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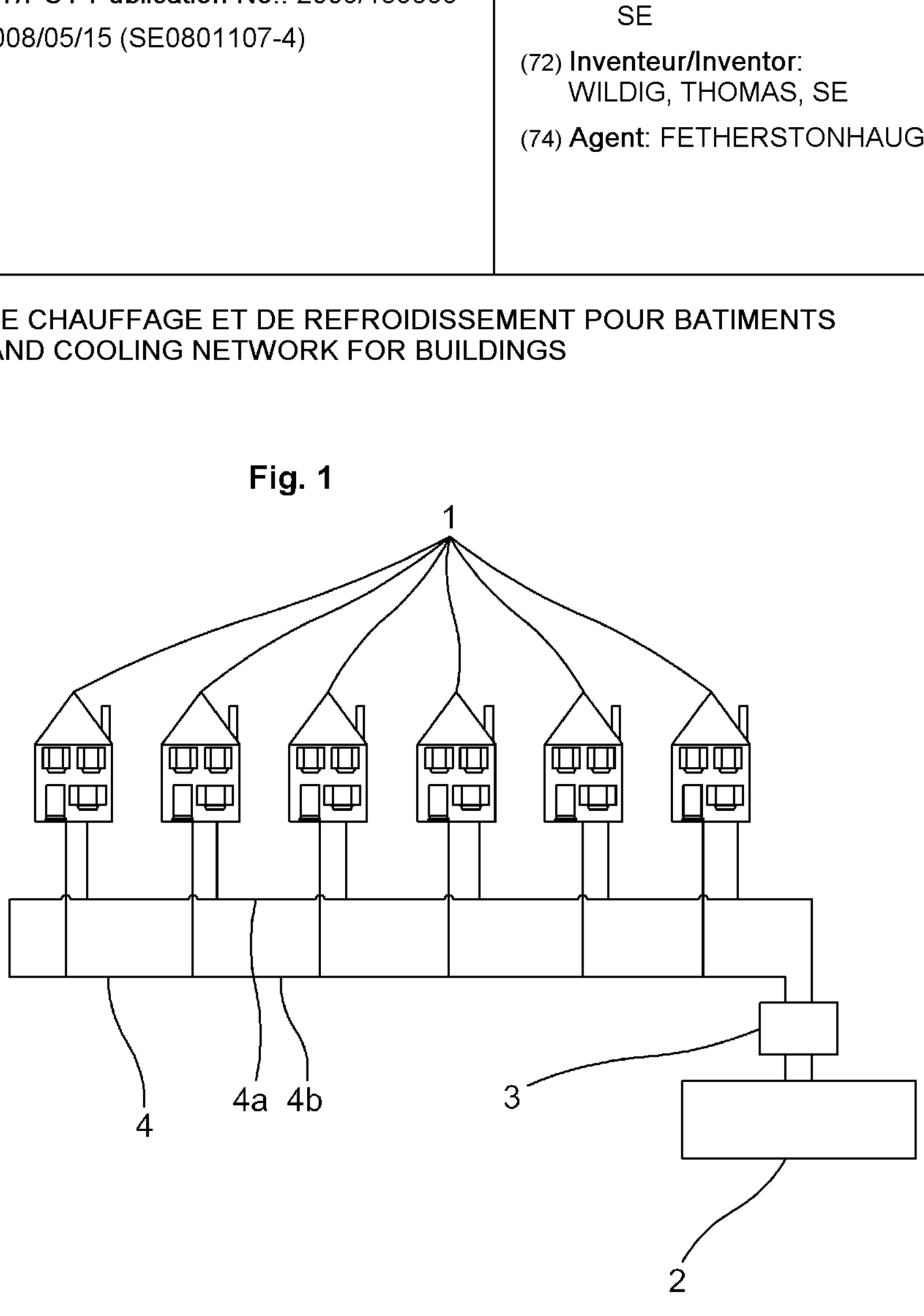
(54) Titre : RESEAU DE CHAUFFAGE ET DE REFROIDISSEMENT POUR BATIMENTS
(54) Title: HEATING AND COOLING NETWORK FOR BUILDINGS

Fig. 1



(57) Abrégé/Abstract:
Device for heating and cooling, respectively, of more than one house, where at least two small houses (1) are connected to a common energy storage (2) in the ground and where a control device (3) is arranged to transport a heat carrier in a pipe work (4) connected to the energy storage (2). The invention is characterised in that the small houses (1) each are arranged having a separate respective heat pump device, and in that each heat pump device is connected to the pipe work (4), so that, firstly, the heat carrier can flow through the heat pump device and, secondly, the small houses (1) are connected in parallel in relation to each other to the pipe work (4).

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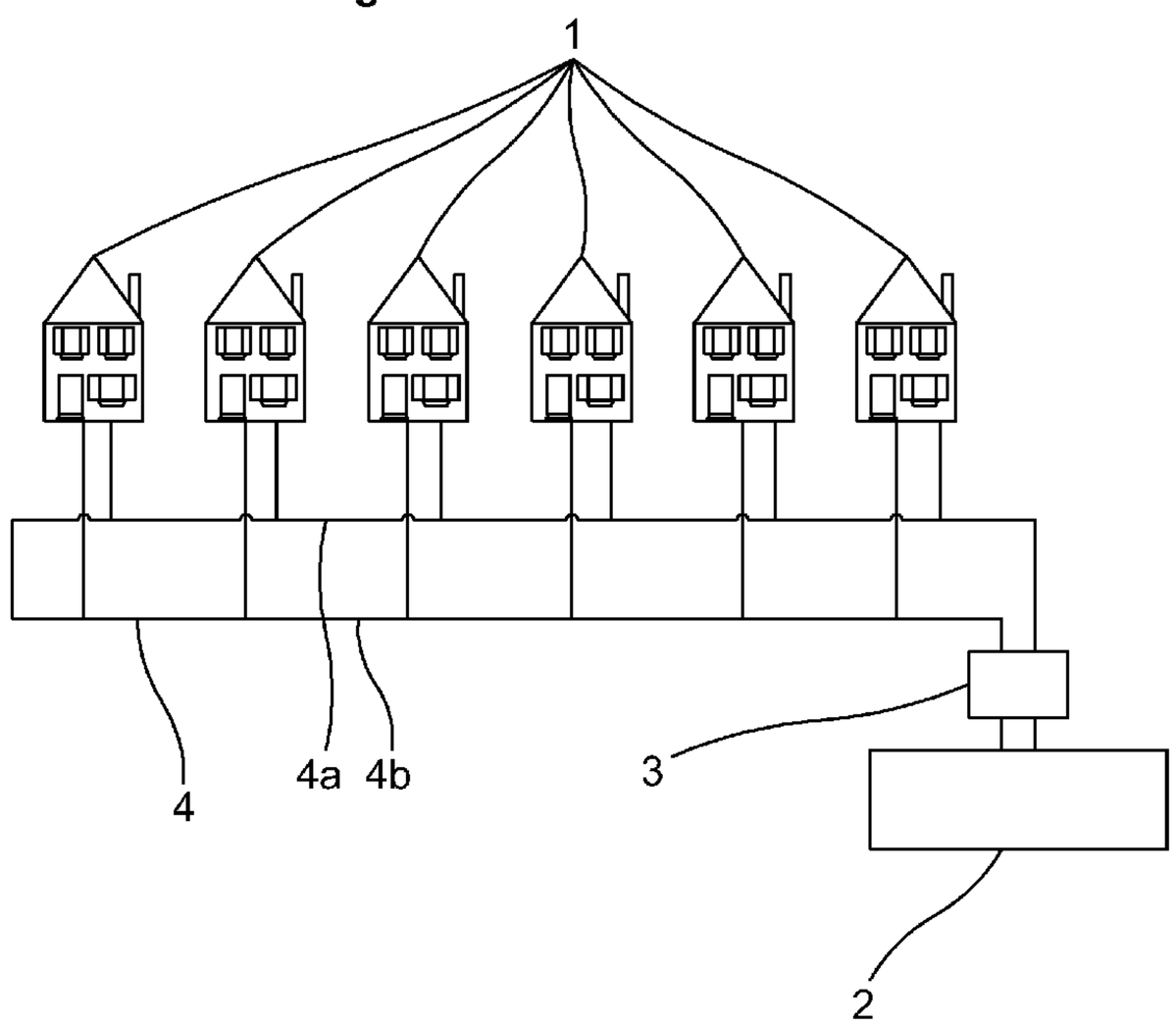
(54) **Title**: HEATING AND COOLING NETWORK FOR BUILDINGS



(57) **Abstract**: Device for heating and cooling, respectively, of more than one house, where at least two small houses (1) are connected to a common energy storage (2) in the ground and where a control device (3) is arranged to transport a heat carrier in a pipe work (4) connected to the energy storage (2). The invention is characterised in that the small houses (1) each are arranged having a separate respective heat pump device, and in that each heat pump device is connected to the pipe work (4), so that, firstly, the heat carrier can flow through the heat pump device and, secondly, the small houses (1) are connected in parallel in relation to each other to the pipe work (4).

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Heating and cooling network for buildings

The present invention relates to a method and a device for heating and/or cooling of a plurality of small houses.

Today, it is common for small houses to be heated by the use of so called geothermal heating, namely a heat pump connected to a heat carrier circulating in the ground. Such arrangements may in some cases also be used for cooling of small houses during the summer.

A common problem with such geothermal heating arrangements is that the ground around the bore hole, also called the energy well, during heating operation runs the risk of being cooled down more than what is necessary, which negatively affects the efficiency of the arrangement when the temperature is successively lowered locally in the ground as the heat carrier during heating operation during the winter cools the bore hole.

When doing new installations, it becomes more difficult as more proprietors of small houses in a given area install geothermal heating to respect the prescribed distance, usually about 30 meters, between two neighbouring bore holes for these not to negatively affect each other thermally. For example, this may lead to general cooling of the ground in a densely built-up area, in turn decreasing efficiency of the arrangements.

In order to avoid these problems, it is possible to install one geothermal heating arrangement common to several properties, which exploits one or several common bore holes. This way, increased control over the flow of heat carrier in the

hole or holes can be achieved, whereby the effects of the above described problems may be mitigated.

Such a system can be comprised of a central heat pump from which heat or coldness is distributed to the connected properties in the form of distant heating or distant cooling.

However, such systems only allow eiher heating or cooling operation at any one instance in time. For instance, this means that a separate system must be installed in order to provide for simultaneous cooling of indoor air in the connected properties and heating of tap water. This is also the case if certain house proprietors want to heat the indoors air at the same time as others want to cool the air, something which can be imagined for example when the temperature of the outdoors air is close to 20 degrees.

Moreover, the installation as well as maintenance of a central heat pump and distribution arrangement is costly.

The present invention solves the above described problems.

Thus, the invention relates to a device for heating and cooling, respectively, of more than one house, where at least two small houses are connected to a common energy storage in the ground and where a control device is arranged to transport a heat carrier in a pipe work connected to the energy storage, and is characterised in that the small houses each are arranged having a separate respective heat pump device, and in that each heat pump device is connected to the pipe work, so that, firstly, the heat carrier can flow through the heat pump device and, secondly, the small houses are connected in parallel in relation to each other to the pipe work.

In the following, the invention will be described in detail, with reference to exemplifying embodiments of the invention and to the appended drawings, where:

Figure 1 is an explanatory sketch which illustrates an area of small houses and an energy storage according to the present invention.

Figure 2 is an explantory sketch which in closer detail shows an energy storage according to the present invention.

Figure 3 is an explanatory sketch which in closer detail shows a heat pump device according to the present invention.

In Figure 1, a number of small houses 1 are shown, all being connected to a common energy storage 2. The number of small houses 1 may vary, but in order to achieve the purposes of the invention at least two small houses must be connected to the energy storage 2. Furthermore, the present inventors have discovered that a number of between about 10 and 100 small houses of average size, or the corresponding building volumes, can be heated and/or cooled using on single common energy storage 2 in an especially efficient way.

The energy storage 2 consists of a number of holes arranged in the ground, by way of example in the form of drilled holes. The energy storage 2 may be constructed in a suitable location with respect to the disturbances accompanying such an installation, and to access possibilities during subsequent maintenance work. It is preferred that the energy storage 2 is constructed in the vicinity of the small houses in

a common or non-built up area, such as on a piece of grass-covered land, for example in a park or in a grove.

A control device 3 is arranged to control the transport of a heat carrier in a pipe work 4 connected to the small houses 1 as well as to the energy storage 2. The heat carrier may be of a suitable, conventional type, such as water with the addition of anti-freeze agent. It is preferred that the pipe work 4 is comprised of a closed system in which the heat carrier is transported.

Each small house 1 is equipped with an own respective heat pump device. Moreover, each small house 1 is connected to the pipe work 4 in such a manner so that the small houses are connected in parallel to the pipe work 4 in relation to each other, and therefore also to the energy storage 2. Such parallel connection can, for example, be achieved by arranging two main conduits 4a, 4b for heat carrier, whereof one at a given point in time is arranged to convey heat carrier from the energy storage 2 and the other one at a given point in time is arranged to convey heat carrier back to the energy storage 2, and where the two main conduits 4a, 4b are interconnected at their respective distant ends, so that the heat carrier is first led out from the energy storage 2 through a first of the main conduits and thereafter immediately back to the energy storage 2 through a second main conduit. Thereafter, each respective small house 1 may be connected to both the first and second main conduits, so that heat carrier is drawn from the first and led back via the second main conduit. Of course, other suitable pipe work configurations may also be used, such as in the form of more than two main conduits and so forth.

The pipe work 4 and the respective heat pump device in each small house 1 are thus arranged so that heat carrier is conveyed through the respective heat pump arrangement, from the first main conduit to the second. Hence, if a reversible heat pump device is used in a certain small house, the heat pump device may, by adding or removing thermal energy to or from the heat carrier flowing through the heat pump device, generate coldness or heat, which in turn may be used locally in the small house for, by way of example, cooling of the indoors air or heating of the air or tap water. If the heat pump device is not reversible, it may be arranged to either generate only heat or only coldness by the help of the heat carrier flowing through it.

Since the small houses 1 are connected in parallel to the energy storage 2, the thermal influence of an individual small house on the heat carrier, as a consequence of mixing with return heat carrier from the small house in question with the rest of the heat carrier flowing in the main conduit, will to merely limited extent affect the temperature of the heat carrier as this reaches the rest of the small houses. This is true regarding both heating and cooling operation in each respective small house.

In other words, an individual small house will only to a limited extent affect the temperature in the heat carrier which is conveyed to other small houses, independently of if the small house in question adds or removes thermal energy from the heat carrier. Since the energy storage consists of a number of holes drilled into the ground through which the heat carrier is conveyed, the heat carrier flowing out from the energy storage will hold an approximatively constant temperature, essentially corresponding to the mean annual

temperature for the geographical location at hand. Thus, certain houses may exploit the heat carrier flowing through their respective heat pump device for cooling, at the same time as other houses are operated for heating. The temperature of the return heat carrier to the energy storage 2 is determined by the total added and exploited thermal energy, respectively, in all connected small houses 1.

By using a central energy storage 2 for several small houses 1, rather than using a local energy storage for each respective small house, which is the situation when each small house 1 has a separate geothermal heating arrangement, the advantage is achieved that the energy balance of the ground can be better maintained. Specifically, the throughput of heat carrier through the various respective energy wells of the energy storage 2 will be controllable, so that the ground around individual energy wells is not cooled so much so that the efficiency runs the risk of being deteriorated more than what is necessary, even during heavy and long-term heating operation in the small houses. Moreover, the efficiency in the heat pump devices may be increased during heating operation, since the average temperature of the heat carrier can be higher.

By connecting each small house in parallel to the energy storage 2, one achieves that no major losses arise between two neighbouring small houses. Also, and as mentioned above, each small house may at each instance in time be set optionally for heating or cooling operation, independently of the mode of operation for the rest of the small houses. This is especially useful during the summer, when there for example is a general desire for hot water at the same time as certain small houses require cooled indoors air. For example, alter-

nating operation between heating of tap water and cooling of indoors air may be desirable. In these specific cases, the thermal energy taken from the heat carrier to produce hot water can partly correspond to the thermal energy being added to the heat carrier during cooling of the indoors air.

By arranging a separate heat pump arrangement in each respective small house, the advantage is achieved that heat pumps of standard type may be used, implying comparatively cheap and quick installations, good access to cost efficient maintenance and spare parts as well as large flexibility in terms of for example function and dimensioning of the heating/cooling system in each individual house.

In order to increase efficiency in the energy storage 2 as much as possible, it is preferred that an energy storage of the type described in the Swedish patent application no. 0600428-7 is used. Such an energy storage 6 is illustrated in Figure 2.

According to a preferred embodiment, the energy storage 2 comprises at least four energy wells 21, through which the control device 3 is arranged to circulate the heat carrier in a closed system and thereby heating or cooling, respectively, the ground 25 around the respective energy wells 21. The energy wells 21 are arranged essentially along at least two concentric circles 22, 23, 24. In the Figure 2, three concentric circules 22, 23, 24 are shown, whereof the innermost circle 22 only comprises one single energy well.

The control device 3 comprises a control member 31, arranged to control a first valve system 32, in turn arranged to control the heat carrier to energy wells arranged along a cer-

tain circle, and thereby heating or cooling, respectively, the ground along the circle in question. Along each respective circle 22, 23, 24, a conduit runs, in which the heat carrier can flow from the valve system 32, via the energy wells arranged along the circle in question one by one, and finally back to the valve system 32.

A number of temperature sensors 33 are arranged along each outflow- and return flow conduit, respectively, of each respective circle 22, 23, 24, which temperature sensors 33 are connected to the control member 31. Thereby, the control member 31 can control the first valve system 32 so that the heat carrier is only circulated through a certain circle or several certain circles, depending on the operation conditions.

Thus, the control device 3 is arranged so that the control member 31, via the first valve system 32, controls the heat carrier so that inner circles are heated before outer circles when the temperature of the heat carrier is higher than the temperature of the surrounding ground 25, that is when the small houses 1 on average are operated for cooling of the indoors air. Inversely, the heat carrier is controlled so that outer circles are cooled before inner circles when the temperature of the heat carrier is lower than the temperature of the ground 25, that is when the small houses 1 on average are operated for heating of the indoors air and/or hot water.

The above described main conduits are connected to the first valve system 32, so that the heat carrier is distributed to the small houses 1 (not shown in Figure 2).

By arranging the energy storage 2 in this way, the advantage is achieved that stored heat or coldness efficiently can be exploited for later needs, as described in the above mentioned Swedish patent application. As a consequence, the energy balance in the common energy storage 2 can be maintained in a considerably more efficient way than what is the case when several small houses have their own geothermal heating arrangements, not operated with a common supervision and control over the tapping-off of heat and coldness. Notably, major economic gains are achieved since it is possible to efficiently store thermal energy generated during cooling of indoors air in the energy storage 2 during the summer season, and then to again exploit this stored thermal enregy from the energy storage 2 for heating during winter.

In order to fully benefit from the advantages of the present invention, it is preferred that at least one of the heat pump devices arranged in the small houses 1 is arranged to optionally be ablo to generate heat or coldness for local use in the small house in the form of heating of indoors air and/or tap water or cooling of indoors air. As a result, advantageously each respective small house may independently exploit heat as well as coldness from the energy storage 2, independently of the current mode of operation for the rest of the small houses.

According to a preferred embodiment, to this end is used a reversible heat pump device of the type described in the Swedish patent application no. 0602688-4. Such a heat pump device 100 is depicted in simplified form in Figure 3.

The heat pump device 100 comprises two sides 101, 102, whereof during operation one side is a cold side and the other

side is a warm side. The side 101 is, via conduits 101a, 101b, connected to the energy storage 2. The side 102 is, via conduits 102a, 102b, connected to a heating/cooling unit (not shown). During heating operation, the side 102 is the warm side and the heating/cooling unit is arranged to heat the indoors air in the small house in question, or hot water, in a manner which is conventional *per se*. At the same time, the side 101 is in this case the cold side. During cooling operation, the side 102 is instead the cold side, and the heating/cooling unit is arranged to cool the indoors air. At the same time, the side 101 is the warm side. Thus, the sides 101, 102 can switch roles with each other in a way which is more closely described in the above mentioned Swedish patent application, and also in the following.

A respective heat exchanger 103, 104 is connected to each of the said sides 101, 102. A second valve system 105, comprising an expansion valve (not shown), is connected to each of the respective heat exchangers 103, 104. Furthermore, a compressor 106 is connected to the second valve system 105. The second valve system 105 is arranged to optionally connect the warm or the cold side of the heat pump device 100 to the heating/cooling unit, whereby the heating/cooling unit optionally can emit heat or coldness. This is achieved by the second valve system 105 being arranged to interconnect the heat exchangers 103, 104, the compressor 106 and the expansion valve so that a closed loop is formed in the heat pump device, through which loop a second heat carrier is circulated so that heat pump action is obtained by the aid of the compressor 106 in combination with the expansion valve and the heat exchangers 103, 104. Using such a valve system to reverse the flow direction of the second heat carrier, a

reversal of which side is warm and which side is cold in the heat pump device 100 is also achieved.

The heat pump device is of the type liquid-liquid. This results in a number of advantages, such as the possibility to efficiently heat several rooms at the same time and a low degree of condensation during operation in warmer climates.

Such a heat pump device 100 is thus reversible, and offers very good efficiency and economy both during heating and cooling operation. It is preferred that at least one of the small houses 1, preferably several and most preferably all of the houses 1, are equipped with a heat pump device 100 of this type, since the use of efficient and reversible heat pump devices together with a common energy storage 2 according to the present invention, to which a number of small houses 1 are connected in parallel, makes it possible to obtain a good energy balance more easily for the system as a whole.

It is preferred that at least one of the heat pump devices arranged in the small houses during heating operation is arranged to lower the temperature of the heat carrier by about 3 to 4 °C.

Analogously, it is preferred that at least one of the heat pump devices arranged in the small houses during cooling operation is arranged to rise the temperature of the heat carrier by about 3 to 4 °C.

Hence, by using the present invention one achieves efficient and cheap heating and cooling, respectively, of several small houses, whereby the risk of poor coefficient of utilization

is lower than what is the case when using conventional art. Moreover, the advantage is achieved that different small houses that are connected to the system can optionally tap off heat or coldness according to need, without having to take into consideration the usage pattern of the neighbours. Finally, a system is obtained which to a large extent consists of commercially available standard components, with the therewith associated advantages in terms of cost efficiency, maintenance and availability of spare parts, flexibility and so forth.

Above, preferred embodiments have been described. However, it is apparent for the skilled person that many modifications may be made to the described embodiments without departing from the idea of the invention. Thus, the invention is not to be limited by the described embodiments, but to be variable within the scope of the enclosed claims.

C L A I M S

1. Device for heating and cooling, respectively, of more than one house, where at least two small houses (1) are connected to a common energy storage (2) in the ground (25), where a control device (3) is arranged to transport a heat carrier in a pipe work (4) connected to the energy storage (2), where the small houses (1) are each arranged having a separate respective heat pump device, and where each heat pump device is connected to the pipe work (4), so that the heat carrier can flow through the heat pump device, **c h a r a c t e r i s e d i n** that said heat pump devices are connected in parallel in relation to each other to the pipe work (4) by way of, firstly, the pipe work (4) comprising two main conduits (4a, 4b) for heat carrier, said two main conduits (4a, 4b) being interconnected at their respective distant ends in relation to the energy storage (2), one of said main conduits being arranged to convey heat carrier from the energy storage (2) and the other one to thereafter convey heat carrier back to the energy storage (2), and, secondly, each respective heat pump device being connected to, on the one hand, one of the main conduits (4b) from which heat carrier is conveyed to the respective heat pump device, and on the other hand to the other main conduit (4a) via which heat carrier is again conveyed back to the energy storage (2), and in that at least one of the heat pump devices arranged in the small houses (1) is arranged to optionally be able to generate heat or coldness for local use in the small house in the form of heating of indoors air and/or tap water or cooling of indoors air.

2. Device according to claim 1, **c h a r a c t e r i s e d i n** that the energy storage (2) comprises at least four

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energy wells (21), through which the control device (3) is arranged to circulate the heat carrier in a closed system and to thereby heat or cool, respectively, the ground (25), in that the energy wells (21) are arranged essentially along at least two concentrical circles (22;23;24), in that the control device (3) comprises a control member (31), arranged to control a first valve system (32), which in turn is arranged to direct the heat carrier to energy wells arranged along a circle and to thereby heat or cool, respectively, the ground along the circle, and in that the control member (31) is arranged to control the first valve system (32) so that, when the temperature of the heat carrier is higher than the temperature of the surrounding ground (25), inner circles are heated before outer circles, and, when the temperature of the heat carrier is lower than the temperature of the ground (25), outer circles are cooled before inner circles.

3. Device according to claim 1 or 2, **characterised in** that the said at least one heat pump device (100) comprises two sides (101;102) whereof one is a cold side and one is a warm side, in that heat exchangers (103;104) are connected to the said cold side and to the said warm side, respectively, in that one of the heat exchangers (104) is connected to a heating/cooling unit, in that the second heat exchanger (103) is connected to the pipe work (4), in that a second valve system (105) is arranged to optionally be able to connect the warm or cold side of the heat pump device (100) to the heating/cooling unit, whereby the heating/cooling unit optionally may emit heat or coldness, and in that the heat pump (100) in question is of the type liquid-liquid.

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4. Device according to any one of the preceeding claims, **characterised in** that the number of small houses (1) that are connected to the energy storage (2) is between 10 and 100.

5. Method for heating and cooling, respectively, of more than one house, where at least two small houses (1) are caused to be connected to a common energy storage (2) in the ground (25), where a control device (3) is caused to transport a heat carrier in a pipe work (4) connected to the energy storage (2), where the small houses (1) each are caused to be equipped with a separate respective heat pump device, and where each heat pump device is caused to be connected to the pipe work (4), so that the heat carrier can be caused to flow through the heat pump device, **characterised in** that said heat pump devices are caused to be connected in parallel in relation to each other to the pipe work (4) by way of, firstly, the pipe work (4) being caused to be arranged to comprise two main conduits (4a, 4b) for heat carrier, said two main conduits (4a, 4b) being caused to be interconnected at their respective distant ends in relation to the energy storage (2), one of said main conduits being caused to be arranged to convey heat carrier from the energy storage (2) and the other one to thereafter convey heat carrier back to the energy storage (2), and, secondly, each respective heat pump device being caused to be connected to, on the one hand, one of the main conduits (4b) from which heat carrier is conveyed to the respective heat pump device, and on the other hand to the other main conduit (4a) via which heat carrier is again conveyed back to the energy storage (2), and in that at least one of the heat pump devices arranged in the small houses (1) is caused to be arranged to optionally be able to generate heat or coldness for local use in the small

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house in the form of heating of indoors air and/or tap water or cooling of indoors air.

6. Method according to claim 5, **characterised in** that the energy storage (2) is caused to comprise at least four energy wells (21), through which the control device (3) is caused to circulate the heat carrier in a closed system and to thereby heat or cool, respectively, the ground (25), in that the energy wells (21) are caused to be arranged essentially along at least two concentrical circles (22;23;24), in that the control device (3) is caused to comprise a control member (31), which is caused to control a first valve system (32), which in turn is caused to direct the heat carrier to energy wells arranged along a circle and to thereby heat or cool, respectively, the ground along the circle, and in that the control member (31) is caused to control the first valve system (32) so that, when the temperature of the heat carrier is higher than the temperature of the surrounding ground (25), inner circles are heated before outer circles, and, when the temperature of the heat carrier is lower than the temperature of the ground (25), outer circles are cooled before inner circles.

7. Method according to claim 5 or 6, **characterised in** that the said at least one heat pump device (100) is caused to comprise two sides (101;102) whereof one is caused to be a cold side and one is caused to be a warm side, in that heat exchangers (103;104) are caused to be connected to the said cold side and to the said warm side, respectively, in that one of the heat exchangers (104) is caused to be connected to a heating/cooling unit, in that the second heat exchanger (103) is caused to be connected to the pipe work (4), in that a second valve system (105) is caused

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to optionally be able to connect the warm or cold side of the heat pump device (100) to the heating/cooling unit, whereby the heating/cooling unit optionally may be caused to emit heat or coldness, and in that the heat pump (100) in question is caused to be of the type liquid-liquid.

8. Method according to any one of the claims 5-7, **characterised in** that the number of small houses (1) being connected to the energy storage (2) is caused to be between 10 and 100.

9. Method according to claim 6 or 7, **characterised in** that the said at least one heat pump device is caused to lower the temperature of the heat carrier during heating operation with about 3 - 4 °C.

10. Method according to claim 6 or 7, **characterised in** that the said at least one heat pump device is caused to rise the temperature of the heat carrier during cooling operation with about 3 - 4 °C.

AMENDED SHEET

Fig. 1

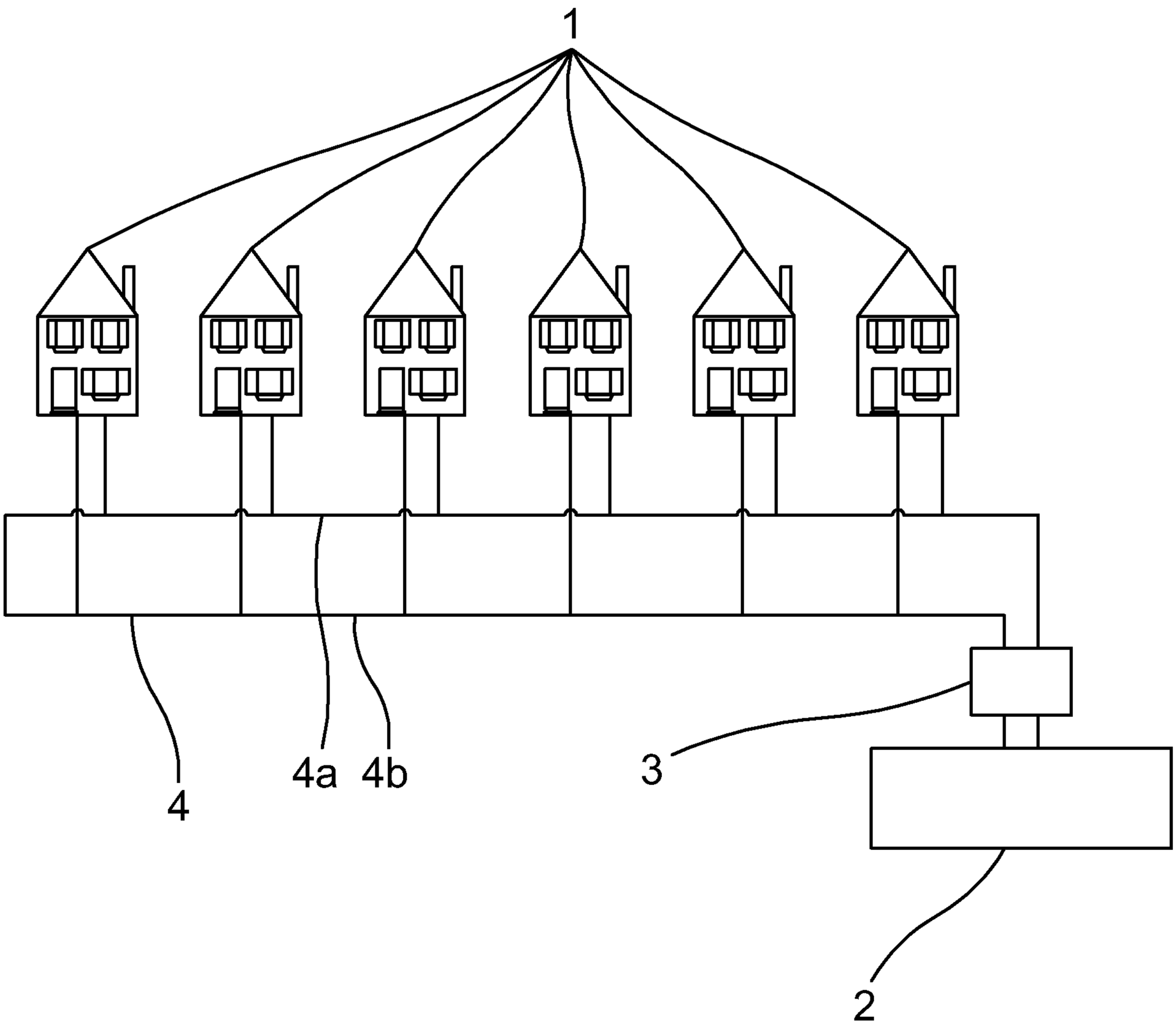

Fig. 2

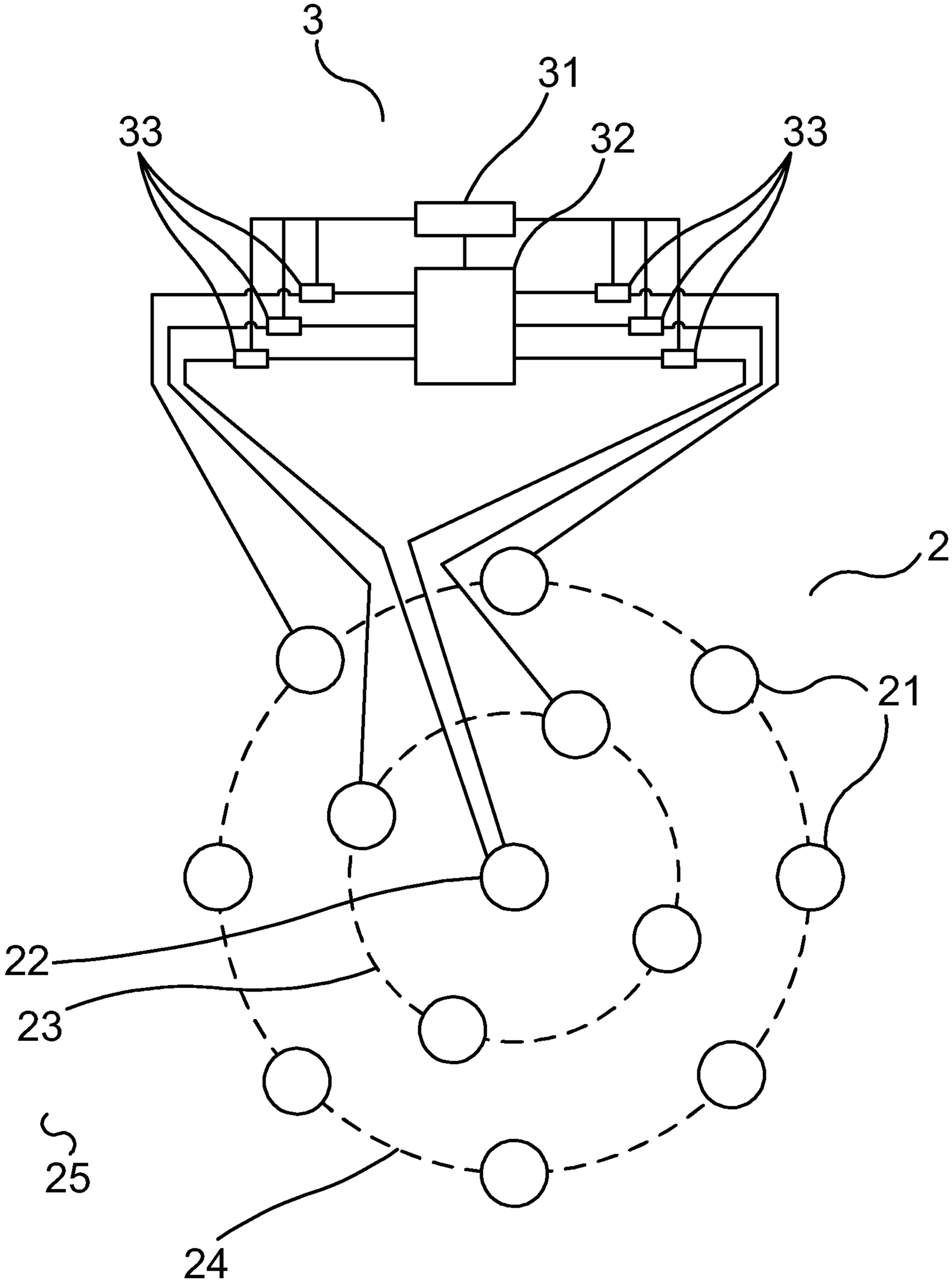

Fig. 3

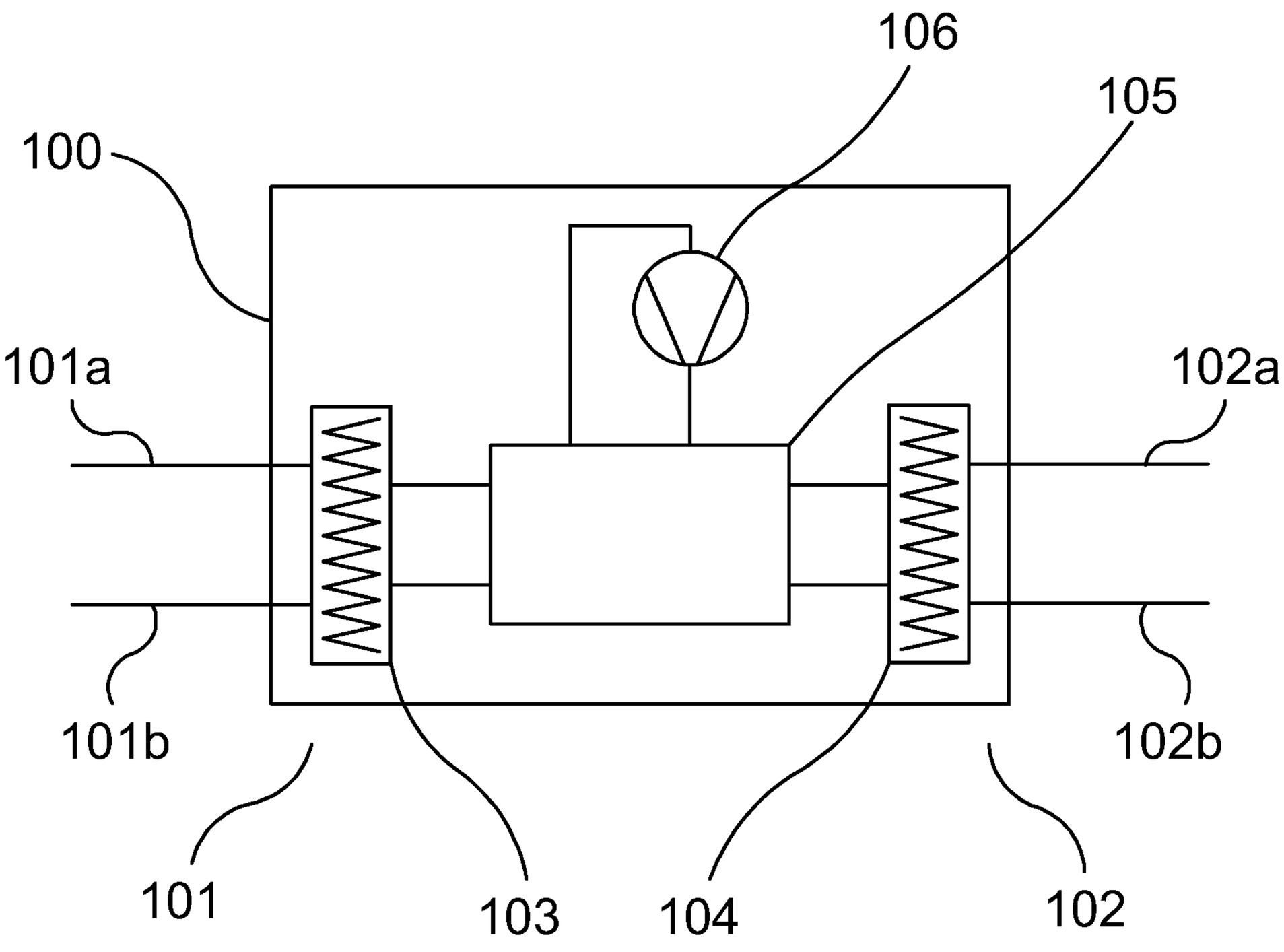

Fig. 1