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## (54) HVAC SYSTEM, METHOD FOR UPGRADING AN EXISTING HVAC SYSTEM AND A KIT FOR UPGRADING AN EXISTING HVAC SYSTEM

(57) Upgrade kit with a signal switch (4) for each HVAC zone (3), wherein each signal switch (4) comprises a first input (41) connected to the first output (321) of the thermostat (32), a second input (42) connected to the second output (322) of the thermostat (32), a first output (43) connected to the first control element (33), and a second output (44) connected to the second control element (34), wherein the signal switch (4) switches between a first switching state and a second switching state, wherein the signal switch (4) connects in the first switching state the first and second input (41, 42) with the first and second output (43, 44), wherein the signal switch (4) connects in the second switching state the second input (42) with the first output (43).

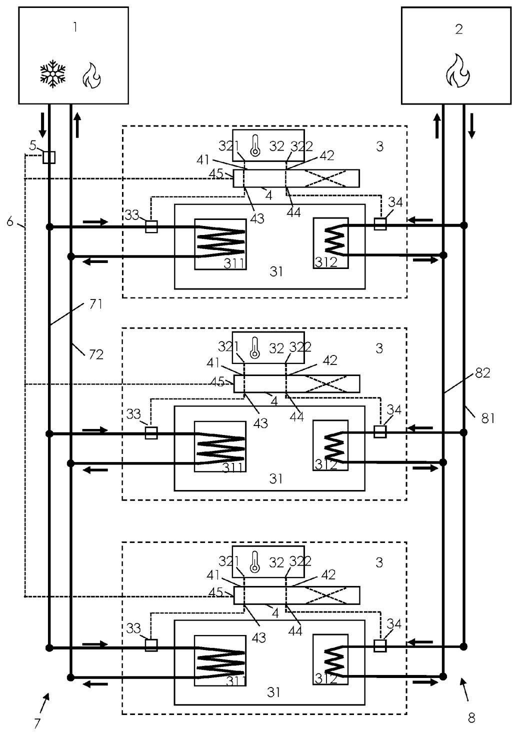


Fig. 2

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## Description

### Technical Field

**[0001]** The present invention relates to an HVAC system, a method for upgrading an existing HVAC system and a kit for upgrading an existing HVAC system.

### Prior art

**[0002]** Existing bigger buildings had often a four pipe heating ventilation air conditioning (HVAC) system like shown in Fig. 1. Such four pipe HVAC systems had a chiller 9 and an independent heat producing device 2, normally a boiler. The chiller 9 is connected via a first piping network 7 to a plurality of terminal units 31. The boiler 2 is connected via a second piping network 8 to the plurality of terminal units 31. The building has different zones and contains in each zone 3 a zone equipment comprising a thermostat 32 and a terminal unit 31. The terminal unit 31 has a first or cooling coil 311 to cool the air in the zone and a second or heating coil 312 to heat the air in the zone. The cooling coil 311 is connected via the first piping network to the chiller 9. The cooling coil 311 can be connected to or disconnected from the remaining first piping network 7 by a valve 33. When the valve 33 is open, the cooling fluid from the chiller 9 and/or from the first piping network 7 flows through the cooling coil 311 in order to cool the air in the zone, and, when the valve 33 is closed, the cooling fluid from the chiller 9 and/or from the first piping network 7 does not flow through the cooling coil 311, thus not cooling the air in the zone. The heating coil 312 is connected via the second piping network to the heat producing device 2. The heating coil 312 can be connected to or disconnected from the remaining second piping network 8 by a valve 34. When the valve 34 is open, the heating fluid from the boiler 2 and/or from the second piping network 8 flows through the heating coil 312 in order to heat the air in the zone, and, when the valve 34 is closed, the heating fluid from the boiler 2 and/or from the second piping network 8 does not flow through the heating coil 312, thus not heating the air in the zone 3. The thermostat 32 measures the temperature in the zone 3, compares it with a reference temperature and controls the valves 33 and 34 based on this comparison. The reference temperature of each zone can be set via the thermostat of the zone 3. If the temperature measured in the zone is too cold, the valve 34 will be opened to heat the air in the zone. If the temperature measured in the zone is too hot, the valve 33 will be opened to cool the air in the zone.

**[0003]** Since the heating in these existing HVAC systems are based on the combustion of fossil energies like gas or oil, it is desirable to replace the boiler 2 by a electrically powered heating device which can be powered by electricity which is produced by renewable energy sources. The preferred choice for such a electrically powered heating device is a heat pump. A reversible heat pump could theoretically replace the chiller 9 and the boiler 2. However, it is not easy or sometimes not even possible to simply replace the boiler 2 by a heat pump or even more complicated to replace the chiller 9 and the boiler 2 by a reversible heat pump.

**[0004]** If the boiler 2 is replaced by a heat pump without any further changes of the second piping network 8 and the terminal units 31, the heating will not use the full efficiency of the heat pump due to significant losses in the second piping network 8 and the heating coil 312. The boiler 2 produces normally a heating liquid at a high temperature, normally between 70° and 90°C, the so-called inlet temperature of the second piping network 8. After the heating fluid has passed the heating coils, the returning liquid has a reduced temperature, the so-called outlet or return temperature. The temperature difference between the inlet temperature and the outlet temperature is normally 20°C or higher. On the other side, a heat pump works normally at a low temperature of around 35° ... 45°C with a low temperature difference between inlet temperature and outlet temperature of around 6°C. Since the heat producing part of the existing HVAC system is designed too small to allow the higher flow required for a heat pump operating at a low temperature, and thus to give the needed power when it is supplied at low temperature by the heat pump. Thus, it would be necessary to change also all the heating coils 312 or terminal units 31 in the zone 3, if the heat pump should work properly. This is why most old HVAC systems continue to work with fossil based boilers 2.

**[0005]** If a reversible heat pump shall replace the chiller 9 and the boiler 2, a first practical problem is that the chiller 9 and the boiler 2 are very often arranged in different sites of the building, e.g. the chiller 9 on the roof and the boiler 2 in the basement. If the reversible heat pump is arranged at the site of the chiller 9, the second piping network 8 must be connected to the reversible heat pump, or vice versa, if the reversible heat pump is located at the site of the boiler 2. In addition, the same problems apply for the heat operation of the reversible heat pump working at low temperature in the heating coils 312 and the second piping network 8 designed for high temperature.

**[0006]** The chiller 9 has actually a low temperature difference between inlet temperature and outlet temperature, something in the range of 6°C. Therefore, the first piping network 7 has always a larger diameter than the second piping network 8, similar the cooling coil 311 is larger than the heating coil 312 in order to cool sufficiently the air in the zone. Thus, theoretically the replacement of the chiller 9 with a reversible heat pump would use less fossil energy. However, this would require that the operation of the valve 33 must be changed. While for the heating operation, the valve 33 was closed and the valve 34 was opened, it would now be necessary to open valve 33 to connect the coil 311 over the first piping network 7 to the reversible heat pump in the heating operation. This can however not be achieved with the pre-existing thermostats in such systems which were not programmable nor communicative to change their operation mode depending on the operation mode of the reversible heat pump. Thus, the heating by the reversible heat pump over the first piping network 7 and the cooling coils 311 necessitates to replace the thermostats or at least their regulators by communicative and programmable ones so that they can change their operation principles based on the operation mode of the reversible heat pump.

**[0007]** For these reasons, it is rather difficult to upgrade a "traditional" HVAC system with a heat pump, and most operators of HVAC system either decide to do nothing or decide to replace the complete system.

**[0008]** Similar problems appear for an energy efficient improvement of HVAC system with terminal units allowing cooling with a chiller 9 and heating.

**[0009]** The above problems might not appear with new installations as the thermostats can be chosen from the beginning as communicative and programmable thermostats. However, those "smart" thermostats are significantly more expensive and also more complex to configure than traditional thermostats.

## Brief summary of the invention

**[0010]** It is the object of the invention to provide a HVAC system, an upgrade method and an upgrade kit which allows to operate existing HVAC systems efficiently with reversible heat pump or which allows to use traditional thermostats in new HVAC systems with reversible heat pumps.

**[0011]** According to the invention, this object is solved by an HVAC system comprising a chiller configured to cool a cooling fluid, a plurality of zones, wherein each zone comprises a terminal unit, a thermostat, a first control element and a second control element, wherein the terminal unit comprises a coil to exchange heat between the cooling fluid and the air in the zone, wherein the terminal unit comprises further a heat producing element configured to heat the air in the zone, and a piping network connecting the terminal units with the chiller so that the cooling fluid can flow from the chiller through the piping network to the coil of the terminal unit and back to the chiller. The first control element is configured to switch the flow of the cooling fluid through the coil on and off, and the second control element is configured to switch the function of the heat producing element on and off. The thermostat comprises a first output connected to the first control element and a second output connected to the second control element, wherein the thermostat is configured to measure a zone temperature, to control the first control element over the first output to switch the flow of the cooling fluid through the coil on, when the measured zone temperature is above a reference zone temperature range, and to control the second control element over the second output to switch the heat producing element on, when the measured zone temperature is below a reference zone temperature range, wherein the chiller is a reversible heat pump configured to heat the cooling fluid in a heating mode and to cool the cooling fluid in a cooling mode, wherein each zone comprises a signal switch configured to switch between a first switching state and a second switching state, wherein the signal switch connects in the first switching state the second output of the thermostat with the second control element, wherein the signal switch connects in the second switching state the second output of the thermostat with the first control element so that, when the reversible heat pump is in the heating mode and the signal switch in the second switching state, the thermostat controls the first control element over the second output to switch the flow of the cooling fluid through the coil on, when the measured zone temperature is below a reference zone temperature range.

**[0012]** According to the invention, this object is solved by a method to operate an HVAC system according to invention comprising the following steps: switching the signal switches in the first switching state, and to heat the zones whose measured zone temperature is below the reference zone temperature range with the heat producing element of the terminal unit of the zone and to cool the zones whose measured zone temperature is above the reference zone temperature range with the reversible heat pump operating in the cooling mode, and switching the signal switches in the second switching state and to heat the zones whose measured zone temperature is below the reference zone temperature range with the reversible heat pump operating in the heating mode.

**[0013]** The following aspects of the invention refer to an upgrade of an existing HVAC system. The HVAC system to be upgraded is defined as follows. the HVAC system to be upgraded comprises a chiller, a piping network and a plurality of zone, wherein each zone comprises a terminal unit, a thermostat, a first control element and a second control element, wherein the chiller is configured to cool the cooling fluid, wherein the terminal unit comprises a coil to exchange heat between the cooling fluid and the air in the zone, wherein the terminal unit comprises further a heat producing element configured to heat the air in the zone, wherein the piping network connects the coils of the terminal units with the chiller so that the cooling fluid can flow from the chiller through the piping network to the coils of the terminal units and back to the chiller, wherein first control element is configured to switch the flow of the cooling fluid through the coil on and off, wherein the second control element is configured to switch the function of the heat producing element on and off, wherein the thermostat comprises a first output connected to the first control element and a second output connected to the second control element, wherein the thermostat is configured to measure a zone temperature, to control the first control element over the first output to switch the flow of the cooling fluid through the coil on, when the measured zone temperature is above a reference zone temperature range, and to control the second control element over the second output to switch the heat producing element on, when the measured zone temperature is below a reference zone temperature range.

**[0014]** According to the invention, this object is solved by an upgrade kit for upgrading the HVAC system to be upgraded. The upgrade kit comprises a signal switch for each thermostat of the HVAC system, wherein the signal switch comprises a first input terminal configured to be connected to the first output of the thermostat of the zone, a second input terminal configured to be connected to the second output of the thermostat of the zone, a first output terminal configured to be connected to the first control element of the zone, and a second output terminal configured to be connected to the second control element of the zone, wherein the signal switch is configured to switch between a first switching state and a second switching state, wherein the signal switch connects in the first switching state the first input terminal with the first output terminal and the second input terminal with the second output terminal, wherein the signal switch connects in the second switching state the second input terminal with the first output terminal.

**[0015]** According to the invention, this object is solved by a method to upgrade the HVAC system to be upgraded. The method comprises the following steps: replacing the chiller with a reversible heat pump so that the cooling fluid of the pipe system can be heated by the reversible heat pump in a heating mode and cooled by the heat pump in a cooling mode; connecting in each zone a signal switch between the thermostat of the zone and the first and second control element of the zone, wherein the signal switch comprises a first input terminal which is connected to the first output of the thermostat of the zone, a second input terminal which is connected to the second output of the thermostat of the zone, a first output terminal which is connected to the first control element of the zone, and a second output terminal which is connected to the second control element of the zone, wherein the signal switch is configured to switch between a first switching state and a second switching state, wherein the signal switch connects in the first switching state the first input terminal with the first output terminal and the second input terminal with the second output terminal, wherein the signal switch connects in the second switching state the second input terminal with the first output terminal.

**[0016]** The signal switches according to the invention allow to replace the chiller by a reversible heat pump and to use the cooling coil of terminal units of an existing HVAC system without the need to replace the existing thermostats or without the need to have complex systems with smart thermostats. The signal switches themselves can be realized very simple to realize the necessary inversion of the second output of the thermostat on the first control element, when the heat pump is operated in the heating mode. The current invention allows thus to use a heat pump with the correctly dimensioned cooling coil of the terminal units without the need of smart thermostats. In addition, the current solution has the further big advantage that the pre-existing heat producing element of the terminal units can still be used for situations when it is very cold and the heat pump does not heat efficiently.

**[0017]** The dependant claims refer to further advantageous embodiments.

**[0018]** In one embodiment, the signal switch connects in the first switching state the first output of the thermostat with the first control element.

**[0019]** In one embodiment, the signal switch connects in the second switching state the first output of the thermostat with the second control element. This allows that the signal switch would also properly work, if the input or output cables are connected in an inverted way.

**[0020]** In one embodiment, the signal switch is configured to be mechanically or manually switched between the first switching state and the second switching state. This allows to make the signal switches very simple and reduces the complexity of the system.

**[0021]** In one embodiment, the HVAC system or the upgrade kit comprising a central switching controller (to be) connected electrically to all signal switches of the zones, wherein the central switching controller is configured to control all signal switches to switch (all) in the first switching state or to switch (all) in the second switching state. This facilitates the maintenance of the HVAC system, as the signal switches must not be switched manually in each zone to the second switching state, when the heat pump shall be used for the heating.

**[0022]** In one embodiment, the central switching controller comprises a heat pump mode detector configured to detect, if the reversible heat pump is in the heating mode or in the cooling mode, wherein the central switching controller is configured to switch the signal switches based on the detected mode of the reversible heat pump. This embodiment allows to switch the signal switches automatically in the second switching state, when the heat pump is detected to be in the heating mode.

**[0023]** In one embodiment, the heat pump mode detector comprises a temperature sensor configured to detect a cooling fluid temperature in the piping network, wherein the heat pump mode detector detects the mode of the reversible heat pump based on the detected cooling fluid temperature. This is a very simple and robust way to detect the heat pump mode.

**[0024]** In one embodiment, the heat pump mode detector is realized by an output of the reversible heat pump outputting, if the reversible heat pump is in the heating mode or the cooling mode.

**[0025]** In one embodiment, the HVAC system (to be upgraded and/or upgraded) comprises a controller configured to receive an outside temperature and to control the HVAC system based on the outside temperature as follows: when the outside temperature is below a first temperature threshold, to switch the signal switches in the first switching state and to heat the zones whose measured zone temperature is below the reference zone temperature range with the heat producing element of the terminal unit of the zone; when the outside temperature is between the first temperature threshold and a second temperature threshold, to switch the signal switches in the second switching state and to heat the zones whose measured zone temperature is below the reference zone temperature range with the reversible heat pump operating in the heating mode; and when the outside temperature is above the second temperature threshold, to switch the signal switches in the first switching state and to cool the zones whose measured zone temperature is above the reference zone temperature range with the reversible heat pump operating in the cooling mode.

**[0026]** In one embodiment, the HVAC system (to be upgraded and/or upgraded) comprises: a heat producing unit configured to heat a heating fluid; a heating coil in the terminal unit of each zone, wherein the heating coils is configured to transfer heat from the heating fluid flowing through the coil to the air in the zone; a further piping network connecting the terminal units with the heat producing unit so that the heating fluid can flow from the heat producing device through the further piping network to the coil of the terminal unit and back to the heat producing unit, wherein second control element is configured to switch the flow of the heating fluid through the coil on and off. The invention is particularly well suited for such 4-pipe HVAC systems.

**[0027]** In one embodiment, the terminal unit is a 4-pipe fan coil, a chilled beam, a 4-pipe chilled ceiling or any other 4-pipe terminal unit.

**[0028]** In one embodiment, the terminal unit is a 2-pipe + electric heating fan coil in which the heat producing element is an electrical heating which is switched on and off by the second control element.

**[0029]** In one embodiment, each signal switch comprises a control interface, wherein the upgrade kit comprises further a central switching controller connected electrically to the control interfaces of the signal switches, wherein the central switching controller is configured to control the signal switches to switch in the first switching state or to switch in the second switching state.

**[0030]** In one embodiment, the central switching controller comprises a heat pump mode detector configured to detect, if the reversible heat pump is in the heating mode or in the cooling mode, wherein the central switching controller is configured to switch the signal switches based on the detected mode of the reversible heat pump.

**[0031]** In one embodiment, the upgrade kit comprises a reversible heat pump configured to replace the chiller of the HVAC system and configured to heat the cooling fluid in a heating mode and to cool the cooling fluid in a cooling mode.

**[0032]** In one embodiment, the first input of the signal switch comprises a first input terminal and a second input terminal, wherein the second input of the signal switch comprises a first input terminal and a second input terminal, wherein the first output of the signal switch comprises a first output terminal and a second output terminal, wherein the second output comprises a first output terminal and a second output terminal, wherein signal switch is configured to connect in the first switching state the first input terminal of the first input with the first output terminal of the first output, the second input terminal of the first input with the second output terminal of the first output, the first input terminal of the second input with the first output terminal of the second output and the second input terminal of the second input with the second output terminal of the second output, wherein the signal switch is configured to connect in the second switching state the first input terminal of the second input with the first output terminal of the first output and the second input terminal of the second input with the second output terminal of the first output.

**[0033]** In one embodiment, the signal switch comprises a first cable pre-installed in the first input of the signal switch to be connected with the first output of the thermostat of the HVAC system to be upgraded and a second cable pre-installed in the second input of the signal switch with the second output of the thermostat of the HVAC system to be upgraded.

**[0034]** In one embodiment, the method to upgrade comprising further the step of connecting a central switching controller with the signal switches, wherein the central switching controller is configured to control the signal switches to switch in the first switching state or to switch in the second switching state.

**[0035]** In one embodiment, the method to operate an HVAC system according to invention comprising the following steps: when the outside temperature is below a first temperature threshold, to switch the signal switches in the first switching state and to heat the zones whose measured zone temperature is below the reference zone temperature range with the heat producing element of the terminal unit of the zone; when the outside temperature is between the first temperature threshold and a second temperature threshold, to switch the signal switches in the second switching state and to heat the zones whose measured zone temperature is below the reference zone temperature range with the reversible heat pump operating in the heating mode; and when the outside temperature is above the second temperature threshold, to switch the signal switches in the first switching state and to cool the zones whose measured zone temperature is above the reference zone temperature range with the reversible heat pump operating in the cooling mode.

**[0036]** Other embodiments according to the present invention are mentioned in the appended claims and the subsequent description of an embodiment of the invention.

## Brief description of the Drawings

**[0037]**

Fig. 1 is a schematic view of a 4-pipe HVAC system according to the prior art.

Fig. 2 is a first embodiment of the HVAC system according to the invention.

Fig. 3 shows the first embodiment of Fig. 2 in a first switching mode.

Fig. 4 shows the first embodiment of Fig. 2 in a second switching mode. of the HVAC system according to the invention.

Fig. 5 shows a second embodiment of the HVAC system according to the invention.

Fig. 6 shows a third embodiment of the HVAC system according to the invention.

Fig. 7 shows exemplary output signals from the first and second output of the thermostat.

Fig. 8 shows the different operation modes of the HVAC system according to the invention.

Fig. 9 shows an alternative embodiment of the signal switch.

Fig. 10 shows a more detailed example of the signal switch.

**[0038]** In the drawings, the same reference numbers have been allocated to the same or analogue element.

## Detailed description of an embodiment of the invention

**[0039]** Other characteristics and advantages of the present invention will be derived from the non-limitative following description, and by making reference to the drawings and the examples.

**[0040]** Before explaining the invention in detail, the HVAC system of the prior art which can be upgraded with the present invention shall be described in more detail. The HVAC system before the upgrade (HVAC system according to prior art) shall be named HVAC system to be upgraded, and the HVAC system after the upgrade, i.e. the HVAC system according to the invention, shall be called the upgraded HVAC system or the HVAC system according to the invention.

**[0041]** The HVAC system to be upgraded comprises a chiller 9, a piping network 7 and a plurality of zones 3. The HVAC system can in some embodiments further comprise a heat producing unit 2 and a further piping network 8.

**[0042]** The piping network 7 connects the chiller 9 with the plurality of zones 3. The piping network 7 is filled with a cooling fluid. The cooling fluid is preferably water, however it would also be possible to have piping networks 7 working with different cooling fluids. The piping network 7 has a first pipe 71 conducting the cooling fluid from the chiller 9 to the zones 3 and a second pipe 72 conducting the cooling fluid from the zones 3 back to the chiller 9. The pipes 71, 72 of the piping network 7 have preferably a minimum nominal inner diameter (DN) larger than 20 mm, preferably larger than 30 mm, preferably than 45 mm, preferably larger than 50 mm, preferably larger than 55 mm. The minimum nominal inner diameter of the pipes 71, 72 can be for example 60 mm. Obviously, other minimum nominal diameters of the pipes 71, 72 are possible. The minimum nominal diameter of the pipe network 7 is normally in the zone pipe branches, i.e. the pipe 71, 72 connecting only one or only few terminal units 31 with the main piping network. The zones 3 are connected preferably in parallel so that the cooling fluid from the first pipe 71 flowing through one zone 3 flows directly back to the chiller 9 through the second pipe 72 without flowing through other zones 3. The piping network 7 comprises preferably a main piping network conducting the cooling fluid to and from multiple zones 3 / terminal units 31 and zone pipe branches conducting only the cooling fluid from and to one zone 3 or one terminal unit 31. Each zone pipe branch connects the main piping network to (the terminal unit 31 of) one zone 3. The cooling fluid temperature in the first pipe 71 is also called the inlet temperature of the piping network 7, while the cooling fluid temperature in the second pipe 72 is called the outlet temperature. The temperature difference between the inlet temperature and the outlet temperature is preferably smaller than 10° C, preferably than 8° C, preferably than 7° C. The temperature difference is normally in a range between 3° C and 6° C.

**[0043]** The chiller 9 is configured to cool the cooling fluid flowing through the piping network 7. Preferably, the chiller 9 has an internal refrigerant which is cooled down. This internal refrigerant is used to cool down the cooling fluid flowing through the piping network 7. The cooling fluid coming out of the chiller 9 is fed in the first pipe 71. The temperature of the cooling fluid coming out of the chiller 9 and/or fed into the first pipe 71 corresponds to the inlet temperature of the piping network 7. The inlet temperature has normally a temperature below 15° C, preferably below 12°C, preferably below 10° C, preferably below 8°C.

**[0044]** The further piping network 8 connects the heat producing unit 2 with the plurality of zones 3. The further piping network 8 is filled with a heating fluid. The heating fluid is preferably water, however it would also be possible to have different heating fluids. The further piping network 8 has a first pipe 81 conducting the heating fluid from the heat producing unit 2 to the zones 3 and a second pipe 82 conducting the heating fluid from the zones 3 back to the heat producing unit 2. The pipes 81, 82 of the further piping network 8 have preferably a diameter smaller than the pipes 71, 72 of the piping network 7. The pipes 81, 82 of the further piping network 8 have preferably a minimum nominal diameter smaller than 60 mm, preferably smaller than 50 mm, preferably smaller than 40 mm, preferably smaller than 30 mm, preferably than 25 mm, preferably than 20 mm. The minimum nominal diameter of the pipes 81, 82 can be for example 15 mm. Obviously, other diameters of the pipes 81, 82 are possible. The minimum nominal diameter of the pipe network 7 is normally in the zone pipe branches, i.e. the pipe 71, 72 connecting only one or only few terminal units 31 with the main piping network. The zones 3 are connected preferably in parallel so that the heating fluid from the first pipe 81 flowing through one zone 3 flows directly back to the heat producing unit 2 through the second pipe 82 without flowing through other zones 3. The further piping network 8 comprises preferably a main piping network conducting the heating fluid to and from multiple zones 3 / terminal units 31 and zone pipe branches conducting only the heating fluid from and to one zone 3 or one terminal unit 31. Each zone pipe branch connects the main piping network to (the terminal unit 31 of) one zone 3. The cooling fluid temperature in the first pipe 81 is also called the inlet temperature of the further piping network 8, while the heating fluid temperature in the second pipe 82 is called the outlet temperature of the further piping network 8. The temperature difference between the inlet temperature and the outlet temperature of the further piping network 8 is preferably larger than 10° C, preferably than 15° C, preferably than 18° C.

**[0045]** The heat producing device 2 is configured to heat the heating fluid flowing through the further piping network 8. Preferably, the heat producing device 2 is a boiler. Preferably, the heat producing device 2 heats the heating fluid by a combustion process, e.g. by combustion of a gas or oil. However, it would also be possible that the boiler is driven by an electrical resistance. The heating fluid is fed into the first pipe 81. The temperature of the heating fluid coming out of the heat producing device 2 or fed into the first pipe 81 corresponds to the inlet temperature of the further piping network 8. The inlet temperature has normally a temperature above 50°C, preferably above 60°C, preferably above 70° C.

**[0046]** In a preferred embodiment, the HVAC system to be upgraded comprises the further piping network 8 and the heat producing unit 2. In this case, the HVAC system to be upgraded is also called a 4-pipe HVAC system. However, the invention works also with HVAC systems to be upgraded without the further piping network 8 and the heat producing unit 2, whose heat producing is realized directly in the terminal units 31 of the zones 3.

**[0047]** The HVAC system to be upgraded has a plurality of zones 3. In Fig. 1 three exemplary zones 3 are shown without any limitation to the number of zones of the invention. The HVAC system can have two zones 3 or any other number above three. A zone 3 in an HVAC system is defined as one part 3 of the building whose air temperature can be conditioned/controlled by the HVAC system independent from the other parts/zones 3 of the building. The term building shall not be limited to buildings in the classic sense but should extend to anything which could be separated into zones 3 which are conditioned by a HVAC system, e.g. a natural cave, etc..

**[0048]** Each zone 3 comprises a zone equipment of the HVAC system. Each zone 3 or each zone equipment comprises a terminal unit 31, a thermostat 32, a first control element 33 and a second control element 34.

**[0049]** The terminal unit 31 comprises a coil 311 and heat producing element 312.

**[0050]** The coil 311 is often also called a cooling coil 311. The coil 311 is configured to conduct the cooling fluid of the piping network 7, in particular from the first pipe 71 through the coil 311. The coil 311 is configured to exchange heat between the cooling fluid and the air in the zone 3, in particular to remove heat from the zone 3 by conducting the cooled cooling fluid from piping network 7 through the coil 311 in order to cool down the temperature in the zone 3. The coil 311 is connected at a first end with the first pipe 71 and at a second end with the second pipe 72. Thus, the cooling fluid cooled by the chiller 9 (having the inlet temperature) flows through the first pipe 71, the coil 311 of the zone 3 where it is heated up by the air of the zone 3, and back to the chiller 9 through the second pipe 72. The coil 311 is preferably designed for a temperature difference between inlet temperature and outlet temperature of smaller than 10°C, preferably than 8°C. The coil 311 is preferably designed for a temperature difference between inlet temperature and temperature of the air of the zones 3 smaller than 40°C, preferably than 35°C, preferably than 30°C, preferably than 25°C.

**[0051]** The heat producing element 312 is configured to heat the air in the zone 3. In a preferred embodiment, the heat producing element 312 is also a coil 312 as shown in the example of Fig. 1. This coil 312 is often also called the heating coil 312. The coil 312 conducts a heating fluid of the further piping network 8 connecting the heating coils 312 of the terminal units 31 with the heat producing unit 2. The heating coil 312 is connected at a first end with the first pipe 81 and at a second end with the second pipe 82. Thus, the heating fluid heated by the heat producing unit 2 (having the inlet temperature) flows through the first pipe 81, the coil 312 of the zone 3 where it is cooled down by the air of the zone 3 (heating thus the air of the zone 3), and back to the heat producing unit 2 through the second pipe 82. The heating coil 312 of the terminal unit 31 is normally designed for a larger temperature difference between inlet temperature and outlet temperature. The temperature difference between inlet temperature and outlet temperature is preferably larger than the temperature difference of the piping network 7. The temperature difference between inlet temperature and outlet temperature is preferably larger than 10°C, preferably larger than 15°C, preferably larger than 17°C, preferably larger than 18°C, preferably larger than 19° C. The coil 312 is preferably designed for a temperature difference between inlet temperature and temperature of the air of the zones 3 larger than 40°C, preferably than 50°C, preferably than 55°C. The cooling coil 311 is preferably larger than the heating coil 312.

**[0052]** Even if the realization of the heat producing element 312 as heating coil 312 connected to a heat producing unit 2 over a further piping network 8 is preferred, the heat producing element 312 can also be realized as any other heat producing element which is able to heat the air of the zone 3 and can be controlled independently from the coil 311. The heat producing element 312 can for example be realized by an electrical heating element, e.g. a resistance or a radiation element like an infrared lamp.

**[0053]** To resume, the terminal units 31 of HVAC systems which can be upgraded with the current invention have a cooling coil 311 and any heat producing element 312. The following are examples for terminal units 31 with a heating coil 312 like a 4-pipe fan coil, a 4-pipe chilled beam or a 4-pipe chilled ceiling. The 4-pipe fan coil has in addition to the cooling coil 311 and the heating coil 312 also a fan to blow the air of the zone 3 through the cooling coil 311 and the heating coil 312. An example for a terminal unit 31 not having a coil as a heat producing element 312 is a 2-pipe electric heating fan coil in which the heat producing element 312 is an electrical heating element. The electric heating element is normally realized by a resistance.

**[0054]** The first control element 33 is configured to switch the flow of the cooling fluid through the coil on and off. The first control element 33 is actuated based on an electrical signal received from the thermostat. The first control element 33 is preferably realized as a valve. The valve can be a simple on/off valve which can be switched (only) between on (opening the flow of cooling fluid through the coil 311) and off (stopping the flow of cooling fluid through the coil 311). However, the control valve could also be realized by more complex valve, e.g. a valve controlling the amount of cooling fluid flowing through the coil 311. The valve 33 is arranged such that the valve 33 in the off state would stop the flow of the cooling fluid from the piping network 7 through the cooling coil 311 without stopping the flow of the cooling fluid through the other coils 311 of the terminal units 31 of the other zones 3. Thus, the first control element 33 of a zone controls the functioning of the coil 311 of only this zone 3 without affecting the functioning of the coils 311 of the other zones. The valve 33 is preferably arranged in the zone pipe branch of the zone 3 so that the closure of the valve will stop only the flow through the coil 311 of this zone 3. The valve 33 can be arranged in the first pipe 71 or in the second pipe 72.

**[0055]** The second control element 34 of each zone 3 controls the functioning of the heat producing element 312 of this zone 3. The second control element 34 of the zone 3 switches preferably the heat producing element 312 on and off. The second control element 34 of a zone 3 controls the functioning of the heat producing element 312 of only this zone 3 without affecting the functioning of the heat producing elements 312 of the other zones 3. The second control element 34 is actuated based on an electrical signal received from the thermostat.

**[0056]** Preferably, the second control element 34 is configured to switch the flow of the heating fluid through the heating coil 312 on and off. The second control element 34 is preferably realized as a valve. The valve 34 can be a simple on/off valve which can be switched (only) between on (opening the flow of cooling fluid through the heating coil 312) and off (stopping the flow of cooling fluid through the heating coil 312). However, the valve 34 could also be realized by more complex valve, e.g. a valve controlling the amount of cooling fluid flowing through the heating coil 312. The valve 34 is arranged such that the valve 34 in the off state would stop the flow of the heating fluid from the piping network 8 through the heating coil 312 without stopping the flow of the cooling fluid through the other heating coils 312 of the terminal units 31 of the other zones 3. The valve 34 is preferably arranged in the zone pipe branch of the zone 3 so that the closure of the valve 34 will stop only the flow through the heating coil 312 of this zone 3. The valve 34 can be arranged in the first pipe 81 (i.e. before the heating coil 312) or in the second pipe 82 (i.e. after the heating coil 312).

**[0057]** If the heat producing element 312 is not a coil, the second control element 34 is normally not a valve, but anything which can control the heat producing function of the heat producing element 312. If the heat is produced electrically in the terminal unit 31 by the heat producing element 312, the second control element 34 could be realized simply as a switch which switches the heat producing element 312 on and off.

**[0058]** The thermostat 32 is configured to measure the temperature in the zone 3 and to control the control elements 33 and 34 based on the temperature measured. The thermostat 32 has a reference temperature range $T_R$ as shown for example in Fig. 7. The reference temperature range $T_R$ can preferably varied by a user interface of the thermostat 32. The user interface normally allows to change a target temperature of the zone 3. For example, some user set the target temperature to 21 °C, others prefer a warmer zone 3 and put the target temperature to 23°C. The reference temperature range $T_R$ of the zone 3 is preferably defined by the target temperature, e.g. the target temperature +/- 1°C. The target temperature minus a lower temperature difference (e.g. 1°C) gives a lower temperature threshold $T_{R1}$ and the target temperature plus a higher temperature difference (e.g. 1°C) gives a higher temperature threshold $T_{R2}$ defining the reference threshold from $T_{R1}$ to $T_{R2}$. In some thermostats, the target temperature can be programmed over time, e.g. to have during the night a lower target temperature than during the day.

**[0059]** The thermostat 32 has two outputs 321, 322 connected to the first and second control elements 33, 34. A first output 321 of the thermostat 32 is connected to the first control element 33 to control the operation of the cooling coil 311. A second output 322 of the thermostat 32 is connected to the second control element 34 to control the operation of the heat producing element 312.

**[0060]** The thermostat 32 is configured, if the measured temperature is above the reference temperature range $T_R$, to provide an output signal O1 on the first output 321 which controls the first control element 33 to cool the air in the zone 3 and/or to switch on the flow of the cooling fluid through the cooling coil 311. The measured temperature being above the reference temperature range $T_R$ shall mean that the measured temperature is larger than the upper temperature threshold $T_{R2}$ of the temperature range $T_R$. That means, if the measured temperature is above the reference temperature range $T_R$, the output signal O1 output on the first output 321 of the thermostat 2 opens the valve 33 so that the cooling fluid can flow (from the first pipe 71) through the cooling coil 311 (to the second pipe 72) in order to remove heat from the air in the zone 3. When the measured temperature in the zone 3 reaches again the target temperature or another temperature in the temperature range $T_R$ being below the upper temperature threshold $T_{R2}$, the thermostat 32 will give out an output signal O1 on the first output 321 which controls the first control element 33 to stop cooling the air in the zone 3 and/or to stop the flow of the cooling fluid through the cooling coil 311 and/or to switch off the flow of the cooling fluid through the cooling coil 311. Thus, above the upper temperature threshold $T_{R2}$ the output signal O1 indicates to switch on the operation of the cooling coil 311, while below the target temperature the output signal O1 indicates to switch off the operation of the cooling coil 311. Between the upper temperature threshold $T_{R2}$ and the target temperature, the output signal O1 depends on where the temperature measured comes from to obtain a hysteresis effect to avoid flipping on and off of the terminal unit 31. When the temperature measured enters in this hysteresis range from above the upper temperature threshold $T_{R2}$, the output signal O1 keeps to indicate to switch on the cooling coil 311 until the target temperature has been reached in cooling the zone 3, then O1 changes to indicate to switch off the cooling coil 311. When the temperature measured enters in this hysteresis range from below the target temperature, the output signal O1 keeps to indicate to switch off the cooling coil 311 until the upper temperature threshold $T_{R2}$ has been reached, then O1 changes to indicate to switch on the cooling coil 311. Fig. 7 shows an exemplary realization of the output signal O1 having a first amplitude below the target temperature and a second amplitude above the upper temperature threshold $T_{R2}$. The first amplitude being larger than the second amplitude, e.g. the first amplitude 0V and the second amplitude 10V or any other non-zero voltage. Obviously, many other control signals are possible. Preferably, the output signal O1 is an analogue signal (not a digital control signal).

**[0061]** The thermostat 32 is configured, if the measured temperature is below the reference temperature range $T_R$, to provide an output signal O2 on the second output 322 which controls the second control element 34 to heat the air in the zone 3 and/or to switch on the operation of the heat producing element 312. The measured temperature being smaller than the reference temperature range $T_R$ shall mean that the measured temperature is smaller than the lower temperature threshold $T_{R1}$ of the temperature range $T_R$. In case of a heating coil 312, if the measured temperature is below the reference temperature range $T_R$, the output signal O2 output on the second output 322 of the thermostat 2 opens the second valve 34 so that the heating fluid can flow (from the first pipe 81) through the heating coil 312 (to the second pipe 82) in order to heat the air in the zone 3. When the temperature in the zone 3 raises above the target temperature or another temperature in the reference temperature range $T_R$ being above the lower temperature threshold $T_{R1}$, the thermostat 32 will give out an output signal O2 on the second output 322 which controls the second control element 34 to stop heating the air in the zone 3 and/or to stop the flow of the heating fluid through the heating coil 312 and/or to switch off the heat producing element 312. Thus, below the lower temperature threshold $T_{R1}$ the output signal O2 indicates to switch on the operation of the heat producing element 312, while above the target temperature the output signal O2 indicates to switch off the operation of the heat producing element 312. The output signal O1 on the first output 321, when the measured temperature is above the reference temperature range $T_R$, corresponds preferably to the output signal O2 on the second output 322, when the measured temperature is below the reference temperature range $T_R$. The output signal O1 on the first output 321, when the measured temperature is below (and/or in) the reference temperature range $T_R$, corresponds preferably to the output signal O2 on the second output 322, when the measured temperature is above (and/or in) the reference temperature range $T_R$. Between the lower temperature threshold $T_{R1}$ and the target temperature, the output signal O2 depends on where the temperature measured comes from to obtain an hysteresis effect to avoid a flipping on and off of the terminal unit 31. When the temperature measured enters in this hysteresis range from below the lower temperature threshold $T_{R1}$, the output signal O2 keeps to indicate to switch on the heating coil 312 until the target temperature has been reached by heating the zone 3, then O2 changes to indicate to switch off the heating coil 312. When the temperature measured enters in this hysteresis range from above the target temperature, the output signal O2 keeps to indicate to switch off the heating coil 312 until the lower temperature threshold $T_{R1}$ has been reached, then O2 changes to indicate to switch on the heating coil 312. Fig. 7 shows an exemplary realization of the output signal O2 having a second amplitude below the lower temperature threshold $T_{R1}$ and a first amplitude above the lower temperature threshold $T_{R1}$. The first amplitude being larger than the second amplitude, e.g. the first amplitude 0V and the second amplitude 10V or any other non-zero voltage. Obviously, many other control signals are possible. Preferably, the output signal O2 is an analogue signal (not a digital control signal).

**[0062]** To resume, the function of the thermostat 32 in each zone 3 is to control the terminal unit 31 to heat, when the zone temperature measured is below the reference temperature range $T_R$, and to control the terminal unit 31 to cool, when the zone temperature measured is above the reference temperature range $T_R$. The described function of the thermostat 32 can be realized by one or two or even more devices. Sometimes the thermostat 32 is divided in a temperature sensor or thermostat and a regulator. In this case, the outputs 321, 322 are arranged

I in the regulator. However, for the present invention the regulator and the temperature sensor together are still referred to as thermostat 32.

**[0063]** The thermostat 32 in some embodiments can also be configured to control (in addition to the control elements 33, 34) the speed of a fan of the terminal unit 31. Therefore, the thermostat 32 has normally a three-wire cable connecting the thermostat 32 with the fan of the terminal unit 31. Each wire is normally related to a different speed of the fan, like low, medium and high.

**[0064]** There are different types of thermostats 32 and/or control elements/valves 33, 34 which require different cable connections between them.

**[0065]** In the most common embodiment, the first output 321 of the thermostat 32 is connected with a two-wire cable with the first control element 33. Thus, in this case, the first output 321 of the thermostat 32 has two output terminals to connect two wires of the cable connecting the first output 321 with an input of the first control element 33. Equally, the input of the first control element has two input terminals to connect two wires of the cable connecting the first output 321 with the input of the first control element 33. Normally, also the second output 322 of the thermostat 32 is connected with a two-wire cable with the second control element 34. However, there are also other types of valves 33, 34 and/or thermostats 32 which require cables with three or more wires. For example three point valves require three wires, a first conducting the on information, the second conducting the off information and a third one for the zero. In this case, the control elements/valves 33, 34 have three input terminals and the thermostat 32 has three output terminals to connect the first output 321 of the thermostat 32 with the first control element 33 via a three-wire cable and/or to connect the second output 322 of the thermostat 32 with the second control element 34 via a three-wire cable. There are also other thermostats 32 and control elements 33, 34 requiring four or five-wire cables to connect them.

**[0066]** The HVAC system to be updated can cool zones 3 via the chiller 9, the pipe network 7 and the cooling coils 311 of the terminal units 31 of the zones 3 to be cooled (based on the thermostat 32). The HVAC system to be updated can heat zones 3 via the heat producing elements 312 of the terminal units 31 of the zones 3 to be heated (based on the thermostat 32). In a preferred embodiment, the zones 3 to be heated are heated over a (central) heat producing unit 2 conducting a heating liquid to the heating coils 312 of the terminal units 31 of the zones 3 to be heated. Thus, the HVAC systems to be updated are configured to heat some zones 3 while cool some other zones 3 at the same time.

**[0067]** A zone 3 in an HVAC system was defined as one part 3 of the building whose air temperature can be conditioned/controlled by the HVAC system independently from the other parts/zones 3 of the building. Thus, a zone 3 can there also be defined by the thermostat 32 measuring the temperature of the zone 3 and controlling the terminal unit(s) 31 of the zone 3 so to obtain the target temperature or the reference temperature range. In most cases, a zone 3 comprises (only) one thermostat 32 and (only) one terminal unit 31. However, it is also possible that a zone 3 has two or more terminal units 31 connected to the same thermostat 32, i.e. controlled in the same way. There are also some HVAC systems with a zone 3 having two or more thermostats 32 which however depend on each other, e.g. connected in a master-slave connection. In such a scenario, each thermostat 32 of the same zone 3 controls different terminal units 31 of the zone 3. However, the control for the at least one slave thermostat 32 is provided by the master thermostat 32 of the same zone 3. Afterwards the invention is described with zones comprising one thermostat 32 and one terminal unit 31 as this is the standard scenario. The invention is obviously equally applicable for a zone 3 having more than one thermostat 32 and/or more than one terminal unit 31. The zone 3 can thus also be called temperature controlled zones.

**[0068]** The HVAC system to be upgraded can comprise different spaces. A space is normally a sub-group of zones 3 of the HVAC system. A classic example is a building with different floors or levels, wherein the zones 3 of each floor are grouped in a common space. The pipe network 7 comprises preferably a main pipe (network), space pipe branches and zone pipe branches. A space is often defined by having one common space pipe branch connecting all the zones 3 of the space to the main pipe (network). Each terminal unit 31 or each zone 3 in one space is preferably connected via a zone pipe branch to the space pipe branch. In the example of the multi-level building, the main pipe (network) could be a vertical pipe which on each floor/level has a space pipe branch connecting each terminal unit 31 or each zone 3, e.g. the different rooms on this floor. The different spaces can obviously also relate to other distributions of buildings, e.g. different wings or facades on the same floor, etc. These spaces are sometimes also called zones. However, the term "zone" in here shall refer to the temperature controlled zone as defined above.

**[0069]** The HVAC system according to the invention is based on the HVAC system to be updated, wherein the chiller 9 is replaced by a reversible heat pump 1 and each zone 3 comprises additionally a signal switch 4. Preferably, the HVAC system comprises one signal switch 4 per thermostat 32. Fig. 2 to 7 show different embodiments of the HVAC system according to the invention.

**[0070]** The reversible heat pump 1 is configured to be operated in a cooling mode and in a heating mode. The reversible heat pump 1 heats the cooling fluid in the pipe network 7 in a heating mode and cools the cooling fluid in a cooling mode. Notwithstanding the fact that the cooling fluid in the pipe network 7 is used for cooling and heating, it is for consistency always called cooling fluid (also to distinguish from the heating fluid of the further pipe network 8). The name cooling fluid shall have no limitation on the function of the same to cooling. It is clear that the cooling fluid is also heated, when the reversible heat pump 1 is in a heating mode, and used for heating the zones 3 to be heated. Thus, the HVAC system according to the invention allows to heat the zones 3 with the heat producing unit 2 and to cool the zones 3 with the heat pump 1 in the cooling mode as described above for the HVAC system to be upgraded. However, the HVAC system can alternatively also heat with the heat pump 1 in the heating mode.

**[0071]** The signal switch 4 is arranged between the thermostat 32 and the first and second control elements 33, 34 (of the zone 3). The signal switch 4 is configured to switch between a first switching state and a second switching state. The signal switch 4 connects in the first switching state the second output 322 of the thermostat 32 with the second control element 34, and connects in the second switching state the second output 322 of the thermostat 32 with the first control element 33. This allows that, when the reversible heat pump is in the heating mode and the signal switch 4 in the second switching state, the thermostat 32 controls the first control element 33 over the second output 322 to switch the flow of the (heated) cooling fluid through the coil 311 on, when the measured zone temperature is below a reference zone temperature range. This means that the signal switch 4 avoids that the complete thermostat must be replaced by a new one which is a waste of resources, which infers more work and involves a complicated programming of these new thermostats. With the current invention, simply the signal switches 4 are placed between the existing "traditional" thermostat 32 and the control elements 33 and 34. Preferably, in the first switching state, the first output 321 of the thermostat 32 is connected to the first control element 33. Thus, in the first switching state, the HVAC system operates equally as in the HVAC system to be updated as the first output 321 of the thermostat 32 is connected with the first control element 33 and the second output 322 of the thermostat 32 is connected with the second control element 34. Thus, the zones 3 can be heated via the heat generation elements 312 of the terminal units 31 and cooled over the reversible heat pump 1 in the cooling mode and the coils 311 of the terminal units 31 with the normal control scheme of the thermostat. If the heat pump 1 shall be operated in the heating mode, the signal switch 4 is switched in the second switching state so that second output 322 of the thermostat responsible for controlling the heating operation of the terminal unit 31 of the zone 3 does not any more control the second control element 34, but the first control element 33. Thus, when the reversible heat pump 1 is operated in the heating mode, the signal switches 4 are switches in the second switching state. This allows to heat the zones 3 with the heat pump and the pipe network 7, because the control logic for heating of the second output 322 of the thermostat 32 is switched from the second valve 34 (in the first switching state) to the first valve 33 (in the second switching state) so that the temperature control will open the valve 33 to heat over the coil 31, when the measured temperature in the zone 3 falls under the reference temperature range.

**[0072]** Fig. 3 shows the embodiment of Fig. 2, when the heat pump 1 is in the cooling mode and/or the heat producing unit 2 producing heat and the signal switches 4 are all in the first switching state. In this configuration, the HVAC system according to the invention works equally as the HVAC system to be upgraded described above. When the heat pump 1 shall now be operated in the heating mode, the signal switches 4 shall be switched in the second switching mode so that the heat pump 1 can heat with the coil 311 of the terminal units 31 using the control logic of the second output 322 of the thermostat 32 (see Fig. 4).

**[0073]** Fig. 8 shows a preferred method of operation of the HVAC system according to the invention. When it is very cold outside, the zones 3 are heated by heat producing unit 2 (or elements 312), because the heat pump 1 becomes less effective below a certain temperature, e.g. below 3°C. In this case, the signal switches are in the first switching state. When the outside temperature is so that heating is needed, but the heat pump 1 can be operated efficiently in the heating mode, the zones 3 are heated by the heat pump 1 in the heating mode. In this case, the signal switches 4 are in the second switching state. When the outside temperature becomes so hot that the zones 3 require cooling, the heat pump 1 is operated in the cooling mode and the signal switches 4 are switched in the first switching state. This operation of the HVAC system could also be automated by implementing this in a control unit, e.g. as the control unit 5'' in Fig. 6 or by the control units present in most new reversible heat pumps 1. In this case, the control would work as follows. When the outside temperature is below a first temperature threshold T1, the zones 3 are heated by heat producing unit 2 (or elements 312), because the heat pump 1 becomes less effective below a certain temperature. In this case, the signal switches are in the first switching state. When the outside temperature is between the first and second temperature threshold T1 and T2, the zones 3 are heated by the heat pump 1 in the heating mode. In this case, the signal switches 4 are in the second switching state. When the outside temperature is above the second temperature threshold T2 (or above a third temperature threshold T3 being higher than T2), the heat pump 1 is operated in the cooling mode and the signal switches 4 are switched in the first switching state.

**[0074]** Subsequently, more details about the signal switches 4 are described.

**[0075]** In a preferred embodiment, in the second switching state, the first output 321 of the thermostat 32 is connected to the second control element 34. Thus, the signal switch 4 works like a commutator commutating the signal outputs of the first and second outputs 321, 322 of the thermostat 32 to the second and first control element 34, 33, respectively, when the signal switch 4 is in the second switching state. This is functionally not necessary and thus optional. However, it is preferred, because the signal switch 4 would work equally when the cables to the signal switch 4 are connected in an inverted way. Alternatively, the second switching state could simply separate the first output 321 from the first and/or second control element 33, 34 as shown in Fig. 9, while connecting the second output 322 with the first control element 33.

**[0076]** In a first embodiment, the signal switch 4 is actuated mechanically. In this case, when the zones 3 shall be heated with the heat pump 1 in the heating mode, a person needs to switch the signal switch 4 from the first switching state in the second switching state in all zones 3. This embodiment is not explicitly shown in the figures.

**[0077]** In a second embodiment, the signal switches 4 are connected to a central switching controller 5 connected electrically to the signal switches 4 of the zones 3. Preferably, the central switching controller 5 is connected by a cable 6 connection 6 to the signal switches 4. In this embodiment, the signal switch 4 has a control input 45 connected to the central switching controller 5 via the cable connection 6. However, it would also be possible to have the central switching controller 5 connected via a wireless communication, e.g. a radio connection, e.g. a WiFi connection. However, the connection over a cable is preferred as this allows for example to provide the power for the switching of the signal switch 4 by the cable. This avoids that each signal switch 4 necessitates an own power supply. The central switching controller 5 is configured to control the connected signal switches 4 to switch (all) in the first switching state or to switch in the second switching state. Preferably, the central switching controller 5 is (only) configured to switch all connected signal switches 4 together (not individually). That is that the signal switches 4 connected to the central switching controller 5 are either all in a first switching state or all in a second switching state 4. This keeps the system simple. It is also possible that the HVAC system according to the invention comprises two or more central switching controllers 5 connected each to different sub-groups of signal switches 4. For example, each central switching controller 5 could connect the signal switches 4 of the same space. It is sometimes difficult to provide in existing buildings cables from all zones 3 to one place. However, the zones 3 of the same space are often well accessible so that a central switching controller 5 could be well connected via a cable to the central switching controller 5 of the space. In a less preferred embodiment, it would also be possible that the central switching controller 5 can control the switching state of the different signal switches connected individually.

**[0078]** In a simple realization (not shown), the central switching controller 5 comprises a manual switch. This switch can be manually activated, when the heat pump 1 shall be used in the heating mode to switch all signal switches 4 at once from the first switching state into the second switching state. In a preferred realization, the central switching controller 5 comprises a heat pump mode detector configured to detect, if the reversible heat pump is in the heating mode or in the cooling mode, wherein the central switching controller 5 is configured to switch the signal switches 4 based on the detected mode of the reversible heat pump 1. If the heat pump mode detector detects that the heat pump 1 works in a heating mode, the central switching controller 5 switches all the signal switches 4 in the second switching state. Otherwise or If the heat pump mode detector detects that the heat pump 1 works in a cooling mode, the central switching controller 5 switches the signal switches 4 in the first switching state. Fig. 2, 5, 6 and 7 disclose different embodiments for the realization of the heat pump mode detector in the central switching controller 5.

**[0079]** In the embodiment in Fig. 2, the heat pump mode detector comprises a temperature sensor configured to measur the temperature in the cooling fluid of the pipe network 7, preferably in the first pipe 71. In this embodiment, the heat pump mode detector or the central switching controller 5 comprises preferably a user input for inputting the threshold temperature above which the temperature of the cooling fluid is considered to result from the heat pump in the heating mode. The threshold temperature can preferably be set by the user input between 35°C and 45°, preferably between 30°C and 50°C. Thus, the heat pump mode detector can be set to correspond to the inlet temperature of the pipe network 7. The threshold temperature of the heat pump mode detector is preferably set a bit below the input temperature of the heat pump in the heating mode so that the heating mode of the heat pump 1 is robustly detected. In this embodiment, a bridge connection between the first and the second pipe 71, 72 is arranged at the end of the main pipe network, after the last zone pipe branch so that even if all first control elements 33 of all zones 3 are closed, there is always a small circulation of the cooling fluid through the heat pump mode detector. This bridge connection has preferably a reduced throughput compared to the first and second pipe 71, 72 so that only the minimal necessary flow is guaranteed so that the temperature in the first pipe 71 remains always the temperature of the cooling fluid coming out of the heat pump 1. The temperature sensor can be arranged even outside of the pipe, but inside of the thermal insulation arranged around the pipe 71 or 72. Especially, for metal pipes 71, 72 the temperature of the cooling fluid corresponds mainly to the temperature of the pipe 71, 72. The temperature sensor or the heat pump mode detector 5 is preferably arranged in the first pipe 71 of the main pipe branch. In case that a plurality of central switching controllers 5 are arranged in the different spaces, the temperature sensor of a central switching controller 5 of the respective space is arranged in the space pipe branch of the space.

**[0080]** Fig. 5 shows an alternative embodiment of the heat pump mode detector. Here the heat pump mode detector is realized as an output of the heat pump 1 itself. Some heat pumps 1 are able to give out relay signal or another signal indicating that the heat pump 1 is in the heating mode (or is in the cooling mode). The central switching controller 5 can use this signal to switch the signal switches in the first or second switching state. When the output signal from the heat pump 1 can be directly used as signal to switch the signal switches 4 in the second switching state, when the heat pump 1 is in the heating mode, the output of the heat pump 1 can be considered as the central switching controller 5' (and the heat pump mode detector). In other cases, there might be a separate central switching controller 5' which generates a signal to switch the signal switches 4 based on the output of the heat pump 1.

**[0081]** Fig. 6 shows another embodiment of the central switching controller 5". In this embodiment, the HVAC system comprises a HVAC controller 5" which controls the operation of the HVAC system, e.g. based on the outside temperature or based on predictions, etc. The HVAC controller 5'' can for example be configured to control the operation of the heat pump 1 and of the heat generation unit 2. The HVAC controller 5'' can for example also control, if the heat pump 1 operates in the heating mode or in the cooling mode. Since the HVAC controller 5'' knows, if the heat pump 1 operate in the heating mode or if the heat pump 1 operates in the cooling mode or the heat producing unit 2 operates, the HVAC controller 5'' can give directly the control signal to the signal switches 4 to switch in the first switching state (if the heat pump 1 operates in the cooling mode or the heat producing unit 2 operates) and in the second switching state (if the heat pump 1 operate in the heating mode).

**[0082]** There are obviously many more ways to detect automatically that the heat pump operates in the heating mode to automatically switch the signal switches in the second switching state.

**[0083]** Each signal switch 4 is preferably realized as an independent device so that the signal switch 4 can be added to between the thermostat 32 and the control elements 33, 34 of an HVAC system to be upgraded. Fig. 10 shows an exemplary embodiment of the signal switch 4. The signal switch 4 comprises preferably a first input 41 (to be) connected to the first output 321 of the thermostat 32, a second input 42 (to be) connected to the second output 322 of the thermostat 32, a first output 43 (to be) connected to the first control element 33 and a second output 44 (to be) connected to the second control element 34. A switch 48 is configured in the first switching state to connect the first input 41 with the first output 43 and the second input 42 with the second output 44 (illustrated by continuous lines), and in the second switching state, connecting the second input 42 with the first output 43. In an optional embodiment, the first input 41 is connected with the second output 44, when the switch 48 is in the second switching state.

**[0084]** In a preferred embodiment of the HVAC system to be upgraded, the first output 321 and the second output 322 of the thermostat 32 are each connected with the first and second control element 33, 34 via a two-polarity cable. Therefore, preferably the first input 41 comprises a first input terminal 411 and a second input terminal 412. Therefore, preferably the second input 42 comprises a first input terminal 421 and a second input terminal 422. Therefore, preferably the first output 43 comprises a first output terminal 431 and a second output terminal 432. Therefore, preferably the second output 44 comprises a first output terminal 441 and a second output terminal 442. The first and second terminal of each input 41, 42 and of each output 43, 44 is configured to connect a first polarity and a second polarity of a two-polarity cable, respectively. The switch 48 in this embodiment is configured to connect in the first switching state the first input terminal 411 of the first input 41 with the first output terminal 431 of the first output 43, the second input terminal 412 of the first input 41 with the second output terminal 432 of the first output 43, the first input terminal 421 of the second input 42 with the first output terminal 441 of the second output 44 and the second input terminal 422 of the second input 42 with the second output terminal 442 of the second output 44. The switch 48 in this embodiment is configured to connect in the second switching state the first input terminal 421 of the second input 42 with the first output terminal 431 of the first output 43 and the second input terminal 422 of the second input 42 with the second output terminal 432 of the first output 43. The switch 48 in this embodiment is optionally configured to connect in the second switching state the first input terminal 411 of the first input 41 with the first output terminal 441 of the second output 44 and the second input terminal 412 of the first input 41 with the second output terminal 442 of the second output 44.

**[0085]** Preferably, the signal switch 4 comprises a first cable 413 connecting or to connect the first input 41 of the signal switch 4 with the first output 321 of the thermostat 32 and a second cable 423 connecting or to connect the second input 42 of the signal switch 4 with the second output 322 of the thermostat 32. The pre-installed cable in the signal switch 4 makes the connection of the signal switch 4 between the thermostat 32 and the first and second control element 33, 34 very easy. The pre-existing cables of the HVAC system between the thermostat 32 and the first and second control element 33, 34 are removed at the side of the thermostat 32. The pre-installed cables 413 and 423 are connected to the outputs 321, 322 of the thermostat 32 and the free-ends of the pre-existing cables of the HVAC system (before connected to the outputs 321, 322 of the thermostat 32) are connected to the outputs 43, 44 of the signal switch 4. Consequently, the fitter does not need to cut and de-insulate any cables for the mounting of the signal switch 4. The fitter must only remove the pre-existing cable and connect the free end in the outputs 43, 44 of the signal switch 4 and then connect the pre-installed cables 413, 423 of the signal switch 4 with the outputs 321, 322 of the thermostat 32. The pre-installed first cable 413 is connected to the first input 41 at a first end and is (to be) connected to the first output 321 of the thermostat 32. The first cable 413 comprises preferably a first wire connected at the first end with the first input terminal 411 and (to be) connected at the second end with a first output terminal of the first output 321 of the thermostat and a second wire connected at the first end with the second input terminal 412 and (to be) connected at the second end with a second output terminal of the first output 321 of the thermostat 32. The first wire and the second wire are electrically insulated between each other, i.e. are not galvanically connected. The pre-installed second cable 423 is connected to the second input 41 at a first end and is (to be connected) to the second output 322 of the thermostat 32. The second cable 423 comprises preferably a first wire connected at the first end with the first input terminal 421 of the second input 42 and (to be) connected at the second end with a first output terminal of the second output 322 of the thermostat 32 and a second wire connected at the first end with the second input terminal 422 of the second input 42 and (to be) connected at the second end with a second output terminal of the second output 322 of the thermostat 32. The first wire and the second wire are electrically insulated between each other, i.e. are not galvanically connected.

**[0086]** In a first embodiment, the signal switch 4 comprises a manual mechanism to manually switch the switch 48 from the first switching state into the second switching state and vice versa. The manual mechanism could be a mechanical mechanism (like a traditional mechanical switch mechanism) and/or an electrical mechanism (like a touch switch). However, preferably, the switch mechanism is such that the switch mechanism does not require a power supply and the switch can be activated (only) by a user.

**[0087]** In a second embodiment, the signal switch 4 comprises a control input 45 to receive the control signal from the central switching controller 5. The control input 45 comprises preferably a first control input terminal 451 and a second control input terminal 452 to connect a two-wire cable between the central switching controller 5 and the signal switch 4. In the second embodiment, the signal switch 4 comprises further electronic means to electronically switch the switch 48 between the first and second switching state. The electronic means can be electromechanical (e.g. using an actuator) or electronic (e.g. using a transistor). The power supply for the signal switch 4 of the second embodiment could result from the control input 45. E.g. a set of transistors to realize the switch 48 could be powered directly by the control signal of the control input 45. Alternatively, it is also possible to realize an independent power supply for the signal switch 4. Preferably, the signal switch 4 comprises further a control output to connect control signal received at the control input 45 to further signal switches 4. Preferably, the control output comprises a first control output terminal 454 connected to the first control input terminal 451 and a second control output terminal 453 connected to the second control input terminal 452.

**[0088]** It would also be possible that the signal switches 4 comprise a control input 45 to be switched by the central switching controller 5 and a manual mechanism to switch the switch 48. This would allow to simply upgrade the HVAC system according to the invention by a central switching controller 5 without the need to replace again the signal switches 4.

**[0089]** In an optional embodiment, the signal switch 4 comprises further a plurality of further input terminals 461, 462, 463, 464, 465, 466 connected with a plurality of further output terminals 471, 472, 473, 474, 475, 476, respectively. Preferably, there is at least one further input terminal 461, 462, 463 (preferably at least two) to connect at least a third wire (preferably a third and fourth wire) of a three-(four or more)- wire cable connecting the first input 41 of the signal switch 4 with the first output 321 of the thermostat 32. Preferably, there is at least one further input terminal 464, 465, 466 (preferably at least two) to connect at least a third wire ( preferably a third and fourth wire) of a three(four or more)-wire cable connecting the second input 42 of the signal switch 4 with the second output 322 of the thermostat 32. Preferably, there is at least one further output terminal 471, 472, 473 (preferably at least two) to connect at least a third wire (preferably a third and fourth) wire of a three(four or more)-wire cable connecting the first output 43 of the signal switch 4 with the first control element 33. Preferably, there is at least one further output terminal 474, 475, 476 (preferably at least two) to connect at least a third wire (preferably a third and fourth) wire of a three (four or more)-wire cable connecting the second output 44 of the signal switch 4 with the second control element 34. This allows to connect other wires (which do not require a switching) of the cables connecting the thermostat 32 and the first and second control element 33, 34 over the signal switch 4. This could be for example the power supply for the first and second control element 33, 34. This could be the zeros of a three-point valves. For example, the two input terminals 461, 462 and the two output terminals 471, 472 could be used for connecting the power supply from the thermostat 32 to the power supply of the first control element 33. For example, the two input terminals 464, 465 and the two output terminals 474 475 could be used for connecting the power supply from the thermostat 32 to the power supply of the second control element 34.

**[0090]** In a preferred embodiment, the signal switch 4 comprises four control lights indicating the activity of the inputs 41, 42 and outputs 43, 44. Each control light is configured to be illuminated, if the respective input or output conducts a current. A first control light is preferably connected between the first input terminal 411 of the first input 41 and the second input terminal 412 of the first input 41. A second control light is preferably connected between the first input terminal 421 of the second input 42 and the second input terminal 412 of the second input 42. A third control light is preferably connected between the first output terminal 411 of the first output 41 and the second output terminal 412 of the first output 41. A second control light is preferably connected between the first output terminal 421 of the second output 42 and the second output terminal 412 of the second output

42. This allows to see right away which input 41, 42 and which output 43, 44 of the signal switch 4 is used. Preferably, the signal switch 4 comprises further a fifth control light to be illuminated if the control input 45 conducts a current. The fifth control light (not shown) is preferably configured to light up, if the control input 45 receives a control signal to switch in the second switching state, and to be switched of, if the control input 45 does not receive a control signal or receives a control signal indicating that the signal switch 4 is in the first switching state. In combination with the other 4 control lights, this allows to verify that the signal switch 4 is correctly switched in the first and second switching state based on the control input 45. The fifth control light can be connected between the first control terminal 451 and the second control terminal 452.

**[0091]** The upgrade kit according to the invention comprises a plurality of signal switches 4 as described above. If the upgrade kit comprises signal switches 4 according to the second embodiment, the upgrade kit could comprise also a central switching controller 5. However, it would also be possible to use a central switching controller 5 of the heat pump 1 or of a central controller 5". The upgrade kit could further comprise the reversible heat pump 1 which should replace the chiller 9.

**[0092]** The invention comprises further a method to upgrade the HVAC system to be upgraded (as described above) with the upgrade kit described above. The method comprises the following steps:

In a first step, in each zone 3, the thermostat 32 of the zone 3 is connected via one of the signal switches 4 of the upgrade kit with the first and second control element 33, 34 of the zone 3. Preferably, the first input 41 is connected via a first cable 413 with the first output 321 of the thermostat 32, preferably with the pre-installed first cable 413 of the signal switch 4. Preferably, the second input 42 is connected via a second cable 423 with the second output 322 of the thermostat 32, preferably with the pre-installed second cable 423 of the signal switch 4. Preferably, the first output 43 is connected via a cable with the first control element 33, preferably with the pre-existing cable of the HVAC system to be upgraded used between the first control element 33 and the first output 321 of the thermostat 32. Preferably, the second output 44 is connected via a cable with the second control element 34, preferably with the pre-existing cable of the HVAC system to be upgraded used between the second control element 34 and the second output 322 of the thermostat 32.

**[0093]** Some zones 3 of existing HVAC systems might comprise two or more terminal units controlled by the same thermostat 32 of a zone 3. In this case, the different terminal units 31 of the same zone 3 could be controlled by the same signal switch 4. The cables going out of the thermostat 32 of the pre-existing HVAC system controlling the different terminal units 31 of the zone 3 must simply be connected to the outputs 43, 44 of the signal switch 4 so that the control output of the thermostat 32 will be correctly switched for all terminal units 31 at the same time. It is however also possible to have one signal switch 4 per terminal unit 31 and connect then different signal switches 4 to the same thermostat 32.

**[0094]** If the upgraded HVAC system should be centrally controlled by a central switching controller 5, the central switching controller 5 must be connected to all signal switches 4 (second step). Preferably, this is achieved by a cable connection between the signal switches 4 and the central switching controller 5. If the central switching controller 5 comprises a heat pump mode detector installed in the pipe network 7, second step would comprise further to mount the heat pump mode detector in the pipe network 7, preferably in the first pipe 71. If there are multiple central switching controllers 5 (including each a heat pump mode detector), each of those central switching controllers 5 is installed in the respective space in the HVAC system. In this embodiment, the second step comprises preferably also to install a small bridge conduct between the end of the first pipe 71 and the end of the second pipe 72 in order to have always a circulation of the cooling fluid in the first pipe 71 to have a reliable temperature measurement for the cooling fluid in the first pipe 71.

**[0095]** The method comprises preferably a third step of replacing the chiller 9 of the HVAC system to be upgraded by a reversible heat pump 1.

**[0096]** The order of the first to third step can be arbitrarily changed without any effect on the invention.

**[0097]** It should be understood that the present invention is not limited to the described embodiments and that variations can be applied without going outside of the scope of the claims.

## Claims

1. HVAC system comprising:

 a chiller (1) configured to cool a cooling fluid,
 a plurality of zones (3), wherein each zone (3) comprises a terminal unit (31), a thermostat (32), a first control element (33) and a second control element (34), wherein the terminal unit (31) comprises a coil (311) to exchange heat between the cooling fluid and the air in the zone (3), wherein the terminal unit (31) comprises further a heat producing element (312) configured to heat the air in the zone (3),
 a piping network (7) connecting the terminal units (31) with the chiller (1) so that the cooling fluid can flow from the chiller (1) through the piping network (7) to the coil (311) of the terminal unit (31) and back to the chiller (1),
 wherein first control element (33) is configured to switch the flow of the cooling fluid through the coil (311) on and off,
 wherein the second control element (34) is configured to switch the function of the heat producing element (312) on and off,

wherein the thermostat (32) comprises a first output (321) connected to the first control element (33) and a second output (322) connected to the second control element (34), wherein the thermostat (32) is configured to measure a zone temperature, to control the first control element (33) over the first output (321) to switch the flow of the cooling fluid through the coil (311) on, when the measured zone temperature is above a reference zone temperature range, and to control the second control element (34) over the second output (322) to switch the heat producing element (312) on, when the measured zone temperature is below a reference zone temperature range,

**characterized in**

**that** the chiller (1) is a reversible heat pump configured to heat the cooling fluid in a heating mode and to cool the cooling fluid in a cooling mode,

**that** each zone (3) comprises a signal switch (4) configured to switch between a first switching state and a second switching state, wherein the signal switch (4) connects in the first switching state the second output (322) of the thermostat (32) with the second control element (34), wherein the signal switch (4) connects in the second switching state the second output (322) of the thermostat (32) with the first control element (33) so that, when the reversible heat pump (1) is in the heating mode and the signal switch (4) in the second switching state, the thermostat (32) controls the first control element (33) over the second output to switch the flow of the cooling fluid through the coil (311) on, when the measured zone temperature is below a reference zone temperature range.

**2.** System according to the previous claim, wherein the signal switch (4) connects in the first switching state the first output of the thermostat (32) with the first control element (33).

**3.** System according to the previous claim, wherein the signal switch (4) connects in the second switching state the first output (321)of the thermostat (32) with the second control element (34).

**4.** System according to one of the previous claims, wherein the signal switch (4) is configured to be mechanically or manually switched between the first switching state and the second switching state.

**5.** System according to one of claims 1 to 3 further comprising central switching controller (5) connected electrically to all signal switches (4) of the zones (3), wherein the central switching controller (5) is configured to control all signal switches (4) to switch all in the first switching state or to switch all in the second switching state.

**6.** System according to the previous claim, wherein the central switching controller (5) comprises a heat pump mode detector configured to detect, if the reversible heat pump is in the heating mode or in the cooling mode, wherein the central switching controller (5) is configured to switch the signal switches (4) based on the detected mode of the reversible heat pump (1).

**7.** System according to the previous claim, wherein the heat pump mode detector comprises a temperature sensor configured to detect a cooling fluid temperature in the piping network (7), wherein the heat pump mode detector detects the mode of the reversible heat pump (1) based on the detected cooling fluid temperature.

**8.** System according to one of the previous claims further comprising:

a heat producing unit (2) configured to heat a heating fluid,

a heating coil (312) in the terminal unit (31) of each zone (3), wherein the heating coils (312) are configured to transfer heat from the heating fluid flowing through the heating coil (312) to the air in the zone (3),

a further piping network (8) connecting the terminal units (31) with the heat producing unit (2) so that the heating fluid can flow from the heat producing unit (2) through the further piping network (8) to the heating coil (312) of the terminal unit (31) and back to the heat producing unit,

wherein second control element (34) is configured to switch the flow of the heating fluid through the heating coil (312) on and off.

**9.** Upgrade kit for upgrading an HVAC system,

wherein the HVAC system to be upgraded comprises a chiller (9), a piping network (7) and a plurality of zone (3), wherein each zone (3) comprises a terminal unit (31), a thermostat (32), a first control element (33) and a second control element (34), wherein the chiller (9) is configured to cool the cooling fluid, wherein the terminal unit (31) comprises a coil (311) to exchange heat between the cooling fluid and the air in the zone (3), wherein the terminal unit (31) comprises further a heat producing element (312) configured to heat the air in the zone (3), wherein the piping network (7) connects the coils (311) of the terminal units (31) with the chiller (9) so that the cooling fluid can flow from the chiller (9) through the piping network (7) to the coils (311) of the terminal units (31) and back to the chiller (9), wherein first control element (33) is configured to switch the flow of the cooling fluid through the coil (311) on and off, wherein the second control element (34) is configured to switch the function of the heat producing element (312) on and off, wherein the thermostat (32) comprises a first output connected to the first control element (33) and a second output connected to the second control element (34), wherein the thermostat (32) is configured to measure a zone temperature, to control the first control element (33) over the first output to switch the flow of the cooling fluid through the coil (311) on, when the measured zone temperature is above a reference zone temperature range, and to control the second control element (34) over the second output to switch the heat producing element (312) on, when the measured zone temperature is below a reference zone temperature range,

wherein the upgrade kit comprises a signal switch (4) for each zone (3) of the HVAC system, wherein the signal switch (4) comprises a first input (41) configured to be connected to the first output (321) of the thermostat (32) of the zone (3), a second input (42) configured to be connected to the second output (322) of the thermostat (32) of the zone (3), a first output (43) configured to be connected to the first control element (33) of the zone (3), and a second output (44) configured to be connected to the second control element (34) of the zone (3), wherein the signal switch (4) is configured to switch between a first switching state and a second switching state, wherein the signal switch (4) connects in the first switching state the first input (41) with the first output (43) and the second input (42) with the second output (44), wherein the signal switch (4) connects in the second switching state the second input (42) with the first output (43).

**10.** Upgrade kit according to the previous claim, wherein each signal switch (4) comprises a control interface, wherein the upgrade kit comprises further a central switching controller (5) connected to the control interfaces of the signal switches (4), wherein the central switching controller (5) is configured to control the connected signal switches (4) to switch in the first switching state or to switch in the second switching state.

**11.** Upgrade kit according to the previous claim, wherein the central switching controller (5) comprises a heat pump mode detector configured to detect, if the reversible heat pump is in the heating mode or in the cooling mode, wherein the central switching controller (5) is configured to switch the signal switches (4) based on the detected mode of the reversible heat pump.

**12.** Upgrade kit according to one of claims 9 to 11 comprises a reversible heat pump (1) configured to replace the chiller (9) of the HVAC system and configured to heat the cooling fluid in a heating mode and to cool the cooling fluid in a cooling mode.

**13.** Upgrade kit according to one of claims 9 to 12, wherein the first input of the signal switch (4) comprises a first input terminal (411) and a second input terminal (412), wherein the second input (42) of the signal switch (4) comprises a first input terminal (421) and a second input terminal (422), wherein the first output (43) of the signal switch (4) comprises a first output terminal (431) and a second output terminal (432), wherein the second output (44) comprises a first output terminal (441) and a second output terminal (442), wherein signal switch (4) is configured to connect in the first switching state the first input terminal (411) of the first input (41) with the first output terminal (431) of the first output (43), the second input terminal (412) of the first input (41) with the second output terminal (432) of the first output (43), the first input terminal (421) of the second input (42) with the first output terminal (441) of the second output (44) and the second input terminal (422) of the second input (42) with the second output terminal (442) of the second output (44), wherein the signal switch (4) is configured to connect in the second switching state the first input terminal (421) of the second input (42) with the first output terminal (431) of the first output (43) and the second input terminal (422) of the second input (42) with the second output terminal (432) of the first output (43).

**14.** Method to upgrade an HVAC system,

wherein the HVAC system to be upgraded comprises a chiller (9), a piping network (7) and a plurality of zone (3), wherein each zone (3) comprises a terminal unit (31), a thermostat (32), a first control element (33) and a second control element (34), wherein the chiller (9) is configured to cool the cooling fluid, wherein the terminal unit (31) comprises a coil (311) to exchange heat between the cooling fluid and the air in the zone (3), wherein the terminal unit (31) comprises further a heat producing element (312) configured to heat the air in the zone (3), wherein the piping network (7) connects the coils (311) of the terminal units (31) with the chiller (9) so that the cooling fluid can flow from the chiller (9) through the piping network (7) to the coils (311) of the terminal units (31) and back to the chiller (9), wherein first control ele-

ment (33) is configured to switch the flow of the cooling fluid through the coil (311) on and off, wherein the second control element (34) is configured to switch the function of the heat producing element (312) on and off, wherein the thermostat (32) comprises a first output connected to the first control element (33) and a second output connected to the second control element (34), wherein the thermostat (32) is configured to measure a zone temperature, to control the first control element (33) over the first output to switch the flow of the cooling fluid through the coil (311) on, when the measured zone temperature is above a reference zone temperature range, and to control the second control element (34) over the second output to switch the heat producing element (312) on, when the measured zone temperature is below a reference zone temperature range,
wherein the method comprises the following steps:

replacing the chiller (9) with a reversible heat pump (1) so that the cooling fluid of the pipe system can be heated by the reversible heat pump (1) in a heating mode and cooled by the heat pump (1) in a cooling mode;
connecting in each zone (3) a signal switch (4) between the thermostat (32) of the zone (3) and the first and second control element (33, 34) of the zone (3), wherein the signal switch (4) for each zone (3) of the HVAC system comprises a first input (41) which is connected to the first output (321) of the thermostat (32) of the zone (3), a second input (42) which is connected to the second output (322) of the thermostat (32) of the zone (3), a first output (43) which is connected to the first control element (33) of the zone (3), and a second output (44) which is connected to the second control element (34) of the zone (3), wherein the signal switch (4) is configured to switch between a first switching state and a second switching state, wherein the signal switch (4) connects in the first switching state the first input (41) with the first output (43) and the second input (42) with the second output (44), wherein the signal switch (4) connects in the second switching state the second input (42) with the first output (43).

**15.** Method to operate an HVAC system according to one of claims 1 to 9, the method comprising the following steps:

when the outside temperature is below a first temperature threshold, to switch the signal switches (4) in the first switching state and to heat the zones (3) whose measured zone temperature is below the reference zone temperature range with the heat producing element (312) of the terminal unit (31) of the zone (3);
when the outside temperature is between the first temperature threshold and a second temperature threshold, to switch the signal switches (4) in the second switching state and to heat the zones (3) whose measured zone temperature is below the reference zone temperature range with the reversible heat pump operating in the heating mode; and
when the outside temperature is above the second temperature threshold, to switch the signal switches (4) in the first switching state and to cool the zones (3) whose measured zone temperature is above the reference zone temperature range with the reversible heat pump operating in the cooling mode.

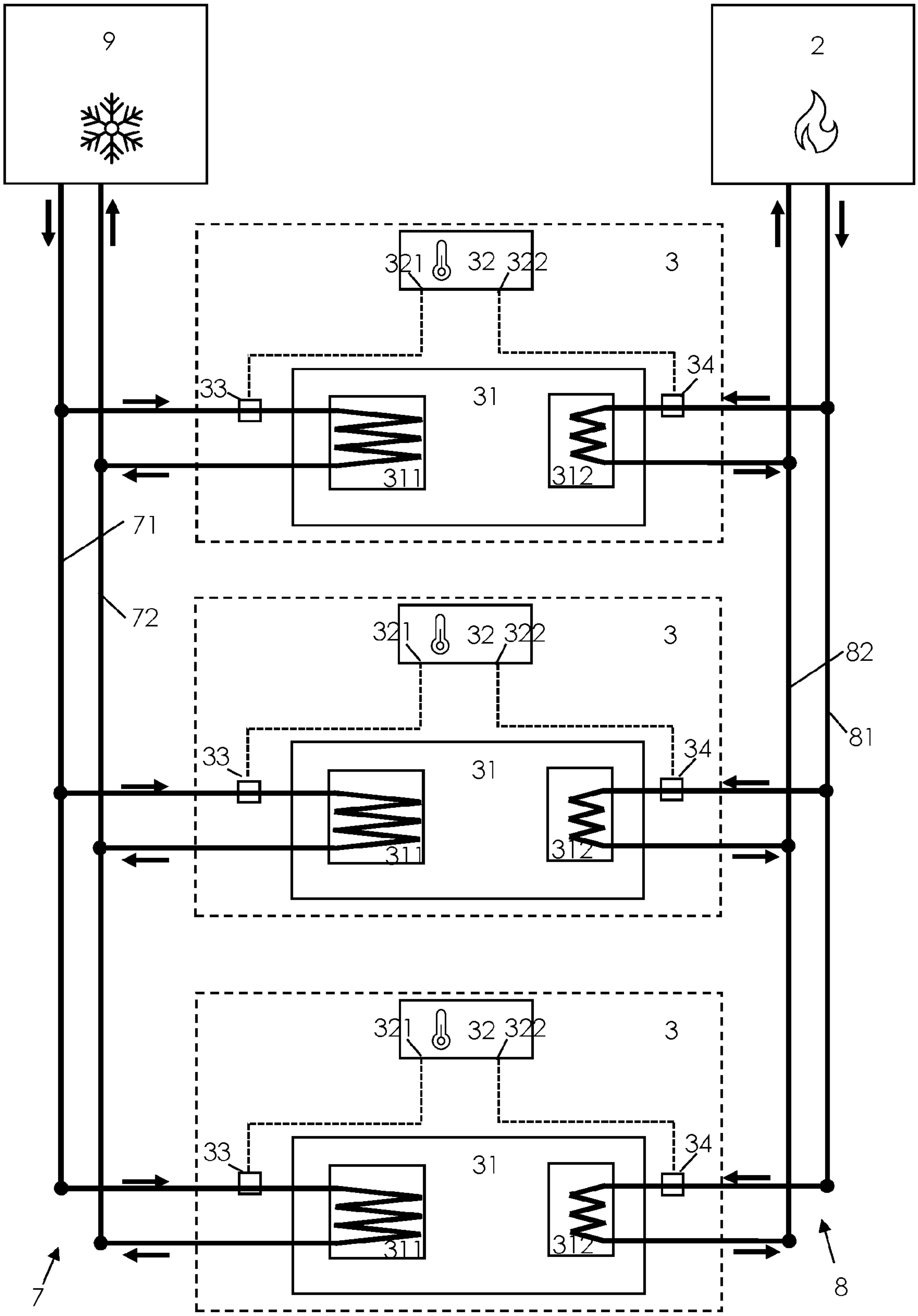


**Fig. 1 Prior Art**

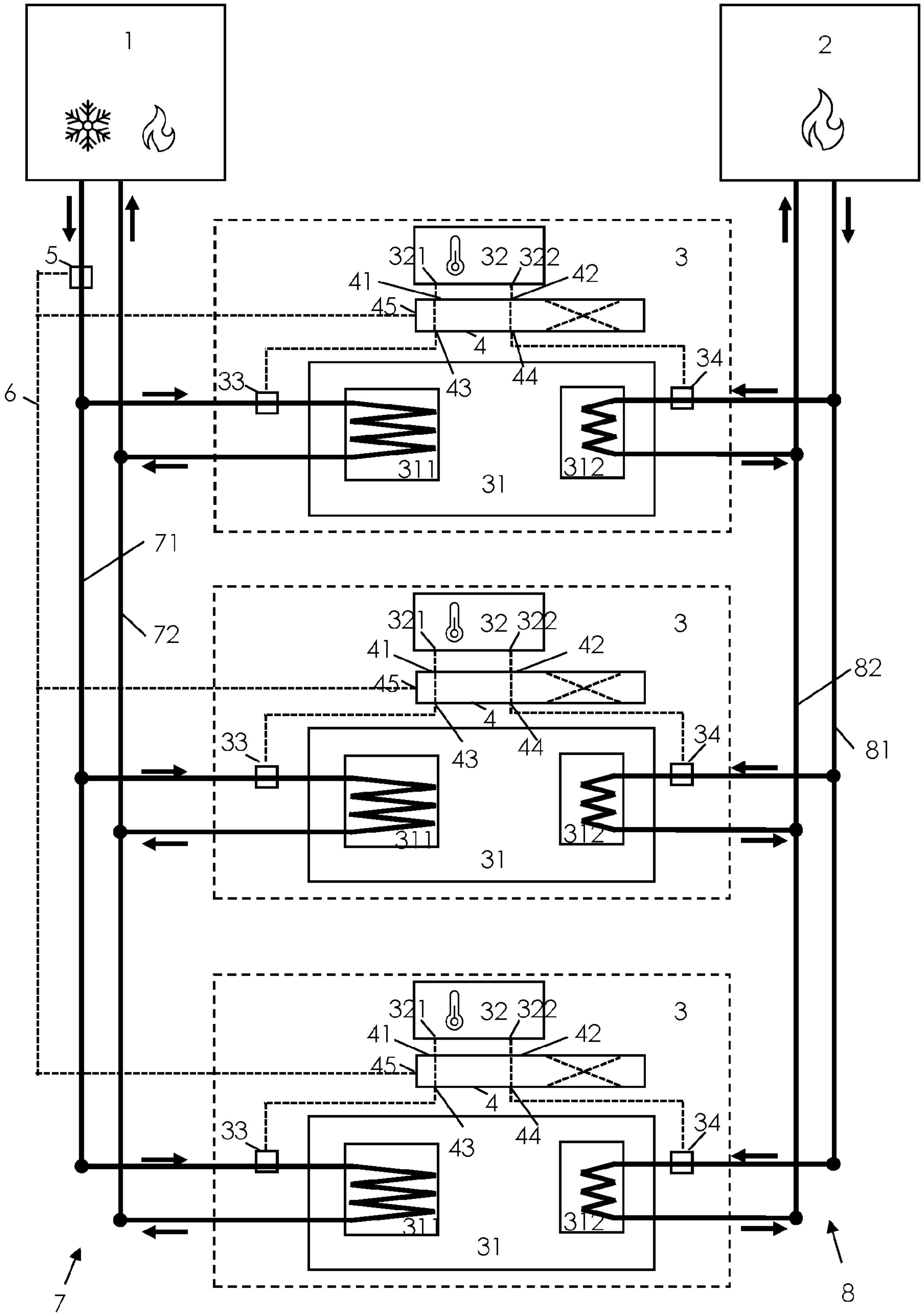


**Fig. 2**

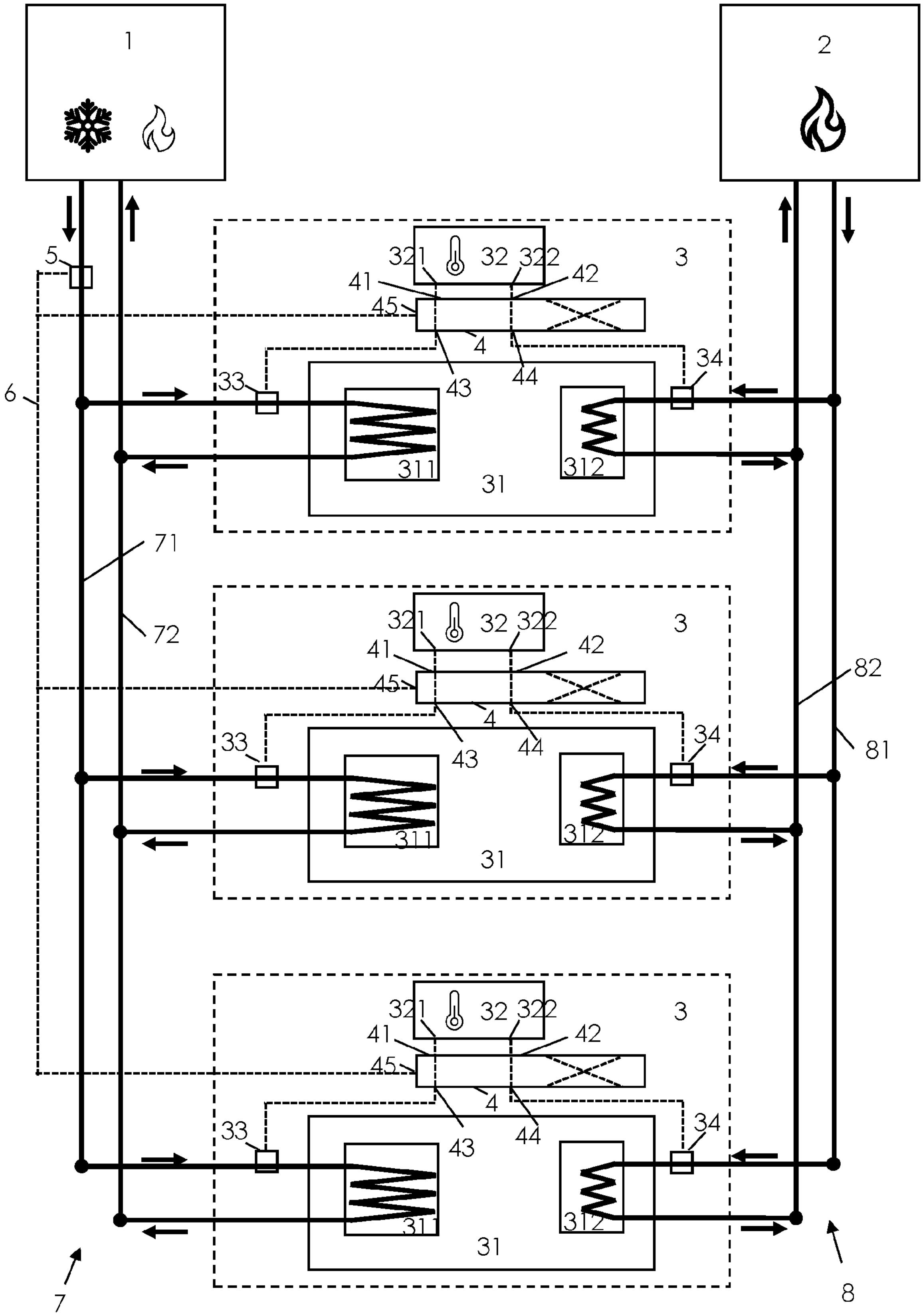


Fig. 3

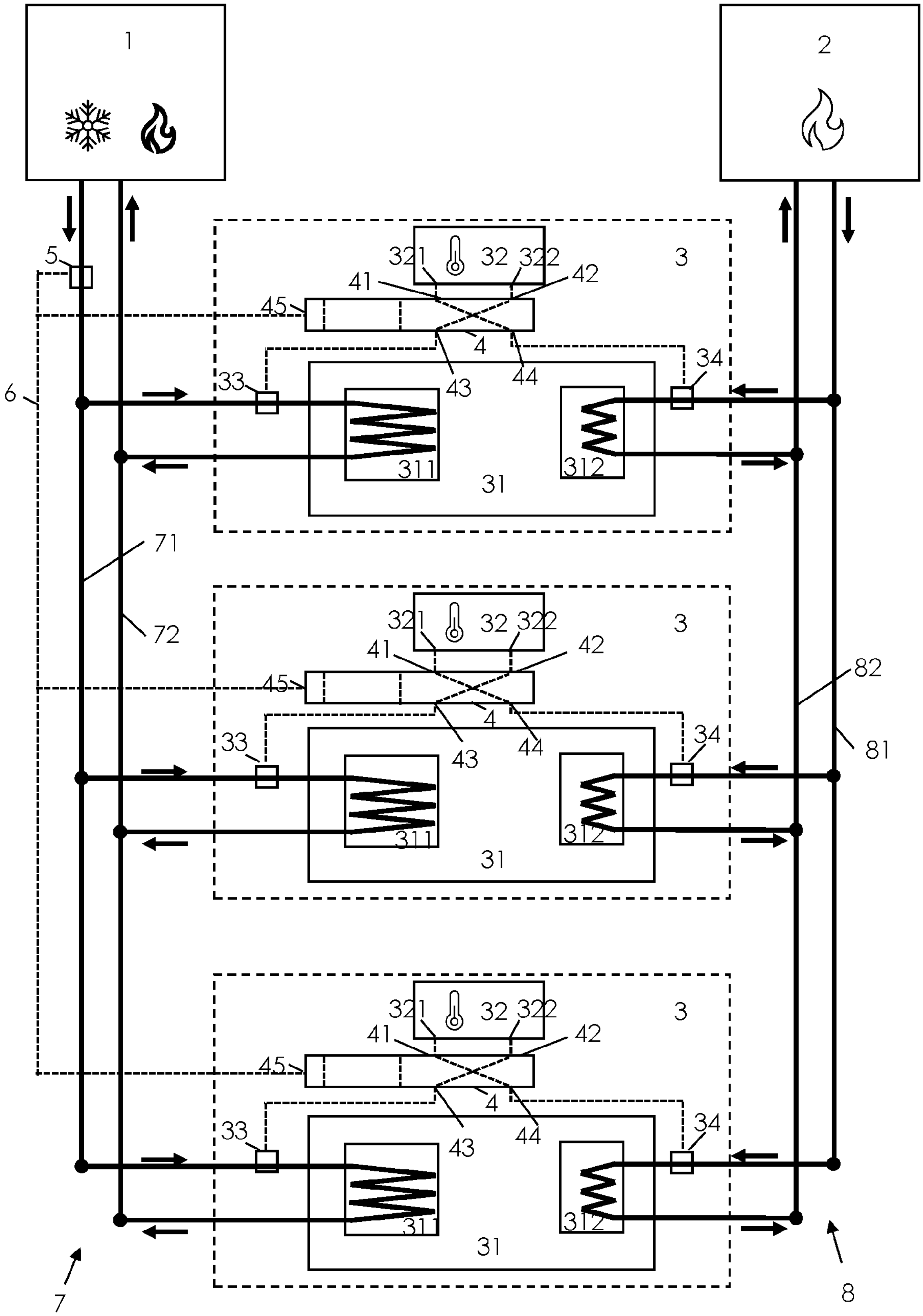


Fig. 4

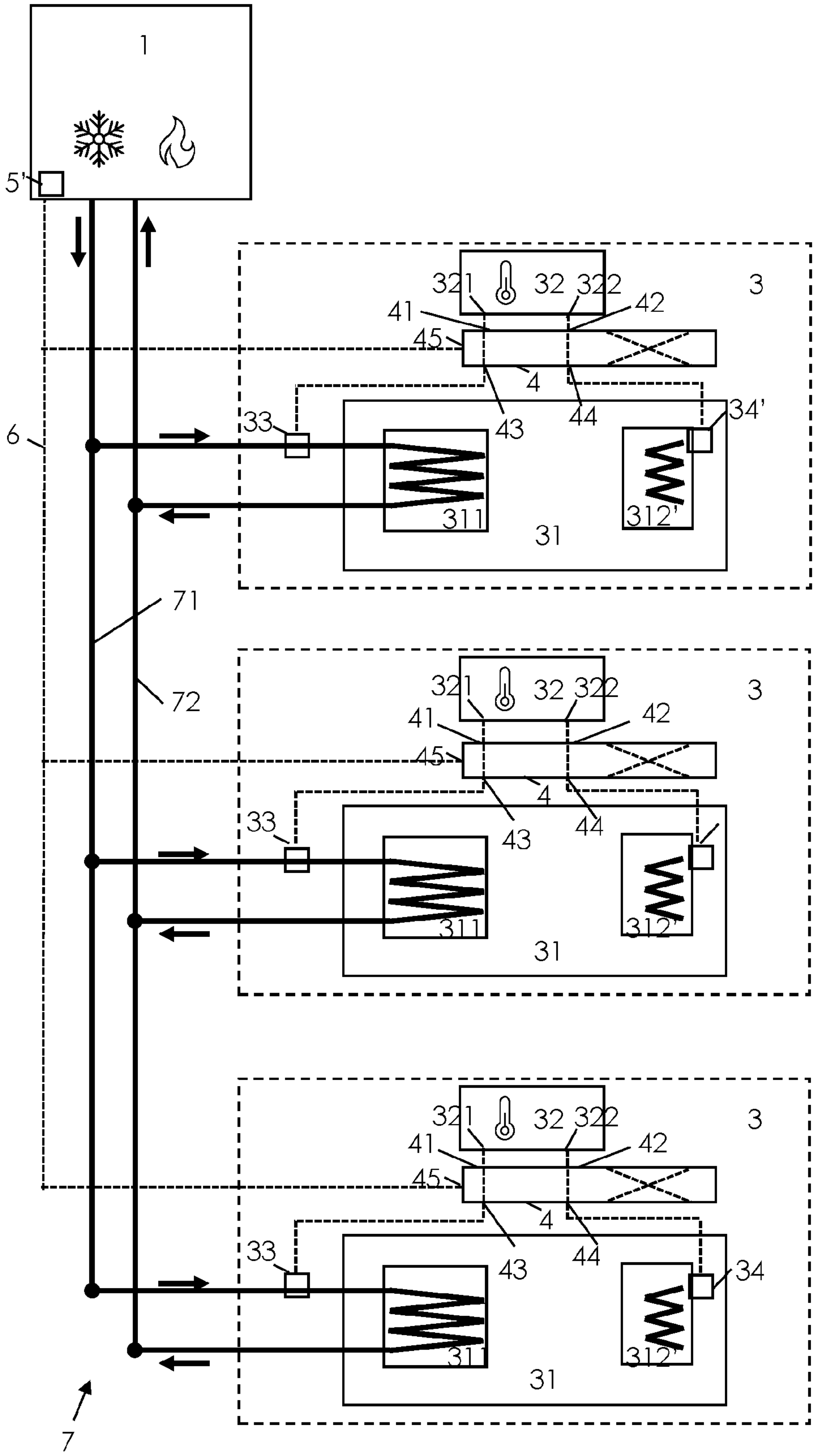


**Fig. 5**

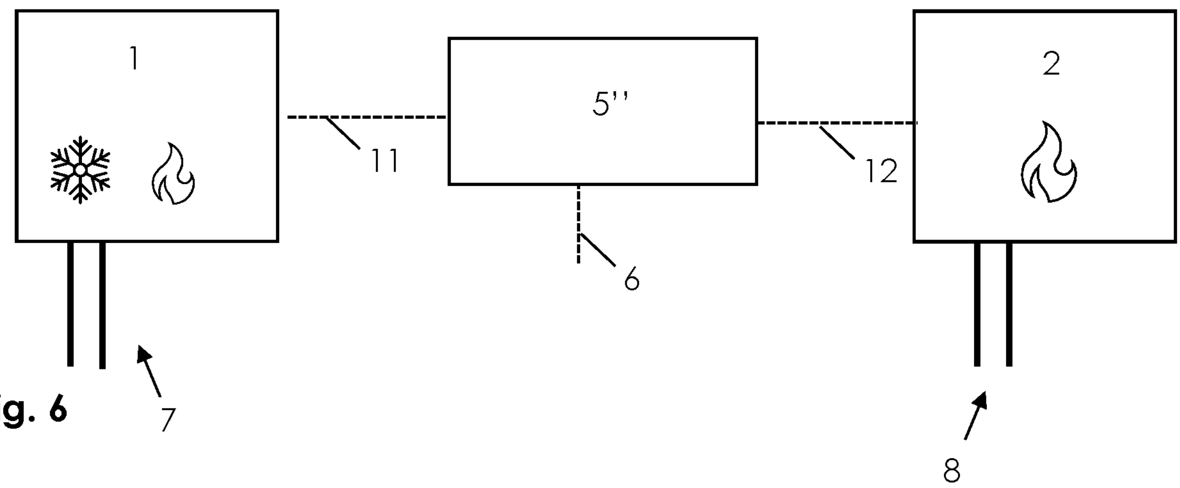


Fig. 6

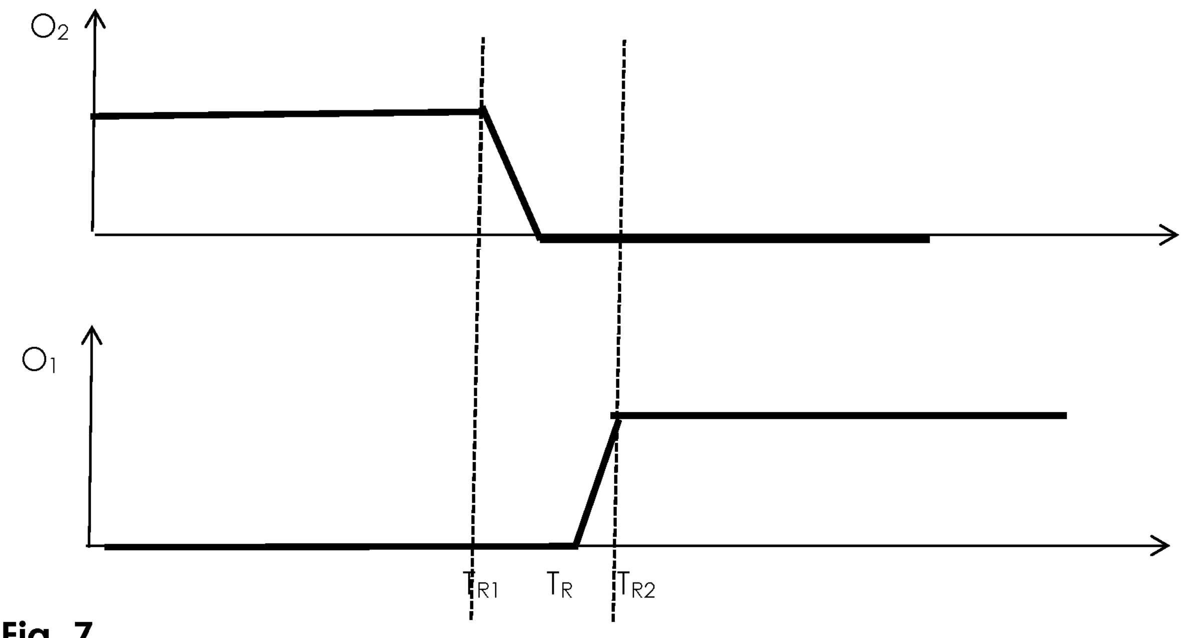


Fig. 7

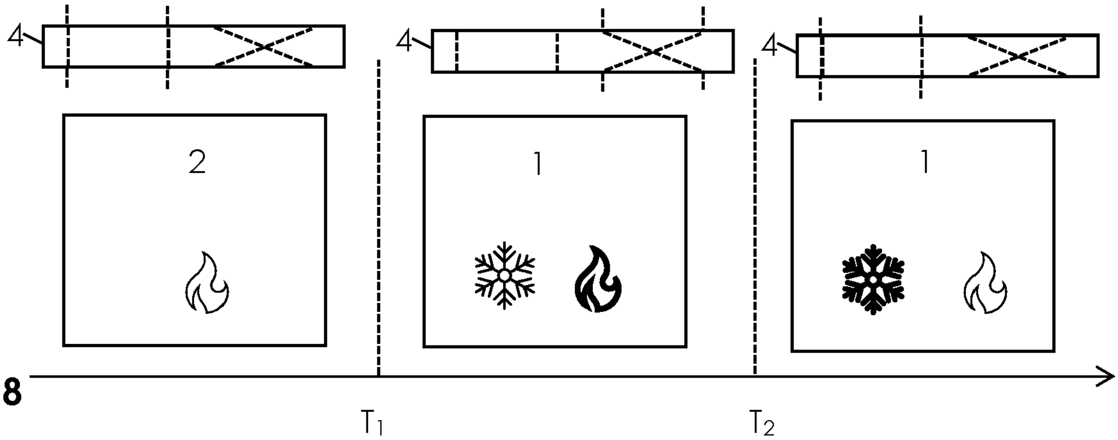


**Fig. 8**

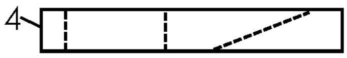


**Fig. 9**

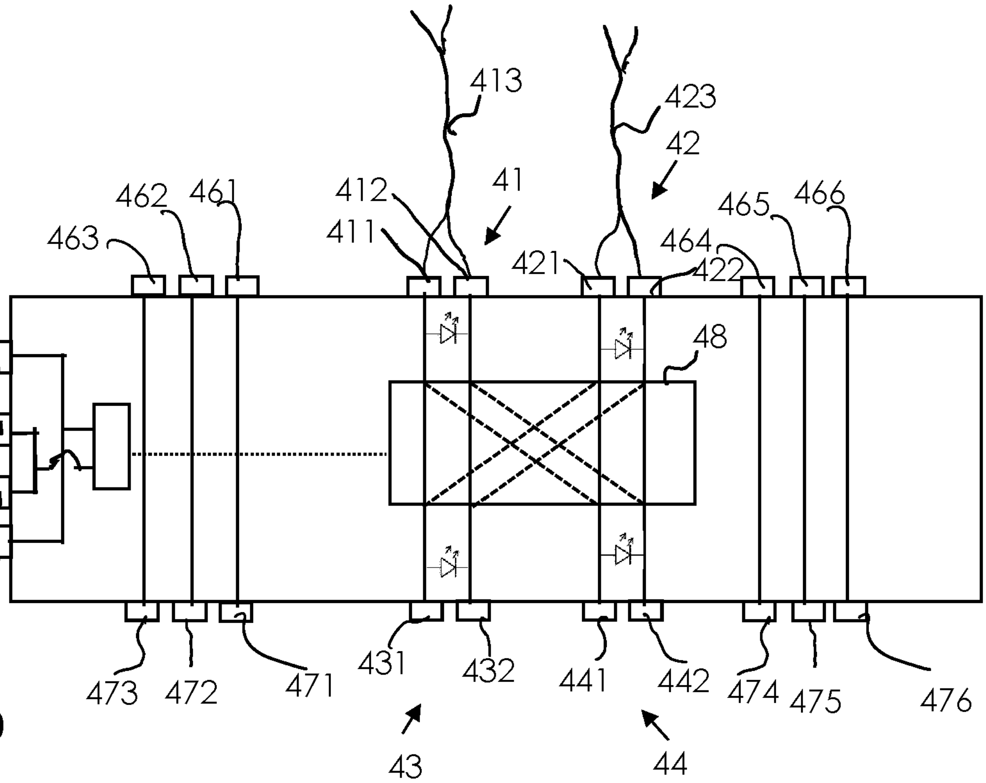


**Fig. 10**

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# EUROPEAN SEARCH REPORT

Application Number
EP 23 18 7453

## 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<br>Y<br>A | WO 2009/111503 A2 (JEUNG YOUNG-CHUN [US]) 11 September 2009 (2009-09-11)<br>* the whole document *<br>----- | 9-12<br>13<br>1-8,14, 15 | INV.<br>F24F11/54<br>F24D19/10<br>F24F11/67<br>F24F11/84<br>F24H4/00<br>F24F5/00 |
| X | JP 2010 261909 A (NIPPON SOKEN) 18 November 2010 (2010-11-18)<br>* paragraph [0024]; figure 3 *<br>----- | 9 | |
| Y | US 2010/169402 A1 (CHEN HUNG-LIN [TW] ET AL) 1 July 2010 (2010-07-01)<br>* figures 3,4G,5 *<br>----- | 13 | |
| A | US 5 772 113 A (GERSTMANN JOSEPH [US] ET AL) 30 June 1998 (1998-06-30)<br>* the whole document *<br>----- | 1,9,14 | |

| TECHNICAL FIELDS SEARCHED (IPC) |
|---|
| F24F<br>F24H<br>F24D |

The present search report has been drawn up for all claims

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| Munich | 19 December 2023 | Blot, Pierre-Edouard |

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