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This article has been written with the aim of providing information about the salient features of various types of solar water heaters developed at the Central Building Research Institute, Roorkee, which has been one of the first Institutions in India in developing commercially feasible solar water heating systems. Four types of solar water heaters have been developed to suit varied requirements, namely, domestic type, large size, low cost and pipe type (also low cost) units. These have been tested under field conditions and are found to give desired performance. The problem of integration of these units in buildings has also been discussed in brief.

Solar Water Heaters for Low Temperature Applications

In buildings solar energy can be readily employed for the supply of hot water as also for heating small spaces during winter season. In India, a tropical country, solar energy is available in abundance and can be made use of as an alternative source of energy. Heating of water by solar energy has now been accepted as a practical and economical means of hot water supply particularly for domestic needs in many countries throughout the world. At Central Building Research Institute, Roorkee, investigations on solar water heating systems were initiated many years back. During past several years persistent efforts were made to design and develop various types of solar water heaters [1,2,3,4] to cope with the demand of hot water for domestic and community uses. This has resulted into four commercially viable units of different specifications.

Design Features

Two varieties of solar water heating system have been developed depending upon whether overnight storage of hot water is desired or not. Two units, namely, domestic type and large size were designed to provide hot water in the early morning hours and their essential components are, (a) solar collector, (b) storage tank and (c) circulation system. The other units *viz.* low cost solar water heater and pipe type solar water heater are solar collector cum-storage type providing hot water for use only during day time unless provision is made for a separate storage tank. Further details of these systems are given in subsequent sections.

Domestic Solar Water Heater

This type of solar water heater consists of two numbers of tube-in-plate type flat plate collectors of approximately 1 m² absorber area each and a properly insulated storage tank of 140 litres capacity. To form the collectors, a grid of G. I. pipes of 19 mm. dia. 1.2 m length, spaced 10 cm centre to centre and welded at both ends to two header pipes of 25 mm dia is tagged over an aluminium sheet of 28 SWG suitably bent to fit the contour of the pipes so that the sheet and the pipes are in good thermal contact. This is blackened on the front surface and enclosed in a suitably tagged box of mineral wool or fibre glass insulation. A glass sheet of thickness 3 mm is placed at a distance of about 5.0 cm above the aluminium sheet and suitably supported at its edges The collectors are then oriented due south at an inclination angle of latitude plus 15 degrees to trap maximum high temperature radiation from the sun. The heat losses due to re-radiation of long wave radiation and convection are reduced to minimum. The tank is placed at a height of about 30 cm above the upper edge of the collectors and connected to the absorbers as shown in Fig. 1. The natural circulation of water takes place due to thermosyphon action between the tank and the collectors. In the evening the water temperature in the tank is of the order of 55°C. After night losses the temperature of water in the morning is about 48-50°C. The system can be provided with an auxiliary electric heater of 1.5 kW which is thermostatically controlled.

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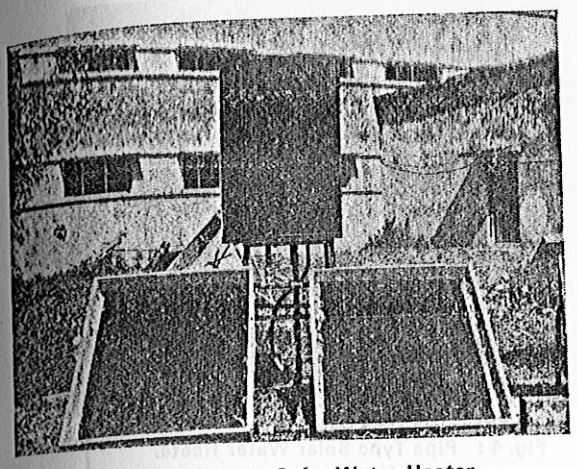

Fig. 1 : Domestic Solar Water Heater.

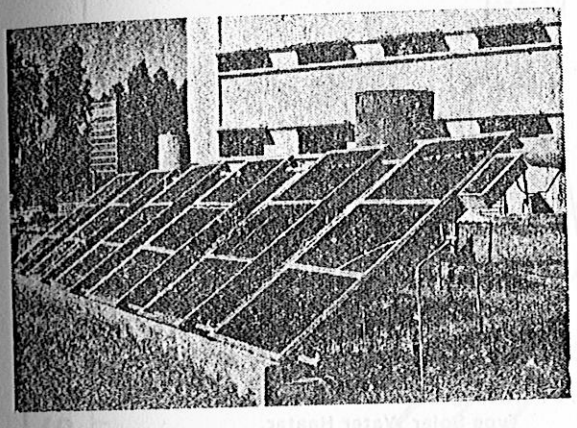

Fig. 2 : Large Size Solar Heater.

This system is sufficient for providing hot water to a family of 5 persons. Its present estimated cost is about Rs. 2000/-. Some units of this type have been working for many years without any trouble. Recently some improvements were made in this model thereby reducing the cost marginally and improving its efficiency.

Large Size Solar Water Heater

In hospitals, hostels and large kitchens the demand of water is usually high and hot water is needed intermittently. The domestic type heater described above can not cope with such demands. In view of this the large size solar water heater was designed and developed (Fig. 2). The system is fully automatic and is capable of heating 600 litres of water upto 55°C by about 16.00 hrs. in winter months. The morning temperature in the tank is about 45-50°C. The quantity of water is estimated to be sufficient for use by about 20 persons.

Total absorber area for heating 600 litres of water to the desired temperature comes out to be 8.4 m^2 at Roorkee or Delhi. Normally six absorbers of 1.4 m^2 area each are preferred. The storage tank which is usually cylindrical, should have a height twice its diameter to reduce the surface area and hence the heat losses. The tank is adequately lagged by providing 10 cm thick loose mineral wool or fibreglass and an outer tank. A 3 kW immersion heater can be fitted in the tank and connected in series with a safety thermostat. As the storage tank is of large capacity in this case, it is impractical to mount it above the absorbers. Therefore, a booster pump of 1/8 H.P. capacity is used to circulate the water through absorbers. The power consumption by the pump is very nominal (=0.25kW/day).

Recently this type of solar water heater was installed at R. K. Mission Hospital, Kankhal, Hardwar which is giving satisfactory performance. In this unit Roll Bond Aluminium panels available in the market have been used as flat plate absorbers in place of tube-in-plate type collectors described earlier. Roll bond panels are supposed to have better efficiency. During its two years of operation there has been no indication of any difficulty with these panels. Further, two storage tanks of 300 litres capacity each connected in parallel at the levels of cold water inlet and hot water outlet have been used in this installation instead of a single tank of 600 litres capacity. This facilitates easy handling of storage system and distributes the heavy load of the tank over a larger

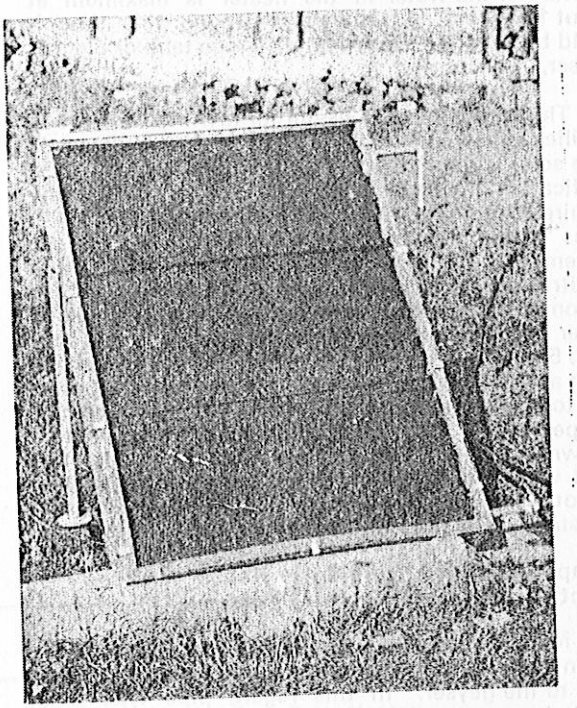

Fig. 3 : Low Cost Solar Geyser.

area of the terrace of the building on which it is installed.

Low Cost Solar Geyser

A low cost solar water (90 litres capacify) comprising a tank which performs the dual function of absorbing solar energy and storing the heated water was designed and a prototype tested under different operational conditions (Fig. 3). The mean temperature of water available at 16.00 hrs. is about 50°C. However, an improved version of low cost solar water heater described below is preferred over this unit.

Pipe Type Solar Water Heater

This is a built-in-storage type low cost solar water heater. It consists of eight pipes fabricated from 20 SWG G.I. sheets. Its total capacity is 100 litres. Each of the pipes is 1 m long with an inner diameter of 12.5 cm. Each end of the pipes are closed by circular discs from the G.I. sheet, with a central hole of diameter 12.50 mm for fixing the heater. All the eight pipes are placed close together horizontally with a spacing of 2.5 cm and welded to two G.I. pipe headers at both ends. The exposed surface of the pipes is coated with ICI black paint. This is enclosed in an insulated tough of Mild Steel (MS) asbestos cement sheet. The complete unit is shown in Fig. 4. Apart from its built-in-storage capacity for daytime use it could be coupled to a separate small storage tank in the bath room or kitchen or electric geyser for overnight and early morning use. The temperature of the water in the heater is maximum at about 15.00 hrs. (67-70°C) and around this time it could be stored in the separate storage tank or electric geyser, if necessary.

This unit can prove useful for low income group families which cannot afford high cost of domestic type solar water heater. This unit can also find its application in villages where hot water is normally required intermittently and around noon hours. In areas where no cold water supply line exists the system can be provided with a small tank (about 50 litres capacity) which can be placed on a stand or some other inexpensive structure near the solar water heater for supplying the cold water to it (Fig. 5). The hot water can be withdrawn starting from about 10.00 hrs. at the rate of 1 or 2 buckets (15 to 30 litres) hourly or two hourly. The average temperature of the water withdrawn at each hour is shown in Fig. 6. It is advisable to pour immediately cold water into the supply tank, equal to the amount of hot water withdrawn from the heater to ensure constant availability of cold water supply.

Coupling of Pipe Type Solar Heater with Electric Geyser

Many people already having electric geysers are often desirous of having solar water heater in addition to the geyser. In this regard pipe type solar water heater coupled with the geyser may prove to be an useful proposition. This combined system will conserve electricity and result in overall economy. We have carried out feasibility studies on this aspect. The connections of the solar heater to the geyser can be made as shown in Fig. 7. The hot water will have to be transferred to the geyser at about 15.00 hrs. for morning use. In the process of this transfer about 50 litres (3½ buckets) of hot water at a temperature of about 40°C will come out through the geyser outlet and can be utilised at this time. The hot water that remains in the geyser overnight, though cooled sufficiently, still provides a savings of about 50 percent in the electric power consumption. Further saving in the electric power consumption could be achieved by adding to the geyser insulation which is inadequate for night storage as also by incorporating certain minor changes in the geyser design. During daytime the hot water can be directly drawn from the solar water heater by providing an extra tap T. This may be particularly useful for daytime use and also when geyser is normally not operated such as during load shedding periods.

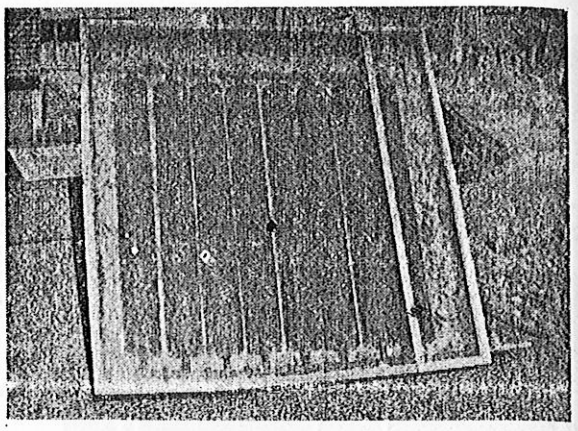

Fig. 4 : Pipe Type Solar Water Heate.

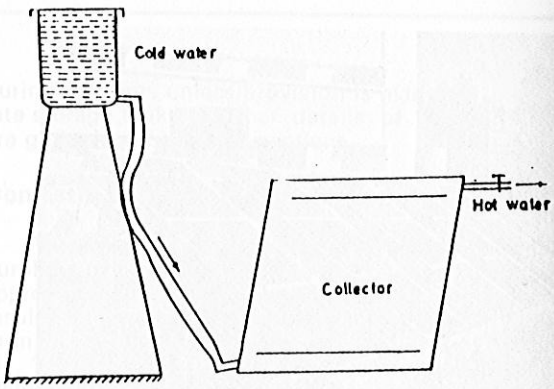

Fig. 5 : Arrangement for Cold Water Supply to Pipe Type Solar Water Heater.

13-2-80 x——x One bucket drawn hourly

18-2-80 o——o One bucket drawn after two hours

19-2-80 •——• Two buckets drawn hourly

20-2-80 Δ——Δ Two buckets drawn after two hours

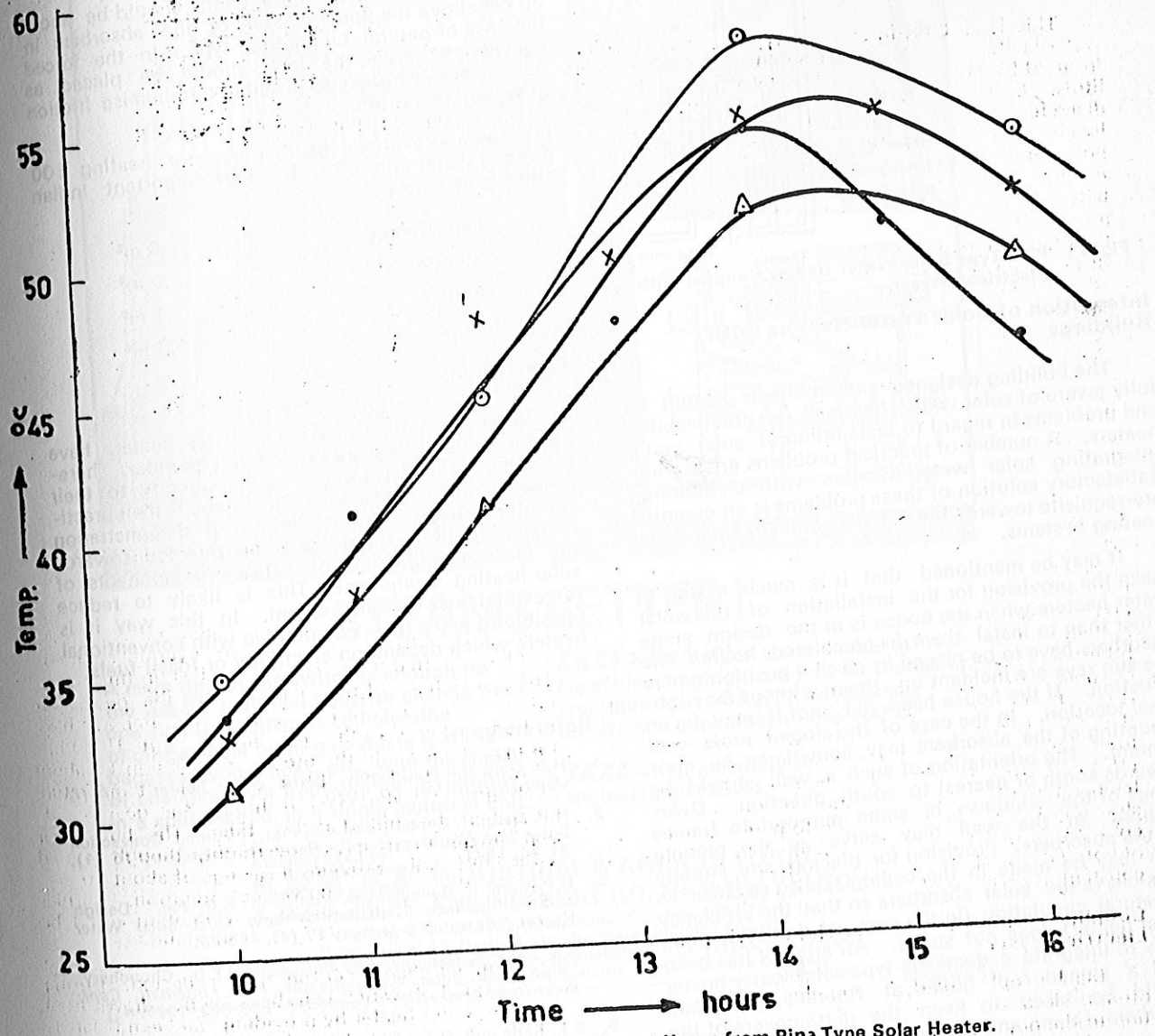

Fig. 6 : Temperature of Water Drawn at Different Hours from Pipe Type Solar Heater.

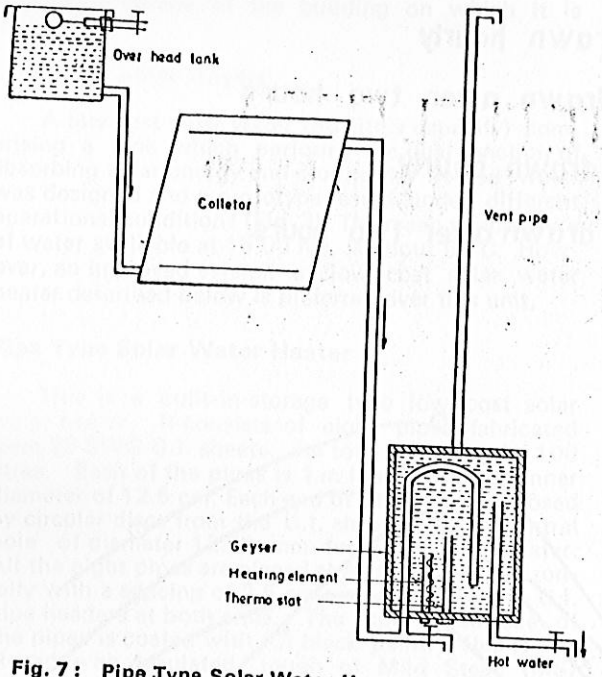

Fig. 7 : Pipe Type Solar Water Heater Coupled with Electrical Geyser.

Integration of Solar Water Heaters with Buildings

The building designers and architects should be fully aware of solar water heating, its practicability and problems in regard to installation of solar water heaters. A number of practical problems arise while integrating solar water heaters with a building. Satisfactory solution of these problems is an essential pre-requisite towards the popularisation of solar water heating systems.

It may be mentioned that it is much easier to make the provision for the installation of the solar water heaters when the house is in the design stage rather than to instal them in completed hours. The absorbers have to be placed in such a position where the sun rays are incident on them without any obstruction. If the house has a flat roof it may be an ideal location. In the case of the sloped roofs wall mounting of the absorbers may sometimes be convenient. The orientation of such a wall should be towards south or nearest to south direction. Overhangs of the windows or some appropriate frames grouted in the wall may serve as the mounts for the absorbers. Provision for placing the storage tank may be made in the ceiling space as close as possible to the solar absorbers so that the efficiency of natural circulation (in the case of domestic solar water heater) does not suffer. An attempt has been made to integrate a domestic type solar water heater with a sloped roof house at Roorkee [5]. Care should be taken to keep the glass covers of the absorbers clean and intact, insulation dry, pipe work well insulated and the black paint over the absorbers in a sound condition.

In addition to the above general remarks, the following technical points should always be taken into consideration while installing a solar water heater on a building.

i) The absorbers should face south and should be inclined at an angle equal to the latitude of the place plus 15 degrees from horizontal for winter use. For year round use the inclination is approximately equal to the latitude of the place.

ii) The bottom of the storage tank should be about 30 cm above the upper headers of the absorbers in the case of natural circulation type. In the forced convection system, the tank should be placed as near to the absorbers as possible to minimise friction in water circulation.

iii) The approximate absorber area for heating 100 litres of water upto 55°C for four important Indian cities is as below :

Delhi/Roorkee	1.6 m²
Calcutta	2.0 m²
Poona	1.1 m²
Madras	1.3 m²

Conclusion

Although a number of solar water heaters have been developed they are not yet very popular. Therefore, there is a need to give due publicity to their salient features and remove doubts about their practicability through the installation of demonstration units. Attention should also be directed towards the mass manufacture of various components of solar heating equipment. This is likely to reduce the capital cost to some extent. In this way it is possible to make them competitive with conventional heaters which depend on electricity or fossil fuels.

References

1. H.P. Garg and R. Ganguly, "Solar water heater", *I.E. (I) Journal-IDGE*, Vol. 50, 1970.

2. H.P. Garg, R. Ganguly and J.S. Puri, "Forced Convection Solar Hot Water system", *Research & Industry 16* (1), 31-34, 1971.

3. H.P. Garg, R. Ganguly, J.S. Puri, and R.S. Pal," Design and Performance Prediction of Low Cost Solar Water Heater, "*Research & Industry* 17 (4), 125-29.

4. S.K. Kaila, R. Ganguly, J.S. Puri and N.K.D. Choudhury, "Pipe Type Solar Water Heater, *Proc. I Internatl. Conf. Solar Build Tech., RIBA*, London, 2, 598-602, 1977.

5. S.K. Kaila and N.K. Garg, "Integration of Solar Water Heater with Buildings", *Proc. Natl. Solar Energy Convention*, CMCRI, Bhavnagar, 616-22, 1978.