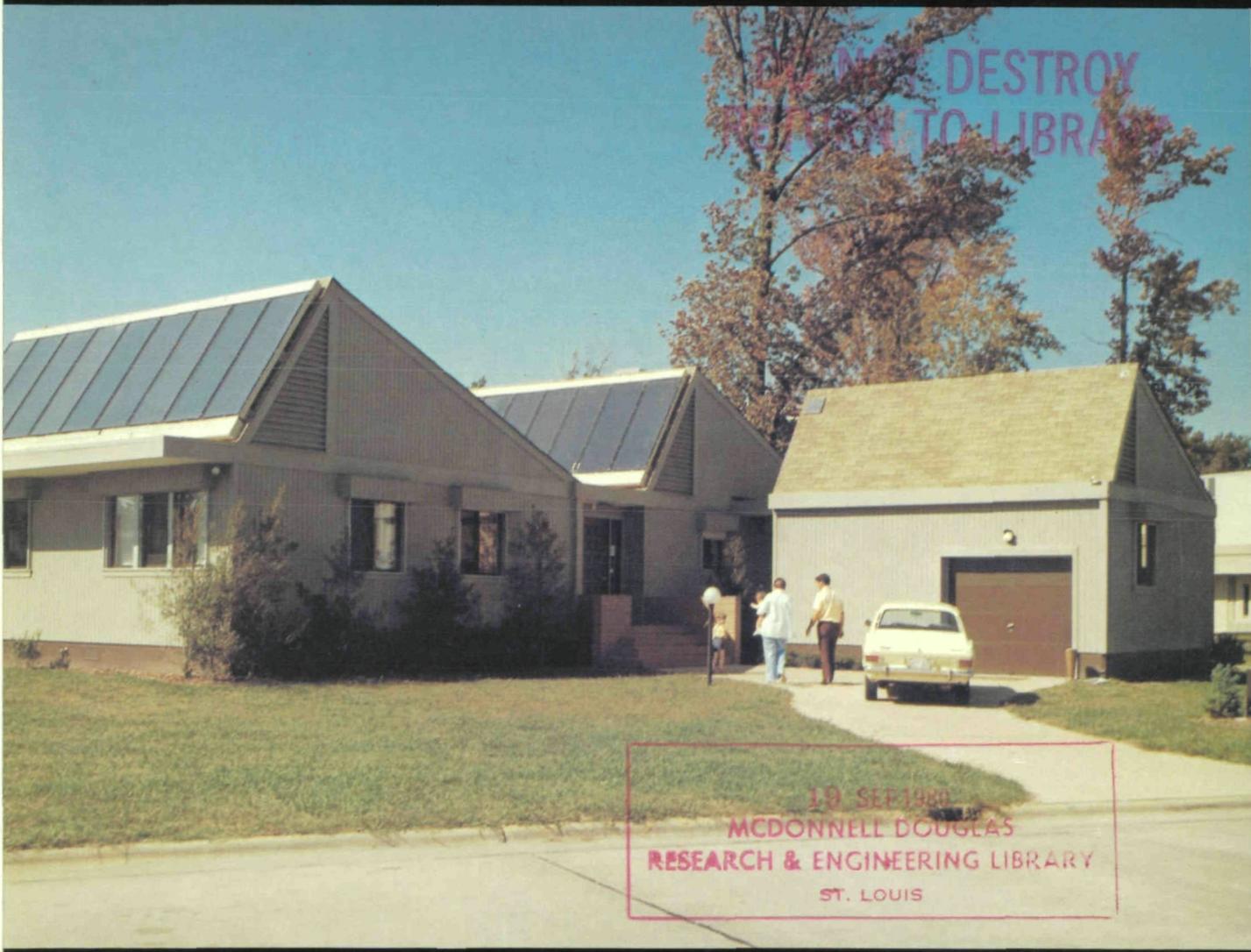


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ASA Tech House

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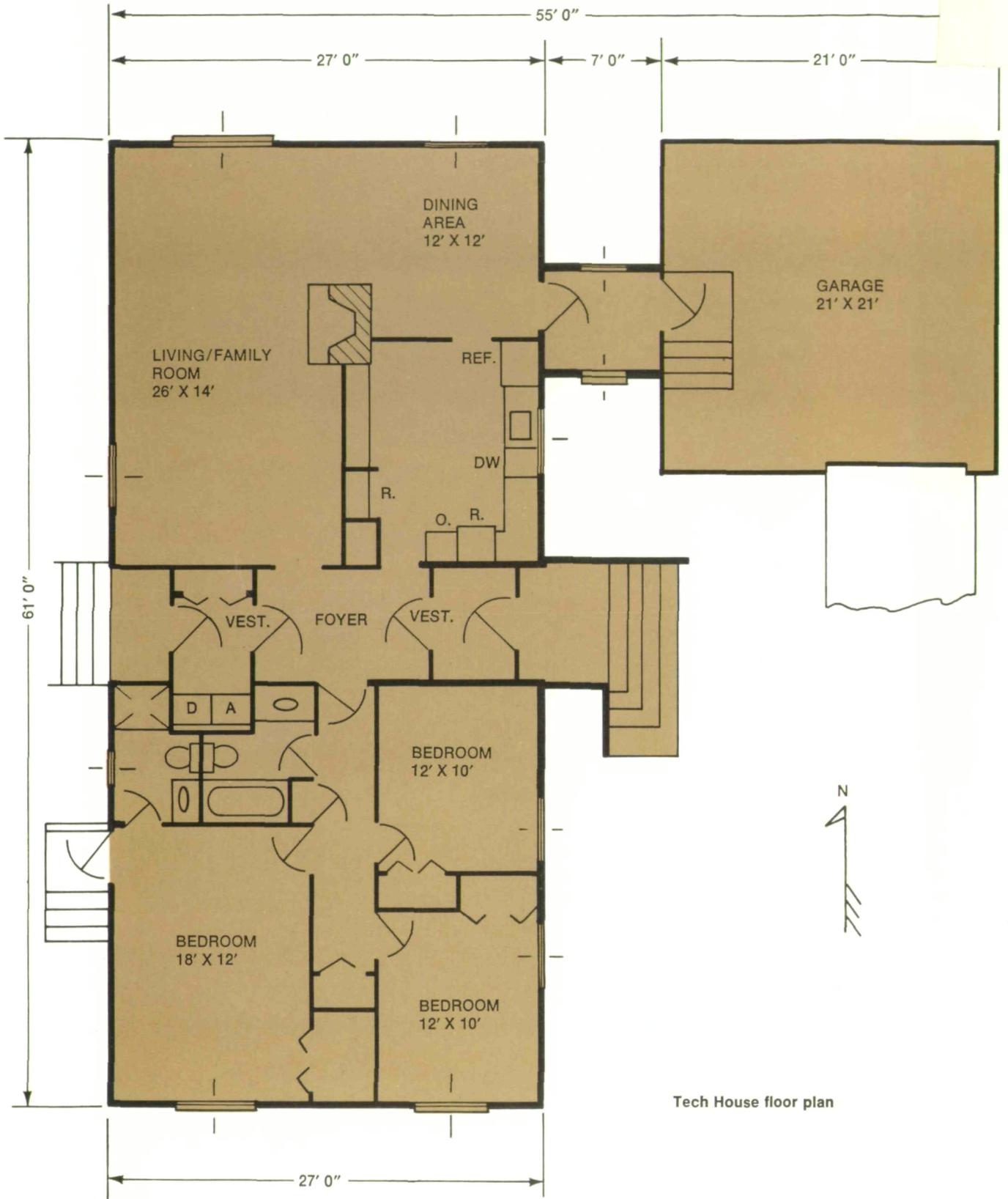


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Tech House floor plan

NASA Tech House

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Preface

The homebuilding industry is a blend of technology and economics. Most design and construction practices used today have been developed and refined over many years to enable designers and builders to provide homes in a wide variety of designs and sizes at a reasonable cost. The current consumer awareness of energy shortages and limited natural resources is providing an additional challenge to the industry to apply appropriate new technology as rapidly as is economically feasible. Builders and manufacturers, as well as the homeowner, must strive for new concepts which require less energy and resources.

Introduction

As a homeowner you soon may be the beneficiary of significant new technology, much of it coming from the nation's space program. New building materials, better use of existing energy as well as new uses of solar energy, water conservation, fire-prevention techniques, and a variety of household products are outgrowths of our national investment in the aerospace program.

Builders and manufacturers of homes and housing equipment need new methods and materials to survive in a highly competitive market. Probably the most significant opportunity for change in houses over the next few decades will be in energy management. Our homes consume about 20 percent of the energy used in the United States each year—an amount almost equal to all imported crude oil.

The NASA Technology Utilization House, called Tech House, was designed and constructed at NASA's Langley Research Center in Hampton, Virginia, to demonstrate new technology that is available or will be available in the next several years and how the application of aerospace technology could help advance the homebuilding industry. Solar energy use, energy and water conservation, safety, security, and cost were major considerations in adapting the aerospace technology to the construction of Tech House.

A committee, comprised of representatives from the Department of Housing and Urban Development, the National Association of Home Builders Research Institute, the National Bureau of Standards, the Consumer Product Safety Commission, and NASA personnel, was formed for the purpose of identifying new technology and guiding the design of Tech House. In addition to this committee, NASA employed an architectural engineering firm to perform system studies, evaluate proposed construction methods, perform cost effectiveness studies, and prepare final drawings incorporating technological outgrowths into Tech House construction.

Tech House is a single level structure of contemporary design, comprised of two square modules connected by a flat-roofed hallway containing entry vestibules at the front and rear and a laundry room in the rear vestibule. It is expected to consume only about one-third the electricity and one-half the water of comparably-sized homes.

The equipment and materials in Tech House are now on the market or

will be within five years. Properly installed, they could bring about reductions in the homeowner's utility bills for heating, cooling, and water over a 20-year period that would exceed their cost by some \$20,000.

While Tech House is not large, it is extremely functional and contains approximately 1500 square feet of enclosed living space consisting of three bedrooms, living room with fireplace, dining area, kitchen, two bathrooms, and laundry room, plus an attached garage. It is expected that within 5 years the house, with all its special features, could be built commercially for approximately \$50,000 (in 1977 dollars) on an existing lot. However, this forecast is based on the mass production of components and is subject to each homeowner's personal preferences and location.

One of the first steps in Tech House planning was to determine energy consumption requirements and how total energy could be reduced. This was accomplished by analyzing different types of ceilings, roofs, windows, doors, and insulations to determine which would be most energy efficient and cost effective. A system or product was considered "cost effective" if its added initial cost plus 10 percent interest could be returned to the buyer through energy or other savings over the lifetime of that system. The results of these studies, showing a comparison of energy consumption in a contemporary house, electrically heated and constructed by 1974 standards, with energy consumption projected for Tech House, follow:

Energy Consumption	Contemporary House (KW-HR)	Tech House (KW-HR)
Central heating	29,300	6,000
Central air conditioning	3,600	2,100
Water heating	4,380	1,500
Lights	2,000	1,000
Appliances	5,609	3,400
Miscellaneous	1,111	1,000
Total	46,000	15,000
		(Approx. 66% reduction)

A study which had previously been conducted by NASA determined that a significant reduction in domestic water consumption could be achieved by recycling waste water for toilet flush and using recently developed water

saving fixtures, such as water saver shower heads and low profile water closets. The following comparative figures were based on that study:

Water Consumption (For a Family of Four; Excluding Lawn Watering)	Contemporary House (Gals.)	Tech House (Gallons)
Bathing	22,265	16,480
Dishwashing	2,920	2,190
Laundry	5,840	5,840
Cleaning	2,190	2,190
Toilet	32,485	0
Miscellaneous	7,300	7,300
Total	73,000	34,000

(Approx.
50% reduction)

While the reduction in energy and water consumption represents considerable savings in utility costs, it is important to note that additional savings can result from fire-resistant construction and solar energy usage. The use of fire-resistant carpets, drapes, furniture covers, insulation, and other materials can result in lower fire insurance rates, and many states encourage the use of solar energy by providing tax-break incentives for homeowners.

The safety and security of the homeowner's family also were considered in choosing products to be installed in Tech House. Therefore, advanced security detectors for protection against fire, smoke, and intruders were incorporated in its construction.

It should be pointed out that energy-conserving homes are most efficient when carefully designed to fit specific sites with their particular characteristics of access, orientation to sun and winds, history of weather conditions, and thermal requirements. For this reason, Tech House was not intended to be, and should not be, considered a prototype or mass-producible design suitable for all locations. Instead, Tech House should be viewed as a demonstration model and research facility containing many individual systems, components, products, and ideas which can be applied in some degree to all housing.

A complete set of drawings and specifications of Tech House may be ordered for \$10 from:

North Carolina Science and
Technology Research Center
P.O. Box 12235
Research Triangle Park,
North Carolina 27709
Telephone: (919) 549-0671

Checks or money orders should be made payable to the North Carolina Science and Technology Center.

This booklet describes systems and features incorporated in Tech House. A product directory on Page 19 covers items being marketed at the time of publication.

Solar Heating

Preliminary experience indicates that solar energy can provide 70 to 80 percent of Tech House annual heating requirements. Eighteen 3x8-foot solar collectors (16 for home heating, 2 for water heating) are mounted at an angle of 58 degrees on the south-facing roof of Tech House, providing maximum exposure to Virginia's winter Sun. (The most efficient solar collector angle depends upon the latitude where the house is located.)

The glass of the solar collectors acts like a one-way valve, admitting light and other solar radiation but trapping heat reflected from the interior. This so-called greenhouse effect is commonly experienced when leaving a closed car in sunlight.

Water passing through the collectors carries the heat to the building heating system. A heat exchanger transfers the heat from the water to ducts that distribute the warm air throughout the house.

If heat is not required, the hot water from the collectors is diverted into a 1900-gallon underground thermal storage tank. Hot water is circulated from the tank to the heat exchanger at night and during cloudy periods to provide required heating. The tank stores sufficient heat for as long as 3½ consecutive overcast days.

If a longer stretch of overcast days occurs, the heat in the storage tank may drop below 90 F. In this case, the water from the storage tank is used to supply an electric heat pump to heat the house. If skies are overcast for some 5 to 7 days and the temperature in the tank drops below 55 F, two deep wells with water at about 55 F are used to supply water to the heat pump. Supplying the heat pump with preheated water reduces the amount of electricity needed to heat the house. A heat pump heats by extracting heat from air, the outside air, or a reservoir of water and pumping the heat into the house.

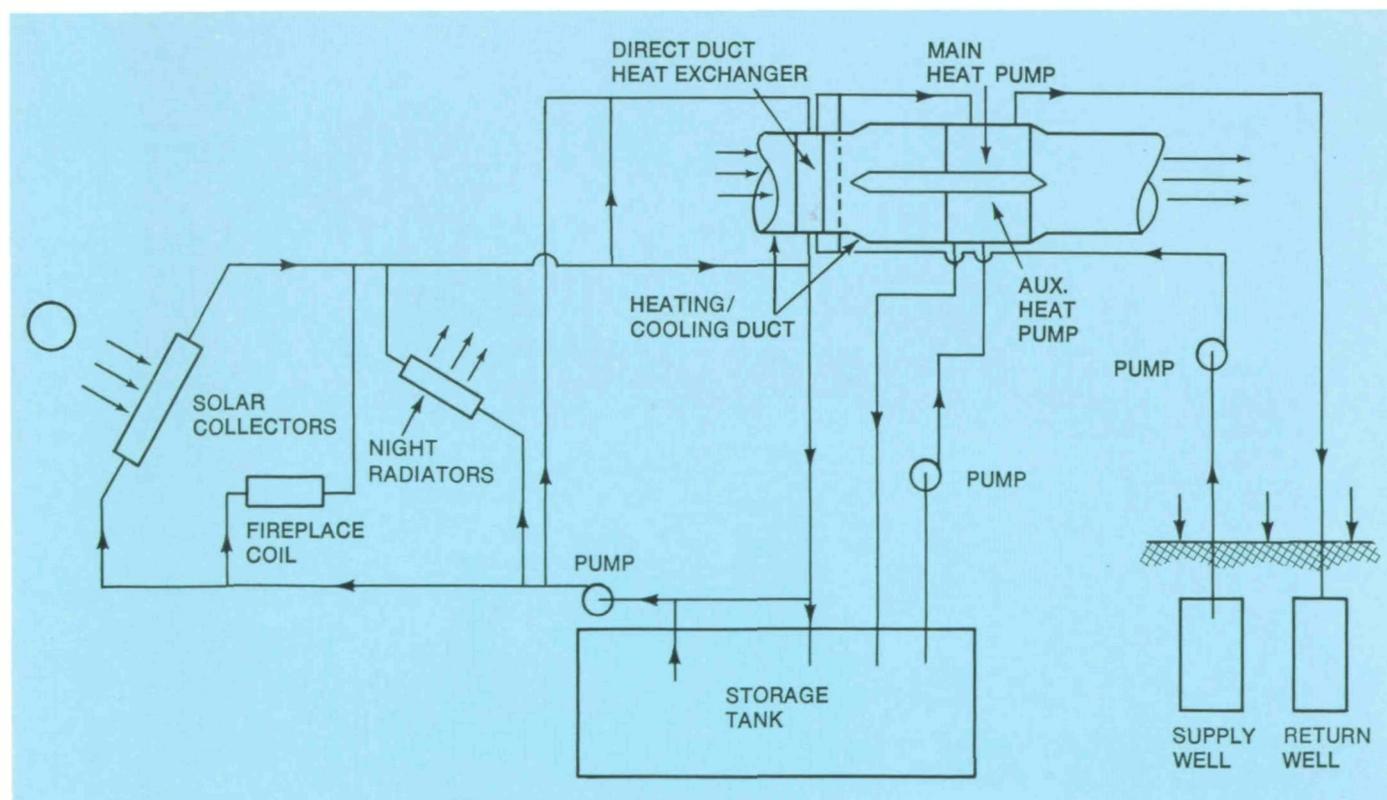
Air Conditioning

For air conditioning, the heat pump extracts heat from the house and ejects the heat into the air or a reservoir of cool water. Tech House is air conditioned by the heat pump but uses only about half the electricity for air conditioning that is consumed in comparably sized conventional homes. The reduction in the air conditioning load is due to better insulation in the walls and ceiling, shielding windows from direct summer sunlight, area

temperature control, large attic louvers, the availability of cool water for the heat pump, and night radiators.

The solar collector system used for heating the house is cut off during the summer. The main heat pump transfers heat from the house to the well water. If the heat load exceeds the capacity of the main pump, the auxiliary heat pump, using cool water from the storage tank, assists in cooling the house.

At night, the water in the storage tank is circulated through night radiators facing north on the garage roof. The radiators radiate the heat from the water to the outside air, reducing the temperature of water in the tank.



Simplified diagram of heating and cooling system.

Area Temperature Controls

Inside temperatures are monitored and controlled by area by a computer system in accordance with the family's normal activities. Only those areas in use are heated or cooled. For example, in winter, the system would keep living areas warm and bedrooms cool during the day. It would keep the bedrooms warm and turn down the heat in the living areas after bedtime. This zone control system contributes significantly to energy efficiency. If the computer malfunctions, it returns temperature control to conventional thermostats.

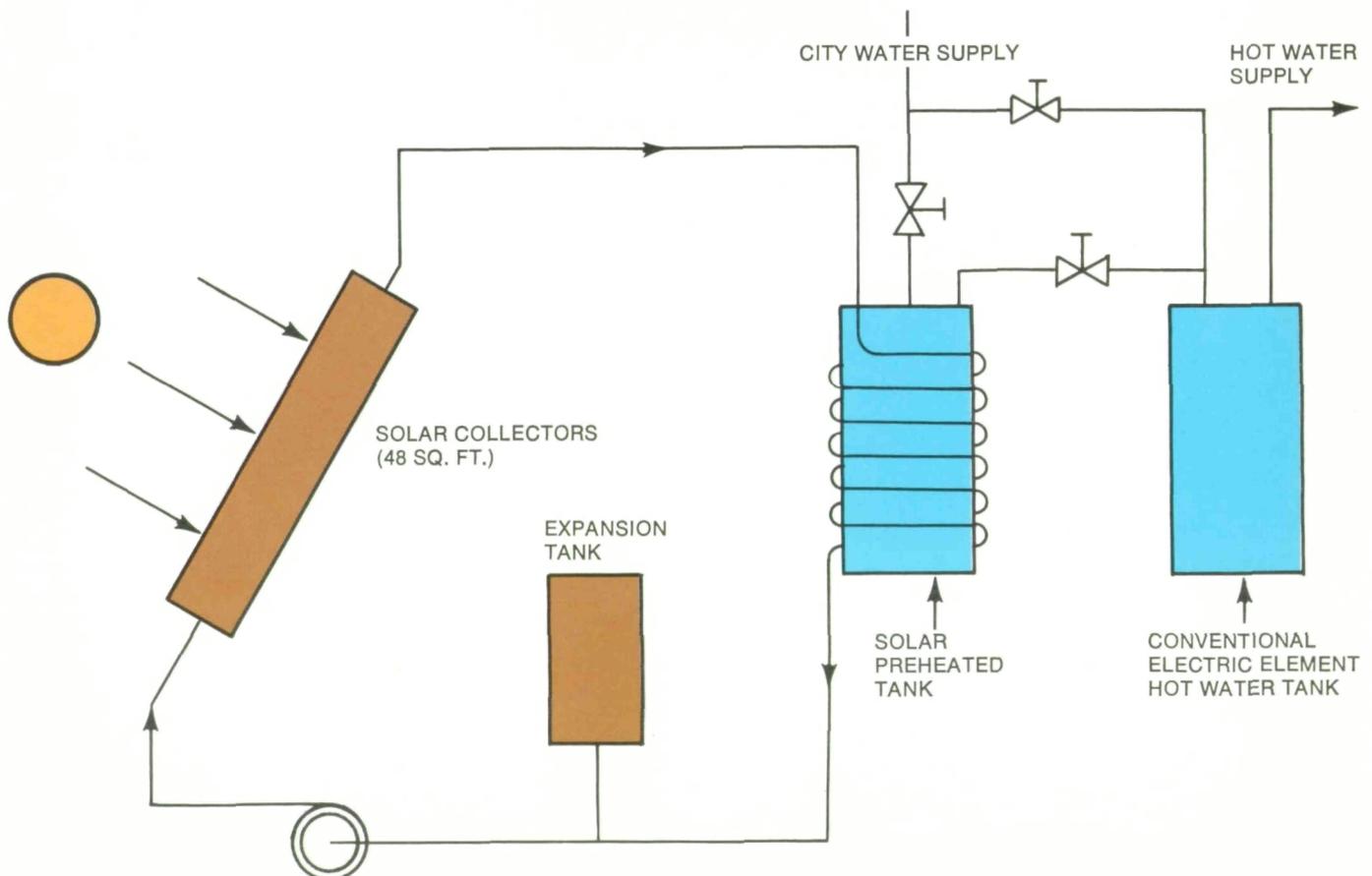
Solar Hot Water System

Two of the 18 solar collectors mounted on the Tech House roof provide solar-heated water which is circulated into a preheat tank coil to heat incoming city water. This exchange of heat raises the temperature of the city water to about 140 F at the inlet of the main water heater tank. In the conventional electric water heater tank the water is



heated additionally, if needed. This system decreases electricity usage for hot water heating by about 75 percent. The solar collector system for hot water operates year round to provide for laundry, bath, shower and sinks. The water in the solar collectors circuit is mixed with automobile antifreeze to preclude possible freezing, just as is done to prevent freeze-up of the family car.

Smaller preheat tank sits beside conventional hot water tank.



Solar hot water system.

Fireplace

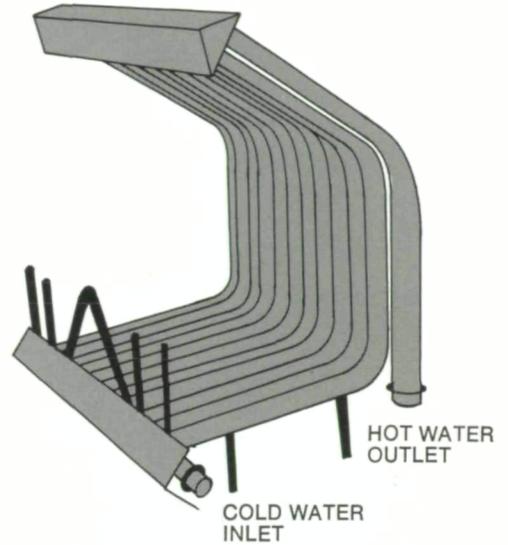
Fireplaces usually contribute little to home heating. Although radiant heat is felt by people near the fireplace, most of the heat, which is convective, sweeps up the chimney.

But the Tech House fireplace is designed to eliminate waste of room heat and to direct a much greater share of fireplace heat into the home. A duct system under the floor of the house supplies outside air rather than already heated room air to the open hearth for combustion. Low ducts on each side of the fireplace draw room air into them. The room air circulates through a double-walled firebox which raises the temperature of the air. The additionally heated room air then returns to the living room through grills above the fireplace.

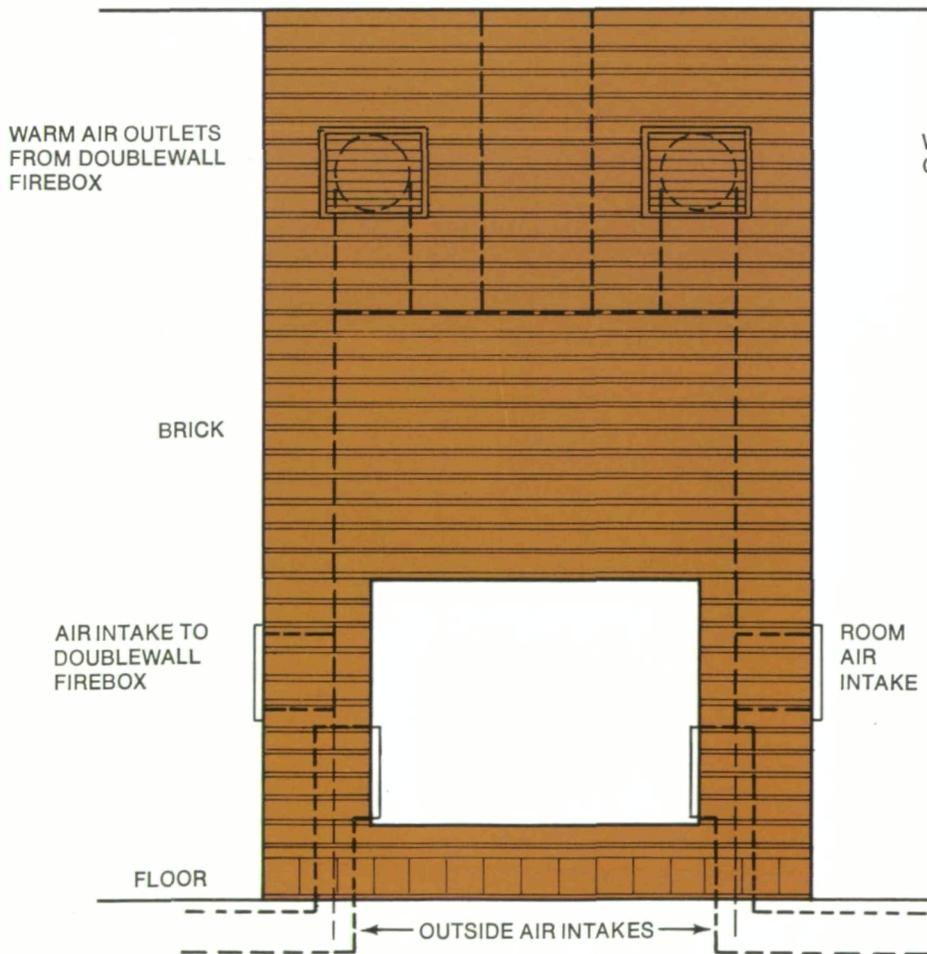
The major fireplace contributor to house heating, however, is the special fireplace grate which is part of the main heating system. The grate is a coil through which water is circulated.

The heated water can either be delivered to the air duct heat exchanger to help heat the house or returned to the underground hot water storage tank. All of the above features are expected to increase fireplace efficiency from the usual 10 to more than 50 percent.

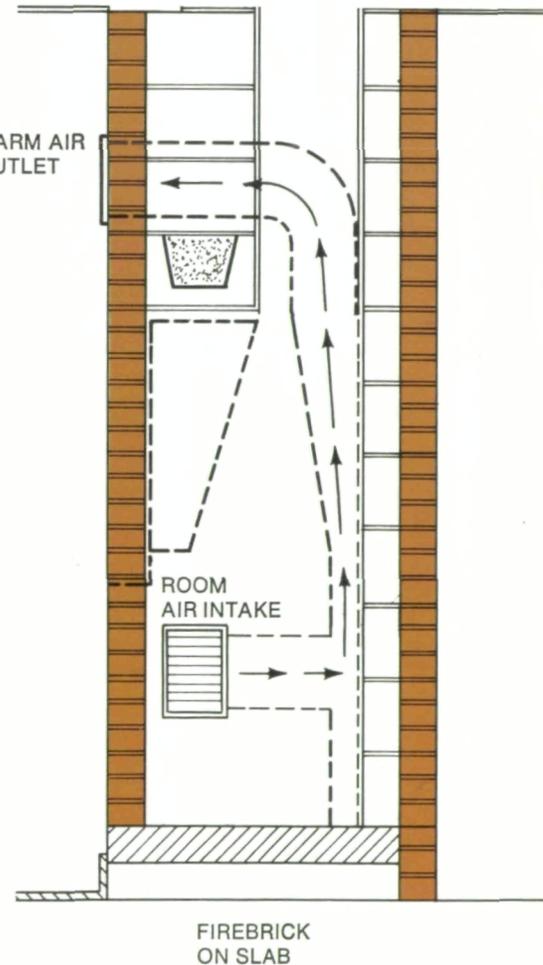
The water grate system used in Tech House is available commercially, can be installed in existing fireplaces, and is adaptable to hot water, forced air, or electrically heated systems. Tests of an earlier model fabricated at Langley showed that it increased heating efficiency of the fireplace to 47 percent.



Fireplace grate



Fireplace design





Windows

Direct sunlight streaming through the windows of a house heats whatever objects it strikes. These in turn give off heat that is trapped for a time inside of the house. Tech House utilizes this so-called greenhouse effect to best advantage. A large window area on the south side permits the maximum amount of direct sunlight to enter the house in wintertime. But a larger than normal roof overhang protects the south-facing windows from direct sunlight during the summer. In addition,

in summertime, windows facing west are covered with a reflective plastic sheeting that obstructs the Sun's rays. All windows are double-paned for insulation and a plastic material that has low thermal conductivity separates the framing that holds the panes.

Shutters

Tests have shown that the exterior shutters of Tech House windows can cut heat loss through windows on cold winter nights by about 65 percent. The shutters can also be rolled down to block direct sunlight during the summer. They can be slightly opened or

adjusted to admit light and air.

The shutters have a number of other advantages. As they cannot be opened from the outside, they contribute to house security. They can protect windows from flying debris whipped up by violent storms. They can reduce the volume of outside noise heard inside. The shutters can be raised or lowered in seconds by a hand crank or electric motor.

Doors and Entry Vestibules

Entry vestibules at the front and rear of Tech house act as airlocks to reduce loss of large quantities of warm or cool air when people enter or leave the house. The exterior doors have hot-dipped galvanized steel surfaces for resistance to rust and corrosion and are guaranteed never to warp. Polyurethane foam between the inside and outside metal facings prevents conducting of heat or cold.

Magnetic weatherstripping further reduces heat loss. When the door is closed, an adjustable sill on the door bottom automatically lowers to cut off air flow beneath the door. Heat loss through the Tech house door is about 65 percent less than it would be through a conventional wooden door.

Attic Louvers

Heat developing in attic space can reach 160°F when summer temperatures are 100°F, adding to the cost of air conditioning. Large ventilation louvers in the attic of Tech House keep attic temperatures near outside temperatures. Unlike attic fans, louvers burn no electricity.



Insulation

Urea-tripolymer foam insulates the Tech House ceiling, exterior walls, and selected interior walls. Approximately 7½ inches of the foam were used in the ceiling; 5½ inches, in exterior walls. (Usually, 6 inches of fiberglass are used in ceilings, 3½ inches, in exterior walls.) Tech House ceiling heat loss appears to be about 30 percent and wall heat loss about 45 percent less than it would be with conventional fiberglass insulation.

Tripolymer is also nonflammable, forming a charred crust when exposed to flame and extinguishing itself as soon as the flame is removed. Flames cannot advance on tripolymer beyond the point of ignition. Tripolymer is also nontoxic, odor-free, and rodent-resistant.

Tripolymer is cold-setting and non-expanding and does not settle or lose its insulating ability. It fills every crack and cranny, blocking noise as well as heat and cold. It flows around pipes,

wires, and other obstructions. It can be applied through openings as small as 1½ inches in diameter, making it suitable for insulating existing buildings.

Skylight

A skylight over the hallway serves a number of useful functions. It reduces the need for artificial lighting. Sunlight streaming through the skylight on cold days helps heat the hallway. The skylight can be opened to allow heated air to escape on warm fall or spring days. To block heating from direct sunlight on hot summer days, a reflective plastic sheeting is stretched across the bottom of the skylight.



Energy-Saving Appliances

Another contribution to energy conservation is made through a microwave oven that reduces cooking time and adds little heat to the house (a particular advantage during the summer) and by a heat pipe which speeds up the cooking of roasts in a conventional oven. The heat pipe uses the capillary action of a liquid in a sealed pipe to transfer heat. Inserted into the middle of the roast to heat the inside as well as the outside simultaneously, it can cut cooking time in half.



Water Conservation

Water from the Tech House bathtub, washing machine, and shower is collected in a tank, chlorinated and filtered, and used to supply the toilet tanks. This water recycling together with smaller (low profile) toilet tanks and water-saving shower heads reduces water consumption to half of what it normally would be. It also trims the sewage load, an advantage for areas plagued by overloaded sewer systems or septic fields.

Security Against Intruders

An alarm system and other devices are designed to protect Tech House against burglars and other criminals. The house has an alarm system that is activated by punching a code into a wall-mounted digital control panel.

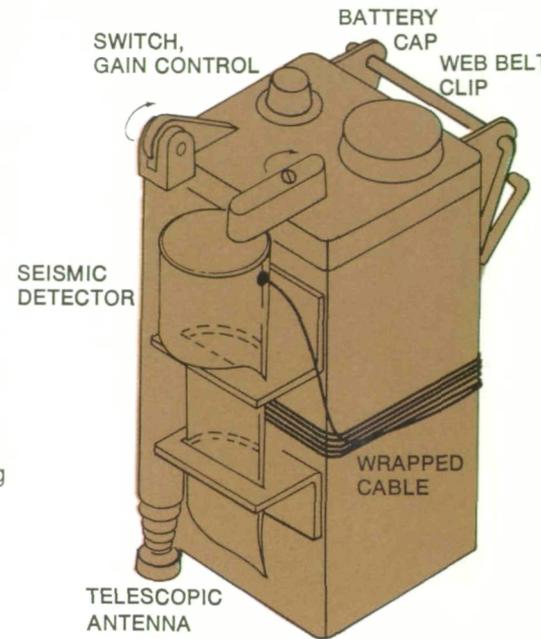
Alarm wires are woven into window screens. Cutting or removing the screens sets off a loud alarm. Pressure sensitive pads are emplaced in the hallway near the outside doors. A person stepping on one sets off the

alarm. A built-in delay gives the occupant entering the house time to override the alarm.

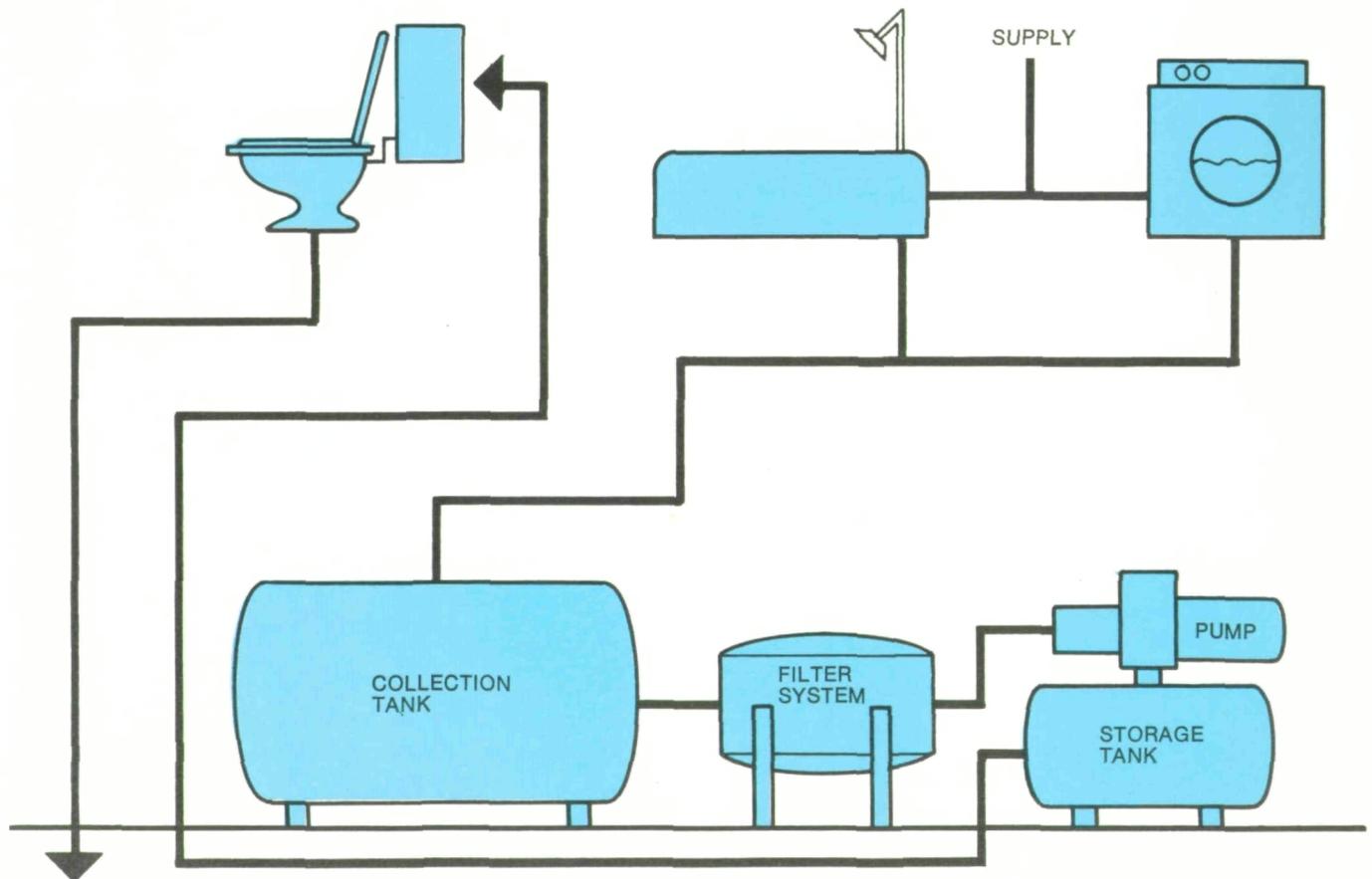
Self-locking hinges fabricated at Langley are used on the outward opening exterior doors. The hinge was developed at John F. Kennedy Space Center to secure cabinets and doors with exposed hinge pins. Doors with self-locking hinges cannot be opened even if the hinge pins are removed.

An exterior security system is designed to alert the occupants to potential intruders near the house. It can detect footsteps on the lawn, for example, and by the signals it generates indicate the movement of the intruder—whether slow or fast, walking or running.

The system employs a seismic detector like that used to detect quakes, meteoroid impacts, or volcanic activity on the Moon or Mars. The detector generates a microwave radio signal that is reflected into the house by an



Intruder detection system



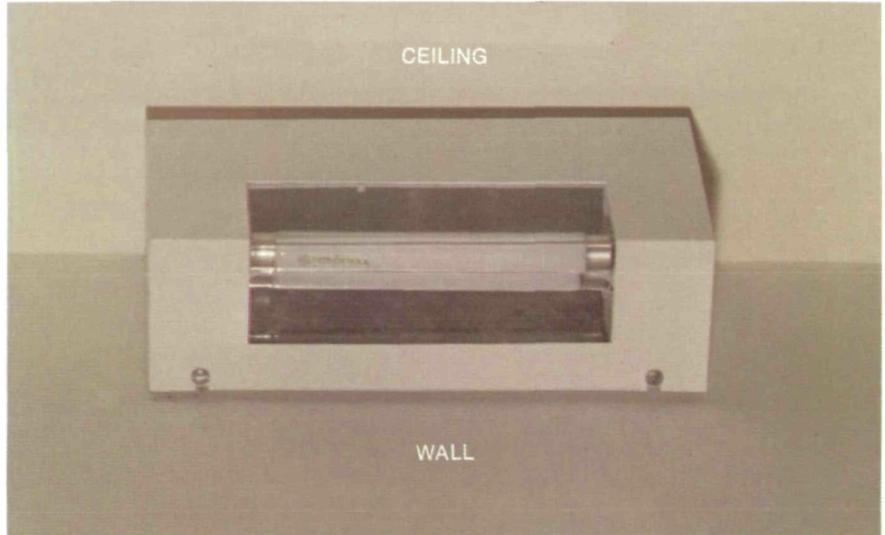
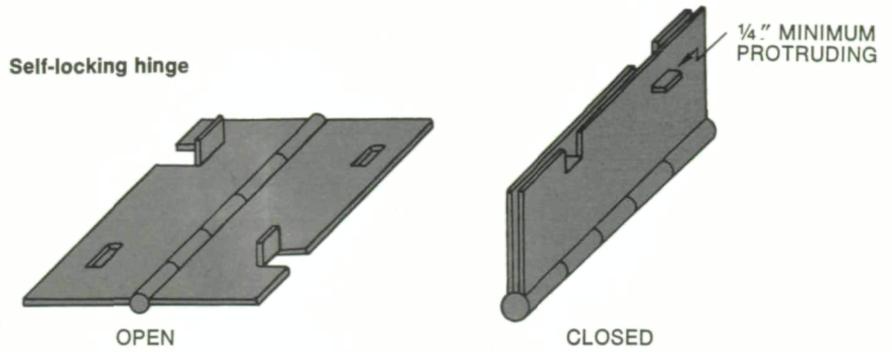
Water reuse system.

antenna under the eaves of the house. The signal can be picked up by a conventional FM radio in the house tuned to certain frequencies.

Muggers and robbers sometimes lurk in the nighttime shadows of houses, intending an ugly surprise for returning occupants. The Tech House occupant can use a pocket transmitter about the size of a fountain pen to send out an ultrasonic signal that turns on the porch light. The transmitter, called Scan, can work from a distance of 30 feet.

The 1977 power failure in New York City indicated the potential for crime that such blackouts possess. In case of power failure, three emergency lights (Satellights in Tech House) automatically turn on. They are more than adequate for security, providing even enough light to read by. The lights utilize low voltage, high frequency power generated by solid state electronic lamp drives and a 12-volt automobile battery. The battery is recharged by a solar cell on the garage roof. Solar cells, which convert light into electricity, power most United States spacecraft. The Satellight was developed originally to illuminate spacecraft such as the Skylab experimental manned space station.

In addition to helping to provide peace of mind, use of security devices such as described above can contribute to lowering the premiums for homeowners' insurance policies.



Emergency light shown installed, top photo. Pressure alarm goes under carpet at doorway, bottom photo.

Smoke Detection

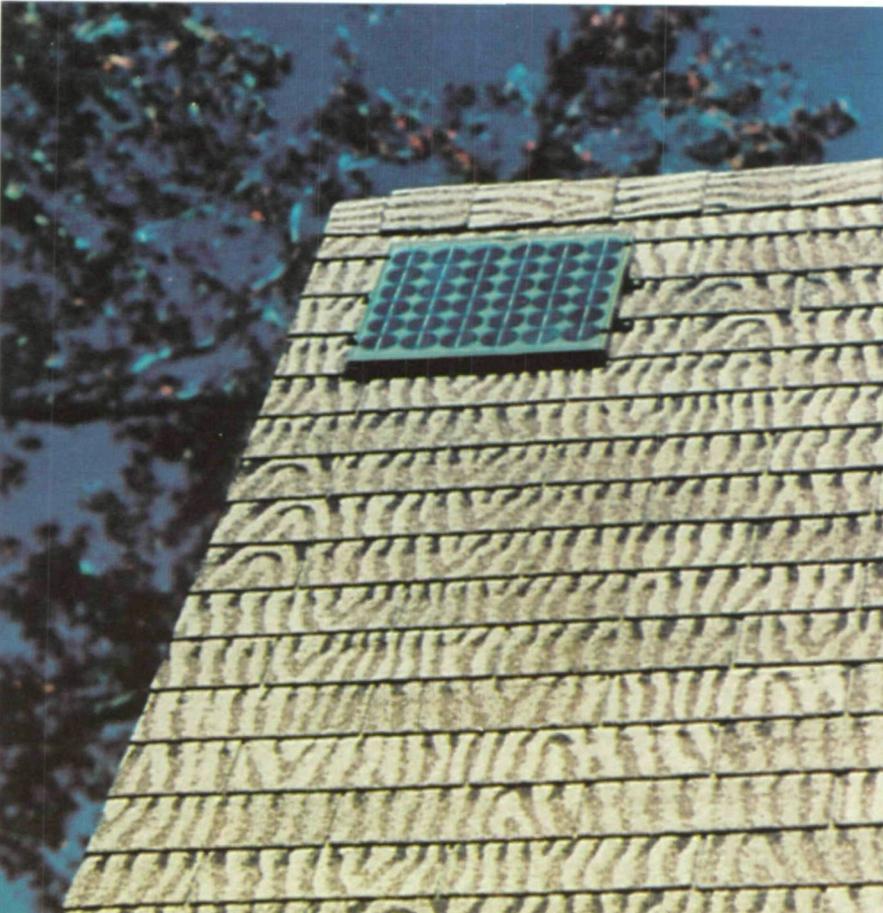
A smoke detector in the hallway can sense combustion products long before they are noticeable to people. It sounds a horn loud enough to awaken the soundest sleeper. Retail stores carry numerous brands of smoke detectors. Characteristics and features of the detectors should be carefully studied by the homeowner to make certain that the purchase meets his or her needs.

Prefab Floor and Wall

Tech House builders used several prefabricated items basically, not for economy but to provide a basis for technical evaluation of the performance of such commercially available units. Because a crane is generally employed, use of the prefabricated components can cost more than conventional techniques. The economies inherent in some forms of prefabrication are best realized when several prefab houses are built in the same general area at about the same time.

The Tech House precast floor is made of concrete reinforced with welded wire fabric and insulated with gypsum foam. The precast wall, located between the master bedroom and bathrooms, is made of a steel frame supporting glass-fiber reinforced gypsum. The gypsum foam insulation fills all voids, reducing heat loss or gain and noise transmission. It is noncombustible.





Solar cell atop garage recharges battery that powers emergency lights.

Flat Conductor Cable

Flat conductor cable has been used extensively in airplanes and spacecraft. It is easier to install and modify and uses less conductor metal (copper) than conventional round wires. It offers a way to reduce the high cost of electrical wiring. U.L. approval was pending and limited use for commercial buildings was being considered by the National Electrical Code Committee as this booklet was written.

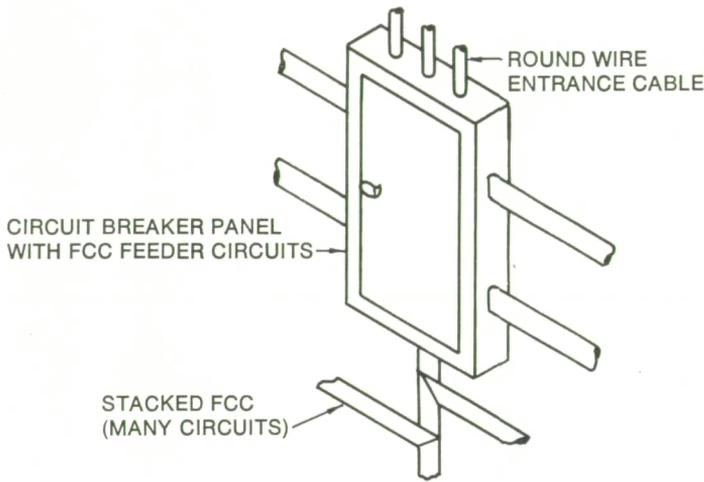
Floor Coverings

Various coverings are used for the concrete cast floor. Of particular interest is the thick foam-backed vinyl with a urethane coating that covers the kitchen. The foam backing provides softness that makes it less tiring to walk or stand on. The naturally shiny urethane coating needs minimum care.

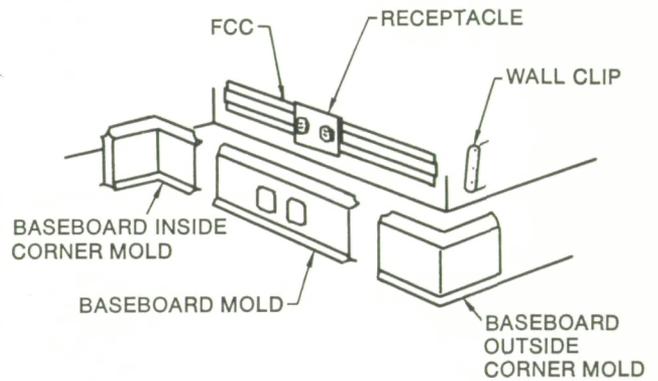
Other floor coverings were: bathroom, ceramic tile; entrance and foyer, slate; and bedroom, hallway, and living and dining areas, carpet.

Temper Foam

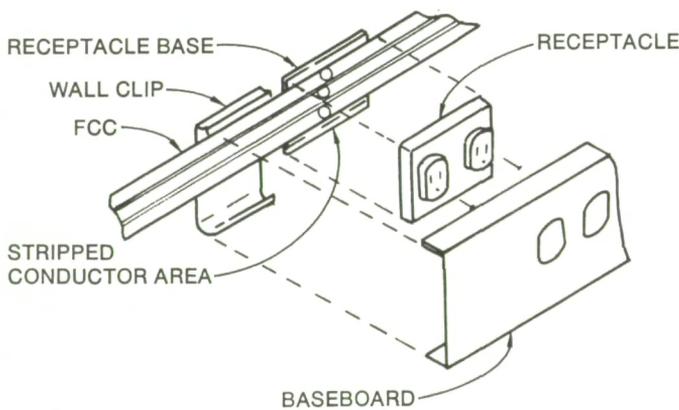
Temper Foam was used to cushion a bench by the fireplace. Developed originally to pad seats in the Apollo spacecraft, Temper Foam can provide comfortable seating for everyone. It contours to one's shape and distributes weight evenly over the contact surface. It also transpires moisture away from the body for cooler seating comfort. Among other things, it has been found effective in preventing bedsores in bedfast patients.



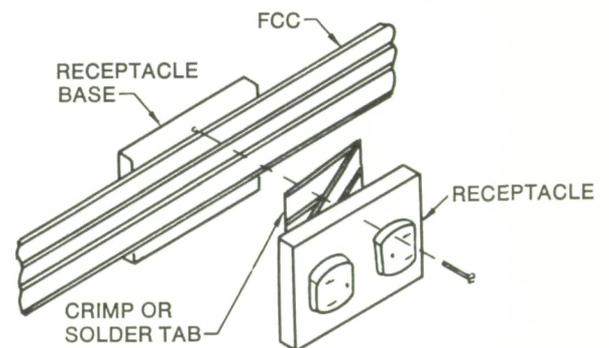
Circuit breaker panel



Snap-on cover baseboard system



Receptacle with pressure contacts

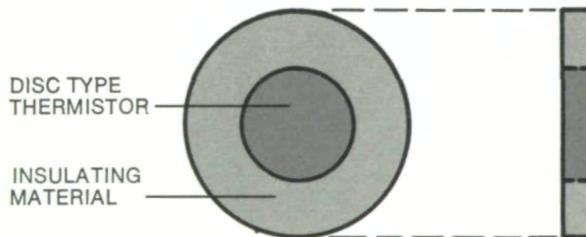
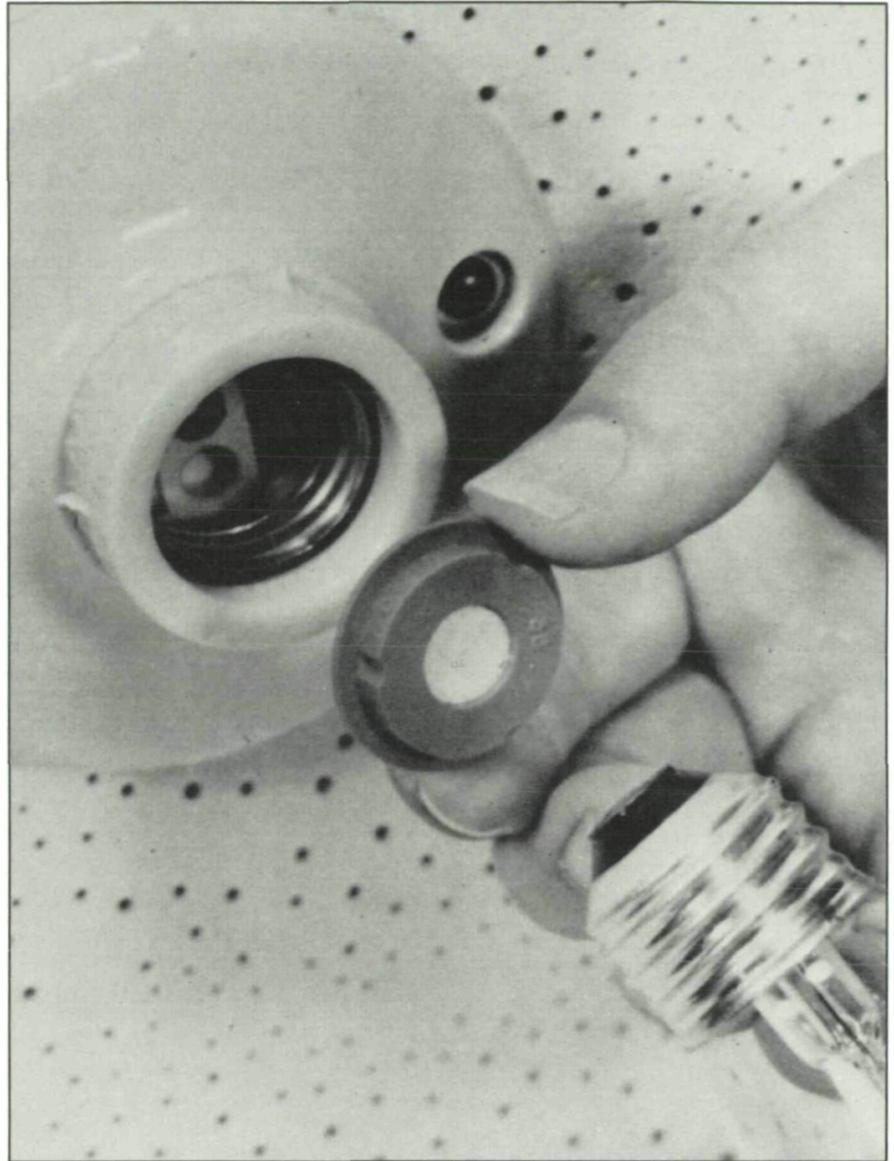


Receptacle with crimp or solder tab

Flat conductor cable (FCC) system

Light Bulb Saver

Light bulb savers have been installed in lamp sockets throughout Tech House. About the size of a quarter, the bulb saver which can triple light bulb life can easily be inserted in a lamp socket. It shields the bulb against the surge of electric current to the filament when the light switch is turned on or when electrical equipment such as air conditioning is turned off. Bulb saver originates from the temperature-compensating thermistor developed to protect the Saturn booster, used in the Apollo manned lunar exploration project, from transient overloads due to current surges.



Light bulb saver



Product Directory

Tech House equipment already on the market can be purchased from several companies. NASA cannot recommend any particular company. However, for informational purposes, products used in Tech House and the companies from which they were obtained are listed below.

Product	Company
Solar Collectors	Chamberlain Manufacturing Co. 845 Larch Ave. Elmhurst, Ill. 60126 Telephone: (312) 279-3600
Heat Pump	Florida Heat Pump Corp. 610 Southwest 12th Ave. Pompano Beach, Fla. 33060 Telephone: (305) 781-0830
Night Radiators	Olin Brass Corp. East Alton, Ill. 62024 Telephone: (618) 258-2000
Shutters	Pease Company 2001 Troy Ave. New Castle, Ind. 47362 Telephone: (317) 529-1700
Exterior Door	Pease Company 900 Laurel Ave. Hamilton, Ohio 45023 Telephone: (513) 867-333
Heat Pipe (Super Skewer)	Isothermics, Inc. P.O. Box 86 Augusta, N.J. 07822 Telephone: (201) 383-3500
Satellite	UDEC Corp. 223 Crescent St. Waltham, Mass. 02154 Telephone: (617) 899-6400
Solar Cell	Solarex Corp. 1335 Piccard Dr. Rockville, Md. Telephone: (301) 948-0202
Manufacturer of Scan and Interior Security System	Sentry Products, Inc. 245 Stockton Ave. San Jose, Calif. 95126 Telephone: (408) 286-3515
Window Screens wired by	Maxwell Alarm Screens 2820 N.W. Fourth Ave. San Jose, Calif. 95126 Telephone: (305) 782-7710
Interior Security System installed by	Southern Burglar Alarm Co. 2400 Granby St. Norfolk, Va. 23517 Telephone: (804) 622-1378
Seismic Detector*	

Product	Company
Prefabricated Floor and Wall	General Electric Co. Reentry and Environmental System Division, Product Information 3188 Chestnut St. Philadelphia, Pa. 19101 Telephone: (215) 835-2669
Flat Conductor Cable	Parlex Corp. 145 Mild St. Methuen, Mass. 01844 Telephone (617) 685-4341
Kitchen Floor Covering	Mr. Robert B. Wylie Building Products Group GAF Corp. 140 West 51st Street New York, N.Y. 10020 Telephone: (212) 582-7600
Temper Foam	Edmont-Wilson 1300 Walnut St. Coshocton, Ohio 43812 Telephone: (614) 622-4311
Bulb Saver	Bulb Miser Sales P.O. Box 55554 Houston, Tex. 77055 Telephone: (713) 686-4735
Urea-Triopolymer Foam	C.P. Chemical Co. Inc. 25 Home Street White Plains, New York 10606 Telephone: (914) 428-2517
Fireplace Grate System	Ridgway Steel Fabricators, Inc. Box 382 Ridgway, Pa. 15853 Telephone: (814) 776-1323

*Information about the outside detector may be obtained by requesting NASA Tech Brief 70-10638 and the Technical Support Package from:
Technology Utilization Office
NASA Ames Research Center
Code AU-230-2
Moffett Field, Calif. 94035

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