DESIGN AND CONSTRUCTION OF ATTIRE DRYER FOR HIGH-RISE BUILDING

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ABSTRAK

Solar pengering pakaian ini telah direka, dibina, dan diuji. Dalam projek ini, beberapa ujian kecekapan telah dijalankan untuk mengetahui kebolehan sistem pengering yang berdasarkan kesan rumah hijau. Pengering yang dibina adalah mudah, fleksibel, berkos murah dan mudah alih. Dengan itu, pengering ini dapat digunakan di semua tempat termasuklah di bangunan yang tinggi. Pengering ini telah menunjukkan pretasi yang baik dalam proses ujikaji. Ia berjaya mencatatkan suhu dalam julat 35°C–52°C. Oleh itu, pengering ini mampu mengeringkan 10 helai pakaian dalam masa 3 jam dalam keadaan suhu di sekitar Kuching. Pengering tersebut juga dapat digunakan semasa waktu hujau.

ABSTRACT

A solar attire dryer was designed, constructed and tested. In this project, several technical performance tests have been conducted to study the application of the greenhouse effect solar dryer systems. The apparatus constructed are simple, flexible, low-cost and also portable. Therefore it could used for any locations even for high rise building. The solar dryer has worked well in the process of testing. It produces temperatures of around 35°C–52°C, which implies a drying rate of less than 3 hours for 10 clothes per day at Kuching's condition. Also, it can work even under raining condition.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

By definition a star, such as our sun, generates its own energy. The energy emitted from the sun is understood to be generated by nuclear fusion, based on hydrogen. The surface temperature of the sun is about 6000°K. Our sun, with the nine planets in orbits around it, together with a number of moons orbiting the various planets, is called our solar system. Proceeding outward from the sun, the earth is the third planet, an average of 93 million miles from the sun. Because of the great distance of the earth from the sun, the rays of light energy coming from the sun may be considered to be parallel rays. The amount of energy arriving at the outer boundary of the earth's atmosphere per unit time per unit area, referred to as the solar constant, is about 2 calories per minute per square centimeter, or in language more familiar in the United States, 130 watts per square foot. It may be remembered that 0.239 calorie is equivalent to 1 joule, and 1 joule per second is 1 watt.

When the rays of sunlight enter the earth's atmosphere, a substantial portion of the energy is absorbed by the atmosphere. When the sun is directly overhead, the distance travelled through the atmosphere will be a minimum. For parallel rays, as the point of impact upon the outer boundary of the atmosphere moves away from perpendicular, the length of the path to the surface of the earth becomes longer, the amount of energy absorbed increases, and the fraction of the solar constant actually striking the earth's surface decreases. The various decreases in energy along the path to a point on the surface of the earth where it may be desired to utilize the energy from the sun are represented in Figure 1 and presented in Table 1. In the figure, the energy striking the boundary of the atmosphere, points (a) and (c), is 130 watts per square foot. When the ray strikes the atmosphere at perpendicular, the energy striking the surface of the earth point (b)) is 92 watts per square foot, or 71 percent of the solar constant. However, at 40 degrees north latitude, which is a line about halfway between the north and south boundaries of the United States, the energy is only about 63 watts per square foot (point (d)), or about 48 percent of the solar constant, due to the longer path through the atmosphere.

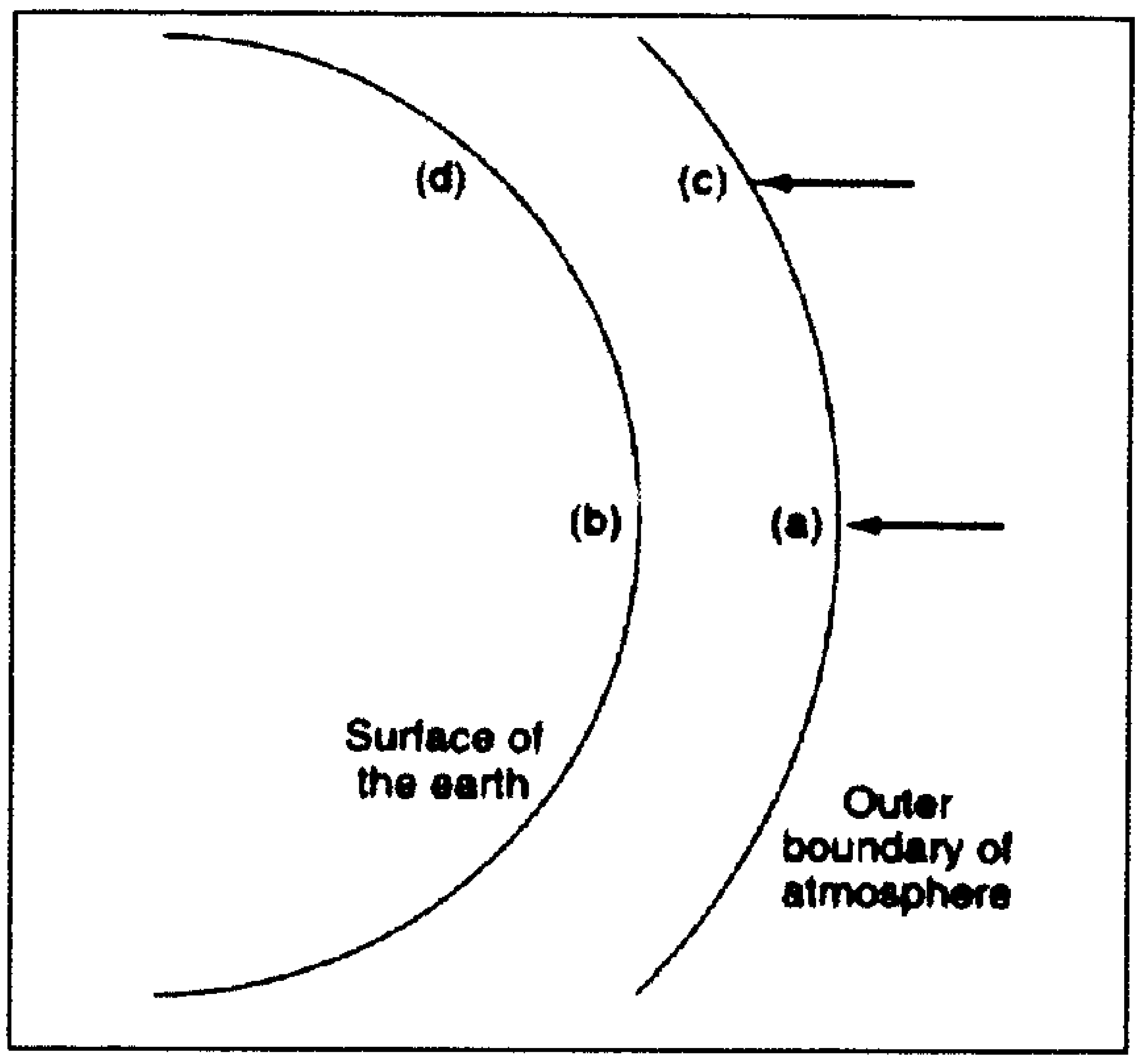

Figure 1: Representation of rays from the sun striking the earth's atmosphere at perpendicular and at a point away from perpendicular (not to scale).

Table 1: Availability of Energy at Point of Use.

Point of impact	Watts/square foot	Percent of original
Upper boundary of atmosphere	130	100
Earth's surface, perpendicular	92	71
Earth's surface, 400 latitude	63	48
Avenge, 8:00 a.m. to 4:00 p.m.	53	41
Average, 24-hour period	18	14

The numbers in the above paragraph are averages for noonday. In the winter season, when solar heating would be most needed, there is sufficient energy in the sun's rays only between 8:00 a.m. and 4:00 p.m. to be of practical value. The average over that period is about 85 percent of the noonday amount, or 53 watts per square foot, representing about 41 percent of the solar constant. However, heat is required over the 24-hour period. The energy received during that 8-hour period from 8:00 a.m. to 4:00 p.m. must serve the needs for the 24-hour period. Hence, the energy received, measured per unit time over the full 24-hour period, is only one-third of the *53* watts per square foot, or about 18 watts per square foot, which represents only 14 percent of the solar constant amount, or the energy striking the outer boundary of the earth's atmosphere per unit time over 24 hours. This amount will be further reduced by clouds, dust, and pollutants in the atmosphere.

1.2 Space heating

The greatest interest in the use of solar energy, with the present status of technologies, is for heating in the winter season. Within that framework of interest, it is mainly in the cooler portions of the United States where the technologies may find significant application. Further to that application, in order for a solar heating system to be acceptably effective, enough heat must be collected and stored during the hours of sufficient sunshine (meaning about 8:00 a.m. to 4:00 p.m. for winter season application) to provide the necessary heat through the 24-hour period. There are two broad concepts for use of solar energy for heating a small building such as a home.

1.3 Passive System

By definition, the passive system is completely self-contained as regards energy input, with all of the energy being supplied from the sun. The concept, by definition, therefore excludes the use of fans, pumps, or any other device that would require supply of electricity from some other source. Heat transfer utilizes only natural means of conduction, convection, and radiation. As much as the energy flux that actually impinges upon the collecting area, calculated over the 24-hour period, is only about 14 percent of that reaching the outer boundary of the earth's atmosphere (Table 1), a large collecting area must be provided in relation to the volume of space within the building which is to be heated. The most practical house structure to meet that demand is a non-symmetrical house, with one outer wall of the house being the tallest portion of the house, consisting of a system of windows extending from near ground level to the roof, with the windows occupying the entire wall of the building. The tallest portion of the building is this window-wall, with the roof sloping back from the window side of the structure. Inasmuch as the heat must be transferred from the collecting area to the remainder of the building without the aid of fans or pumps, and warmed air naturally moves upward but not downward, the heat-collecting area cannot be located in the roof. Special care must be exercised relative to a number of factors that impact the amount of direct sunshine entering the building.

These include the following:

- Location of the building on a south-facing slope, if such an option exists.
- Orientation of the building on the lot to maximize exposure of the windows to direct rays from the sun
- Location of windows to face the sun for maximum reception of sunlight in winter, including angle of incidence
- Proper attention to shadow lines, for example roof overhang, trees, other buildings, etc.

Heat is received during only about eight hours, but it must be sufficient to heat the building for 24 hours. For this reason, the window-wall must usually be larger than one side of a symmetrical building. A large area must be provided within the building such that the sunlight will strike it. One option utilized with success is to have a large, open floor area immediately inside the window with the capacity to store a large amount of heat. A second option is to place a vertical wall in the room a few feet from the window, with space provided between wall and window, as well as beneath the wall, such that air can circulate by natural processes to receive heat from the wall and deliver it, also by natural processes, to other areas of the building.

In a passive system this wall and/or floor area becomes the total heat storage area. Care is exercised in relation to several factors for energy storage and recovery. These include:

- Capacity for storing large amount of beat per unit volume. This property manifests itself in the volumetric heat capacity of the material, expressed, for example, as Btu per cubic foot per degree Fahrenheit temperature increase.

- High thermal conductivity. This allows for rapid transfer of the heat to the interior of the storage material, then allows sufficiently rapid transfer of the heat to the surface for recovery as needed, expressed, for example, as Btu per hour per square foot of cross-sectional area of entry into the material, per degree Fahrenheit temperature gradient, and this per inch of penetration into the storage material.

A few materials possessing an acceptably large volumetric heat capacity, and at the same time being available at reasonable cost, are presented in Table 1.2. Of these materials, iron exhibits the highest value of volumetric heat capacity. However, all of them possess volumetric heat capacities large enough to be attractive.

Table 1.2 Examples of Heat Storage Materials

	Volumetric heat capacity, (Btu/ft3)/°F	**Thermal conductivity material, Btu/ (in./hr)/ft2/°F**
Iron	54	320
Concrete	22	12
Brick	25	4.6
Stone	34	3.0
Wood (oak)	29	1.4

Similar relative values in relation to thermal conductivity do not exist among these candidates. For example, iron exhibits a thermal conductivity, in units expressed above, of 320, whereas wood (oak) exhibits a value of 1.4. As a consequence, a wall or floor made of iron would transfer heat to the interior of the mass very rapidly, whereas the rate of heat transfer into wood would be extremely slow. Of greater significance is the rate of heat transfer from the interior of a wood floor or wall, which is too slow when attempting to recover the heat in the nighttimes.

A person may have experienced this great difference by stepping on a cold wooden floor with bare feet, in contrast to the sensation created by stepping with bare feet on a cold iron plate, or even a cold stone or brick floor. Because of the very high heat transfer in the iron, when stepping on the iron with a bare foot, heat is carried from the foot at a very high rate, making it seem very cold. By contrast, when stepping on the wood floor with a bare foot, heat is carried from the foot at a low rate, due to the very low heat transfer rate in the wood, making the iron seem much colder, even though they may both be at the same temperature.

Transfer of heat without the use of fans, pumps, or other devices, must rely upon conduction, convection or radiation. Conduction is the transfer of energy from atom, or molecule, to neighbouring atoms or molecules with which they are in physical contact. It is the only means of energy transfer in solids, but to a much lesser degree in liquids and gases. Conduction cannot occur in a vacuum, where there are no molecules for such neighbour-to-neighbour transfer. Convection is a term applied to movement of a fluid on the basis of difference in density the difference in density created by a difference in temperature. In a room as described above, where heat from the sun has been stored during the day when the sun was shining on the wall or floor, in the night time, as cool air comes into contact with the warm floor or wall, it will become warmed, decreasing its density in relation to surrounding air which is cooler and therefore more dense. As the warmed air rises, it is replaced by cooler air, which then becomes warmed and less dense. This natural convection establishes a slow but detectable movement of the air. With proper arrangement of walls and entrances within the house, the air can flow by this means to other rooms, to provide some measure of heating to them.

Application of the principle of convection for cooling of a bedroom at night was widely used in homes where windows were made to slide up and down. In the evening the window would be opened partway down from the top and partway up from the bottom. As the outside air cooled, it would flow into the room through the bottom opening of the window. Being cooler, and therefore more dense, than the air in the room, the incoming air would flow toward the floor. The warmer, less dense air in the room would rise, being replaced by the incoming cool air, and would be forced from the room through the upper opening of the window. The principles of convection may not have been understood by family members in the home, but the action needed to bring about the desired result was well known. Radiation is a term applied to transfer of energy by means of electromagnetic waves. Inasmuch as movements of molecules are not involved, transfer of heat by radiation can occur even in a vacuum. This is the means of transfer of energy from the sun to the earth. For heat transfer by radiation to become significant, temperature differences between the two bodies must be much greater than required for conduction or convection. Therefore, in solar heating in a building, where temperature differences may be small, radiation is usually not a significant factor. Although a measure of satisfaction has been realized utilizing a passive system in a few areas such as Arizona or New Mexico, in general it has not been satisfactory in colder regions of the country. This is due in part to physical limitations on storage of heat. However, it is much more due to limitations in distribution of heat to areas of the house where needed.

In theory, at least, it is possible to provide for additional storage of heat in some other location in the house. If such an area is to be utilized, there must be provision for transfer of heat, by convection or conduction, to the storage area, then from the storage area in the night time. The principles are the same as described above, but the system becomes much more complex. It is difficult to achieve satisfactory service through operation of a passive system, except in the mildest of climates. The need for a fan or other means of movement of a fluid to carry the heat becomes essential for satisfactory service.

1.4 Active System

The greatest disadvantage with the passive system is the limitation on the capacity for delivering heat to areas in the building where needed. In the active system, a blower or pump is utilized to deliver the heat-carrying fluid, gas or liquid, to the storage area, then from the storage area to the area to be heated. The energy-collecting area is usually in the roof, eliminating the need for such a high degree of non-symmetrical as described for a passive system. The principal time of use is the winter months, when the sun is lower in the sky, resulting in a steeper pitch to that roof section to provide an optimum angle of incidence to the sun's rays. This often, although not always, results in the two longest roof sides of the building being unsymmetrical. However, architectural patterns in construction of homes and other buildings in today's market often employ unsymmetrical designs for reasons of economy in construction. So an unsymmetrical roof does not appear to be out of style.

In a typical design, the section of roof acting as the solar collector contains a bank of tubes extending the horizontal length of the roof, running back and forth through use of hairpin turns at each end of the roof. A fluid, most commonly water with an antifreeze liquid such as ethylene glycol added, is circulated through the bank of tubes to be heated by the sun. The collector tubes are specially coated, usually black, for maximum absorption of heat. The tubes are then housed under one or two layers of glass, specially tinted or coated to allow for entrance of most of the wide spectrum of wavelengths of energy from the sun, but trapping the wavelengths that are specific to the emitting surfaces of the tubes. The principles of operation are the same as utilized in a greenhouse. By this means the fluid circulating through the tubes may achieve high temperatures.

When the collector fluid leaves the bank of tubes in the roof, it is hot and is pumped to a storage area, usually located in the basement of the structure. As the fluid passes through the storage material, in intimate contact with it, heat is transferred to it. At night, the circulating fluid is cool, and heat is transferred from the storage material to the fluid. A system of valves enables one to direct the fluid such that the pathway in the daytime constitutes a circuit involving roof and storage area, whereas at night the circuit includes the storage area and areas of the building to be heated, but excludes the roof. Materials for the storage area are the same as discussed in connection with the passive system, requiring the same properties, and for the same reasons.

Solar heating systems are capital intensive. Most of the expense is an upfront expense, generally much greater than the installation cost of a forced air system. However, operation and maintenance costs are very low by comparison. Therefore, if it were possible to operate in an acceptable comfort range with only the solar system, the capital investment cost would be recovered within a period of five to ten years, as a result of the lower operating and maintenance costs, and thereafter a substantial savings would be realized.

1.5 Goal and objectives of current study

The goal of this project is to design and fabricate the solar attire dryer for high-rise building. Thus, it is included the complete design detail of the dryer and the procedure of how the construction been done. After success building the solar dryer, the prototype was testing in the several conditions to find out the factor that affect the performance of the solar dryer. Based on the data collect, further component is installing to improve the efficiency of the solar dryer.

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CHAPTER 2

LITERATURE REVIEW

2.1 Literature review

A comprehensive review of the various designs, detail of construction and operational principles of the wide variety of practically-realised design of solar energy drying systems reported previously is presented. Solar energy dryer have been classify into two generic groups, passive or natural-circulation solar energy dryer and active or forced convection solar energy dryer. Three subgroups of these can also be identified, integral type (direct mode), distribution type (indirect mode) and the mixed mode type.

Keyword: Solar energy systems; systematic classification; high temperature dryer; low temperature dryer; open to sun drying; passive solar drying; natural circulation solar dryers; active solar dryer; forced convection solar dryers; hybrid solar dryer; integral type solar dryer; direct solar dryer; distribution type solar dryer; indirect solar dryer; mixed mode solar dryer; application by rural farmer.

2.2 Classification of solar energy drying systems

In board terms, they can be classified into two major groups namely [1]:

- active solar energy drying systems
- passive solar energy drying systems

Three distinct subclasses of either the active or passive solar drying systems can be identified which vary mainly in the design arrangement of system components and the mode of utilisation of solar heat, namely [1]:

- integral type solar dryers
- distribution type solar dryer and
- mixed mode solar dryer

The main features of typical design of the various classes of solar energy dryer are illustrated in figure 2.1.

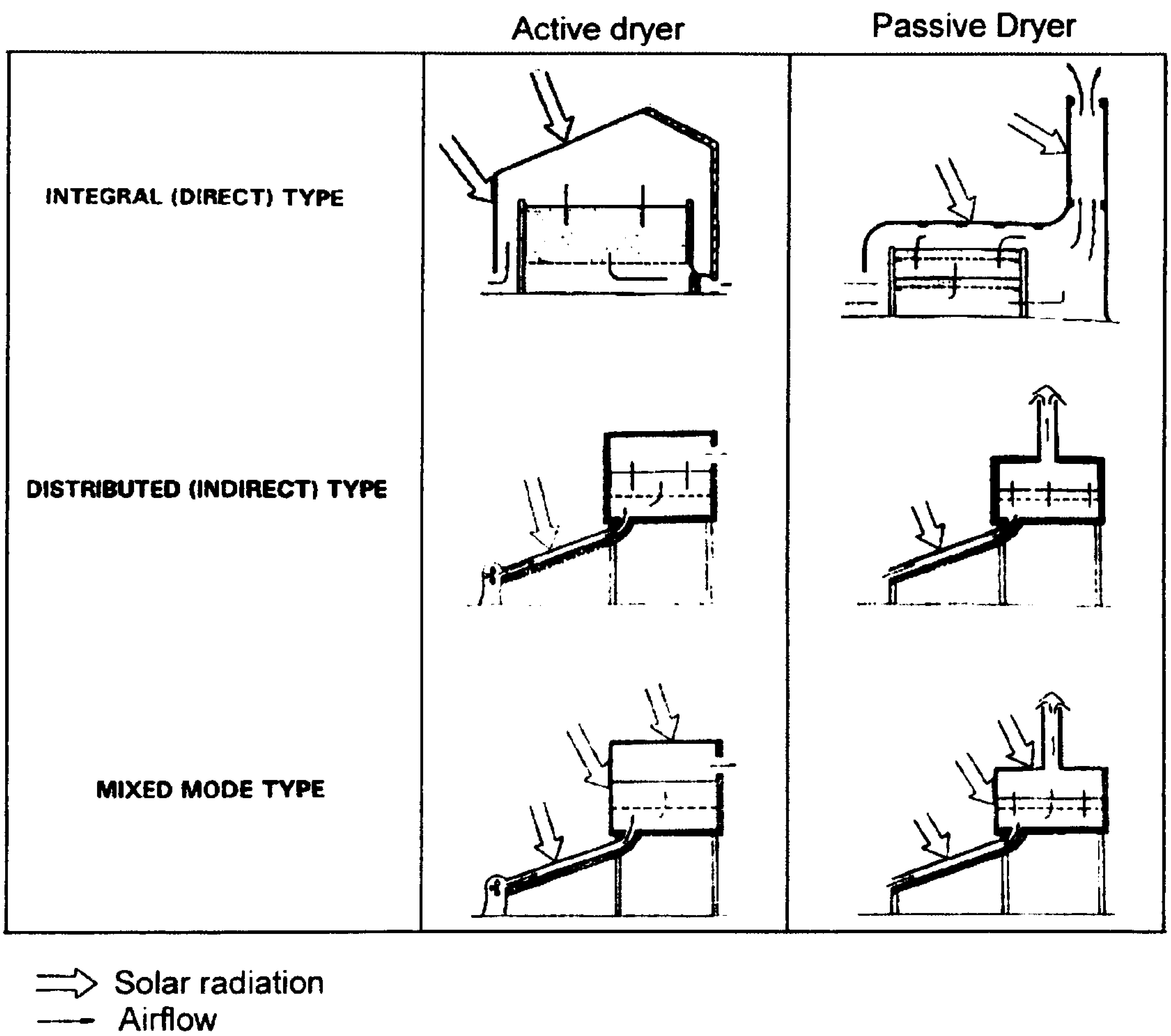

Figure 2.1: Typical solar energy dryer design.

2.2.1 Integral type natural circulation solar energy dryers

In integral type natural circulation solar energy dryer (direct solar dryer), the crop is placed in a placed in a drying chamber with transparent wall that allow the isolation necessary for the drying process to be transmitted. Thus, solar radiation impinges directly on the product. The heat extracts the moisture from the crop and concomitantly lowers the relative humidity of the resident air, thereby increasing its carrying capability. In addition, it expands the air in the chamber, generating its circulation and the subsequent removal of moisture along with the warm air. The features of a typical integral passive solar dryer are illustrated in figure 2.2.

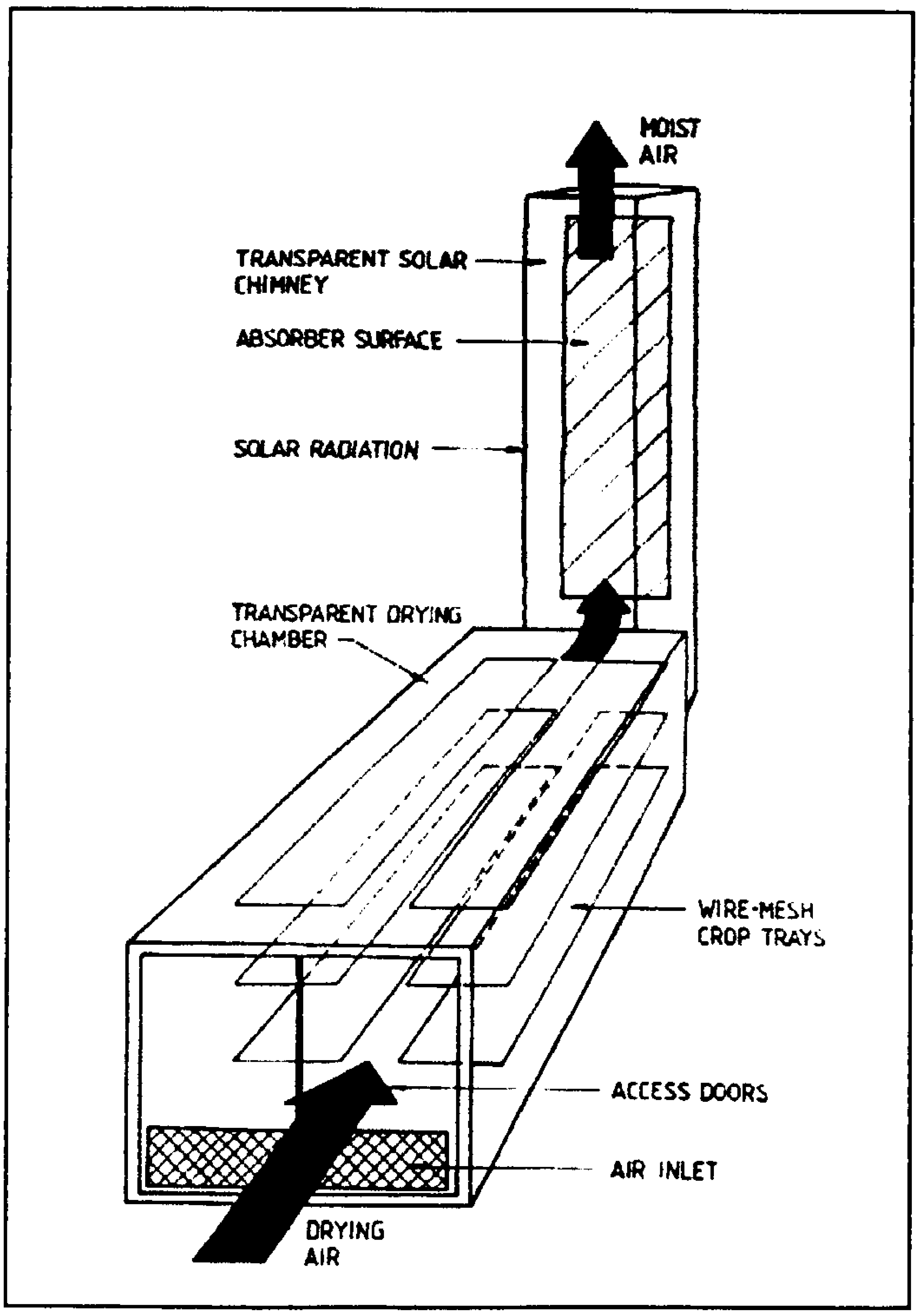

Figure 2.2: Features of typical type natural circulation solar energy dryer.

Integral type natural circulation solar energy is both simpler and cheaper to construct than those of distribution type for the same loading capacity [4, 5]. They require no elaborate structures, such as separate air heating collector and ducting. However, the potential drawback of the former are the liability to over heat locally and relatively slow overall drying rates achieved due to poor vapour removal [4,33]. To overcome these limitations, a solar chimney can be employed, which increases the buoyancy force imposed on the air stream, to provide a greater air flow velocity and, thus a more rapid rate of moisture removal.

The design reported by Gustafsson, tested in Nicaragua (figure 2.3) [11] had a mesh work floor to allow for air inlet and a chimney at the north end of the cabinet. The chimney was constructed from three vertical wooden poles with an asbestos sheet mounted on the back side and black PVC foil absorber at the south facing front side. Test results indicated that a better drying efficiency was obtained compared with the traditional passive cabinet dryer without chimney and four times better drying rate than open sun drying.

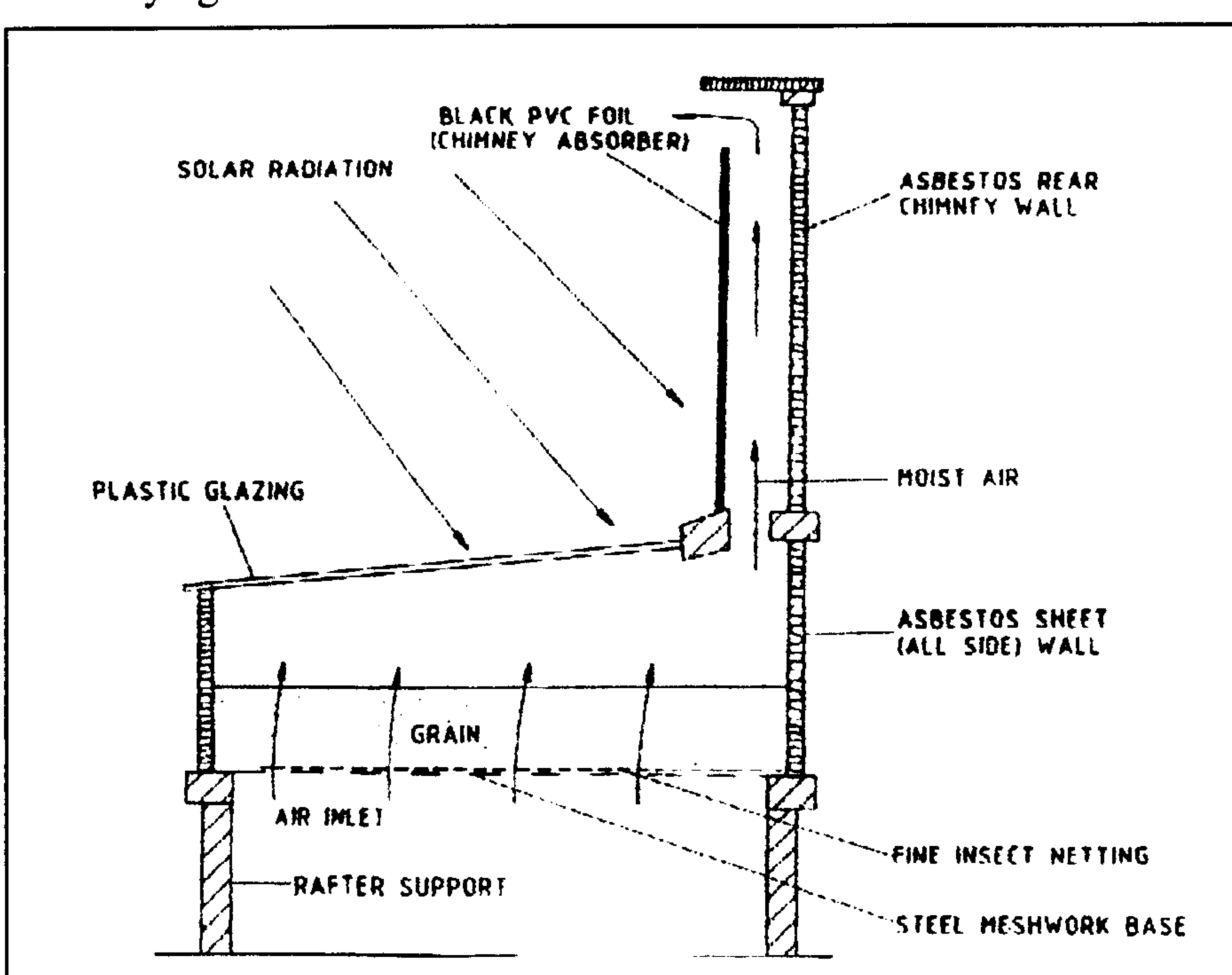

Figure 2.3 Natural circulation solar energy cabinet dryer with chimney