



(51) International Patent Classification:

*F24F 1/24* (2011.01) *F25B 27/02* (2006.01)  
*H05K 7/20* (2006.01) *F25B 31/00* (2006.01)  
*B60H 1/00* (2006.01) *F25B 5/04* (2006.01)

(21) International Application Number:

PCT/US2016/027705

(22) International Filing Date:

15 April 2016 (15.04.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

201510176775.9 15 April 2015 (15.04.2015) CN

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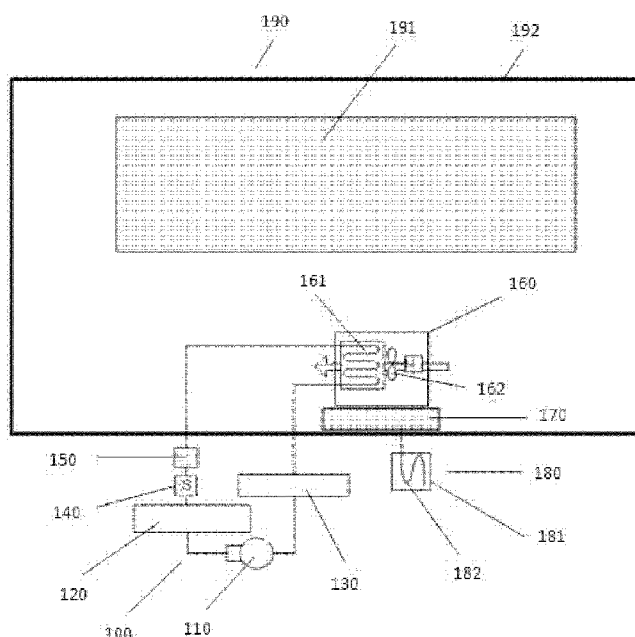
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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: REFRIGERATION SYSTEM AND COOLING METHOD FOR ELECTRIC CONTROL DEVICE THEREOF



(57) Abstract: A refrigeration system comprising: an electric control device comprising a case and an electronic device arranged in the case; a refrigeration loop comprising a compressor, a condenser, an electromagnetic valve, an expansion device and an evaporator which are sequentially connected through a pipeline and form a closed loop; and an electronic device cooling device serially connected between the expansion device and the evaporator; wherein the electronic device cooling device is arranged within the case and is spaced from the electronic device, which is used for reducing temperature and humidity of the electronic device and an environment within the case.

**Declarations under Rule 4.17:**

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))

— of inventorship (Rule 4.17(iv))

**Published:**

— with international search report (Art. 21(3))

## **REFRIGERATION SYSTEM AND COOLING METHOD FOR ELECTRIC CONTROL DEVICE THEREOF**

### **FIELD OF THE INVENTION**

[0001] The present invention relates to a refrigeration system. Specifically, the present invention relates to a cooling arrangement and a cooling method for an electric control device of a refrigeration system.

### **BACKGROUND OF THE INVENTION**

[0002] A refrigeration system usually needs a special electric control device. For example, for some large-scale refrigeration systems, the electric control device can be a frequency converter start cabinet. However, electronic devices in the frequency converter start cabinet have a comparatively great amount of heat, and a relatively larger temperature rise has a certain influence on a working state thereof. Therefore, the electronic devices need to be cooled to satisfy performance demands thereof.

[0003] At present, there are several electronic device cooling methods. For example, a plurality of openings are provided on a case of the electric control device and the heat of the electronic devices is dissipated through natural convection or forced convection; for another example, a water-cooled heat exchange apparatus is arranged within the case and the heat of the electronic devices is dissipated by introducing cooling water from an external water source; or even a set of refrigeration system dedicated to cooling the electronic devices is arranged within the case. At this moment, when the amount of the heat emitted by the electronic devices is too large and excess cooling needs to be performed, if surrounding temperature thereof is lower than a dew point temperature, condensate is easily produced on the electronic devices, which may directly cause the electronic devices to fail. As a result, the above-mentioned electronic device cooling methods have either the problem of comparatively low efficiency or the problem that the electronic devices in the cabinet are caused to fail due to improper dehumidification under high-temperature and high-humidity environments.

[0004] Based on this, the applicant has already submitted a U.S. patent application with publication number US6116040, which provides a cooling system of an electronic device, wherein the electronic device is arranged on heat sinks and the heat sinks are connected in parallel in a main refrigeration system loop of a refrigeration system itself to which the electronic device belongs. Such a design effectively improves the cooling efficiency and reliability of the electronic device, and has a lower cost compared with the above-mentioned methods. However, in addition to the electronic device within the case of the electric control device, there are comparatively large remaining spaces, the temperature of these spaces will also gradually rise due to the heat emitted by the electronic device and the cooling rate of the electronic device is influenced upon cooling the electronic device. Besides, if the electronic device is in a high-humidity environment, this scheme cannot effectively prevent the electronic device within the case from being influenced by high humidity, either.

## SUMMARY OF THE INVENTION

[0005] An object of the present invention is to provide a refrigeration system, which can improve the problem of heat dissipation inside an entire electronic device and improve the humidity within a case.

[0006] According to one aspect of the present invention, a refrigeration system is provided, which comprises: an electric control device comprising a case and an electronic device arranged in the case; a refrigeration loop comprising a compressor, a condenser, an electromagnetic valve, an expansion device and an evaporator which are sequentially connected through a pipeline and form a closed loop; and an electronic device cooling device serially connected between the expansion device and the evaporator; wherein the electronic device cooling device is arranged within the case and is spaced from the electronic device, which is used for reducing temperature and humidity of the electronic device and an environment within the case.

[0007] Optionally, the electronic device cooling device comprises an air-refrigerant heat exchanger and a fan for providing forced air convection, the air-refrigerant heat exchanger being serially connected between the expansion device and the evaporator.

[0008] Optionally, the refrigeration system further comprises a condensed water collection device arranged below the air-refrigerant heat exchanger within the case.

[0009] Optionally, the condensed water collection device is a water pan.

[0010] Optionally, the refrigeration system further comprises a condensed water discharge device for discharging condensed water out of the case, the condensed water discharge device being arranged outside the case and being in fluid communication with the condensed water collection device.

[0011] Optionally, the electromagnetic valve and the expansion device are arranged outside the case.

[0012] Optionally, the expansion device is a capillary tube or an electronic expansion valve.

[0013] Optionally, the refrigeration system further comprises a temperature sensor and/or a humidity sensor, the temperature sensor and/or the humidity sensor being arranged within the case, and the refrigeration system being used for controlling the opening or start-stop of the electromagnetic valve, the expansion device and the fan according to parameters detected by the temperature sensor and/or the humidity sensor.

[0014] Optionally, the compressor is a centrifugal compressor.

[0015] According to another aspect of the present invention, a cooling method for an electric control device of a refrigeration system is further provided, which comprises the following steps of: when it is detected that environmental temperature within a case of the electric control device is higher than a preset temperature, opening an electromagnetic valve and a fan in an electronic device cooling device; and/or when it is detected that a dew point temperature corresponding to environmental humidity within the case of the electric control device is lower than the environmental temperature within the case of the electric control device, opening the electromagnetic valve and the fan in the electronic device cooling device; and/or when it is detected that a dew point temperature corresponding to environmental humidity within the case of the electric control device is higher than or equal to the environmental temperature within the case of the electric control device, sending out an alarm signal and/or closing the electromagnetic valve, the fan in the electronic device cooling device and a compressor main circuit in a refrigeration loop.

[0016] According to the refrigeration system of the present invention, by serially connecting the electronic device cooling device in the refrigeration loop to provide a cooling and dehumidification method for the electric control device thereof, the entire space within the case of the electric control device can be effectively cooled and dehumidification can be performed thereto. This structural design can not only avoid the high cost of arranging a set of special cooling system, but also avoid the problems of the traditional cooling method of the electronic device that the efficiency is low and the electronic device within the cabinet is caused to failure due to improper dehumidification under high-humidity environment, thus having very high practical value and universality. Additionally, according to the cooling method for the electric control device of the refrigeration system of the present invention, corresponding start-stop methods of the electromagnetic valve and fan are provided according to changes of temperature and/or humidity within the electric control device, which better realize the function of regulating and improving the temperature and humidity of the elements and the environment inside the electric control device in cooperation with the refrigeration system of the present invention.

## DESCRIPTION OF THE DRAWINGS

[0017] Fig. 1 is a schematic diagram of one embodiment of a refrigeration system of the present invention.

## DESCRIPTION OF THE EMBODIMENTS

[0018] Fig. 1 illustrates one embodiment of a refrigeration system of the present invention, wherein a refrigeration system 100 has an electric control device 190, the electric control device 190 comprising a case 192 and an electronic device 191 arranged in the case 192 and being used for controlling various operations of the refrigeration system 100.

[0019] The refrigeration system 100 further has a refrigeration loop of conventional components, i.e., a compressor 110, a condenser 120, an evaporator 130, an electromagnetic valve 140 and an expansion device 150 which are sequentially connected through a pipeline, wherein the electromagnetic valve 140 can be used for controlling the opening and closing of the loop and providing a partial throttling effect to refrigerant; and the expansion device 150

is mainly used for providing a throttling effect and can be a capillary tube with a fixed throttling effect or an electronic expansion valve with an adjustable throttling effect, or other devices which can be used for throttling. Additionally, the refrigeration system 100 further comprises an electronic device cooling device 160 serially connected between the expansion device 140 and the evaporator 130, the electronic device cooling device 160 being used for cooling the electronic device and reducing humidity of an environment in which the electronic device is located. The electronic device cooling device 160 is in spaced apart arrangement from the electronic device 191 within the case 192 to realize simultaneously cooling of the electronic device and air and or other parts within the case 192.

**[0020]** The electronic device cooling device 160 comprises an air-refrigerant heat exchanger 161 and a fan 162 through which a forced convection heat exchange between air and refrigerant in the heat exchanger 161 is realized. Wherein, the heat exchanger 161 in the electronic device cooling device 160 can adopt a universal heat exchanger design method. For example, various specification parameters of the heat exchanger 161 are designed according to the amount of the heat emitted by the electronic device. Compared with the existing conventional electronic device cooling methods, the structure of the electronic device cooling device 160 of the present invention and the cooling method adopted thereof bring a better cooling effect relative to conventional direct ventilation cooling, and bring better device reliability relative to conventional water-cooled cooling, without having the problems of water leakage and potential safety hazard caused to the electronic device.

**[0021]** Since condensed water is inevitably produced during temperature reduction and dehumidification of the above heat exchanger, in order to centrally treat the condensed water, a water pan 170 can be arranged below the electronic device cooling device 160. Of course, the water pan 170 can be replaced with other types of condensed water collection devices.

**[0022]** In order to optimize the structural layout within the electric control device 190, reasonably arrange various parts so as to improve the space utilization rate, the electronic device cooling device 160 in this embodiment can be arranged close to a position below the case 192 of the electric control device 190 and the water pan 170 is arranged close to an inner side below the case 192, such that the water pan 170 is exactly arranged below the

heat exchanger 161 to receive the condensed water which is possibly produced on fins of the heat exchanger 161.

[0023] Preferably, in order to prevent the increase of the environmental humidity within the case 192, the condensed water can be introduced out of the case 192 for treatment through a condensed water discharge device 180. Optionally, the condensed water discharge device 180 comprises: a drainage pipe 182 which is connected to a bottom of the water pan 170 for introducing the condensed water out of the water pan 170; and a water tank 181 which is arranged outside the case 192 and is used for receiving the condensed water introduced out by the drainage pipe 182, so as to centrally treat the condensed water.

[0024] Optionally, the electromagnetic valve 140 and the expansion device 150 can be directly arranged within the case 192 so as to avoid the layout of the parts outside the electric control device from being too compact.

[0025] Additionally, in order to better control the timing of operating the refrigeration system 100 to cool the electric control device 190 and control the opening of the expansion device, the present invention further comprises a temperature sensor and/or a humidity sensor arranged in the electric control device 190, so as to control the opening and closing of the electromagnetic valve 140 and the action of the expansion device according to a temperature index and/or a humidity index in the electric control device 190.

[0026] When the set of refrigeration system is applied to a large-scale refrigeration unit (such as a centrifugal unit or a screw unit), a better effect can be achieved because the cooling demand to the emitted heat during the convention operation of such a electric control device 190 is usually between 3kW and 5kW and this only accounts for a very small proportion with respect to the refrigeration capacity of the large-scale refrigeration unit which is frequently hundreds or even thousands of tons of refrigeration. Therefore, serially connecting the electronic device cooling device 160 in the refrigeration system of the large-scale refrigeration unit will substantially have no influence on the working of the original refrigeration system.

[0027] A working process of the present invention will be described below in combination with the above-mentioned embodiments. When it is detected that the temperature and/or humidity index within the case 192 of the electric control device 190 is

higher than a certain value, the electromagnetic valve 140 is opened, at this moment, the refrigerant which is cooled by the condenser 130 and is expanded by the electromagnetic valve 140 and the expansion device 150 flows through the air-refrigerant heat exchanger 161 and exchanges heat with an air flow blown by the fan 162. The cooled air flow flows within the entire case 192, such that not only can the cooling and dehumidification of the electronic device 191 be realized, but also the regulation and control of the environmental temperature and humidity within the entire case 192 can be realized during the convection of the air flow, thereby effectively achieving the temperature reduction of the electronic device 191 and the environment within the case 192 and controlling the humidity thereof to be below a threshold.

[0028] Wherein, it should be understood that, in this embodiment, the cooling of the electric control device 190 and the operation of the corresponding refrigeration system need to be simultaneously performed because the electronic device cooling device 160 is serially connected in the set of refrigeration system and the on and off states of the refrigeration loop can be uniformly controlled through the electromagnetic valve 140. Such a design, on one hand, simplifies the complexity of the refrigeration loop and the complexity of the control method of cooling the electric control device 190, which greatly improves the device reliability; and on the other hand, by performing cooling directly using a small portion of cold carried by the refrigerant in the main refrigeration loop, not only can a better cooling effect than the conventional cooling methods be brought, but also no influence will be caused to the working of the main refrigeration loop itself. Effects such as improving the cooling effect, improving the device reliability and reducing the system complexity are comprehensively realized.

[0029] The present invention further provides an embodiment of a corresponding cooling method for the electric control device of the refrigeration system. For example, when the system is controlled based on temperature, a main controller of a centrifuge refrigeration system, upon receiving an internal environmental temperature signal of the case 192 of the electric control device 190, compares the environmental temperature with a built-in preset temperature and outputs a control signal to open the electromagnetic valve 140 and the fan 162 in the electronic device cooling device 160 if the environmental temperature is higher

than the preset temperature. At this moment, after passing through the opened electromagnetic valve 140 and being throttled via the expansion device 150, the refrigerant is communicated to the electronic cooling device 160 and exchanges heat with the air which flows through the heat exchanger 161 under the drive of the fan, and thus the environmental temperature within the entire case 192 is improved and kept to be below the preset temperature to prevent the electric control device from being too hot.

**[0030]** Additionally, when the system is controlled based on both temperature and humidity, the main controller of the centrifuge refrigeration system, upon receiving internal environmental temperature and environmental humidity signals of the case 192 of the electric control device 190, calculates a dew point temperature corresponding to the relative environmental humidity, compares the dew point temperature with the detected environmental temperature and outputs a control signal to open the electromagnetic valve 140 and the fan 162 in the electronic device cooling device 160 if the calculated dew point temperature is lower than the environmental temperature. At this moment, after passing through the opened electromagnetic valve 140 and being throttled via the expansion device 150, the refrigerant is communicated to the electronic cooling device 160 and exchanges heat with the air which flows through the heat exchanger 161 under the drive of the fan, and thus the environmental temperature within the entire case 192 is improved and kept to be above the dew point temperature to prevent the electric control device from being too wet and condensing so as to prevent the electric control device from failing. If the calculated dew point temperature is higher than or equal to the detected environmental temperature, an alarm signal or a protection signal is output to remind a user or directly close the electromagnetic valve 140, the fan 162 in the electronic device cooling device 160 and the compressor main circuit in the refrigeration loop.

**[0031]** The specific embodiments of the present invention are described above in detail according to the drawings. One skilled in the art can make equivalent transformations or variations to the specific features in the embodiments according to the above-mentioned description. Undoubtedly, such varied embodiments shall also fall into the protection range covered by the claims.

**CLAIMS**

1. A refrigeration system, which is characterized by comprising:  
an electric control device comprising a case and an electronic device arranged in the case;  
a refrigeration loop comprising a compressor, a condenser, an electromagnetic valve, an expansion device and an evaporator which are sequentially connected through a pipeline and form a closed loop; and an electronic device cooling device serially connected between the expansion device and the evaporator; wherein the electronic device cooling device is arranged within the case and is spaced from the electronic device, which is used for reducing temperature and humidity of the electronic device and an environment within the case.
2. The refrigeration system according to claim 1, characterized in that the electronic device cooling device comprises an air-refrigerant heat exchanger and a fan for providing forced air convection, the air-refrigerant heat exchanger being serially connected between the expansion device and the evaporator.
3. The refrigeration system according to claim 2, characterized by further comprising a condensed water collection device arranged below the air-refrigerant heat exchanger within the case.
4. The refrigeration system according to claim 3, characterized in that the condensed water collection device is a water pan.
5. The refrigeration system according to claim 3, characterized by further comprising a condensed water discharge device for discharging condensed water out of the case, the condensed water discharge device being arranged outside the case and being in fluid communication with the condensed water collection device.
6. The refrigeration system according to claim 1, characterized in that the electromagnetic valve and the expansion device are arranged outside the case.
7. The refrigeration system according to claim 6, characterized in that the expansion device is a capillary tube or an electronic expansion valve.
8. The refrigeration system according to claim 2, characterized by further comprising a temperature sensor and/or a humidity sensor, the temperature sensor and/or the humidity sensor being arranged within the case, and the refrigeration system being used for controlling

the opening or start-stop of the electromagnetic valve, the expansion device and the fan according to parameters detected by the temperature sensor and/or the humidity sensor.

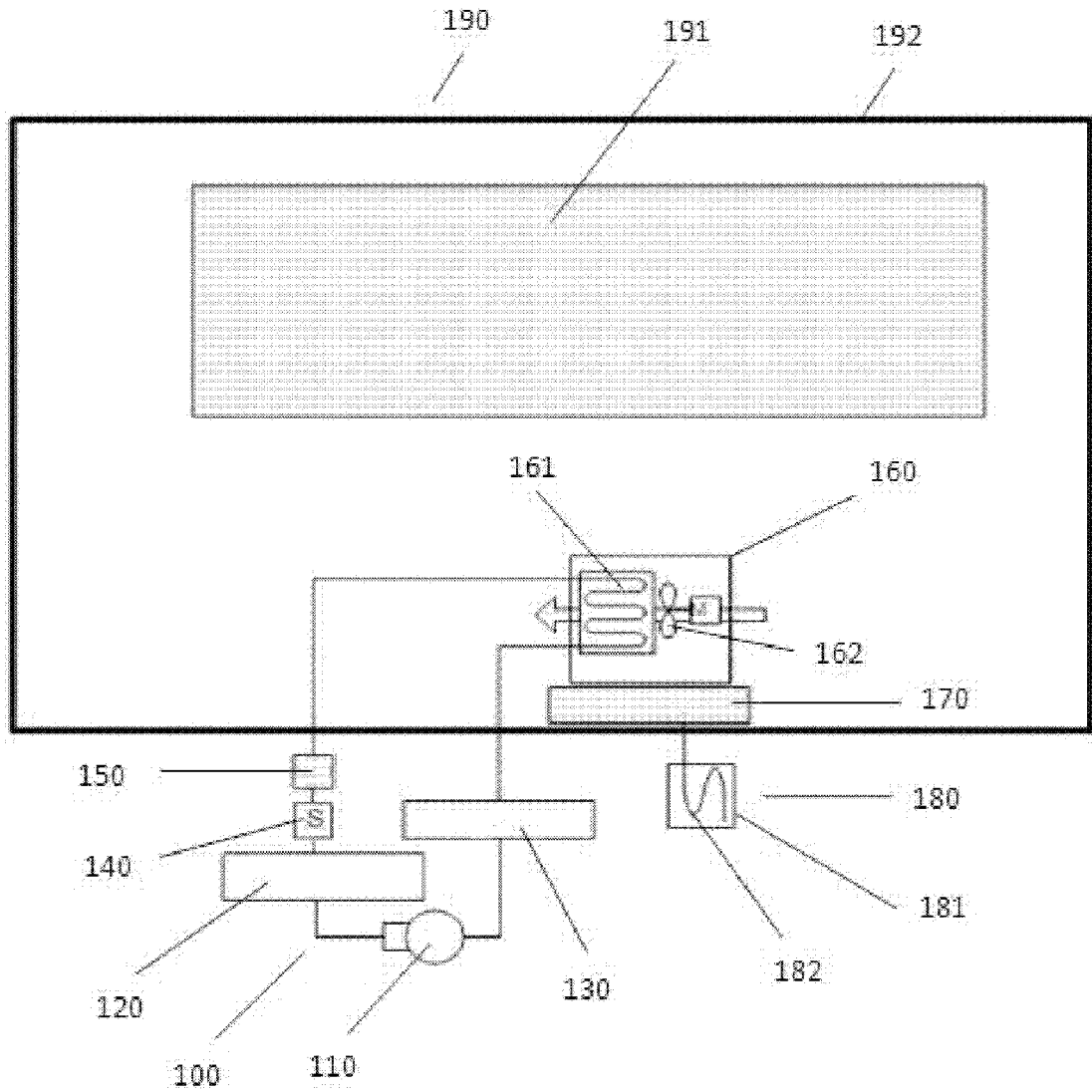
**9.** The refrigeration system according to claim 1, characterized in that the compressor is a centrifugal compressor.

**10.** A cooling method for an electric control device of a refrigeration system, characterized by comprising the following steps of:

when it is detected that environmental temperature within a case of the electric control device is higher than a preset temperature, opening an electromagnetic valve and a fan in an electronic device cooling device; and/or

when it is detected that a dew point temperature corresponding to environmental humidity within the case of the electric control device is lower than the environmental temperature within the case of the electric control device, opening the electromagnetic valve and the fan in the electronic device cooling device; and/or

when it is detected that a dew point temperature corresponding to environmental humidity within the case of the electric control device is higher than or equal to the environmental temperature within the case of the electric control device, sending out an alarm signal and/or closing the electromagnetic valve, the fan in the electronic device cooling device and a compressor main circuit in a refrigeration loop.



## INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2016/027705

## A. CLASSIFICATION OF SUBJECT MATTER

INV. F24F1/24 H05K7/20 B60H1/00 F25B27/02 F25B31/00  
F25B5/04

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25B F24F H05K B60H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                             | Relevant to claim No. |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| X         | WO 2013/001829 A1 (PANASONIC CORP [JP];<br>INOUE SHIGEYUKI; OKA KOUJI; ISHISONE<br>TSUKASA; TAK) 3 January 2013 (2013-01-03)<br>abstract; figures 1-8<br>----- | 1-10                  |
| X         | DE 10 2013 206996 A1 (BOSCH GMBH ROBERT<br>[DE]) 23 October 2014 (2014-10-23)<br>the whole document<br>-----                                                   | 1-10                  |
| X         | US 2013/319038 A1 (KAWASE YASUHIRO [JP] ET<br>AL) 5 December 2013 (2013-12-05)<br>the whole document<br>-----                                                  | 1-10                  |



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Date of the actual completion of the international search

1 July 2016

Date of mailing of the international search report

11/07/2016

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/027705

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s)                                                                 | Publication<br>date                                                |
|-------------------------------------------|---------------------|--------------------------------------------------------------------------------------------|--------------------------------------------------------------------|
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| DE 102013206996 A1                        | 23-10-2014          | NONE                                                                                       |                                                                    |
| US 2013319038 A1                          | 05-12-2013          | CN 103380014 A<br>EP 2678175 A1<br>JP 2012172917 A<br>US 2013319038 A1<br>WO 2012114182 A1 | 30-10-2013<br>01-01-2014<br>10-09-2012<br>05-12-2013<br>30-08-2012 |