# SOLAR ENERGY

**Can Palm Mills Utilise It?**

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**Introduction**

1. Solar energy is a very large inexhaustible source of energy, which is clean, environment friendly and above all free for all unlike fossil fuels. The energy content of solar energy is estimated to be 18 x $10^{10}$MW! In the hottest regions the solar radiation flux is about 1kW/$m^2$ and in a day is seven units (kWh)/$m^2$, which being low necessitates the use of large collector plates. As the intensity of radiation fluctuates widely during 24 hours a method of storing thermal energy, while radiation is available (to be released during non radiation periods) becomes a necessity, which in turn would increase the cost of equipments to tap solar energy.

There are two direct methods of solar energy utilization.

1. Thermal
2. Photovoltaic

In this paper we shall look into the thermal method of solar energy utilization. The principle involved in thermal method is to expose a dark surface to absorb the radiation, which then transfer the heat to air or water circulating to utility points.

The most popular type of solar collector is the "flat-plate collector", working within a temperature range of 40°C to 100°C. It's construction is simple and requires little maintenance, having no moving parts.

**2. Description**

*2.1 Liquid Flat Plate Collector (Figure 1)*

It consists of a flat absorber plate made from a metal sheet having thickness ranging from 0.2 mm to 1 mm. Attached to the bottom of the plate are a number of copper tubes 10 mm to 15 mm in diameter placed 5 cm to 12 cm apart, brazed or soldered to the plate. These tubes could be made integral with the plate. They are also made from special polymers, which could withstand degradation from prolonged exposure to radiation. They are also cheap and light in weight. The absorber plate is placed in a casing and two transparent covers about 4 to 5 mm thick, made up of toughened glass are mounted on top separated by space ranging from 1.5 cm to 3 cm.

The solar radiation which falls on the absorber plate after passing through the transparent covers impart part of it to the water circulating through the tubes attached to it. The top glass covers help to reduce heat loss by convection and re-radiation. The sides and bottom of the plate assembly is well insulated using mineral wool, rock wool or glass wool encased in aluminium cladding. The insulation thickness varies from 25 to 80 mm. The whole assembly is mounted in a tray with provision for tilting at any desired angle. The surface area of collectors is usually 2$m^2$.

*2.2 Solar Air Heater (Figure 2)*

The construction of this is quite similar to the liquid flat-plate collector except that the pipes are replaced by air passages, which is made generous in size, to reduce pressure drop. In order to improve heat transfer the air passages are sometimes provided with longitudinal fins, or by the use of corrugated absorber plate in order to increase the surface area. Efficiency is about 58%. The absorber plate is usually made of galvanized steel about 1 mm thick and the covers are made up of glass about 4 to 5 mm thick. Bottom and side insulations are either mineral wool or glass wool having a thickness not less than 50 mm. If large quantities of hot air is required, forced circulation would be necessary. Investigators have come up with a number of variations of the basic system designed to improve heat transfer efficiency by reducing losses. They are:-

a) Two pass solar air heater
b) Overlapped glass plate air heater
c) Matrix air heater
d) Honeycomb porous-bed air heater
e) All-plastic air heater
f) Jet plate air heater

The two-pass air heater is identical to the conventional solar air heater except that the space between the absorber plate and the first glass cover serve as air passage to be channeled to the air passage below the plate. This way some of the heat loss by radiation is captured back increasing heat transfer efficiency.

The heaters b, c, d and e use porous absorbers. The circulating air pass through them and during the process gets heated. They have large flow areas and small pressure drops and are more efficient in heat transfer than the simple solar air heaters.

2.2.1 *Overlapped Glass Plate Air Heater (Figure 3)*

This type was first used in Colorado for residential heating. It consists of a number of overlapping parallel glass plates with the bottom plates blackened. The air inlet is formed by a cell consisting of a number of short parallel plates which serve to maintain uniform air velocity. The whole unit is insulated at the sides and bottom.

2.2.2 *Matrix Air Heater (Figure 4)*

In this the air is forced to flow through a porous matrix and during the passage heat is transferred. The matrix is made up of wire screen meshes, metallic foils, copper screens or aluminium foils having a depth of 40 mm. Heat transfer efficiency of 75% is possible at very low pressure drop.

2.2.3 *Honey-comb Porous-bed Heater*

This is similar to matrix air heater except that a honey comb porous bed is added to the matrix on the top, which aids in reducing re-radiation losses. Efficiencies may go up to 80% in well-designed heaters.

2.2.4 *All-plastic Air Heater (Figure 5)*

Designed and developed in Germany in 1982 by Bansal *et al.*, this type of heaters can handle large mass flow of air in the region of 700 m3/hour using 10 m3 surface area. The absorber is made up of polyester which is black, porous and flexible. Transparent PVC sheets form the cover on both sides. 60 mm thick polyethylene serve as insulation material at the back.

2.2.5 *Jet-plate Solar Heater (Figure 6)*

This is quite similar to the basic solar air heater except that a perforated plate (Jet Plate) is inserted between the absorber plate and bottom plate, with an interspace in the region of 50 mm. Air drawn in at the bottom passage (*i.e.* between jet plate and bottom plate) which is closed at other end, mixes with air drawn in at the top passage allowing additional heat transfer by convection thereby increasing heat transfer efficiency by some 25%.

## 3. Heat Storage Systems

For industrial heating system, heating is a continuous process and heat collected during solar radiation should be stored up to utilize them during night time or when solar radiation is not available.

There are three types of such storage systems:

a) Sensible heat storage
b) Latent heat storage
c) Thermochemical storage

If the temperature encountered is below 100°C, sensible heat storage system is the choice using water as the medium for heater transfer. For higher temperature refractory bricks may be used for absorbing heat.

*3.1 Sensible Heat Storage.*

a) Water

Water is obviously the ideal choice requiring a capacity of about 80 litres of water per square meter of collector plate area. The water tank should be well insulated (about 150 mm) to prevent convection losses, which is likely to add considerably to the cost, unless palm fibre is used as an insulating material!. Boiler feed make-up tank appears to be an attractive medium for heat storage in palm oil mills.

For a 4m x 3m x 3m water tank, which contains 36,000 litres, we need 450 $m^2$ of absorber plate area. Considering that the domestic heaters came with 2$m^2$ plate area, we need 225 such heaters to heat up 36,000 litres to 100°C from ambient temperature.

b) Solids

If water is not the preferred choice, rocks or pebbles may be used as a storage medium, and there is no shortage of such materials in palm oil mill, as they accompany the FFB and may be collected at de-stoner outlet and graded to obtain sizes ranging from 10 mm to 50 mm. Quantity required is about 1/2 tonne/$m^2$ of absorber plate area, a significant increase in volume, as compared to water. Other materials used are earth, magnesia, alumina and silicon oxide.

3.2 *Latent Heat Storage*

The principle involved is to give up or absorb latent heat during change of phase *e.g.* steam condensation or vapourising. Phase changing materials can be organic materials like paraffin waxes, hydrated salts like calcium chloride hexahydrate or inorganic substances like sodium nitrate. They all should have properties like good thermal conductivity, non corrosive and low vapour pressure.

3.3 *Thermochemical Storage*

The solar energy input in certain materials causes an endothermic reaction called foreword reaction and during discharge reversal take place due to exothermic reaction.

An example of thermochemical storage is the endothermal reaction of sulphur trioxide when it is reduced to sulphur dioxide and oxygen during forward reaction. They combine back in the presence of a catalyst releasing heat during the exothermal reverse reaction.

3.4 *Solar Ponds*

These are artificially contructed ponds with salt dissolved in the water to prevent convection losses and heat storage is in the lower region. Salt concentration gradient causes the lower region to be denser than top region, despite the fact that it is hotter. Thus convection losses are effectively arrested in these ponds, the heat being tapped off for utilization by pumping out hot water from lower regions and transfer of heat in a heat exchanger. There are many such ponds around the world, the largest being in Israel with a surface area of 250 00 $m^2$ and generating 5 MW electric power. The others are a 2000 $m^2$ pond in Miamisburg in Ohio for swimming pool heating and another 2 500 $m^2$ pond in El Paso, Texas to provide hot water for a factory.

## 4. Application in Palm Oil Mills

In Malaysia we have abundant supply of solar radiation and being free, the mills could consider using

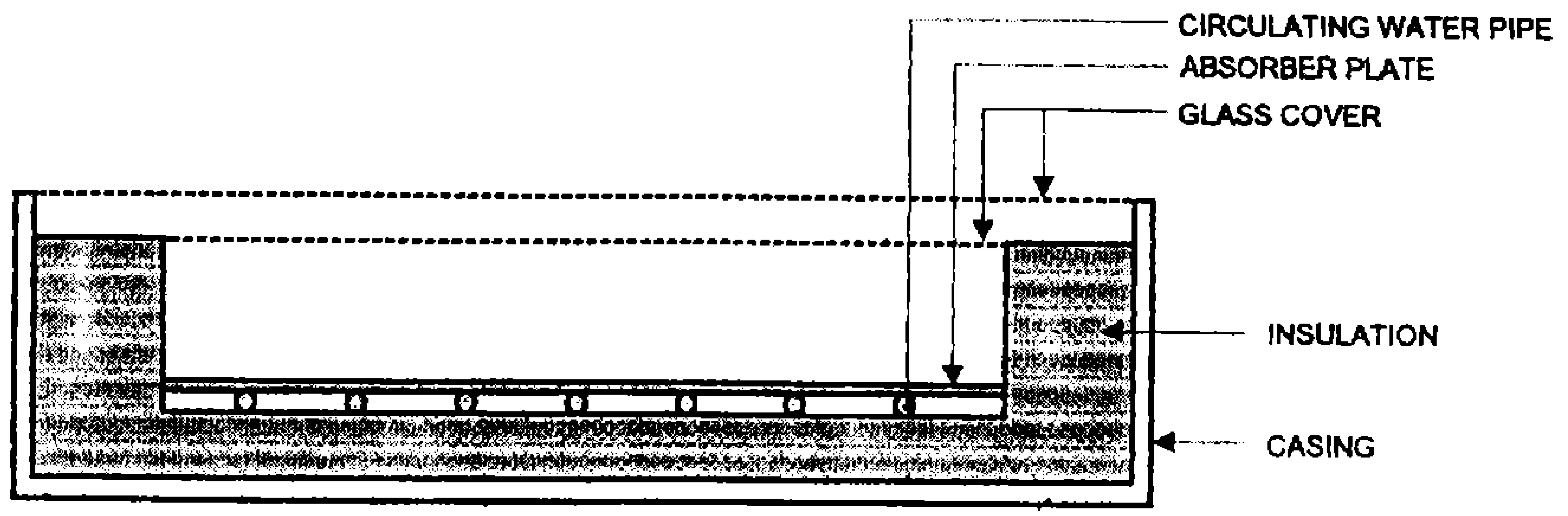


*Figure 1. Liquid Flat-Plate Collector*

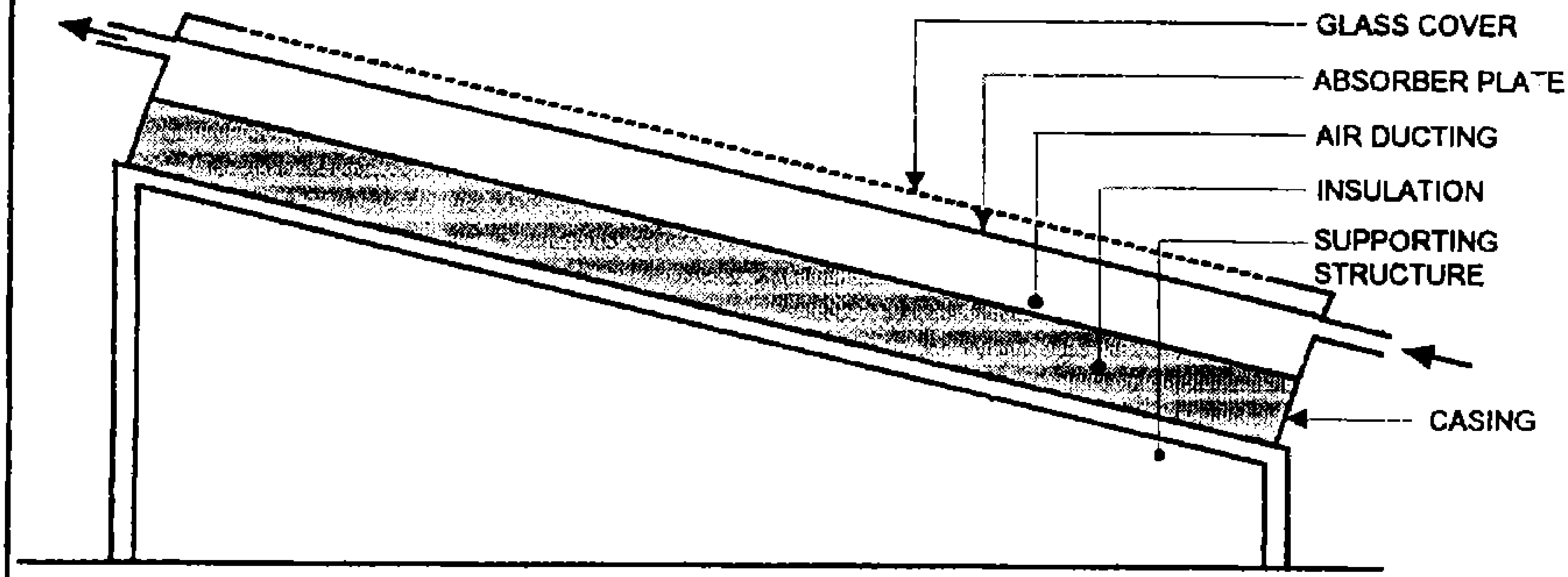


*Figure 2. Solar Air Heater*

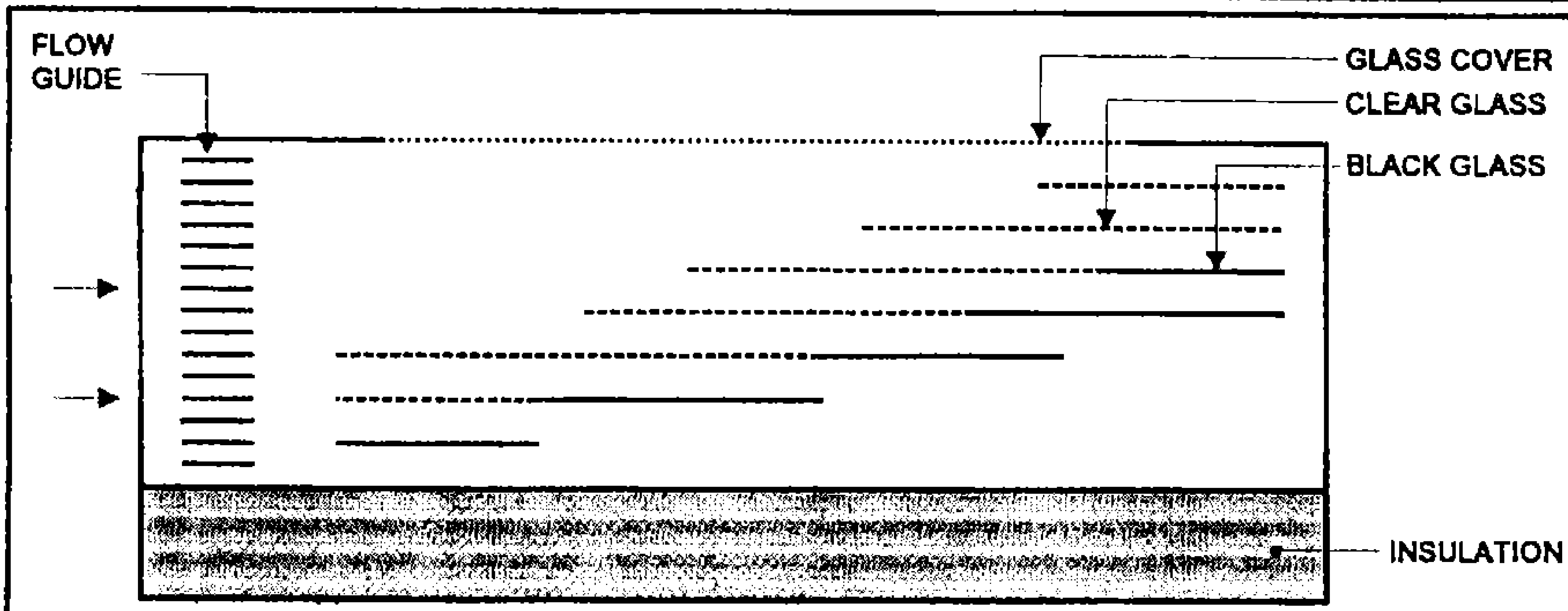


*Figure 3. Overlapped Glass Plate Air Heater*

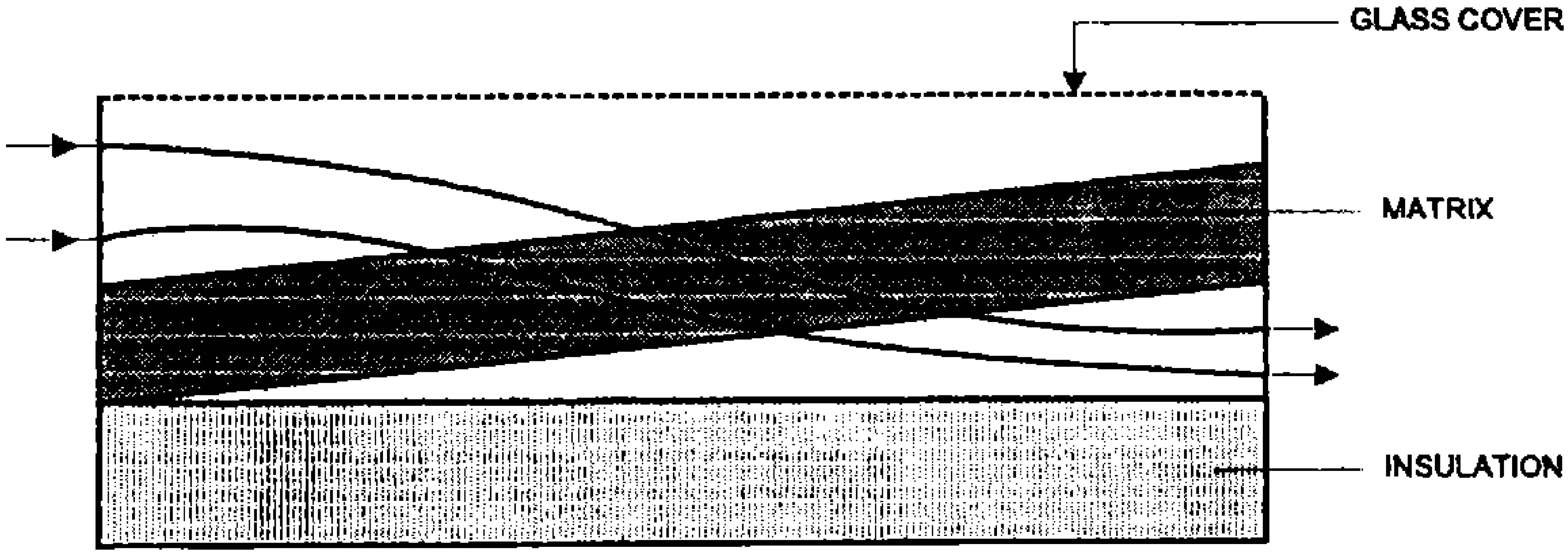


*Figure 4. Matrix Air Heater*

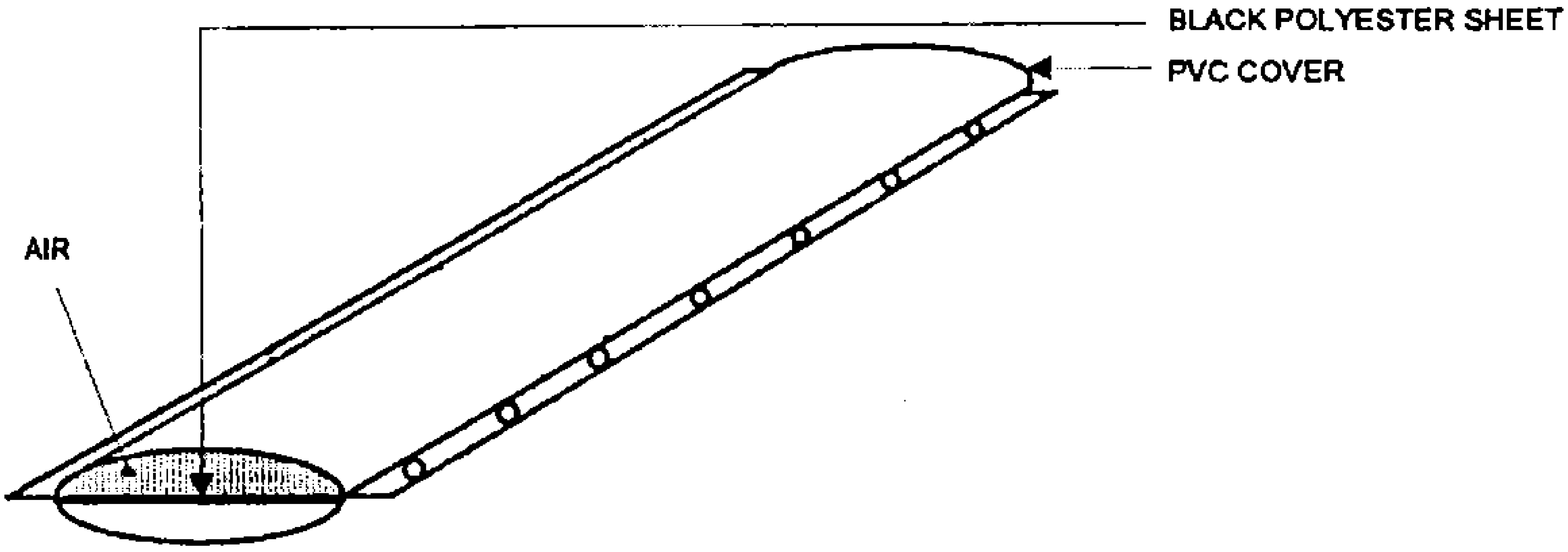


*Figure 5. All-plastic Air Heater*

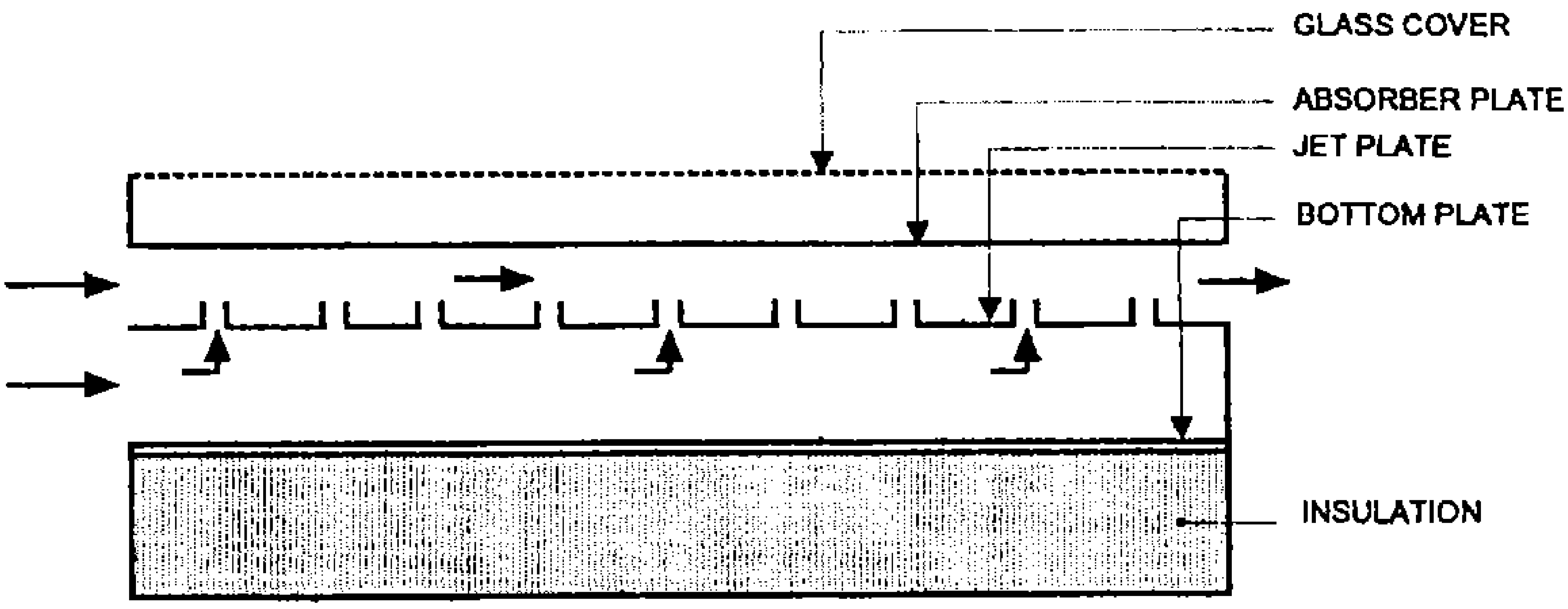


*Figure 6. Jet Plate SolarAir Heater*

this energy for a number of applications, especially if the mills are operating on the boarder line with respect to steam availability and demand. If kernel heating could be accomplished by using solar air heaters, the surplus steam could be used for better sterilization or process water heating both of which play vital role in the oil extraction process. If this could contribute towards an increase of 0.5% the extraction ratio. The cost of installing solar heaters could be justified. Another advantage is minimum maintenance cost. It this is not attractive enough, perhaps a basin type solar-still plant could be considered for producing distilled water from effluent. If any mill manager/engineer is interested he may contact the author for discussion on how best solar energy could be utilised in a Palm Oil Mill.