14. ADDITIONAL METHODS FOR SOLAR HEATING/COOLING

The examples of the previous two chapters illustrate the basic ideas behind solar heating and cooling systems. In addition to the examples cited, there are other experimental houses, or plans therefore, that have been developed. Some of these are briefly noted in this chapter for the purpose of illustrating the diversity of approaches that are possible to questions of solar heating and air conditioning. References are provided (some of them not readily available, unfortunately) for sources in addition to these brief comments.

14.1 *COLLECTOR-STORAGE WALL SYSTEMS*

The combination of collector and storage into a single structural part of the building--the south wall--was a major feature of the second house in the series of MIT houses, and is today being used in several buildings. The walls are vertical and the angle of incidence of solar radiation on them is high in the winter and low in the summer; these systems are for winter operation only.

Hollingsworth (1947) described the second MIT experimental structure, which consisted of a building oriented in an east-west direction with seven small cubicles along its length, each having its south wall made up of double glazing with a solid wall of heat storage material behind the glazing. Movable insulating shades and fans for air circulation were used to control losses and increase the rate of heat transfer from the storage wall to the room. (The designers of this experiment used separate collector and storage units in MIT House III.)

More recently, Trombe and his colleagues (1972) have built several houses at Odeillo, France, using similar principles. A cross section of one of these houses, showing the collector-storage wall, is shown in Figure 14.1.1 and a photograph of one of the houses is shown in Figure 14.1.2. The south wall is double glazed. Behind the glazing, at a distance of about 10 to 20 cm from the glass, there is a concrete wall about 20 cm thick,

painted black, which serves as both a radiation absorber and a heat storage medium. Openings are provided through the concrete at top and bottom, so that air circulates through the space between the glass and concrete, and through the room. This circulation is by natural convection, and no pumps or controls are used. Operating information on these houses and how it relates to the climate in the Pyrenees is not yet available.

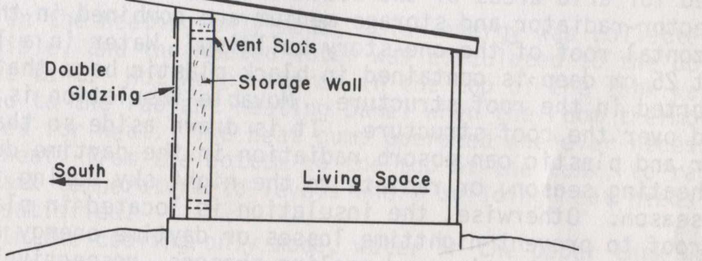

Figure 14.1.1 Schematic section of the Odeillo solar heated houses.

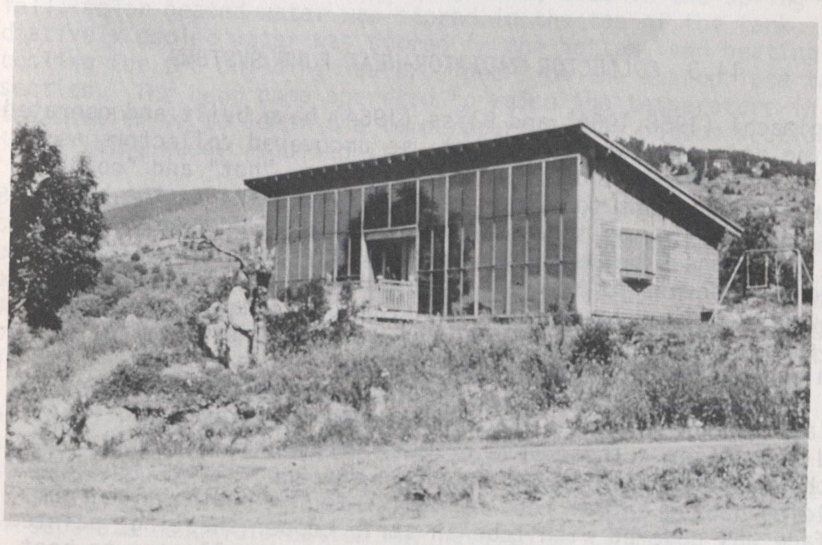

Figure 14.1.2 Odeillo solar heated house.

Baer (1973) has constructed buildings in New Mexico with the south walls including stacked drums of heat storage material and with movable hinged covers on the exterior to control thermal losses and radiation on the storage wall.

14.2 COLLECTOR-RADIATOR-STORAGE SYSTEM

Hay (1973) and Hay and Yellott (1970) describe a building de-
signed for arid areas of the southwestern United States. The
collector-radiator and storage medium are combined in the flat,
horizontal roof of the one-story building. Water in a layer
about 25 cm deep is contained in black plastic bags that are
supported in the roof structure. Movable insulation is pro-
vided over the roof structure. It is drawn aside so that the
water and plastic can absorb radiation in the daytime during
the heating season, or radiate to the night sky during the cool-
ing season. Otherwise, the insulation is located in place over
the roof to prevent nighttime losses or daytime energy absorp-
tion during the heating and cooling seasons, respectively. In
a test house in Arizona, movable insulation was also provided
under the roof (ceiling) to control heat transfer by radiation
and convection between the storage medium and the living spaces.
A new house has been built in 1973 in California to study this
system; data on its operation should be available in 1974.

14.3 COLLECTOR-RADIATOR-HEAT PUMP SYSTEMS

Yanagimachi (1958,1964) and Bliss (1964) have built and operated
heating and cooling systems that use uncovered collectors as
daytime collectors and nighttime radiators, "hot" and "cold"
water storage tanks to supply heating or cooling to the build-
ings, and heat pumps to assume maintenance of adequate tempera-
ture differences between them. The Yanagimachi system was ap-
plied to a series of houses in the Tokyo area. The Bliss sys-
tem was used on a laboratory in Tucson, Arizona. The systems
are similar in concept, and we summarize here information on de-
sign and operation of the Bliss system.

The site of the Tucson laboratory is characterized by high
radiation, low rainfall, hot summers, mild winters, and low
wind velocities. These were primary considerations in design
of the experimental structure, which was a one-story laboratory
building having a flat roof tilted 7° to the south. The roof
surface was covered with tube-in-strip copper sheeting, painted
dark; it served as an uncovered solar energy collector to heat
water and as a radiator to reject heat to clear night skies.

A vertical water tank, divided at its midpoint by a thermal baffle, provided storage of both hot water (in the top section) and cold water (in the bottom section). In addition, a heat pump was provided to transfer heat from the cold to the hot tank sections; the evaporator coil was in the bottom of the tank and the condenser coil was in the top.

A schematic diagram of the system is shown in Figure 14.3.1. Its operation was in any one of three modes; heating only, cooling only, or heating and cooling.

A. In the heating-only mode, solar energy was collected when possible, and the heated water was circulated to the bottom of the tank. Hot water stored in the top of the tank was circulated to the radiant heating panel when the room thermostat called for heat. The heat pump operated whenever necessary to "pump heat" from the bottom to the top of the tank, to raise the top tank temperature to levels where building heat needs could be satisfied.

B. In the cooling-only mode, water in the upper tank was cooled by nocturnal radiation from the collector-radiator. Cooling water for cooling the building was withdrawn from the bottom of the tank, and when building needs required it, the heat pump lowered the temperature of the water in the bottom section.

C. In the heating and cooling mode, used in the spring and fall, solar heated water was stored in the top of the tank, radiatively cooled water was stored in the bottom, and heating or cooling for the building was provided from the appropriate tank section. The heat pump operated to raise the temperature in the top section or to lower the temperature in the bottom section if building needs required it.

Bliss provides operating information from this building, that shows electrical energy consumption, energy gained and rejected by the collector-radiator, energy transferred to or from the buidling, and other items in the energy balance. These monthly balances are shown in Figure 14.3.2. Data from this building show that the monthly average energy radiated from the collector in the cooling season is, at best, about 360 Btu/ft^2/night.

Bliss points out that with systems in which cooling for the building is provided by radiator panels, dehumidification is not accomplished. Thus such systems, that reject heat from room air at temperatures well above evaporator temperatures encountered in the usual air conditioners, may be restricted to dry climates or separate dehumidification may have to be provided.