Chapter One
Description of the Model TEA

1.1 Overall System

The MODEL-TEA system consists of a solar collector, delivery and control system, and storage. The collector receives energy from the sun, which heats a black metal plate within the collector. Air is blown through the collector, becomes hot, and then is delivered to the living space of the house. The control system automatically governs the air flow according to the demand for heat and available sun. For large systems a storage bin is provided. Then when the collector is providing more heat than the living space requires, the surplus heat is sent to storage to be held in reserve for use at night or during periods of cloudy weather.

This general relationship of subsystems is similar to that of most commercially available active solar systems. All of these solar systems use either a liquid (water or anti-freeze) or air to carry heat from the collector to the living space. Air was chosen as the heat-carrying medium for the MODEL-TEA system. Chapter 2 contains a complete discussion of this choice and of other decisions made in the design of this system. The most important difference between the MODEL-TEA and commercially available systems is that the MODEL-TEA is actually built on site, fully integrated into the building structure, thus providing a tremendous savings in cost.

1.2 Collector

The MODEL-TEA collector is an air-type, flat plate collector designed for installation on either pitched roofs or vertical walls in new or existing buildings. A perspective sketch of the roof version is shown in Figure 1.1. The major components of the collector are a

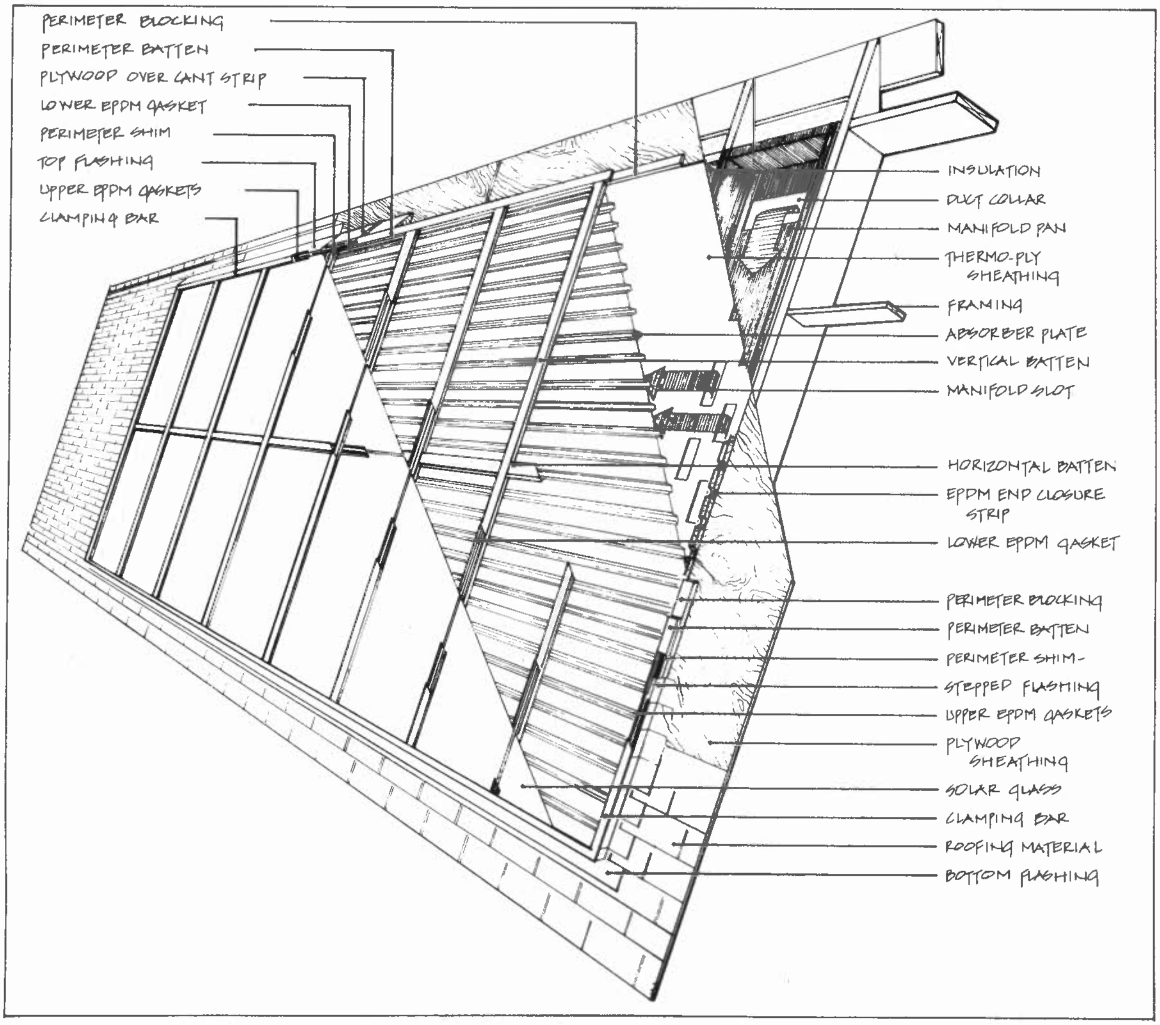

Figure 1.2 MODEL-TEA Roof Collector

glass cover system, a black-ribbed metal absorber plate, Thermo-ply building sheathing, and sheet-metal manifold pans located between the outer studs or rafters.

Sunlight passes through the glazing cover and is converted to heat on the black absorber plate. The glazing cover reduces losses to the outdoor air and the collector plate heats up. Air from the room or rock bin is ducted into the collector manifold pan, as indicated by the arrow in the upper right of Figure 1.2. The air passes through the manifold openings in the sheathing, and travels the length of the collector in the horizontal channels formed between the raised portion of the ribbed absorber and the sheathing. Heat is transferred from the absorber to the air, and heated air then passes through manifold openings into a manifold pan at the opposite end of the collector, and is returned to the room or a rock bin through air ducts. A blower is required to move the air through the system. Other components found in a complete system include rock bin storage, thermostatic controllers, and motorized dampers.

The construction of the MODEL-TEA collector is straightforward. The roof (or wall) is framed in the usual manner, horizontal blocking is added, and manifold blocking is installed. Sheet metal manifold pans are fastened between the rafters (or studs) at each end of the collector, as shown in Figure 1.2. For collectors longer than 24 feet, manifold pans are also located between the rafters on each side of the center rafter, as explained in Chapter 7. Caulking is applied generously all around the upper edge of the manifold pans. The Thermo-ply sheathing is attached to the roof (or wall), and all seams are carefully caulked. Manifold slots are cut in the sheathing. Blocking is fastened around the perimeter of the Thermo-ply.

The absorber plate is eight inch ribbed industrial aluminum siding, painted flat black. It is installed over the sheathing, extending to the outer manifold blocking. Then the ends are sealed with EPDM rubber end closure strips and a continuous caulk bead, and the top and bottom edges are caulked. Battens are fastened to the absorber plate. The glazing system is then attached, a single layer of glass on the roof version, and double glass on the wall collector. The collector is completed by installing flashing and collector edge details.

1.3 Air-Handling and Controls

The air-handling system consists of fans, ductwork, automatic dampers, and controls which operate to deliver the heated air. If the collector is small, the house can usually receive all the heated air directly from the collector, eliminating the need for a storage bin. Then the required air-handling system is very simple: it consists of one fan and supply and return ductwork between the collector and the living space. Whenever there is sufficient sunshine and the living space is below the overheating temperature, the controls turn on the fan.

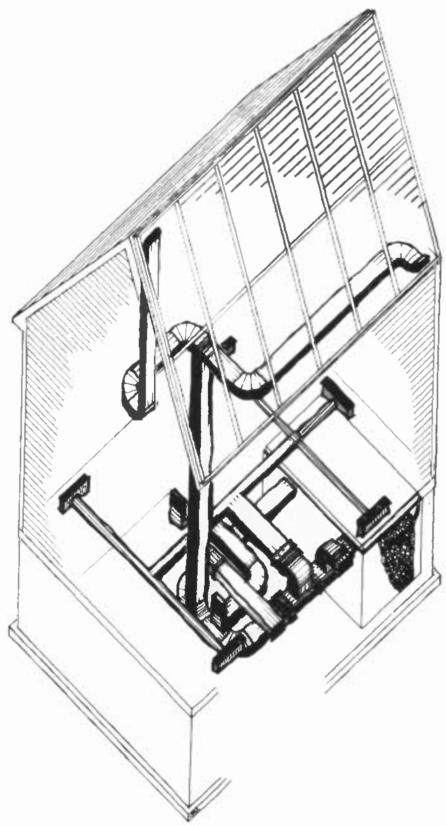

Figure 1.3 Air Handling System

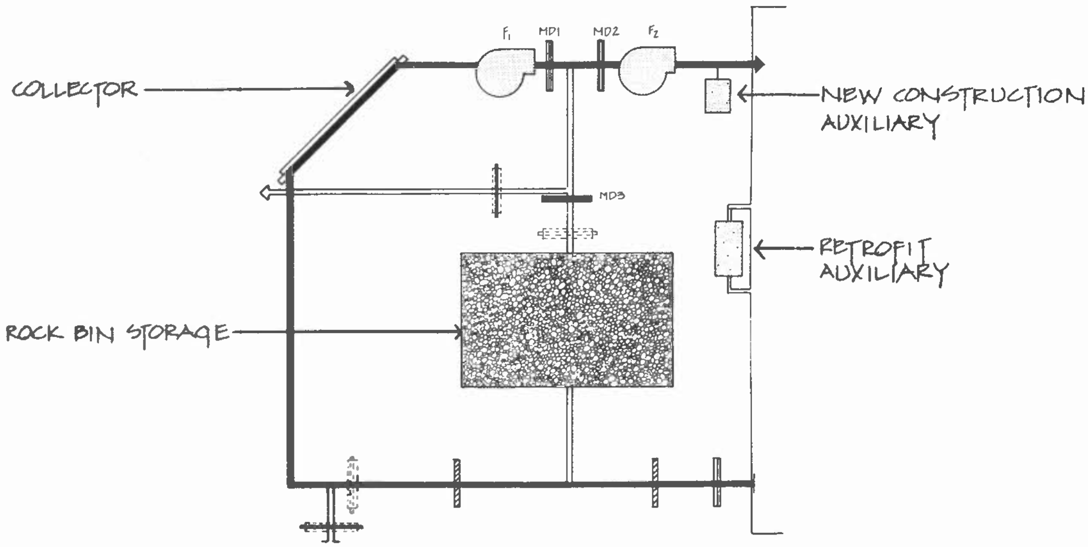

Figure 1.4

Collector to House Mode

A larger collector can usually deliver more heat to the living space in the daytime than is necessary. In these systems, a storage rock bin is used to hold the surplus heat for a later time, such as at night, when it is needed. This type of full-scale installation is characterized by three air-handling modes: collector to house, collector to storage, and storage to house. When the collector is producing useful heat and the house concurrently requires heat, the first mode is activated. Air from the house is drawn through the collector, heated, and then delivered back to the house. If the collector heat is not sufficient to totally fulfill the house need, the house temperature continues to drop, and the second stage of the thermostat activates the auxiliary heating system. The collector to house mode continues to operate as long as there is both a heating need and the collector air temperature remains above a minimum set temperature.

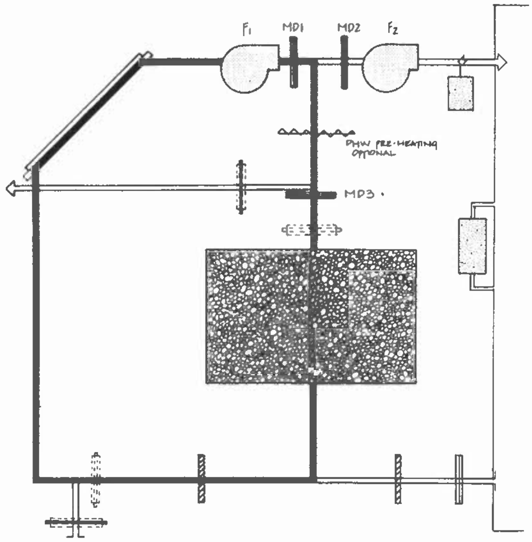

Figure 1.5
Collector to Storage Mode

The second mode, collector to storage, is engaged whenever the collector is warmer (by 20°F) than the cool side of the rock bin, and the house does not require heat. Air from the cool side of the rock bin is drawn through the collector, heated, and then returned to the hot side of the rock bin. If the collector air temperature drops to within approximately 4°F of the cool side of the rock bin, this mode is halted.

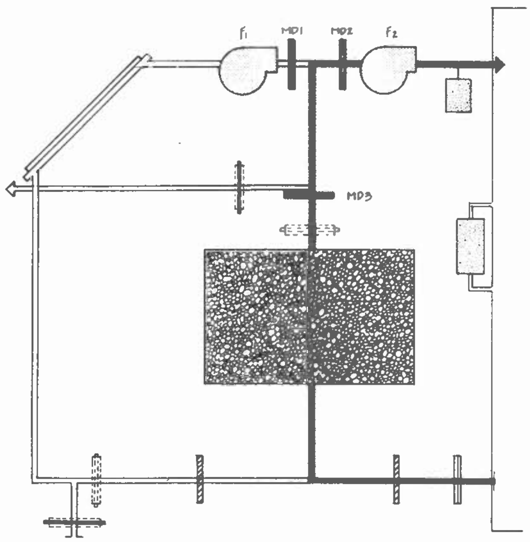

Figure 1.6
Storage to House Mode

The third mode, storage to house, operates when the house requires heat, but the collector is not hot enough to turn on. Air is drawn from the hot side of the rock bin, delivered to the house, and returned to the rock bin's cool side. If this heat is insufficient to meet the house need, the house temperature continues to drop, and the second stage of the thermostat activates the auxiliary heating system. The storage to house mode continues until either the house demand is satisfied or, in the case of retrofit, the air being delivered from the rock bin drops below $85^{o}F$.

The three mode air-handling system presented in this manual uses two fans and three on/off dampers. It is assembled on site from standard components and is suitable for either new construction or retrofitting to existing buildings. A water coil can be placed in the ductwork so the system may provide domestic hot water (DHW) in addition to space heating. The cost-effectiveness of the system is thereby increased, since it can provide useful service throughout the year.

TEA also developed an innovative air-handling system which is suitable only for new construction. This is an even lower cost system, obtained by careful integration with the building design and the use of a different type of rock bin. This system is described in detail in Chapter 9.

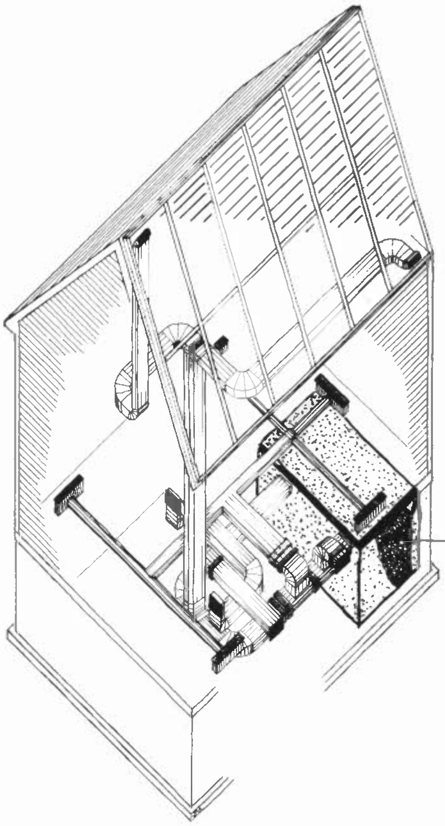

Figure 1.7
Rock Bin Storage

1.4 Storage

Installations with sufficiently small collector areas (less than 200 ft^2 for retrofit and less than 150 ft^2 for new super-insulated houses), do not require storage. For larger collector areas, storage is essential to achieving efficient use of the collected heat. Storage for the MODEL-TEA system consists of an insulated box, or bin, filled with small rocks. The rocks have sufficient spaces (voids) between them such that air can be blown through the bin between duct connections on the two ends. As heated air from the collector is blown through the bin, heat is transferred from the air to the rocks, and the cooled air then returns to the collector to be reheated. There is good heat transfer from the air to the rocks due to the large surface to volume ratio of the rocks. In addition, rocks have the capacity to store a large amount of heat with only a moderate rise in temperature.

In the storage to house mode, air flows through the rock bin in the opposite direction. Cool house air is drawn into the cool side of the bin, heated by the rocks as it passes, and delivered from the hot side back to the house. Since air flow direction reverses, depending upon whether the rock bin is being charged or discharged, this type of storage is known as a two-way rock bin. Thermal stratification, the fact that the rock bin usually maintains a temperature difference between the two sides, is due to the relatively poor thermal conductivity of the rock-void combination.

The MODEL-TEA rock bin has a U-shaped air flow path which allows both inlet and outlet duct connections to be made at the top of the bin, and limits the overall height. These are important features when retrofitting rock bins into existing basements where space may be tight. Rocks can usually be dumped into the bin on a chute through a basement window. For houses on slabs, the rock bin must be integrated into a space on the first floor. The rock bin is constructed on site from standard framing lumber, and lined with plywood and Gypsum Board. Joints are carefully caulked and taped to prevent air leakage, and the bin is fully insulated. Chapter 9 contains a description of the one-way rock bed used in TEA's innovative system, suitable only for new construction.