

SUMMARY

COMPACT SOLAR WATER HEATER WITH CONCENTRATION OF SUNLIGHT

5           The present invention concerns appliances for the heating of liquids by thermal conversion of solar energy at low and medium temperatures and in particular solar water heaters.

10           The appliance which is the subject of this invention is made from a tank for liquids the outside casing 1 of which is a surface of revolution which is for example cylindrical and with a more or less horizontal axis, which is equipped on its outside with reflecting screens 6, for example parabolic, which latter  
15 concentrate the sun's radiation onto its sun-facing front, and which is equipped inside with a thermally insulating lining 2. This lining has, for example, a cylindrical shape, and comprises on its upper and lower parts, evenly spaced orifices 5 communicating with  
20 circulation channels 4 which are situated between the casing 1 and the internal lagging 2. This feature allows natural circulation by thermosiphon of the liquid between the main volume 3 and the front part of the casing 1 which latter is heated by solar radiation.

25           Figure for summary: fig.3

COMPACT SOLAR WATER HEATER WITH CONCENTRATION OF SUNLIGHT

The present invention concerns appliances for the heating of liquids by thermal conversion of solar energy at low and medium temperatures and in particular solar water heaters.

Most solar water heaters are made from two distinct elements:

- a solar collector
- 10 - a water tank

which are general purpose appliances here used for a specific purpose.

In one category of usual products these two elements are used spaced apart from one another and linked by a circuit of heat carrying liquid which is caused to circulate by thermosiphon or, as is more often the case, by a pump using an external source of energy and controlled by a regulating device.

In a second category of products usually considered as single unit devices the two appliances are adjacent to one another and linked, the tank usually being situated above the solar collector and liquid circulation being by the natural effect of thermosiphon.

In these two cases the water heater requires the manufacture of two different devices and assembly parts all put together for the single aim of producing hot water. This both complicates the equipment and causes a multiplication of heat losses from its constituent parts.

The appliance here described improves on this, allowing much simplified manufacture and higher thermal efficiency as it is comprised of only one appliance which

serves both for the collection of solar energy and the storage of the water it operates autonomously by thermosiphon, its front facing the sun's rays and linked to the water supply under pressure.

5       The invented appliance, described below and called an compact solar water heater with concentration of sunlight is composed of a tank which is, for example cylindrical or spherical. This is equipped with reflecting screens on the outside, the cross-sections of  
10       which are, for example, parabolic, the concave side concentrating the rays and determining the front or sun side. Inside the tank are devices which determine the natural circulation by thermosiphon from the main part of the tank to the front where it is heated by sunlight. The  
15       relative dimensions of the tank and the reflecting screens depend both on the daily hot water requirements and the usual available solar energy.

      Figure 1 gives the general outside appearance of the appliance. It is comprised of a cylindrical tank with a  
20       more or less horizontal axis Oz. Ideally, the Oy axis would point south and the angle of the plane of symmetry yOz with horizontal plane would be fixed so as to optimise collection on the front of the appliance and its reflecting screens: this angle would be equal to the  
25       sun's elevation at the equinoxes at solar noon if one adopts a single average annual position; about the elevation of the sun at solar noon, at summer solstice and winter solstice if one adopts two opposite positions, winter and summer; or angle changed daily, and  
30       automatically if possible.

Figure 2 gives the general outside appearance of the appliance made with a spherical tank. In this configuration an automatic sun-following device becomes necessary for satisfactory functioning. Such a device  
5 being outside the field of the present patent and not yet available at low cost, given the present state of the art, we shall therefore deal here with the configuration seen in figure 1.

The following description gives the main  
10 specifications and way of functioning of the appliance which is the subject of this patent and referring to plans in the appendix which are given only as examples:

- Fig.3: half cross-section at the plane  $xOy$  of the configuration shown in figure 1
- 15 - Fig.4: diagram showing the hydraulic linking in series of two (or more) of the patent appliances.

This invention is made up of the following integrated parts (fig.3):

- the main outside casing 1 serving as the tank walls  
20 is, for example, cylindrical with a horizontal axis, and made from, for example, sheet metal, with at either or both ends an opening part. The whole is able to support without deformation the reglementary test pressure of the liquid which it is destined to  
25 contain.
- an internal heat insulating lining 2 made, for example, from a moulded synthetic thermal insulation which is rigid, and easily compressible under transversal pressure, and if necessary lined on the  
30 surfaces in contact with the liquid in the main

liquid-containing volume 3, by an appropriate sanitary quality covering.

- circulation channels 4 spaced out regularly and formed by open channels on the outside of the internal heat insulating lining 2 which are closed by contact with the outside casing 1.
- orifices 5 of channels 4 crossing the lining 2 to the main liquid containing volume 3; the same orifices can be found in the top and bottom part of the main volume, 0y being the axis of symetry. When the front side of the solar-energy absorbing external casing 1 is heated by the sun's radiation, the liquid in the channels 4 becomes hotter than the liquid in the main volume 3. A thermosiphon effect comes into play and the hot liquid rises in the channels due to the higher weight of the cold liquid which itself flows towards the channels 4 through the orifices at the bottom of the main volume 3; the hot liquid flows from the channels 4 towards the main volume 3 through the orifices 5 in the top side of the main volume 3 the content of which therefore gradually heats up. The channels 4 or their orifices 5 can be equipped with one-way valves to prevent any inverse thermosiphon which could occur, particularly at night, when the temperature of the liquid in the channels drops below that of the liquid in the main volume. This is an undesireable effect as it cools the contents of the tank. The valves would cause little resistance to desireable flow. Their design is not however the subject of this patent.

- reflecting screens 6 are fixed onto the outside of the casing 1 by, for example, bolts, and made of, for example, a synthetic material of high density, their front surfaces being covered with a reflecting material 7 for example by aluminisation, and which concentrate the sun's radiation on the front of the tank casing 1 which can itself receive a coating which has high solar radiation absorption qualities at low wavelengths, and low infra-red loss at normal temperatures and high wavelengths. The cross-section of the reflecting screens 6 is, for example, parabolic, the geometric characteristics and focus of which are such that, even with a non-ideal angle of incidence of the sun's rays a satisfactory concentration of radiation is achieved on the front of the casing 1.
- a cover 8 which is transparent to solar radiation made for example from a synthetic material which is unaffected by ultraviolet rays, weather resistant, particularly to hail, and causing a "greenhouse effect" in front of the absorber. This transparent cover may not be necessary in locations where the surrounding air temperature is high.
- a layer of air 9 between the transparent cover 8 and the front part of the casing 1 which serves as a solar energy absorber. This layer is connected to outside air through openings in the lower part of the covering 8 in order to reduce internal condensation and for the evacuation of condensates.
- a rear external insulating shell 10 which is not necessarily as thick as the internal insulation 2.

It is made of a thermally insulating material, the surface of which is protected by a rigid skin, and is for reducing heat loss from the back of the casing 1 heated by solar energy at the front through its absorbing part.

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- a hot water outlet pipe 11, with evenly spaced holes 12, which is more or less horizontal and situated at the top of the main volume 3, also a cold water inlet pipe placed symmetrically to the outlet pipe in relation to the axis Oy and at the bottom of the volume 3. These two pipes broach and are welded to the lateral walls of the casing 1; to permit differential movement of the pipes and the casing, each of the pipes comprises of two lengths assembled by a ring fixed only to one of the lengths and allowing the two lengths to slide to or from each other. These pipes permit the linking between the cold water supply and the hot water system, of one or more units of the invention which is the subject of this patent, as shown for example in fig.4 for the case of two units. The conception of such a solar water heater should take into account the risk of freezing of the liquid contained in the tank and its inlet and outlet pipes during unfavourable climatic conditions and should cause a reduction of the risk of freezing, or at least of the risk of irreversible degradation due to freezing of the liquid.

In the appliance which is the subject of this patent, the antifreeze protection is passive through the cylindrical shape of the external casing 1, the

compressibility of the internal insulating lagging 2, and the appropriate flat design of the channels 4 which are particularly exposed to the cold, all this allowing the freezing of a part of the liquid without causing any notable degradation.

The heat insulated piping linking the appliance to the cold water supply and that to the hot water distribution circuit, can be given active anti-freeze protection by permanent forced circulation of the water by a low power electric pump 13 as illustrated in Fig. 4, and/or by a thermostatically switched gate which allows the recycling of some of the warmer water as soon as the temperature of the circuit drops below a given temperature. The presence of the circulator pump 13 being in permanent use, also improves user comfort by reducing hot water access time.

The potential of the appliance which is the subject of this patent resides not only in its high thermal efficiency but also its compactness and ease of conception and manufacture from an ordinary tank fitted with interior and exterior accessories which are themselves easily available or easily manufactured. The appliance can therefore be easily mass produced and at low cost, well below that of other solar water heaters on the market which are of more complex design and thus more complex to build.

Due to its low cost and high efficiency it could be distributed widely and particularly in the domestic and tertiary sectors.

CLAIMS

1) Compact solar water-heater with thermosiphon and concentration, characterised in that it is made from  
5 a tank for liquid, of which the outer casing 1 is a surface of revolution with a more or less horizontal axis, it is equipped with one or more external reflecting screens 6 which concentrate the sun's radiation onto its front surface, and it contains an internal thermally  
10 insulating lining 2 with orifices 5 at its top and bottom, linking the liquid in the main volume 3 and in the circulation channels 4 which latter are situated between the internal lining 2 and the external casing 1.

2) Solar water-heater as in claim 1),  
15 characterised in that all or some of the linking orifices 5 and the circulation canals 4 are equipped with one-way valves.

3) Solar water-heater as in claim 1) or 2), characterised in that the external casing is covered on  
20 its front surface with a coating reputed to be selective and of high absorption of solar radiation at low wavelengths, and low infra-red emission at ordinary temperatures and high wavelengths.

4) Solar water-heater as in any of claims 1) to  
25 3), characterised in that the front of the casing 1 is equipped with a cover 6 which is transparent to solar radiation.

5) Solar water-heater as in any of claims 1) to  
4), characterised in that the back of the external  
30 casing 1 is equipped with a thermally insulating shell 10.

6) Solar water-heater as in any of claims 1) to 5), characterised in that it is equipped with a hot water extraction pipe 11 with evenly-spaced orifices 12 along its length and situated at the top of the main volume 3, and a cold water inlet pipe with evenly spaced orifices situated at the bottom of the main volume 3.

7) Solar water-heater as in claim 6) characterised in that the hot water extraction pipe is equipped with a thermostatic flushing valve 14.

8) Solar water-heater as in claim 6) or in claim 7), characterised in that the cold water supply and hot water outlet circuit is equipped with a permanently functioning circulator 13.

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