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(54) **AIR CONDITIONER POWER CONSUMPTION ESTIMATION METHOD AND DEVICE**

(57) The present invention discloses a method for estimating power consumption of an air conditioner, and belongs to the technical field of air conditioners. The method includes: acquiring types of n first air conditioners which are located in the same region with a second air conditioner, and operating parameters of each of the first air conditioners within a time period T (S101), wherein the operating parameters include s times of powers P_{ix} reported by each of the first air conditioners within the time period T and an operating time t_{ix} corresponding to each power P_{ix}; determining power correction coefficients α_i of the n first air conditioners according to the types of the n first air conditioners and the type of the second air conditioner (S102); and calculating estimated power consumption W1 of the second air conditioner within the time period T according to the operating parameters within the time period T and the power correction coefficient α_i of each of the n first air conditioners (S103). The present invention also discloses a device for estimating power consumption of an air conditioner.

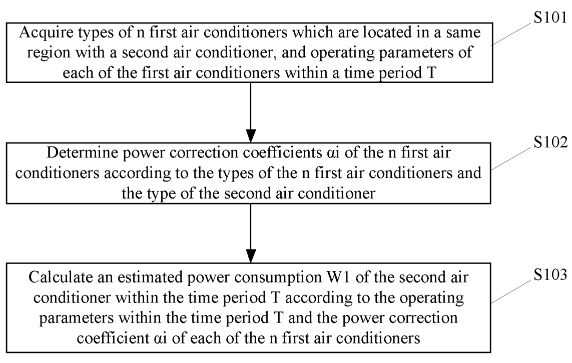

FIG. 1

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Description

[0001] The present application is proposed based on China patent application No. 201710302173.2, filed on May 2, 2017, and claims priority to the China patent application, the entire contents of which are hereby incorporated by reference.

Technical Field

[0002] The present invention relates to the technical field of air conditioners, and particularly relates to a method and a device for estimating power consumption of an air conditioner.

Background

[0003] With the progress of science and technology and the development of culture, industrial development and economic activities require a large amount of energy. Energy is not inexhaustible; in addition, the consumption of non-clean energy will bring environmental pollution. In view of greenhouse effect, high-price trend of the energy, exhaustion of traditional energy and other problems, how to save energy and correctly evaluate an energy-saving effect becomes the most concerned issue in the world. In the prior art, such as in the technical field of air conditioners, many energy-saving control methods have appeared. The power consumption of the air conditioners is generally estimated by relying on laboratory data when the quantity of saved electricity is measured. However, the method has a relatively large error since the power consumption of the air conditioners is affected by many factors such as geographical location, outdoor environment, indoor environment, house type and machine type.

Summary

[0004] Embodiments of the present invention provide a method and a device for estimating power consumption of an air conditioner, so as to solve a problem of relatively large error since the power consumption of the air conditioner is estimated by using laboratory data in the prior art. In order to basically understand some aspects of the disclosed embodiments, a brief summary is given below. The summary is not a general comment, nor tends to determine key/critical constituent elements or describe a protection scope of these embodiments, and only aims to present some concepts in a simplified form as an introduction of the following detailed description.

[0005] A method for estimating power consumption of an air conditioner is provided according to a first aspect of the embodiments of the present invention.

[0006] In some exemplary embodiments, the method for estimating the power consumption of the air conditioner includes:

acquiring types of n first air conditioners which are located in the same region with a second air conditioner, and operating parameters of each of the first air conditioners within a time period T, where the operating parameters include s times of powers P_{ix} reported by each of the first air conditioners within the time period T and an operating time t_{ix} corresponding to each power P_{ix}; i = 1, 2, ..., n; the n is a positive integer not less than 1; x = 1, 2, ..., *s*; and the *s* is a positive integer not less than 1;
determining power correction coefficients α_i of the n first air conditioners according to the types of the n first air conditioners and the type of the second air conditioner; and
calculating an power consumption of the second air conditioner within the time period T according to the operating parameters within the time period T and the power correction coefficient α_i of each of the n first air conditioners.

[0007] In some illustrative embodiments, the calculating the estimated power consumption of the second air conditioner within the time period T according to the operating parameters within the time period T and the power correction coefficient α_i of each of the n first air conditioners includes:

calculating a correction power P_i of each of the n first air conditioners;
calculating an average correction power $\overline{P}$ of the n first air conditioners according to the correction power P_i of each of the n first air conditioners; and
calculating the estimated power consumption W1 of the second air conditioner within the time period T according to the average correction power $\overline{P}$ of the n first air conditioners.

[0008] In some illustrative embodiments, the calculating the power consumption of the second air conditioner within the time period T according to the following formula includes:

calculating the correction power P_i of each of the n first air conditioners according to a formula 1:

$$P_i=\frac{\sum_{x=1}^{s} P_{ix} * t_{ix}}{\sum_{x=1}^{s} t_{ix}} \alpha_i$$

[0009] In some illustrative embodiments, the determining the power correction coefficients α_i of the n first air conditioners according to the types of the n first air conditioners and the type of the second air conditioner includes:

determining a coefficient a_0 of the second air conditioner according to the type of the second air conditioner;
determining coefficients a_i of the n first air conditioners according to the types of the n first air conditioners; and
calculating the power correction coefficients α_i of the n first air conditioners according to a formula 4:

$$\alpha_i=\frac{a_i}{a_0} \quad (4).$$

[0010] In some illustrative embodiments, after calculating the power consumption of the second air conditioner within the time period T, the method further includes:

calculating an actual power consumption W2 of the second air conditioner within the time period T, where a set temperature of the second air conditioner within the time period T is a second temperature, and the second temperature is different from the first temperature; and
calculating a power consumption saving value Δ W of the second air conditioner within the time period T according to the following formula:

$$\Delta W = W1 - W2.$$

[0011] In some illustrative embodiments, the calculating the actual power consumption W2 of the second air conditioner within the time period T includes:

acquiring the operating parameters of the second air conditioner within the time period T, where the operating parameters include *m* times of powers P_y reported by the air conditioner within the time period T and an operating time t_y corresponding to each power P_y; and
calculating the actual power consumption W2 according to the following formula:

$$W2=\sum_{y=1}^{m} P_y * t_y$$

where y = 1, 2, ... , m, and the m is a positive integer not less than 1.

[0012] In the above embodiments, the power consumption of the second air conditioner within the time period T when the set temperature is the first temperature is estimated according to the types of the n first air conditioners and the operating parameters of each of the first air conditioners within the time period T. In the present embodiment, when the power consumption of the air conditioner is estimated, the adopted data are not calculated according to the laboratory data, but are acquired by taking the types and the operating parameters of the n first air conditioners in the same region and within the same operating time period; and the power consumption of the second air conditioner within the time period is estimated according to the parameters. In the present embodiment, the operating parameters of the n first air conditioners are collected within the same operating time period; and the parameters are affected by geographic location, outdoor environment, indoor environment, house type, machine type and other factors of each of the first air conditioners. In addition, the estimated power consumption of the second air conditioner also corresponds to the time period. Thus, the power consumption of the air conditioner converted by the present embodiment is more accurate than a mode of calculating with the experimental data in the prior art.

[0013] A device for estimating power consumption of an air conditioner is provided according to a second aspect of the embodiments of the present invention.

[0014] In some exemplary embodiments, the device for estimating the power consumption of the air conditioner includes a signal receiver and a processor.

[0015] The signal receiver is configured to acquire types of n first air conditioners which are located in a same region with a second air conditioner, and operating parameters of each of the first air conditioners within a time period T; where the operating parameters include s times of powers P_{ix} reported by each of the first air conditioners within the time period T and an operating time t_{ix} corresponding to each power P_{ix}, where the x = 1, 2, ..., *s*; the *s* is a positive integer not less than 1; i = 1, 2, ..., n; the n is a positive integer not less than 1; and

the processor is configured to determine power correction coefficients α_i of the n first air conditioners according to the types of the n first air conditioners and the type of the second air conditioner, and calculate the power consumption of the second air conditioner within the time period T according to the operating parameters within the time period T and the power correction coefficient α_i of each of the n first air conditioners.

[0016] In some illustrative embodiments,

the processor is further configured to calculate a correction power P_i of each of the n first air conditioners, calculate an average correction power $\overline{P}$ of the n first air conditioners according to the correction power P_i of each of the n first air conditioners, and calculate the estimated power consumption W1 of the second air conditioner within the time period T according to the average correction power $\overline{P}$ of the n first air conditioners.

[0017] In some illustrative embodiments,

the processor is further configured to calculate the correction power P_i of each of the n first air conditioners according to the following formula:

$$P_i=\frac{\sum_{x=1}^{s} P_{ix}*t_{ix}}{\sum_{x=1}^{s} t_{ix}}\alpha_i$$

[0018] In some illustrative embodiments,

the processor is further configured to determine a coefficient a_0 of the second air conditioner according to the type of the second air conditioner,

determine coefficients a; of the n first air conditioners according to the types of the n first air conditioners, and

calculate the power correction coefficients α_i of the n first air conditioners according to the following formula:

$$\alpha_i=\frac{a_i}{a_0}$$

[0019] In some illustrative embodiments,

the processor is further configured to acquire the operating parameters of the second air conditioner within the time period T, where the operating parameters include m times of powers P_y reported by the second air conditioner within the time period T and an operating time t_y corresponding to each power P_y,

calculate the actual power consumption W2 according to the following formula:

$$W2=\sum_{y=1}^{m} P_y * t_y,$$

where y = 1, 2, ... , m, and m is a positive integer not less than 1, and

calculate a power consumption saving value Δ W of the second air conditioner within the time period T according to the following formula:

$$\Delta W = W1 - W2.$$

[0020] Technical solutions provided by the embodiments of the present invention may include beneficial effects below.

[0021] In the above embodiments, the power consumption of the second air conditioner within the time period T when the set temperature is the first temperature is estimated according to the types of the n first air conditioners and the operating parameters of each of the first air conditioners within the time period T. In the present embodiment, when the power consumption of the air conditioner is estimated, the adopted data are not calculated according to the laboratory data, but are acquired by taking the types and the operating parameters of the n first air conditioners in the same region and within the same operating time period; and the power consumption of the second air conditioner within the time period is estimated according to the parameters. In the present embodiment, the operating parameters of the n first air conditioners are collected within the same operating time period; and the parameters are affected by geographic location, outdoor environment, indoor environment, house type, machine type and other factors of each of the first air conditioners. In addition, the estimated power consumption of the second air conditioner also corresponds to the time period. Thus, the power consumption of the air conditioner converted by the present embodiment is more accurate than a mode of calculating with the experimental data in the prior art.

[0022] It should be understood that the above general description and the following detailed description are merely exemplary and illustrative, and not restrictive to the present invention.

Brief Description of the Drawings

[0023] The accompanying drawings herein, which are incorporated in the description and constitute a part of the description, illustrate embodiments consistent with the present invention and serve to explain principles of the present invention together with the description.

FIG. 1 is a flow chart of a method for estimating power consumption of an air conditioner according to an exemplary embodiment;

FIG. 2 is a flow chart of a method for estimating power consumption of an air conditioner according to an exemplary embodiment; and

FIG. 3 is a block diagram of a device for estimating power consumption of an air conditioner according to an exemplary embodiment.

Detailed Description

[0024] The following description and accompanying drawings fully illustrate specific embodiments of the present invention so that those skilled in the art can practice the specific embodiments. The embodiments only represent possible variations. Individual components and functions are optional unless explicitly required, and a sequence of operations is variable. Parts and features of some embodiments may be included in or substituted for parts and features of other embodiments. A scope of the embodiments of the present invention includes a full scope of claims and available equivalents of the claims. In this description, various embodiments may be individually or generally represented by a term "invention" for convenience only. If more than one invention is actually disclosed, the scope of the application is not automatically limited to any individual invention or inventive concept. In this description, relational terms such as first, second, etc. are only used to distinguish one entity or operation from another entity or operation, and do not require or imply any actual relationship or order among these entities or operations. Moreover, the terms such as "include", "contain" or any other variation thereof are intended to cover non-exclusive inclusions, such that a process, method or apparatus including a series of elements not only includes those elements, but also includes other elements not explicitly listed. Each embodiment herein is described in a progressive manner, and focuses on illustrating differences from other embodiments. Same and similar parts of the various embodiments can be referred to each other. Structures, products and the like disclosed in the embodiments correspond to the parts disclosed in the embodiments, and thus are described relatively simply; and the relevant parts refer to the descriptions of the method.

[0025] The quantity of saved electricity of an air conditioner needs to be calculated after the air conditioner is subjected to electricity-saving control in the prior art. The quantity of saved electricity is determined according to a difference between an estimated power consumption of the air conditioner and an actual power consumption of the air conditioner in a period of regulating a first state to a second state of the air conditioner, i.e., a time period T after the air conditioner is subjected to electricity-saving control. In the above process, the actual power consumption of the air conditioner can be calculated according to a power and a time fed back by the air conditioner.

[0026] However, the estimated power consumption of the air conditioner needs to be calculated according to the laboratory data. However, since the power consumption of the air conditioner may be affected by geographical location, outdoor environment, indoor environment, house type, machine type and other factors of the air conditioner, the laboratory data cannot reflect an actual operating state of the air conditioner; and the calculated estimated power consumption is relatively large in error. An overall concept of the present invention is to acquire types and operating parameters of a plurality of air conditioners in the first state within the time period T, and calculate the estimated power consumption within the time period T when calculating that the air conditioner is in the first state according to the above parameters.

[0027] In the present invention, the first state refers to a state of the air conditioner before electricity-saving control; the second state refers to a state of the air conditioner after electricity-saving control; and the first state and the second state may be regulation for a set temperature of the air conditioner, e.g., a first temperature is adjusted to a second temperature, and may also be regulation for a fan speed of the air conditioner, e.g., a first fan speed is adjusted to a second fan speed.

[0028] First air conditioners are a type of air conditioners of which the types and the operating parameters are taken from a database when calculating the estimated power consumption of the second air conditioner. Operating states of the first air conditioners within the time period T are the same as an operating state of a second air conditioner before electricity-saving control, i.e., the first air conditioners are in the first state. The first air conditioners and the second air conditioner are located in the same region, such as the same city or the same region; and the outdoor environments are basically the same.

[0029] The second air conditioner is an air conditioner which is subjected to electricity-saving control and requires calculation of the estimated power consumption. The second air conditioner is in the first state as the first air conditioners before electricity-saving control. The second air conditioner is adjusted from the first state to the second state after performing electricity-saving control on the second air conditioner.

[0030] The types of the first air conditioners or the second air conditioner refer to a type of parameters capable of reflecting a horsepower and an energy consumption level of the air conditioner, such as a machine type and a machine code.

[0031] The energy consumption level can be represented by an energy rating label and can be classified into five levels according to national standards. A level 1 indicates that an electricity-saving effect of the product has reached an international advanced level and the energy consumption is the lowest; a level 2 indicates that the product is relatively electricity-saving; a level 3 indicates that an energy efficiency of the product is at an average level of the Chinese market; a level 4 indicates that the energy efficiency of the product is lower than the average level of the market; a level 5 is a market access indicator of the product, in which the products that fail to meet the requirements of the level are not allowed to be produced and sold; and the energy consumption level can also be classified according to industry standards or enterprise standards.

[0032] A power correction coefficient is determined according to the types of the first air conditioners and the type of the second air conditioner, and is used for correcting powers of the first air conditioners and further calculating correction powers of the first air conditioners.

[0033] The estimated power consumption corresponds to the power consumption of the second air conditioner within the time period T before electricity-saving control, i.e., in the first state.

[0034] The actual power consumption corresponds to the power consumption of the second air conditioner within the time period T after electricity-saving control, i.e., in the second state.

[0035] FIG. 1 is a flow chart of an embodiment of the present invention. As shown in the FIG. 1:
In some exemplary embodiments, the method for estimating the power consumption of the air conditioner includes:

> step S101, types of n first air conditioners located in the same region and operating parameters of each of the first air conditioners within the time period T are acquired, where the operating parameters include s times of powers P_{ix} reported by each of the first air conditioners within the time period T and an operating time t_{ix} corresponding to each power P_{ix}; i = 1, 2, ..., n; n is a positive integer not less than 1; x = 1, 2, ..., s; and s is a positive integer not less than 1;
> step S102, the power correction coefficients α_i of the n first air conditioners are determined according to the types of the n first air conditioners and the type of the second air conditioner; and step S103, the estimated power consumption W1 of the second air conditioner within the time period T is calculated according to the operating parameters within the time period T and the power correction coefficient α_i of each of the n first air conditioners.

[0036] In the above embodiments, the estimated power consumption of the second air conditioner within the time period T is calculated according to the types of the n first air conditioners and the operating parameters of each first air conditioner within the time period T. In the present embodiment, when the power consumption of the air conditioner is estimated, the adopted data are not calculated according to the laboratory data, but are acquired by taking the types and the operating parameters of the n first air conditioners in the same region and within the same operating time period; and the estimated power consumption W1 of the second air conditioner is calculated according to the parameters. In the present embodiment, the operating parameters of the n first air conditioners are collected within the same operating time period; and the parameters are affected by geographic location, outdoor environment, indoor environment, house type, machine type and other factors of each of the first air conditioners. In addition, the estimated power consumption W1 of the second air conditioner also corresponds to the time period. Thus, the power consumption of the air conditioner converted by the present embodiment is more accurate than a mode of calculating with the experimental data in the prior art.

[0037] In some optional embodiments, the set temperature of a second home appliance before the electricity-saving control is a first temperature; and the set temperature after the electricity-saving control is set to a second temperature. The set temperature of the n first air conditioners taken in the above embodiment is the first temperature; and the calculated estimated power consumption is a power consumption of the second home appliance within the operating time period T when the set temperature is the first temperature. In the present embodiment, the second home appliance achieves a purpose of saving electricity by adjusting the set temperature. Therefore, in the present embodiment, the first state of the n first home appliances means that the set temperature is the first temperature. The second state of the second home appliance after the electricity-saving control means that the set temperature is the second temperature.

[0038] In some optional embodiments, the types and operating parameters of the n first air conditioners may be acquired from a cloud server or other devices in the step S101. The cloud server or other devices are configured to monitor the operating states of the air conditioners in the same region, such as the first state and the second state; when the power of the air conditioner changes, the air conditioner may actively report the change to the cloud server or other devices and inform them of a current power; and therefore, the cloud server or other devices also record the power of each air conditioner and the operating time corresponding to the power.

[0039] In some optional embodiments, the power correction coefficients α_i of the n first air conditioners may be queried from a local or cloud server or other devices in the step S102.

[0040] Optionally, the power correction coefficients α_i of the air conditioners of different types are recorded in a database; and the power correction coefficients α_i of the first air conditioners can be directly queried according to the types of the first air conditioners and the type of the second air conditioner.

[0041] Optionally, coefficients of the air conditioners corresponding to different horsepower and different energy consumption levels are recorded in the database, as shown in a Table 1.

Table 1

Horsepower	Level-1 energy consumption	Level-2 energy consumption	Level-3 energy consumption
1P	A11	A12	A13
1.5P	A21	A22	A23
2P	A31	A32	A33
3P	A41	A42	A43

[0042] The type of the air conditioner corresponds to the horsepower and the energy consumption level of the air conditioner. The horsepower and the energy consumption level of the air conditioner can be determined by identifying the type of the air conditioner.

[0043] Further, the step S102 specifically includes:

a coefficient a_0 of the second air conditioner is determined according to the type of the second air conditioner;
coefficients a; of the n first air conditioners are determined according to the types of the n first air conditioners; and
the power correction coefficients α_i of the n first air conditioners are calculated according to a formula 4:

$$\alpha_i=\frac{a_i}{a_0} \qquad (4).$$

[0044] For example, the horsepower corresponding to the type of the second air conditioner is IP, and the energy consumption level is the level-1 energy consumption, and then a_0 is A11; a total of n first air conditioners are acquired and numbered from 1 to n, where the horsepower corresponding to the type of the first air conditioner numbered as 3 (i.e., i=3) is 3P, and the energy consumption level is the level-2 energy consumption; and then a_3=A42; α_3=A42/A11 can be calculated according to the above information and formula 4. Similarly, the coefficients α_i of the n first air conditioners, i.e., α_1, α_2, ..., α_n, can be calculated.

[0045] In some illustrative embodiments, the step S103 includes:

the correction power P_i of each of the n first air conditioners is calculated;
the average correction power $\overline{P}$ of the n first air conditioners is calculated according to the correction power P_i of each of the n first air conditioners; and
the estimated power consumption W1 of the second air conditioner within the time period T is calculated according to the average correction power $\overline{P}$ of the n first air conditioners.

[0046] Further,
the correction power P_i of each of the n first air conditioners is calculated according to a formula 1:

$$P_i = \frac{\sum_{x=1}^{S} P_{ix} * t_{ix}}{\sum_{x=1}^{S} t_{ix}} \alpha_i \quad (1).$$

[0047] Further,
the average correction power $\overline{P}$ of the n first air conditioners is calculated according to a formula 2:

$$\overline{P} = \frac{1}{n} \sum_{i=1}^{n} P_i \quad (2).$$

[0048] Further,
the estimated power consumption W1 of the second air conditioner within the time period T is calculated according to a formula 3:

$$W1 = \overline{P} * T \ (3).$$

[0049] In the above embodiment, a specific calculation method and a corresponding formula for calculating the estimated power consumption W1 are given. The correction power P_i of each first air conditioner is calculated after the types and state parameters of the n first air conditioners are acquired; then, the calculated correction powers P_i are averaged to calculate the average correction power $\overline{P}$ of the n first air conditioners, i.e., the estimated power consumption of the second air conditioner within the time period T in the first state before electricity-saving control; and then, $\overline{P}$ calculated in the above step is multiplied by T to calculate the estimated power consumption W1 of the second air conditioner within the time period T.

[0050] In some optional embodiments, the method further includes the quantity of saved electricity of the second air conditioner after electricity-saving control is calculated. For example, the actual power consumption W2 of the second air conditioner within the time period T is calculated when the set temperature is adjusted from the first temperature to the second temperature after the second air conditioner is subjected to electricity-saving control; and then the quantity of saved electricity, i.e., a power consumption saving value Δ W of the second air conditioner within the time period T is calculated according to W1 and W2.

[0051] Further, the power consumption saving value Δ W of the second air conditioner within the time period T is calculated according to a formula 5:

$$\Delta W = W1 - W2 \ (5).$$

[0052] Further, the calculating the actual power consumption W2 specifically includes:

the operating parameters of the second air conditioner within the time period T are acquired, including *m* times of powers P_y reported by the second air conditioner within the time period T and an operating time t_y corresponding to each power P_y;
the actual power consumption W2 is calculated according to a formula 6:

$$W2 = \sum_{y=1}^{m} P_y * t_y \quad (6)$$

where y=1, 2, ... , m, and m is a positive integer not less than 1.

[0053] In the above embodiment, the actual power consumption W2 is calculated according to the operating parameter of the second air conditioner within the time period T; and the second air conditioner reports a current power when the power changes during operation, so that at least one operating power within the time period T and the corresponding operating time are acquired. Optionally, the operating parameters of the second air conditioner within the time period T may be recorded in a local database, or acquired from the cloud server or other devices.

[0054] In some illustrative embodiments, m first air conditioners having the same type as the type of the second air conditioner are acquired first in the step S101, where the m is a positive integer less than or equal to n. If m is less than n, n-m first air conditioners are randomly acquired. If n is 100, the first air conditioners having the same type as the type of the second air conditioner and using the first temperature as the set temperature are acquired from the database first; and if only 60 first air conditioners meet the condition in a current database, the first air conditioners using the first temperature as the set temperature in the remaining 40 first air conditioners are randomly acquired from the database. Further, the m first air conditioners and the second air conditioner have the same type, and the power correction coefficient $\alpha_i = 1$. In the above embodiment, the first air conditioners having the same type as the type of the second air conditioner are preferentially acquired from the database to ensure that the operating environment of the extracted first air conditioners is the most similar to the operating environment of the second air conditioner, thereby improving the accuracy of the estimated power consumption.

[0055] In order to give specific descriptions of the above embodiments, FIG. 2 is a flow chart of the method for estimating the power consumption of the air conditioner according to an embodiment of the present invention. As shown in FIG. 2, the method includes:

step S201, a set temperature of the air conditioner of a user is adjusted from T11 to T12 according to an electricity-saving control solution;
step S202, the actual power consumption W2 of the air conditioner of the user within the time period T, e.g., 10:00-11:00, is calculated according to the reported powers;
the data acquired according to the reported powers are as follows:
P_i=700W, 10 min; P_2 = 1000W, 20 min; P_3 = 800W, 15 min; and P_4 = 600W, 15 min;

[0056] In the formula 6: $W2=\sum_{y=1}^{m} P_y * t_y$, where m = 4,
W2 = 48 KW·min = $2880*10^3$J.

[0057] Step S203, operating data of a plurality of air conditioners using T11 as the set temperature in the same region are collected to calculate the estimated power consumption W1.

[0058] Considering that the number of air conditioners having the same type in a certain region may be different, we require collecting 100 air conditioners in the same region to estimate the power consumption at the temperature T11. The air conditioners having the same type are preferred. When the number of the air conditioners having the same type is less than 100, the air conditioners are randomly selected to make up 100. The power consumption W1 at the temperature T11 is estimated according to a weighted average of the power consumptions of the 100 devices.

[0059] A method for calculating W1 is specifically as follows:
The method for calculating the power consumption of each first air conditioner is the same as the formula 6. The number of the first air conditioners within the time T in the same region is n, where n = 100; the respective operating time is t_{ix}; n = 1, 2, ..., n; x = 1, 2, ..., s; and $t_i=\sum_{x=1}^{s} t_{ix}$.

[0060] The correction power of each first air conditioner is $P_i=\frac{\sum_{x=1}^{s} P_{ix}*t_{ix}}{\sum_{x=1}^{s} t_{ix}}\alpha_i$. α_i = 1 when m = n, i.e., m = 100, and the average correction power P of the 100 first air conditioners is calculated as follows:

$$\overline{P} = \frac{1}{n}\sum_{i=1}^{n} P_i.$$

[0061] The coefficient correction is performed according to the corresponding energy consumption level and horse-power when m < 100, and the average correction power P of the 100 first air conditioners is calculated as follows:

$$\overline{P} = \frac{1}{n}\left(\sum_{i=1}^{m} P_i + \sum_{i=n-m}^{n} P_i\right).$$

[0062] Finally, the estimated power consumption W1 is calculated according to the calculated P:

$$W1 = \overline{P}*T$$

[0063] Step S204, the quantity of saved electricity within 10:00-11:00 is calculated according to the estimated power consumption W1 and the actual power consumption W2 of the air conditioner of the user.

[0064] See Table 1 for the correction factor. Table 1 records the average unit energy consumption of devices with the same horsepower and the same energy consumption level in the past year.

[0065] For example, the air conditioner of a user in a certain region has 1p and a level-2 energy consumption and is operated for 1 hour when T11 is adjusted to T12; 60 air conditioners with the same type are set at T11 within the 1 hour in the region; the correction coefficients of the 60 air conditioners are α_{1-60} = 1; the remaining 40 air conditioners are extracted from the air conditioners which have other types and are set at T11 within 1 hour; and if the extracted air conditioners have 1p and a level-1 energy consumption, the correction coefficients of the 40 air conditioners are α_{61-100}=A12/A11.

[0066] The estimated power consumption W1 of the air conditioner of the user at the set temperature of T11 is:

$$W1=\frac{1}{100}\left[\sum_{i=1}^{60} P_i + \sum_{i=61}^{100} P_i\right]*1.$$

[0067] The above embodiment provides a specific implementation mode of the method for estimating the power consumption of the air conditioner according to the present invention. In the above embodiment, the estimated power consumption of the second air conditioner, i.e., the air conditioner of the user, within 1 hour from 10:00 to 11:00 is calculated according to the types of the 100 first air conditioners and the operating parameters of each of the first air conditioners within 10:00-11:00. The power consumption of the air conditioner converted in the present invention is more accurate than a mode of calculating with the experimental data in the prior art. FIG. 3 shows a device for estimating the power consumption of the air conditioner according to an embodiment of the present invention. As shown in FIG. 3:
In some exemplary embodiments, the device for estimating the power consumption of the air conditioner includes a signal receiver 301 and a processor 302.

[0068] The signal receiver 301 is configured to acquire types of the n first air conditioners and operating parameters of each first air conditioner within the time period T. The operating parameters include s times of powers P_{ix} reported by each of the first air conditioners within the time period T and an operating time t_{ix} corresponding to each power P_{ix}; x = 1, 2, ..., s; s is a positive integer not less than 1; i = 1, 2, ..., n; and n is a positive integer not less than 1.

[0069] The processor 302 is configured to determine the power correction coefficients α_i of the n first air conditioners according to the types of the n first air conditioners and the type of the second air conditioner, and calculate the estimated power consumption of the second air conditioner within the time period T according to the operating parameters within the time period T and the power correction coefficient α_i of each of the n first air conditioners.

[0070] In the above embodiments, the estimated power consumption of the second air conditioner within the time period T is calculated according to the types of the n first air conditioners and the operating parameters of each of the first air conditioners within the time period T. In the present embodiment, when the power consumption of the air conditioner is estimated, the adopted data are not calculated according to the laboratory data, but are acquired by taking the types and the operating parameters of the n first air conditioners in the same region and within the same operating time period; and the estimated power consumption W1 of the second air conditioner is calculated according to the parameters. In the present embodiment, the operating parameters of the n first air conditioners are collected within the same operating time period; and the parameters are affected by geographic location, outdoor environment, indoor environment, house type, machine type and other factors of each of the first air conditioners. In addition, the estimated power consumption W1 of the second air conditioner also corresponds to the time period. Thus, the power consumption of the air conditioner converted by the present embodiment is more accurate than a mode of calculating with the experimental data in the prior art.

[0071] In some optional embodiments, the set temperature of a second home appliance before the electricity-saving control is the first temperature; and the set temperature after the electricity-saving control is set to the second temperature. The set temperature of the n first air conditioners taken in the above embodiment is the first temperature; and the estimated power consumption calculated by the processor 302 is a power consumption of the second home appliance within the operating time period T when the set temperature is the first temperature. In the present embodiment, the second home appliance achieves a purpose of saving electricity by adjusting the set temperature. Therefore, in the present embodiment, the first state of the n first home appliances means that the set temperature is the first temperature. The second state of the second home appliance after the electricity-saving control means that the set temperature is the second temperature.

[0072] In some optional embodiments, the signal receiver 301 can also be configured to acquire the types and the operating parameters of the n first air conditioners from a cloud server or other devices. The cloud server or other devices are configured to monitor the operating states of the air conditioners in the same region, such as the first state and the second state. When the power of the air conditioner changes, the air conditioner may actively report the change to the server or other devices and inform them of a current power. Therefore, the cloud server or other devices also record the power of each air conditioner and the operating time corresponding to the power.

[0073] In some optional embodiments, the processor 302 can query the power correction coefficients α_i of the n first air conditioners from a local or cloud server or other devices.

[0074] Optionally, the power correction coefficients α_i of the air conditioners of different types are recorded in a database of the local or cloud server or other devices; and the power correction coefficients α_i of the first air conditioners can be directly queried according to the types of the first air conditioners and the type of the second air conditioner.

[0075] Optionally, coefficients of the air conditioners corresponding to different horsepower and different energy consumption levels are recorded in the database, as shown in Table 1. The type of the air conditioner corresponds to the horsepower and the energy consumption level of the air conditioner. The horsepower and the energy consumption level of the air conditioner can be determined by identifying the type of the air conditioner.

[0076] Further, the processor 302 is further configured to determine a coefficient a_0 of the second air conditioner according to the type of the second air conditioner, determine coefficients a; of the n first air conditioners according to the types of the n first air conditioners, and calculate the power correction coefficients α_i of the n first air conditioners according to a formula 4:

$$\alpha_i = \frac{a_i}{a_0} \qquad (4)$$

[0077] For example, the horsepower corresponding to the type of the second air conditioner is IP, and the energy consumption level is the level-1 energy consumption, and then a_0 is A11. A total of n first air conditioners are acquired and numbered as 1 to n, where the horsepower corresponding to the type of the first air conditioner numbered as 3 is 3P, and the energy consumption level is the level-2 energy consumption, and then a_3=A42. α_3 = A42/A11 can be calculated according to the above information and formula 4. Similarly, the coefficients α_i of the n first air conditioners, i.e., α_1, α_2, ..., α_n, can be calculated.

[0078] In some optional embodiments,
the processor 302 is further configured to calculate the correction power P_i of each of the n first air conditioners, calculate the average correction power $\overline{P}$ of the n first air conditioners according to the correction power P_i of each of the n first air conditioners, and calculate the estimated power consumption W1 of the second air conditioner within the time period T according to the average correction power $\overline{P}$ of the n first air conditioners.

[0079] Further, the processor 302 is further configured to calculate the correction power P_i of each of the n first air conditioners according to a formula 1:

$$P_i = \frac{\sum_{x=1}^{S} P_{ix} * t_{ix}}{\sum_{x=1}^{S} t_{ix}} \alpha_i \qquad (1).$$

[0080] Further, the processor 302 is further configured to calculate the average correction power $\overline{P}$ of the n first air conditioners according to a formula 2:

$$\overline{P} = \frac{1}{n} \sum_{i=1}^{n} P_i \qquad (2).$$

[0081] Further, the processor 302 is further configured to calculate the estimated power consumption W1 of the second air conditioner within the time period T according to a formula 3:

$$W1 = \overline{P} * T \qquad (3).$$

[0082] In the above embodiment, a specific calculation method and a corresponding formula for calculating the estimated power consumption W1 are given. The processor 302 calculates the correction power P_i of each first air conditioner after the signal receiver 301 acquires the types and state parameters of the n first air conditioners, then averages the calculated correction powers P_i to calculate the average correction power $\overline{P}$ of the n first air conditioners, i.e., the estimated power consumption of the second air conditioner within the time period T in the first state before electricity-saving control, and then multiplies P calculated in the above step by T to calculate the estimated power consumption W1 of the second air conditioner within the time period T.

[0083] In some optional embodiments, the processor 302 is further configured to calculate the quantity of saved electricity of the second air conditioner after electricity-saving control. For example, the processor 302 is configured to calculate the actual power consumption W2 of the second air conditioner within the time period T when the set temperature is adjusted from the first temperature to the second temperature after the second air conditioner is subjected to electricity-saving control, and then calculate the quantity of saved electricity, i.e., a power consumption saving value Δ W of the second air conditioner within the time period T according to W1 and W2.

[0084] In some optional embodiments,
the processor 302 is further configured to calculate the power consumption saving value Δ W of the second air conditioner within the time period T according to a formula 5:

$$\Delta W = W1 - W2 \qquad (5).$$

[0085] In some optional embodiments,
the processor 302 is further configured to acquire the operating parameters of the second air conditioner within the time period T, including *m* times of powers P_y reported by the second air conditioner within the time period T and an operating time t_y corresponding to each power P_y. The actual power consumption W2 is calculated according to a formula 6:

$$W2 = \sum_{y=1}^{m} P_y * t_y \qquad (6)$$

where y=1, 2, ... , m, and m is a positive integer not less than 1.

[0086] In the above embodiment, the actual power consumption W2 is calculated by the processor 302 according to the operating parameter of the second air conditioner within the time period T; and the second air conditioner reports a current power when the power changes during operation, so that at least one operating power within the time period T and the corresponding operating time are acquired.

[0087] Optionally, the operating parameters of the second air conditioner within the time period T may be recorded in a local database, or acquired from the cloud server or other devices by the signal receiver 301.

[0088] It should be understood that the present invention is not limited to processes and structures described above and shown in the accompanying drawings, and can be subjected to various modifications and changes without departing from the scope thereof. The scope of the present invention is only limited by the appended claims.

Claims

1. A method for estimating power consumption of an air conditioner, comprising:

   acquiring types of n first air conditioners which are located in a same region with a second air conditioner, and operating parameters of each of the first air conditioners within a time period T, wherein the operating parameters include s times of powers P_{ix} reported by each of the first air conditioners within the time period T and an operating time t_{ix} corresponding to each power P_{ix}; i = 1, 2, ..., n; the n is a positive integer not less than 1; x = 1, 2, ..., s; and the s is a positive integer not less than 1;
   determining power correction coefficients α_i of the n first air conditioners according to the types of the n first air conditioners and the type of the second air conditioner; and
   calculating an estimated power consumption W1 of the second air conditioner within the time period T according to the operating parameters within the time period T and the power correction coefficient α_i of each of the n first air conditioners.

2. The method according to claim 1, wherein the calculating the estimated power consumption of the second air conditioner within the time period T according to the operating parameters within the time period T and the power correction coefficient α_i of each of the n first air conditioners comprises:

   calculating a correction power P_i of each of the n first air conditioners;
   calculating an average correction power P of the n first air conditioners according to the correction power P_i of each of the n first air conditioners; and
   calculating the estimated power consumption W1 of the second air conditioner within the time period T according

to the average correction power P of the n first air conditioners.

3. The method according to claim 2, wherein the correction power P_i of each of the n first air conditioners is calculated according to the following formula:

$$P_i=\frac{\sum_{x=1}^{s} P_{ix}*t_{ix}}{\sum_{x=1}^{s} t_{ix}}\alpha_i.$$

4. The method according to any one of claims 1 to 3, wherein the determining the power correction coefficients α_i of the n first air conditioners according to the types of the n first air conditioners and the type of the second air conditioner comprises:

determining a coefficient a_0 of the second air conditioner according to the type of the second air conditioner;
determining coefficients a_i of the n first air conditioners according to the types of the n first air conditioners; and
calculating the power correction coefficients α_i of the n first air conditioners according to the following formula:

$$\alpha_i=\frac{a_i}{a_0}.$$

5. The method according to claim 4, wherein after calculating the estimated power consumption of the second air conditioner within the time period T, the method further comprises:

calculating an actual power consumption W2 of the second air conditioner within the time period T; and
calculating a power consumption saving value ΔW of the second air conditioner within the time period T according to the following formula:

$$\Delta W= W1-W2.$$

6. The method according to claim 5, wherein the calculating the actual power consumption W2 of the second air conditioner within the time period T comprises:

acquiring the operating parameters of the second air conditioner within the time period T, wherein the operating parameters include m times of powers P_y reported by the second air conditioner within the time period T, and an operating time t_y corresponding to each power P_y; and
calculating the actual power consumption W2 according to the following formula:

$$W2=\sum_{y=1}^{m} P_y * t_y$$

wherein y = 1, 2, ... , m, and the m is a positive integer not less than 1.

7. A device for estimating power consumption of an air conditioner, comprising a signal receiver and a processor, wherein
the signal receiver is configured to acquire types of n first air conditioners which are located in a same region with a second air conditioner, and operating parameters of each of the first air conditioners within a time period T; wherein the operating parameters include s times of powers P_{ix} reported by each of the first air conditioners within the time period T and an operating time t_{ix} corresponding to each power P_{ix}, wherein the x = 1, 2, ..., s; the s is a positive integer not less than 1; i = 1, 2, ..., n; the n is a positive integer not less than 1; and
the processor is configured to determine power correction coefficients α_i of the n first air conditioners according to the types of the n first air conditioners and the type of the second air conditioner, and calculate an estimated power consumption of the second air conditioner within the time period T according to the operating parameters within the time period T and the power correction coefficient α_i of each of the n first air conditioners.

8. The device according to claim 7, wherein

the processor is further configured to calculate a correction power P_i of each of the n first air conditioners, calculate an average correction power P of the n first air conditioners according to the correction power P_i of each of the n first air conditioners, and calculate the estimated power consumption W1 of the second air conditioner within the time period T according to the average correction power P of the n first air conditioners.

9. The device according to claim 8, wherein
the processor is further configured to calculate the correction power P_i of each of the n first air conditioners according to the following formula:

$$P_i=\frac{\sum_{x=1}^{s} P_{ix}*t_{ix}}{\sum_{x=1}^{s} t_{ix}}\alpha_i.$$

10. The device according to any one of claims 7 to 9, wherein
the processor is further configured to determine a coefficient a_0 of the second air conditioner according to the type of the second air conditioner,
determine coefficients a_i of the n first air conditioners according to the types of the n first air conditioners, and calculate the power correction coefficients α_i of the n first air conditioners according to the following formula:

$$\alpha_i=\frac{a_i}{a_0}.$$

11. The device according to claim 10, wherein
the processor is further configured to acquire the operating parameters of the second air conditioner within the time period T, wherein the operating parameters include m times of powers P_y reported by the second air conditioner within the time period T and an operating time t_y corresponding to each power P_y,
calculate the actual power consumption W2 according to the following formula:

$$W2=\sum_{y=1}^{m} P_y * t_y,$$

wherein y = 1, 2, ... , m, and m is a positive integer not less than 1, and
calculate a power consumption saving value Δ W of the second air conditioner within the time period T according to the following formula:

$$\Delta W = W1 - W2.$$

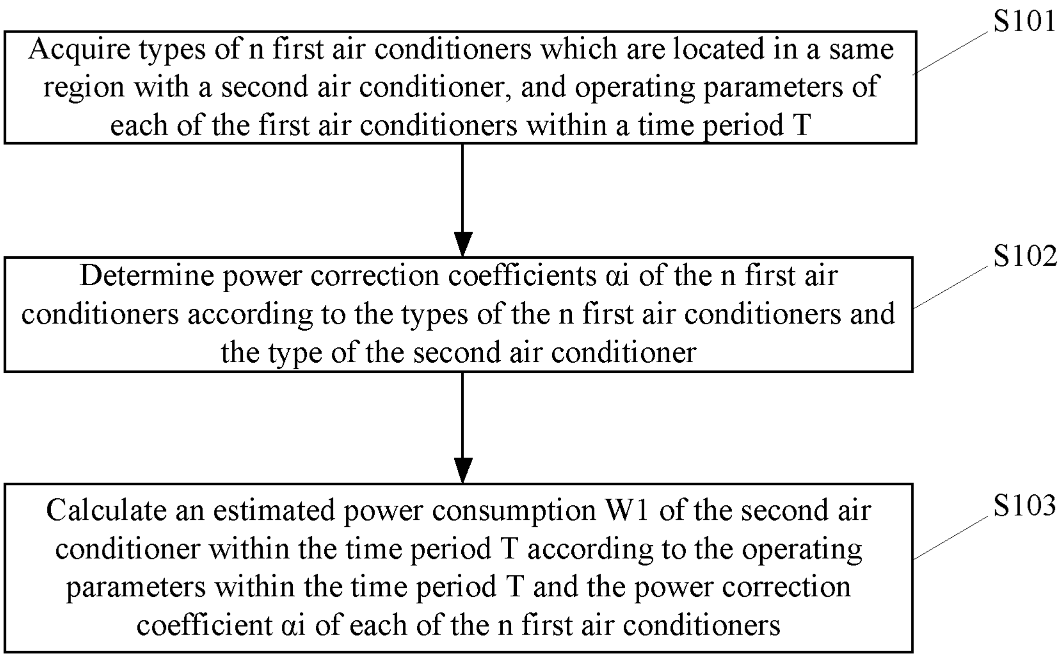
S101
Acquire types of n first air conditioners which are located in a same region with a second air conditioner, and operating parameters of each of the first air conditioners within a time period T
S102
Determine power correction coefficients αi of the n first air conditioners according to the types of the n first air conditioners and the type of the second air conditioner
S103
Calculate an estimated power consumption W1 of the second air conditioner within the time period T according to the operating parameters within the time period T and the power correction coefficient αi of each of the n first air conditioners

FIG. 1

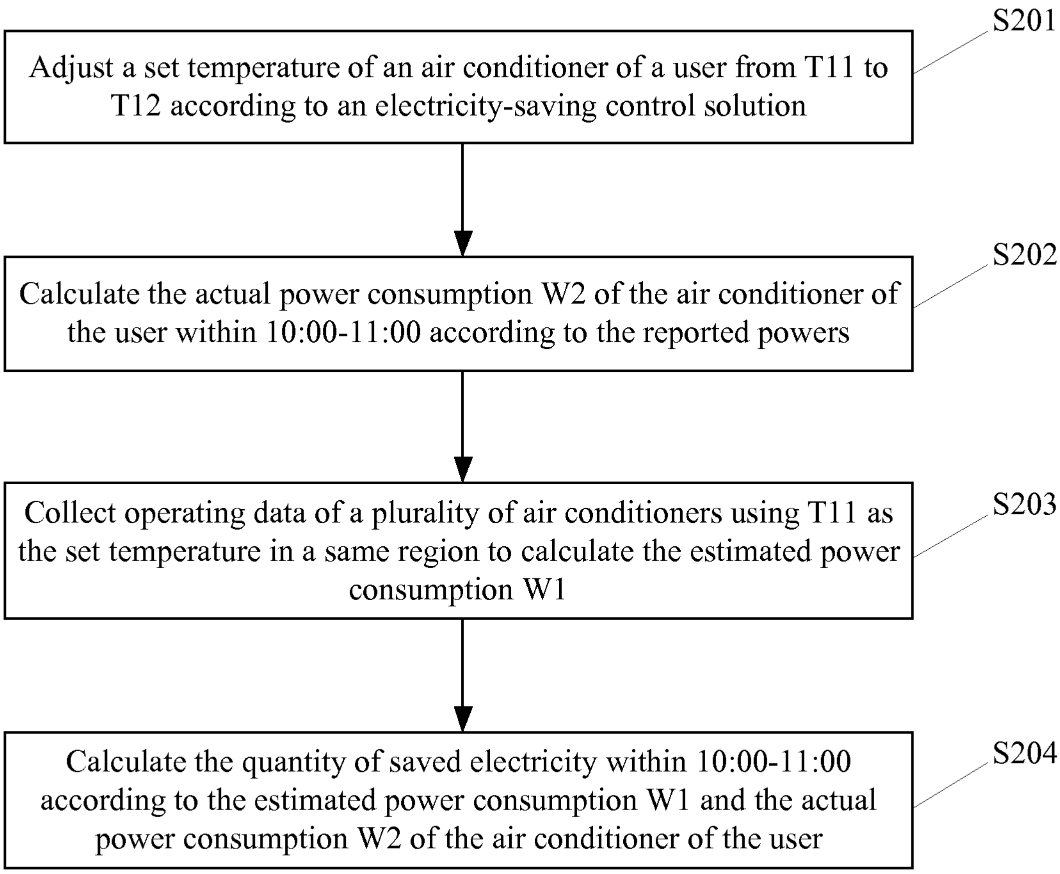
S201
Adjust a set temperature of an air conditioner of a user from T11 to T12 according to an electricity-saving control solution
S202
Calculate the actual power consumption W2 of the air conditioner of the user within 10:00-11:00 according to the reported powers
S203
Collect operating data of a plurality of air conditioners using T11 as the set temperature in a same region to calculate the estimated power consumption W1
S204
Calculate the quantity of saved electricity within 10:00-11:00 according to the estimated power consumption W1 and the actual power consumption W2 of the air conditioner of the user

FIG. 2

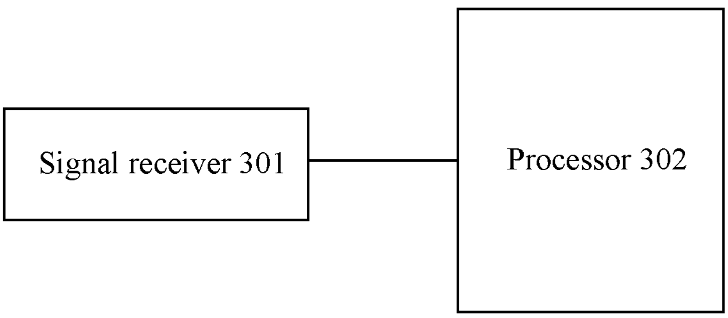
Signal receiver 301
Processor 302

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/085032

A. CLASSIFICATION OF SUBJECT MATTER

F24F 11/00 (2018.01) i

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)

F24F

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)

CNABS, CNKI, DWPI, VEN: 空调, 功耗, 估算, 同一地区, 型号, 时间, 运行参数, 功率, 修正系数, air conditioner, consumption, estimate, same area, model, time, operating parameters, power, correction factor

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 104977461 A (GUANGDONG MIDEA REFRIGERATION EQUIPMENT CO., LTD.) 14 October 2015 (14.10.2015), description, paragraphs [0030]-[0124], and figures 1-5	1-11
A	CN 105135592 A (TCL CORPORATION) 09 December 2015 (09.12.2015), entire document	1-11
A	CN 101893309 A (NINGBO AUX ELETRIC CO., LTD.) 24 November 2010 (24.11.2010), entire document	1-11
PX	CN 107246705 A (QINGDAO HAIER AIR-CONDITIONER CO., LTD.) 13 October 2017 (13.10.2017), claims 1-11	1-11
A	US 2017017735 A1 (TATA CONSULTANCY SERVICES LTD.) 19 January 2017 (19.01.2017), entire document	1-11
A	JP H0886490 A (TOSHIBA K.K.) 02 April 1996 (02.04.1996), entire document	1-11

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 July 2018	16 July 2018

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Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/085032

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 104977461 A	14 October 2015	CN 104977461 B	31 October 2017
CN 105135592 A	09 December 2015	None	
CN 101893309 A	24 November 2010	CN 101893309 B	05 December 2012
CN 107246705 A	13 October 2017	None	
US 2017017735 A1	19 January 2017	None	
JP H0886490 A	02 April 1996	None	

Form PCT/ISA /210 (patent family annex) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- CN 201710302173 **[0001]**