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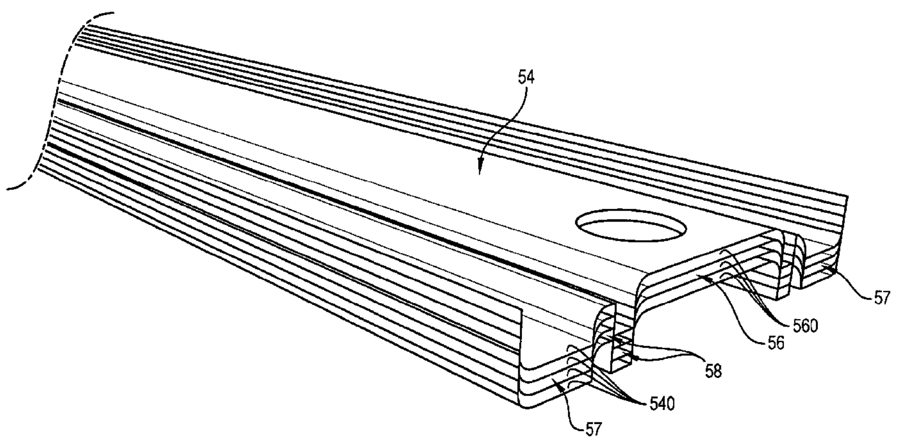
(54) Title: SOLAR THERMAL COLLECTOR

FIG. 2a



(57) **Abstract**: The invention relates to a solar thermal collector for heating a fluid to be heated (600), comprising :- a thermally insulating body (1); - a light transparent barrier (2); - a heat accumulator (3) comprising a thermal accumulating material (30), and - a heat exchanger (5) designed for transmit thermal energy from the phase transfer material to the fluid to be heated (600), wherein heat exchanger (5) is formed by a pileup of die-forged metal sheets and wherein the thermal accumulating material comprises a salt solutions based hydrogel and gelling agents.

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SOLAR THERMAL COLLECTOR

Technical Field

This invention relates to solar thermal technology, in particular to the equipment designed for the conversion of solar energy into thermal energy, and can be used for heating water, especially residential or industrial water.

Background Art

It is known a solar thermal collector, consisting of a body in the form of a water cylinder with light-transparent (translucent) glazing and light-absorbent coating (see for example document RU 2’108’520).

Such collector has the following drawback: water is heated by the sun through a light-absorbent coating but it lacks heat accumulation capacity.

It is also known from the state of the art a solar thermal collector consisting of an insulated body with a lid comprising a light-transparent glazing and a corrugated inner wall. The area between the base of the body and the corrugated wall is filled a heat accumulating material in the form of a phase transformation material (for example paraffin). Water is supplied into the thermal energy collector via a flow heat exchanger (for instance a heater coil) so as to exchange thermal energy with the thermal accumulating material (see for example documents RU 2’230’263 and CN 101285622).

In reference to figure 7, a thermal collector according to the state of the art comprise the following important features: a thermally insulating body 1, flow heat exchanger 5 (to heat the water), a light-transparent glazing 2, a selective light absorption material 4, a heat accumulator 3 in the form of a phase transformation material, flow pipes 6 for water circulation and thermal conductive elements.

However in the mentioned existing solar thermal collector solar energy R is first absorbed by the water. When there is too much sun, the excess energy heats and melts the phase transformation material (heat accumulator 3), i.e. thermal energy is accumulated. When there is no sun, the water is heated by the thermal energy radiated when the phase transformation material crystallises.

According to another embodiment, solar energy R is first absorbed by the selective light absorption material which then transmits thermal energy to the phase transformation material. Metallic ribs inside the thermal collector allow the transition of the thermal energy from the phase transformation material to the water enhance the thermal transmission.

Furthermore heat accumulating material as paraffin does not have the ability to keep the thermal energy for a long time and loses thermal energy by thermal transmission, convection and emission.

It also has to be noted that calculation of the volume of the tank is based on the condition that overheating of the water collected in the tank is not permitted, i.e. the water must not be heated to 100° C or above. In other words, the volume of the tank is calculated from the maximum value of energy received by the heater from the heat source (an intensity index is introduced), taking into account the practical specific heat of water and the maximum allowed temperature, 100° C.

An example of solar collector calculation follows. For an area with a maximum solar insulation per day of 17 MJ/m^2, the capacity of a collector equals: 17,000,000J / 4190J/kg/K / 80g x K = 50.75 *l*/m^2.

This implies that, if the efficiency of the solar collector were 100%, one square metre would be sufficient to heat 50.75 *l* of water to 80° C. Consequently, the tank must hold at least 50.75 *l* of water per one metre square of the absorbing surface of the solar collector. In practice however, efficiency of solar collectors is no greater than 40-70%. Consequently, a solar collector with an absorbing surface area of 2 m^2 requires at least 71.5 *l* heat accumulation tank.

To attract buyers, that volume is usually increased to 100 – 150 *l*. The result is obvious: the larger volume of water in the tank requires more heat; therefore either the water is not heated to the required temperature or an additional heat source is required (a gas or electric heater for example). On the other hand, even on maximal conditions (hot and sunny days), when the water does reach the required temperature heated only by the sun, the customer cannot use that volume of heated water efficiently because hot water is discharged from the collecting heater by displacing an equal volume of cold water, i.e. hot water mixes with cold water. Thus discharging just 30 *l* of water heated to 58°C from a 100*l* collector and replacing it with tap water at 20°C results in a temperature drop to 46.6°C. The use of the next 30*l* results in the temperature dropping to 42°C.

To eliminate this drawback, manufacturers resort to various structural devices, such as a layer-by-layer filling, installing additional tanks inside the main one (to achieve convective heat exchange), etc.

However the following drawback is shared: heat is accumulated with the increase of the internal energy of the material (heating the water) during the heating process. In other words, energy accumulation depends linearly on the temperature of the material.

In addition to this major drawback, the collectors according to the state of the art suffer precipitation of insoluble salts from the water because the conditions inside boilers are favourable to the growth of crystals, creating a serious bacteriological problem: colonies of harmful bacteria develop in the warm, porous deposits on their walls,….

Also, these deposits are responsible for a dramatic drop of heat exchange efficiency: efficiency drops, while energy consumption increases. If the tank is not flushed regularly, water in it might overheat. This will cause the increase of pressure in the tank and the primary heat carrier supply pipes, which often results in failures. Only having their structure cardinally altered can eliminate these generic problems of accumulating heaters.

Summary of Invention

Technical Problem

It is an object of the present application to provide a novel solar thermal collector avoiding those drawbacks.

More particularly, an object of the present invention is to improve the design of flow solar thermal collector for reducing heat losses during heat accumulation and water heating, thus improving efficiency of the solar energy use.

Solution of the problem

This object is achieved by a solar thermal collector according to annexed claim 1.

Advantageously but optionally the present invention comprises at least one of the following features:

- at least one surface of the heat accumulator is coated with a selectively light-absorbing material,
- the thermal accumulating material comprises a sodium acetate solution in distilled water (acetate trihydrate) with a gelling agent,
- the gelling agent comprises a solution of carboxymethyl cellulose (CMC) and/or a solution of polyvinylpyrollidon (PVP) and/or a solution of sodium laureth sulphate and/or carrageenan,
- the thermal accumulating material comprises a coating of high coefficient thermal dilatation material,
- the high coefficient thermal dilatation material comprises paraffin.

Advantageous effects of Invention

The present invention is essentially based on the combination of salt solutions based hydrogel and gelling agents as phase transformation material and thermal conductive die-forged metal sheets that are piled up in order to constitute a heat exchanger means.

The solar thermal collector according to the present invention ensures:

- firstly that the surface of the heat accumulator absorbs sunlight with high efficiency, which results in that a greater amount of thermal energy is transferred to the phase transformation material;
- secondly it improves the convection heat transfer between the heat accumulator and the elements of the flow heat exchanger.

As a result, heat losses are reduced and it allows efficient thermal collector.

Brief description of the figures

Fig. 1a represents a schematic overview of the solar thermal collector according an embodiment the present invention;

Fig. 1b represents lateral cross-section of solar thermal collector of Fig. 1a;

Fig. 2a and 2b represent a solar thermal collector inner structure according to a specific embodiment of the present invention;

Fig. 3a, 3b and 3c represent a solar thermal collector inner structure according to a specific embodiment of the present invention;

Fig 4a and 4b represent a solar thermal collector according to another embodiment of the present invention;

Fig. 5 represents a solar thermal collector designed to be put in a window according to a specific embodiment of the present invention;

Fig. 6 represents a solar thermal collector designed to be put on a roof according to a specific embodiment of the present invention;

Fig. 7 represents a solar thermal collector according to the state of the art.

Detailed description

In reference to figures 1a and 1b, the collector C of solar thermal energy according to a particular embodiment of the present invention includes a thermally insulated body 1 with a light-transparent glazing 2.

The body 1 comprises flow pipes 6 and more particularly an inlet pipe 60 and an outlet pipe 62 feeding the solar thermal collector C with fluid to be heated as water. More particularly, the fluid to be heated enters into the solar thermal collector body 1 through pipe 60, is heated inside the body 1 and then exits trough pipe 62. It can be used in a domestic or industrial field.

A heat accumulator bloc 3 is arranged inside the body 1. The heat accumulator bloc 3 is filled with thermal accumulating material 30.

The heat accumulator 3 comprises a selective light absorption coating 4. The heat accumulator is in cooperation with a flow heat exchanger 5 troughs which the fluid to be heated flows.

The coating 4 is made of a material with high absorption coefficient and low reflection coefficient (blackened copper might be used for example or niello copper).

The heat accumulator 3 is hydraulically connected to flow pipes 6 (inlet pipe 60 and exit pipe 62).

The heat exchanger 5 is designed to provoke a thermal energy exchange between the phase transformation material 30 and the fluid to be heated 600 (e.g. the water) flowing inside the heat exchanger 5.

In reference to figures 2a and 2b and according to a specific embodiment of the present invention, the heat exchanger 5 comprises a core structure 54 for the thermal energy exchange between the fluid to be heated 600 and the thermal accumulating material 30.

The heat exchanger core structure 54 is formed with die-forged metal sheets 540 which are piled up.

All the sheets 540 of the heat exchanger core structure 54 are identical. Each sheet 540 comprises deformations obtained in a die-forged process.

When the sheets 540 of the heat exchanger core structure 54 are piled up, the deformations of the sheets form closed compartments 560 of a global channel 56 receiving for the fluid to be heated (e.g. the water) and being hermetically sealed by hermetic seal channels 58. When the sheets 540 are piled up it also forms cavities 57 that are designed to receive the accumulating material 30. In this embodiment, the channel 56 forms a straight longitudinal channel along the piled-up sheets. Each sheet 540 comprises a hole 542 located along this channel 56.

In reference to figure 2b the hole 542 of a given sheet is located in the opposed extremity of the channel 56 than the hole of the subsequent sheets.

For instance the hole of sheets 540a and 540c (holes 542a and 542c) are located on the left side of the channel 56 and the hole of sheets 540b and 540d (holes 542b and 542d) are located of the right side of the channel 56.

As a consequence, the water begins to flow by hole 542a, enters into the channel compartment 560 located between sheets 540a and 540b, then flows along the channel compartment until hole 540b, then flows through the hole to arrive inside the channel compartment located between sheets 540b and 540c.

And so on until the water has circulated inside each channel compartments until the exit after the hole 542d.

In reference to figures 3a, 3b and 3c and according to another embodiment of the present invention, the heat exchanger 5 comprises an inlet 50 linked to the inlet pipe 60 of the solar thermal collector and an outlet 52 linked to the outlet pipe 62 of the solar thermal collector.

A channel 56 inside the heat exchanger 5 links the inlet 50 to the outlet 52 along which the thermal energy exchange is performed between the fluid to be heated 600 is heated and the thermal accumulating material 30.

The heat exchanger 5 comprises at least one channel 56 for the flow of fluid 600 to be heated (as water) and cavities 57 through which it is heated by the heat release by the thermal accumulating material 30 inside the heat accumulator 3.

The heat exchanger 5 comprises a core structure 54 for the thermal energy exchange between the fluid to be heated 600 and the thermal accumulating material 30.

The heat exchanger core structure 54 is formed with die-forged metal sheets 540 which are piled up.

All the sheets 540 of the heat exchanger core structure 54 are identical. Each sheet 540 comprises a deformation 5401, preferably in a half-pipe form groove. This groove is along a path following the trajectory 5042 of the channel 56.

When the sheets 540 of the heat exchanger core structure 54 are piled up, the deformation 5401 form closed compartments 560 of the channels 56 receiving the fluid to be heated (e.g. the water) and being hermetically sealed by hermetic seal channels 58.

The areas outside of the fluid channel 56 (and seal channel 58) form cavities 57 to be filed with thermal accumulating material 30. Accordingly cavities 57 and channels 56 are separated each from other by hermetic seal channels 58.

Sheets 540 material of the heat exchanger 5 represents the heat transfer medium between the thermal accumulating material and the fluid to be heated.

This heat exchanger core structure 54 allows building a one-flow or a multi-flow heat exchanger of any kind: liquid-solid, liquid-liquid, liquid-gas, gas-solid etc.

Moreover this heat exchanger core structure 54 comprises single standard components (sheets 540) and contains no soldered or welded joints. Thus it is highly suitable for computerised/automated manufacturing.

Furthermore maintaining and repairing such heat exchanger core structure 54 is easy as sheets 540 can be dismantled and re-assembled several times without resorting to either soldering or welding equipment.

All the channel compartments 560 formed between each sheets 540 of the heat exchanger core structure are fixed by a fixing means as a single threaded bush (not shown) that draws together all the sheets into a single block.

A by-pass valve (not shown), either rotating around the rotation axis of the bush or longitudinally-sliding along that axis can be installed inside the bush, enabling to switch the channels (there is also room for a small turbine-oscillator for agitating sound waves in the fluid to be heated).

In addition to the bush, all the sheets 540 are drawn together by pins 59. The required capacity of the at least one channel 56 is achieved by designing it accordingly: a gap between the sheets is controlled by gaskets (not shown).

In addition, the channel compartments 560 have dome-shaped section, which imparts to them excess resilience in both longitudinal and crosswise directions. Accordingly the assembly of the sheets 540 pulls them together very tightly.

Hermetic sealing of the channel compartments 560 can be enhanced by the using of a fluoro-rubber, butyl, latex, or silicon compound coating, placed into the grooves hermetic seal channels 58 running along the fluid channel 56.

In a first embodiment the water flowing from the inlet 50 and enters in the first compartment 560, circulates along the zigzag channel 56 and once arrived at the opposed hole, the water flows into the subsequent channel compartment in the same manner than previously explained (except that the channel 56 has a zigzag form).

Alternatively the flowing of the water from inlet 50 to outlet 52 can be parallel inside all the channel compartments 560.

In order to from the heat accumulator 3, the assembled heat exchanger block 5 is placed in a hermetically sealed body 1 filled with a thermal accumulating material 30.

The Z-shaped channel forms a hydraulic seal to eliminate the possibility of the air breaking into the heat exchanger when the fluid is discharged from the heat exchanger ('totally air-locked').

Concerning the pipes 6 the air-lock principle has been applied:

- a height difference must be ensured in the flow heater, installing it at an angle to the horizon to let the air out when the heat exchanger is being filled with water,
- a by-pass valve – to turn off water and to force out the left-over water from the heat exchanger, and
- a wash ramp: a pipe with sprayers for cleaning the glass of the solar accumulator.

Water is let into the heat exchanger only when the customer opens the supply valve. When the valve is shut, water is discharged to the customer. The length and cross section of the discharge are selected so as to ensure that leftover fluid is sucked out from the heat exchanger by gravity when the valve at the uppermost point in the system is open. Water is supplied either through the vent on the supply main – the simplest case – or via a special slide valve, In addition to being influenced by gravity, the leftover fluid in the heat exchanger expands during the heating, i.e. the water is 'squeezed out' through the gaps in the heat exchanger. Having the smallest possible space inside the channel is a necessary requirement for speeding up heat transfer and minimising the heat loss.

The thermal accumulating material 30 is basically a hydrogel and gelling agents as phase transformation material.

Particularly, the thermal energy accumulation happens in the form of salt dissolution in crystallisation water and fixing (envelopment) of the water residues by the gelling agents.

Preferably the thermal accumulating material 30 is a eutectic mixture and preferably a sodium acetate hydrate gel can be used as the phase transfer material.

Such thermal accumulating material quickly reaches its melting point when heated. Using this type of material has the following advantage over continuous, linear heating: it receives and releases energy when the material undergoes the liquid-crystalline phase transformation while the temperature remains constant.

A molten crystalline material, for example, releases 60-80% of its useful heat while its temperature does not drop. In other words, with such thermal accumulating material, the first 60-80% of the total volume of the fluid to be heated by the thermal accumulating material is heated at a constant temperature.

The temperature begins to drop only after crystallisation is completed. Consequently, the amount of the thermal energy used does not affect the efficiency of this accumulator.

The thermal energy release (because of the salt crystallisation) is triggered by an external solicitation which can be mechanical or electrical on the gel.

In comparison to the prior art embodiment using the paraffin, the present invention uses the dissolution process of the salt in a solvent, as crystallisation water. Accordingly the thermal accumulation material does not "melt" during the temperature increase but "dissolves" (into ions in the electrolyte).

The hot dissolution of the salt crystals is stabilised by the gelling agents when the hydrogel is formed.

Thus the gelling agents have the following functions:

- envelopment of all additive elements,
- avoiding convection phenomena,
- absorption of mechanical oscillation,

Accordingly the emergence probability of a crystallisation centre decreases.

In the event gel is subjected to a violent shock (ultrasound, cavitations, electrical …), salt begins precipitation in the saturated solution. This phenomenon is exothermic.

In a specific embodiment, the hydrogel is cover by a coating of high coefficient thermal expansion material whose melting temperature is higher than the dissolution temperature (e.g. the paraffin). This kind of material decreases in volume when the temperature decreases and thus compensates for the volume increase due to the crystallisation. Therefore mechanical tensions inside the heat accumulator are reduced. Preferably the high coefficient thermal expansion material volume represents 5-10% of the total volume.

In a preferred embodiment, a super-saturated aqueous solution of sodium acetate is used as a thermal accumulating material.

A saturated solution has the following advantage over solids: when its temperature decreases, the solubility decreases, which means that it is able to form a “super-cooled” (‘chilled’) molten salt, dissolved in a fluid that will release its melting heat during recrystallization.

Sodium acetate solutions can be “super-cooled” in a range from 50°C to 60°C (generally by 52°C) without releasing the accumulated thermal energy. Consequently, it is possible to provide a thermal energy accumulator material that stores the energy not due to intensive thermal insulation (like with a thermal flask) but due to a phase transformation, and thus releases the accumulated thermal energy when required.

The dissolution point of commercial sodium tri-hydrate acetate is in the range of 50 to 60°C and generally 58°C.

Sodium tri-hydrate acetate is not as corrosive as other salts. Accordingly using this salt enables to build a compact heat accumulator while maintaining good capacity.

To ensure stable thermo-physical properties, a special hydrogel (also called "aquagel") can be used: a sodium acetate solution in distilled water (acetate trihydrate) with a gelation agent: a weak solution of carboxymethyl cellulose (CMC) and/or of polyvinylpyrollidon (PVP) and/or sodium laureth sulphate and/or carrageenan.

In a preferred embodiment, the following ratio is used:

Hydrogel composition (mass percent):

sodium acetate trihydrate	96%
CMC 700	3.0%
PVP	1.0%

The dissolution/crystallisation heat of this gel is 282,000 J/kg, while it thermal capacity goes from 2,650 to 2,800 J/kg/^{o}C.

The mixing process has been verified with a weak solution (0.001% by mass) of phenolphthalein, an acidity indicator. The thermal accumulating material itself did not overheat when the heat accumulator was re-loaded. It neither boils nor causes explosion because the boiling temperature of this hydrogel is far above 100^{o} C, while the point of equilibrium between the heat inflow and heat losses by radiation in the solar collector lies in the 90 to 96^{o} C interval.

To allow the expansion of the gel due to the thermal increase, the heat accumulator is designed with spare capacity.

In a preferred embodiment of the present invention, 10% of the space occupied by the heat accumulating material is provided as spare capacity.

Using a eutectic mixture, a sodium acetate hydrate gel for example, as the phase transformation material, reduces the amount of energy required to melt the phase transformation material because the melting temperature of a eutectic mixture is lower than the melting temperature of a mixture of any other composition; this also results in the reduction of heat loss.

The charging–discharging of the heat accumulator follows a certain sequence: a rapid temperature increase and stabilisation during the charging stage and, vice versa, a long plateau of discharge temperature, which does not require any additional control or stabilisation.

The discharge of the heat accumulator 3 includes two phases:

- the thermal charging when salts are dissolved and the mixture supercools ;
- the thermal discharge due to the re-crystallization of the eutectic mixture at any moment chosen by the customer with a mechanical or electrical trigger as previously explained.

A solar thermal collector according to the present invention with direct heat absorption allows the most efficient use of solar energy. Applying the sun radiation absorbing layer directly on the surface of the heat accumulation block sets ideal conditions for the storage of solar energy:

First of all, the present invention has eliminated various auxiliary devices, primary lines used in other designs, so that thermal energy is directly transmitted to the accumulating material 30.

Secondly, heat transfer has two stages:

- in the first stage, the accumulating material is simply heated until its melting starts (salts dissolution). Since the mass of the accumulating material is smaller than that of a water boiler of a similar capacity, while its heat capacity is about half of that of the latter, the accumulating material 30 heats up three times faster than a similar water boiler, which is also more heavily insulated.
- During the second stage the accumulating material melts, while its temperature stays practically constant. This makes the solar thermal collector even more efficient because its losses through radiation are lower and also because its functioning in changeable cloudiness conditions i.e. the influx of thermal energy is not affected by the temperature variation due to the direct heat transfer from the selectively absorbing layer.

- Thirdly, the heat transfer is carried out without any auxiliary electrical or mechanical devices, such as circulation pumps, heat syphons, etc., which makes its work extremely reliable throughout the entire process.

Advantageously the absorbing layer is protected by a guard made of super-transparent borosilicate glass. The guard can be made in the form of a one- or multi-chamber pack of glass.

The thickness of the assembled heat exchanger block has been set on the following basis: the thermal accumulating material 30 needs to be melted. Consequently, the hydrogel layer (accumulating material 30) must be thick enough to let in a quantity of solar energy sufficient for the melting the entire volume of the thermal accumulating material 30 on an average sunny day – given a particular surface area. Consequently, the mass of the heat accumulation material 30 needs to be from 30 to 70 kg/m^2 of the absorbing surface, depending on the average-annual insulation of the location where the solar thermal collector is going to be used.

Three different accumulators have been tested while respecting the weight per unit surface: 60, 45 and 30 mm thick.

Also, to improve the range of appropriate insulation levels in an average size solar accumulator, the author decided to assemble three blocks of accumulators of different thickness, connected in series: the thickest one nearest to the water supply, then the average, then the thinnest one.

The advantage of this distribution over an accumulator consisting of three identical block is that even when sun energy is very small, insufficient for heating through the thick and heavy blocks, the thin blocks will still store some energy, sufficient to heat up a small amount of water. On the other hand, even the thickest blocks of great capacity will still transfer some of its energy to the water, although at lower temperatures, while the thin, hotter blocks will further heat the water.

The thermal insulation of the solar thermal collector includes the thermal insulation of the accumulator blocks and the insulation from the atmosphere on the absorbing surface side.

The insulation guard of the solar thermal accumulator can be of any type as a vacuum cavity.

In the preferred embodiment of the invention, the insulation consists of a glass made of pure glass with silica gel in the distance control frame.

To reduce the heat losses through radiation in the infrared range, the transparent guard is provided with an inner layer of infrared mirror. Also the transparent guard is designed with two-glass plate glass packs in order to reduce convection losses.

For example, an infrared mirror can be made by gluing some special TC-88 film manufactured by the 3M Company to the glass inner surface, or by depositing a thin layer of indium oxide, using a vacuum ionic device.

It is also possible to use a packing between the accumulator block and the distance control frame of the glass, manufactured from a composite material able to insulate the glass from the hot absorbing surface.

According to a specific embodiment of the present invention, this material is manufactured by the impregnation of sheets of very thin basalt fibres (no greater than 2 µm in diameter) with liquid ceramic insulation. A free area is left between the distance-control frame and the body, which runs along the perimeter of the glass. This area is painted with an absorbing black paint (a primer) on the inside.

The collector according to a specific embodiment of the present invention also comprises heat-conducting elements to conduct heat from the selectively light-absorbing coating to the phase transformation material and optionally to the water in the heat exchanger. For example the heat-conducting elements are in the form of ribs. To eliminate heat losses by thermal radiation through the bottom surfaces of the ribs, the latter are insulated with a special composite coating on the inside. Furthermore the ribs can be installed in a network of the glass fibre dipped in liquid ceramic thermal insulation material as previously described.

As another measure designed to reduce convection losses: a heated butt of the glass absorbs less heat from the inner air layer, which prevents convection.

The thermal insulation of the accumulator includes three stages:

- first of all it is the body of the accumulator block itself, which is manufactured from polished metal and works like a mirror for infrared thermal radiation.
- Secondly, the ‘liquid ceramic’ layer deposited onto the accumulator blocks, represents a specialised high-temperature insulation (for example “Astratech”® or similar products of the domestic industries can be used). The heat resistance of these materials is very high.
- The third stage is formed of polyurethane foam, which, similar to sandwich structures, also works as a structural component, keeping together the outer casing and the inner blocks.

The body of the solar collector withstands considerable stresses: heat distortion, atmospheric precipitation, transportation stresses. Therefore, according to a preferred embodiment of the present invention, the body is made of polyvinylchloride.

Alternatively, vacuum-formed shell bodies from thermoplastic materials or glass-reinforced plastics, based on acrylic or epoxy resin can be chosen. Indeed such features are commonly widespread in the industry.
Also shell bodies with a polyurethane packing, sandwich structures, possess high mechanical and impact strength, are heat and frost resistant, cheap and not heavy.
Advantageously the transparent guard is secured to the body by being glued with a polyurethane glue for glass at the special notches (for example “Teroson”®). The distance control frame is glued between the accumulator block and the glass by the means of a butyl heat resistant glue. This allows for some movement and glass vibration and protects the glass from fracturing.

Referring to figures 4a and 4b and according to another specific embodiment of the present invention, the thermal accumulator further comprises thermal conductive elements 7 for example in the form of metal bars 70 comprising ribs 72 (preferably in form of louvers) thermally linked to the metal bars 70. Thermal conductive elements 7 are thermally linked and are preferably joined into a pack, made of heat conducting material, metal for example.

The solar energy collector operates as follows. Sun rays reach the absorption louvers 72 and heats them. Thermal energy is transferred from the louvers 72 to the metal bars 70 that bring further thermal energy to the collector.

In a specific embodiment, the metal bars 70 can be filed with any fluid able to efficiently transport thermal energy. In a specific embodiment of the present invention, the fluid is an evaporating fluid. Accordingly when the evaporating fluid is heated by the absorption of solar energy (metal louvers also allow the absorption and the conduction of the thermal energy to the metal bars 70) the evaporating fluid begins to evaporate, raises inside the metal bars and then reach the extremity 700 of the bars 70 that terminally linked to the collector.

This solar thermal collector has the following advantages over the solar energy collectors according to the state of the art:

- It can be installed in an existing window frame W (as represented in figure 5). Such window lets into the house some of the reflected and of the scattered light, acting not only as a heater but also as an ordinary window.
- According to figure 6, a solar thermal collector according to the invention can also be installed at an angle frame, incorporated into the roof for example. It can be also used as skylight windows.

CLAIMS

1. A solar thermal collector for heating a fluid to be heated (600), comprising
   - a thermally insulating body (1),
   - a light transparent barrier (2),
   - a heat accumulator (3) comprising a thermal accumulating material (30), and
   - a heat exchanger (5) designed for transmit thermal energy from the phase transfer material to the fluid to be heated (600),

   wherein heat exchanger (5) is formed by a pileup of die-forged metal sheets and wherein the thermal accumulating material comprises a salt solutions based hydrogel and gelling agents.

2. A solar thermal collector according to claim 1, wherein at least one surface of the heat accumulator (3) is coated with a selectively light-absorbing material (4).

3. A solar energy collector according to claim 1 or 2, wherein the thermal accumulating material comprises a sodium acetate solution in distilled water (acetate trihydrate) with a gelling agent.

4. A solar energy collector according to any of claims 1 to 3 wherein the gelling agent comprises a solution of carboxymethyl cellulose (CMC) and/or a solution of polyvinylpyrollidon (PVP) and/or a solution of sodium laureth sulphate and/or carrageenan.

5. A solar energy collector according to any of claims 1 to 4 wherein the thermal accumulating material comprises a coating of high coefficient thermal dilatation material.

6. A solar energy collector according to claim 5, wherein the high coefficient thermal dilatation material comprises paraffin.

7. A solar energy collector according to any of claims 1 to 6 wherein it further comprises metal bars (70) thermally linked to thermally insulating body (1).

8. A solar energy collector according to claim 7 wherein it further comprises metal ribs (72) thermally linked to the metal bars (70).

9. Window comprising at least a solar energy collector according to claim 8 wherein the metal ribs (72) are in the form of louvers.

FIG. 1a

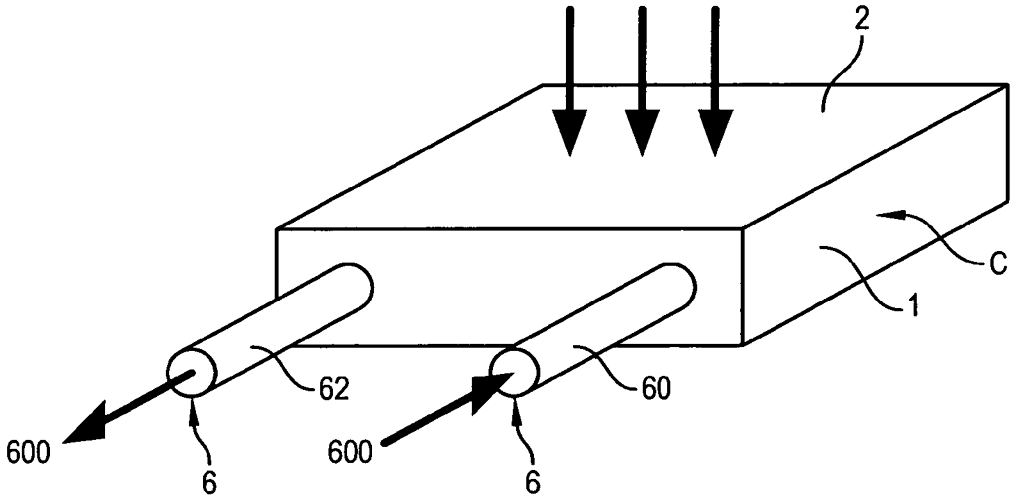
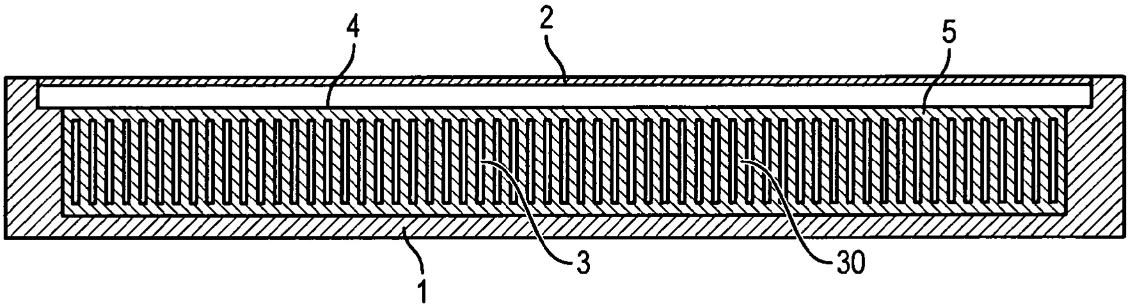


FIG. 1b



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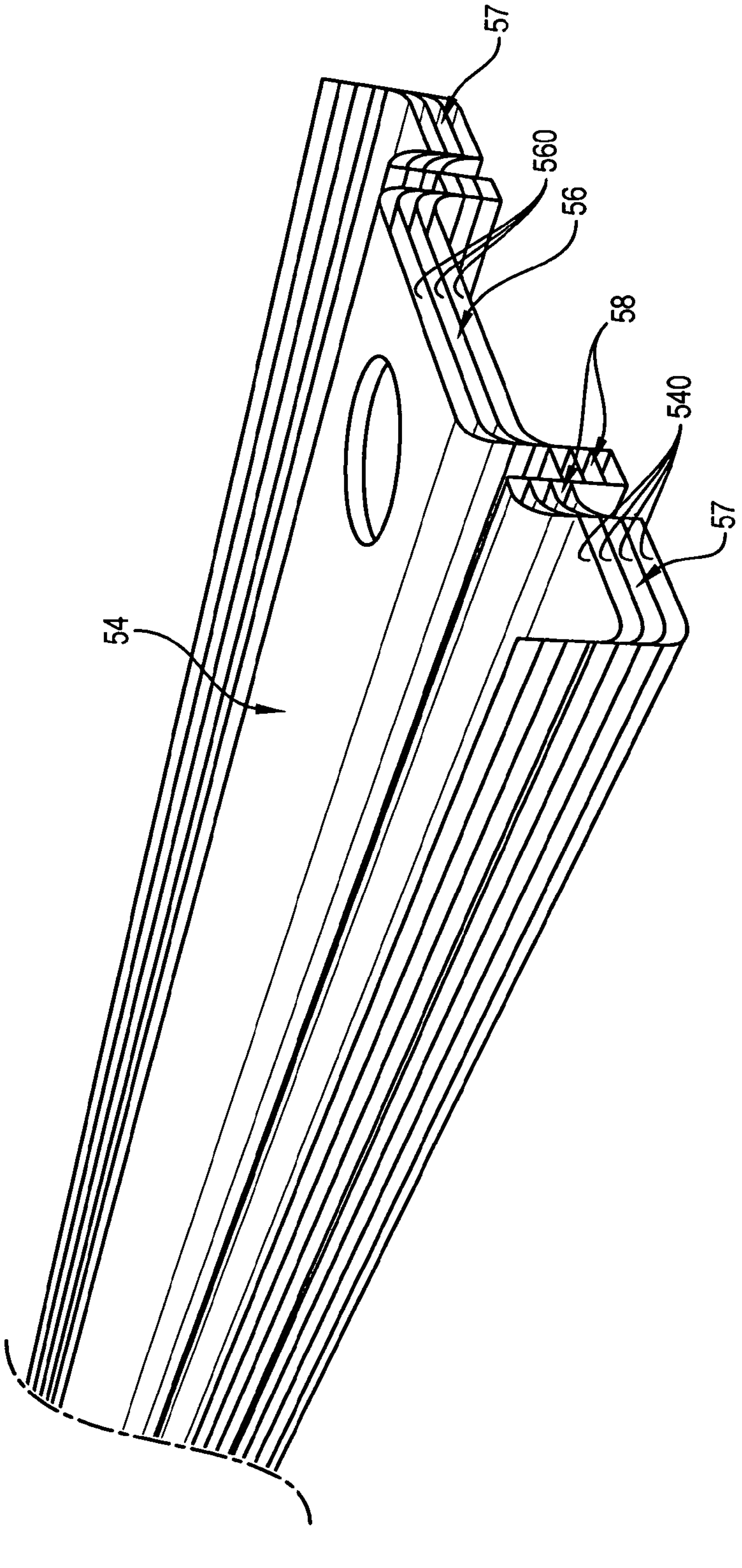

FIG. 2a

FIG. 2b

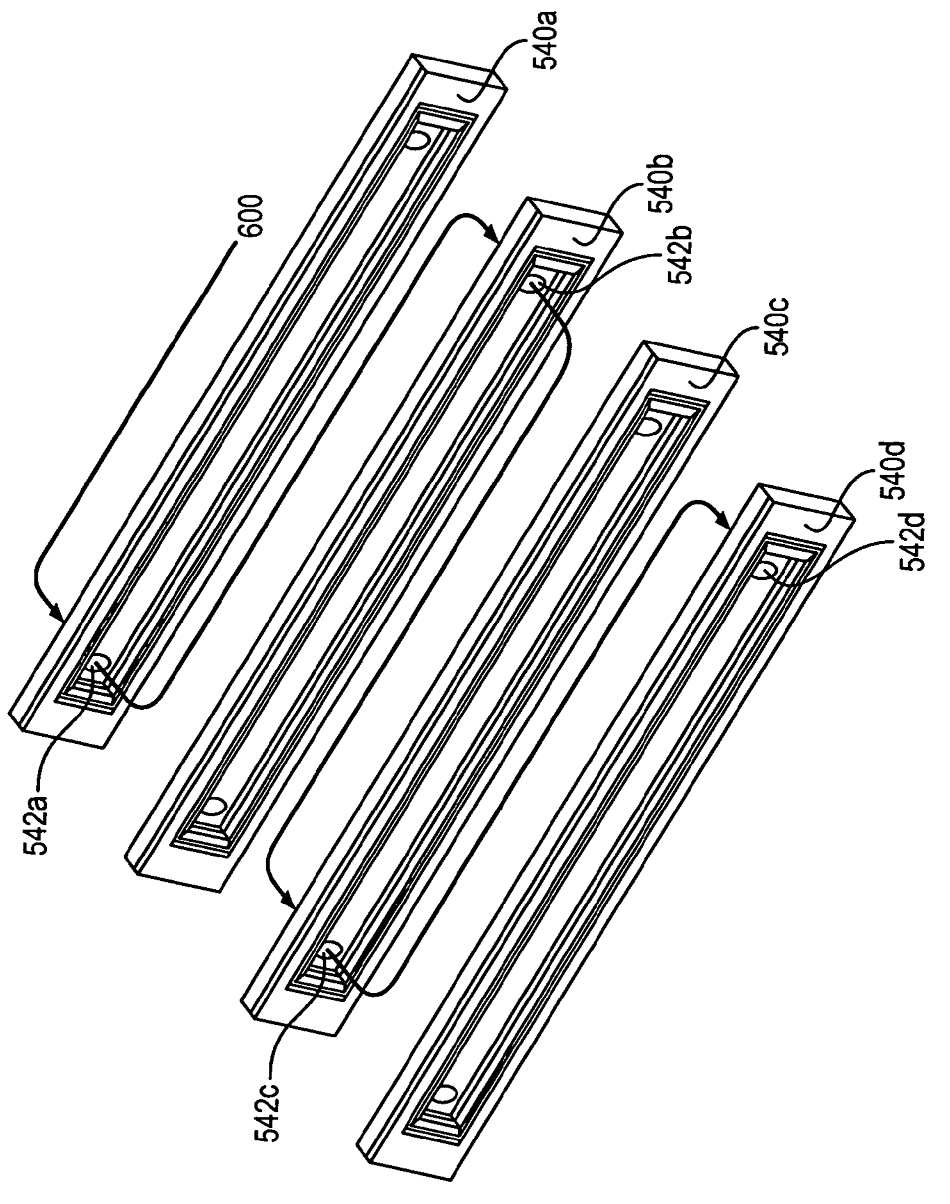

FIG. 3b

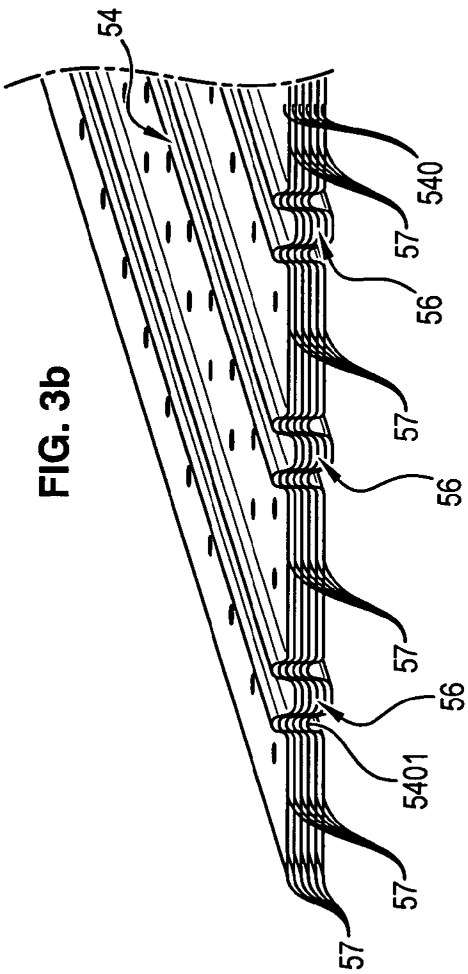

FIG. 3c

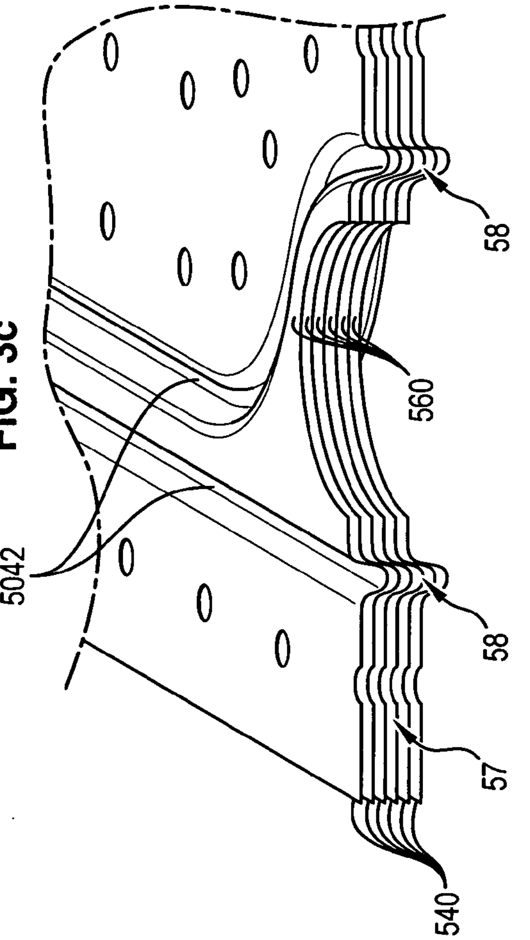

FIG. 3a

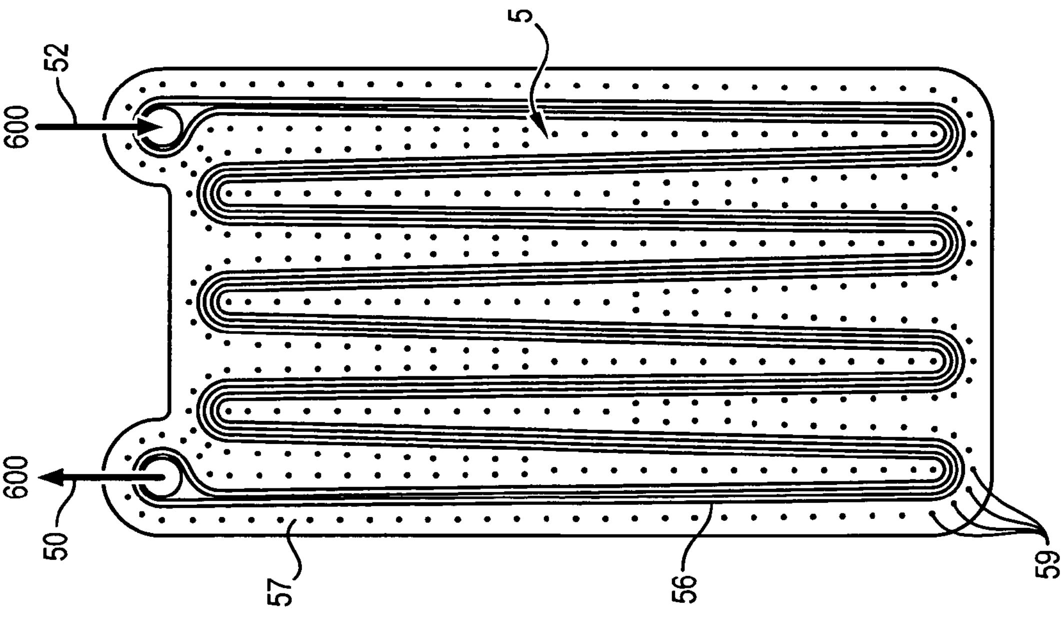

FIG. 4a

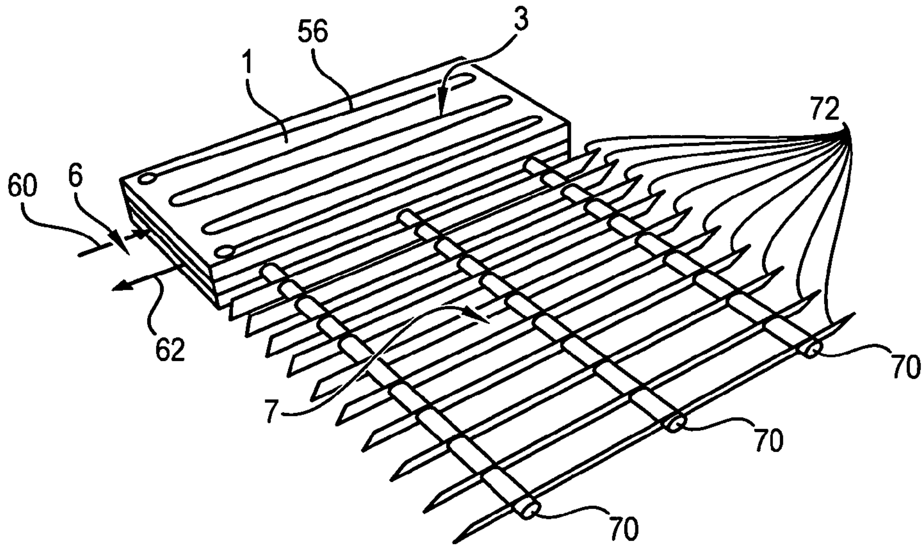

FIG. 4b

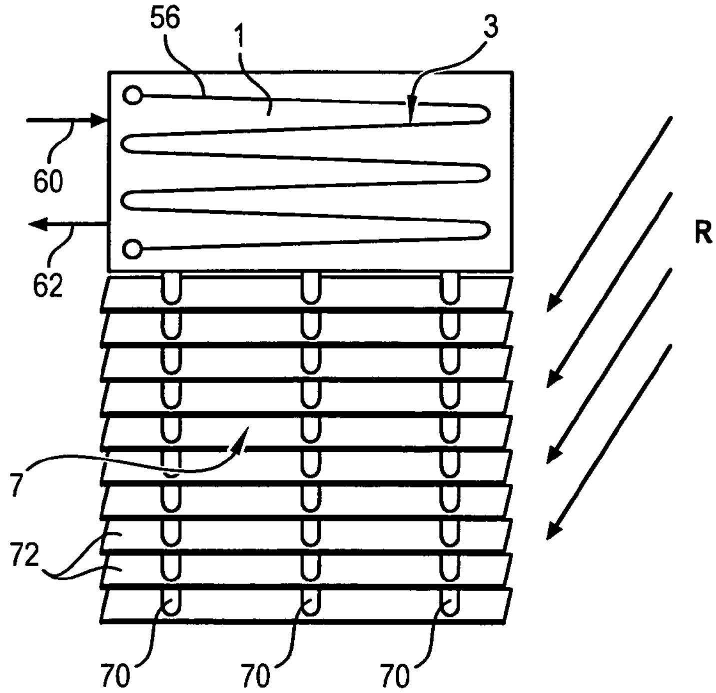

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FIG. 5

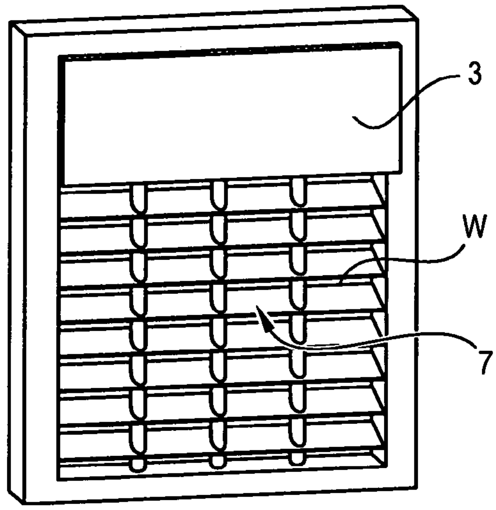

FIG. 6

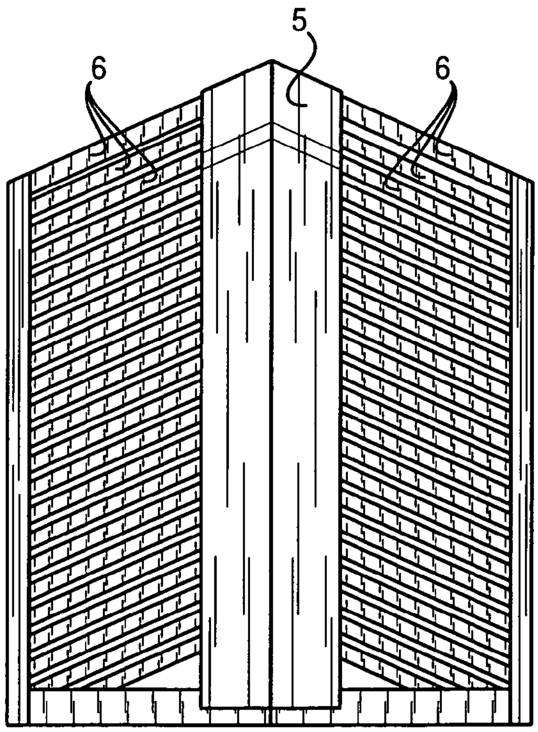

FIG. 7
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