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(54) DEVICE FOR HEATING A LIQUID BY SOLAR ENERGY

(71) I, LARS ANDERS BERGKVIST, of: Gottne, 890 42 Mellansel, Sweden, a Swedish citizen, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed to be particularly described in and by the following statement—:

This invention relates to a device for use in heating a liquid, preferably water, by solar energy. The device is a heat exchanger in which the liquid is in contact with a surface exposed to solar radiation, which heats the surface and in consequence the liquid is heated.

Several such devices have been proposed in recent years for heating water in single-family houses. These devices, so-called solar panels; are intended to be positioned on the roof of the house. Normally the heated water is intended to be stored in a water tank located in the house.

Generally, such a device has a black dull surface exposed to the sun's rays and piping, which contains water and is metallic and thereby heat-conductive, contacts said surface.

In places in the North, as for example in Sweden, the radiation intensity of the sun is relatively low during a great part of the year, and it is lowest in wintertime. The period of low radiation intensity coincides with the colder period of the year. Known devices in most cases are designed as described above, but it is also known to concentrate the solar radiation optically, in order to increase the temperature of the heated water. This is desirable, because from a consumption point of view it is preferable to store water of a temperature suitable for use as hot water, i.e. of at least 60°C. During the cold period of the year the solar panel is cold, and such a water temperature is difficult to obtain with a conventional design of solar panel.

There is a great risk, however, in concentrating the radiation by conventional lenses or mirrors, because the water flowing through the solar heating device and being heated therein is relied upon to cool the device. If this cooling effect ceases because of an interruption of the flow of water through the device (caused, for example, by a faulty pump), the device can be damaged through overheating, and also there is a fire risk to the house.

The present invention seeks to provide a device for concentrating the sun's rays and simultaneously being of such a nature as to prevent its overheating due to disturbed water circulation.

According to the present invention there is provided a device for heating a liquid preferably water by means of solar energy, comprising one or more heat absorbing members which, in use, contain the liquid to be heated and have an upper surface preferably of metallic material to be heated by solar radiation, and one or more lenses located above and spaced from the upper surface of the or each said member, which lenses each consist of a hollow shell connected to the supply of the liquid to be heated so as, in use, to contain said liquid as a light refracting medium, and arranged so that upon a cessation of, or predetermined reduction in the liquid flow in the member or members, the amount of liquid contained in the lens or lenses decreases and thereby the light refracting effect of the lens or lenses is reduced.

An embodiment of the invention is described in greater detail in the following, with reference to the accompanying drawings, in which

Figure 1 shows a device embodying the invention applied to a single-family house,

Figure 2 shows a portion of the device of Figure 1 seen from the side,

Figure 3 shows a portion of the device seen from above,

Figure 4 shows a lens and heat absorbing member which are parts of the device and are in section perpendicular to the longitudinal axis of the lens,

Figure 5 shows a lens and heat absorbing member seen parallel to the longitudinal axis of the lens.

In Figure 1 a device 1 embodying the invention is shown positioned on the roof of a single-family house 2. In this case the aforementioned liquid to be heated is water. When the device 1 for heating water is applied to a house 2, the house is built with a suitable roof angle, in order that the device is exposed to a maximum of solar energy. The device should of course, face to the south.

In Figures 2—5 different views of an embodiment of a device according to the invention are shown.

As shown by Figures 1—3, the device comprises a plurality of lenses 3 in parallel arrangement relative to each other. The device further comprises heat absorbing members 4 each provided with a hollow space 13 containing liquid. There is a lens 3 associated with, and spaced from, each member 4. The heat absorbing members, for example, may be a passageway with rectangular cross-section, in which passageway the liquid, water, is advanced. An upper surface 5, which is plane and located perpendicularly to the optic axis of the lens 3 associated with the member 4 is preferably black and dull. The size of said upper surface 5 is so chosen that substantially all the radiation incident on an associated lens, after refraction in the lens, is directed onto said surface 5.

Said members 4 are arranged in parallel with each other and located as described above with a lens 3 associated with each member 4.

Each lens 3 has a substantially cylindrical shape, with a substantially oval cross-section 3′, so that parallel light 6 inciding perpendicular to generators of the cylinder and parallel to the minor axis, i.e. short diameter, of the oval cross-section of the cylinder as shown in Figure 4, which short diameter is the optic axis of the lens, is refracted to be incident on a narrow oblong area at a certain distance from the cylinder. The size of said area is substantially the same as the size of the upper surface 5 of the member 4.

Each lens 3 consists of a hollow shell 7 preferably of a transparent plastics material, although other transparent materials, of course, can be used. The outer shell 7 of the lens 3 defines a hollow space in the lens which is filled with the liquid. For this purpose, the lens 3 is provided with an opening 8 for the supply of liquid, and with an opening 9 for the discharge of liquid. The liquid, which here as mentioned is exemplified by water, is designated by 10. The supply opening 8 and discharge opening 9, respectively, preferably are located in the two respective end walls 11, 12 of the lens, which preferably consist of the same material as the shell 7 of the lens 3. The light refracting medium in the hollow space defined by the shell 7 of the lens 3, as mentioned above, is said liquid, for example water. In consequence the lens 3 is active as a light refracting member only when the lens is filled with water. Upon a small reduction in volume of the water in the lens 3, it loses its refracting effect to such a degree, that the upper surface 5 of the heat absorbing member 4 is irradiated by a smaller amount of radiation than that incident on the lens. Consequently, upon a reduction in volume of the water in the lens said upper surface 5 assumes a lower temperature than if the lens 3 were full of water. When the lens does not contain any water, said upper surface 5 is exposed only to the amount of solar radiation which would be expected in the absence of the lens.

By using lenses to refract the light to a smaller surface than the lens surface, an increase in the energy density is obtained, and thereby a higher water temperature can be obtained in the heat absorbing medium 4. The desired water temperature is obtained by a suitable combination of the configuration of the lens, the size of the upper surface 5 of the heat absorbing member 4, and the water flow through said member. However, the use of refraction in order to obtain a higher temperature at said member would normally give risk of overheating of said member in the event that the water supply to the member is disturbed or stopped.

In order to protect said member 4 against overheating, and consequent damage, and to eliminate a possible fire risk to the house 2 consequent upon overheating, one of the two openings of each lens communicates with the water bearing hollow space 13 in the heat absorbing member associated with the respective lens, in such a manner, that when the water supply to the member 4 is stopped or reduced to a predetermined degree, the water amount in the lens decreases and thereby its light refracting effect decreases.

For this purpose a connecting pipe 14 to the supply opening 8 of the lens 3 is connected to a pump 15, which pumps cold water into the system. The discharge pipe 16 from the lens 3 is also connected to said pump 15, to the suction side thereof, so that the cold water discharged from the lens 3 is again pumped into the system. From said supply pipe 14, further, an additional pipe 17 extends, through which water is pumped into the heat absorbing member 4. Said member 4 is further provided with an outlet pipe 18, through which heated water flows to a collecting tank for hot water, radiators etc. Cold water is supplied to the system from a cold water conduit 27, which is connected to the suction side of the pump 15. The arrows in Figure 5 indicate the flow direction of the water. In the event of a reduction or interruption of the water supply along the cold water conduit 27, water continues to be abstracted from the lens 3 by the pump and part of the water from the lens is pumped away through the heat absorbing member 4 and its outlet pipe 18, thereby reducing the water volume in the lens. If the pump 15 should stop operating, the water in the system is sucked out through the outlet pipe 18 by siphon effect. In the event of water reduction in the system, the water volume is replaced by air flowing into the system via a valve 19 of a suitable type located, for example, at the supply opening of each lens 3.

During the cold period of the year, if the liquid in the system is water, some heating of the water in the lens 3 may be necessary in order to prevent freezing of said water in the lens. To effect this heating a part of the heated water flowing in the outlet pipe 18 is directed via an adjustable flow valve 20 and a pipe 21 to the supply pipe 14 for the lens 3. The valve 20 is of a suitable known type and so actuated by the temperature of the outside air, that a suitable temperature of the water to be directed into the lens is obtained.

The members 4 are preferably provided with several internal walls 22, 23, 24 to be bathed by the flowing water in order to provide the member 4 with as large a surface for transmitting heat to the water as may be possible or desired. Several structural designs are known for achieving this.

The members 4 are secured on a plate 25 common to the entire device. From said plate 25 extend supporting legs 26 carrying the lenses 3. At its parts adjoining a lens 3, each supporting leg 26 is shaped in conformity with the outer curvature of the lens. The plate 25 is preferably arranged to be rotatable for varying the inclination of the normal to the plate relative to the horizontal plane and, of course, also rotatable for varying the angle of its normal relative to the south. This lastmentioned rotation possibility, however, is of less importance because the cylindrical lenses provide a ray concentration with relatively small variation in size when the light incides at an angle slightly exceeding or less than 90° to the longitudinal axis of the cylinder, provided that the light is in parallel with the optic plane of the lens. The configuration of the lens 3, thus, implies a high energy exchange between inciding radiation energy and radiation energy meeting said members when the device is mounted stationary with the longitudinal axes of the lenses lying in a horizontal plane.

The invention, of course, can also be applied to round convex lenses or lenses of another configuration, or systems of lenses.

Light-refracting media other than water can be used, for example a water-glycol mixture or a water-alcohol mixture, in which case the member 4, the conduits 16, 14, 21, the pump 15 and the lens 3 form a closed system. The conduit 27 is used only for filling the system, and the conduit 18 is used only for draining the system. An expansion vessel preferably is provided in connection to the valve 19.

In this latter embodiment, the members 4 are designed as a heat exchanger, in which one system of flow passages contains the circulating liquid 10 and another system contains, for example, water. Heat energy is transferred from the liquid 10 to a medium, for example water, which is to be heated and thereafter transported to a container for storing said medium, radiators etc. The heat exchanger can be of a suitable known type.

The lenses 3 and members 4, respectively, as mentioned above, are located in parallel relationship to each other. As regards flow, the members may be connected in parallel relative to each other, as indicated in Figure 2, but they may also be connected in series. Mutual parallel connection of the members 4 is, however, preferable. Each of the lenses 3 is preferably connected to a respective member 4 as described above, but also may be connected in another suitable way.

The invention is not to be regarded as restricted to the embodiments described above, but can be varied within its scope defined in the attached claims.

WHAT I CLAIM IS:—

1. A device for heating a liquid by means of solar energy, comprising one or more heat absorbing members which, in use, contain the liquid to be heated and have an upper surface to be heated by solar radiation, and one or more lenses located above and spaced from the upper surface of the or each said member, which lenses each consist of a hollow shell connected to the supply of the liquid to be heated, so as, in use, to contain said liquid as a light refracting medium, and arranged so that upon a cessation of or predetermined reduction in the liquid flow in the member or members, the amount of liquid contained in the lens or lenses decreases and thereby the light refracting effect of the lens or lenses is reduced.

2. A device according to claim 1 wherein the said upper surface is metallic.

3. A device according to claim 1 or claim 2 wherein each lens is arranged to have a flow of liquid therethrough, an opening for the supply of liquid to the lens and an opening for the discharge of liquid from the lens being provided in the shell of the lens.

4. A device according to claim 3 wherein one of the two openings of each lens communicates with a liquid bearing hollow space in a said member associated with that lens, so that upon a cessation of or predetermined

reduction in the liquid flow in the said member, the amount of liquid contained in the said lens decreases and thereby its light refracting effect is reduced.

5. A device according to any one of the preceding claims wherein the shell of each lens consists of a transparent plastics material.

6. A device according to any one of the claims 1—5, wherein each lens has an elongate substantially cylindrical form, the cross-section of which has a substantially oval shape such that parallel light, which incides parallel to the minor axis of the oval cross-section of the cylinder, which constitutes the optical axis of the lens, is refracted to a narrow elongate area at a certain distance from said cylinder.

7. A device according to any one of the preceding claims, wherein a plurality of lenses are arranged parallel to each other, and said heat absorbing members are arranged parallel to each other, and the upper surface of each member being located perpendicularly to the optic axis or optic plane of a said lens associated with the member.

8. A device for heating a liquid by means of solar energy, substantially as herein described with reference to the accompanying drawings.

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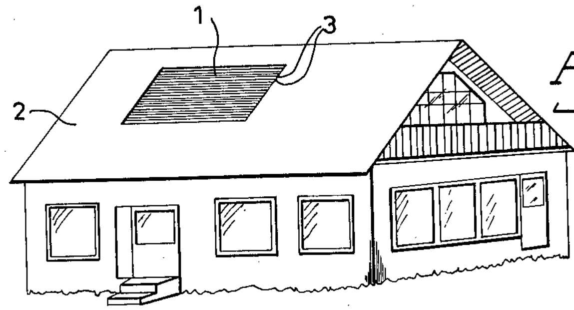

Fig. 1

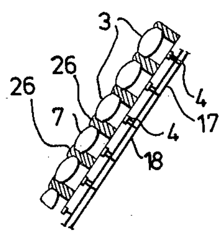

Fig. 2

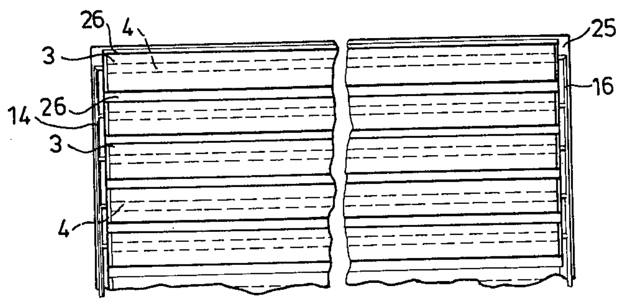

Fig. 3

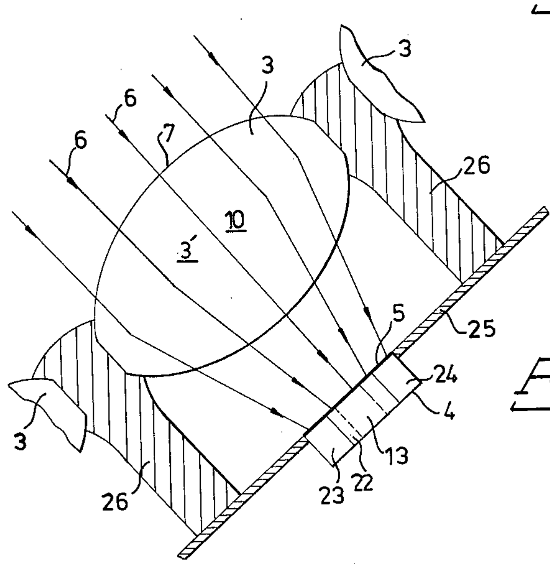

Fig. 4

1576257 COMPLETE SPECIFICATION

2 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 2

Fig. 5