Chapter Nine
Design Options

9.1 Commercial Air-Handlers

As discussed in Section 2.2, TEA studied commercially available air-handlers, and decided instead to feature a site-assembled air-handler in this manual. The design for the MODEL-TEA conventional air-handling system is less expensive, more flexible, and has a more effective control strategy than most commercially manufactured air-handlers. A list of available air-handlers is included in Appendix A.2.

However, two commercially available air-handlers are available for approximately $1000, and thus are potentially attractive alternatives to a site-built air-handling system. The Delta-H air-handler uses a standard blower but a very innovative damper design. It provides a standard 3-mode operation and comes with a complete control system and a DHW coil. The other product, the CSI "No Frills", uses conventional dampers but a propeller fan rather than a blower. It also provides the standard 3-mode operation and comes with a complete control package, but the $1000 price does not include the DHW option. CSI sells a separate complete DHW water package, including the coil, and control board with differential, for roughly $600.

TEA has no direct field experience with either product. If they are successful, they offer major benefits of vastly simplifying system installation and reducing costs. Whereas the MODEL-TEA site-assembled system requires a knowledgeable professional to install the control system, these two air-handlers have the controls already connected. The consumer must weigh low cost and ease of installation on one hand, against the low-risk of standard components and a conventional design on the other.

9.2 Innovative System

The innovative system, illustrated in Figure 9.1, utilizes a one-way rock bed. This system can be built at a potentially lower cost, but it is more critically dependent upon precise sizing and engineering, and requires extensive integration with the building design. For these reasons, this system should not be used unless the services of an experienced solar designer are available.

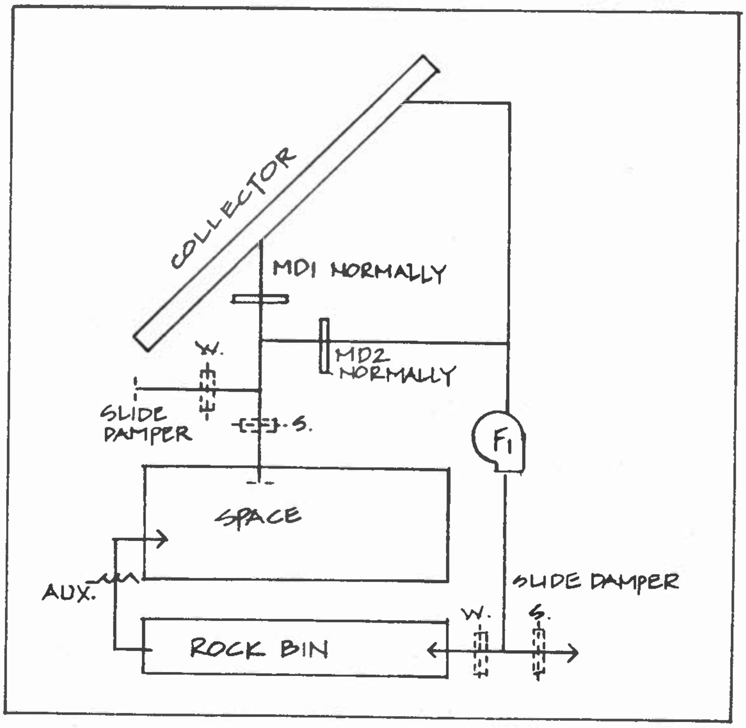

Figure 9.1 Innovative System Schematic

The one-way rock bed allows a much simpler air-handling system, and thorough building integration permits major savings in ductwork. The system has two modes. In the first mode, collection mode, air is drawn from the house to the collector, heated, blown through the rock bed and returned to the house. In the second mode, storage to house, air is drawn

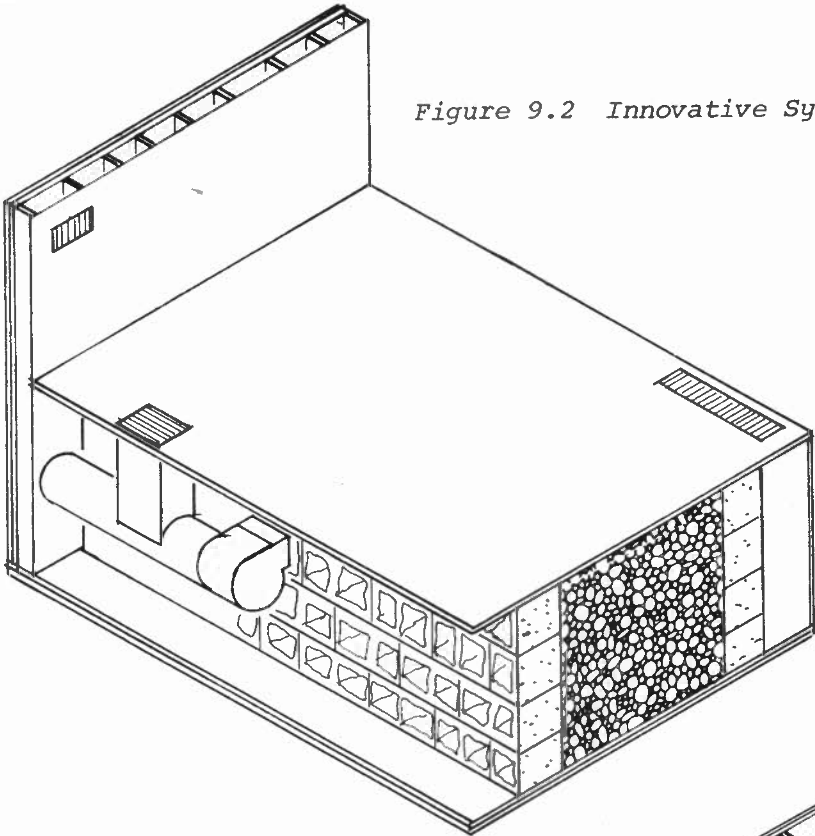

Figure 9.2 Innovative System Under Floor Rock Bed

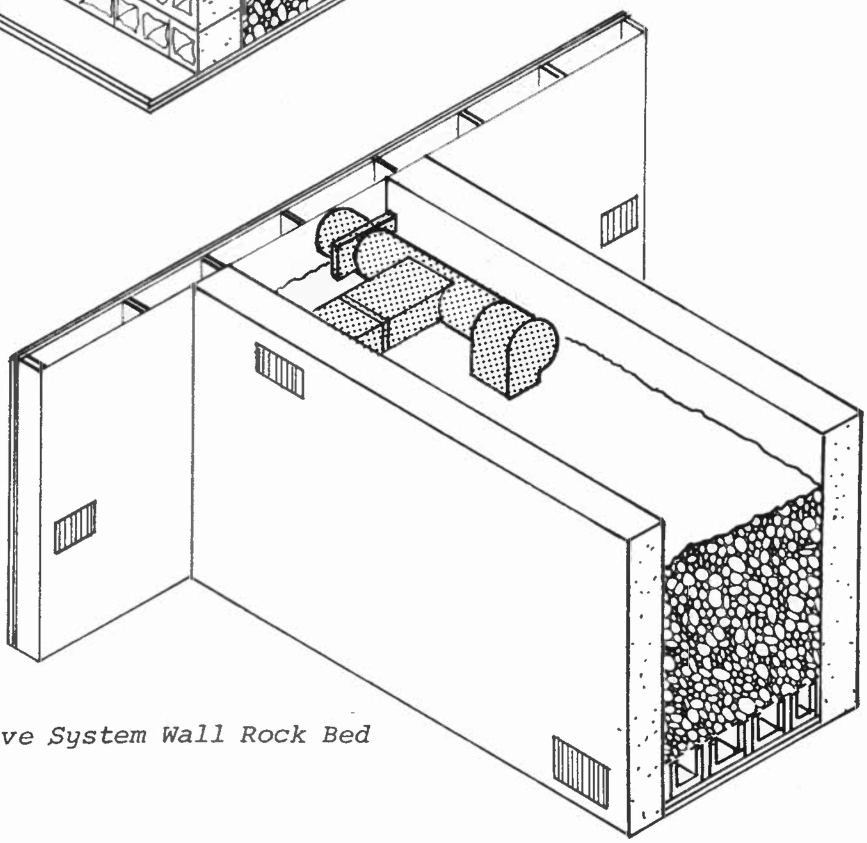

Figure 9.3 Innovative System Wall Rock Bed

from the house to the rock bed, heated, and delivered back to the house. Air flow through the rock bed is in the same direction in both modes. The auxiliary heater is located in series between the rock bed and the living space, and whenever the solar-heated air cannot meet the house heating demand, the auxiliary boosts the air temperature.

MODE	FAN	MD1	MD2	AUX.	SIGNALS
SPACE/COLL/ROCK BIN/SPACE	ON	O	C	OFF	ΔT
SPACE/ROCK BIN/SPACE	ON	C	O	OFF	W_1
AUXILIARY STAGE 1	ON	O	C	ON	W_2, ΔT
AUXILIARY STAGE 2	ON	C	O	ON	W_2
STANDBY	OFF	C	C*	OFF	-

* MD2 IS CLOSED IF MECHANICALLY GANGED TO MD1.

Table 9.1 Mode Schedule for Innovative System

The basic concept of this system is that the one-way rock bed provides a time delay; the collector primarily heats the rock bed during the day, by the end of the day the rock bed is saturated, and during the night the bed heats the house. The sizing of the rock bed is very critical. Too small a bed would cause early saturation and possibly over-heating of the living space in the afternoon. Too large a bed would result in lower temperature air being delivered to the house in the evening. TEA conducted computer simulations of year-long one-way rock bed performance to determine optimum numbers for air flow rate and rock bed size. The best combination is approximately an air flow rate of 3 CFM per ft^2 of collector and a rock bed size of 2 ft^3 per ft^2 of collector. These numbers represent compromises between conflicting goals. For example, lowering the air flow rate results in higher collector outlet temperatures, reducing collector efficiency but producing more useful heating temperatures. Because of the critical engineering required, and the variety of ways this system can be integrated into a new design, any installation should benefit from the services of an experienced solar consultant.

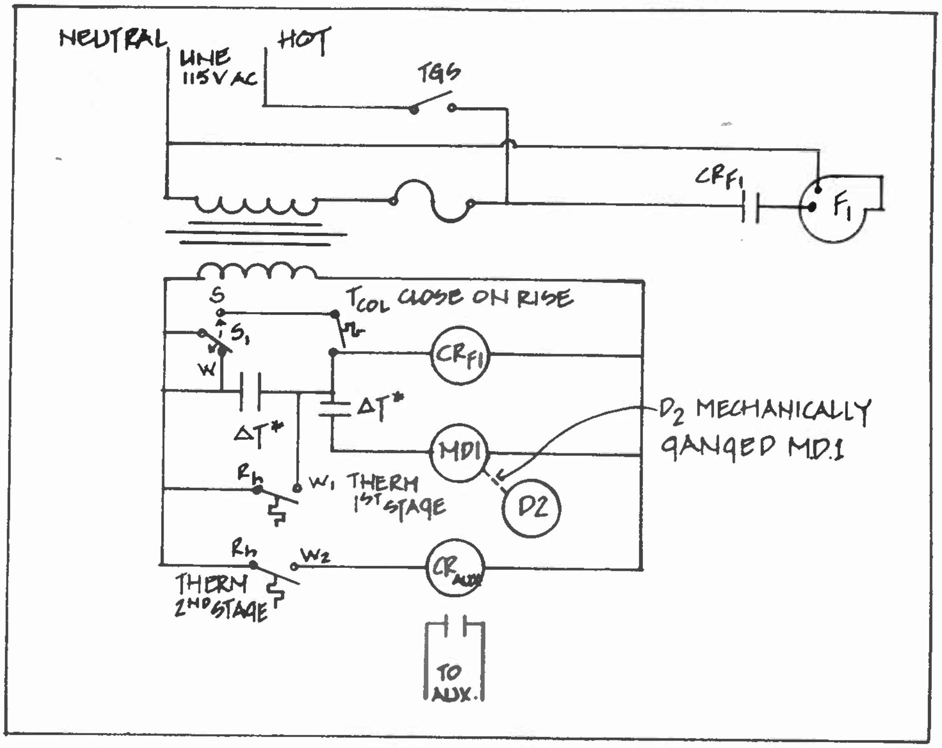

Figure 9.4 Innovative System Wiring Schematic

9.3 Isophenol Insulation

In the development of the collector design, TEA was very concerned with potential problems caused by exposing wood to moderately high temperatures for long periods of time. The project staff consulted with both the American Plywood Association and the U.S. Department of Agriculture, Forest Products Laboratory, in order to be better acquainted with the current understanding of the relevant wood properties. Wood can endure very long exposure to temperatures as high as 200°F without significant degradation. But wood exposed continuously to 300°F for one year will undergo major weight loss and probably begin to char. Reaching the charcoal state is essential to initiation of spontaneous smoldering combustion. After one year of 300°F exposure, the wood has charred, and the probability of spontaneous combustion significantly increases.

The MODEL-TEA collector will normally operate below 200°F, but if it were allowed to stagnate, the roof collector could reach temperatures of 300°F or higher for short periods of time (a few hours per day). At night the collector temperature would always be down to ambient temperature. If the roof collector were allowed to stagnate throughout the summer, it could spend a total of between 500 and 1000 hours (depending upon climate) above 250°F. For this reason, the roof collector is always power vented. This decision to power vent is discussed in more detail in Section 2.4. Vertical wall collectors are not subject to many hours at high stagnation temperatures and therefore do not require power venting.

If the power venting system fails, the collector will reach high summer stagnation temperatures, roughly 300°F, but short exposures to these temperatures will not have deleterious effects. Since Thermo-ply (see Section 2.3) is the only material between the absorber and the wood rafters, the wood will reach a temperature very close to that of the absorber. TEA does not believe this to be a problem as long as proper power venting is employed. In some areas, however, codes may require more insulation between any wood structure and the collector. If insulation is required, it must be chosen carefully.

There are a number of rigid insulation materials available, but most cannot be used in the MODEL-TEA collector. Polyurethane, polystyrene, and isocyanurate insulations are not acceptable since they are quite flammable and release fumes and toxic gases. Use of one of these materials under the MODEL-TEA absorber would be particularly dangerous due to proximity to the air stream through the collector. Foamglass is not flammable and could be used under the Thermo-ply, however it is extremely abrasive, making it very unpleasant to work with.

The best available material seems to be Isophenol, a rigid phenolic foam. It has a much better flame resistance than polystyrene or polyurethane, and a very low emission of smoke or noxious fumes in a fire situation. Since the Isophenol is available with a foil facing its use eliminates the need for the Thermo-ply. In addition, Isophenol is relatively inexpensive -- \$.28/bf plus an extra \$.15/ft^2 for the foil face. The material is fairly fragile, as is foamglass, and requires careful handling. Even though the foil-faced material is used, the insulation would be exposed to the air stream at the manifold cut-outs. Since the material easily flakes and crumbles, these exposed areas should be covered with special high temperature tape which can endure stagnation temperatures. Standard duct tape is not sufficient. (See Appendix A). The introduction of any rigid insulation to the area under the absorber will change some of the dimensions given in the construction drawings, and the builder will have to determine the appropriate new dimensions.

9.4 Aluminum Battens

TEA believes that the use of wood for inner collector battens presents no significant problem. For the reasons discussed in the previous section, the wooden battens should not suffer any serious long term degradation due to collector temperatures. However, if it is desired, these battens can be replaced with metal, thereby eliminating all wood from the collector. Aluminum must be used, not steel, since galvanic corrosion could exist between the aluminum absorber and steel battens. The substitution of aluminum battens for wood will raise the materials cost of the collector approximately $\$.65/ft^2$.

In the standard MODEL-TEA collector the wooden battens are fastened to the absorber ribs, not the valleys. This is done because the compressible wood can make an air tight seal over the absorb rib. If instead the batten screws fastened to the valleys, the Thermo-ply would be perforated and there is a possibility of the aluminum absorber and the Thermo-ply becoming slightly separated by the screw. While there normally would not be any air flow in the valley, there would be some possibility of leakage in this case. Thus, TEA decided it would be more prudent to fasten the wooden battens to the ribs. But aluminum battens would not seal as well to the ribs, and since most of the air flow is under the ribs, it is probably safer to fasten these battens to the valleys. Sources for aluminum battens are listed in Appendix A.2.