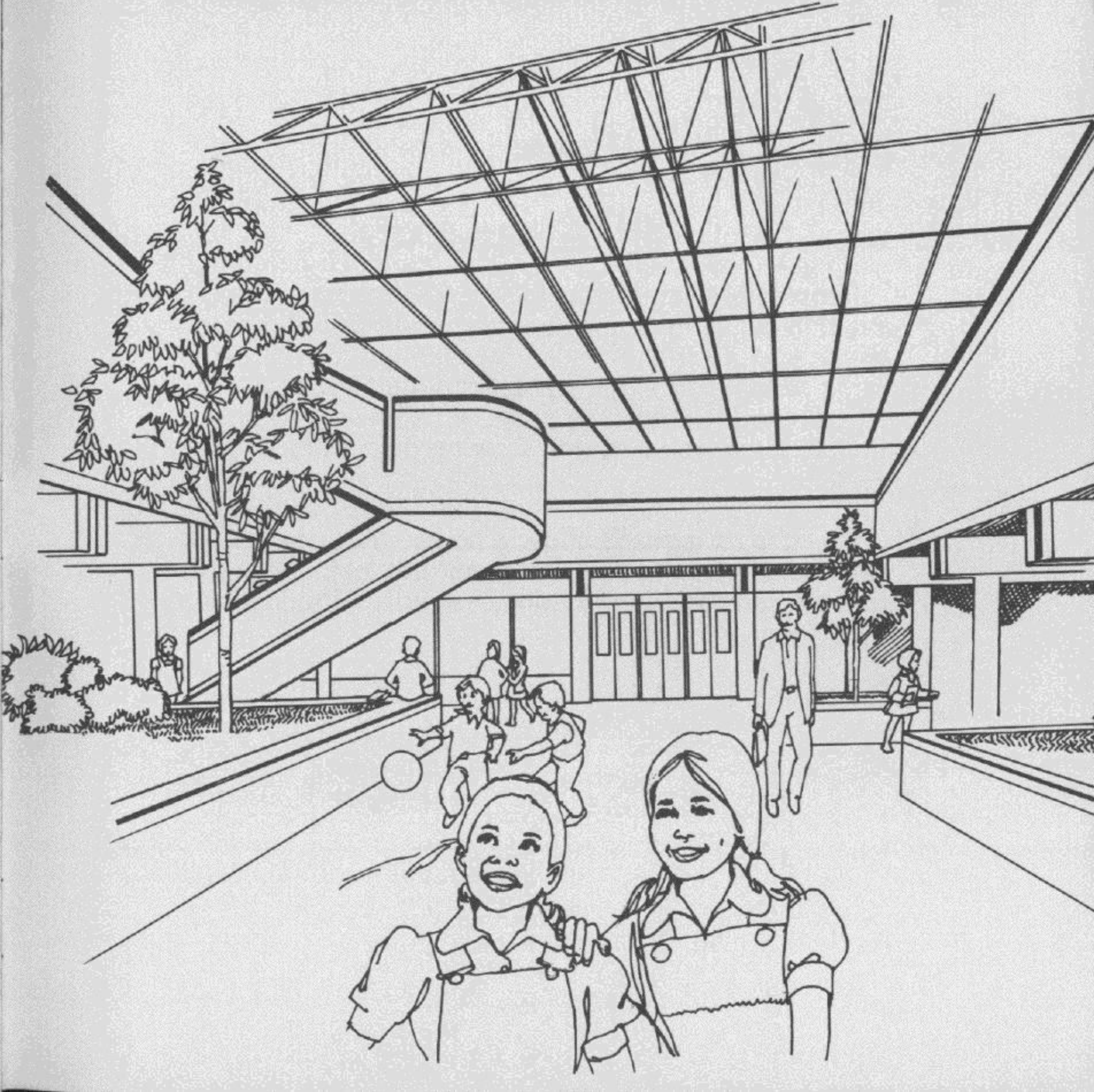


Media center. Terraset's library is literally the heart and center of the school. But our ways of learning are changing radically. So it's not called a library. It's called a media center,—with not only books but movies, slides and even video cassettes. There are carpeted steps all around for lounging and reading.

Community access. The four circles and media center are just for children. Flanking the solar courtyard and concentrated in one area of the building, are the office, gymnasium, cafeteria and other support rooms. The entire community shares these.

Solar canopy. The solar courtyard provides the entry to the school as well as a place for playing or just sitting. The depressed bus loop drops children at the courtyard entrance. This drop-off point is covered by bridges and cantilevers to protect the children during bad weather.

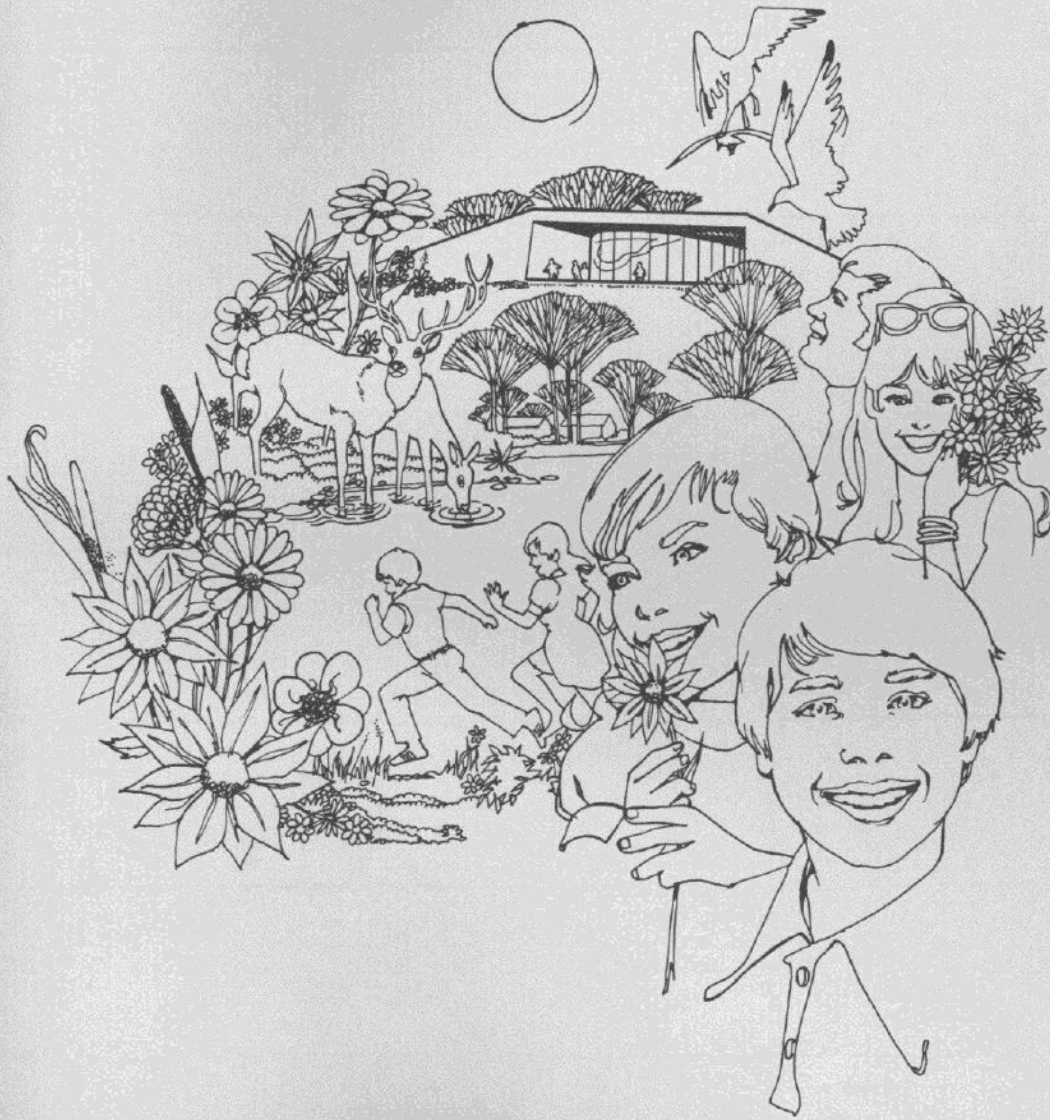
Lighting. Localized bright spot lights are combined with Higher Visual Performance Lights, which increase the quality of light at a lower fixture count.



Sun . . . Earth . . . People

Peoples of the past built their shelters from the earth itself. They knew how to guard against winter winds and summer sun. They toiled without architects. We, on the other hand, burdened but also aided by our technology, have to turn to our wisest people for ways to strike a new bargain with the earth.

So Terraset is really about a hope—that people can again live in harmony with nature, taking less so that we can continue to enjoy the earth's abundance.



Terraset Elementary School
11411 Ridge Heights Road
Reston, Virginia 22091

Construction completion:
January, 1977

Funding:
local funds and private grant

Population:
990 students
50 administrative personnel

Area:
69,000 sq. ft. (gross, indoors)
65,000 sq. ft. (air conditioned)

Architectural description:
Earth covered, cast-in-place, reinforced concrete structure with adequate outdoor visibility.

Mechanical System description:
All electric, solar assisted heat pump/heat reclaim heating and cooling hydronic system, central air handling, VAV induction zone boxes, plenum air return through light fixtures, perimeter convective heating, auxiliary electric boiler, 100 percent outside air capability with enthalpy control, computerized data collection, monitoring and control.

Estimated Fuel Savings:
Around $30,000/year cf. conventional all electric school (based on 3¢ per kilowatt hour)
Around $20,000/year cf. conventional oil heated school (based on 40¢ per gallon)

Construction Cost:
$2,470,200. General construction
393,000. HVAC
551,500. Solar

Owner: Fairfax County School Board
10700 Page Avenue, Fairfax, Va. 22030
Alton C. Hlavin, Director of Design and Construction (703) 691-3131
Anthony A. Martin, Program Manager (703) 691-3135

Consultants:

Architects
Davis, Smith and Carter
Reston, Virginia (703) 471-1220

Structural Engineers
Tibor Szegezdy and Associates
New York, N.Y. (212) 532-0398

Mechanical/Electrical Engineers
Vinzant and Associates
Washington, D.C. (202) 785-4811

Solar System Engineers
Smith, Hinchman and Grylls
Detroit, Michigan (313) 964-3000

Solar Collector Supplier
Owens-Illinois, Inc.
Toledo, Ohio (419) 242-6543
(Atten: R. E. Ford)

Computer Control Supplier:
Sunkeeper
Andover, Mass. (617) 470-0555

Contractors:
E. H. Glover, Inc. (GC)
James A. Federline, Inc. (HVAC) (Solar)

Project Recognition:
Owens-Corning 1975 Energy Conservation Award (1st Place) for Institutional Buildings.

American Association of School Administrators'/A.I.A. Walter Taylor Award by the jury for the 1976 Exhibition of School Architecture.

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