engineer Bill Alschuler, designed a passive-collection, active-delivery forced hot-air system for the Langley residence. Air from the heavily insulated storage plenum above the kitchen/greenhouse area is drawn down to a 25-ton rockbed in the basement where it is heated in winter or cooled in summer. The conditioned air is then ducted in-line through a Thermopride multi-fuel furnace and is passed by an auxiliary electric resistance element before being fed to the lower rooms and children's bedrooms through operable floor registers. The master bedroom is open to convective heating from the living room below, which has a backup wood stove. The design/builders could not find a multi-fuel unit with built-in electric backup that met local code requirements, so they were forced to improvise with less-than-compatible components and controls.

In an effort to achieve the higher efficiencies sought in active system rock storage, the consulting engineer designed a reversing system (two-way flow) with separate collection and delivery modes for heating and cooling, and an additional mode for electrically boosted auxiliary heating. In summer, the owners open vent windows in the upper air plenum to convert it to a thermosiphoning tower, which both vents the sunspace and draws cooling air through the house.

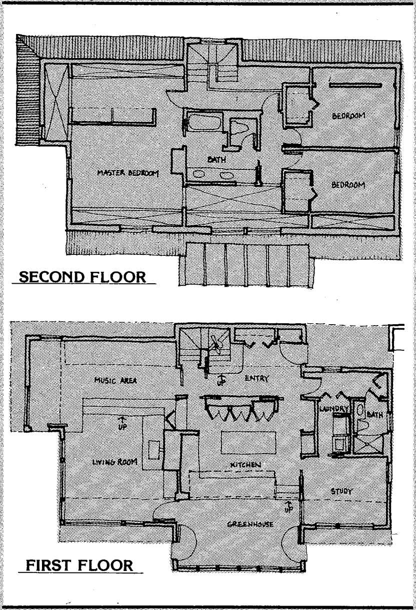
Thermal Performance

According to performance criteria supplied by the design team, the Langley home was designed to attain a Solar Savings Fraction of .37, an ambitious goal for New England, in this case requiring 460 square feet of south-facing glass. This figure indicates that 37 percent of the heat required to maintain design temperatures in an identical non-solar home would be supplied by solar. At this level of performance, 5½ cords of hardwood, supplying 55 million Btu's of auxiliary heat, would be required to maintain indoor temperatures at an average of 65°F.

In fact, in the heating season of 1981-82, the Langleys burned only 5½ cords of hardwood, but design temperatures were not approached. Based on data compiled by the owner on a multi-thermistor Heliologic control module, house temperatures were as follows: while average daytime temperatures were maintained close to 63°F throughout much of the house, the nighttime average dropped to 58°F. The kitchen/greenhouse area rarely exceeded the high 50's. After a sunny day with no auxiliary heat, the house averaged 60°-62°F before sunset. On these days the upper plenum reached the mid-70's, the rockbed the mid-60's, and warm air to the room approximately 60°F. The owners report that the air from the registers, even when warmer than room temperature, feels cold to the skin. It's not like the 110°-120°F air they expected from a forced hot-air system.

While the owners are very pleased with their home, with the thoughtful and imaginative use of space, the grand views and fine detailing throughout, they express disappointment in the solar performance. They report that the rockbed does not work as expected and, in fact, was not needed since overheating is not a problem. On winter mornings, the Langleys tolerate a chilly kitchen, feeling it's the price they pay for the glass and views. They also wish they had more control over temperatures in the master bedroom, which is always open to the living room below. When they warm the living room by lighting the wood stove, they automatically warm the bedroom above to a few degrees higher. The Langleys, however, like to sleep in a cold room.

The design/build team feels that the owners do not fully understand the function of the rock storage—that it is a thermal flywheel meant to stabilize temperature swings rather than to supply high-temperature air to the registers on its own. The consulting engineer, after being alerted to the problems, carefully rechecked his calculations and later visited the completed site. His measurements indicated a 35 percent reduction in insolation at the greenhouse due to shading (on October 2 at 2:00 p.m.). He also noted the lack of nighttime insulation and, as water leaks have plagued the greenhouse glazing, suspected high infil-



tration losses as well.

A closer look at the project reveals a degree of truth in all of these assertions. First, the design calculations were based on a number of assumptions that have not been met, explaining the wide discrepancy between projection and performance. The consultant who performed the calculations assumed an unobstructed southern exposure, while the owners and designer were planning to leave trees for summer shading and landscaping. After some trimming of trees, the owners estimate a 20-percent shading loss may still remain. As for the R-9 night insulation in the calculations, the owners plan to install some night insulation as soon as they tackle the greenhouse leakage problems.

The lack of nighttime insulation alone dramatically lowers the SSF from .37 to just above .1, raising auxiliary heating requirements by 23 million Btu's, or almost 2½ cords of wood. The estimated shading coefficient of 20 percent at the sunspace would account for an additional loss of 6.6 million Btu's annually. If glazing repairs reduce air infiltration in the sunspace, greater savings would accrue. The house as a whole has a relatively high heat loss compared with passive solar homes of a similar size. This is partly due to the liberal use of non-south-facing windows and the inclusion of the greenhouse as primary living space. The amenities that resulted from these design decisions must certainly be weighed in the economic equation.

The rock storage

A reversing rockbed, when operated effectively, will perform at a higher efficiency than a simpler one-way-flow rockbed. But the additional cost and complexity may not be justified in a passive-collection system such as this. Temperature gradients across the rockbed are too small to make much of a difference. (see "Rockbeds," *Solar Age*, 3/82). The designers, in retrospect, tend to agree. If the whole house were brought up to design temperatures by correcting the heat loss and shading problems, then the owners would probably be more satisfied with the rockbed as "flywheel." Fine-tuning the system so that control settings, air-temperatures, and blower speeds are balanced for owner comfort could help further.

Despite any shortcomings in the home's thermal performance, the Langleys report that "the home offers so much flexibility that we have found ways to make it do what we want." And as corrective measures help bring the house in conformity with its original design criteria, it will likely fulfill its promise as an exciting and working passive solar home.

Participants

Architect/Contractor: Donald J. and Mollie B. Bourgeois-Moran
Energy Consultant: Energy Design Team

Building Data

Completion date: August 1981
Square footage: 2100
Heating degree days: 6197
Design heating load: 7.8 Btu/(°F-day ft^2)
Auxiliary heating load: (calculated) 4.2 Btu/(°F-day ft^2)
Collector: direct gain, 460 square feet south glazing
Thermal storage: 21,300 Btu/°F: concrete slab, brick masonry walls, 50-ton remote rock bin

Conservation Package

Foundation: R-10, 2-inch Styrofoam™
Walls: R-28, 6-inches fiberglass, 1-inch Thermax™
Ceiling: R-40, 12 inches fiberglass
Glazing: double-glazing on the south, triple on additional 177.5 square feet
Night insulation: R-9, to be installed on south glazing