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(54) **DEVICE TO CONTROL THE FUNCTIONING OF A HEAT EXCHANGER, HEAT EXCHANGER COMPRISING SAID DEVICE AND CORRESPONDING CONTROL METHOD BASED ON MEASURING AN ELECTROMAGNETIC FIELD**

VORRICHTUNG ZUR STEUERUNG DER FUNKTION EINES WÄRMETAUSCHERS, WÄRMETAUSCHER MIT DIESER VORRICHTUNG UND ZUGEHÖRIGES STEUERUNGSVERFAHREN AUF GRUNDLAGE DER MESSUNG EINES ELEKTROMAGNETISCHEN FELDES

DISPOSITIF POUR LA COMMANDE DU FONCTIONNEMENT D’UN ÉCHANGEUR THERMIQUE, ÉCHANGEUR THERMIQUE COMPORTANT LEDIT DISPOSITIF ET PROCÉDÉ DE COMMANDE CORRESPONDANT BASÉ SUR LA MESURE D’UN CHAMP ÉLECTROMAGNÉTIQUE

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Description

FIELD OF THE INVENTION

[0001] The present invention concerns a device to control the functioning of a heat exchanger, comprised by way of example in a plant or an apparatus, for cooling and/or conditioning.

[0002] The present invention also concerns the heat exchanger that includes the control device according to the invention, and the corresponding method of controlling the functioning of a heat exchanger based on the measurement of an electromagnetic field.

BACKGROUND OF THE INVENTION

[0003] Various control devices are known, for controlling the functioning of heat exchangers and in particular those that allow to detect the presence of ice or frost on parts of the exchanger, in particular on the fins.

[0004] The presence of ice in heat exchangers is indeed a particularly serious problem and these control devices can be used, in association, for example, with heaters which can be selectively activated in order to carry out, for example, an automatic defrosting of the parts of the heat exchanger affected by the formation of ice.

[0005] In this context, devices are known that are based on controlling the temperature at determinate intervals of time, detecting for example if the temperature measured falls below a determinate threshold at different instances of time.

[0006] One disadvantage of these control devices is that they are not very precise or reliable since, detecting the overall temperature inside the exchanger, they do not allow to appreciate, for example, deposits of small amounts of ice and/or localized in specific parts of the exchanger.

[0007] Control devices are also known that are based on measuring the flow of air, in which a flow sensor supplies an indication on the movement of air generated by a difference in temperature present in different parts of the heat exchanger.

[0008] One disadvantage of these control devices is that they are particularly expensive.

[0009] Control devices are also known based on:

- humidity measurements;
- measurements of the speed of flow of the refrigerant mass;
- comparison of the transfer of heat between the part of the heat exchanger exposed to the air and that exposed to the refrigerant;
- the effect of thermal insulation;
- the use of optical sensors;
- methods of artificial intelligence, such as neural networks.

[0010] Control devices are also known that are based on measurements of the capacity between two electrodes that can be covered with ice or frost.

[0011] Some disadvantages of the devices cited above are high installation costs, difficulties in installing the sensors in proximity to the points where the ice forms, high costs of the sensors used and their limited duration over time.

[0012] Moreover, a common problem of such control devices is that they are not able to detect the presence of ice on all the parts of the heat exchanger in a uniform manner.

[0013] In the state of the art various solutions have been proposed to detect the presence of ice or frost on the fins of a heat exchanger.

[0014] For example, document EP 0 563 751 A1 describes an ice sensor based on a simple capacitive detection. This document describes the use of a low-frequency oscillator that does not emit any RF electromagnetic field, but detects the capacity reactance of the equivalent capacitor.

[0015] The functioning is based on an oscillator whose frequency varies with the variation of the value of "C" represented by the conductors.

[0016] Document EP 0 644 386 A1 describes a system for defrosting based on a microprocessor using an ice sensor of the capacitive type and an algorithm that monitors evaporation temperature and defrosting time. Here too, the ice sensor is based on a simple capacity detection. The sensor described in this document also uses a low-frequency oscillator that does not emit an RF electromagnetic field but, in this case too, as in the previous one, it detects the capacity reactance of the equivalent capacitor. Documents JP 2001 264446 A, EP 787 961, US 4.374.709, US 2011/185755 and US 2011/185755 also describe defrosting systems based on an ice sensor of the capacitive type.

[0017] None of the prior art documents mentions the use of an electromagnetic field or the detection of variations in an RF or medium-high frequency field. On the contrary, using resistance and referring to the Vdc, all these documents necessarily imply using oscillators with a low if not very low frequency. Document JP S60 155876 A describes an sensor using radio waves to detect frost on a heat exchanger.

[0018] One purpose of the present invention is to obtain a device to control the functioning of a heat exchanger that is reliable, durable and robust to obtain measurements.

[0019] Another purpose of the present invention is to obtain a device to control the functioning of a heat exchanger that is economical and that has reduced installation costs.

[0020] Another purpose of the present invention is to obtain a control device of the above type which is simple to make.

[0021] Another purpose of the present invention is to obtain a control device which is as little invasive as possible on the exchanger itself.

[0022] Another purpose of the present invention is to obtain a heat exchanger in which, in particular and as a preferential application, it is possible to detect the presence of frost or ice efficiently.

[0023] Moreover, it is also a purpose of the present invention to realize a method to control the functioning of a heat exchanger that uses a device of the type indicated above to obtain said advantages.

[0024] The Applicant has devised, tested and embodied the present invention to overcome the shortcomings of the state of the art and to obtain these and other purposes and advantages.

SUMMARY OF THE INVENTION

[0025] The present invention is set forth and characterized in the independent claims, while the dependent claims describe other characteristics of the invention or variants to the main inventive idea.

[0026] In accordance with the above purposes, the invention concerns a device to control the functioning of a heat exchanger, comprised, by way of example, in a plant or apparatus for cooling and/or conditioning, in particular, but not only, a heat exchanger of the finned type.

[0027] The control device according to the present invention comprises:

- a medium or high frequency electric generator suitable to generate an electric current and/or tension;
- at least an emission element, disposed in an emission point or zone connected to the electric generator and associable to the heat exchanger, configured to generate in the latter a high frequency electromagnetic field by means of the electric current and/or tension generated by the generator;
- at least a detection element, disposed in a detection point or zone, distanced from the emission element, and not in physical contact with it, possibly also outside the exchanger itself, associable to the heat exchanger and configured to detect a value of the electromagnetic field received in the detection point, with respect to the value generated by the electromagnetic field and emitted by the emission element at the emission point;
- a detector, connected to the detection element to determine the functioning conditions of the heat exchanger as a function of the electromagnetic field detected in the detection point or zone;
- a frequency generator configured to determine at least a frequency with which the electric generator operates, wherein the frequency generator is configured to generate a frequency from about 100 kHz to 1 GHz, more preferably from 1 MHz to 500 MHz, even more preferably from 10 MHz to 50 MHz; and
- an encoded modulator configured to create a real and proper signature on a signal generated by said electric generator until the signal is recognized uniquely and unequivocally even in the presence of disturbances of any type, and an encoded de-modulator configured to recognize the electromagnetic field generated by said emission element. The action of the control device according to the present invention is based on the principle which exploits the electromagnetic properties of the materials through which an electromagnetic field generated by the emission element passes, until it reaches the detection element, in order to determine the presence of determinate materials.

[0028] Between the emission point and the detection point there is the part of the exchanger subjected to the control of the presence or formation of ice or frost, or other element to be monitored.

[0029] The control device can therefore be used to detect, for example, the presence of ice, frost, water or other materials inside the heat exchanger.

[0030] In particular, using an electromagnetic field, which is transmitted by an emission element and received by a detection element, passing through components of the heat exchanger, allows to perform said detections without direct contact with the materials to be detected, therefore without the emission and detection elements being invasive and/or posing problems and difficulties of installation with respect to the components of the exchanger.

[0031] Moreover, the invention allows to detect the presence of materials in every position of the heat exchanger, in particular disposing the emission element and the detection element in opposite peripheral positions, since the whole part of the heat exchanger, interposed between the emission element and the detection element and through which the electromagnetic field emitted passes, can be investigated.

[0032] In possible implementations of the present invention, the emission element and the detection element are metal conductors with a shape chosen for example from a group comprising an elongated shape, such as a cable or a bar, plate-shape, mesh-shape, spiral-shape and solenoid-shape, on condition that they can be used as receiving or transmitting antennas.

[0033] The emission element and the detection element, according to these forms of embodiment, are particularly economical and simple to install, therefore particularly non-invasive.

[0034] The emission element and the detection element are also robust in obtaining measurements, durable and reliable, as well as simple to achieve.

[0035] Using modern technologies in this context, it is possible to achieve, according to these forms of embodiment, control devices with particularly reduced sizes and at the same time economical.

[0036] According to other forms of embodiment, the frequency generator can supply frequencies in the microwave spectrum.

[0037] According to other forms of embodiment, the control device comprises external communication means, to send data to external apparatuses, such as a heater which can be selectively activated or an external controller.

[0038] Such forms of embodiment allow to achieve, for example, the automatic defrosting of the heat exchanger, based on the values of the electromagnetic field detected.

[0039] According to other implementations of the present invention, the control device comprises a timing device, configured to measure instants of time in which determinate values of electromagnetic field are detected.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040] These and other characteristics of the present invention will become apparent from the following description of some forms of embodiment, given as a non-restrictive example with reference to the attached drawings wherein:

- fig 1 shows forms of embodiment of device to control the functioning of a heat exchanger according to the present invention;
- fig. 2 is a block diagram of a form of embodiment of a control device according to the present invention;
- fig. 3 is a simplified block diagram of the functioning of the control device according to the present invention;
- figs. 4a-4d and 5 show some example implementations of the present invention.

[0041] To facilitate comprehension, the same reference numbers have been used, where possible, to identify identical common elements in the drawings. It is understood that elements and characteristics of one form of embodiment can conveniently be incorporated into other forms of embodiment without further clarifications.

DETAILED DESCRIPTION OF SOME FORMS OF EMBODIMENT

[0042] We shall now refer in detail to the various forms of embodiment of the present invention, of which one or more examples are shown in the attached drawing. Each example is supplied by way of illustration of the invention and shall not be understood as a limitation thereof. For example, the characteristics shown or described insomuch as they are part of one form of embodiment can be adopted on, or in association with, other forms of embodiment to produce another form of embodiment. It is understood that the present invention shall include all such modifications and variants.

[0043] Fig. 1 is used to describe forms of embodiment of a device 10 to control the functioning of a heat exchanger 11, comprised, by way of example, in a plant or an apparatus for cooling and/or conditioning.

[0044] The control device 10 comprises an electric generator 12 suitable to generate an electric quantity, such as a current and/or a tension, with suitable modulation and encoding method, and a high-frequency emission element 13, disposed in an emission point or zone, connected to the electric generator 12 and associable to the heat exchanger 11.

[0045] The emission element 13 is configured to generate an electromagnetic field, with suitable modulation and encoding, by means of the electric quantity generated by the electric generator 12.

[0046] The emission element 13, in a preferred solution, can be disposed in a peripheral position even not in contact with, or only near, the heat exchanger 11, but such that the electromagnetic field emitted passes through parts of the heat exchanger 11.

[0047] The electric generator 12 can be a tension generator, as shown in figs. 1 and 2, for example high-frequency alternate tension.

[0048] According to some variants, the electric generator 12 can be, by way of example, an alternate current generator, which generates current for example with a square or sinusoidal wave shape, with suitable modulation and encoding, for example by means of a suitable encoded modulator 32 (fig. 3) so as to create a real and proper signature on this signal until the signal is recognized uniquely and unequivocally even in the presence of disturbances of any type.

[0049] The emission element 13 is typically a metal conductor with adequate impedance.

[0050] According to some forms of embodiment, the emission element 13 has an elongated shape, as can be seen in the example shown in fig. 1, and can be made, by way of example, with a cable, or a bar, suitable for the transmission of an electromagnetic field.

[0051] According to other forms of embodiment, the emission element 13 can be, for example, a plate, a mesh, a spiral or a solenoid.

[0052] The control device 10 also comprises a detection element 14, disposed at a detection point or zone, distanced with respect to the emission element 13, associable to the heat exchanger 11 and configured to detect a value of the electromagnetic field received in the detection point, with respect to the value generated by the electromagnetic field in the emission point with a suitable de-modulation and de-coding method.

[0053] According to some forms of embodiment, the detection element 14 can be disposed in peripheral positions of the heat exchanger 11, advantageously distant from and/or opposite and/or external to the positions of the emission element 13, so that the electromagnetic field emitted by the emission element 13 and received by the detection element 14 passes through at least a part 18 (see fig. 3 again) of the heat exchanger 11.

[0054] The detection element 14 is typically a metal conductor with impedance suitable to be used as a receiving antenna of the signal emitted by the transmission conductor of the emission element 13.

[0055] According to some forms of embodiment, the detection element 14 has an elongated shape, as can be seen in the example shown in fig. 1, and can be made, by way of example, with a cable, or a bar, suitable for the transmission of an electromagnetic field.

[0056] According to other forms of embodiment, the detection element 14 can be for example a plate, a mesh, a spiral, a solenoid or a real antenna.

[0057] The control device 10 also comprises a detector 15, connected to the detection element 14, and able, by means of a suitable method to de-modulate and de-code the signal received, to determine the functioning conditions of the heat exchanger 11 as a function of the electromagnetic field detected in the detection point or zone by the detector element 14.

[0058] The detector 15 can also comprise a measuring mean 19 suitable to measure the intensity of the electromagnetic field detected by the detection element 14.

[0059] In the case of fig. 1, the measuring mean 19 is an amperometer configured to measure a signal quantity on the detection element 14, as generated by the electromagnetic field emitted by the emission element 13.

[0060] According to variants forms of embodiment, the measuring mean 19 can be, by way of example, a voltmeter, able to detect a difference in potential generated by the electromagnetic field received. The control action of the control device 10, according to the form of embodiment in figs. 1 and 2, allows to verify the presence of determinate materials, for example deposited in the zone 18 of the heat exchanger 11 through which the electromagnetic emission field passes, until it reaches the detection element.

[0061] These electromagnetic properties can be, by way of non-restrictive example, the electric permittivity ε, also called dielectric constant, the magnetic susceptibility or the capacity.

[0062] In the form of embodiment in figs. 1 and 2, the control device 10 is configured to detect the electric permittivity ε in the heat exchanger 11.

[0063] Indeed, in the configuration shown, the emission element 13 and the detection element 14 are comparable to two plates of a capacitor, while the heat exchanger 11 can be considered as a dielectric material interposed between the plates, that therefore function as transmission and reception antennae.

[0064] In a capacitor, the load quantity Q that is deposited on each plate is given by the formula

$$Q=C\bullet V$$

where V is the difference in potential between the two plates and C is the capacity of the capacitor.

[0065] The capacity of the capacitor C, given the same distance between the plates and size of the plates, is proportional to the electric permittivity ε.

[0066] Therefore, detecting the current that is generated on the detection element 14, once received, demodulated and de-coded, it is possible to quantify the quantity of electromagnetic field that, transiting from the antenna considered the transmission antenna to the antenna considered the reception antenna, of which one part is proportional to the load Q, is deposited at the heads of the equivalent plates, in this case on the emission element 13 and on the detection element 14, as a consequence of the electromagnetic field generated.

[0067] Said electromagnetic field generated, in particular, is due to the tension created by the generator 12, suitably modulated and encoded, which is equal to the difference in potential V between the plates of the capacitor in the capacity detection methods.

[0068] In particular, the quantity of field transmitted in the form of current circulating in the detection element 14 measured by the amperometer 19 is measured.

[0069] It is therefore possible to have an indication of the electric permittivity ε of the materials interposed, for example deposited in the zone 18, between the emission element 13 and the detection element 14, knowing the tension generated by the generator 12 and the current measured on the amperometer 19.

[0070] In particular, the electric permittivity ε quantifies the tendency of a material to contrast the intensity of the electromagnetic field that passes through it.

[0071] The electric permittivity ε can be considered as the product of the relative permittivity ε_r, dependent on the materials affected by the electromagnetic field generated, and of the permittivity of the vacuum ε_0, not dependent on the materials.

$$\varepsilon = \varepsilon_r \cdot \varepsilon_0$$

[0072] Ice, in particular, is a material that has a high relative permittivity ε_r, and consequently a high electric permittivity ε, that leads to consistent variations in the electromagnetic field detected, if present, even in reduced quantities, inside the heat exchanger 11.

[0073] By way of example, the relative permittivity ε_r of ice has a value of about 86.4 against a relative permittivity ε_r of the air of 1.00059.

[0074] The control device 10 is therefore particularly effective to detect the presence of ice inside the heat exchanger 11.

[0075] The variation in thickness of the layer of ice also leads to a proportional variation in the electric permittivity ε.

[0076] According to other forms of embodiment, the control device 10 can be used to detect the presence of water, in the form of condensation or frost for example, or other types of materials, for example encrustations, lime scale, dirt, dust or other.

[0077] According to some forms of embodiment, the control device 10 can also include a frequency generator 21 configured to determine at least a frequency with which the electric generator 12 operates.

[0078] The electric permittivity ε is indeed a function of the frequency of the electromagnetic field, generated and transmitted, and consequently, depending on the control to be carried out in the heat exchanger 11, a suitable frequency of the emission element 13 can be set, in different forms of embodiment, by means of the electric generator 12.

[0079] To this end, the electromagnetic field emitted by the emission element 13 advantageously has a frequency suitable for the purpose and a precise and stable power.

[0080] With reference to the schematic example shown in fig. 3, the control device 10 can also comprise the encoded modulator 32, connected to the emission element 13 and configured to modulate the electromagnetic field produced, so that it can be distinct from the detection element 14 even in the presence of disturbing signals, such as for example background noises that can modify the characteristics thereof.

[0081] In particular, in order to detect the presence of ice, frost and/or water, since their constituting molecules, with the chemical formula H_2O, are electric dipoles, it is preferable to set frequencies, by means of the frequency generator 21, comprised in the spectrum of radio frequencies.

[0082] The frequency generator 21 can also provide means to interface with a user to modify the frequency supplied thereby.

[0083] As can be seen in the examples in figs. 4a-d and 5, the emission element 13 and the detection element 14 can use wire antennas, and can be mounted on a single physical structure (fig. 4a), with the corresponding antenna elements in communication with each other; or on two physically separate units (fig. 4b) with a receiving unit equipped with a dipole wire antenna to improve reception; or again they can be separate and near (fig. 4c) with the receiving unit equipped with dipole wire antenna to improve reception, or they can be separate and distanced with the receiving unit equipped with a wire antenna.

[0084] It is also possible (fig. 5) to have several benches, each with a corresponding emission element 13, that communicate if ice is present to a detection element 14, which recognizes the specific bench thanks to the presence, associated to the detection element, of an encoded de-modulator 33 (fig. 3).

[0085] In the forms of embodiment in figs. 1-2, the frequency generator 21 is comprised in the electric generator 12.

[0086] In possible implementations, the frequency generator 21 can determine a frequency from about 100 kHz to 1 GHz, more preferably from 1 MHz to 500 MHz, even more preferably from 10 MHz to 50 MHz.

[0087] According to some forms of embodiment of the present invention, frequencies can be set, by means of the frequency generator 21, comprised in the spectrum of microwaves, to detect determinate materials.

[0088] According to some forms of embodiment, combinable with those shown above, the electromagnetic field detected on the detection element 14, given the same electromagnetic field generated, can be a function, by way of example, of the magnetic susceptibility.

[0089] In this case, for example, at least an emission element 13 and/or a detection element 14 of a spiral and/or solenoid shape can be provided.

[0090] The control device 10 can also comprise a processing element 20, able to process data coming at least from the measuring mean 19 and/or from the detection element 14 using a suitable modulation and encoding method.

[0091] Again with reference to fig. 3, the control device 10 also comprises the encoded de-modulator 33, configured, as we said, to recognize the electromagnetic field generated by the emission element 13.

[0092] Subsequently, the signal detected is transmitted to the processing element 20 which, by way of example, can compare the quantity measured by the measuring mean 19 and at least a threshold quantity.

[0093] In other forms of embodiment, the processing element 20 can allow to trace the development of the quantity over time, measured by the measuring mean 19, possibly providing to generate graphs.

[0094] According to some forms of embodiment, the processing element 20 can, for example, allow to obtain information on the composition of the materials, analyzing the quantity measured.

[0095] With reference to the form of embodiment in fig. 1, the heat exchanger 11 is made as a bundle of tubes, and comprises a coil 16 in which a heat-carrying liquid flows.

[0096] The coil 16 is made of rectilinear tubular elements 17 connected by U shaped curved pipes.

[0097] A plurality of fins 18 (which identify, in this example, the generic zone 18 of fig. 3 which the electromagnetic field passes through), that is, metal plates, which have the function of increasing the heat exchange surface, are solidly associated to the coil 16, transversely to the longitudinal extension of the tubular elements 17.

[0098] The control device 10, in accordance with the form of embodiment in fig. 1, can be used to detect the presence of layers of ice that can be deposited on the fins 18 or on the coil 16.

[0099] According to other forms of embodiment, the control device 10 can be used to detect the presence of water, for example in the form of condensation, or other types of materials deposited on the fins 18 or on the coil 16.

[0100] In the form of embodiment in fig. 1, the emission element 13 and the detection element 14 are stably associated to the heat exchanger 11 and pass through it, from one lateral end to the other.

[0101] The electromagnetic field generated by the emission element 13, in this case, has concentric field lines, with the center in correspondence to the section of the emission element 13 itself.

[0102] The emission element 13 and the detection element 14, in the case shown, are disposed parallel to each other.

[0103] Moreover, the emission element 13 and the detection element 14 are disposed respectively at the upper and lower end of the heat exchanger 11, that is, with a peripheral disposition on the heat exchanger 11.

[0104] This peripheral disposition allows to pass through, with the electromagnetic field generated by the emission element 13, an ample portion of the heat exchanger 11 before detection by the detection element 14.

[0105] To allow the passage and/or the assembly of the emission element 13 and the detection element 14, through holes can be provided on the fins 18.

[0106] According to other forms of embodiment, the control device 10 can comprise monitoring means 22 to allow a user to monitor the functioning of the heat exchanger 11 (fig. 1).

[0107] The monitoring means 22, by way of example, can allow to display the current and/or tension values detected by the detector 15.

[0108] According to variant forms of embodiment, the monitoring means 22 can signal, for example using light indicators, liquid crystal displays or audio diffusion means, the presence of ice, frost and/or condensation in the heat exchanger 11.

[0109] The control device 10 can also comprise adaptation means, which allow to adapt the electric quantities exiting from the detection element 14 to those sustainable and/or supportable by the detector 15 and/or by the monitoring means 22.

[0110] The adaptation means can comprise, by way of example, suitable detection, modulation and encoding circuits, filters, a preamplifier, an amplifier, an analog/digital converter, a transformer, or other device known in the state of the art.

[0111] In possible implementations, the adaptation means can be integrated in the detector 15.

[0112] According to variant forms of embodiment, a plurality of emission elements 13 can be provided, configured to generate a plurality of electromagnetic fields and associated to the same heat exchanger 11 and/or parts of it.

[0113] The use of several emission elements 13 can generally allow to investigate a greater portion of the heat exchanger 11.

[0114] According to some forms of embodiment, the generation of a plurality of electromagnetic fields, with different characteristics of frequency and/or intensity, can allow to detect the position of the ice with precision.

[0115] By way of example, electromagnetic fields can be generated at different frequencies, by different emission elements 13, and on the basis of the values detected on the detection element 14 paths can be identified in the heat exchanger with a different electric permittivity ε.

[0116] According to variant forms of embodiment, a plurality of detection elements 14 can be provided, distanced from each other, to detect with greater precision changes in electric permittivity ε, in determinate directions, and to identify, for example, the position of the ice in the heat exchanger 11.

[0117] In particular, the detection elements 14 can communicate the possible presence of ice to a single emission element 13, so that the latter is able to identify the specific position where the ice has formed.

[0118] With reference to fig. 2, another form of embodiment is described, combinable with the form of embodiment shown in fig. 1, of a control device 10 in accordance with the present invention.

[0119] The control device 10 comprises a feeder 23 suitable to supply energy at least to the electric generator 12 and to the detector 15.

[0120] The measuring mean 19 and the processing element 20 are connected by a first internal line 24a for the transmission of data.

[0121] The control device 10, in the form of embodiment in fig. 2, also comprises external communication means 27, for the transmission of data to external apparatuses, in this case a heater 31.

[0122] The heater 31, also called defrosting device, can be configured to supply heat to the heat exchanger 11, by way of example, selectively making a fluid flow at high temperature in the coil 16, or activating an electric resistance.

[0123] In the example form in fig. 2, the external communication means 27 comprise a first external line 29 and a second external line 30, which achieve a connection between the processing element 20 and the heater 31.

[0124] The external communication means 27 also comprise a transmitter 28, configured to send data on the external lines 29, 30.

[0125] In the form of embodiment in fig. 2, the processing element 20 is configured to compare, after a suitable detection, de-modulation and de-coding, the quantity measured by the measuring mean 19 with at least a threshold quantity.

[0126] In particular, a direct comparison is made between parameters supplied by the electric generator 12 and parameters detected by the detector 15, connecting with a second internal line 24b the electric generator 12 to the processing element 20.

[0127] Supplementary internal lines 26 can also be provided, for the connection, for example, of the electric generator 12 and the detector 15 to the feeder 23.

[0128] In particular, in this form of embodiment, the presence of ice is detected by setting a first threshold quantity and a second threshold quantity: when these are exceeded, a semi-defrosting command and a defrosting command are respectively sent to the heater 31.

[0129] The first threshold quantity is set to detect a smaller amount of ice than the amount of ice detected with the second threshold quantity, and consequently the heater 31 delivers a smaller amount of heat with the semi-defrosting command, compared with the defrosting command.

[0130] By way of example, the difference between the electromagnetic field generated and the electromagnetic field detected can be used as the threshold quantity.

[0131] In this case, the first external line 29 and the second external line 30 have a parallel configuration, respectively sending the semi-defrosting command and the defrosting command.

[0132] According to some forms of embodiment, a timing device can also be provided, not shown, configured to achieve timed activations of the heater 31, to further reduce the probability of ice deposits.

[0133] It is clear that modifications and/or additions of parts may be made to the device to control the functioning of a heat exchanger, the heat exchanger comprising said device and the corresponding control method as described heretofore, without departing from the field and scope of the present invention.

Claims

1. Device to control the functioning of a heat exchanger (11), said device comprising:

- a current and/or tension electric generator (12), associable to the heat exchanger (11);
- at least an emission element (13), disposed in an emission point or zone, connected to the electric generator (12) and associable to the heat exchanger (11), configured to generate a medium- or high-frequency electromagnetic field by means of the electric current and/or tension generated by said electric generator (12);
- at least a detection element (14), disposed in a detection point or zone, distanced from the emission element (13) and not in physical contact with it, and in such a manner that between the emission element (13) and the detection element (14) there is a zone (18) of the heat exchanger (11), the detection element being configured to detect a value of the electromagnetic field received in the detection point, with respect to the value generated by the electric or electromagnetic field in the emission point;
- a detector (15), connected to the detection element (14) to determine functioning conditions of the heat exchanger (11) as a function of the electromagnetic field detected in the detection point or zone,

the device further comprising a frequency generator (21) configured to determine at least a frequency with which the electric generator (12) operates, wherein the frequency generator (21) is configured to generate a frequency from about 100 kHz to 1 GHz, more preferably from 1 MHz to 500 MHz, even more preferably from 10 MHz to 50 MHz, **characterised in that** the device further comprises an encoded modulator (32) configured to create a real and proper signature on a signal generated by said electric generator (12) until the signal is recognized uniquely and unequivocally even in the presence of disturbances of any type, and an encoded de-modulator (33) associated to the detection element configured to recognize the electromagnetic field generated by said emission element (13).

2. Control device as in claim 1, **characterized in that** the emission element (13) and the detection element (14) are metal conductors having a shape chosen from a group comprising:

- an elongated shape, such as a cable or a bar;
- plate-shape;
- mesh-shape;
- spiral-shape;
- solenoid-shape.

3. Control device as in any claim hereinbefore, **characterized in that** it comprises external communication means (27), for sending data to external apparatuses, such as a heater (31) or an external controller.

4. Control device as in any claim hereinbefore, **characterized in that** it comprises a feeder (23) suitable to supply energy at least to the electric generator (12) and to the detector (15).

5. Method to control the functioning of a heat exchanger (11), said method comprising:

- generating an electric current and/or tension;
- generating an electromagnetic field by means of an electric generator (12) operating at a frequency generated by a frequency generator (21) from about 100 kHz to 1 GHz, more preferably from 1 MHz to 500 MHz, even more preferably from 10 MHz to 50 MHz, with a suitable modulation and encoding method by means of an encoded modulator (32) configured to create a real and proper signature on a signal generated by said electric generator until the signal is recognized uniquely and unequivocally even in the presence of disturbances of any type, in the heat exchanger (11), by means of the electric current and/or tension generated, in an emission point or zone;
- detecting the electromagnetic field in a detection point or zone, distanced from the emission point or zone with an appropriate de-modulation and de-coding method by means of an encoded de-modulator (33), wherein between the emission point and the detection point there is a zone (18) of the heat exchanger (11);
- determining functioning conditions of the heat exchanger (11) as a function of the electromag-

netic field detected.

6. Heat exchanger comprising a device (10) to control its functioning as in any claim from 1 to 4.

7. Heater, configured to supply heat to a heat exchanger (11), comprising a device (10) to control the functioning of the heat exchanger (11) as in any claim from 1 to 4.

8. Heater as in claim 7, **characterized in that** the control device (10) comprises a timer device, configured to obtain timed activations of the heater.

Patentansprüche

1. Vorrichtung zum Steuern der Funktion eines Wärmetauschers (11), wobei die Vorrichtung aufweist:

- einen elektrischen Strom- und/oder Spannungsgenerator (12), der dem Wärmetauscher (11) zugeordnet werden kann;
- mindestens ein Emissionselement (13), das an einer Emissionsstelle oder
- zone angeordnet ist, verbunden mit dem Generator (12) und dem Wärmetauscher (11) zuordenbar, das dafür ausgelegt ist, mittels des von dem Generator (12) erzeugten Stroms und/oder der Spannung ein elektromagnetisches Mittel- oder Hochfrequenzfeld zu erzeugen;
- mindestens ein Detektionselement (14), das an einer Detektionsstelle oder
- zone angeordnet ist, beabstandet von dem Emissionselement (13) und nicht in physischem Kontakt mit diesem und zwar derart, dass zwischen dem Emissionselement (13) und dem Detektionselement (14) eine Zone (18) des Wärmetauschers (11) liegt, wobei das Detektionselement dazu ausgelegt ist, einen Wert des an der Detektionsstelle empfangenen elektromagnetischen Felds in Bezug auf den von dem elektrischen oder elektromagnetischen Feld an der Emissionsstelle erzeugten Wert zu detektieren;
- einen Detektor (15), der mit dem Detektionselement (14) verbunden ist, um Funktionsbedingungen des Wärmetauschers (11) in Abhängigkeit von dem an der Detektionsstelle oder -zone detektierten elektromagnetischen Feld zu bestimmen, wobei die Vorrichtung ferner einen Frequenzgenerator (21) aufweist, der dazu ausgelegt ist, mindestens eine Frequenz zu bestimmen, bei der der Generator (12) arbeitet, wobei der Frequenzgenerator (21) dazu ausgelegt ist, eine Frequenz von etwa 100 kHz bis 1 GHz, mehr bevorzugt von 1 MHz bis 500 MHz, noch mehr bevorzugt von 10 MHz bis 50 MHz, zu erzeugen,

dadurch gekennzeichnet, dass die Vorrichtung ferner einen codierten Modulator (32), dazu ausgelegt, eine reale und echte Signatur auf einem von dem Generator (12) erzeugten Signal zu erstellen, bis das Signal auch bei Vorliegen von Störungen irgendeiner Art eindeutig und zweifelsfrei erkannt wird, und einen codierten Demodulator (33) aufweist, der dem Detektionselement zugeordnet und dazu ausgelegt ist, das von dem Emissionselement (13) erzeugte elektromagnetische Feld zu erkennen.

2. Steuervorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** das Emissionselement (13) und das Detektionselement (14) Metallleiter sind, die eine Form aufweisen, die aus der Gruppe ausgewählt ist, die umfasst:

- eine längliche Form, wie ein Kabel oder eine Stange;
- eine Plattenform;
- eine Netzform;
- eine Spiralform;
- eine Solenoidform.

3. Steuervorrichtung nach einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** sie externe Kommunikationsmittel (27) zum Senden von Daten an externe Einrichtungen, wie eine Heizung (31) oder einen externen Controller, aufweist.

4. Steuervorrichtung nach einem der vorstehenden Ansprüche, **dadurch gekennzeichnet, dass** sie einen Speiser (23) aufweist, der geeignet ist, zumindest dem Generator (12) und dem Detektor (15) Energie zuzuführen.

5. Verfahren zum Steuern der Funktion eines Wärmetauschers (11), wobei das Verfahren aufweist:

- Erzeugen eines elektrischen Stroms und/oder einer Spannung;
- Erzeugen eines elektromagnetischen Felds durch einen Generator (12), der bei einer von einem Frequenzgenerator (21) erzeugten Frequenz von etwa 100 kHz bis 1 GHz, mehr bevorzugt von 1 MHz bis 500 MHz, noch mehr bevorzugt von 10 MHz bis 50 MHz, arbeitet, mit einem geeigneten Modulations- und Codierverfahren mittels eines codierten Modulators (32), der dafür ausgelegt ist, eine reale und echte Signatur auf einem von dem Generator erzeugten Signal zu erstellen, bis das Signal auch bei Vorliegen von Störungen irgendeiner Art eindeutig und zweifelsfrei erkannt wird, in dem Wärmetauscher (11) mittels des erzeugten elektrischen Stroms und/oder der Spannung an einer Emis-

sionsstelle oder -zone;

- Detektieren des elektromagnetischen Felds an einer Detektionsstelle oder

- zone, die von der Emissionsstelle oder -zone beabstandet ist, mit einem passenden Demodulations- und Decodierverfahren mittels eines codierten Demodulators (33), wobei zwischen der Emissionsstelle und der Detektionsstelle eine Zone (18) des Wärmetauschers (11) liegt;

- Bestimmen von Funktionsbedingungen des Wärmetauschers (11) in Abhängigkeit von dem erkannten elektromagnetischen Feld.

6. Wärmetauscher, aufweisend eine Vorrichtung (10) zum Steuern seiner Funktion nach einem der Ansprüche 1 bis 4.

7. Heizung, die dazu ausgelegt ist, einem Wärmetauscher (11) Wärme zuzuführen, aufweisend eine Vorrichtung (10) zum Steuern der Funktion des Wärmetauschers (11) nach einem der Ansprüche 1 bis 4.

8. Heizung nach Anspruch 7, **dadurch gekennzeichnet, dass** die Steuervorrichtung (10) eine Zeitsteuerungsvorrichtung aufweist, die dafür ausgelegt ist, Zeitaktivierungen der Heizung zu erhalten.

Revendications

1. Dispositif pour la commande du fonctionnement d'un échangeur de chaleur (11), ledit dispositif comprenant :

- un générateur électrique de courant et/ou de tension (12), pouvant être associé à l'échangeur de chaleur (11) ;
- au moins un élément d'émission (13), situé dans un point ou une zone d'émission, connecté au générateur électrique (12) et pouvant être associé à l'échangeur de chaleur (11), conçu pour générer dans celui-ci un champ électromagnétique à moyenne ou haute fréquence au moyen du courant et/ou de la tension électriques générées par ledit générateur électrique (12) ;
- au moins un élément de détection (14), situé dans un point ou une zone de détection, à distance de l'élément d'émission (13) sans être en contact avec celui-ci, et de façon qu'il y ait une zone (18) de l'échangeur de chaleur (11) entre l'élément d'émission (13) et l'élément de détection (14), l'élément de détection étant conçu pour détecter une valeur du champ électromagnétique reçu dans le point de détection par rapport à la valeur générée par le champ électrique ou électromagnétique dans le point d'émission ;
- un détecteur (15), connecté à l'élément de détection (14) pour déterminer des conditions de fonctionnement (11) en fonction du champ électromagnétique détecté dans le point ou la zone de détection, le dispositif comprenant également un générateur de fréquence (21) conçu pour déterminer au moins une fréquence de fonctionnement du générateur électrique (12), dans lequel le générateur de fréquence (21) est conçu pour générer une fréquence de 100 kHz à 1 HGz, de préférence d'1 MHz à 500 MHz, de préférence encore de 10 MHz à 50 MHz, **caractérisé en ce que** le dispositif comprend également un modulateur codé (32) conçu pour créer une véritable signature sur un signal généré par ledit générateur électrique (12) jusqu'à ce que le signal soit reconnu de façon unique et non équivoque même en présence de bruit de n'importe quel type, et un démodulateur (33) associé à l'élément de détection conçu pour reconnaître le champ électromagnétique généré par ledit élément d'émission (13).

2. Dispositif de commande selon la revendication 1, **caractérisé en ce que** l'élément d'émission (13) et l'élément de détection (14) sont des conducteurs métalliques ayant une forme choisie dans un groupe comprenant :

- une forme allongée, tel qu'un câble ou une barre;
- une forme de plaque ;
- une forme de filet ;
- une forme en spirale ;
- une forme de solénoïde.

3. Dispositif de commande selon n'importe laquelle des revendications précédentes, **caractérisé en ce qu'**il comprend des moyens de communication externe (27), pour l'envoi de données vers des appareils externes, comme un réchauffeur (31) ou un contrôleur externe.

4. Dispositif de commande selon n'importe laquelle des revendications précédentes, **caractérisé en ce qu'**il comprend un chargeur (23) apte à fournir de l'énergie au moins au générateur électrique (12) et au détecteur (15).

5. Procédé de commande du fonctionnement d'un échangeur de chaleur (11), ledit procédé comprenant les étapes consistant à

- générer un courant et/ou une tension électriques
- générer un champ électromagnétique au moyen d'un générateur électrique (12) fonctionnant à une fréquence générée par un générateur de fréquence (21) d'environ 100 kHz à 1 GHz, de préférence d'1 MHz à 500 MHz, de préféren-

ce encore de 10 Mhz à 50 MHz, par un procédé approprié de modulation et de codage, au moyen d'un modulateur codé (32) conçu pour créer une véritable signature sur un signal généré par ledit générateur électrique jusqu'à ce que le signal ne soit reconnu de façon unique et non équivoque, même en présence de bruit de n'importe quel type, dans l'échangeur de chaleur (11), au moyen du courant et/ou de la tension électriques générés, dans un point ou une zone d'émission ;

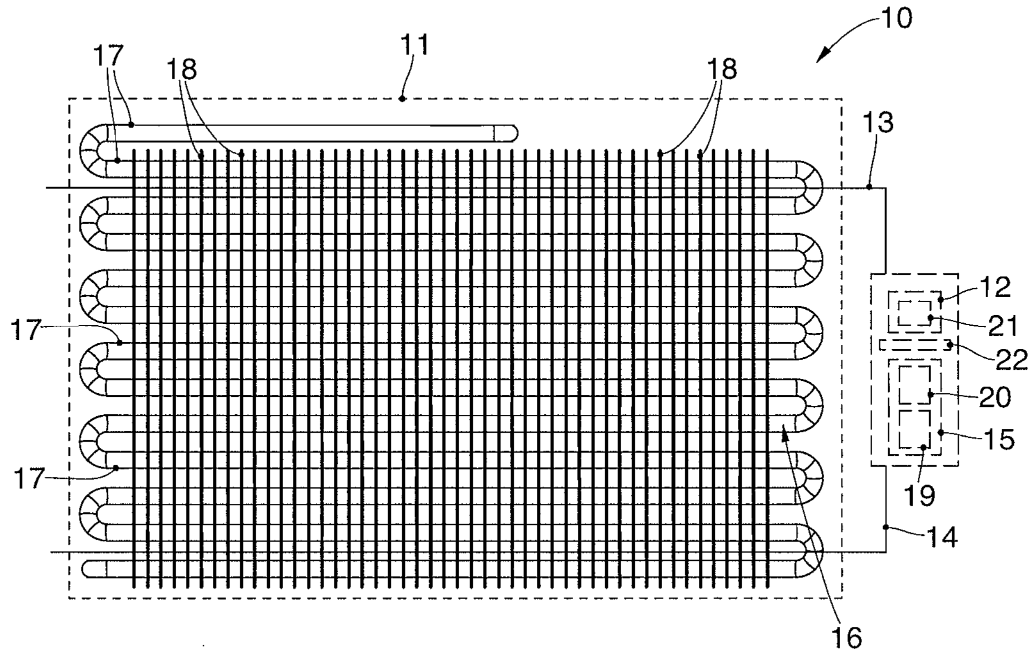
- détecter le champ électromagnétique dans un point ou une zone de détection, à distance du point ou la zone d'émission par un procédé approprié de démodulation et de décodage au moyen d'un démodulateur codé (33), dans lequel une zone (18) de l'échangeur de chaleur (11) est située entre entre le point d'émission et le point de détection ;

- déterminer des conditions de fonctionnement de l'échangeur de chaleur (11) en fonction du champ électromagnétique détecté.

6. Échangeur de chaleur comprenant un dispositif (10) de commande de son fonctionnement selon n'importe laquelle des revendications 1 à 4.

7. Réchauffeur conçue pour fournir de la chaleur à un échangeur de chaleur (11), comprenant un dispositif (10) pour commander le fonctionnement de l'échangeur de chaleur (11) selon n'importe laquelle des revendications 1 à 4.

8. Réchauffeur selon la revendication 7, **caractérisé en ce que** le dispositif de commande (10) comprend un dispositif de temporisation, conçu pour obtenir des activations temporisées du réchauffeur.


10
11
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18
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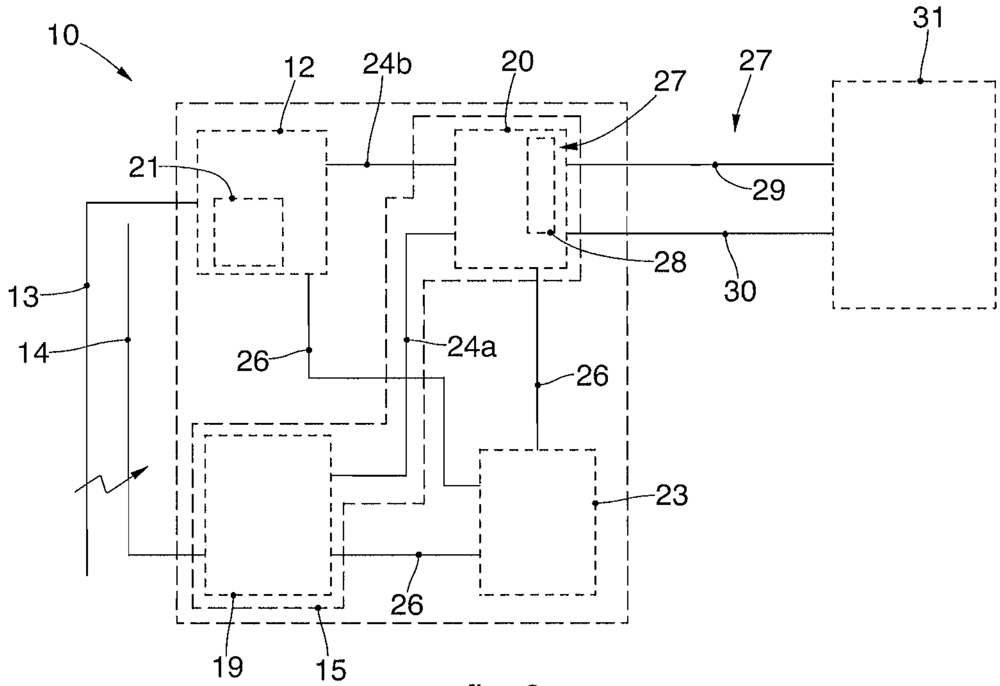
17

fig. 1


10
12
24b
20
27
27
31
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28
30
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14
24a
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23
26
19
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fig. 2

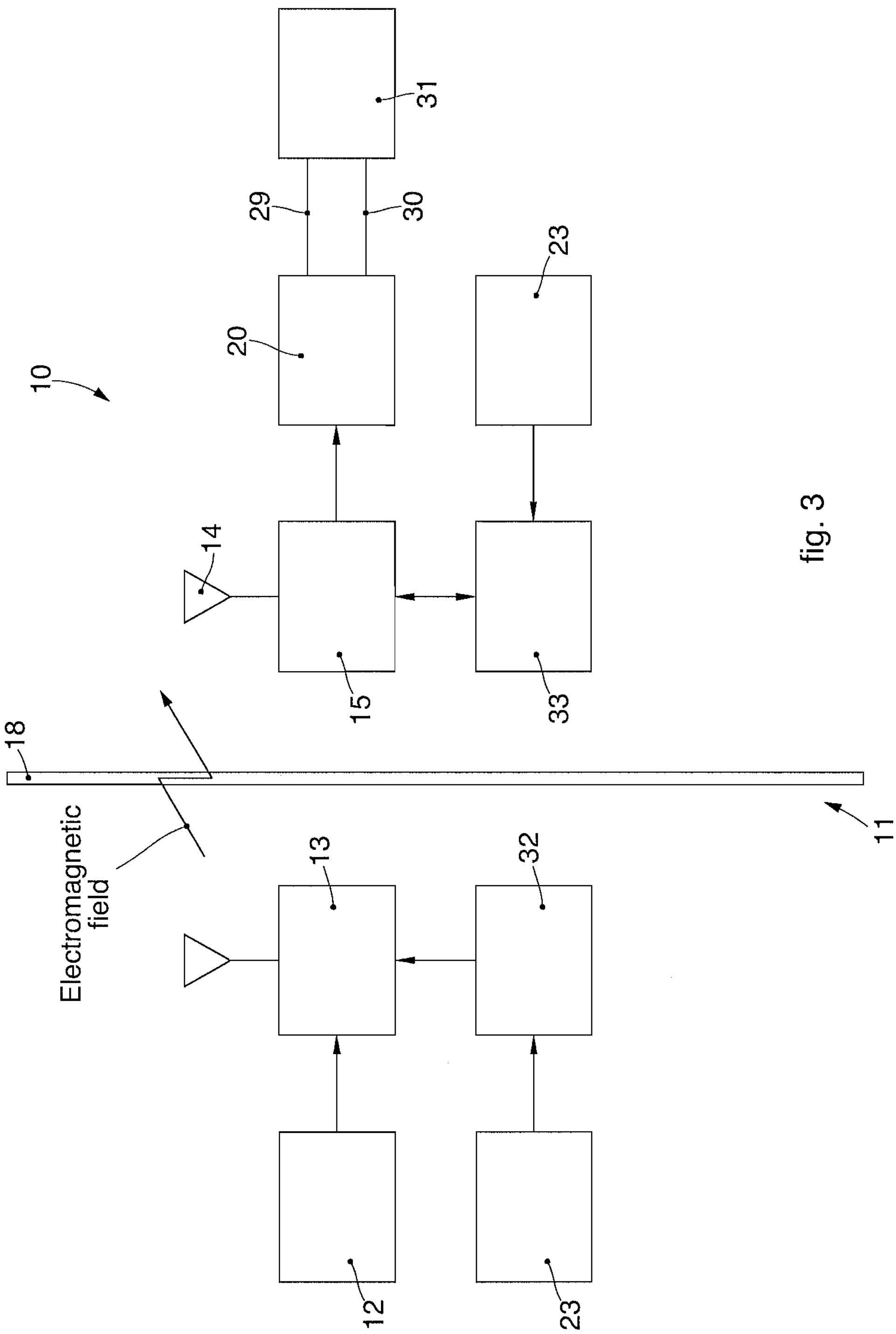
10
31
29
30
20
23
14
15
33
18
Electromagnetic
field
13
32
11
12
23

fig. 3

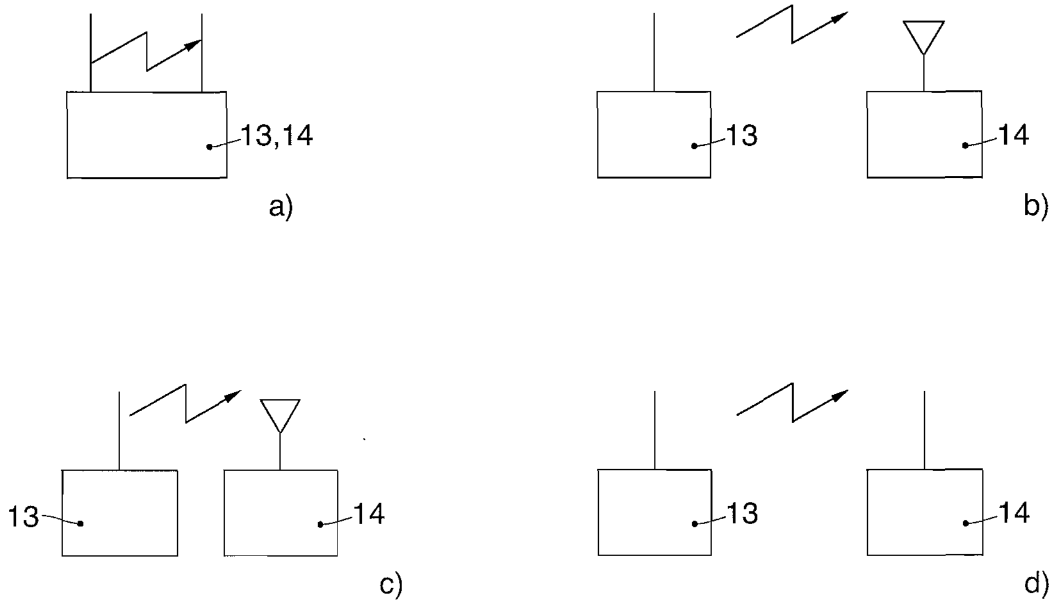

fig. 4

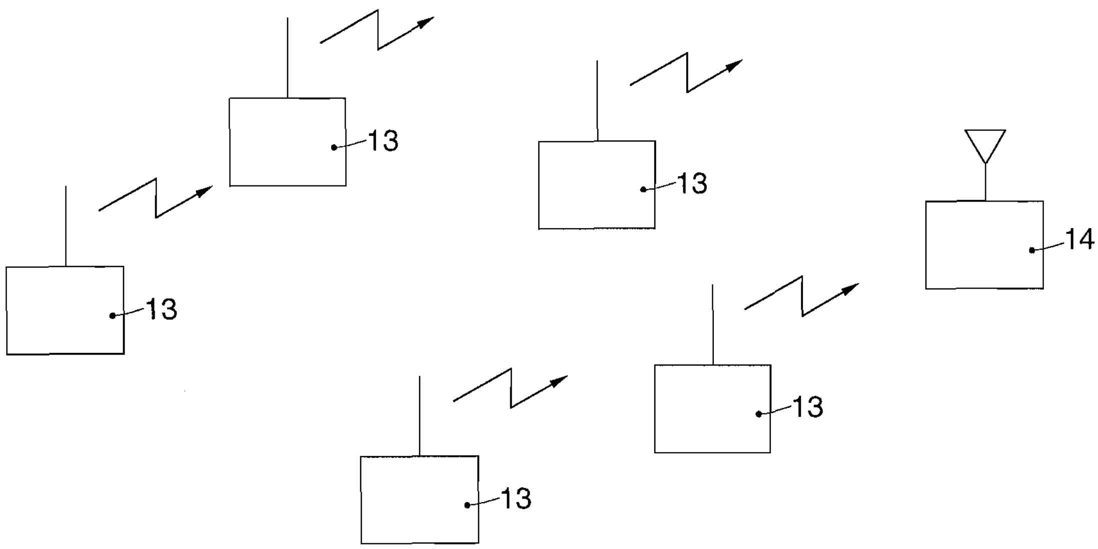

fig. 5

REFERENCES CITED IN THE DESCRIPTION

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