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TITLE OF THE INVENTION

REFRIGERATOR WITH A FREEZER COMPARTMENT AND METHOD OF
USING IT

5 BACKGROUND OF THE INVENTIONFIELD OF THE INVENTION

The present invention relates to a refrigerator with
a freezer compartment, which includes a new temperature
zone of freezer compartment or a compartment switchable
10 to a new temperature zone of freezer compartment.

DISCUSSION OF BACKGROUND

In Figure 30 is shown a cross-sectional view of a
refrigerator as shown in e.g. JP-B-427475. In this
figure, reference numeral 200 designates a freezer
15 compartment, reference numeral 100 designates a
refrigerating compartment, reference numeral 700
designates an icing temperature compartment, and
reference numeral 400 designates a vegetable compartment.
The refrigerator is formed by an outer casing and an
20 inner casing with heat insulating material foamed and
filled therebetween. In the refrigerator, the
compartments are separated and have different temperature
zones. Reference numeral 2 designates a fan, and
reference numeral 3 designates a cooling device. Part of
25 air which has been cooled by the cooling device 3 is
blown out into the freezer compartment 200 by the fan 2,
and the remaining air is blown out into the refrigerating

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compartment 100, the icing temperature compartment 700 and the vegetable compartment 400.

The temperature zones in the respective compartments may be determined so that the freezer compartment 200 is
5 set at from -18°C to -20°C , the refrigerating compartment 100 is set at from 3°C to -5°C , the icing temperature compartment (chilled compartment or partially freezing compartment) 700 is set at from 0°C to -3°C and the vegetable compartment 400 is set at from 3°C to 7°C for
10 instance. The temperature zones are determined, mainly considering the storing terms and the kinds of stored food.

In particular, the icing temperature compartment can provide a longer storing term than the refrigerating
15 compartment or the vegetable compartment to realize about one week of storage.

The freezer compartment can realize about one month of storage by freezing articles of food.

The number of families with not higher than two
20 persons and the number of woman workers caused by a decrease number of children have recently increased, and a further decrease in housework is demanded. From this viewpoint, the icing temperature compartment and the freezer compartment have had an increased frequency of
25 use.

However, the icing temperature compartment 700, for instance, can not always provide a proper temperature for

a long term of food storage. This is because the icing temperature compartment has a temperature zone from 0°C to -3°C, and because there is a good possibility that the temperature in the icing temperature compartment is in a range from -1°C to -5°C has a maximum ice forming temperature zone wherein the moisture in articles of food starts freezing and the articles are in such an unstable state to be likely to denature.

The increase number of woman workers increases opportunities to buy required articles of food on weekends. Although it is supposed to usually buy meat, fish and so on required for one week on weekends, it is often impossible to use up the bought meat and fish in one week because of a sudden change in planed meals or a change in the amount of use.

In such cases, it is usual to store articles of food in the freezer compartment in consideration of safety since the one week of storage in the icing temperature compartment is insufficient.

Although the freezer compartment can provide a quite longer term of storage than the icing temperature compartment by freezing articles of food, there is a case that a drop in the temperature of the articles of food to -18°C completely freezes the moisture in the articles of food to damage surfaces of the articles of food or make the articles of food tasteless.

In addition, it is necessary to thaw an article of

food for cooking since the article is completely frozen.
It is usual to spontaneously thaw an article of food or
thaw an article of food by a microwave oven and so on.
It usually takes more than one hour to spontaneously thaw
5 an article of food, making the thawing extremely
troublesome. Although it takes a shorter time to thaw an
article of food by a microwave oven, it is often to heat
the surface of the article too much when a central
portion in the article starts being thawed. This is
10 because an article of food is gradually thawed from the
surface thereof toward the central portion thereof.

Unless next required part of an article of food is
separated from the entire article before freezing the
entire article, it is necessary to thaw the entire
15 article at one time since the frozen article is too hard
to separate the next required part from the entire
article.

If a procedure wherein even unused part of an
article of food is also thawed and frozen again is
20 repeated, the article of food has freshness degraded, and
it takes some time for thawing and cooking, which is
contradictory to a decrease in housework.

Since the conventional refrigerator is constructed
as stated above, there is a possibility that the icing
25 temperature compartment stores articles of food in the
maximum ice forming zone (from -1°C to -5°C), creating a
problem in that the freshness in the articles is likely

to degrade.

There is also created a problem in that the one week of storage in the icing temperature compartment has become insufficient due to a change in family make-up and
5 an increase number of woman workers.

There is also created a problem in that the food storage in the freezer compartment damages the surfaces of articles of food since the articles are completely frozen.

10 There is also created a problem in that the completely frozen articles of food require to be thawed for cooking, which introduces failure in thawing and needs troublesome work.

It is also created a problem in that when an article
15 of food is frozen, it is necessary to thaw the entire frozen article to use even a small part of the frozen article, and that the remaining unused part of the article is required to be frozen again, making the freshness in the article degraded.

20 SUMMARY OF THE INVENTION

It is an object of the present invention to solve these problems, and to provide a refrigerator which includes a new temperature zone of freezer compartment having a longer term of food storage than an icing
25 temperature compartment and capable of minimizing the degradation of stored articles of food.

It is another object of the present invention to

provide a refrigerator with a freezer compartment capable of being conveniently used and offering a food storing state which requires no wasteful time for cooking.

The present invention provides a refrigerator with a
5 freezer compartment, which comprises a compartment for storing articles of food, which has one or more temperature zones; and a new temperature zone of freezer compartment as a compartment having a new temperature zone not higher than a lower limit of a maximum ice
10 forming temperature zone and higher than (that is to say, beyond) a freezing temperature zone.

The new temperature zone may include a temperature that allows articles of food stored in the new temperature zone of freezer compartment to be divided
15 without be thawed.

The new temperature zone of freezer compartment may be a compartment which can have a temperature therein changed to at least one of a freezer compartment temperature, a temperature in the new temperature zone, a
20 refrigerating compartment temperature, a vegetable compartment temperature and an icing temperature.

A set temperature or an actual temperature in the compartment may be variably displayed on an outer or inner surface of the refrigerator. The set temperature
25 or the actual temperature includes a temperature in the new temperature zone, and at least one of the freezer compartment temperature, the refrigerating compartment

temperature, the vegetable compartment temperature and the icing temperature.

The refrigerator may further comprise one or more freezer compartments having the freezing temperature zone
5 set therein.

The refrigerator may further comprise at least two freezer compartments, wherein one of the freezer compartments can be changed to the new temperature zone of freezer compartment.

10 At least one of the freezer compartments may be automatically and variably set at a temperature in the new temperature zone.

The new temperature zone of freezer compartment may be provided above the freezer compartments.

15 The refrigerator may further comprise a duct for blowing out cooled air into the new temperature zone of freezer compartment; an outlet provided to the duct; a temperature detector for detecting a temperature in the new temperature zone of freezer compartment, and a damper
20 for controlling an amount of the blown cooled air into the new temperature zone of freezer compartment in response to the detected temperature.

The duct may be provided in at least one of a top wall and a side wall of the new temperature zone freezer
25 compartment.

The new temperature zone of freezer compartment may sequentially change a temperature therein in the new

temperature zone.

The new temperature zone of freezer compartment may be configured to cool the article of food at a cooling speed faster than that in an icing temperature
5 compartment and slower than that in a freezer compartment.

The new temperature zone of freezer compartment may prevent an article of food with a rich content of salt or sugar from being frozen.

The new temperature zone of freezer compartment may
10 be provided as one of sections divided in a single compartment.

The new temperature zone of freezer compartment may be provided with a return path for cooled air so that the return path is independent of other return paths for
15 cooled air.

The present invention also provides a method for using a refrigerator wherein a compartment for storing articles of food is provided so as to have one or more temperature zones and wherein the compartment can be
20 changed to a new temperature zone of freezer compartment having a new temperature zone not higher than a maximum ice forming temperature zone and higher than a freezing temperature zone; comprising storing an article of food in the compartment, changing, based on a required storing
25 term, a temperature in the compartment to a temperature in the new temperature zone; and taking the article out of the compartment changed to the new temperature zone to

cook the article.

In accordance with the refrigerator with a freezer compartment according to the present invention, it is possible to store articles of food in the new temperature
5 zone of freezer compartment for a longer term than in an icing temperature compartment, and to save the time and labor for cooking.

When the new temperature zone includes a temperature that allows an article of food stored in the new
10 temperature zone of freezer compartment to be divided without being thawed, it is easy to divide a stored article of food immediately after taking the article out of the refrigerator. This arrangement can provide a user-friendly refrigerator.

15 When the new temperature zone of freezer compartment is a compartment which can have the temperature therein changed to at least one of the freezer compartment temperature, a temperature in the new temperature zone, the refrigerating compartment temperature, the vegetable
20 compartment temperature and the icing temperature, it become convenient to use the refrigerator, and it is possible to make good use of the refrigerator in a reasonable way.

When a set temperature or an actual temperature in
25 the compartment, which includes a temperature in the new temperature zone, and at least one of the freezer compartment temperature, the refrigerating compartment

temperature, the vegetable compartment temperature and the icing temperature is variably displayed on the outer or inner surface of the refrigerator, the temperature zone in the compartment can be seen at a glance, and the refrigerator becomes convenient to a user.

When the refrigerator further comprises one or more freezer compartments having the freezing temperature zone, it is possible to separately store articles of food depending on usage thereof.

When the refrigerator further comprises at least two freezer compartments, wherein one of the freezer compartments can be changed to the new temperature zone of freezer compartment, it becomes convenient to use the refrigerator.

When at least one of the freezer compartments can be automatically and variably set at a temperature in the new temperature zone, proper temperature setting can be made with simple operation, providing the refrigerator with an energy-saving property.

When the new temperature zone of freezer compartment is provided above the ordinary freezer compartments, it is easy to take out articles of food in the new temperature zone of freezer compartment having a greater frequency of use than the ordinary freezer compartments.

When the refrigerator further comprises the duct for blowing out cooled air into the new temperature zone of freezer compartment, the outlet provided to the duct, the

temperature detector for detecting the temperature in the new temperature zone of freezer compartment, and the damper for controlling the amount of the blown cooled air into the new temperature zone of freezer compartment in response to the detected temperature, it is possible to control the temperature in the new temperature zone of freezer compartment so as to match the freezer compartment to multiple purposes and to provide the refrigerator with an energy-saving property.

10 When the duct is provided on at least one of the top wall and the side wall of the new temperature zone of freezer compartment, it is possible to improve a temperature distribution in the new temperature zone of freezer compartment.

15 When the new temperature zone of freezer compartment is configured to be capable of sequentially changing the temperature therein in the new temperature zone, it is possible to store articles of food in a better frozen state.

20 When the new temperature zone of freezer compartment is configured to cool an article of food at a cooling speed faster than that in an icing temperature compartment and slower than that in a freezer compartment, the article can be stored without losing taste.

25 When the new temperature zone of freezer compartment is configured to be capable of preventing an article of food with a rich content of salt or sugar from being

frozen, such an article can be provided with a novel and good taste.

When the new temperature zone of freezer compartment is provided as one of sections divided in a single
5 compartment, the refrigerator can be provided so as to have a temperature zone matched with dietary habits of a user.

When the new temperature zone of freezer compartment is provided with a return path for cooled air so that the
10 return path is independent of other return paths for cooled air, the formation of ice by the cooled air can be avoided.

In accordance with the method for using a refrigerator according to the present invention, wherein
15 a compartment for storing articles of food is provided so as to have one or more temperature zones, and wherein the compartment can be changed to a new temperature zone of freezer compartment having a new temperature zone not higher than a maximum ice forming temperature zone and
20 higher than a freezing temperature zone; comprising storing an article of food in the compartment, changing, based on a required storing term, a temperature in the compartment to a temperature in the new temperature zone; and taking the article out of the compartment changed to
25 the new temperature zone to cook the article, the article can be used in an easy-to-cook way with good timing.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by
5 reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

Figure 1 is a front view of the refrigerator according to a first embodiment of the present invention;

10 Figure 2 is a schematic view showing the air path structure according to the first embodiment of the present invention;

Figure 3 is a graph showing the new temperature zone according to the first embodiment of the present
15 invention:

Figure 4 is a graph showing the relationship between temperatures of an article of food and cutting loads in the first embodiment;

Figure 5 is a graph showing the relationship between
20 temperatures of another article of food and cutting loads in the first embodiment;

Figure 6 is a view showing the distribution of surface temperatures of an article of food in the first embodiment;

25 Figure 7 is a view showing the distribution of surface temperatures of another article of food in the first embodiment;

Figure 8 is a circuit diagram of the new temperature zone setting device according to the first embodiment of the present invention;

Figure 9 is a graph showing dripping amounts of
5 substance flowed out of articles of food in the first embodiment;

Figure 10 is a graph showing compression stresses applied to articles of food in the first embodiment;

Figure 11 is a graph showing compression stresses
10 applied to articles of food in the first embodiment;

Figure 12 is a picture showing a transverse section of the muscular tissue of an article of food observed microscopically in the first embodiment;

Figure 13 is a picture showing a transverse section
15 of the muscular tissue of another article of food observed microscopically in the first embodiment;

Figure 14 is a graph showing the hardness of an article of food in the first embodiment;

Figure 15 is a graph showing the stickiness of the
20 article in the first embodiment;

Figure 16 is a view showing the compartment arrangement according to a second embodiment of the present invention;

Figure 17 is a view showing a compartment
25 arrangement according to a third embodiment of the present invention;

Figure 18 is a view showing another compartment

arrangement according to the third embodiment of the present invention;

Figure 19 is a view showing another compartment arrangement according to the third embodiment of the present invention;

Figure 20 is a view showing another compartment arrangement according to the third embodiment of the present invention;

Figure 21 is a view showing another compartment arrangement according to the third embodiment of the present invention;

Figure 22 is a view showing the compartment arrangement according to a fourth embodiment of the present invention;

Figure 23 is a view showing the air path structure according to a fifth embodiment of the present invention;

Figure 24 is a view showing an air path structure according to a sixth embodiment of the present invention;

Figure 25 is a view showing an air path structure according to the sixth embodiment of the present invention;

Figure 26 is a cross-sectional view of a storage section provided in a refrigerating compartment according to the sixth embodiment;

Figure 27 is a cross-sectional view of the storage section and a return path therefor according to the sixth embodiment;

Figure 28 is a cross-sectional view of the storage section as viewed from the direction indicated by an arrow A in Figure 27;

Figure 29 is a front view of a refrigerating
5 compartment according to the sixth embodiment; and

Figure 30 is a cross-sectional side view of a conventional refrigerator.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

EMBODIMENT 1

10 Now, a first embodiment according to the present invention will be described, referring to the accompanying drawings.

In Figure 1 is shown a front view of the refrigerator according to the first embodiment. In this
15 Figure, reference numeral 1 designates a main body of the refrigerator. The main body 1 comprises a refrigerating compartment 100 with a door provided at an upper most portion in the main body, a freezer compartment 200 with a drawer provided under the refrigerating compartment
20 100, a new temperature zone of freezer compartment 300 with a drawer provided at a lowest portion in the main body and working as a freezer compartment at a higher temperature than an ordinary freezing temperature (-18°C) to carry out soft-freezing, and a vegetable compartment
25 400 with a drawer provided between the new temperature zone of freezer compartment 300 and the freezer compartment 200.

The freezer compartment 200 includes a storage casing 201 to store articles of food. The new temperature zone of freezer compartment 300 also includes a storage casing 301 to store articles of food. The vegetable compartment 400 also includes a storage casing 401 to store articles of food.

Figure 2 is shown a cross-sectional side view of the refrigerator to show the air path structure according to the first embodiment. Air is cooled by a cooling device 3 and is circulated in the main body 1 by a fan 2. Part of the cooled air is supplied into the new temperature zone freezer compartment 300 through an air path 5 for the new temperature zone of freezer compartment. The remaining part of cooled air is supplied into the freezer compartment 200 through an air path 4 for the freezer compartment. Part of the cooled air which has entered the air path 4 is supplied into the refrigerating compartment 100 above the freezer compartment to cool the inside of the refrigerating compartment. The cooled air which has cooled the inside of the refrigerating compartment 100 is supplied into the vegetable compartment 400 through a return path 6 for the refrigerating compartment to cool the inside of the vegetable compartment. The cooled air which has cooled the inside of the vegetable compartment is returned to the cooling device 3 through a return path 7 for the vegetable compartment.

Now, the new temperature zone of freezer compartment 300 will be explained.

In Figure 3 is shown reaction speeds for degree of change in the surface color of an article of food (conversion into metmyoglobin) with respect to storing temperatures. The ordinate represents reaction speeds for conversion to metmyoglobin, and the abscissa represents food storing temperatures. Under the abscissa are indicated a food storing term and a thawing time for the food. The reaction speeds for conversion into metmyoglobin take the maximum value in a maximum ice forming temperature zone of from -1°C (upper limit) to -5°C (lower limit) wherein moisture in articles of food start freezing. In the maximum ice forming temperature zone, articles of food are liable to be subjected to denaturation, takes an unstable state and degrades the surface color thereof. This means that the cells in the articles are damaged to make the articles tasteless.

In accordance with the present invention, the temperature in the new temperature zone of freezer compartment is set at not higher than -5°C in order to store articles of food in such a way to avoid the maximum ice forming temperature zone. The temperature in the new temperature zone of freezer compartment may be set at a temperature value higher than e.g. -15°C in order to store articles of food in such a way to avoid the freezing temperature zone (not higher than -18°C) since

it takes some time to thaw articles of food frozen in the freezing temperature zone though the storing term can be long in the freezing temperature zone.

As explained, the articles of food in the new
5 temperature zone of freezer compartment 300 can not be frozen hard unlike articles of food stored in the ordinary freezer compartment since the articles of food in the new temperature zone of freezer compartment are stored in a range from -5°C to -15°C for instance. The
10 articles of food in the new temperature zone of freezer compartment are softly frozen (subjected to soft-freezing, lightly frozen or cuttably frozen) so that the articles of food can be divided by a kitchen knife or hands. In addition, the storing term for the articles of
15 food can be lengthened to not less than one week, and the articles of food can be kept in a better state than the articles of food in the icing temperature compartment for a long time.

In Figures 4 and 5 are shown data of the
20 relationships between temperatures of articles of food and cutting loads, which indicate how a person feels about the articles of food (slightly hard, proper or too soft) when he or she actually cuts the articles with a knife and so on. In Figure 4 is shown the results of
25 tuna as the articles, and in Figure 5 is shown the results of pork as the articles. It has been found that most articles of food are frozen properly hard or

slightly hard so as to be cuttable when they are stored at a temperature from -5°C to -7°C , and that the cutting loads are about from 5-6 kg at that time.

In Table 1 are shown acceptable storing terms for articles of food in storing compartments having different storing temperatures. The storing compartments are a chilled compartment (about 0°C), a partially freezing compartment (about -3°C) and a new temperature zone of compartment (about -7°C).

Table 1

Acceptable storing terms (days) at different storing temperatures
(The underlined values indicate the minimum acceptable storing terms.)

Article of food	Criteria	Storing temperature ($^{\circ}\text{C}$)		
		Chilled compartment (0)	Partially freezing compartment (-3)	New temperature zone of compartment
For tuna sashimi (fresh slices of raw tuna)	Sensory evaluation ④ K value 20%	<u>4</u> 4	<u>6</u> 10	<u>14</u> 30
For tuna to be cooked	Sensory evaluation ③ K value 60% Bacteria on surface 10^4	<u>6</u> 24 18	<u>10</u> Not less than 40 Not less than 40	<u>24</u> Not less than 40 Not less than 40
For ground meat to be cooked	Sensory evaluation ③ Numbers of living bacteria 10^6	<u>6</u> <u>5</u>	<u>14</u> <u>10</u>	<u>35</u> Not less than 40
Broccoli (branched)	Sensory evaluation ③ Numbers of living bacteria 10^6	<u>12</u> 25	Not less than 35 Not less than 35	Not less than 35 Not less than 35
Meat source (reheated one stored in a can commercially available)	Sensory evaluation ③ Numbers of living bacteria 10^6	Not less than 35 Not less than 35	Not less than 35 Not less than 35	Not less than 35 Not less than 35

Sensory evaluation criteria: ⑤ absence of stench or

discoloration, ④ presence of slight stench and slight
discoloration, ③ eatable limit, ② presence of stench and
discoloration, ① rotten

In Table 1 are shown acceptable storing terms (days)
5 under criteria for sashimi or fresh slices of raw fish
(fresh slices of raw tuna), fish to be cooked (for tuna
to be cooked), meat to be cooked (for ground meat to be
cooked), branched (boiled) vegetables (broccoli) and
processed food such as caned food (meat source). As the
10 criteria are selected required ones among sensory
evaluation criteria (① rotten, ② presence of stench and
discoloration, ③ eatable limit, ④ presence of slight
stench and discoloration, and ⑤ absence of stench or
discoloration), a K value criterion, criterion of the
15 numbers of bacteria on surface, and a criterion of the
number of living bacteria. With regard to the K value,
it is normally determined that when the value is not
greater than 20%, articles of food are eatable without
being heated, and that when the value is not greater than
20 60%, articles of food are at the eatable limit though
being required to be heated. With respect to the number
of bacteria on surface, it is normally determined that
when the number is 10^4 , articles of food are at the
eatable limit. With respect to the number of living
25 bacteria, it is normally determined that when the number
is 10^6 , articles of food are at the eatable limit. From
this viewpoint, days that passed until articles of food

reach at the eatable limit were found. The K value is a ratio of substance associated with ATP (adenosine triphosphate), which indicates the freshness index of articles of food.

5 With regard to the acceptable storing term for tuna sashimi or fresh slices of raw tuna, the days at respective storing temperatures are shown when the sensory evaluation was ④ and the K value was 20% as the criteria. With regard to the acceptable storing term in
10 the case of tuna to be cooked, the days at respective storing temperatures are shown when the sensory evaluation was ③, the K value was 60% and the number of bacteria on surface was 10^4 as the criteria. With respect to the acceptable storing term for ground meat to
15 be cooked, for branched broccoli and for reheated meat source stored in a can commercially available, days at the respective storing temperatures are shown when the sensory evaluation was ③ and the number of living bacteria was 10^6 as the criteria. The underlined values
20 in Table 1 are the shortest ones among the acceptable storing terms (days) under respective pairs of criteria. For example, the acceptable storing term for tuna sashimi in the new temperature zone of freezer compartment was 14 days in terms of the sensory evaluation criteria and 30
25 days in terms of the K value criteria, and consequently the shortest acceptable storing term (the underlines portion) was 14 days.

According to these data, it has been determined that the new temperature zone (about -7°C) can store articles of food not required to be cooked or heated for not less than 2 weeks and articles of food to be cooked for not
5 less than 3 weeks, and that the new temperature zone can store articles of food for 2 or 3 weeks without causing trouble.

The data also show that the acceptable storing terms in the new temperature zone were days of not less than 3
10 times the temperature zone in the chilled compartment and days of not less than 2 times the temperature zone in the partially freezing compartment, and that the new temperature zone of compartment is superior to the chilled compartment or the partially freezing compartment
15 in terms of the acceptable storing term. With respect to vegetable and processed products, the data show that the shortest acceptable storing terms were not less than 35 days. Since such articles of food vary in initial quality, storing of such articles of food at a lower
20 temperature in the new temperature zone is superior in terms of convenience in separation of the articles or thawing of the articles and storage of the articles.

Now, thawing times for frozen articles of food are shown.

25 Table 2 shows how long articles of food stored at -18°C take to become cuttable in different thawing methods (thawing in a refrigerating compartment, a room

temperature and a microwave oven). Table 3 shows what surface temperature articles of food stored at -7°C and articles of food stored at -18°C have when being thawed in a microwave oven.

5

Table 2 Time that articles of food stored at -18°C take to become cuttable (time required for the temperatures of the articles to reach -6°C : minute)

Thawing method Articles of food	Refrigerating compartment	Room temperature	Microwave oven
Beefsteak (8×11×2 cm)	50	18	1
Mixture of ground beef and ground pork (8×11×2 cm)	66	23	1
Tuna (6×11×2 cm)	52	21	1

10

Table 3 Surface temperature of articles of food when having been thawed in a microwave oven

Surface temperature of article ($^{\circ}\text{C}$)	minimum	maximum
-7°C * All the articles	-3	0
-18°C Beefsteak	-3	3
-18°C A mixture of ground beef and ground pork	-3	9
-18°C Tuna	-3	6

* No thawing was required in the case of -7°C (When the articles was put at a room temperature.)

15

Table 2 shows that thawing of articles of food in a refrigerating compartment or at a room temperature involves a troublesome work, such as taking out of the articles in advance, and a time-consuming work since it

takes some time to thaw the articles. Thawing of articles of food in a microwave oven is not time-consuming though such a troublesome work is needed. When articles of food are stored at -7°C in accordance with the present invention, the waiting time is 0 since articles of food are cuttable immediately after they are taken out.

Table 3 shows that the articles of food stored at -7°C had a surface temperature of 0°C as the maximum value when having been thawed in a microwave oven. This value is much lower than surface temperatures of 3°C , 6°C and 9°C of the articles of food stored at -18°C when having been thawed in the microwave oven. This means that the articles stored at -7°C can minimize degradation due to thawing.

In Figure 6 is shown a surface temperature distribution of an article of food that had been stored at -7°C and was taken out in a place at a room temperature. In Figure 7 is shown a surface temperature distribution an article of food that had been stored at -18°C and was thawed in a microwave oven. In Figure 6, the entire surface of the meat was in the same color, and the surface temperature of the article was equal in the entirety. In Figure 7, the surface of the meat varied in color and the surface temperature of the article had a wide distribution. The article shown in Figure 7 had higher temperatures in the entirety than the articles

shown in Figure 6. When ground meat was thawed in the microwave oven, fatty portions of the ground meat had higher temperatures since the portions were apt to be selectively heated. The surface temperature distribution
5 after thawing varies on the storing temperature for an article of food.

This shows that since articles of food stored at -7°C can be thawed without using a microwave oven and so on (can be used without being thawed), it is possible to
10 avoid an uneven temperature distribution or degradation due to overthawing, which is caused when articles of food stored at -18°C are thawed in a microwave oven.

As explained, the new temperature zone is superior to other temperature zones in terms of the time that
15 articles of food take to be thawed to a cuttable temperature. The fact that articles of food can be cut immediately after being taken out results in a reduction in the time required for housework since finely cutting of, e.g., ground meat taken out enlarges an area of the
20 article to be exposed to air, thereby accelerating thawing, and since cutting articles of food immediately after taking out is very convenient even when the articles are thawed in a raw state.

Now, how to set the temperature in the new
25 temperature zone of freezer compartment 300 will be explained.

In Figure 8 is shown a temperature setting device

for the new temperature zone of freezer compartment 300. In this figure, reference numeral 302 designates a thermistor for temperature detection (temperature detector) provided in the new temperature zone of freezer compartment 300, reference numeral 303 designates a
5 preset resistor and reference numeral 304 designates a microcomputer which outputs commands for opening and closing a damper (indicated by 5a in Figure 23), and to which a dc voltage of 5V is applied. The damper 52
10 controls the amount of blown cooled air into the new temperature zone of freezer compartment 300. The damper 5a is provided in the air path 5 for the new temperature zone of freezer compartment. When the thermistor for temperature detection 302 detects that the temperature in
15 the new temperature zone of freezer compartment is not less than a certain set temperature, the damper is opened to open an cooled air outlet, supplying the cooled air into the new temperature zone of freezer compartment 300 for temperature control.

20 In this embodiment, the present resistor 303 is coupled in series with the thermistor for temperature detection 302 provided in the new temperature zone of freezer compartment 300 as shown in Figure 8, and an A/D value corresponding to a voltage across the preset
25 resistor is inputted into the microcomputer 304 to determine a set temperature. This arrangement can provide measures to determine the set temperature in an

inexpensive cost.

When the preset resistor is of a variable type, the temperature in the new temperature zone of freezer compartment can be sequentially changed so as to set at
5 an arbitrary temperature. The temperature in the other compartments can be set by similar measures.

The temperature selection in the new temperature zone according to the present invention will be described. Although articles of food are frozen and
10 stored at a temperature to be capable of being cut in the new temperature zone, the freezing temperature and the frozen state inevitably vary with articles of food. The freezing temperature and the frozen state vary with not only the articles of food per se but also the processed
15 state thereof (such as a seasoning way and a cooking way). In particular, how to store articles of food vary with families. From this viewpoint, it is required to be taken into account that temperature setting can be changed in order to control the frozen state so as to
20 match with the kind or the processed state of articles of food to be stored.

For example, when meat or fish is stored without being cooked (or heated) or processed, it is preferable to set the temperature at -7°C . When articles of food
25 seasoned with miso (fermented soybean paste), soy source or salt, or fatty articles of food are stored, it is preferable to set the temperature at a lower level, such

as -10°C , than that for uncooked or unprocessed articles of food since the seasoned or fatty articles have a lower freezing temperature.

The new temperature zone according to the first
5 embodiment can extend the storing term for articles of food to a term of about two weeks. Even if articles of food bought on, e.g., weekends are not completely spent due to a change in planned meals, the remaining portions of the article or the remaining articles can be stored in
10 safety until the next week.

Since the moisture in food is not completely frozen, the surface of the stored food can be prevented from being damaged and the taste is prevented from degraded. Articles of food with much moisture (such as curried
15 food, stew, grated radish and baked eggplants) can not be frozen hard, avoiding a case wherein such food is desiccated to destroy taste or crispness.

The articles of food which are stored in the new temperature zone of freezer compartment can be softly
20 frozen without being frozen hard, and the articles of food do not need thawing by a microwave oven or not less than one hour of spontaneous thawing. The articles of food stored in the new temperature of compartment can be cut by a kitchen knife without need for thawing,
25 eliminating failure in thawing and avoiding thawing work.

Since the articles of food in the new temperature zone freezer compartment (soft-freezing room) can be

divided even just after having been taken out of the soft-freezing room, the articles of food are not required to be divided before storage, eliminating preparation before storage.

5 Since articles of food are not frozen hard in the new temperature zone which provides the largest storing term in terms of storage of the articles in a cuttable state, articles of food containing a lot of sugar content, such as fruit like a banana, dessert like
10 pudding and jelly, and fruit juice take a sherbet form in the new temperature zone. The new temperature zone can provide good taste possible only in soft-freezing and unavailable in freezing or refrigerating. This also applies to articles of food containing salt, such as
15 salted cod roe, salted salmon and beverage for sports occasions in addition to the articles of food containing a lot of sugar content.

 The new temperature zone can prevent ordinarily beer (alcohol content of about 5%) from being frozen. The new
20 temperature zone can avoid a case that a beer bottle is exploded by leaving the bottle in the temperature zone provided by the freezer compartment. It was experimentally verified that ordinary beer is not frozen at not less than -7°C .

25 When articles of food are stored in the new temperature zone, taste and nutritive values can be held since a quicker cooling speed in the new temperature zone

in comparison with a partially frozen compartment (an icing temperature compartment) and a chilled compartment extends a term required for decreasing vitamin as a nutritive value and a term required for a change in a taste in terms of deliciousness. The quality of articles of food can be maintained in the new temperature zone since the decreasing amount of anthocyan as an index indicative of discoloration in articles of food, such as strawberry, is small and the changing speed of chlorophyll as an index indicative of discoloration in articles of food, such as spinach, is slow, for instance.

It has been stated that the quality of stored articles of food, in particular a denaturalization in protein, is generally affected as the speed passing through the maximum ice forming temperature zone (-1°C to -50°C) becomes slower. It is reported that when the passing speed is slow, crystals of ice grow larger and collapse cell membranes of articles of food to increase the dripping amount after thawing (cause' tasty substance to leave) or to provide a bad feeling of crunchiness or crispness.

In Figure 9 are shown values that were obtained by measuring the dripping amounts from beefsteak and a mixture of ground beef and ground pork that were thawed after having had been stored at -7°C and -18°C for 2 weeks. In Figure 10 and 11 are shown data that were obtained by measuring the compression stress (hardness)

of the cooked ones having had been stored and thawed in the same way as the articles shown in Figure 9. In Figures 12 and 13 are shown the results that were obtained by microscopic observation of a transverse
5 section of a muscular tissue of beefsteak after having had been stored and thawed in the same way as the articles shown in Figures 9 through 11. In Figures 12 and 13, black portions indicate muscular fibers and white portions indicate connective tissues (the main component
10 is collagen).

The results show that there was no great difference between the articles frozen and stored at -7°C and the article frozen and stored at -18°C in terms of the dripping amount, and that there was no great difference
15 between both tissue states. The results show that there was no significant difference between the articles frozen and stored at the respective temperatures in terms of compression stress indicative of a feeling of crunchiness or a crispness. The results indicate that the articles
20 frozen and stored at the respective temperatures had no significant difference in terms of quantitative evaluation, and that no problem was created in terms of the quality of the articles of food. The microscopic observation shown in Figures 12 and 13 also indicate that
25 the tissues had a systematic and uniform arrangement and were not subjected to a change such as collapse in the cell membranes. A taste test, which was carried out as a

sensory test, shows that no difference was detected. In particular, it is clear that there is no problem in terms of actual use since articles of food are seasoned in most of cases.

5 The reason is supposed that the cell membranes in articles of food are not promptly collapsed by crystals of ice since the cell membranes are elastic and that the lapse of time is a great factor to the collapse. That is to say, it is supposed that the cell membranes are not
10 collapsed by crystals of ice within a period of 2-3 weeks.

As explained, the storage in the new temperature zone proposed by the present invention can ensure the quality of articles of food within a period of 2-3 weeks
15 and provide a convenient temperature. In comparison with the storage of articles of food by a chilled temperature (about 0°C), a partially freezing temperature (about -3°C) or a freezing temperature (about -18°C) as the known-storing temperatures in the conventional
20 refrigerators, the new temperature zone according to the present invention provide a new concept of storage as a new storing temperature, which combines a easy-to-use form as in the chilled or partially freezing temperature and a storing property as in the freezing temperature.

Table 4 Hardness and stickiness in boiled rice

Stress (g)			
	Thawing time	Hardness	stickiness
Immediately after having boiled	-	1605	256
In 1 hour after having boiled	-	1145	249
5°C 1W	1 hour 30 minutes	1660	49
0°C 1W	1 hour 30 minutes	1869	100
-7°C 1W	2 hours 30 minutes	1163	64
-18°C 1W	3 hours	1250	75

Thawing by microwave oven (500 W)

5 In Table 4 are shown influences on the thawing time, the hardness and the stickiness of an article of food in respective storage states (just after having boiled rice, in 1 hour after having boiled rice, and stored at 5°C, 0°C, -7°C and -18°C). In Figures 14 and 15 are shown the
10 data on the hardness and the stickiness shown in Table 4 as bar graphs for comparison. The hardness of the boiled rice is represented by compression stresses (g) and the stickiness of the boiled rice is represented by tensile stresses (g).

15 The data show that the rice stored at storing temperatures of 0°C and 5°C became harder than the rice in 1 hour after having boiled the rice. The data show that the rice stored at temperatures of -7°C and -18°C were similar to the rice in 1 hour after having boiled

rice, and find that the rice stored at these freezing temperatures created no problem in quality.

The data show that the storage in the new temperature zone according to the present invention can provide a superior storing property as well as an energy-saving property since the storage at a temperature of -7°C can shorten the thawing time than the storage at a temperature of -18°C. This can apply to heating in cooking.

10 The data show that the article of food which was frozen at a temperature of -7°C and was stored at a temperature -7°C had quality equal to the article of food stored at a temperature -18°C in the conventional freezing temperature zone, which is set to provide a superior effect to the conventional other storing temperature zones. If an article of food is used in 2 or 3 weeks, the article may be frozen and stored at a temperature of -18°C first, be stored in a compartment at -7°C at the time of using it, and be divided in pieces for use after having thawed to a temperature of -7°C without having completely thawed. In the storage in the conventional freezing temperature, articles of food are required to be promptly used after having completely thawed. However, when articles of food has thawed at a temperature of -7°C, the articles are in a cuttable state and can be stored for a couple of weeks without trouble. Since the articles are cuttable, the articles are not

required to be divided before being frozen, and the storage in the new temperature zone can provide convenience.

If articles of food are stored at a temperature of
5 -7°C so that they can be easily divided into pieces for use, and if the articles are not expected to be used for some time, the articles may be stored in the freezing temperature zone and be maintained at a lower temperature until next use. If the articles are used, the articles
10 may be stored at a temperature of -7°C before use.

In accordance with the present invention, the new temperature zone, which is an intermediate temperature zone between the complete freeze and the thaw, can be provided to make fuller and more reasonable use of
15 articles of food.

Even if a chance of frozen meat or fish (an article of food that is quick frozen before sale) is inexpensive, such an article has been too large in terms of unit of sale for a family with a small number of members to buy
20 the article since the article has been required to be used up after being thawed. However, the new temperature zone according to the present invention allows everybody to buy articles of food at lower prices and is expected to have influence on purchase of articles of food and
25 patterns of distribution in the future since even a family with a small number of members can use the articles, dividing the articles in a semi-thawed state.

Although explanation of the new temperature zone according to the present invention has been made with respect to the reasonable use at home, the new temperature zone according to the present invention

5 allows articles of food to be processed or stored at a lower temperature than conventional food processing so as to be cut or separated, being superior to the conventional food processing in terms of hygiene and processing.

10 As a mode of the present invention, there is provided a freezer compartment that automatically becomes a compartment in the new temperature zone on use of an article of food by setting a timer through a microcomputer or setting a day to use it or days left
15 before use of it through a display on an outer surface of the refrigerator. Thus, the refrigerator can be utilized so that the article is taken out of the freezer compartment in the new temperature zone on using it and the article can be promptly cooked. For example, an
20 article of food that is expected to use in a one month is stored in such a compartment and the timer is set. Provided that the article stored in the freezing temperature zone takes around 1 day to become at a temperature in the new temperature zone, the article can
25 be available in a proper state on the expected day by inputting a day in 1 month minus 1 day (or days) into the timer. Since there is a possibility that the expected

day is slightly changed, the timer may be set at a day in
1 month minus about 1 week (in about 3 weeks). The timer
may be configured so as to automatically calculate a
properly planned day shifted to the new temperature zone
5 when an expected day is inputted.

In this manner, an articles of food can be stored in
such way to be easily cooked by simple manipulation
(setting), and the articles of food can be spent in an
easy-to-cook state with good timing. Since neither
10 sorting operation before thawing nor thawing operation is
required, a wasteful time or work can be eliminated. If
an article of food stored in a refrigerating compartment
is used in a couple of days, it is sufficient to set the
expected day since the article is slightly frozen in
15 comparison with the refrigerated state so as to be
instantly processed or cooked.

The storage in the new temperature zone according to
the present invention has merits in easy-to-cut or easy-
to-handle because of firmer tissues than raw tissues and
20 in difficult propagation in bacteria because of a low
temperature. The working area as well as articles of
food per se may be set at a temperature of, e.g., -7°C in
the new temperature zone according to the present
invention.

25 An increase in the number of most of bacteria which
degrade articles of food can be restrained in the new
temperature zone. The new temperature zone minimizes

collapse of cells on freezing and restrains taste, and prevents flavor and nutritive value from being damaged since articles of food can not be completely frozen hard.

Since articles of food are subjected to soft-freezing (are softly frozen) in the new temperature zone, the energy that has been required to thaw articles of food for dividing the articles of food can be eliminated, saving energy. Since it is not necessary to thaw articles of food, a thawing step among series of steps from taking articles of food out of the refrigerator, thawing the articles of food, dividing the articles of food and starting cooking can be eliminated, shortening a time required for meal preparation.

EMBODIMENT 2

In Figure 16 is shown a second embodiment according to the present invention to explain the arrangement of compartments in the refrigerator. Reference numeral 500 designates a switchable compartment with a drawer, which is provided under a refrigerating compartment 100 and which can set the temperature zone therein at any one of the freezing temperature (-18°C), the new temperature zone, an ordinary refrigerating compartment temperature, an ordinary vegetable compartment temperature and an ordinary chilled compartment temperature. Under the refrigerating compartment 100 are provided the switchable compartment 500, an ordinary freezer compartment 200 at the lowest portion, and a vegetable compartment 400 with

a drawer provided between the switchable compartment and the freezer compartment. The switchable compartment 500 includes a storage casing 501 to store various kinds of articles of food. Likewise, the vegetable compartment 5 400 includes a storage casing 401.

For example, when the switchable compartment 500 is set at a temperature of around 0°C in an icing temperature zone (a chilled temperature zone or a partially freezing compartment zone) to provide a 10 compartment capable of storing articles of food for about one week without freezing the articles, the refrigerator can be easily accessible and convenient to a person fond of uncooked articles of food.

If the switchable compartment 500 is switched to a 15 temperature (-18°C) in the freezing temperature zone to store ice cream or ice in summer, such articles can be kept at an easily accessible position.

When the temperature in the switchable compartment 500 is switched to a temperature in the new temperature 20 zone of freezer compartment 300 according to the first embodiment, the second embodiment can offer advantages similar to the first embodiment, providing the switchable compartment with a wide range of usage.

Reference numerals 8a-8d designate display units 25 that indicate the temperature zone in the respective compartment. The display unit 8a shows the temperature in the refrigerating compartment 100, the display unit 8b

shows the temperature in the switchable compartment 500, the display unit 8c shows the temperature in the vegetable compartment, and the display unit 8d shows the temperature in the freezer compartment. After the set values for the respective compartments are determined, the set values are stored in a microcomputer, and the data on the set values stored in the microcomputer are transmitted to the display units 8a-8d to show the respective temperatures. The display units may show actual temperatures at that time instead of the data on the set values or may show the actual temperatures as well as the set values. The indication of temperatures may be made with numerical values or different colors. Although the display units are provided on the respective compartments in the example shown in Figure 16, a single display unit may be provided on only a compartment important to a user, such as the switchable compartment where the temperature zone is difficult to be seen, the new temperature zone of compartment, and the freezer compartment where the freezing temperature is required to be seen. A single display unit may show temperatures in the temperature zones of a plurality of compartments. Although the display units are provided on an outer surface of the refrigerator in the example shown in Figure 16, the display units may be provided in the refrigerator.

Since at least one of the set temperature or actual

temperature and the temperature zone for each of the compartments can be seen at a glance as explained, the temperature zone of the switchable compartment 500 can be seen without opening the refrigerator. This arrangement
5 can avoid a case wherein if the switchable compartment is required to be opened, the other compartments will not be opened inadvertently. Even if the number of the temperature zones in the compartments increases, the present invention can provide a user-friendly
10 refrigerator though the new temperature zone is added.
EMBODIMENT 3

In Figure 17 is shown a third embodiment according to the present invention to explain an arrangement of compartments in a refrigerator 1. The refrigerator
15 includes a refrigerating compartment 100 at an upper portion therein, a vegetable compartment 400 for storing vegetables under the refrigerating compartment, and a freezer compartment 200 at the lowest portion therein. The new temperature zone of freezer compartment 300 is
20 provided between the vegetable compartment and the freezer compartment.

When one or more freezer compartments are provided in a refrigerator with the new temperature zone of freezer compartment independently provided therein, e.g.
25 long storage of frozen food can be stored in the freezer compartment 200, and meals, leftovers in cooked food and meat required for division can be stored in the new

temperature zone of freezer compartment 300, realizing separate storage so as to match with difference in usage. Having the leftovers at once (successively) becomes unnecessary, and having similar meals or articles of food
5 at intervals in terms of days become possible.

The new temperature zone of freezer compartment 300 may be a switchable compartment which can be set at any one of the freezing temperature, a temperature in the new temperature zone, the refrigerating temperature, the
10 vegetable compartment temperature and the icing temperature (chilled temperature).

As another arrangement of the compartments, the refrigerating compartment 100 is provided at an upper portion in the refrigerator, the new temperature zone of
15 freezer compartment 300 is provided under the refrigerating compartment, the ordinary freezer compartment 200 is provided at the lowest portion in the refrigerator, and the vegetable compartment 400 is provided between the new temperature zone of freezer
20 compartment and the ordinary freezer compartment as shown in Figure 18.

The new temperature zone of freezer compartment 300 shown in Figure 18 may be a compartment which can be set at any one of the freezing temperature, a temperature in
25 the new temperature zone, the refrigerating temperature, the vegetable compartment temperature and the icing temperature (chilled temperature). By changing the set

temperature for the new temperature zone of freezer compartment 300, the new temperature zone of freezer compartment can be set at temperatures in the respective temperature zones.

5 The refrigerating compartment 100 may be provided at the upper portion in the refrigerator, the ordinary freezer compartment 200 is provided under the refrigerating compartment, the vegetable compartment 400 may be provided at the lowest portion in the
10 refrigerator, and the new temperature zone freezer compartment 300 may be provided between the ordinary freezer compartment and the vegetable compartment as shown in Figure 19.

 The new temperature zone of freezer compartment 300
15 shown in Figure 19 may be a compartment which can be switchable among a freezer compartment, the new temperature zone of freezer compartment, a refrigerating compartment, a vegetable compartment and an icing temperature compartment (chilled temperature
20 compartment).

 As shown in Figure 20, an ice storing compartment 600 may be independently provided so as to be in parallel with the new temperature zone of freezer compartment 300. That is to say, the refrigerating compartment 100 may be
25 provided at the upper portion in the refrigerator, the new temperature zone of freezer compartment 300 and the ice storing compartment 600 are provided side by side

under the refrigerating compartment, the ordinary freezer compartment 200 is provided at the lowest portion in the refrigerator, and the vegetable compartment 400 may be provided between the ordinary freezer compartment, and
5 the new temperature zone of freezer compartment and the ice storing compartment provided side by side. As shown in Figure 21, the refrigerating compartment may be provided at the upper portion in the refrigerator, the new temperature zone of freezer compartment 300 (which
10 can be replaced by a compartment changeable among the freezer temperature zone, the new temperature zone, the refrigerating temperature zone, the vegetable compartment temperature zone and the chilled temperature zone) and the ice storing chamber 600 may be provided side by side
15 under the refrigerating compartment, the vegetable compartment may be provided at the lowest portion in the refrigerator, and the ordinary freezer compartment 200 may be provided between the vegetable compartment, and the new temperature zone of freezer compartment and the
20 ice storing compartment provided side by side.

The new temperature zone of freezer compartment 300 may be a compartment which is changeable to any one of a freezer compartment, the new temperature zone of freezer compartment, a refrigerating compartment, a vegetable
25 compartment and an ice temperature compartment (chilled temperature compartment).

When the new temperature zone of freezer compartment

300 is provided above the ordinary freezer compartment 200, accessibility is improved since the new temperature zone of freezer compartment has a shorter storing term and a greater frequency of access than the ordinary
5 freezer compartment. The ordinary freezer compartment is provided at a lower portion in the refrigerator since the ordinary freezer compartment has a small frequency of access than the refrigerating compartment and the vegetable compartment. When the ordinary freezer
10 compartment is provided at a lower portion in the refrigerator, it is preferable that the freezer compartment is provided with a drawer instead of a door for easy access to articles of food stored at a deep position therein.

15 EMBODIMENT 4

Although separate storage by the provision of one or more of ordinary freezer compartments in addition to the independent new temperature zone of freezer compartment 300 has been referred to in the explanation of the third
20 embodiment, there is a case wherein two or more of compartments suited for long term of storage are required rather than a demand of separate storage when being away from home for a long term due to travel for instance. For example, the provision of two compartments for long
25 term of storage can be realized by providing the refrigerating compartment 100 at an upper portion in the refrigerator, the vegetable compartment 400 under the

refrigerating compartment, a first freezer compartment
200 under the vegetable compartment, and a second freezer
compartment 250 at the lowest portion in the refrigerator
as shown in Figure 22 so that one of the two freezer
5 compartments (there may be provided more than two of
freezer compartments) can be set to any one of a new
temperature zone of freezer compartment and an ordinary
freezer compartment.

When one of the two freezer compartments is the
10 ordinary freezer compartment and the other is the new
temperature zone of freezer compartment, the provision of
the new temperature zone of freezer compartment above the
ordinary freezer compartment improves accessibility since
the new temperature zone of freezer compartment provides
15 a shorter storing term and has a greater frequency of
access than the ordinary freezer compartment.

EMBODIMENT 5

Figure 23 is shown an example of the air path
structure of the refrigerator according to a fifth
20 embodiment of the present invention. The compartment
structure of the refrigerator shown in Figure 20 is
adopted in the fifth embodiment as an example. The
refrigerator includes the refrigerating compartment 100
at an upper portion therein, the ice storing compartment
25 600 and the new temperature zone of freezer compartment
300 provided side by side under the refrigerating
compartment, the ordinary freezer compartment 200 at the

lowest portion therein, and the vegetable compartment 400 above the ordinary freezer compartment.

In this figure, reference numeral 2 designates the fan motor for circulating the cooled air, reference
5 numeral 3 designates the cooling device and reference numeral 5 designates the air path for the new temperature zone of freezer compartment. The damper 5a are opened and closed to control the flow rate of the cooled air in order to carry out temperature control in the new
10 temperature zone of freezer compartment 300 so as to obtain a set temperature therein. The damper 5a is provided in the air path, and the damper can control the blowing amount of the cooled air into the new temperature zone of freezer compartment 300 to carry out the
15 temperature control in the new temperature zone of freezer compartment.

For example, in a case wherein the set temperature in the new temperature zone of freezer compartment is -7°C , the damper 5a is closed to shut the cooled air when
20 the temperature detector (the thermistor for temperature detection) 302 in the new temperature zone of freezer compartment detects that the temperature in the new temperature zone of freezer compartment is -7.5°C . When the temperature in the new temperature zone of freezer
25 compartment rises to -6.5°C after that, the damper 5a is opened to flow the cooled air into new temperature zone of freezer compartment. Such operation can be repeated

to realize stable temperature control in the new temperature zone of freezer compartment.

EMBODIMENT 6

Figure 24 is shown a cross-sectional side view of
5 the new temperature zone of freezer compartment 300 according to a sixth embodiment of the present invention to explain an air path structure for the new temperature zone of freezer compartment 300. Reference numeral 5
10 designates an air path for the new temperature zone of freezer compartment, which supplies the cooled air into the new temperature zone of freezer compartment 300.

As shown in this figure, the new temperature zone of freezer compartment 300 has an extension air path for blowing out the cooled air thereinto provided on a top
15 wall 305 thereof, and the extension air path is formed with cooled air outlets 306 to provide a better temperature distribution.

Even if the extension air path is provided independently from the top wall, stable temperature
20 control can be obtained likewise.

As shown in a cross-sectional plan view of Figure 25, the new temperature zone of freezer compartment 300 may have the extension air path provided on at least one of both side walls 307 thereof instead of the top wall
25 305, and the extension air path may be formed with cooled air outlets 308, offering similar effects.

When the extension air path is provided on each of

the top wall 305 and the side walls 307, more stable temperature control can be realized in the new temperature zone of freezer compartment.

When a tray which has a bottom made of good thermal conductivity of material such as aluminum is put in the new temperature zone freezer compartment, or when a storage case to be put in the new temperature zone of freezer compartment is made of good thermal conductivity of material, the temperature distribution is improved.

Although the new temperature zone of freezer compartment 300 is shown to be a compartment separated by partition walls and so on in the embodiments, the new temperature zone of freezer compartment may be provided in a compartment having a different temperature zone by separating with a casing for instance.

In Figure 26 is shown a cross-sectional view of a storage section 800 provided in the refrigerating compartment 100. Reference numeral 801 designates a partition wall to the refrigerating compartment 100. Reference numeral 802 designates thermal insulation material for insulating the storage section 800 from the refrigerating compartment 100. Reference numeral 805 designates a duct which is provided on the thermal insulation material 802 to provide an air path for cooling the storage section 800. Reference numeral 800c designate outlets provided in the duct 805. The storage section 800 has a front portion provided with a lid 803.

The lid 803 has thermal insulation material or thermal insulation by air provided therein, and the lid has packing 806 provided on the circumference thereof. The storage section has a tray 804 put at the bottom therein,
5 and the tray is made of plastic material or good thermal conductivity of material such as aluminum. The storage section 800 is cooled by controlling a damper 800a for airflow rate adjustment so that the cooled air generated by the cooling device is supplied into the storage
10 section 800 to provide the storage section with a set temperature. Reference numeral 100a designates a damper for a refrigerating compartment 100.

In Figure 27 is shown a cross-sectional view of the storage section 800 including a return path. In Figure
15 28 is shown a cross-sectional view of the storage section as viewed from the direction indicated by an arrow A in Figure 27. Reference numeral 800d designates an inlet for the storage section 800, through which the cooled air that has been blown out of the outlets 800c and
20 circulated in the storage section paths to is returned to the cooling device via the return path 800e. The return path 800e for the storage section 800 is provided independently of the other return paths so that the returned cooled air in the return path 800e is
25 independent of the returned cooled air having an increased temperature and humidity, such as the returned cooled air from the refrigerating compartment, and is

prevented from mixing with the other returned cooled air to avoid the formation of ice in the return path 800e.

In Figure 29 is shown a front view of the refrigerating compartment 100, which has a water supply tank 900 for an automatic ice making device provided on a bottom surface thereof. Reference numeral 900a designates a heater for avoiding the formation of ice in the water supply tank 900, which prevents ice from being formed under the influence of the temperature in the storage section 800. Reference numeral 900b designates a heater for preventing the formation of ice in a compartment under the storage section 800, which is provided on at a rear portion of the refrigerator main body so that the compartment is prevented from being affected by the temperature in the storage section 800. If the storage section 800 is set as the new temperature zone of freezer compartment according to the present invention, the switchable compartment referred to in the other embodiments may be used to carry out freezing as a compartment specialized for ice cream so as to be matched with the life pattern of a user, or the switchable compartment may be set at a temperature in the new temperature zone and is combined with the new temperature zone of freezer compartment to provide a large volume of storage in the new temperature zone.

Although explanation has been made with respect to a case wherein the storage section 800 is provided in the

refrigerating compartment 100, the storage section 800 may be provided in a compartment (having a door common to the storage section) having a different storing temperature from the refrigerating compartment, or a

5 plurality of storage sections may be provided in a compartment with a door common to the storage section so as to be matched with the usage of the refrigerator to a user. For example, if a plurality of storage sections are provided so as to work as a new temperature zone of

10 freezer section and a refrigerating section in the refrigerating compartment, and if an article of food that has been stored in the refrigerating section to be promptly used is required to be stored for 2 or 3 weeks because of a change in the plan, the article can be moved

15 to the new temperature zone of freezer section in the common door, providing easy work. For example, the new temperature zone freezer section is provided in the freezer compartment, and if an article of food that has been stored in the new temperature zone of freezer

20 section because of planned use in 2 or 3 weeks is required to be stored for a long term because of a change in the plan, the article can be easily moved to the freezer compartment, making reasonable use of the refrigerator. The reverse movement of each of the

25 articles between the section and the compartment can be easily made. A combination of the section and the compartment may be selected so as to be matched with the

usage of a user, and the arrangement of the section and the compartment in the vertical or horizontal direction may be selected so as to be matched with the usage of the user. The storage section may be separated by a simple
5 partition wall.

The provision of not less than two of switchable sections or independent compartments in the refrigerator can provide the refrigerator with temperature zones, which are well matched with the dietary habits of the
10 user.

The compartment as the freezer compartment may be configured to be automatically and variably set at a temperature in the new temperature zone (about -7°C) by being controlled under a microcomputer based on an input
15 through a switch on the external surface of the refrigerator or a temperature control in the refrigerator. By such arrangement, if an article of food that is expected to be stored for 2 or 3 weeks is erroneously put in the new temperature zone of freezer
20 compartment set for long term of storage, or a plan to use an article of food is suddenly changed, proper temperature setting can be made by such simple operation (modification in setting) without moving the article, providing the refrigerator with an energy-saving
25 property.

A cold storage (large size refrigerator), chilled car for frozen food and so on may have the temperature

therein set at an arbitrarily storing temperature including a temperature in the temperature zone of the new temperature zone of freezer compartment (soft-freezing room). The storing temperature can be

5 sequentially changed in the temperature zone not higher than the lower limit of the maximum ice forming temperature zone (from -1°C to -5°C) and higher than the freezing temperature zone (from -18°C to -20°C) so as to be adequately set, depending on storing days

10 (transportation days), the purpose for storage and the contents of articles of food. The storing temperature may be changeable to any temperature value at any time, using the temperature control method referred to be respect to the first embodiment. Thus, the articles of

15 food can be frozen for storage in a better state.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be

20 practiced otherwise than as specifically described herein.



CLAIMS:

1. A refrigerator with a freezer compartment,
comprising:

a compartment for storing articles of food, which
5 has one or more temperature zones; and

a new temperature zone of freezer compartment as a
compartment having a new temperature zone not higher than
a lower limit of a maximum ice forming temperature zone
and higher than a freezing temperature zone.

10 2. The refrigerator according to Claim 1, wherein the
new temperature zone includes a temperature that allows
articles of food stored in the new temperature zone of
freezer compartment to be divided without being thawed.

3. The refrigerator according to Claim 1, wherein the
15 new temperature zone of freezer compartment is a
compartment which can have a temperature therein changed
to at least one of a freezer compartment temperature, a
temperature in the new temperature zone, a refrigerating
compartment temperature, a vegetable compartment
20 temperature and an icing temperature.

4. The refrigerator according to Claim 3, wherein a set
temperature or an actual temperature in the compartment
is variably displayed on an outer or inner surface of the
refrigerator, the set temperature or actual temperature
25 including a temperature in the new temperature zone, and
at least one of the freezer compartment temperature, the
refrigerating compartment temperature, the vegetable



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compartment temperature and the icing temperature.

5. the refrigerator according to any one of Claims 1 to 4, further comprising one or more freezer compartments having the freezing temperature zone.

5 6. The refrigerator according to Claim 1, further comprising at least two freezer compartments, wherein one of the freezer compartments can be changed to the new temperature zone of freezer compartment.

7. The refrigerator according to Claim 6, wherein at
10 least one of the freezer compartments can be automatically and variably set at a temperature in the new temperature zone.

8. The refrigerator according to any one of Claims 3, 5 and 6, wherein the new temperature zone of freezer
15 compartment is provided above a freezer compartment.

9. The refrigerator according to Claim 1, further comprising:

a duct for blowing out cooled air into the new temperature zone of freezer compartment;

20 an outlet provided to the duct;

a temperature detector for detecting a temperature in the new temperature zone of freezer compartment, and

a damper for controlling an outlet amount of the blown cooled air into the new temperature zone of freezer
25 compartment in response to the detected temperature.

10. The refrigerator according to Claim 9, wherein the duct is provided on at least one of a top wall and a side



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wall of the new temperature zone of freezer compartment.

11. The refrigerator according to Claim 1, wherein the new temperature zone of freezer compartment can sequentially change a temperature therein in the new
5 temperature zone.

12. The refrigerator according to Claim 1, wherein the new temperature zone of freezer compartment is configured to cool the article of food at a cooling speed faster than that in an icing temperature compartment and slower
10 than that in a freezer compartment.

13. The refrigerator according to Claim 1 or 12, wherein the new temperature zone of freezer compartment can prevent an article of food with a rich content of salt or sugar from being frozen.

14. The refrigerator according to any one of Claims 1 to 13, wherein the new temperature zone of freezer
15 compartment is provided as one of sections divided in a single compartment.

15. The refrigerator according to Claim 14, wherein the
20 new temperature zone of freezer compartment is provided with a return path for cooled air, the return path being independent of other return paths for cooled air.

16. A method for using a refrigerator wherein a compartment for storing articles of food is provided so
25 as to have one or more temperature zones, and wherein the compartment can be changed to a new temperature zone of freezer compartment having a new temperature zone not



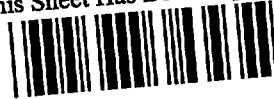
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higher than a lower limit of a maximum ice forming temperature zone and higher than a freezing temperature zone; comprising storing an article of food in the compartment, changing, based on a required storing term, 5 a temperature in the compartment to a temperature in the new temperature zone; and taking the article out of the compartment changed to the new temperature zone to cook the article.



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