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(54) Benævnelse: **Fremgangsmåde til tilvejebringelse af en strøm af varmt vand og tilsvarende system**

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Background of the invention

The invention relates to a method for producing a hot water flow and an associated system. It applies particularly in the field of domestic hot water heating but also in the field of heating hot water used in industrial processes.

Heat pumps using grey water are known as described in patents FR2885406 (application 05 04597), EP 1 724 531, or CN2779309.

Grey water is warm collected water whose temperature is dependent on the use made by users (private or industry) of water distributed through the distribution network, these grey waters come for example from showers, sinks, bathtubs, washing sinks, industrial washing systems, excluding toilets whose water is called black water.

Grey water is thus warm water generally originating from a mixture of stored hot water and distributed water that becomes grey due to the addition of soap, grease, food debris during the use of this grey water. These have a higher temperature than the temperature of the distributed tap water or of the distributed industrial water. They constitute throughout the year a source of heat with a variable temperature, typically around 32°C, provided that the pipes are insulated and these waters are collected as close as possible to their source.

Therefore, grey water is a very suitable source for the production of hot water, this production can be performed using a heat pump, including a pump using a zeotropic mixture (that is to say that boils at variable temperature by losing its initial composition) of refrigerant fluids.

In residential housing, in industrial production sites, or in catering kitchens, a specific network equipped with thermal insulation, independent from the black water collection network, must nevertheless be put in place if it does not already exist to collect grey water in order to extract calories.

Grey water, as indicated in patent FR2885406, must be filtered and may be stored in a dedicated thermally insulated reservoir, before their passage through a heat pump. After extraction of their energy, the water can be used for various purposes or be discharged in the main drainage system.

The temperature of the distributed tap water is measured to modulate one or the other of the flows flowing to the condenser of the heat pump, that is to say the flow rates of distributed cold water and of refrigerant, in order to set stable condensation conditions. The temperature of the distributed tap water and the grey water temperature are also measured for starting-up the system.

As indicated by various scientific publications and patent CN101504190, it is also interesting in terms of energy to drain the warmth of grey water, whose flow is not adapted, in two successive exchangers. In a first exchanger of grey water and tap water, the grey water is cooled and the tap water is warmed. In a second exchanger constituting the evaporator of a heat pump, the grey water is cooled once more. Tap water, already preheated in the heat exchanger which is upstream to the condenser, is heated in the condenser of the heat pump to its temperature of use or of storage.

Nevertheless, more energy-efficient solutions are yet to be found, so as to avoid any loss. The technical problem addressed is therefore to improve the energy efficiency of such a system for producing hot water using grey water as a heat source.

Object and summary of the invention

The invention consists in a method for heating domestic hot water by a heat pump using stored grey water, stored in a collection reservoir. More precisely, the invention consist in a method of production of a flow of domestic or industrial hot water at a desired temperature starting from tap water, by a heat pump including a condenser capable of heating tap water using a refrigerant fluid which is condensed there and an evaporator in which grey water circulates capable of condensing said refrigerant fluid, said grey water being stored upstream of said evaporator in a reservoir fed by used warm water obtained by mixing hot water and tap water, the method including a step of obtaining at least one temperature among the temperature of the tap water and the temperature of the used warm water, and characterized in that it also includes a step of adjusting the flow rate of grey water leaving said reservoir and

entering into said evaporator as a function of the at least one temperature obtained earlier.

This particular adjustment of the grey water flow rate makes it possible to improve the energy efficiency with respect to existing processes, by taking into account a temperature value that is energetically determining for heat transfer, which can vary and have an impact on the heat transfer, unfavorable if such a variation is not taken into account.

According to a preferred embodiment, the method comprises a step of obtaining of each of the temperatures among the temperature of the tap water and of the temperature of the used warm water. In this case, the step of adjusting the flow of grey water leaving said reservoir and entering said evaporator can be performed according to the two temperatures. Thus, the two parameters that can vary and have an impact on the heat transfer are taken into account.

According to a particular embodiment, the method further comprises a step of calculating a flow amplification ratio equal to the ratio of the temperature gap of the hot water and the tap water to the gap between the temperatures of the used warm water and the tap water, and a step of adjusting the flow of grey water leaving said reservoir and entering into said evaporator such that the ratio between this flow rate and said flow rate of hot water to be produced is a function of said flow amplification ratio.

Advantageously, the ratio of the grey water flow rate to the flow rate of hot water to be produced is chosen to be equal to within 10 or 20% of the amplification ratio. A correction depending on other parameters can also be introduced without departing from the scope of the invention. The grey water flow rate is always greater than the tap water flow rate to be heated because the flow amplification ratio is always greater than 1. The energy optimum is obtained when the ratio of the grey water flow rate by the hot water flow rate to be produced is chosen equal to the amplification ratio.

The method may comprise a prior determination of the flow rate of hot water to be produced using a learning method, for example by genetic algorithm, using at least

one time history of the measured water level in said reservoir fed by the used warm water, thus accessing repeated variations in hot water needs over weeks and seasons. Thanks to this feature, the hot water needs are accurately predicted and the installation is as economical as possible. Thus, a regulator chooses the hot water production of the day to come, this production being preferably the lowest possible. This makes it possible to minimize the operating time of the heat pump and also to minimize the thermal losses of the hot water reservoir, which may only be partially filled.

Optionally, the method comprises a step of pre-heating tap water using said grey water in a direct exchange exchanger situated downstream of said reservoir and upstream of said condenser. As mentioned in the introduction, this characteristic is also advantageous in terms of energy. The preheating step can thus be performed so as to bring the temperature of the tap water to a temperature which is 2 K lower than said grey water temperature stored in said reservoir, to increase the energy efficiency of the device. This optimization is possible because the variation over time of the flow amplification ratio is less than 8 or 10%. In general, the small variation in the ratio of grey water flow rates and tap water to be heated makes it possible to also dimension the two exchangers of the heat pump as a function of the flow rates and their ratio.

According to a first approach, the step of obtaining the temperature of the used warm water consists in estimating this temperature based on a temperature of the grey water stored in the reservoir and measured by a sensor and a theoretical heat loss between the used warm water and the stored grey water. Alternatively, according to another approach, the step of obtaining the temperature of he used warm water comprises a direct measuring step of said temperature.

According to an implementation feature at startup, the method may comprise a step consisting in verifying that the temperature of the used warm water is greater than a threshold temperature before storing this used warm water in said reservoir.

According to another implementation feature at startup, the method comprises a preliminary step of filling said reservoir with water at a target temperature comprised between plus and minus 8 K around the expected temperature for grey water,

determined depending on a use of said method. This feature allows starting up the method in an easier manner. Other possibilities for starting the system can be envisaged.

The invention also relates to a system of production of a flow of hot water at a desired temperature starting from tap water, by a heat pump in which grey water circulates, said grey water being stored upstream of said evaporator in a reservoir fed by used warm water obtained by mixing hot water and tap water, the system comprising means of obtaining at least one temperature among the temperature of the tap water and the temperature of the used hot water and being characterized in that it also includes means of adjusting the flow rate of grey water leaving said reservoir and entering into said evaporator as a function of the at least one temperature.

This system makes it possible to improve energy efficiency, by taking into account an energy-determining value for heat transfer, which can vary and have an impact on the heat transfer, an unfavorable impact if such a variation is not taken into account. According to a preferred embodiment, the system comprises means for obtaining each of the temperatures among the temperature of the tap water and the temperature of the used warm water, thus taking into account the two parameters that may vary.

According to one embodiment, the system comprises means of calculating a flow amplification ratio equal to the ratio of the temperature gap of the hot water and the tap water and the temperature gap of the used warm water and the tap water, and means of adjusting the flow rate of grey water leaving said reservoir and entering into said evaporator so that the ratio between this flow rate and the hot water flow rate is dependent on said flow amplification ratio. The system is then remarkable in that the ratios of the flow rate of tap water to the condenser and of grey water to the evaporator are adapted to extract, as efficiently as possible, the heat of the grey water to heat distributed tap water and turn it into hot water.

According to a preferred embodiment, the system comprises a hot water reservoir for hot water after heating. In this case, the grey water reservoir is dimensioned, with respect to the grey water storage to maintain the mentioned flow ratio. Thus, it

preferably has a volume substantially equal to the volume of the hot water reservoir for hot water after heating multiplied by the flow amplification ratio. The volume of stored grey water is then sufficient to meet the highest demand considered and is qualified for this as "buffer storage".

Forming a buffer storage of grey water and rather than hot water is advantageous because, in general, energy losses of a storage over time is proportional to the difference in temperatures of the storage and of the environment. It results from this that, at equal insulation properties, the energy losses are much lower for a grey water buffer than for a buffer storage of hot water.

Alternatively, hot water after heating is not stored.

According to a particularly advantageous embodiment, said refrigerant fluid is a mixture of refrigerant fluids in which the phase changes during condensation occur at temperatures separated from one another by at least 12 K between the start and the end of the condensation at constant pressure. This supplementary feature allows improving the efficiency of the heat pump.

In addition, the flow amplification ratio between the hot water flow rate and the grey water flow rate can be controlled with a dual hot water and grey water storage system, or by combining a system for storing hot water with a circulating grey water system, or the combination of a grey water storage system and a circulating hot water system.

Advantageously, night electricity is also used, whose price is lower than the day rate, to constitute the stock of hot water.

Brief description of the figures

Other features and advantages of the invention will emerge from the description given below with reference to the accompanying drawings which illustrate two embodiments having no limiting character.

Figure 1 represents an embodiment of a system according to the invention, in a configuration.

Figure 2 represents a second configuration of the same embodiment of a system according to the invention.

Figure 3 presents a temperature-mass entropy diagram of a mixture of refrigerants used in one embodiment of the invention.

Figure 4 shows a second embodiment of the invention.

Figures 5 to 7 show embodiments of a method according to the invention.

Detailed description of several embodiments

Figure 1 shows a domestic water heating system according to a particular embodiment of the invention.

In the embodiment described herein, this system comprises a reservoir 8 for storing the hot water produced by the system, also called domestic hot water.

We will assume in this example that domestic hot water is stored in reservoir 8 at a T_{ECH} temperature superior to 55°C.

The uses of domestic hot water by domestic users vary from a temperature of about 38°C for showers to a temperature of about 45°C for dishes. However, for safety reasons, especially to limit the proliferation of legionella, the storage of hot water is commonly at a temperature of at least 55°C. It is therefore necessary to mix the hot water drawn from the reservoir 8 to at least 55°C and tap water distributed at variable temperature.

In accordance with the invention, and in general, domestic hot water is obtained by heating distributed tap water, the temperature T_{EV} of distributed tap water being variable and in any case uncontrolled. It is produced by a heat pump 50, using the energy of a grey water storage stored in a reservoir 1.

The heat pump 50 uses a zeotropic mixture of refrigerants. It mainly comprises an evaporator 3, a compressor 5 acting on the refrigerant, a condenser 4, an expansion valve 6 for the refrigerant, a tap water heating circuit 12 and a grey water circuit 14.

The grey water, after transferring its heat, is rejected into discharged into the main drainage system 133.

The flow rates in the condenser 4, where the tap water to be heated circulates (flow M_{ECH}) and the mixture of refrigerants (flow M_{FF}), are against the flow. At the evaporator 3, the grey water (flow M_{EG}) similarly circulates against the flow of the refrigerant (flow M_{FF}).

The used grey water by the heat pump 50 comes from the used warm water by users, residents or industries. For example, there is shown on Figure 1, a sink 7 from which grey water is collected in a reservoir 1.

The warm water was initially obtained, by means of a mixer 110, by mixing domestic hot water at a temperature T_{ECH}, coming, via a pipe 125, from the hot water reservoir 8, and distributed tap water (cold water), at the temperature T_{EV}, brought by a pipe 11. We will assume in this example that the temperature T_{EV} of the distributed tap water supplied by the pipe 11 is likely to vary between 5°C and 20°C.

The mass M_{UTIL} of used warm water, here in the sink 7, is equal to the sum made in the mixer 110 of the masses M_{ECH} of hot water removed from the reservoir 8 and M_{EV} of distributed tap water used.

$$M_{UTIL} = M_{ECH} + M_{EV} \qquad (1)$$

Depending on the use, the temperature T_{UTIL} of the used warm water is typically between 38°C (use temperature for a shower) and 45°C (use temperature for a dishwasher). The temperature T_{EG} of the grey water stored in the reservoir 1 is substantially lower than the temperature of the used warm water T_{UTIL} because of the losses in the sink, shower or dishwasher, which are typically order of 5°C. The temperature T_{EG} of the grey water in the reservoir 1 is therefore generally comprised between 33°C and 40°C.

From an energy point of view, the energy E_{UTIL} of the warm water mass obtained at the mixer 110, expressed in kilojoules, is the sum of the energies E_{ECH} and E_{EV} of the hot water mass and the tap water mass.

$$E_{UTIL} = E_{ECH} + E_{EV} \qquad (2)$$

That is to say, by introducing the mass heat capacity cp (expressed in kJ/kg.K) of water:

$M_{UTIL}.cp.T_{UTIL} = M_{ECH}.cp.T_{ECH} + M_{EV}.cp.T_{EV}$ (2')

Considering the heat capacity of constant water in the considered temperature range, equation (2') is simplified into:

$$M_{UTIL}.T_{UTIL} = M_{ECH}.T_{ECH} + M_{EV}.T_{EV} \quad (3)$$

By introducing the mass ratio $X_m = M_{UTIL}/M_{ECH}$, (ratio of the warm used water mass over the hot water mass removed from the reservoir 8, called the flow amplification ratio), we obtain, by combining with (1):

$$X_m = (T_{ECH} - T_{EV}) / (T_{UTIL} - T_{EV}) \quad (4)$$

Considering the density of water as constant for temperatures between 30°C and 55°C, the flow amplification ratio X_v of the volumes of used warm water and hot water removed from the reservoir 8, expressed in m^3/m^3, is identical to the mass ratio X_m expressed in kg/kg. Therefore:

$$X_v = (T_{ECH} - T_{EV}) / (T_{UTIL} - T_{EV}) \quad (5)$$

This equation (5) is remarkable in that it allows dimensioning the volume of the reservoir 1 of grey water as a function of the volume of the reservoir 8 of domestic hot water.

More precisely, in the example described herein, by considering that the temperature of the domestic hot water T_{ECH} is equal to 55°C, that the temperature T_{EV} of the tap water distributed varies between 5°C and 20°C and that the temperature T_{UTIL} of used warm water varies between 38°C and 45°C, the following is obtained:

$$(55 - 20) / (45 - 20) < X_v < (55 - 5) / (38\text{-}5)$$

$$1.4 < X_v < 1.51$$

It is specified that the mass ratio is defined at the mixing point. Thermal loss (difference between T_{UTIL} and T_{ECH}) does not change the relationship, but requires additional power.

Therefore, in the embodiment described herein, the ratio of the volume of grey water to be stored to the volume of hot water to be stored varies between 1.4 and 1.51, which has for consequence that, in terms of construction, it is advantageous to build the reservoir 1 of grey water so that its volume is about 1.6 times greater than the volume of the reservoir 8 of hot water.

It is also remarkable that the maximum variation in the ratio between the volumes of used warm water and hot water, as a function of the variations in tap water and grey water temperatures is only 1.51/1.4 = 1.08, that is, less than 8%. It can therefore be considered as constant, and on this basis, the heat pump designer can dimension the exchangers 2, 3 and 4.

As mentioned before, it is interesting from an energy point of view to store grey water rather than hot water, the heat loss proportional to the temperature difference, with equal insulation properties, being much lower for grey water having an average temperature of 32°C, than for hot water temperature of 55°C.

In the embodiment described herein, the mass of grey water stored in the reservoir 1 is discharged during the hours when the electric tariff is the lowest, usually at night, typically from 11 pm to 5 am.

In the exemplary embodiment, use is furthermore made of the fact that the use of domestic hot water is predictable on the different days and hours of the week, so that the flow rate M_{ECH} of domestic hot water to be produced is obtained by learning.

More precisely, this flow rate evaluation is carried out by a regulator 17 capable of learning, for example by genetic algorithm, on the basis of the history of domestic hot water consumption for the different days and hours of the past weeks.

The regulator is based on the level and the temperature T_{EG} of the grey water in the reservoir 1 which are measured by sensors 18 and 20. It also uses the temperature T_{EV} of tap water distributed at the arrival of tap water 10, measured by a sensor 19.

The regulator 17 defines the running time of the compressor 5 of the heat pump 50, and a grey water pump 141 controlling the inlet of the tap water distributed in the heat pump 50. It also defines the flow of tap water treated by the heat pump by the

opening time of a regulating valve 121 which controls the entering of tap water distributed in the heat pump.

The dimensioning of the grey water reservoir 1 is established by taking into account the maximum considered demand. The initial load of grey water, constituting a buffer storage, is emptied only for this maximum demand, all the daily requirements being lower.

To produce the domestic hot water to be stored in the reservoir 8, the regulator 17 opens the regulating valve 121 of tap water distributed with a flow M_{ECH} and starts the grey water pump 141 to extract from grey water from reservoir 1, with a grey water flow M_{EG}.

By construction of the system, the volume of grey water to be used must be equal to the volume of used warm water ($M_{EG} = M_{UTIL}$). The ratio of the flow rates M_{EG}/M_{ECH} is thus set equal to the ratio X_m determined previously, by also assimilating T_{EG} and T_{UTIL}.

For example, when the temperature T_{EV} of the distributed tap water and the temperature T_{UTIL} of the used warm water are respectively equal to 5°C and 38°C, the regulator 17 sets the flow ratio as follows:

$$M_{EG}/M_{ECH} = Xm = (T_{ECH} - T_{EV}) / (T_{UTIL} - T_{EV}) = (55 - 5) / (38 - 5)$$

$$M_{EG}/M_{ECH} = 1{,}51.$$

In this example, the grey water flow M_{EG} is set at a value 51% higher than the hot water flow M_{ECH}.

In summary, in the embodiment described herein, the heating system according to the invention comprises a regulator 17 able to:

- obtain the temperature T_{EV} of the tap water inlet 10 and the temperature T_{EG} in the grey water reservoir 1, by using two temperature sensors 19 and 20;
- determine the flow rate M_{ECH} of hot water to be produced by learning;
- calculate the ratio X_m, and deduce from it the grey water flow M_{EG}; and
- control the regulating valve 121 and the grey water pump 141 accordingly.

In the embodiment described herein, the heat pump 50 further comprises a first exchanger 2 for preheating the tap water, configured to allow a first heat exchange between the grey water introduced by the pump 141 and the distributed tap water, brought by the regulating valve 121.

The evaporator 3 and the condenser 4 of the heat pump 50 are dimensioned at the design stage according to the ratio of flow rates M_{ECH} and M_{EG} of domestic hot water and grey water, considered as constant (because varying by less than 8% or 10% in this example as explained above).

In the embodiment described herein, the flow rates are in the end chosen constant, thus constituting a systematic operating point of the heat pump 50.

The operating time of the heat pump 50 is controlled by the regulator 17, depending on the amount M_{ECH} of hot water to be produced.

In practice, the heat pump operates when the valves 121 and 141 are open.

The mixture of refrigerants which evaporates in the evaporator 3 and condenses in the condenser 4 is chosen to minimize the energy losses by minimizing the temperature differences between on one hand the mixture of refrigerants and the grey water to be cooled, and on the other hand between the tap water to be heated.

By way of example, figure 3 is a temperature-mass entropy diagram of a mixture of refrigerants fluids comprising the three fluids CO_2 / R-32 / R-152a in the respective mass compositions of 0.08 / 0.44 / 0.48, which under a pressure of 2.4 MPa, shows a beginning of condensation at 56.6°C and a condensation end at 43°C. These characteristics minimize irreversibilities for water that warms from about 30 to 55°C.

Other mixtures can be conceived which provide temperature slips between 15 and 25 K. These temperature slips can be adjusted by choosing refrigerants that have multi-staged normal boiling temperatures. The normal boiling temperature T_{nb} is the boiling temperature at atmospheric pressure. To obtain a slip of the order of 12 to 25 K, it is necessary to choose fluids whose normal boiling temperatures are distant from the others of the same order of magnitude.

For example, varying proportions of R-152a, R-32 and CO_2 having normal boiling temperatures of -26°C, -47°C and -78°C permit the creation of mixtures with temperature slips at condensation which vary from 12 to 25 K.

The mixture CO_2 / R-32 / R-152a with respective compositions 0.08/0.44/0.48 has for example a slip of 13.6 K for a condensing pressure of 2.4 MPa. Using such a zeotropic mixture of refrigerants in a heat pump significantly improves the performance coefficient (ratio of the useful heat to the electrical power consumed by the compressor).

As the quantity needs of hot water vary according to the day of the week and the season, the temperature of the tap water varies according to the season and the region, the storage of hot water in the reservoir 8 allows limiting the size of the heat pump 50 and using electricity during the night.

The temperature of distributed tap water typically varies from +5°C to +20°C in a country like France between summer and winter and depending on the region. Flow rates measured on buildings indicate variations in hot water flow by a factor of 2 between the different days of the week. These two types of deviations are repetitive and not random.

On this basis, it is possible to implement automated learning. As a result, for production systems that are equipped with variable-volume domestic hot water storage as in patent FR2942299, it is possible to adapt the volume of hot water as close as possible to the foreseeable needs.

It is reminded that if the production of hot water is in excess, this results in a significant decrease in energy performance because the losses of the hot water reservoir to the environment can represent between 10 and 20% of the total energy consumption. These losses are proportional to the exchange surface heated by the hot water stock that constitutes the wall or the wall portion of the storage reservoir in direct contact with the stored hot water.

Moreover, the running time of the heat pump 50 is directly proportional to the mass of hot water produced. A forecast which is the closest to the needs therefore makes it possible to minimize the energy consumption of the heat pump 50.

The variations in demand for domestic hot water according to the days of the week are partly predictable. Their prediction makes it possible to extract just the quantity of grey water from the reservoir 1 necessary to satisfy the expected demand.

According to a learning by genetic algorithm using the data of the grey water level sensor 18 in the reservoir 1 for the collection of the grey water and using the temperature sensors 19 and 20 respectively for the tap water temperature to the inlet of the tap water 10 and the grey water temperature in the reservoir 1, the regulator 17 defines the running time of the compressor 5 of the heat pump 50, the same running time for the grey water pump 141 and the flow of tap water by the same opening time of the regulating valve 121.

The initial dimensioning of the grey water reservoir 1 takes into account the maximum demand. The grey water buffer storage is emptied only for this maximum demand, all other daily requirements being lower.

In figure 2, the system is shown in a configuration where the heat pump 50 has operated to form a large buffer storage in the hot water reservoir 8, in anticipation of significant short-term use.

From this configuration, it is necessary to reconstitute a grey water stock in the reservoir 1. The method may include a prior step of verifying that the warm water temperature T_{UTIL} is above a threshold temperature before storing this used warm water in the reservoir 1.

Figure 4 shows a second embodiment of the invention, similar to the previous embodiment, but for which no buffer stock of hot water is constituted, the outlet of the heat pump 50 being connected directly to the mixer 110. There is therefore no hot water reservoir such as the reservoir 8 of figures 1 and 2. The heat pump 50 is dimensioned to provide a higher hot water flow rate than in the previous embodiment.

The hot water flow M_{ECH} is measured continuously by a flow meter or a tap opening measurement. The measurements of the tap water and grey water temperatures are carried out as in the previous embodiment. The grey water flow M_{EG} is set so that it is equal to the flow of hot water M_{EG} multiplied by the rate of amplification ratio X_m.

In a variant, applicable to the embodiments of figures 1 and 2 and also to the embodiment of figure 4, the evaluation of the temperature of used warm water T_{UTIL} is done by a measurement of this temperature T_{UTIL}, for example by a sensor closest to the outlet of the sink 7, and the average of which is measured over a period of several hours.

Figure 5 shows the sequence of a method according to the invention.

During a step 510, a flow of hot water to be produced is determined. In this scenario, it is an average flow rate to be produced consistently over a period of time, for example during the night.

During a step 520, the temperature T_{EV} of the distributed tap water is measured by the sensor 19, and the temperature T_{EG} of the grey water of the reservoir 1 is measured by the sensor 20.

According to a first variant, indicated by the arrows (a), the regulator 17 calculates the flow amplification ratio X_M during a step 530. This step is carried out on the basis of the prior consideration that the average value of the temperature T_{UTIL} of the used warm water in the mixer 110 is equal to the temperature of the stored grey water plus a loss value, for example 5 K.

During a step 540, the regulator 17 sets the flow of grey water injected into the heat pump 50.

Alternatively, without formally performing step 530, the regulator 17 can directly set the grey water flow rate according to the distributed tap water temperature T_{EV} and the grey water temperature T_{EG}. This variant is indicated by the arrow (b). Even if the amplification ratio is not formally calculated during a specific step, the grey water flow M_{EG} is adjusted according to the temperatures T_{EV} and T_{EG} so that the flow rates M_{EG} and M_{ECH} are in a ratio equal, in fact, to the flow amplification ratio X_M.

Finally, during a step 550, the hot water produced by the heat pump 50 is stored in the reservoir 1.

Figure 6 shows the sequence of a variant of the method according to the invention, based on the installation of figure 4.

The steps are identical to those of the method of FIG. 5, with the exception of steps 510 and 550, replaced by steps 610 and 650.

Step 610 consists in determining an instantaneous flow rate of hot water to be produced, for example by measuring a tap opening that may vary with time, depending on the use made by the user.

Step 650 consists in directly using the hot water produced by the heat pump 50 in step 540, without storage. In parallel with step 650, a new instantaneous flow rate value is calculated in a new step 610.

Figure 7 shows a variant of the invention that can be applied to one or the other of the two methods previously presented in figures 5 and 6.

During a step 710, a flow rate of hot water to be produced, which can be an instantaneous or average flow rate, is determined.

During a step 720, the temperature of the distributed tap water or the temperature of the grey water stored in the reservoir 1 is measured. On this basis, during a step 730, an adjustment is made of the flow of grey water injected into the heat pump. Finally, during a step 740, the heat pump heats the tap water using the energy extracted from the grey water and during a step 750 the hot water thus produced is stored in the reservoir 8, or alternatively, it is used directly in the mixer 110.

The invention is not limited to the embodiments described and extends to alternatives that can be envisaged by those skilled in the art within the scope of the claims for the production of domestic or industrial hot water.

Patentkrav

1. Fremgangsmåde til tilvejebringelse af en strøm (M_{ECH}) af varmt vand med en ønsket temperatur (T_{ECH}) ud fra ledningsvand (10) ved hjælp af en varmepumpe (50) omfattende en kondensator (4), der er i stand til at opvarme ledningsvand ved hjælp af et kølemiddel, der kondenseres der, og en fordamper (3), i hvilken der cirkulerer husspildevand, som er i stand til at fordampe kølemidlet, hvilket husspildevand lagres opstrøms for fordamperen (3) i en beholder (1), der forsynes med brugt lunkent vand opnået ved blanding (110) af varmt vand og ledningsvand (10), hvilken fremgangsmåde omfatter et trin med opnåelse (520; 720) af mindst en temperatur blandt temperaturen (T_{EV}) af ledningsvandet og temperaturen af det brugte lunkne vand (T_{UTIL}), **kendetegnet ved, at** den yderligere omfatter et trin med justering (540; 730) af strømmen af husspildevand (M_{EG}), der kommer ud af beholderen (1) og kommer ind i fordamperen (3), afhængigt af den mindst ene temperatur (T_{EV}, T_{UTIL}).

2. Fremgangsmåde til tilvejebringelse af en strøm (M_{ECH}) af varmt vand ifølge krav 1, omfattende et trin med opnåelse (520) af temperaturen (T_{EV}) af ledningsvandet og temperaturen af det brugte lunkne vand (T_{UTIL}).

3. Fremgangsmåde til tilvejebringelse af en strøm (M_{ECH}) af varmt vand ifølge krav 2,
- yderligere omfattende et trin med beregning (530) af et strømforstærkningsforhold (X_m), som er lig med forholdet mellem forskellen mellem temperaturen af det varme vand (T_{ECH}) og ledningsvandet (T_{EV}) og forskellen mellem temperaturen af det brugte lunkne vand (T_{UTIL}) og ledningsvandet (T_{EV}),
- og i løbet af hvilken trinnet med justering (540) af strømmen af husspildevand (M_{EG}), der kommer ud af beholderen (1) og kommer ind i fordamperen (3), er således, at forholdet mellem denne strøm (M_{EG}) og strømmen af varmt vand, der skal tilvejebringes (M_{ECH}), er en funktion af strømforstærkningsforholdet (X_m).

4. Fremgangsmåde til tilvejebringelse af en strøm (M_{ECH}) af varmt vand ifølge krav 3, **kendetegnet ved, at** trinnet med justering (540) af strømmen af hus-

spildevand (M_{EG}), der kommer ud af beholderen (1) og kommer ind i fordamperen (3), er således, at forholdet mellem denne strøm (M_{EG}) og strømmen af varmt vand, der skal tilvejebringes (M_{ECH}), er lig med strømforstærkningsforholdet (X_m).

5. Fremgangsmåde til tilvejebringelse af en strøm (M_{ECH}) af varmt vand ifølge et af kravene 1 til 4, **kendetegnet ved, at** den omfatter en forudgående bestemmelse (510) af strømmen (M_{ECH}) af varmt vand, der skal tilvejebringes, ved hjælp af en læringsmetode, f.eks. ved hjælp af en genetisk algoritme, under anvendelse af mindst en historik over den målte vandstand (18) i beholderen (1), der forsynes med det brugte lunkne vand.

6. Fremgangsmåde til tilvejebringelse af en strøm (M_{ECH}) af varmt vand ifølge et af kravene 1 til 5, **kendetegnet ved, at** den omfatter et trin ned forvarmning af ledningsvandet ved hjælp af husspildevandet i en veksler (2), der befinder sig nedstrøms for beholderen (1) og opstrøms for kondensatoren(3).

7. Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 6, **kendetegnet ved, at** trinnet med opnåelse af temperaturen af det brugte lunkne vand (T_{UTIL}) består i at estimere denne temperatur (T_{UTIL}) ud fra en temperatur af husspildevand (T_{EG}) målt med en sensor (20) og et teoretisk tab.

8. Fremgangsmåde til tilvejebringelse af en strøm (M_{ECH}) af varmt vand ifølge et af kravene 1 til 7, **kendetegnet ved, at** den omfatter et trin, der består i at kontrollere, at temperaturen af det brugte lunkne vand (T_{UTIL}) er højere end en temperaturtærskel, før at dette brugte lunkne vand (T_{UTIL}) lagres i beholderen (1).

9. Fremgangsmåde til tilvejebringelse af en strøm (M_{ECH}) af varmt vand ifølge et hvilket som helst af kravene 1 til 8, omfattende et indledende trin med fyldning af beholderen (1) med vand med en måltemperatur på mellem plus og minus 8K omkring den forventede temperatur for husspildevand, bestemt afhængigt af en anvendelse af fremgangsmåden.

10. System til tilvejebringelse af en strøm (M_{ECH}) af varmt vand med en ønsket temperatur (T_{ECH}) ud fra ledningsvand (10), ved hjælp af en varmepumpe (50)

omfattende en kondensator (4), der er i stand til at opvarme ledningsvand ved hjælp af et kølemiddel, der kondenseres der, og en fordamper (3), i hvilken der cirkulerer husspildevand, som er i stand til at fordampe kølemidlet, hvilket husspildevand lagres opstrøms for fordamperen (3) i en beholder (1), der forsynes med brugt lunkent vand opnået ved blanding (110) af varmt vand og ledningsvand (10), hvilket system omfatter midler til opnåelse (17, 19, 20) af mindst en temperatur blandt temperaturen (T_{EV}) af ledningsvandet og temperaturen af det brugte lunkne vand (T_{UTIL}) og er **kendetegnet ved, at** det yderligere omfatter midler til justering af strømmen af husspildevand (M_{EG}), der kommer ud af beholderen (1) og kommer ind i fordamperen (3), afhængigt af den mindst ene temperatur (T_{EV}, T_{UTIL}).

11. System til tilvejebringelse af en strøm (M_{ECH}) af varmt vand ifølge krav 10, omfattende midler til opnåelse (17, 19, 20) af temperaturen (T_{EV}) af ledningsvandet og temperaturen af det brugte lunkne vand (T_{UTIL}).

12. System til tilvejebringelse af en strøm (M_{ECH}) af varmt vand ifølge krav 11,
- yderligere omfattende midler til beregning (17) af et strømforstærkningsforhold (X_m), som er lig med forholdet mellem forskellen mellem temperaturen af det varme vand (T_{ECH}) og ledningsvandet (T_{EV}) og forskellen mellem temperaturen af det brugte lunkne vand (T_{UTIL}) og ledningsvandet (T_{EV});
- hvor midlerne til justering (17) af strømmen af husspildevand (M_{EG}), der kommer ud af beholderen (1) og kommer ind i fordamperen (3), yderligere er i stand til at fastslå, at forholdet mellem denne strøm (M_{EG}) og strømmen af varmt vand, der skal tilvejebringes (M_{ECH}), er en funktion af strømforstærkningsforholdet (X_m).

13. System til tilvejebringelse af en strøm (M_{ECH}) af varmt vand ifølge et af kravene 10 til 12, omfattende en beholder (8) til det varme vand tilvejebragt af systemet.

14. System til tilvejebringelse af en strøm (M_{ECH}) af varmt vand ifølge krav 13, hvor beholderen til husspildevand (1) har en volumen, der i det væsentlige er lig med voluminen af beholderen til varmt vand efter opvarmning (8) divideret med strømforstærkningsforholdet (X_m).

15. System til tilvejebringelse af en strøm (M_{ECH}) af varmt vand ifølge et hvilket som helst af kravene 10 til 14, hvor kølemidlet er en blanding af kølemidler, i hvilke faseovergangene ved kondensation sker ved temperaturer, der er mindst 12K fra hinanden.

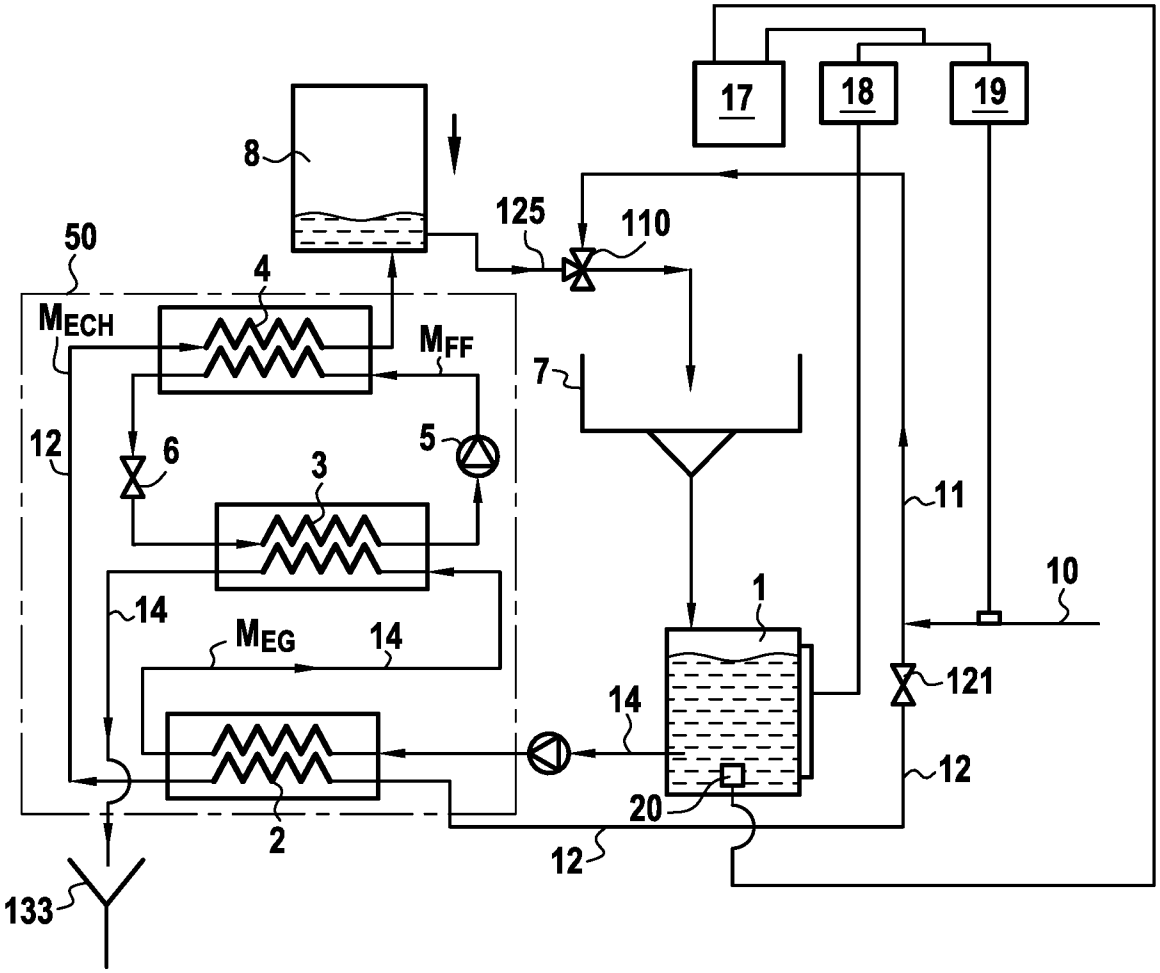
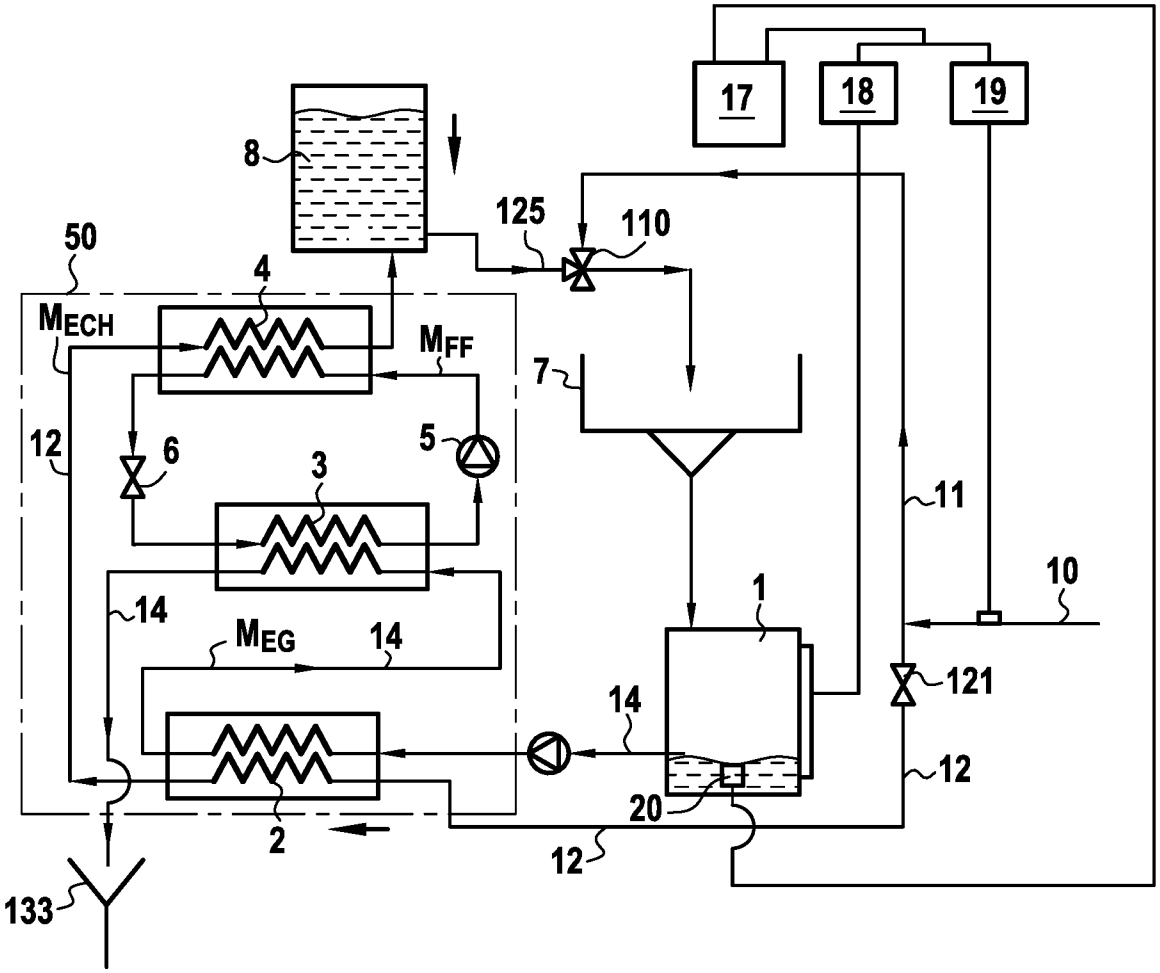

17
18
19
8
125
110
50
4
MECH
MFF
7
12
6
5
3
11
10
1
14
MEG
14
121
14
12
20
2
12
133

FIG.1


17
18
19
8
125
110
50
4
MECH
MFF
7
12
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5
3
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10
1
14
MEG
14
121
14
12
20
2
12
133

FIG.2

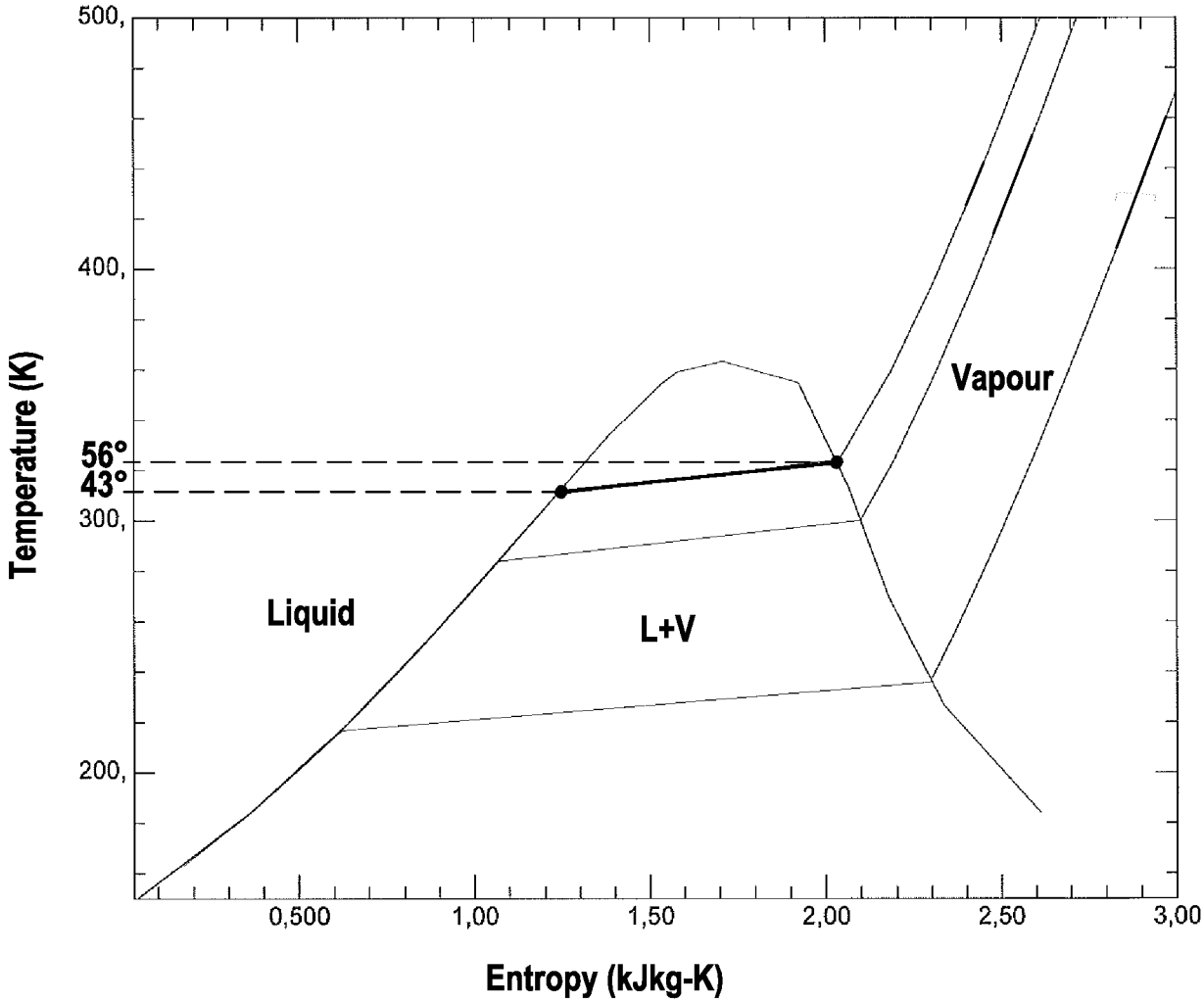
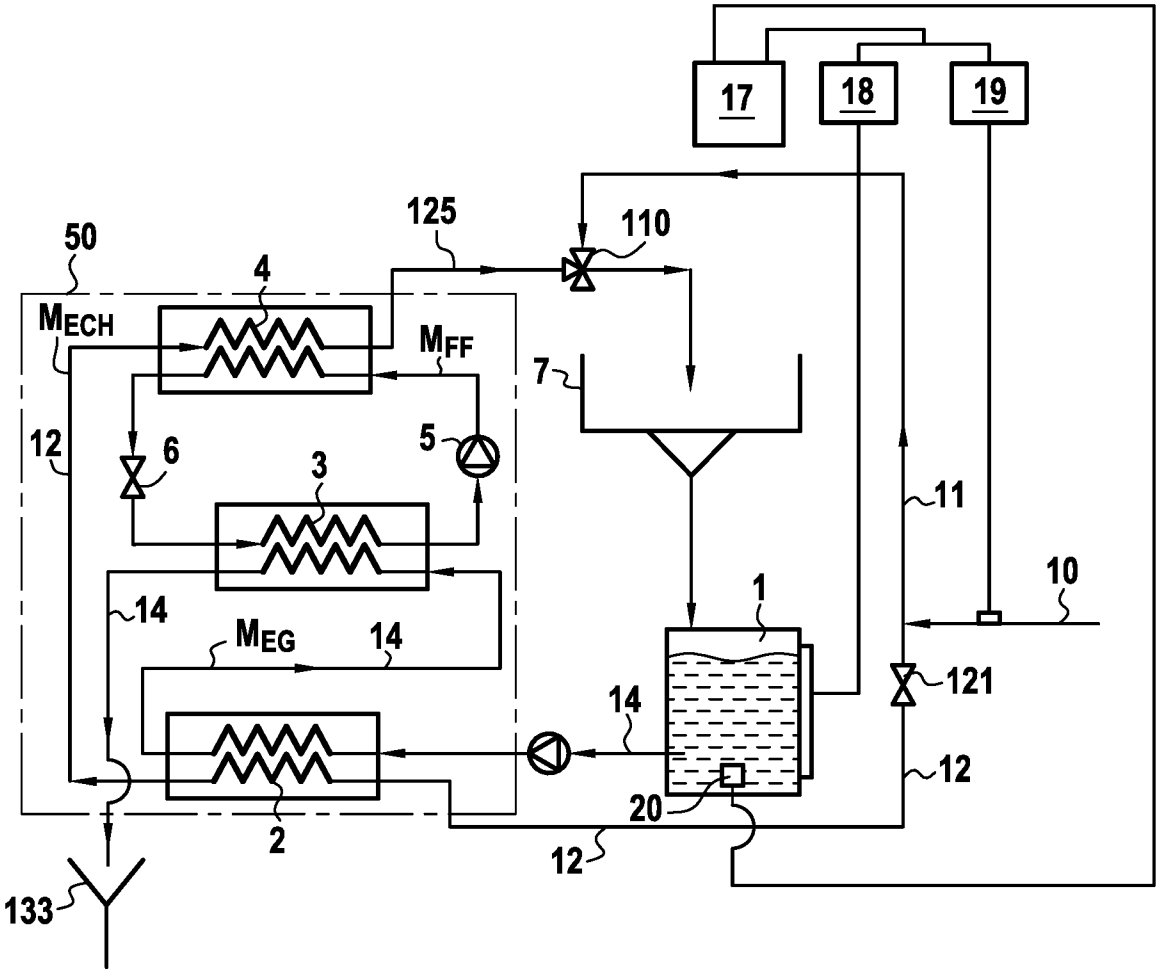

500,
400,
300,
200,
Temperature (K)
56°
43°
Liquid
L+V
Vapour
0,500
1,00
1,50
2,00
2,50
3,00
Entropy (kJkg-K)

FIG.3


17
18
19
125
110
50
4
MECH
MFF
7
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5
3
11
10
1
14
MEG
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121
14
12
20
2
12
133

FIG.4

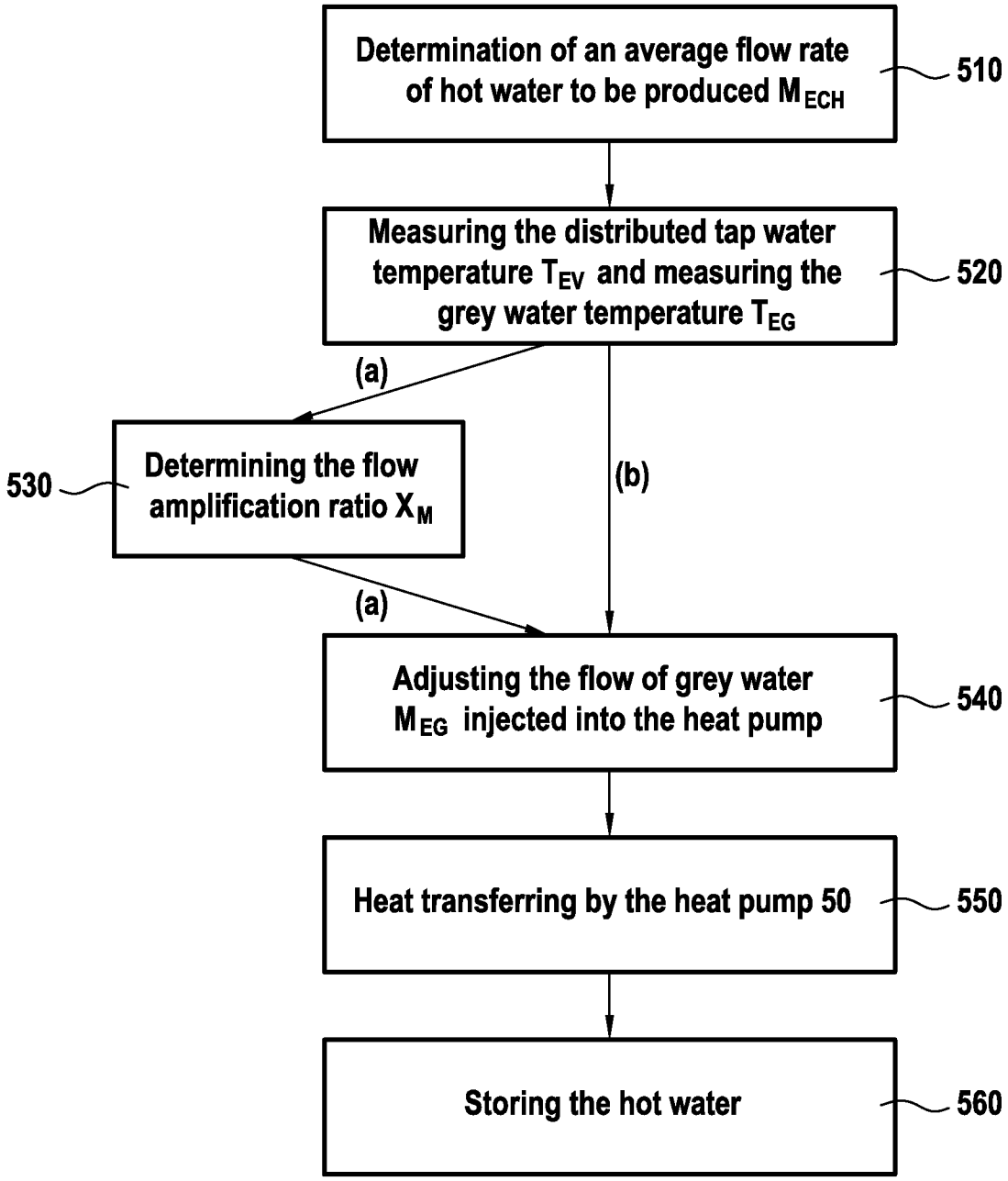
Determination of an average flow rate of hot water to be produced M_{ECH}
510
Measuring the distributed tap water temperature T_{EV} and measuring the grey water temperature T_{EG}
520
(a)
(b)
530
Determining the flow amplification ratio X_M
(a)
Adjusting the flow of grey water M_{EG} injected into the heat pump
540
Heat transferring by the heat pump 50
550
Storing the hot water
560

FIG.5

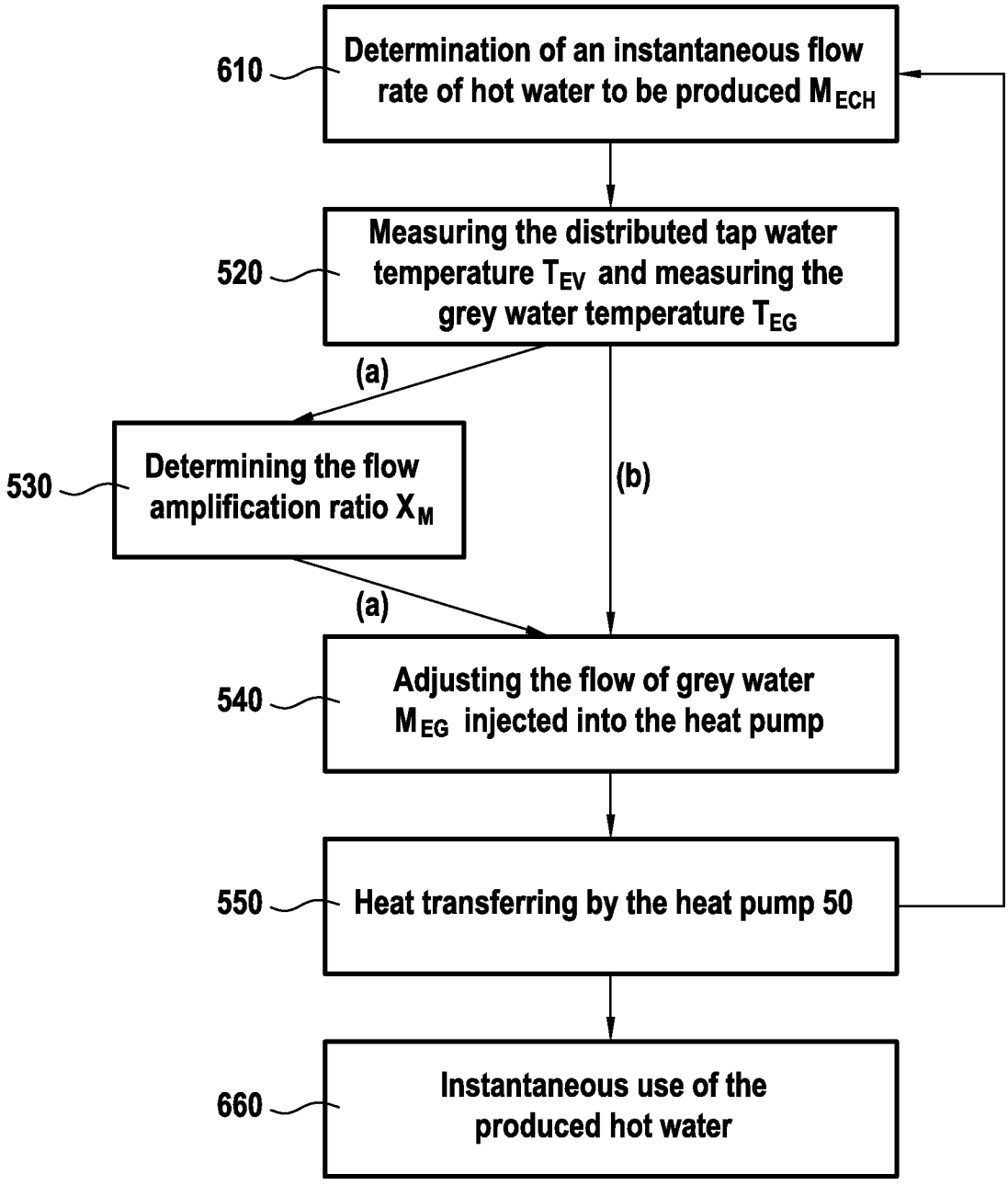
610
Determination of an instantaneous flow rate of hot water to be produced M_{ECH}
520
Measuring the distributed tap water temperature T_{EV} and measuring the grey water temperature T_{EG}
(a)
(b)
530
Determining the flow amplification ratio X_M
(a)
540
Adjusting the flow of grey water M_{EG} injected into the heat pump
550
Heat transferring by the heat pump 50
660
Instantaneous use of the produced hot water

FIG.6

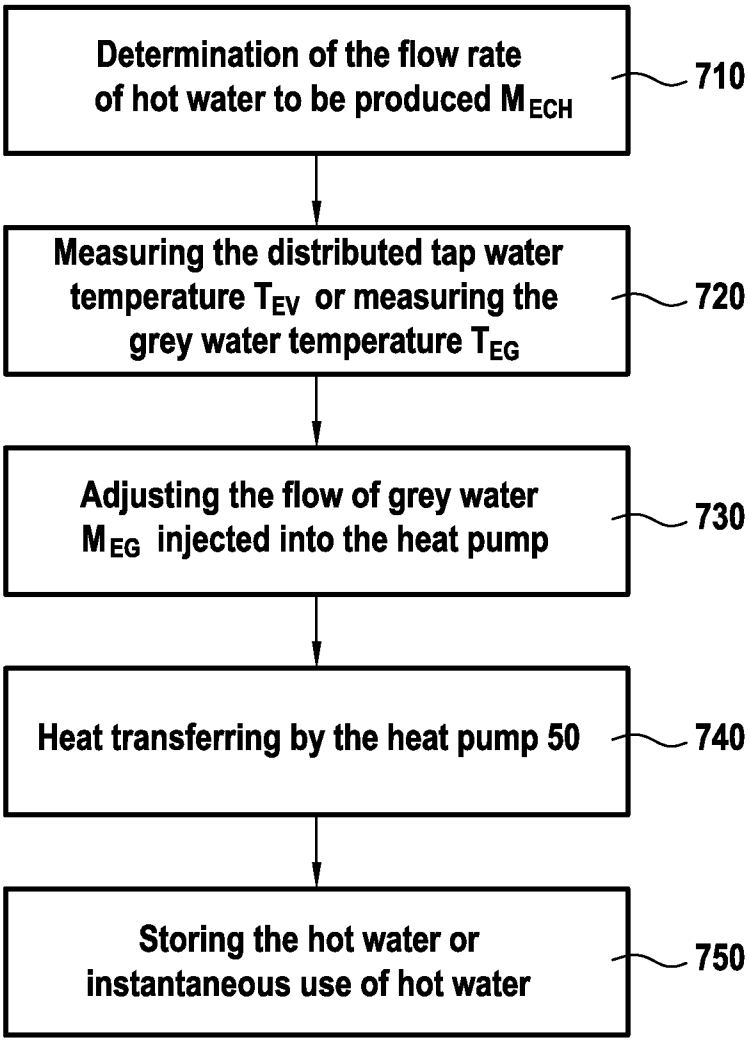
Determination of the flow rate of hot water to be produced M_{ECH}
710
Measuring the distributed tap water temperature T_{EV} or measuring the grey water temperature T_{EG}
720
Adjusting the flow of grey water M_{EG} injected into the heat pump
730
Heat transferring by the heat pump 50
740
Storing the hot water or instantaneous use of hot water
750

FIG.7