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(54) DEVICE FOR EXCHANGING THERMAL ENERGY BETWEEN A HEAT SOURCE AND A SECOND MEDIUM AND METH-OD FOR OPERATING SUCH A DEVICE

(57) The present invention relates to a Device (101, 102) for exchanging thermal energy between at least one heat source (14) and a second medium (M2), comprising a circuit pipe (12) fortransporting a first medium (M1), at least one heat source (14) for heating the first medium (M1), a tank (16) for storing a second medium (M2), preferably domestic water, a first heat exchanger (22) arranged in the circuit pipe (12) and in and/or on the tank (16) for transferring heat from the first medium (M1) to the second medium (M2) in the tank (16), a second heat exchanger (24) arranged in the circuit pipe (12) and in and/or on the tank (16) for transferring heat from the first medium (M1) to the second medium (M2) in the tank (16), wherein the device is configured such that selectively in an operation mode of the device (101, 102) one of the heat exchangers (22, 24) transfers heat from the first medium (M1) to the second medium (2) or in another operation mode of the device (101, 102) the first heat exchanger (22) and the second heat exchanger (24) transfer heat from the first medium (M1) to the second medium (M2).

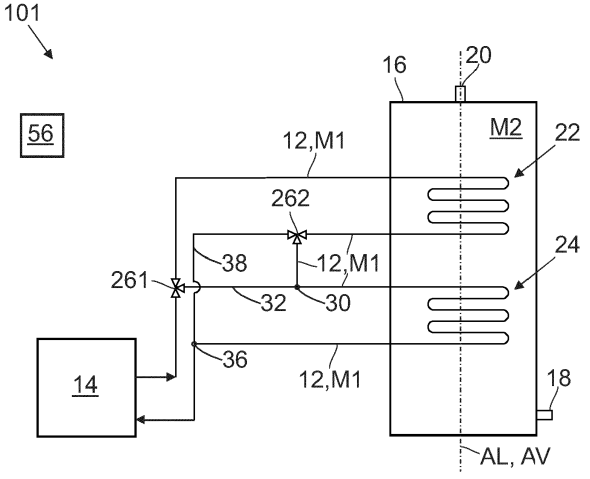


Fig.1

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Description

[0001] The present invention relates to a device for exchanging thermal energy between a heat source and a second medium. Moreover, the present invention is drawn to a method for operating such a device.

[0002] A typical device for exchanging thermal energy is a domestic heating system of a building. The heating system comprises a circuit pipe along which a heat transfer medium can be transported. In a burner, the heat transfer medium, for example, water or a refrigerant, is heated, in most cases by burning fossil fuel like oil or gas. A heat exchanger is arranged inside a tank in which another heat transfer medium, almost always water, is heated. However, other fluids may be used as heat transfer medium. The heated water may be used for domestic purposes, e.g., in the kitchen or bathroom. Alternatively the heated water may be pumped through radiators for heating the air of the rooms of the housing.

[0003] In the pursuit of reducing the CO2-emissions which are to a large extent caused by such heating systems, one strives for not only to use the chemical energy bound in fossil fuels, but also other forms of energy, in particular renewable energy. Examples of renewable energy may be electrical energy generated by photovoltaic panels or wind turbines. Heat pumps transfer thermal energy e.g., from the surrounding air or soil, to a destination medium, is also considered as a renewable energy technology.

[0004] However, the named forms of renewable energy are not always available in the needed extent. Depending on the weather conditions, the solar radiation may be weak and the wind may be weak. In particular in winter and depending on the geographical location, the time the sun is shining is short. Moreover, the heat that can be extracted from the surrounding air and soil is low in winter. At the same time, in winter the demand for hot water is usually higher than in summer. To reliably fulfil the demands for hot water, several forms of energy must be used. For this purpose, several heat exchangers are arranged in the tank. Each heat exchanger is connected to its own heat source and is interacting with the same tank such that several forms of energy can be used to heat the respective heat transfer medium.

[0005] However, although the demand for hot water can roughly be estimated based on empirical values that reflect the habits of the residents living in a given house, the supply in particular of the renewable energy is almost impossible to predict. As a consequence, the heat transfer from the heat transfer medium to the water in the tank cannot be conducted in an optimized way.

[0006] An energy storage installation is disclosed in EP 3 404 334 A1.

[0007] It is an object of the present invention to provide a device and a method by means of which a thermal energy exchange between a heat source and a second medium can be optimized.

[0008] The object is solved by the subject matter of claim 1 and the method of claim 11. Advantageous embodiments are the subject of the dependent claims.

[0009] According to an embodiment of the present invention a device for exchanging thermal energy between a heat source and a second medium is provided wherein the device comprises

- a circuit pipe for transporting a first medium,
- at least one heat source for heating the first medium,
- a tank for storing a second medium, preferably water, more preferably domestic water,
- a first heat exchanger arranged in the circuit pipe and in and/or on the tank for transferring heat from the first medium to the second medium in the tank,
- a second heat exchanger arranged in the circuit pipe and in and/or on the tank for transferring heat from the first medium to the second medium in the tank, wherein
- the device is configured such that selectively in an operation mode of the device one of the heat exchangers transfers heat from the first medium to the second medium or in another operation mode of the device the first heat exchanger and the second heat exchanger transfer heat from the first medium to the second medium.

[0010] The first medium is used to transfer the heat provided by the heat source to the second medium which is typically water. The second medium can be transported via pipelines e.g., to a shower or to a water tap in case of domestic hot water production, or to heat emitters such as radiators in case of primary water. The heat source may be designed such that different forms of energy can be processed, i.e., the heat source can be powered by energy stemming from different energy sources, and the obtained heat transferred to the first medium. However, the technical effects presented in the following can at least partially also be obtained if only one form of energy is processed in the heat source.

[0011] The fact that at least two heat exchangers are provided in the tank, the second medium, in particular water, to be heated can be subdivided into different sections which can be heated independently of each other and depending on the current demand, in particular of the hot water. Due to the fact that the density of the second medium, in particular water, is dependent of the medium temperature, hotter medium, in particular water, is arranged on the top of the tank whereas colder medium, in particular water, is arranged at the bottom of the tank. Thus, there is temperature gradients inside the water in the tank.

[0012] In the operation mode either the first heat exchanger or the second heat exchanger transfers heat from the first

medium to the second medium. That means, in the operation mode the first medium flows through only one of the heat exchangers, namely the heat exchanger by means of which the heat is transferred to the second medium. In the other operation mode, both heat exchangers transfer heat from the first medium to the second medium, respectively. In the other operation mode the first medium flows through both heat exchangers. As is explained below more in detail, the device can have one or more switching element by means of which the device can be configured to be operated selectively in the operation mode or in the other operation mode. Thus, the heat exchanger can be used for conducting the heat exchange in the optimal part of the tank, where the temperature of the water is the optimal one to perform the most efficiency heat exchange with the heat transfer medium. Moreover, both heat exchangers can be used if a high demand for warm water is detected.

[0013] The first and second heat exchanger are connected to the heat source. The term "connect" may be understood such that a fluidical connection is established by the respective connection, thereby enabling e.g., the first medium to be transported to the heat source and/or the first heat exchanger and/or the second heat exchanger.

[0014] Due to the fact that different forms of energy can be processed in the heat source, the choice which heat exchanger is used for the transfer of heat from the first medium to the second medium can be made independent of which form of energy is available. In other words, the selection of the operation mode of the device and/or of the heat exchanger by means of which heat is transferred from the first medium to the second medium can be dependent on the type of heat source, in particular on the energy source used in the heat source. Thus, the efficiency of the heat exchange process can be enhanced.

[0015] According to another embodiment the device comprises at least one switching element arranged in the circuit pipe for directing the first medium through the first heat exchanger and/or the second heat exchanger. The use of a switching element facilitates the choice which heat exchanger is used for transferring the heat from the first medium to the second medium. Thus, by using at least one switching element the operation mode of the device can be easily set. It is noted that the switching element may be arranged inside or outside the heat source or other components of the device. When arranged inside the heat source, the switching element does not form a separate unit located outside the heat source.

[0016] In a further embodiment the device comprises a first switching element that is embodied as a first three-way valve, wherein

- the first three-way valve is arranged between heat source and the first heat exchanger and/or
- the circuit pipe comprises a first branch point between the first heat exchanger and the second heat exchanger and/or
- the device comprises a first bypass line connecting the first three-way valve and the circuit pipe at the first branch point.

[0017] The use of a three-way valve enables a flexible employment of one or both of the heat exchangers. In this embodiment, the first heat exchanger can be bypassed by a respective setting of the first three-way valve. The first three-way valve also offers the possibility to completely stop the flow in the circuit pipe. The term "between" is to be understood as to refer to the flow path. However, the first three-way valve may also be integrated in the heat source or another component of the device and thus not form a separate unit that is arranged between the heat source and the first heat exchanger.

[0018] In another embodiment the device comprises a second switching element that is embodied as a second three-way valve, wherein

- the second three-way valve is arranged between the first heat exchanger and the second heat exchanger and/or
- the circuit pipe comprises a second branch point between the second heat exchanger and the heat source and/or
- the device comprises a second bypass line connecting the second three-way valve and the circuit pipe at the second branch point.

[0019] In this embodiment the second heat exchanger can be bypassed. Both the first three-way valve and the second three-way valve can be included into a control cycle so that by means of a control unit the heat exchanger can be employed in consideration of several parameters, in particular the energy source used and water requirements

A further embodiment is characterized in that the first branch point is arranged between the first switching element and the second heat exchanger. This arrangement offers the possibility to use both heat exchangers at the same time if needed. In case a high demand for hot water is present, the time for delivering the water of the desired temperature may be reduced. Furthermore, when the energy available at the source is important, using two heat exchangers enables a greater quantity of energy to be transferred than with a single exchanger. This case is particularly suitable in the case of a variable energy source, in particular a renewable one, such as the use of a solar thermal panel and/or a solar photovoltaic panel. The aim is to consume as much of this available energy as possible in order to make the most of it at very limited cost and with very low or zero energy costs. This significantly increases the energy performance of the heating system.

[0020] According to another embodiment a third heat exchanger is arranged in the circuit pipe and in or on the tank for transferring heat from the first medium to the second medium in the tank. The third heat exchanger can be arranged

between the first heat exchanger and the second heat exchanger in the circuit pipe. As mentioned, there will almost always be a temperature gradient within the water in the tank. The temperature gradients are usually bigger the bigger the tank and thus the higher the volume of the water stored therein. Thus, the employment of three heat exchangers increases the probability to carry out the heat exchange at an area of high temperature difference.

[0021] In a further embodiment the device comprises a third switching element that is embodied as a third three-way valve, wherein

- the third three-way valve is arranged between the second heat exchanger and the third heat exchanger and/or
- the second bypass line comprises a third branch point between the second three-way valve and the second branch point and/or
- the device comprising a third bypass line connecting the third three-way valve and the second bypass line at the third branch point.

[0022] In this embodiment, it is possible not only to use one of the three heat exchangers, but one heat exchanger or two heat exchangers. The temperature gradients present in the water at a given time can be even better considered for an effective heat transfer.

[0023] A further embodiment is characterized in that the device comprises a fourth switching element that is embodied as a fourth three-way valve, wherein

- the fourth three-way valve is arranged between the second branch point and the third branch point in the second bypass line and/or
- the circuit pipe comprises a fourth branch point between the third three-way valve and the second heat exchanger and/or
- the device comprising a fourth bypass line connecting the fourth three-way valve and the circuit pipe at the fourth branch point.

[0024] In this embodiment, even more combinations of which heat exchangers can be used in the heat transfer can be implemented.

[0025] According to another embodiment the device comprises a fifth switching element that is embodied as a fifth three-way valve, wherein the fifth three-way valve is arranged between heat source and the first three-way valve in the circuit pipe and/or the device comprising a fifth bypass-line connecting the fourth three-way valve and the fifth three-wav valve.

[0026] In this embodiment, even more combinations of which heat exchangers can be used in the heat transfer can be implemented.

[0027] In the end a device can be provided which comprises several operation modes wherein the operation modes differ from each other in the heat exchanger or heat exchangers used for transferring heat from the first medium to the second medium and the number of heat exchangers used for transferring heat from the first medium to the second medium. This operation modes can be easily set by using one or more switching elements.

[0028] In a further embodiment

- the tank defines a vertical axis and comprises
- an inlet for introducing the second medium into the tank,
- an outlet for removing the second medium from the tank,
- the first heat exchanger and the second heat exchanger being arranged spaced from each other with reference to the vertical axis.

[0029] Although a temperature gradient may be established along all directions within the water in the tank, due to convection the most pronounced temperature gradient will be formed along the vertical axis, mainly due to the temperature dependency of the water density. In the absence of disturbances, the water of highest temperature does not mix with water of lower temperature and is positioned at the top of the tank. As a result, in a stabilized heating regime, the hot water accumulates above and at the level of the lowest active heat exchanger. Below this level, there is only unheated water. This phenomenon is also known as stratification. The arrangement of the heat exchangers according to this embodiment takes advantage of the temperature dependency of the water density, thereby enabling an efficient heat transfer between the first medium and the second medium.

[0030] In this embodiment, it is possible to limit the production of hot water to the volume only positioned at and above the lowest active heat exchanger. This avoids an overproduction of hot water and therefore avoids a thermal dissipation of the produced energy.

[0031] In the arrangement according to this embodiment, existing devices may be used for the implementation of the present invention with only small or no modifications.

[0032] In another embodiment the device comprises a control unit for controlling the operation of the device. The choice which operation mode is selected and, thus, which heat exchanger is employed can be based on measuring data that may be collected from sensors and/or based on simulation models. Moreover, the control unit may consider the demand for hot water and decide which and how many heat exchangers should be employed in particular by a respective actuation of the first switching element and the second switching element. The control unit will also manage the flow rate inside the circuit pipe and will activate the adequate pump of the heat source accordingly.

[0033] A further embodiment is characterized in that the heat source comprises at least one heat pump and/or at least one boiler and/or a domestic heating system of a house and/or a solar thermal panel. The heat pump can comprise a heat back up. Additionally or alternatively the second medium can be water and/or the at least one opening of outlet tube of the tank can be arranged above or at the same level as the first heat exchanger with reference to the vertical axis. With "opening" an inlet opening of the outlet tube is meant. The inlet opening is the opening through which the second medium can flow into the outlet tube. An outlet opening of the outlet tube can also be arranged above or at the same level as the first heat exchanger with reference to the vertical axis. Alternatively, it is possible that the outlet opening is arranged below the first heat exchanger with reference to the vertical axis. In domestic applications, the demand for hot water is very pronounced. Thus, the use of water as the second medium is favorable. As noted, the hot water accumulates at the top of the tank. The arrangement of the outlet at the same level as or above the first heat exchanger makes it possible to withdraw the hottest water portion without the need to stir the water to reach a homogenous temperature.

[0034] Another aspect of the invention is directed towards a method for operating a device according to one of the embodiments previously discussed, the method comprising the steps of

- filling the tank with the second medium via the inlet such that heat can be transferred from the first medium to the second medium ,
- warming up the first medium by the heat source,
- circulating the first medium along the circuit pipe such that
    - o the first medium is flowing through the first heat exchanger only, or
    - o the first medium is flowing through the second heat exchanger only, or
    - o the first medium is flowing through the first heat exchanger and the second heat exchanger, and
- removing at least a part of the second medium from the tank via the outlet.

[0035] The technical effects and advantages as discussed with regard to the present device to a large extent also apply to the method. Briefly, the device for exchanging thermal energy between a heat source and a second medium can be operated such that on the one hand the demands for hot water can promptly be satisfied and on the other hand the heat transfer between the first medium and the second medium, in this case water, can be conducted very efficiently and in an optimized way. This approach also makes it possible to adapt operating modes in order to limit heat loss from the storage tank, and to consume available energies in the most appropriate way, depending on their availability and type (green or not, storable or not, cost, temperature, to name a few).

[0036] The following additional operating mode may be implemented: The first medium can bypass all of the heat exchangers and may flow in a circuit. Hereby, it is avoided to cool the tank if the heat pump is defrosting.

[0037] In another embodiment in which the second medium is water, the method comprises the steps of

- setting a warm water demand based on previous demands using the control unit,
- choosing the operation mode by the control unit according to the set warm water demands.

[0038] By using a control unit the choice of which heat exchanger can be used can be based on measuring data provided by sensors and/or based on simulation models. In particular, a self-learning algorithm may be employed that considers the previous demands. Moreover, the demands for warm water can be considered in the choice which and how many heat exchangers should be used. This solution therefore allows the production of hot water and the heating time and the energy consumption according to the needs of the consumer. The device adjusts itself based on previous demands. It may even not be necessary that the user actively inputs his or her warm water demands into the control unit, which is, however, not excluded.

[0039] In another embodiment the second medium is primary water.

[0040] According to a further embodiment the step of setting the warm water demand is based

- on the volume and the temperature of previous warm water demands and/or
- the kind of energy currently processed in the heat source and/or
- on the temperature of the medium which is used by the heat source to transfer heat.

[0041] The volume and the temperature are relevant parameters to set the warm water demand. A predictive setting can be implemented.

[0042] As initially mentioned, the heat source can be designed such that different forms of energy can be processed, i.e., supplied by solar thermal panels, which can be considered in the setting of the warm water demand to ensure that the hot water demands can reliably be served. In addition, the nature of the heat source can affect energy consumption. If an energy source is available in quantity and free of charge, such as water heated by thermal solar panels, it is preferable to consume it as much as possible while it is available to improve the energy performance of the heating system. In particular, when using thermal solar panels, it is preferable to maximize energy consumption and operate as many heat exchangers as possible depending on the power available.

[0043] The present invention can be summarized as follows:
A domestic hot water tank (DHW-tank) is needed to provide hot water in a certain time (heating time criteria). The heating time depends on water volume to be heated and the available heat power. High heat power is required to match tight heating time criteria. Several heat exchangers allow a modification of the volume of water to heat in the tank and the associated heating time and provide more choices of hot water heating control. The entire tank could be heated with full heat power to respect the time criteria The upper part can be heated separately of the bottom part of the tank. Approximately half of the tank could be heated with approximately half the heat power at the same heating time. Alternatively, approximately half of the tank could be heated with full heat power at approximately half the heating time.

[0044] The use of the device according to the present invention offers more freedom of control. The consumed heat power could be reduced while still ensuring comfort. A lower heat power generally allows higher energy saving performances. Lower heat power systems are generally cheaper. A lower heat power reduces the load on the energy network.

[0045] Hot water consumption is typically higher during the day than during the night. During night time, hot water stored in the tank loses heat. In some cases, hot water may be produced in the evening. If there is only one heat exchanger in the tank, all the water will be heated. Several heat exchangers allow more flexibility for a control and allow the heating of the right volume at the right time. The less hot water in the tank the less the heat losses. By using the inventive device, heat losses can be reduced.

[0046] The same is true regarding the temperature: The less the temperature difference between hot water and ambient air of the device, the less thermal dissipation. So it may be better to store the same amount of energy in a given volume at lower temperature than in a smaller volume at higher temperature. For example, one could choose to store 2 liter of water at 40°C instead of 1 liter at 60°C to have lower thermal dissipation and so lower energy lost acting on the assumption than ambient air and cold water is 20°C so approximatively the same energy is comprised in the water at 60°C as twice the same volume at 40°C.

[0047] Water tanks are highly effective energy storages but have a low energy efficiency. Energy storage efficiency is higher than the efficiency for heat pump application. The low exergy efficiency is caused by difficulties in using the energy stored other than for heat applications. Most of the energies have variating costs (financial or CO2-related). Renewable energy is not always available. Heat pumps have better performance during the day (air temperature higher during the day) than at night because the source medium is usually hotter in day than night, providing more accessible calories. One heat exchanger will heat all the water and the storage capacity will be fully used. Using several heat exchangers allow to keep a cold volume to heat when the energy is the most cost effective. This approach also allows for a better adjustment of the temperature and the volume of hot water in a single water tank depending on the water demands and the available energy source.

Example: heat the bottom of the tank only with renewable energy.
Example: pre-heat the bottom of the tank with low temperature application system (fatal heat recovery).
Example with heat pump: heat only the top of the tank at night and all the tank at day.

[0048] As a result, the energy storage efficiency can be increased and the energy costs reduced.

[0049] The greater the coil area of the heat exchanger, the greater the heat exchange efficiency. Heat pump performance depends on temperature difference between the source and the application. The greater the heat exchanger efficiency, the better the heat pump performance. It is more efficient to heat a cold volume and hot volume separately than to heat a mixed volume of uniform temperature. However, if a cold volume is heated, it is thereby converted into a hot volume. If a higher temperature is needed which the heat pump cannot reach or only with a very low efficiency, one may switch to another energy source and heat the hot volume to a "very hot" volume.

[0050] In a very particular case "instantaneous need / fast reload" an electrical or hydraulic backup may be used to provide high temperature that may be transferred in the first heat exchanger only.

[0051] Depending on the energy, the maximal temperature of the first medium can differ. For example, a higher temperature is used with a burner, a thermal solar panel or with an electric heater than with most of the heat pumps. One may have an update of the temperature of the water (as the second medium) inside the tank depending on the temperature

of the first medium. For example, one relevant approach is to use thermal energy from thermal solar panel, because it is cost-efficient, and it will be lost if not used. One option may be to transfer as much energy as possible inside the tank, starting with the top of the tank to have enough hot water at 40°C to fulfill potential hot water demands. Then, the bottom of the tank at 40°C is heated to have the full volume heated at 40°C (low temperature = better heat exchange performance and lower thermal dissipation). After that, if there is still available free hot water from solar panel, the entire water in the tank may be heated at a higher temperature (as much as possible while it's compliant with tank specification). Thus, not only the volume is taken into account but also the temperature of the medium and the source of energy.

[0052] The market tendency is to have one heat exchanger with a long coil in tanks taking a large proportion of the tank's height. A bigger heat transfer area breaks the water stratification. Using at least two heat exchangers allows for firstly heating the bottom water until it reaches the temperature of the top water and then heating the upper tank with a greater heating area. This leads to an optimized heating.

[0053] Reference will now be made in detail to the present exemplary bodies of the disclosure, example of which are illustrated in the accompanying drawings, wherein

Figure 1 shows a first embodiment of a device for exchanging thermal energy between a heat source and a second medium,

Figure 2 shows the device of Figure 1 in a first operating mode,

Figure 3 shows the device of Figure 1 in a second operating mode,

Figure 4 shows the device of Figure 1 in a third operating mode,

Figure 5 shows the device of Figure 1 in a fourth operating mode, and

Figure 6 shows a second embodiment of a device for exchanging thermal energy between a heat source and a second medium,

[0054] Figures 1 to 6 being of principle nature.

[0055] Figure 1 shows a principle drawing of a first embodiment of a device 101 for exchanging thermal energy between a heat source 14 and a second medium M2. The device 101 comprises a heat source 14 which may interact with or comprise at least a heat pump, a burner or boiler of a domestic heating system, solar thermal panels or combinations thereof. A circuit pipe 12 starts from the heat source 14 and connects the heat source 14 with a first heat exchanger 22. The circuit pipe 12 further connects the first heat exchanger 22 with a second heat exchanger 24 and the second heat exchanger 24 with the heat source 14. In other words, both the first heat exchanger 22 and the second heat exchanger 24 are connected to each other and to the heat source 14 by the circuit pipe 12. A first medium M1 can thus be transported through the circuit pipe 12 from the heat source 14 to the first heat exchanger 22, from the first heat exchanger 22 to the second heat exchanger 24 and from the second heat exchanger 24 back to the heat source 14. The first medium M1 may be a liquid, in particular water, preferably primary water. Alternatively, the first medium M1 can be water with glycol. In such a first medium M1 it is prevented that the water freezes.

[0056] The first heat exchanger 22 and the second heat exchanger 24 are arranged in a tank 16 in which the second medium M2 can be stored. In this case the second medium M2 is water, preferably domestic water. The tank 16 defines a longitudinal axis AL. With reference to the intended use of the device 101, the longitudinal axis AL of the tank 16 coincides with the vertical axis AV. The first heat exchanger 22 and the second heat exchanger 24 are arranged space apart from each other along the longitudinal axis AL and with reference to the orientation of the tank 16 in its intended use also spaced apart from each other along the vertical axis AV. The first heat exchanger 22 is arranged above the second heat exchanger 24 with reference to the vertical axis AV.

[0057] The tank 16 comprises an inlet 18 and an outlet 20. The second medium M2, as mentioned in this case water, can be introduced into the tank 16 via the inlet 18 and removed from the tank 16 via the outlet 20. The inlet 18 and the outlet 20 are spaced from each other with reference to the longitudinal axis AL of the tank 16. Referring to the vertical axis AV the inlet 18 is arranged at or near the bottom and the outlet 20 is arranged at or near the top of the tank 16.

[0058] A first switching element 261 is arranged in the circuit pipe 12 between the heat source 14 and the first heat exchanger 22. In the first embodiment of the device 101 the first switching element 261 is a first three-way valve. A second switching element 262 is arranged in the circuit pipe 12 between the first heat exchanger 22 and the second heat exchanger 24. In the first embodiment of the device 101 the second switching element 262 is a second three-way valve.

[0059] It should be noted that the device 101 may also be equipped with the first switching element 261 or the second switching element 262 and not necessarily the combination of the first and the second switching element 261, 262 without compromising the core function of the device. However, when using only one of the switching elements 261, 262, the

device 101 may be operated with less efficiency which may be acceptable depending on the application.

[0060] The circuit pipe 12 comprises a first branch point 30 and a second branch point 36. The first branch point 30 is located between the first heat exchanger 22 and the second heat exchanger 24, more precisely between the second switching element 262 and the second heat exchanger 24. The second branch point 36 is arranged between the second heat exchanger 24 and the heat source 14.

[0061] A first bypass line 32 connects the first switching element 261 and the first branch point 30. A second bypass line 38 connects the second switching element 262 and the second branch point 36.

[0062] The device 101 is further provided with a control unit 56 by which the operation of the device 101 can be controlled. Moreover, a user may input individual settings into the control unit 56 via an interface (not shown), in particular regarding the temperature of the water and the time when the water of the desired temperature should be available. The control unit 56 is communicating in particular with the first switching element 261 and/or the second switching element 262, either via electrical lines (not shown) or wirelessly. Alternatively or cumulatively, the control unit 56 may be set up such that it learns from the previous volume and temperature demands of the consumer in consideration of the heat source that is currently employed and/or is dependent of the energy source nature.

[0063] Figure 2 shows the device 101 according to the first embodiment in a first operation mode in which the tank 16 is almost completely filled with the second medium M2. Bold lines visualize the flow of the first medium M1 inside the device 101. Inside the heat source 14 heat is transferred to the first medium M1. The heat may be delivered by one or more energy sources (not shown). The heated first medium M1 is transported e.g., by a pump (not shown) into the circuit pipe 12. The first switching element 261 is set such that the first medium M1 is flowing to the first heat exchanger 22, while the second switching element 262 is set such that the first medium M1 leaves the circuit pipe 12 at the second three-way valve, enters the second bypass line 38 and reenters to the circuit pipe 12 at the second branch point 36.

[0064] As a result, the first medium M1 is only running through the first heat exchanger 22. Heat is transferred from the first medium M1 to the water at the same level of and above the first heat exchanger 22 only. The upper portion of the water Wh is heated, while the lower portion of the water Wc is not heated. A given heat quantum exchanged in the first heat exchanger 22 is therefore introduced into a relatively small volume of the water in the tank 16, which is, however, heated up fairly extensively. The first operation mode shown in Figure 2 can thus be considered as a "booster mode" in which a small volume of high-temperature water Wh is needed, e.g., for having a shower within a short time. The high-temperature water Wh is removed from the tank 16 via the outlet 20 and fresh but low-temperature water is introduced via the inlet 18 to keep the volume of water in the tank 16 constant. This specific mode can also be considered as a "low-volume mode", when only a part of the water needs to be heated instead of the whole volume of the tank 16. This specific operating mode makes particularly sense if the daily hot water consumption is not constant and associated with changes in the number of users or occupants at the place of installation of the device 101. This operating mode can apply when there is a limited number of users compared to maximum number of users.

[0065] Figure 3 shows a second operation mode wherein the first switching element 261 is set such that the first medium M1 leaves the circuit pipe 12 at the first switching element 261, exist the first bypass line 32 and returns to the circuit pipe 12 at the first branch point 30. The second three-way valve is set such that it closes the circuit pipe 12.

[0066] It is noted that the second operation mode would also be implementable without the second three-way valve as the first medium M1 cannot continuously flow through the first heat exchanger 22.

[0067] As a result, the first medium M1 is only running through the second heat exchanger 24. Heat is transferred from the first medium M1 to the water at the same level of and above the second heat exchanger 24. A big portion of water is heated (heated water Wh). Compared to the first operation mode shown in Figure 2, the same heat quantum is exchanged but introduced into a much larger volume. The second operating mode is therefore applicable when a large volume of lukewarm water is needed, e.g., for domestic purposes in the kitchen, however, not necessarily within a short time.

[0068] Figure 4 shows a third operation mode in which the first medium M1 is only running along the circuit pipe 12 without exiting the same. For this purpose, the first switching element 261 is set such that the first medium M1 is transported to the first heat exchanger 22 while the second switching element 262 is set such that in there the first heat exchange medium cannot leave the circuit pipe 12 but flows to the second heat exchanger 24 and from the second heat exchanger 24 back to the heat source 14.

[0069] Thus, the first medium M1 is running through the first heat exchanger 22 and the second heat exchanger 24.

[0070] As a result, the same volume of water Wh in the tank 16 is heated as in the second operation mode. However, the heat quantum transferred into this volume is bigger compared to the second operation mode (and the first operation mode). The volume of water Wh is thus heated to a larger degree compared to the second operation mode. The third mode can be considered as a "power-mode" in which a maximum heat quantum is transferred to a large volume of water Wh. The second operating mode is therefore applicable when a large volume of high-temperature water is needed within a short time, e.g., for having a shower while concomitantly other demands of high-temperature water need to be fulfilled.

[0071] If the available power of the heat source 14 is limited and the whole heat quantum can be transferred into a single heat exchanger, the first operating mode shown in Figure 2 and the third operating mode of Figure 4 will be the same: All the heat will be shared in the first heat exchanger 22 with no impact on the second heat exchanger 24. The heat quantum

transferred is the same and correspond to the heat supplied by the heat source 14.

[0072] If the heat supplied by the heat source 14 is higher than the heat quantum the first heat exchanger 22 or the second heat exchanger 24 can transfer, there is indeed a bigger heat quantum transferred in this operating mode than previous. Nevertheless, there will be a difference in the heating stratification between the operating modes shown in Figures 3 and 4. First, it will be heated faster but there will also be a higher temperature stratification: The primary fluid flowing through the first heat exchanger 22 is higher than in the second heat exchanger 24. So, during the heating, water at the higher level will be heated at a higher temperature than lower level (until the final state with the whole tank 16 at the same temperature).

[0073] Figure 5 shows a fourth operation mode in which the first switching element 261 is closed. Thus, the transport of the first medium M1 through the circuit pipe is stopped. No heat is transferred into the water Wc which stays at low temperature. The fourth operation mode can be employed when there is no demand for hot water, e.g., at night, or if the heating requirement is directed to another piece of equipment, such as a local heating circuit (not shown here).

[0074] Figure 6 is a second embodiment of the device 102 for exchanging thermal energy between a heat source 14 and a second medium M2. The principle design of the device 102 according to the second embodiment is to a large extent similar to the design of the device 101 according to the first embodiment. Thus, only the key differences will be described in the following.

[0075] The device 102 according to the second embodiment comprises a third heat exchanger 40 that is arranged in the circuit pipe 12 between the first heat exchanger 22 and the second heat exchanger 24. A third switching element 263 that is embodied as a third three-way valve is arranged between the third heat exchanger 40 and the second heat exchanger 24 and inside the circuit pipe 12. The second bypass line 38 forms a third branch point 44. A third bypass line 46 fluidically connects the third switching element 263 and circuit pipe 12 at the third branch point 44.

[0076] Beyond that, a fourth switching element 264 embodied as a fourth three-way valve is arranged between the second branch point 36 and the third branch point 44 in the second bypass line 38. The circuit pipe 12 comprises a fourth branch point 50 between the third switching element 263 and the second heat exchanger 24. A fourth bypass line 58 fluidically connects the fourth switching element 264 and the circuit pipe 12 in the fourth branch point 50.

[0077] The device 102 according to the second embodiment is further equipped with a fifth switching element 265 that is embodied as a fifth three-way valve. The fifth switching element 265 is arranged inside the circuit pipe 12 between the heat source 14 and the first switching element 261. The fourth switching element 264 and the fifth switching element 265 are fluidically connected by a fifth bypass line 54.

[0078] By the layout of the device 102 according to the second embodiment, none, one, two or all of the heat exchangers can be used to transfer heat from the first medium M1 to the second medium M2. Table 1 is a summary of operation modes in which the device 101 according to the second embodiment can be operated. In total eight operation modes are selectable. The key considerations for which demands which operation mode is selected are the same as explained for the first embodiment of the device 101. However, as the number of selectable operation modes is higher compared to the device 101 of the first embodiment, a more precise consideration of the temperature gradient of the water formed along the vertical axis AV of the tank 16 can be implemented.

Table 1: Summary of operation modes of the device according to the second embodiment. X: respective heat exchanger is not in operation; V: respective heat exchanger is in operation.

Mode	Max	Capacity reduction	Eco-Fast heating	Boost	Medium	Eco + capacity reduction	Eco	Stop
Power	Full +++	Power reduced ++	Power reduced ++	Low power +	Power reduced ++	Low power +	Low power +	None
Capacity	All +++	Upper part of tank ++	All +++	Top of tank +	All +++	Upper part of the tank ++	All +++	None
First heat exchanger 22	V	V	V	V	X	X	X	X
Third heat exchanger 40	V	V	X	X	V	V	X	X
Second heat exchanger 24	V	X	V	X	V	X	V	X

Reference list

[0079]

101, 102	device
12	circuit pipe
14	heat source
16	tank
18	inlet
20	outlet
22	first heat exchanger
24	second heat exchanger
261 - 265	switching element
30	first branch point
32	first bypass line
36	second branch point
38	second bypass line
40	third heat exchanger
44	third branch point
46	third bypass line
50	fourth branch point
54	fifth bypass line
56	control unit
58	fourth bypass line

AV	vertical axis
AL	longitudinal axis
M1	first medium
M2	second medium
Wc	cold water
Wh	hot water

Claims

1. Device (101, 102) for exchanging thermal energy between at least one heat source (14) and a second medium (M2), comprising

- a circuit pipe (12) for transporting a first medium (M1),
- at least one heat source (14) for heating the first medium (M1),
- a tank (16) for storing a second medium (M2), preferably water, more preferably domestic water,
- a first heat exchanger (22) arranged in the circuit pipe (12) and in and/or on the tank (16) for transferring heat from the first medium (M1) to the second medium (M2) in the tank (16),
- a second heat exchanger (24) arranged in the circuit pipe (12) and in and/or on the tank (16) for transferring heat from the first medium (M1) to the second medium (M2) in the tank (16), wherein
- the device is configured such that selectively in an operation mode of the device (101, 102) one of the heat exchangers (22, 24) transfers heat from the first medium (M1) to the second medium (2) or in another operation mode of the device (101, 102) the first heat exchanger (22) and the second heat exchanger (24) transfer heat from the first medium (M1) to the second medium (M2).

2. Device (101, 102) according to claim 1,
characterized in that the device (101, 102) comprises at least one switching element (261, 262, 263, 264, 265) arranged in the circuit pipe (12) for directing the first medium (M1) through the first heat exchanger (22) and/or the second heat exchanger (24).

3. Device (101, 102) according to claim 2,
characterized in that the device (101, 102) comprises a first switching element (261) that is embodied as a first three-way valve, wherein

- the first three-way valve is arranged between the heat source (14) and the first heat exchanger (22) and/or
- the circuit pipe (12) comprises a first branch point (30) between the first heat exchanger (22) and the second heat exchanger (24) and/or
- the device (101, 102) comprises a first bypass line (32) connecting the first three-way valve and the circuit pipe (12) at the first branch point (30) .

4. Device (101, 102) according to claim 2 or 3,
characterized in that the device (101, 102) comprises a second switching element (262) that is embodied as a second three-way valve, wherein

- the second three-way valve is arranged between the first heat exchanger (22) and the second heat exchanger (24) and/or
- the circuit pipe (12) comprises a second branch point (36) between the second heat exchanger (24) and the heat source (14) and/or
- the device (101, 102) comprising a second bypass line (38) connecting the second three-way valve and the circuit pipe (12) at the second branch point (36).

5. Device (101, 102) according to claims 3 and 4,
characterized in that the first branch point (30) is arranged between the first switching element (261) and the second heat exchanger (24).

6. Device (101, 102) according to one of the preceding claims,

characterized in that a third heat exchanger (40) is arranged in the circuit pipe (12) and in or on the tank (16) for transferring heat from the first medium (M1) to the second medium (M2) in the tank (16),
the third heat exchanger (40) being arranged between the first heat exchanger (22) and the second heat exchanger (24).

7. Device (101, 102) according to claims 5 and 6,
characterized in that the device (101, 102) comprises a third switching element (263) that is embodied as a third three-way valve, wherein

- the third three-way valve is arranged between the second heat exchanger (24) and the third heat exchanger (40) and/or
- the second bypass line (38) comprises a third branch point (44) between the second three-way valve and the second branch point (36) and/or
- the device (101, 102) comprising a third bypass line (46) connecting the third three-way valve and the second bypass line (38) at the third branch point (44).

8. Device (101, 102) according to one of the preceding claims,
characterized in that

- the tank (16) defines a vertical axis (AV) and comprises
- an inlet (18) for introducing the second medium (M2) into the tank (16),
- an outlet (20) for removing the second medium (M2) from the tank (16),
- the first heat exchanger (22) and the second heat exchanger (24), in particular and the third heat exchanger (40) being arranged spaced from each other with reference to the vertical axis (AV).

9. Device (101, 102) according to one of the preceding claims,
characterized in that the device (101, 102) comprises a control unit (56) for controlling the operation of the device (101, 102).

10. Device (101, 102) according to claims 8 or 9,
characterized in that

- the heat source (14) comprises at least a heat pump and/or at least one boiler and/or a domestic heating system and/or a solar thermal panel and/or
- the second medium (M2) is water, preferably domestic water, and/or

- an inlet opening of the outlet (20) being arranged above or at the same level as the first heat exchanger (22) with reference to the vertical axis (AV).

11. Method for operating a device (101, 102) according to one of the preceding claims, the method comprising the steps of

- filling the tank (16) with the second medium (M2) via the inlet (18) such that heat can be transferred from the first medium (M1) to the second medium (M2) ,
- warming up the first medium (M1) by the heat source (14),
- circulating the first medium (M1) along the circuit pipe (12) such that
    - ◦ the first medium (M1) is flowing through the first heat exchanger (22) only, or
    - ◦ the first medium (M1) is flowing through the second heat exchanger (24) only, or
    - ◦ the first medium (M1) is flowing through the first heat exchanger (22) and the second heat exchanger (24), and
- removing at least a part of the second medium (M2) from the tank (16) via the outlet (20).

12. Method for operating a device (101, 102) according to claim 11, in which the second medium (M2) is water, comprising the steps of

- setting a warm water demand based on previous demands using the control unit (56),
- choosing the operation mode by the control unit (56) according to the set warm water demands.

13. Method according to one of the claims 11 or 12, in which the first medium (M1) is primary water.

14. Method according to one of the claims 12 or 13, wherein the step of setting the warm water demand is based on the volume and the temperature of previous warm water demands and/or the kind of energy currently processed by the heat source (14) and/or regarding the temperature of the medium which is used by the heat source (14) to transfer heat.

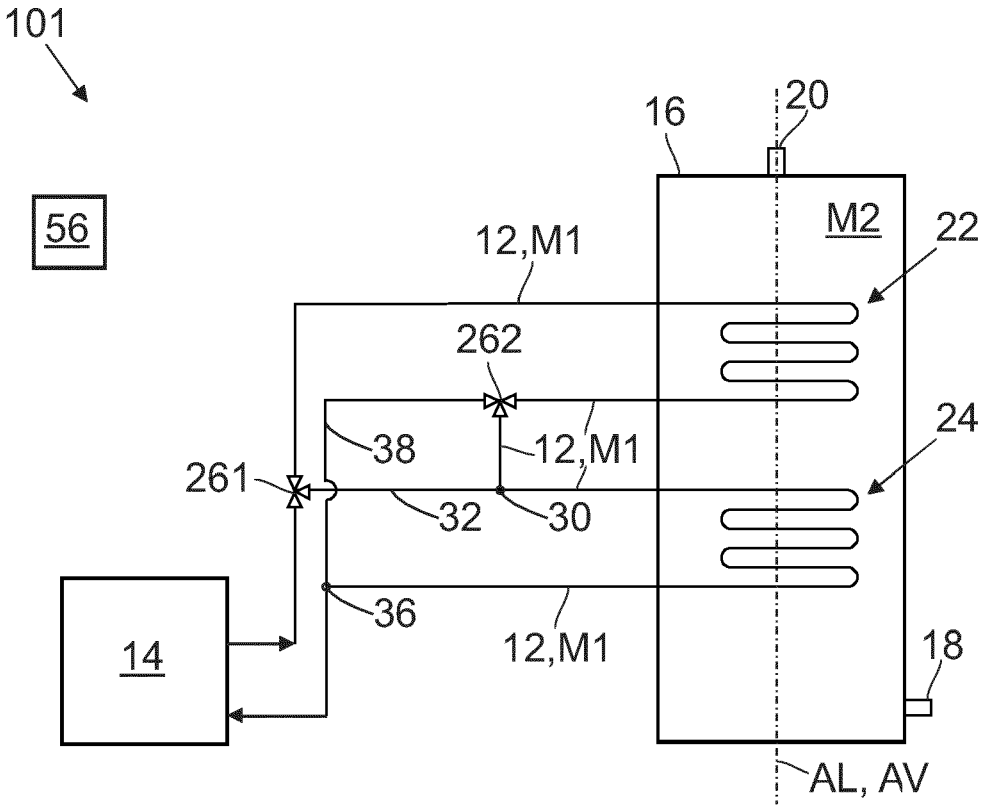

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Fig.1

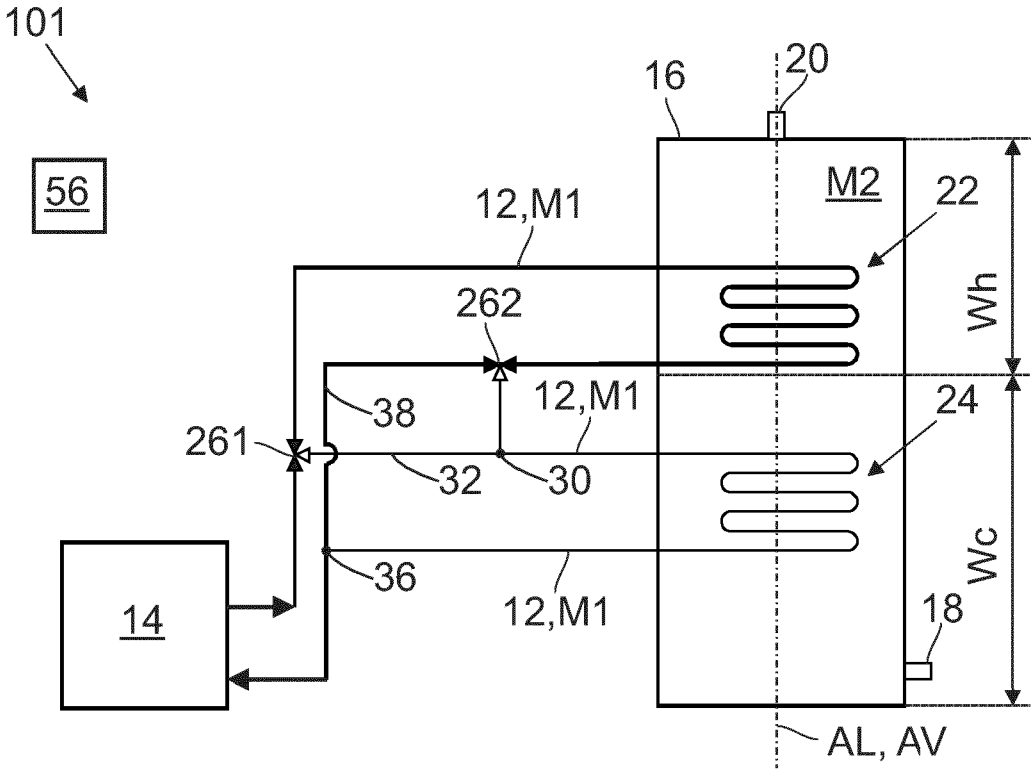

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Fig.2

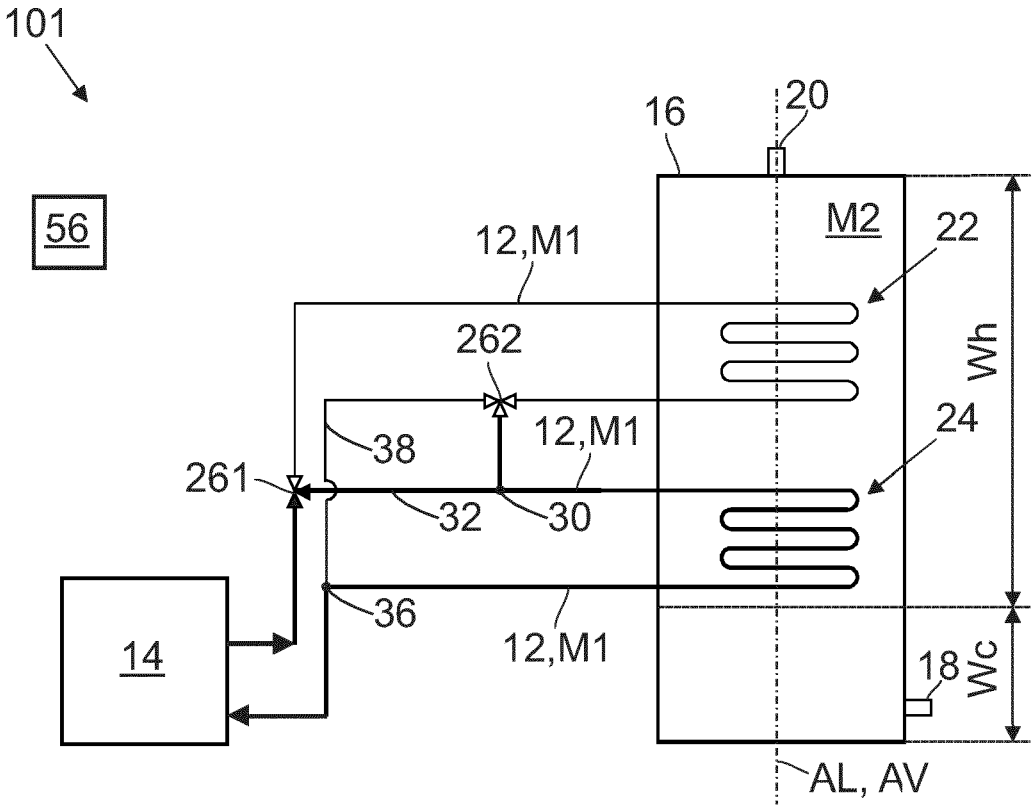

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Fig.3

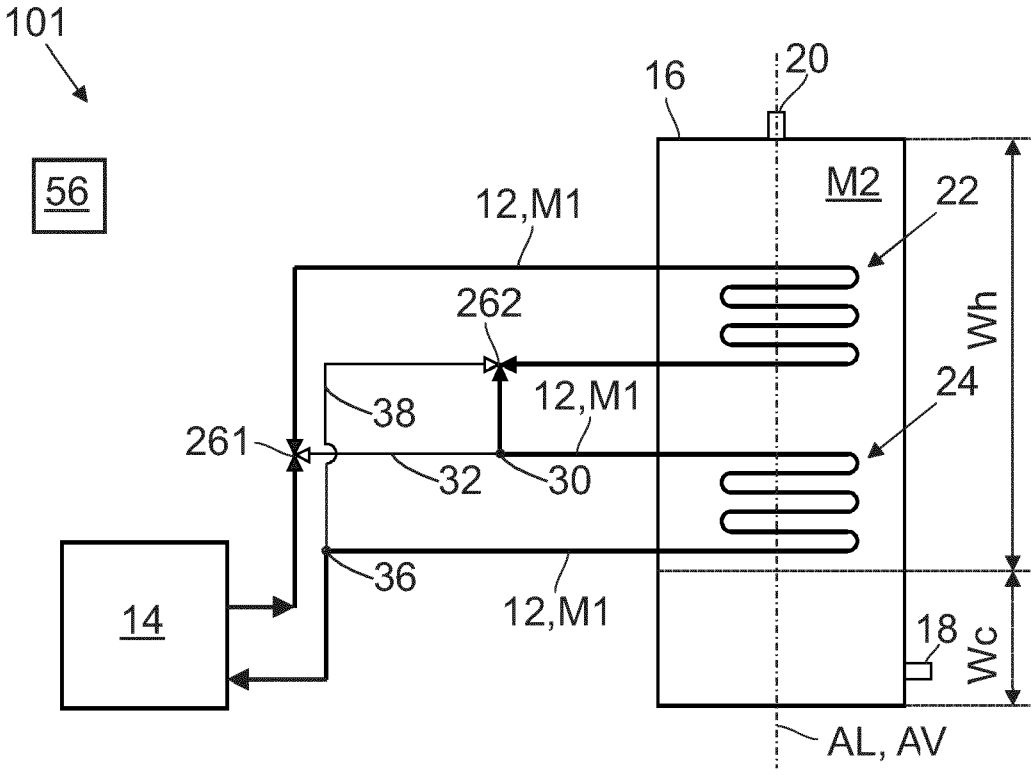

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Fig.4

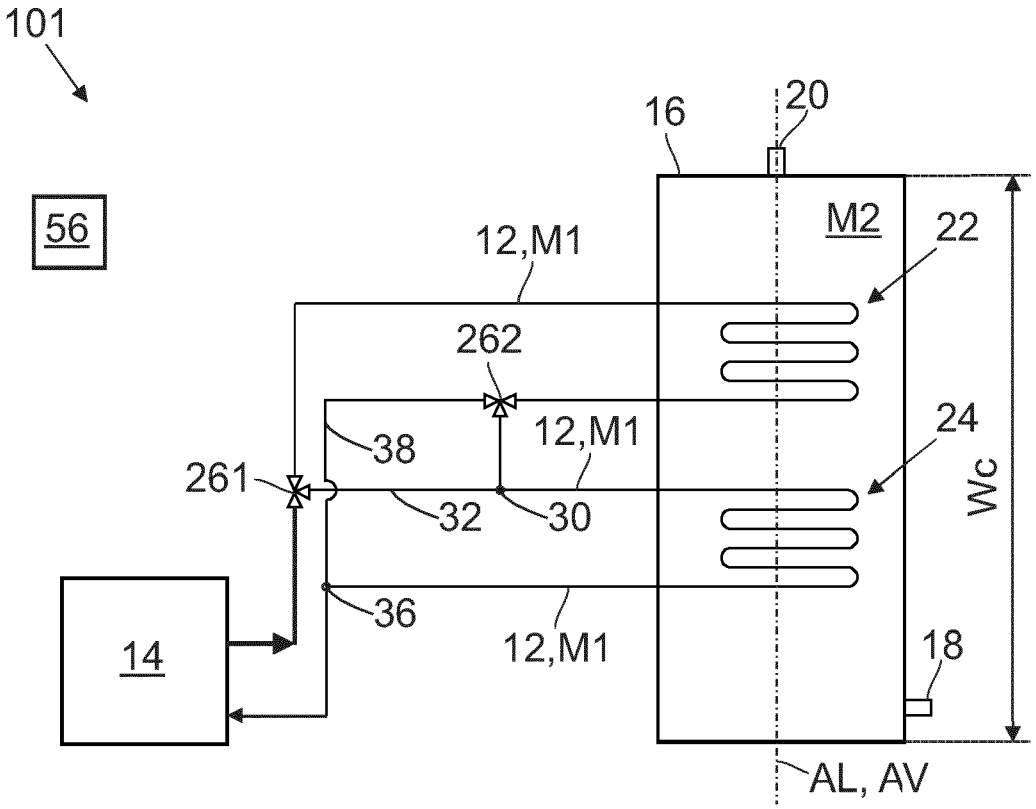

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Fig.5

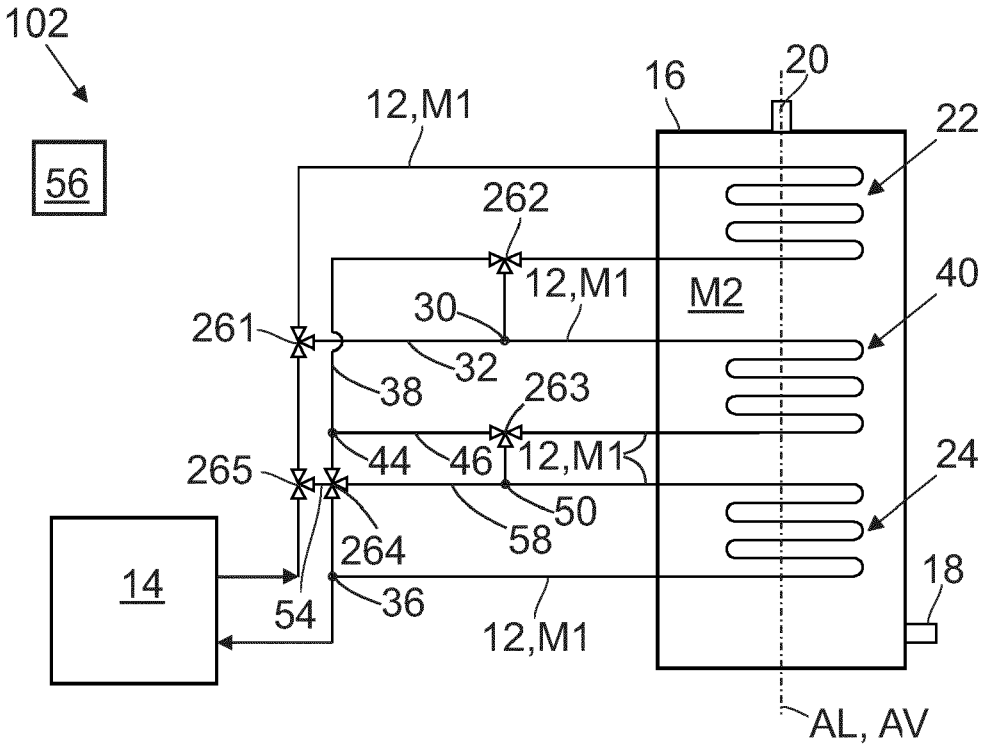

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Fig.6

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EUROPEAN SEARCH REPORT

Application Number
EP 23 20 6380

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	IT FI20 100 060 A1 (PROGRESS S R L) 10 October 2011 (2011-10-10) * page 5, line 14 - page 15, line 11; figures 1-2 *	1-14	INV. F24D17/00 F24D17/02 F24D19/10 F24H1/20
X	GB 2 506 582 A (THERMAL INTEGRATION LTD [GB]; TIDY PLANET LTD [GB]) 9 April 2014 (2014-04-09) * column 3, line 47 - column 544; figure 1 *	1-14	F24H15/156 F28D20/00
X	EP 0 961 082 A2 (DOETZL HEINZ [AT]) 1 December 1999 (1999-12-01) * paragraphs [0012] - [0023]; figure 1 *	1,2,8-14	

TECHNICAL FIELDS SEARCHED (IPC)

F24D
F24H
F28D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	15 March 2024	Hoffmann, Stéphanie

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15-03-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
IT FI20100060 A1	10-10-2011	NONE	
GB 2506582 A	09-04-2014	NONE	
EP 0961082 A2	01-12-1999	AT 2810 U1	26-04-1999
		AT E273485 T1	15-08-2004
		DK 0961082 T3	13-12-2004
		EP 0961082 A2	01-12-1999

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Patent documents cited in the description

- EP 3404334 A1 **[0006]**