US 20120048259A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2012/0048259 A1
(43) Pub. Date: Mar. 1, 2012
Wagner et al.

(54) SOLAR INSTALLATION

(75) Inventors: **Andreas Wagner**, Coelbe (DE); **Thomas Schabbach**, Baunatal-Guntershausen (DE)

(73) Assignee: **Wagner & Co., Solartechnik GmbH**, Colbe (DE)

(21) Appl. No.: **13/052,222**

(22) Filed: **Mar. 21, 2011**

(30) Foreign Application Priority Data

Aug. 26, 2010 (DE) 10 2010 037 181.5

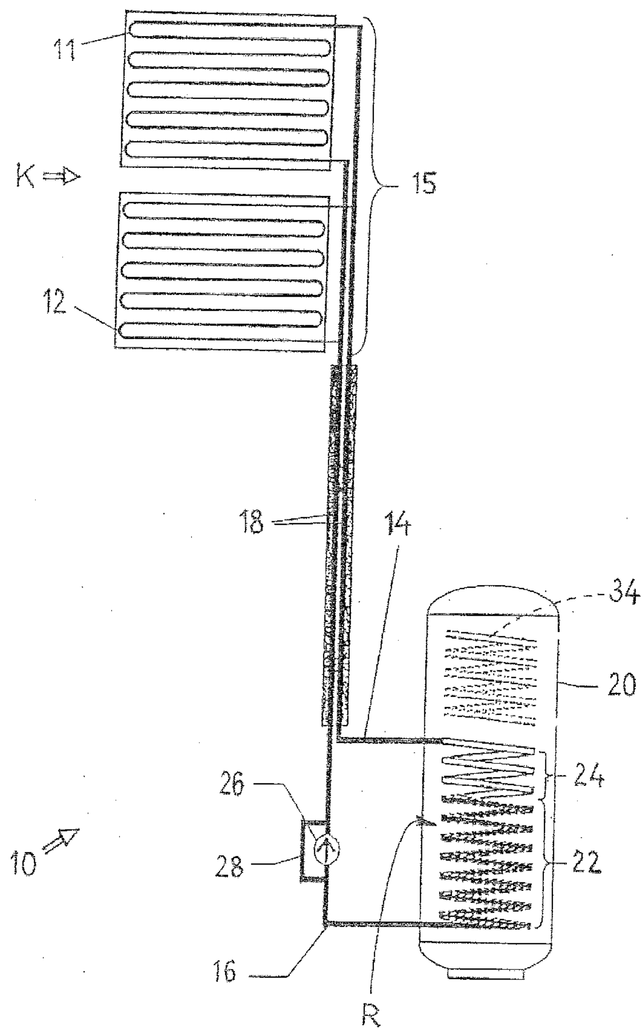
Publication Classification

(51) Int. Cl.
F24J 2/40 (2006.01)
F24J 2/04 (2006.01)

(52) U.S. Cl. **126/585**; 126/641

(57) ABSTRACT

The solar installation (**10**) according to the invention having a collector array (K) and a heat storage container (**20**) has a drain-back holding device (**24**) which is integrated with a heat exchanger (**22**), which is located in the container (**20**), in that its upper area has an expansion and return volume. It is preferably in the form of an integral pipe coil (R), which is a smooth-pipe helix with a uniform gradient. Furthermore, a second heat exchanger (**34**) can be arranged, coaxially with respect to it. The pipe coil (R) has means, at least in the lower area, for reducing the free flow cross section in the pipe interior (**32**), specifically cylindrical or profiled, fixed or moving filling bodies (**30**) which, for example, are individual bodies, which are closed at the end, with a standard form which promotes swirling, and/or which may be composed of a material of high thermal capacity, such as steel, stone, ceramic or the like.



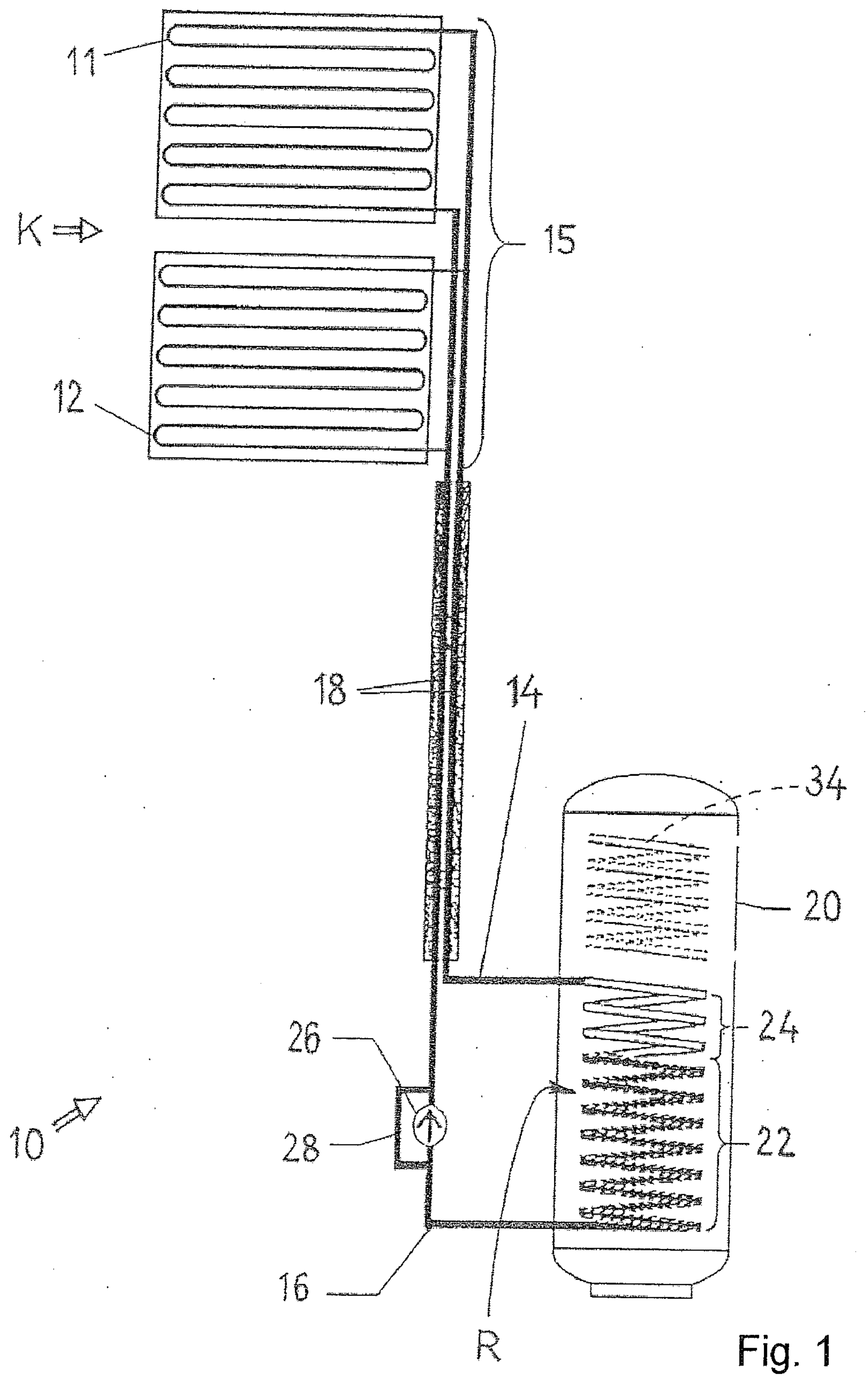


Fig. 1

Fig. 2a

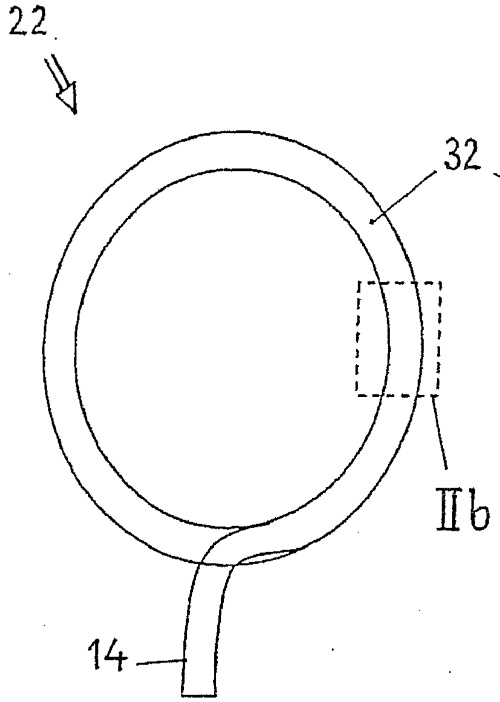


Fig. 2b

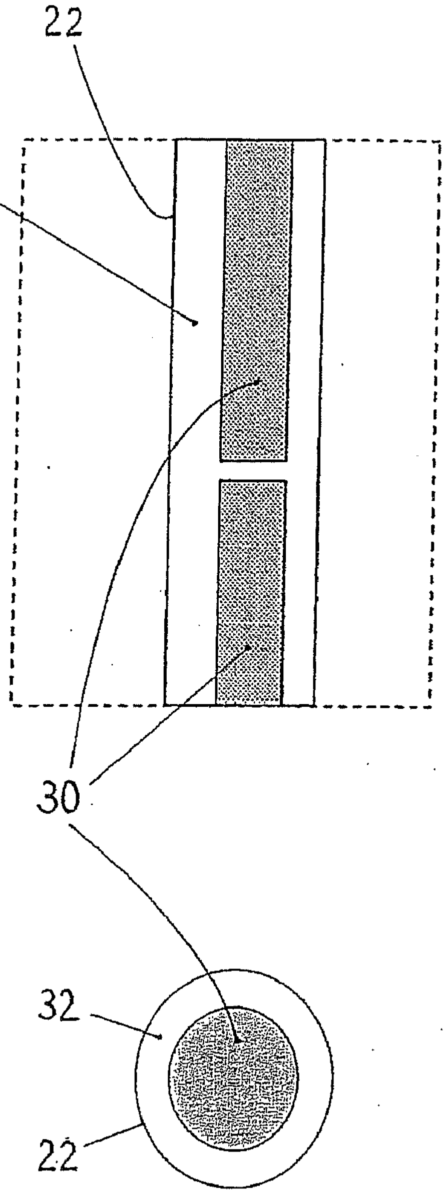


Fig. 2c

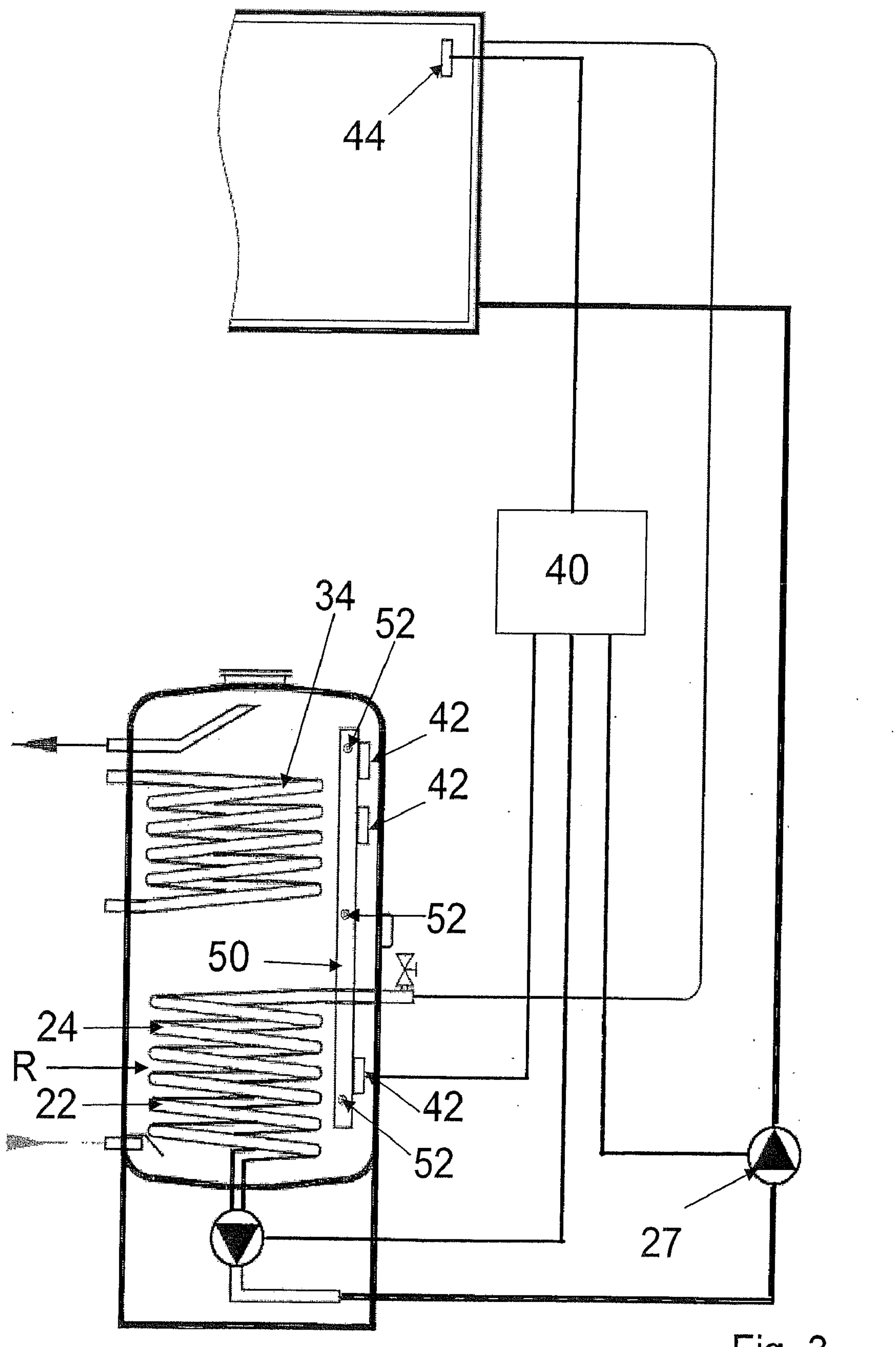


Fig. 3

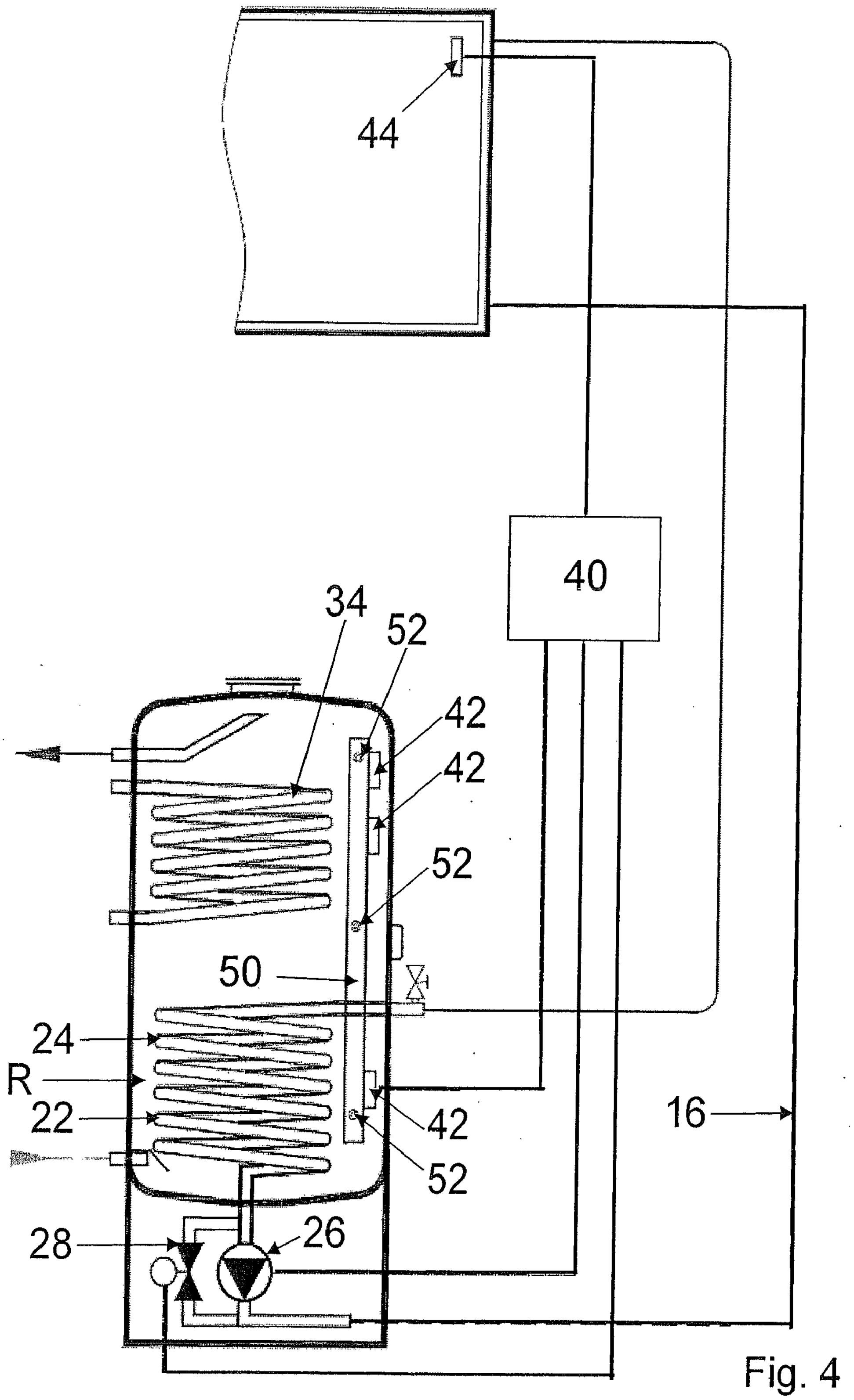


Fig. 4

SOLAR INSTALLATION

[0001] The invention relates to a solar installation as claimed in the preamble of claim **1**.

[0002] Typical solar installations have at least one solar collector which, for example, is arranged on a house roof and is connected via pipelines to a heat store. This is in general a vertical service-water tank, which contains a heat exchanger in the form of a pipe coil. In practice, the temperature is measured directly at the store, for example in the lower area of the solar heat exchanger. A pump which is arranged in the return line can be controlled as a function of the instantaneous temperature difference from the collector temperature.

[0003] If the solar radiation is sufficient, a regulator activates the pump, such that the medium which is located in the lines—generally water with antifreeze—circulates, thus transporting the heat absorbed by the collector into the tank. If the solar heat is not sufficient, then the pump is switched off, in which case the water located in the store can be raised to a desired temperature by conventional heating means, for example via a second heat exchanger. If overheating occurs, for example in hot summer or in the event of an electrical power failure, it is necessary to prevent solar liquid from being lost as a result of excess pressure. By way of example, a safety valve of suitable design is used as a self-protection device for this purpose.

[0004] In order to save physical components, for example a membrane expansion vessel, and also to allow heat carriers to be used without antifreeze, drain-back systems have been developed which allow the heat carrier medium to be fed back into a collecting container when the pump is not running, the inlet side of which collecting container is generally located upstream of the heat storage container. The emptied collector now contains only air; it is not filled with the medium again, and therefore cannot be used, until the pump is operated. Filling the collector circuit with the liquid heat carrier and with air means that, in the event of thermal expansion, an air cushion provides pressure equalization in the collecting container. Freezing and vaporization of solar liquid in the outer area are prevented when the solar liquid is emptied out of the collector when the pump is not running. In this case it is even possible simply to use water as the heat carrier medium, which has the advantage of a greater heat capacity and lower viscosity than glycol/water mixtures. However, this has the disadvantage that the design of the collector array is subject to various restrictions because of the requirements for filling and emptying, as well as uniform flow through it. A minimum gradient is required for the pipe system, as well as special pumps with a high feed rate and a small throughput, e.g. toothed-wheel pumps, whose operating noise can be highly disturbing. Furthermore, a return vessel is required approximately at the store height of the collector circuit inlet, which at the same time must be resistant to temperature and pressure, as well as having particular thermal insulation.

[0005] U.S. Pat. No. 4,574,779 describes a solar installation for warm water production, which has a drain-back device with a return section in combination with a heat exchanger. In this case, a store with a pipe coil at the top in a container and the return section vertically below it are separated by a horizontal separating wall. The pipe coil enters this from above into the return section, from which solar liquid is fed by means of a pump to the heat consumer or consumers. Solar installations such as these involve greater design complexity, because of the need for separation of the liquid systems.

[0006] DE-A-2 753 756 discloses a solar heating installation which is provided with an emptying and expansion vessel and is in the form of an open system. There is therefore a continuous connection to the atmosphere and, in a corresponding manner, the water level must be continuously monitored and added to in order that the heat exchangers for service water and heating water do not become dry. Furthermore, the corresponding components are subject to corrosion attacks.

[0007] One important aim of the invention is to overcome the abovementioned and further disadvantages of the prior art and to achieve improvements by economic means thus allowing a return flow (drain-back) and pressure equalization without an additional external vessel. Novel devices are furthermore intended to allow volume savings, to be capable of being manufactured cost-effectively and also to offer thermodynamic advantages which it has not been possible to achieve until now, specifically an increased heat flow density in the heat exchanging system. A further aim is that the heat storage container should have a longer life and should be better to manufacture.

[0008] The main features of the invention are specified in claim **1**. Refinements are the subject matter of claims **2** to **12**.

[0009] In a solar installation having a collector array which is connected by a forward line and a return line, in places in particular in the form of a line pair, to a heat exchanger of a heat storage container, with the return line having a pump, possibly with a bypass for it, and with a drain-back holding device being provided on the forward side or return side, the invention provides, as claimed in the characterizing part of claim **1**, that the drain-back holding device is located in the heat storage container and is physically combined with the heat exchanger, which is in the form of an integral pipe coil and has an expansion and return volume in its upper area. There is therefore no need for an external expansion vessel, that is to say in the forward line outside the store. The volume of the heat carrier medium is designed such that, when the pump is not running, the drain-back holding device is filled with it, but holds the displaced air during pump operation. When the temperature rises, this cushions the expansion of the heat carrier medium without the pressure increase associated with this leading to premature response of a safety valve.

[0010] A return collecting device has admittedly conventionally previously been arranged within a store, but as a specifically shaped appliance welded in upstream of the heat exchanger in the flow direction. In contrast, according to the invention, the return volume that is required is accommodated directly in the heat exchanger, as a result of which its lower area and its upper area merge seamlessly into one another. This design simplification as well as the use of pressure-resistant and temperature-resistant pipe material without any weld beads and without insulation results in particularly simple production with substantial savings in manufacture, and maintenance simplifications.

[0011] Claim **3** provides that a reheating heat exchanger is arranged above the pipe coil in the heat storage container, preferably coaxially with it, with respect to the container axis. This second heat exchanger is connected to a secondary heater in order to be used as a substitute heat source in the form of a bivalent store, if solar radiation fails or becomes weaker.

[0012] At least the lower pipe coil area can, according to claim **4**, contain devices for reducing the free flow cross section in the interior, for example one or more filling bodies. This improves the heat transfer. The total heat capacity is also increased if such filling bodies are composed of a material with high thermal capacity. While this contributes to long-term heat storage, the system responds, however, to temperature changes with somewhat more inertia.

[0013] Admittedly, hollow elastic inserts had been provided in heat exchanger pipes in an apparatus according to DE-A-3 315 280, which, as passive frost protection, allow water volume increases, and which are therefore intended to prevent heat exchanger pipes in a water cooler from bursting as a result of freezing. However, this has nothing to do with heat transmission.

[0014] Furthermore, a solar installation according to the invention makes it possible to provide for the pump to be a centrifugal pump which is arranged directly under the heat storage container and feeds downward.

[0015] In comparison to displacement pumps, centrifugal pumps have a longer life and produce less noise. Furthermore, flow can pass through them when they are stationary. When the pump is stationary, the solar liquid therefore passes automatically out of the collector back into the drain-back holding device.

[0016] However, cavitation noise can occur in centrifugal pumps, and the circulation of the storage medium can fail, with air entering the storage medium because the pump has not been vented and/or because the input-side water pressure is too low.

[0017] According to the invention, the return of the solar heat exchanger in the store is therefore preferably passed out at the bottom, and the pump is connected directly to it underneath the store, and is aligned such that it first of all feeds directly downward. This arrangement guarantees that, before each start, the pump is completely vented, and cavitation is successfully prevented. Furthermore, this pump arrangement results in as high a water pressure as possible on the inlet side, since the pump is located well below the heat exchanger.

[0018] A particularly advantageous refinement of the invention provides for a second pump to be arranged in the return line. The second pump on the one hand increases the pump power of the overall system, which is advantageous particularly in the case of a solar collector which is a long distance away and is located at a high level. Depending on how high the collector is installed above the heat storage container on the roof, a very high feed height can result for centrifugal pumps, which extends to the limit of their performance. In the case of height differences between the store and the collector of more than about 10 m, relatively small commercially available centrifugal pumps are no longer adequate. In order to make it possible to dispense with expensive displacement pumps in these situations as well, a second centrifugal pump is connected to the system in series, according to the invention. While the first pump is now arranged at the bottom, the second is preferably arranged with its pumping direction at the top, after the flow reversal at the store. The second pump is now subject to less stringent requirements to avoid cavitation, since the inlet side of the secondary pump is already supplied with an increased pressure from the first pump. The electrical drive power which is now required is, however, doubled.

[0019] The solar installation can be controlled particularly efficiently if the pumps are connected via a regulating device directly to the collector temperature sensor and to the store temperature sensor. The regulating device then in each case carries out the control function, and decides which of the pumps is operated at what power, depending on the temperature gradient.

[0020] In order to sustainably reduce the constant electricity consumption of the overall system, one embodiment of the invention provides that the two pumps run jointly only in the starting phase. As soon as the heat storage medium is circulating constantly, the communicating pipes throughout the system also result in a suction effect, thus considerably reducing the feed height power. The invention now provides that, after the starting phase, the second pump is switched off by means of the regulating device, in order to reduce the electricity consumption. The first pump then feeds the solar liquid to the solar collector through the second pump.

[0021] In one development of the solar installation according to the invention, the store temperature sensor is arranged above a sensor terminal strip on the outside of the heat exchanger container. Solutions are known from the prior art in which sensor sleeves are introduced into the heat storage container at a very specific height, through openings. Temperature sensors are then introduced into the heat storage container through these sleeves. This has the disadvantage that every opening must be created individually, and must be welded tight with the sleeve. In the case of enameled heat storage containers, these openings act as fault points which always represent a corrosion risk. These disadvantages are avoided with the development according to the invention with the arrangement of the sensor terminal strip.

[0022] The sensor terminal strip is composed of metal and is attached to the outside of the heat storage container via two small, welded-on threaded bolts. One or more store temperature sensors can then be fitted thereto at any desired height. This avoids potential leakage points on sensor sleeves, the height of the store temperature sensor can be chosen freely, and a plurality of sensors can be fixed to the terminal strip. This likewise avoids penetration in the store insulation, since the store temperature sensors are laid within the insulation of the heat storage container.

[0023] In the case of a solar installation having a solar collector which is connected by a forward line and a return line, in places in particular in the form of a line pair, to a heat exchanger of a heat storage container, with the return line having a pump, possibly with a bypass for it, in particular as claimed in one of claims **1** to **4**, independent claim **5** provides that the heat exchanger is or has a pipe arrangement which, according to the invention, is provided with means for reducing the free flow cross section. Because this results in a reduction in the solar liquid content, the upper part of the heat exchanger is sufficient to hold the expansion or return volume. Like the collector, the pipe arrangement may be a serpentine flat body or else, for example, a vertical heater battery, but is preferably in a helical form, with the helix axis running parallel to the axis of the container. This is because the cross section decreases in the pipe interior, as a result of which the pipe external diameter is constant and a uniform standard pipe can be used for manufacture. The bypass is used when the installation is a drain-back system and, at the same time, the pump is a displacement pump which shuts off when the return flow is stationary, preventing the collector from being emptied.

[0024] It is particularly advantageous if, as claimed in claim **6**, the pipe arrangement is a component of a pipe coil, which guides cylindrical or profiled filling bodies which therefore reduce the free pipe cross section, thus leading to an increased flow velocity and therefore to more turbulence in the pipe system. A pipe can also be used whose volume is reduced by profiling or cross-sectional reshaping. The increased turbulence results in an optimum heat transfer. At the same time, the required heat exchanger volume is less, but can be better utilized, because less heat carrier medium is required and, in the event of a temperature increase, its expansion volume is correspondingly small. There is therefore a considerable difference in comparison to a heat exchanger for sewage installations according to DE-U-1 967 260, which uses a helix composed of round or flat material for passing a heating medium along an inner pipe, which carries slurry, in the form of a helical line within an outer pipe arranged concentrically with respect to it, in order to achieve better heat transfer by extending the path length in this way.

[0025] As claimed in claim **7**, the filling bodies may have a standard, for example tubular, form thus allowing them to be produced easily and with advantageous characteristics, with low costs for manufacture and storage, specifically with a smooth surface which can slide well. As claimed in claim **8**, advantageous swirling is achieved by suitably shaped individual bodies which promote swirling, for example by means of a pipe which is also wound, singly, during heat-exchanger production. In particular, bodies such as these can be closed at the end.

[0026] The filling bodies, which can also be introduced into the heat exchanger retrospectively, can be fixed in the pipe coil or, as claimed in claim **9**, can be guided substantially concentrically therein. However, it is also possible to use eccentric arrangements and/or filling bodies which are not rotationally symmetrical.

[0027] Further features, details and advantages of the invention will become evident from the wording of the claims and from the following description of exemplary embodiments with reference to the drawings, in which:

[0028] FIG. **1** shows a layout of a solar installation according to the invention,

[0029] FIG. **2***a* shows a schematic plan view of a heat exchanger part,

[0030] FIG. **2***b* shows an enlarged partial side view of a pipe section of the heat exchanger from FIG. **2***a*, corresponding to the detail IIb,

[0031] FIG. **2***c* shows a pipe cross-sectional view relating to FIG. **2***b*,

[0032] FIG. **3** shows a layout of a solar installation with two pumps and a sensor terminal strip, and

[0033] FIG. **4** shows an alternative embodiment of a solar installation according to the invention.

[0034] As can be seen from the schematic overview in FIG. **1**, a solar installation which is annotated **10** overall has a collector array K which consists of two solar collectors **11**, **12** which, in the illustrated example, are in the form of serpentine absorbers. These are connected to a distribution line or bus line **15** which continues on the one hand as a forward path **14** and on the other hand as a return path **16** to a heat storage container **20**, in places in the form of a double-pipe pack **18**.

[0035] The heat storage container **20** contains a heat exchanger **22**, which may be a smooth-pipe helix with a vertical helix axis, and is connected at the bottom to the return path **16**, and at the top to the forward path **14**. The upper area of the heat exchanger **22** is in the form of a seamless transition as a drain-back holder **24**, with the elements **22**, **24** forming an integral pipe coil, which is annotated R overall.

[0036] A pump **26** is arranged in the return line **16** and can be bridged by a bypass **28** for the return flow of the heat carrier medium, which flows through the abovementioned components.

[0037] As is indicated by dashed lines, a further heat exchanger **34** can be arranged, in particular coaxially, above the pipe coil R in the heat storage container **20**. It is expediently connected via inlet and outlet lines (which are not illustrated) to a heating device (which is likewise not illustrated) in order to allow reheating in the form of a bivalent solar store when the solar radiation is relatively low.

[0038] As can be seen, the solar installation **10** has a closed collector circuit, which is filled predominantly with a heat carrier medium (line parts shown by thick lines) and partially with air (line and heat exchanger parts which are shown hollow). The volume of the liquid heat carrier medium is designed such that the helixes in the pipe coil R are approximately filled with the heat carrier liquid when the pump **26** is not running. As soon as the pump runs, the upper area **24** of the pipe coil R now holds the displaced air. An air cushion is thus formed which, because of its compressibility, compensates for the volume expansion of the heat carrier medium when the temperature rises. Even in the event of collector overheating, the volume of vaporized heat carrier liquid can be accommodated without the pressure increase leading to response for a safety valve, provided that the collectors are arranged horizontally and the solar liquid vapor pressure forces out the entire collector content, which at the same time prevents vaporization of relatively large amounts of solar liquid.

[0039] The pipe coil R is widened by a number of pipe turns, by means of the drain-back holder **24** which is plugged onto the heat exchanger **22**. This would intrinsically require a correspondingly greater amount of the heat carrier medium. In order to counteract this and at the same time to improve the heat transfer, the invention provides that means for reducing the cross section are provided at least in the lower area of the pipe coil R, that is to say in the heat exchanger **22**, for example—as is shown in FIGS. **2***a* to **2***c*—one or more moving filling bodies **30** and/or fixed installed parts in the pipe interior **32**. A tubular body, for example, or a sequence of individual bodies can be provided, which can also be introduced retrospectively into the pipe coil R and, if required, can be fixed in it. In the example in FIG. **2***b*, a number of cylindrical filling bodies **30** are provided in the interior **32** of the pipe arrangement and are located one behind the other, at a distance from the pipe walls. This reduces the free flow cross section in the pipe mainly in edge areas, as a result of which the flow velocity in the remaining circumferential gap is increased and, at the same time, swirling is produced in a manner known per se.

[0040] The filling bodies **30** are, in particular, closed at the end and are provided with a smooth surface. If they each consist of a pipe piece, then the desired volume displacement is achieved by this pipe piece being closed at both ends or open at one end, but being filled with air which additionally buffers the thermal expansion. The filling bodies **30** may be composed of a material with a high thermal capacity. If they have a profile, for example with radial webs or vanes, this allows or assists preferred concentric guidance in the pipe interior **32**, as is indicated in FIG. **2***c* (with radial supports being omitted). However, provision is also made for the filling bodies **30** to be guided eccentrically in the pipe interior **32** (FIG. **2***b*). Alternatively, it is also possible for the pipe coil to be flattened at defined points, thus likewise increasing the contact area with the storage medium.

[0041] The invention is not restricted to any of the embodiments described above but can be modified in many ways. For example, the nature, arrangement and number of the collectors **11**, **12** can be varied, as can hydraulics connected thereto. Furthermore, individual pipes can be provided instead of the double pipe guidance. The lines **14**, **15**, **16** may, for example, be laid in situ as copper pipes. A pump bypass **28** is not required for all applications.

[0042] When the pump is stationary, it is desirable for air to rise in the forward path **14**. During pump operation, air is prevented from rising therein by the high flow velocity of the heat carrier medium in the collector circuit. Moving filling bodies **30** are held against the dynamic pressure of the flowing liquid in the pipe arrangement by means, for example, of a lower grid insert (which is not shown). Floating up is prevented by the specific gravity of the filling bodies **30** or by suitable design measures.

[0043] Tubular individual bodies **30** can also be incorporated even during the production of the heat exchanger **22**, by winding of the pipe turns. If the filling bodies **30** have a spherical shape, then they can conveniently be wound into the complete pipe coil R.

[0044] As can be seen, one preferred form of a solar installation **10** with a collector array K and a heat storage container **20** has a drain-back holding device **24** on the forward side or return side which, according to the invention, is integrated with a heat exchanger **22** located in the storage container **20**, in that its upper area has an expansion and return volume. An integral pipe coil R is advantageous, particularly a smooth-pipe helix with a uniform gradient. Furthermore—as in the case of bivalent solar stores—a second reheating heat exchanger **34**, which is coaxial with it with respect to the container axis, can be provided. At least in the lower area of the pipe coil R, that is to say in the heat exchanger **22**, means are provided for reducing the free flow cross section in the pipe interior **32**, specifically cylindrical or profiled, preferably moving, filling bodies **30**. In particular, these may be composed of a material of high thermal capacity, for example of steel, stone, ceramic or the like. The filling bodies **30** are expediently individual bodies with a standard form, which in particular promotes swirling. A single filling body **30** is also possible, for example a steel pipe which is closed at the end.

[0045] In addition to the features known from FIG. **1**, FIG. **3** shows a second pump **27**. The figure also shows that both pumps **26**, **27** are connected via a regulating device **40** to the collector temperature sensor **44** and to the store temperature sensors **42**. The store temperature sensors **42** are in this case arranged on a sensor terminal strip **50**. The sensor terminal strip is attached to the heat storage container **20** by means of three threaded bolts **52**. The sensor terminal strip **50** is in this case also located, together with the store temperature sensors **42**, within the insulation. The pump **26** is a centrifugal pump which is arranged directly under the heat storage container, and feeds downward. The second pump **27** feeds upward, and is likewise in the form of a centrifugal pump.

[0046] FIG. **4** shows a modification of the solution shown in FIG. **3**. In this case, the pump **26** is in the form of a displacement pump. The bypass **28** is therefore provided, and is likewise connected to the regulating device **40**.

[0047] All the features and advantages, including design details, spatial arrangements and method steps, which are mentioned in the claims, the description and the drawings may be significant to the invention both in their own right and in the most widely differing combinations.

LIST OF REFERENCE SYMBOLS

[0048] K Collector array
[0049] R Pipe coil
[0050] **10** Solar installation
[0051] **11**, **12** Solar collectors
[0052] **14** Forward line
[0053] **15** Distribution/collecting line
[0054] **16** Return line
[0055] **18** Line pair
[0056] **20** Heat storage container
[0057] **22** Heat exchanger/lower area
[0058] **24** Drain-back holder/upper area
[0059] **26** Pump
[0060] **27** Second pump
[0061] **28** Bypass
[0062] **30** Filling body
[0063] **32** Pipe interior
[0064] **34** Reheating heat exchanger
[0065] **40** Regulating device
[0066] **42** Store temperature sensor
[0067] **44** Collector temperature sensor
[0068] **50** Sensor terminal strip
[0069] **52** Threaded bolt

1. A solar installation (**10**) having a collector array (K) which is connected by a forward line (**14**) and a return line (**16**), in places in particular in the form of a line pair (**18**), to a heat exchanger (**22**) of a heat storage container (**20**), with the return line (**16**) having a pump (**26**), possibly with a bypass (**28**) for it, and with a drain-back holding device (**24**) being provided on the forward side or return side, wherein the drain-back holding device (**24**) is located in the heat storage container (**20**) and is physically combined with the heat exchanger (**22**), which is in the form of an integral pipe coil and has an expansion and return volume in its upper area.

2. The solar installation as claimed in claim **1**, wherein the pipe coil (R) is a smooth-pipe helix with a uniform gradient.

3. The solar installation as claimed in claim **1**, wherein a reheating heat exchanger (**34**) is arranged above the pipe coil (R) in the heat storage container (**20**), preferably coaxially with respect to it.

4. The solar installation as claimed in claim **1**, wherein at least the lower area of the pipe coil (R) contains devices for reducing the free flow cross section in the interior, for example one or more filling bodies (**30**).

5. The solar installation as claimed in claim **1**, wherein the pump (**6**) is a centrifugal pump which is arranged directly under the heat storage container and feeds downward.

6. The solar installation as claimed in claim **1**, wherein a second pump (**27**) is arranged in the return line (**16**).

7. The solar installation as claimed in claim **1**, wherein the pumps (**26**, **27**) are connected via a regulating device (**40**) to the collector temperature sensor (**44**) and to at least one store temperature (**42**).

8. The solar installation as claimed in claim **1**, wherein the store temperature sensor (**42**) is arranged above a sensor terminal strip (**50**) on the outside of the heat exchanger container (**20**).

9. The solar installation as claimed in claim **1**, wherein the heat exchanger (**22**) is or has a pipe arrangement which is provided in its interior (**32**) with means for reducing the free flow cross section.

10. The solar installation as claimed in claim **9**, wherein the pipe arrangement is a component of a pipe coil (R), which guides cylindrical or profiled filling bodies (**30**) in the interior (**32**), at least in its lower area (**22**).

11. The solar installation as claimed in claim **10**, wherein the filling bodies are in a standard, for example tubular, form.

12. The solar installation as claimed in claim **10**, wherein the filling bodies (**30**) are individual bodies which in particular are closed at the end and promote swirling.

13. The solar installation as claimed in claim **10**, wherein the filling bodies (**30**) are guided substantially concentrically in the pipe coil (R).

* * * * *