

[Name of Document] SPECIFICATION

[Title of the Invention] REFRIGERATOR

[Technical Field]

[0001]

The present invention relates to refrigerators, and more specifically, it relates to the illumination within a compartment turned on when a door of the storage compartment of the refrigerator is opened.

[Background Art]

[0002]

Conventionally, incandescent lamps have been commonly used in illuminating systems for storage compartments of refrigerators and storage door pockets provided in a door of refrigerators; however, recently, use of light-emitting-diodes (referred to as LED below) which are advantageous from standpoints of heating value and electric power consumption has been proposed.

[0003]

However, since LED is small in luminous area and strong in directivity in comparison with those of incandescent lamp, its illumination range is small. Hence, for effectively illuminating a large storage compartment, it is necessary to provide LEDs in numbers larger than incandescent lamps. For ensuring the same illuminance in storage compartment as that of incandescent lamps, the manufacturing cost tends to increase.

[0004]

Then, for compensating the small luminous area and the strong directivity, examples have been proposed in that an illuminating system using LEDs is directed toward the rear (back side) of the storage compartment and is mounted at a tilt (see Patent Document 1, for example). Examples have been also proposed in that the illuminating system is arranged such that the LED light in the optical axial direction enters the front of a loading shelf of the storage compartment so as to intensively illuminate the front part of the loading shelf (see Patent Document 2, for example).

[Patent Document 1] Japanese Examined Patent Application Publication No. 4055803

[Patent Document 2] Japanese Examined Patent Application Publication No. 4054365

[Disclosure of the Invention]

[Problems to be Solved by the Invention]

[0005]

For example, in the refrigerator shown in Patent Document 1 mentioned above, the LEDs are directed to emit light toward the rear of the storage compartment. Thereby, the light from the LED can be concentrated in the storage compartment; however, on the other hand, since the illuminance in the front (adjacent to the door) of the storage compartment is reduced, there has been a problem that a storing pocket provided in the door cannot be sufficiently illuminated.

[0006]

Also, in the refrigerator shown in Patent Document 2 mentioned above, light is concentrated in the front side of the loading shelf. On the other hand, since the illuminance in the rear side of the storage compartment is reduced, the back of the storage compartment is darkened. Also, the light in the optical axial direction with highest intensity is emitted to the front edge of the loading shelf. Therefore, the reflected light from the front edge of the loading shelf is intensified, and a problem has arisen that a user feels the glare.

[0007]

The present invention has been made to solve such problems and it is an object of the invention to obtain a refrigerator in that when an illumination system of a storage compartment is constructed using LEDs with the small heating value and electric power consumption, the whole storage compartment can be efficiently illuminated with the LED light.

[Means for Solving the Problems]

[0008]

A refrigerator according to the present invention includes a storage compartment having a space, which is openable to/closable from an exterior space via a door, for accommodating storage goods; one or a plurality of loading shelves for zoning the storage compartment into a plurality of storage spaces in a vertical direction; and an illuminating system in that a plurality of light-emitting diodes are arranged on a side wall of the storage

compartment in the vertical direction at positions adjacent to the door from the loading shelf for illuminating the storage compartment, in which on a plane parallel to the loading shelf, the plurality of light-emitting diodes of the illuminating system are directed such that an angle of an optical axis of the light-emitting diodes defined by the side wall is larger than 60° as well as the light from the light-emitting diodes in the optical axial direction is not allowed to directly enter the loading shelf.

[Advantages]

[0009]

According to the present invention, on the right and left sides of the storage compartment, for example, of the refrigerator, the illuminating systems having a plurality of LEDs are provided at positions adjacent to the front from the loading shelf, and the angle of the optical axis of the light emitted from the LEDs defined by the side is to be larger than 60° as well as the light from the LEDs in the optical axial direction is not allowed to directly enter the loading shelf, so that the light in the optical axial direction of the LEDs is not emitted directly to the front edge of the loading shelf and the glare feeling of a user can be reduced, ensuring the high visibility within the storage compartment. Also, the LEDs of the illuminating system are not directed toward the rear of the storage compartment, so that the door pocket of the door located in the front can be illuminated.

[Best Mode for Carrying Out the Invention]

[0010]

First Embodiment

Fig. 1 is a schematic side sectional view of a refrigerator 1 according to a first embodiment of the present invention. According to the embodiment, the refrigerator 1 includes a plurality of storage compartments, such as a refrigeration compartment 2, an interchangeable compartment 3, a vegetable compartment 4, and a freezing compartment 5, each compartment including a space for accommodating inventory goods (foods). The refrigerator 1 also includes a hinged door 6 (referred to as a door 6 below) and a pullout door 7 so as to open/close the space between the inside and the outside of each compartment. The refrigeration compartment 2 having the door 6 and loading shelves 8 will be described below; however, the invention is not limited to this.

[0011]

As shown in Fig. 1 herein, the refrigerator 1 has a substantially rectangular parallelepiped shape, in which the front side having the door is defined as a front plane and the side rear to the front plane is defined as a rear plane based on the installation direction. In Fig. 1, the upper side (ceiling side) is defined as the top plane and the lower side (floor side) as the bottom plane, and other two surfaces are defined as sides (the left surface viewed from the front is defined as the left

side and the right surface as right side, herein). In the refrigeration compartment 2 openable/closable with the door 6, a plurality of loading shelves 8 are arranged in parallel with the topplane (bottomplane) to zone the inside of the refrigeration compartment 2 for improving inventory goods storage efficiency. Controlling means 100 controls each means included in the refrigerator 1. Herein, the controlling means 100 mainly controls an LED 9 provided in an illuminating system 10 for illuminating within the refrigeration compartment 2.

[0012]

Fig. 2 is a front view of the refrigeration compartment 2. As shown in Fig. 2, on sides of the inner wall of the refrigeration compartment 2 (referred to as inner walls 13 below), the illuminating systems 10 having a plurality of the LEDs 9 as light sources are provided, the LED 9 being to emit visible light, such as white light, such that users can see inventory goods. According to the embodiment, on the inner wall 13, the illuminating system 10 is arranged at a position adjacent to the front side (toward the door 6) from the front edge of the loading shelf 8. As for the vertical direction, the illuminating system 10 is arranged such that the plurality of the LEDs 9 included in the illuminating system 10 are positioned at substantially intermediate positions between the respective two shelves 8 (except upper most and lower most LEDs).

[0013]

Fig. 3 is a drawing of general luminous characteristics of the LED 9. As shown in Fig. 3, the LED 9 generally has strong directivity in light emitting. Hence, the luminous intensity is highest in a direction of optical axis 12 perpendicular to the luminescent plane of the LED 9, and with separating angle from the direction of optical axis 12, the luminous intensity is reduced. The illuminating range with 50% or more luminous intensity of that in the direction of optical axis 12 is defined herein as an effective illuminating range α (however, this does not mean that the LED 9 cannot emit light to out of the illuminating range α). In Fig. 3, when the angle of the direction of optical axis 12 is defined as 0° , the range in approximately $\pm 50^\circ$ is included in the illuminating range α . In the description, the direction of the light emitted from the LED 9 represents a direction on a plane parallel to the loading shelf 8 unless otherwise specified (this does not define the light in the vertical direction).

[0014]

Fig. 4 includes drawings of the refrigeration compartment 2 viewed from the upper plane. As described above, the door 6 is provided on the front plane of the refrigeration compartment 2. In the refrigerator 1 according to the embodiment, on the front plane of the refrigeration compartment 2, doors 6A and 6B are provided for opening to/closing from the outside of the space of the refrigeration compartment 2, the doors 6A and 6B being

connected to the body of the refrigerator 1 via hinges (not shown), respectively, as so-called hinged double doors. The door on the right viewed from the front of the refrigerator 1 is defined herein as the right door 6A, the door on the left as the left door 6B (if distinction is unnecessary, they are described as the door 6). The door 6 is provided with a door pocket 11 arranged inside for storing foods. The illuminating system 10 is configured of a printed circuit board 16 having an electrical circuit printed thereon and a plurality of the LEDs 9, in which the printed circuit board 16 is not exposed inside the refrigeration compartment 2. According to the embodiment, as shown in Fig. 4, the illuminating system 10 is arranged such that the angle θ of the optical axial direction of the LEDs 9 defined by the inner wall 13 is larger than 60° and furthermore, the light in the direction of optical axis 12 of the LED 9 is not directly incident on the loading shelf 8 (especially on the front edge). By increasing the angle θ larger than 60° , during illuminating the whole loading shelf 8, the well-balanced illumination can be achieved without unevenness. Even when increasing the angle θ larger than 60° , if the light in the direction of optical axis 12 is incident on the loading shelf 8, it is preferable to give priority to not directing the light in the direction of optical axis 12 toward the loading shelf 8 directly unless being under situations that the reflected light does not glare on an user. The upper limit of the angle θ is not limited; however, it is preferable to be 90° or less, because

the main object is to illuminate inside the refrigeration compartment 2.

[0015]

Fig. 5 includes plan views of a conventional refrigerator. In conventional refrigerators, since the angle of the LEDs to the inner wall is to be 60° or less so as to direct the light in the optical axial direction of the LED toward the loading shelf 8, so that the rear side of the refrigeration compartment 2 is liable to be illuminated with light in a concentrated manner. Therefore, although the inside of the refrigeration compartment 2 can be brightly illuminated, the light in the direction of optical axis 12 of the LEDs 9 is directly incident on the loading shelf 8. Thus the reflected light from the front edge of the loading shelf 8 is intensively incident on the eyes of users of the refrigerator to glare on them. On the other hand, in the refrigerator 1 according to the embodiment, since the light emitted from the LEDs 9 in the direction of optical axis 12 cannot directly enter the loading shelf 8, the glare due to the reflection can be significantly reduced.

[0016]

As described above, Since the LED 9 that is a light source of the illuminating system 10 has strong directivity, light within the effective illuminating range α centered at the optical axis 12 is intensively emitted. When the angle θ of the direction of optical axis 12 of the LED 9 defined by the inner wall 13 is changed

herein, the effective illuminating range α also changes simultaneously. As shown in Fig. 5, in conventional refrigerators, since the angle of the optical axis 12 of the LED 9 to the inner wall is to be 60° or less so as to intensively illuminate the inside of the refrigeration compartment 2, the opened door 6 is out of the effective illuminating range α . Therefore, the door pocket 11 provided inside the door 6 is scarcely illuminated with light to be darkened. Since the door pocket 11 is a very convenient storage space for taking in/out drinks and small articles, it is preferable to illuminate the door pocket 11 for user's convenience sake.

[0017]

Then, in the refrigerator 1 according to the embodiment, since the angle θ of the optical axis 12 of the LEDs 9 defined by the inner wall 13 is to be 60° or more, the door pocket 11 can be included within the effective illuminating range α (extension range). Therefore, the inside of the refrigeration compartment 2 is illuminated while the door pocket 11 can be illuminated with the light of the LEDs 9.

[0018]

As described above, according to the first embodiment, when the LED 9 capable of reducing the heating value and electric power consumption for energy saving is used for illumination, the illuminating system 10 is arranged by juxtaposing a plurality of the LEDs 9 on the right and left inner walls 13 inside the

refrigeration compartment 2 of the refrigerator 1 and at positions adjacent to the front side (at the side of the door 6) from the loading shelf 8 and in the vertical direction, such that the angle of the optical axis 12 of the light emitted from LEDs 9 defined by the inner wall 13 is to be 60° or more, and also that the light in the direction of optical axis 12 does not enter the loading shelf 8 directly. Thus, the light in the direction of optical axis 12 of the LEDs 9 is not emitted directly to the front edge of the loading shelf 8 and the glare feeling of users can be reduced, ensuring the high visibility within the refrigeration compartment 2. Also, since the illuminating system 10 is not arranged to excessively tilt toward the rear within the refrigeration compartment 2, the front side of the refrigeration compartment 2, that is, the door pocket 11 provided in the door 6 can also be illuminated. Hence, an additional illuminating system for illuminating the door pocket 11 is unnecessary, contributing to the reduction in cost and energy saving.

[0019]

Second Embodiment

Fig. 6 is a drawing showing the relationship between an illuminating system 10 according to a second embodiment and a lamp cover (shade) 15 viewed from the upper plane of the refrigeration compartment 2. According to the embodiment, the illuminating system 10 is also configured of the printed circuit board 16 and a plurality of the LEDs 9. According to the embodiment,

on the inner wall 13, a recess 13A is formed at a position adjacent to the front side (toward the door 6) from the front edge of the loading shelf 8 so as to arrange the illuminating system 10 within the recess 13A. Then, the recess 13A is covered with the lamp cover 15. However, the invention is not limited to this. The illuminating system 10 may also be covered with the lamp cover 15 without forming the recess 13A.

[0020]

The lamp cover 15 is molded from a resin material transparent at least within the range of visible light, and includes claws 14 for integrally fixing the illuminating system 10 thereto by fitting the claws 14 into the illuminating system 10. However, the fixing of the illuminating system 10 is not limited to the fitting of the claws 14. The lamp cover 15 partly includes a lens unit 15A for refracting incident light. For leading the incident light to the rear (the back side) of the refrigeration compartment 2, the lens unit 15A is arranged to have an angle to the inner wall 13.

[0021]

In the first embodiment, by defining the direction of the LEDs 9 to the positioning of the illuminating system 10, the glare of the reflected light from the loading shelf 8 is reduced as well as the illumination of the door pocket 11 is enabled; however, due to the reduced occupation of the effective illuminating range α of the LED 9 in the loading shelf 8, the rear side of the

refrigeration compartment 2 may be insufficiently illuminated. For compensating the reduction in brightness in the refrigeration compartment 2, the number of the LEDs 9 may be increased; however, it is not preferable because of increased cost. Then, according to the embodiment, by using the lamp cover 15 having the lens unit 15A, the brightness of the whole refrigeration compartment 2 is improved with low cost configuration.

[0022]

Fig. 7 includes drawings showing changes in proceeding direction of the light of the LED 9 when using the lamp cover 15. As shown in Fig. 7(a), in the lamp cover 15 according to the embodiment, the light incident on the lens unit 15A is refracted in the lens unit 15A, so that the rear of the refrigeration compartment 2, which is out of the effective illuminating range α , is illuminated therewith. On the other hand, the light incident on parts other than the lens unit 15A goes substantially straight, although it may be refracted in some degree depending on the incident angle, so that the door pocket 11 is illuminated therewith. Whereas, when using no lamp cover 15 or a flat lamp cover 17 without the lens unit 15A, as shown in Fig. 7(b), the light of the LED goes straight in the direction of an original optical axis 18.

[0023]

Part of the light of the LED 9 refracted by the lamp cover 15 proceeds toward the loading shelf 8. Hence, the glare due to the direct incidence of the light upon the loading shelf 8

is an anxious matter. However, the glare is significantly reduced due to the attenuation in luminous intensity during transmission through the lamp cover 15 and the light dispersion due to the difference in light direction due to the refraction caused by the roughness of the surfaces of the lamp cover 15 in comparison with the case where the light of the LED 9 directly enters the loading shelf 8 along the direction of original optical axis 18.

[0024]

Fig. 8 includes drawings showing the positional relationship between the LED 9 and the lamp cover 15. In particular, according to the embodiment, the positional relationship between the LED 9 and the lamp cover 15 is obtained such that the light in the direction of optical axis 12 enters the lens unit 15A so as to be led to the rear side of the refrigeration compartment 2. When using the lamp cover 15 employing the refraction of the light of the LED 9, the positional relationship between the effective illuminating range α of the LED 9 and the lamp cover 15 in the front-rear direction is very important. Fig. 8(a) shows the appropriate positional relationship between the effective illuminating range α of the LED 9 and the lamp cover 15. In that case, the light in the direction of optical axis 12 of the LED 9 enters the lens unit 15A so that the high intensity light is led to the rear side of the refrigeration compartment 2. On the other hand, in the case shown in Fig. 8(b), the light does not enter the lens unit 15A but goes substantially straight, so that

the light to be used for effectively illuminating the inside of the refrigeration compartment 2 is wasted.

[0025]

Fig. 9 includes drawings showing the relationship between the shape of the lamp cover 15 and the light refraction. The degree of light refraction of the LED 9 depends on the specification of the lens unit 15A. Based on the lamp cover 15 shown in Fig. 9(a), for simply increasing the angle of refraction, as shown in Fig. 9(b), the resin thickness of the lens unit 15A (light refracting part) of the lamp cover 15 may be increased. However, if the resin thickness is excessively increased, generally sink is liable to be produced, so that the molding into a desirable mold profile becomes difficult. Accordingly, the resin thickness is preferred to be suppressed up to about 4 mm. Then, for avoiding the sink, as shown in Fig. 9(c), the section of the lens unit 15A may also be formed to have a saw-blade shape (having a plurality of triangular shapes) for forming a plurality of inclined planes with the same thickness as that shown in Fig. 9(b). At this time, as shown in Fig. 9(d), with increasing inclination of the inclined plane, the angle of light incidence is reduced in the relation with the inclination of the inclined plane, increasing the refraction. As described above, the refraction angle is changed due to the angle of inclination of the inclined plane. Accordingly, if the section is molded to have necessary inclination of the inclined plane, the lamp cover 15 with the desirable lens unit

15A can be obtained.

[0026]

Fig. 10 is a table showing characteristics of resin materials. Fig. 10 shows transmission factors and the rank order about unit cost of five kinds of resin material. With higher order (smaller number), it is advantageous. For example, the transmission factor is advantageous in the order of an acrylic resin and polycarbonate (polyca). Since the brightness in the refrigeration compartment 2 may be changed due to the transmission factor, the material must be carefully selected. On the other hand, the unit cost is advantageous in the order of a polystyrene resin and a copolymer resin of acrylonitrile and styrene (AS resin). Since the resin material constitutes part of the inner wall of the refrigeration compartment 2, oil-proof and juice-proof must be taken into account.

[0027]

Fig. 11 includes drawings showing a mounting method of the illuminating system 10 on the refrigerator 1. For example, there are a method to directly mount the illuminating system 10 on the body of the refrigerator 1 as shown in Fig. 11(a) in that the claws 14 are provided in the recess 13A, and the illuminating system 10 is fitted to the claws 14; and a method to mount the illuminating system 10 on the body of the refrigerator 1 after assembling the illuminating system 10 on the lamp cover 15 as shown in Fig. 11(b). If the illuminating system 10 is directly

mounted on the recess 13A, the positional relationship between the LED 9 and the lamp cover 15 may be significantly displaced due to the unevenness during assembling. That may cause concern that the light of the LED 9 within the effective illuminating range α may not efficiently enter the lens unit 15A. On the other hand, in the case where the illuminating system 10 is assembled on the lamp cover 15 in advance, the positional relationship between the LED 9 and the lamp cover 15 may not be significantly displaced. Accordingly, the light of the LED 9 can enter the lens unit 15A under the positional relationship established in advance, so that the desired illumination through the lamp cover 15 within the refrigeration compartment 2 can be optimally achieved. Therefore, the method to mount the illuminating system 10 on the body of the refrigerator 1 after assembling the illuminating system 10 on the lamp cover 15 is rather preferable. By contrast, when the illuminating system 10 is directly assembled on the inner wall 13, it is necessary to eliminate the displacement by the configuration capable of adequately aligning between the illuminating system 10 and the lamp cover 15. By the assembling in such a manner, the yield during manufacturing the refrigerator 1 can be improved.

[0028]

Fig. 12 includes drawings showing examples of the shape of the recess 13A on the inner wall 13. For example, as shown in Fig. 12(a), part of the light may enter not the lamp cover 15

but the recess 13A on the inner wall 13 depending on the arranging direction of the LED 9. Part of the light incident on the recess 13A may continue to proceed toward the different place in the recess 13A, so that the light may not come out of the lamp cover 15.

[0029]

Then, as shown in Fig. 12(b), the light emitted from the LED 9 is reflected on the recess 13A, and for preventing the reflected light from further entering the different place in the recess 13A, the angle of the concave surface forming the recess 13A is devised, so that the light emitted from the LED 9 can be further effectively led outside the lamp cover 15. In particular, since the light incident on the front side of the recess 13A may be frequently wasted perfectly, so that the angle of the recess 13A becomes important for leading the light to the outside of the lamp cover 15, without leading it to the recess 13A. There is the door pocket 11 provided in the door 6 in front of the refrigeration compartment 2, so that with the light coming out of the lamp cover 15 not entering the recess 13A, the door pocket 11 is to be illuminated. In such a manner, when the light to be wasted is led outside the lamp cover 15 due to the angle of the concave surface formed in the recess 13A, even the door pocket 11 provided on the whole plane of the refrigeration compartment 2 can be efficiently illuminated.

[0030]

As described above, the outside of the effective illuminating range α of the LED 9 is not entirely illuminated with the light but part of the light abuts the recess 13A even if the recess 13A is inclined. Hence, it is effective to devise a countermeasure on the recess 13A for leading the light outside the lamp cover 15.

[0031]

Fig. 13 includes drawings showing countermeasures about the reflection in the recess 13A. As shown in Fig. 13(a), if a specific countermeasure is not taken, the reflection factor of the incident light is reduced. Fig. 13(b) shows a high reflection material 13C added on the front concave surface of the recess 13A for increasing the light reflection factor. The material of the high reflection material 13C is not particularly limited; however, the high reflection material 13C may be formed by the vapor deposition of aluminum, for example. Also, an adhesive tape having the high reflection material 13C formed on its one side may also be bonded on the recess 13A. In such a manner, the reflection factor is increased due to the high reflection material 13C, improving the efficiency of the illumination.

[0032]

Fig. 14 is a front view of the refrigeration compartment 2 including a supply opening 26. On the wall inside the refrigeration compartment 2, the supply opening 26 is formed for supplying cold air into the refrigeration compartment 2. For

rapidly cooling storage goods accommodated in the door pocket 11 in front of the refrigeration compartment 2, not only on the back face, but also on the front side of right and left inner walls 13 of the refrigeration compartment 2, the supply openings 26 are formed in Fig. 14.

[0033]

Fig. 15 is a drawing of the lamp cover 15 having the supply opening 26. As shown in Fig. 15, the supply opening 26 provided on the inner wall 13 is formed integrally with the lamp cover 15. By the integrally forming, the reduction in amount of the material used for components is achieved. Also, since the number of the components is reduced, manufacturing cost may also be suppressed. Also, since the LED 9 generally has characteristics in that with increasing temperature of the LED 9, the luminous intensity is reduced, it is preferable to use the LED 9 under low-temperature circumstances as low as possible; the LED 9 can be cooled by the cold air from the supply opening 26.

[0034]

On the other hand, since the LED 9 has characteristics weak to water, it is preferable to directly apply wet air, such as the cold air circulating within the refrigeration compartment 2, on the LED 9 as little as possible. Then, as shown in Fig. 15, a partition plate 27 is formed on the lamp cover 15 for dividing off between the supply openings 26 and the illuminating system 10, so that the space having the illuminating system 10 is cut

off from the space where the cold air flows. Even if the cold air from the supply opening 26 does not abut the LED 9 directly, since the air around the illuminating system 10 is indirectly cooled by the partition plate 27 being cooled with the cold air, the LED 9 can also be cooled. The partition plate 27 may be reinforced with a tape according to circumstances so as to prevent air and water of the supply opening 26 from flowing into inside the partition plate 27.

[0035]

As described above, according to the second embodiment, by the lamp cover 15 having the lens unit 15A, the light emitted from the LED 9 is refracted to increase the amount of the light proceeding toward the rear side of the refrigeration compartment 2, so that in the same way as in the first embodiment, the reduction in glare of users of the refrigerator 1 and the illumination of the door pocket 11 can be achieved. Furthermore, the brightness within the refrigeration compartment 2 can be improved. Even if the number of the LEDs 9 is not increased, the brightness can be improved with low cost. By forming the lens unit 15A in a desirable shape, the illuminating situations of the refrigeration compartment 2 can be changed.

[0036]

The lamp cover 15 is provided with the claws 14, and after the illuminating system 10 is directly assembled on the lamp cover 15, the illuminating system 10 is assembled into the recess 13A,

so that the lamp cover 15 and the LED 9 can be built according to the positional relationship established in advance for illuminating within the refrigeration compartment 2 in a desirable manner. The concave surface angle of the recess 13A is devised such that the reflected light from the recess 13A enters the inside of the refrigeration compartment 2 via the lamp cover 15, so that the refrigeration compartment 2 can be efficiently illuminated. At this time, by increasing the reflection factor with the high reflection material 13C added especially to the front side of the recess 13A, the further efficient illumination can be achieved.

[0037]

Furthermore, by forming the supply opening 26 for supplying cold air to the refrigeration compartment 2 integrally with the lamp cover 15, the amount of the material used for components can be reduced. At this time, the LED 9 can be cooled with the cold air from the supply opening 26, so that the luminous intensity of the LED 9 can be maintained. Also, by providing the partition plate 27 in the lamp cover 15, the LED 9 can be protected from water.

[0038]

Third Embodiment

Fig. 16 includes diagrams showing an example of a driving circuit. As shown in Fig. 16(b), the turning on/off of an incandescent lamp is performed with a mechanical contact, such as a relay 19, whereas, the turning on/off of the LED 9 can use

a semiconductor element, such as a transistor 20 as a switching element, as shown in Fig. 16(a). Hence, the electric voltage/current for emitting (driving) the LED 9 can be reduced in comparison with the incandescent lamp. The driving components for turning on/off of the LED 9 are comparatively inexpensive and have a long life.

[0039]

Since the relay 19 is a mechanical contact, it has limits in switching speed and durable number of times; whereas the semiconductor element, such as the transistor 20, can be turned on/off over these limits far and away. Therefore, not only the turning on/off, but also flashing sign, which is repeating the turning on/off at high frequency, can be easily executed. Accordingly, in the refrigerator 1 having the LED 9 as a light source, the self-diagnosis information of the refrigerator 1 may be represented with the number of flashing times of the LED 9 of the illuminating system 10.

[0040]

Fig. 17 includes drawings showing examples of an operation panel 21 provided on the door of the refrigerator. In a conventional refrigerator, when the controlling means 100 provided in the refrigerator determines that the abnormality is occurred in the refrigerator, the predetermined error code is displayed on a liquid crystal display 22 provided on the operation panel 21 as shown in Fig. 17(a); alternatively, as shown in Fig.

17(b), the self-diagnosis information, such as inaccuracy of a temperature sensor, is represented with number of flashing times of LEDs 23.

[0041]

Fig. 18 is a drawing showing an example of a flashing of the LED 9. According to the embodiment, in addition to the display on the operation panel 21 shown in Fig. 17, for example, the self-diagnosis information is represented by flashing the LED 9. For example, for representing "34" by flashing the LED 9, the controlling means 100 flashes the LED 9 three times and further flashes it four times after filling a blank period of 0.5 seconds, and this sign is repeated.

[0042]

Similarly, for informing that the door 6 is opened for a long period of time, the LED 9 may also be flashed. When the door 6 is opened for a long period of time, the cold air of the refrigeration compartment 2 is leaked, causing increase in the temperature of storage goods and the electric power consumption. In cases where the door is slightly opened when a user thinks that the door is shut; and the door is not perfectly shut because of a foreign material pinched between the door and the body, the flashing sign is also effective.

[0043]

As described above, according to the third embodiment, not only by the liquid crystal display 22 and the LEDs 23 for displaying

abnormality provided on the operation panel 21, but also by using the LEDs 9 having sufficient brightness for originally illuminating the refrigeration compartment 2, the abnormality is displayed for a user of the refrigerator 1, so that the appeal power for the abnormality to the user of the refrigerator 1 can be increased, thereby increasing the degree of recognition of the user.

[0044]

Fourth Embodiment

As described in the third embodiment, the turning on/off of the LED 9 can be switched by the transistor 20. Therefore, the turning on/off can be switched with a further shorter cycle time. For example, if the turning on/off is repeated at a frequency of several kHz, a human cannot view the flashing due to illusion but may recognize the reduced luminous intensity (brightness).

[0045]

Fig. 19 is a drawing showing the relationship between the brightness and the lighting period. As shown in Fig. 19, the degree of brightness is proportional to the rate of the lighting period to the unit time (cycle) (referred to as the duty ratio below). Hence, for example, by gradually changing the duty ratio, the visual effect that the luminous intensity might be gradually changed can be obtained. According to the third embodiment, the self-diagnosis information is represented by simply flashing the LED 9; whereas, according to the embodiment, the information is

represented by regulating the duty ratio so as to change the luminous intensity.

[0046]

Fig. 20 is a drawing showing the relationship between the self-diagnosis information and the duty ratio adjustment. For example, when the LED 9 is simply flashed on and off, since changes in brightness between turning-on and turning-off are intensive, users of the refrigerator may be astonished. However, as shown in Fig. 20, when the LED 9 is not perfectly turned off but the luminous intensity is gradually changed to change the lighting pattern, the abnormality can be informed without astonishing the user.

[0047]

An example of the representation of the self-diagnosis information by the regulation of the luminous intensity due to the adjustment of the duty ratio has been described. Also, the function may also be used to select the regulating method of the luminous intensity of the LED 9 with the adjustment of the duty ratio according to user preference. For example, a user of the refrigerator 1 may set the luminous intensity of the LED 9 optionally from the operation panel 21 shown in Fig. 17, on which the user can instruct the adjustment of the brightness of the illuminating system 10. For example, when the refrigerator 1 is used in a bright place, the outside light enters the refrigeration compartment 2 so that the light of the LED 9 is

not required so much, the level of the brightness of the LED 9 may be lowered; when the refrigeration compartment 2 is necessary to be brightly illuminated for putting storage goods in order for example, the brightness level may be raised, thereby further reducing the electric power consumption.

[0048]

As described above, according to the fourth embodiment, during light emission from the LED 9, by changing the luminous intensity of the LED 9 with the adjustment of the duty ratio, not by flashing on/off, the abnormality may be informed without astonishing a user. Also, the user can change the setting for user's convenience.

[0049]

Fifth Embodiment

Fig. 21 is a front view of a refrigerator 1 according to a fifth embodiment. In Fig. 21, like reference numerals designate like components common to the embodiments described above, and the description is omitted. The refrigerator 1 according to the embodiment is provided with door switches 24A and 24B as detection means for detecting the opening of the right door 6A and the left door 6B, respectively.

[0050]

For example, when taking out the storage goods stored on the left when facing the front of the refrigeration compartment 2, a user can take out them by opening only the left door 6B;

when taking out foods stored on the right, the user may open only the right door 6A. If the door is widely opened, the amount of the cold air leaked from the refrigeration compartment 2 is increased, leading to the increase in electric power consumption. Then, by opening any one of the right door 6A and the left door 6B, the opening of the door during taking out storage goods can be reduced as small as possible, suppressing futile electric power consumption. Then, when any one of the right door 6A and the left door 6B is opened, it is necessary to illuminate within the refrigeration compartment 2 by driving the LED 9 of the illuminating system 10. Accordingly, the door switches 24A and 24B are provided as shown in Fig. 21. The controlling means 100 determines which of the right door 6A and the left door 6B is opened, based on the signal transmitted from the door switches 24A and 24B to allow the illuminating system 10 to perform corresponding illumination.

[0051]

According to the embodiment, when the illuminating system 10 having the LED 9 as a light source described in the above embodiments is mounted on a refrigerator 1A having the right door 6A or the left door 6B, the wasted electric power consumption is to be further suppressed. For example, storage goods to be taken by opening the left door 6B may be stored on the left of the refrigeration compartment 2 where is within a visible range when opening the door. When taking storage goods by opening the right door 6A, the situation is the same. Hence, if the

refrigeration compartment 2 is illuminated within a range visible from the opened door, the necessary and enough effect is achieved.

[0052]

Fig. 22 includes drawings showing the illumination with the LED 9 in the refrigeration compartment 2 according to the fifth embodiment. As shown in Fig. 22(a), when the left door 6B is opened, the LEDs 9 of the illuminating system 10 arranged on the left inner wall 13 are only turned on; by contrast, as shown in Fig. 22(b), when the right door 6A is opened, the LEDs 9 of the illuminating system 10 arranged on the right inner wall 13 are only turned on. Also, as shown in Fig. 22(c), when both the right door 6A and the left door 6B are opened, the LEDs 9 of the illuminating systems 10 arranged on both the right and left inner walls 13, respectively, are turned on, so that the whole refrigeration compartment 2 can be illuminated. As mentioned above, since with the semiconductor element inexpensive and with long life, the switching for turning on/off the LED 9 can be performed, even when the illuminating systems 10 arranged on the right and left inner walls 13, respectively, are turned on/off, respectively, it is not necessary to worry about the cost up.

[0053]

As described above, according to the fifth embodiment, in the refrigerator 1 having the right door 6A and the left door 6B, when any one of the right door 6A and the left door 6B is opened, for example, the LEDs 9 of the illuminating system 10

arranged on the inner wall 13 adjacent to the opened door are only turned on so as to only illuminate the necessary region, so that the excessive electric power consumption is suppressed to obtain an electric power saving refrigerator 1.

[0054]

Sixth Embodiment

In the fifth embodiment described above, only the illuminating system 10 corresponding to the opened door in one of the right door 6A or the left door 6B is turned on; however, depending on the mounting position and the mounting angle, the illuminating system 10 arranged on the inner wall 13 opposite to the opened door may also be turned on. As mentioned above, since the LED 9 has strong directivity, depending on the mounting position, in some cases, emitting the light to the region faraway to some extent rather than to the vicinity may more widely and more efficiently illuminate the illumination range. Then, the controlling means 100 determines which of the right door 6A and the left door 6B is opened, based on the signal transmitted from the door switches 24A and 24B to allow the illuminating system 10 to perform the corresponding illumination.

[0055]

Fig. 23 includes drawings showing the illumination within the refrigeration compartment 2 with the LED 9 according to a sixth embodiment. As shown in Fig. 23(a), when the left door 6B is opened, the LEDs 9 of the illuminating system 10 arranged on

the right inner wall 13 are only turned on; by contrast, as shown in Fig. 23(b), when the right door 6A is opened, the LEDs 9 of the illuminating system 10 arranged on the left inner wall 13 are only turned on. Also, as shown in Fig. 23(c), when both the right door 6A and the left door 6B are opened, the LEDs 9 of the illuminating systems 10 arranged on both the right and left inner walls 13, respectively, are turned on, so that the whole refrigeration compartment 2 can be illuminated.

[0056]

As described above, according to the sixth embodiment, in the refrigerator 1 having the right door 6A and the left door 6B, in cases where the loading shelf 8 is apart from the illuminating system 10 in distance, for example, when any one of the right door 6A and the left door 6B is opened, the LEDs 9 of the illuminating system 10 arranged on the inner wall 13 opposite to the opened door are only turned on so as to only illuminate the necessary region, so that the excessive electric power consumption is suppressed to obtain an electric power saving refrigerator 1.

[0057]

Seventh Embodiment

Fig. 24 includes drawings showing the illumination within the refrigeration compartment 2 with the illuminating system 10 (LED 9) according to a seventh embodiment. In the fifth and sixth embodiments described above, the illuminating systems 10 are provided on both-side inner walls 13, respectively. Depending

on the volume of the refrigeration compartment 2 and the luminous intensity of the LED 9, for example, in some cases, if the illuminating system 10 is provided on any one of the right and left inner walls 13, the whole refrigeration compartment 2 can be illuminated. Then, according to the embodiment, the illuminating system 10 is provided on any one of the right and left inner walls 13 (in Fig. 24, on the left inner wall 13).

[0058]

If the number of the LEDs 9 used for the light source of the illuminating system 10 herein is equalized to that used in the fifth and sixth embodiments, in which the illuminating systems 10 are provided on the right and left inner walls 13, respectively, since the total emission magnitude (total luminous energy) from all the LEDs 9 is not changed, the sufficient emission magnitude can be ensured for illuminating within the refrigeration compartment 2 being in no way inferior to the illumination according to the fifth and sixth embodiments.

[0059]

Also, in the space within the refrigeration compartment 2, since overlapped portions of the effective illuminating ranges α of the respective LEDs 9 are increased, the illumination becomes brighter in comparison with the case where the same number of the LEDs 9 are arranged on the right and left inner walls 13. Hence, as a result, the same brightness is obtained with smaller number of the LEDs 9 in comparison with the case where the

illuminating systems 10 are arranged on the right and left inner walls 13, respectively, thereby reducing the number of the LEDs 9.

[0060]

Fig. 25 is a drawing showing a control example when the illuminating system 10 is arranged on any one of the right and left inner walls 13. As described above, as long as a range visible when a door is opened can only be illuminated with the LEDs 9, the necessary and enough illuminating effect is obtained. For example, when the illuminating systems 10 are arranged on the right and left inner walls 13, respectively, any one of the illuminating systems 10 is turned on according to the door opened, the sufficient illuminating effect and the electric power saving can be achieved. For example, even when the illuminating system 10 is arranged only on one inner wall 13, by the adjustment of the duty ratio of the LEDs 9, the substantially equivalent effect can be achieved.

[0061]

On the basis of the signal transmitted from the door switches 24A and 24B, when the controlling means 100 determines that both the right and left doors are opened, the LEDs 9 are allowed to emit light by setting the duty ratio at 100%. When determining that one door is opened, for example, the LEDs 9 may be allowed to emit light with brightness corresponding to a duty ratio of about 50%.

[0062]

The brightness of the light emitted from the LEDs 9 may also be allowed to differ between a case where the door adjacent (nearer) to the illuminating system 10 is opened and a case where the door opposite (farther) to the illuminating system 10 is opened. For example, when the door adjacent to the illuminating system 10 is opened, the LEDs 9 are allowed to emit light with the brightness corresponding to a duty ratio of about 40%; when the door opposite to the illuminating system 10 is opened, the LEDs 9 are allowed to emit light with the brightness corresponding to a duty ratio of about 60%. Also, by allowing the brightness of the light from the LEDs 9 to differ, the illumination situation may be kept constant in the refrigeration compartment 2 visible from the door opened. By the adjustment of the duty ratio, the electric power consumption can be suppressed. In addition to the adjustment of the duty ratio according to the distance to the illuminating system 10, the duty ratio may also be adjusted in accordance with the area of the necessary illumination range, for example.

[0063]

As described above, according to the seventh embodiment, in the refrigerator 1 having the right door 6A and the left door 6B, when any one of the right door 6A and the left door 6B is opened, the duty ration is reduced smaller than that when both the doors are opened so as to regulate the brightness for the refrigeration compartment 2 for illuminating the necessary region,

so that excessive electric power consumption is suppressed to obtain an electric power saving refrigerator 1. In particular, in the refrigerator 1 having the illuminating system 10 arranged on any one of the right and left inner walls 13, by determining whether the opened door is the door adjacent to the illuminating system 10 or is the door away from the system, the duty ratio is changed, so that fine adjustment to keep the illumination situation constant can be executed.

[0064]

Eighth Embodiment

Fig. 25 is a plan view of a refrigeration compartment 2 according to an eighth embodiment. In the embodiments described above, by attaching the illuminating system 10 such that the angle of the optical axis of the LEDs 9 defined by the inner wall 13 is to be more than 60° , the optical axis 12 of the LEDs 9 does not directly enter the front edge of the loading shelf 8. According to the embodiment, for not allowing the light of the LEDs 9 in the direction of optical axis 12 to directly enter the loading shelf 8, the illuminating system 10 is attached such that the angle of the optical axis 12 of the LEDs 9 defined by the inner wall 13 is to be smaller than 30° . Depending on the shape of the inner wall 13, when the angle θ of the optical axis 12 of the LEDs 9 is to be rather smaller than 30° , the light in the optical axial direction can be effectively not allowed to directly enter the loading shelf 8. Also, by reducing the angle θ smaller

than 30° , during illuminating the whole refrigeration compartment 2, the reflected light from the recess 13A can be used, so that the well-balanced illumination can be performed without unevenness.

[0065]

Fig. 26 includes drawings showing the relationship between the LED 9 and the inner wall 13. When the angle θ of the optical axis of the LED 9 defined by the inner wall 13 is to be smaller than 30° , the effective illuminating range α is to be as shown in Fig. 26(a). Then, the rear side of the recess 13A provided on the inner wall 13 according to the embodiment has a curved part 13B.

[0066]

As for the light emitted from the LED 9, for example, the light proceeding in a direction veered to the right of the optical axis 12 directly enters the refrigeration compartment 2 to illuminate within the refrigeration compartment 2, as shown in Fig. 26(b). On the other hand, the light proceeding in a direction veered to the left of the optical axis 12 is reflected at the recess 13A, as shown in Fig. 26(c). When the light incident on parts other than the curved part 13B is reflected, the light enters within the refrigeration compartment 2. The light reflected at the curved part 13B proceeds in the direction toward the door pocket 11 of the door opened so as to illuminate the door pocket 11.

[0067]

In such a manner, the light in the optical axis of the LED 9 does not enter the loading shelf 8 directly, so that a user of the refrigerator 1 cannot feel glare of the reflected light from the loading shelf 8. The light emitted from the LED 9, including the light directly entering the refrigeration compartment 2 and the light reflected from the inner wall 13, is used for illuminating the refrigeration compartment 2 and the door pocket 11 of the door 6 opened.

[0068]

Fig. 27 includes drawings showing light reflection measures in the recess 13A according to the eighth embodiment. As shown in Fig. 27(a), when any particular measure is not taken, the light reflected from the inner wall 13 is to be attenuated. On the other hand, Fig. 27(b) shows the high reflection material 13C added on the entire concave surface of the recess 13A for increasing the light reflection factor. By adding the high reflection material 13C, the light proceeding toward the recess 13A can be effectively reflected. The material of the high reflection material 13C is not limited particularly; however, it may be formed of aluminum by the vapor deposition.

[0069]

Fig. 27(c) shows the high reflection material 13C added on parts other than the curved part 13B of the recess 13A. As mentioned above, the light reflected at part of the curved part 13B proceeds

toward the door pocket 11 of the door opened; if the reflection factor is excessively increased, the magnitude of the reflected light proceeding toward the front of the refrigeration compartment 2 is increased, raising the possibility that a user of the refrigerator may feel the glare. Then, the light incident on parts other than the curved part 13B is reflected at the high reflection factor so as to enter the refrigeration compartment 2 while the light incident on the curved part 13B is to be attenuated due to the reflection. Alternatively, as shown in Fig. 27(d), a lamp cover 25 may be provided for attenuating the light proceeding toward the door pocket 11 due to diffusion and damping.

[0070]

Fig. 28 includes drawings showing the shapes of the recess 13A. In Fig. 26, etc., by providing the curved part 13B, the light is allowed to proceed toward the door pocket 11; however, the shape of the recess 13A according to the embodiment is not limited to the curved part 13B. For example, as shown in Fig. 28(a), an inclination part 13D forming one inclination part may be provided; as shown in Fig. 28(b), a plural inclination part 13E forming a plurality of inclination parts may also be provided.

[0071]

As described above, according to the eighth embodiment, the angle of the optical axis 12 of the light emitted from the LEDs 9 defined by the inner wall 13 is to be smaller than 30° , and the light in the optical axis 12 is not allowed to directly enter

the loading shelf 8, so that in the same way as that in the first embodiment, the light in the optical axis 12 of the LEDs 9 cannot abut the front edge of the loading shelf 8 directly, alleviating the glare feeling of a user and ensuring high visibility within the refrigeration compartment 2. At this time, as for the light proceeding toward the recess 13A, part of the reflected light is allowed to enter the refrigeration compartment 2 while part of the light reflected at the curved part 13B is used for illuminating the door pocket 11, so that both the inside of the refrigeration compartment 2 and the door pocket 11 can be illuminated. Also, by adding the high reflection material 13C on the concave surface of the recess 13A, the illumination can be performed more efficiently.

[0072]

Ninth Embodiment

Fig. 29 includes drawings showing the arrangement of the LEDs 9 within the refrigeration compartment 2 according to a ninth embodiment. In the embodiments described above, the illuminating system 10 having the LEDs 9 as light sources is arranged within the recess 13A formed on the inner wall 13 of the refrigeration compartment 2, and the printed circuit board 16 having the LEDs 9 mounted thereon is arranged such that the vertical direction of the refrigeration compartment 2 is to be the longitudinal direction of the printed circuit board 16. As shown in Fig. 29(a), the LEDs 9 are fundamentally arranged at equal intervals as equal

as possible for illuminating within the whole refrigeration compartment 2.

[0073]

In the case of Fig. 29(a), the vicinity of the center of the refrigeration compartment 2 is illuminated with the light emitted from two LEDs 9 adjacent to each other in the vertical direction, so that the brightness is increased. On the other hand, the vicinities of upper and lower ends of the refrigeration compartment 2 are illuminated with the light of only one LED 9, respectively, so that the brightness is reduced lower than in the vicinity of the center.

[0074]

Then, according to the embodiment, as shown in Fig. 29(b), the number of the LEDs 9 arranged on the upper end portion or the lower end portion of the illuminating system 10 is increased to have two, for example, so that the vicinities of upper and lower ends of the refrigeration compartment 2 are improved in brightness. On the residual other portion, the LEDs 9 are arranged at equal intervals.

[0075]

As described above, according to the ninth embodiment, by increasing the number of the LEDs 9 arranged on the upper and lower end portions of the illuminating system 10, the brightness unevenness in the vertical direction is improved to unify the brightness within the refrigeration compartment 2, so that the

inexpensive and efficient refrigerator 1 can be obtained.

[Brief Description of the Drawings]

[0076]

[Fig. 1] Fig. 1 is a schematic side sectional view of a refrigerator 1 according to a first embodiment.

[Fig. 2] Fig. 2 is a front view of a refrigeration compartment 2.

[Fig. 3] Fig. 3 is a drawing of general luminous characteristics of an LED 9.

[Fig. 4] Fig. 4 includes plan views of the refrigeration compartment 2.

[Fig. 5] Fig. 5 includes plan views of a conventional refrigerator.

[Fig. 6] Fig. 6 is a drawing showing the relationship between an illuminating system 10 and a lamp cover 15.

[Fig. 7] Fig. 7 includes drawings showing changes in the light of the LED 9 when using the lamp cover 15.

[Fig. 8] Fig. 8 includes drawings showing the positional relationship between the LED 9 and the lamp cover 15.

[Fig. 9] Fig. 9 includes drawings showing the relationship between the shape of the lamp cover 15 and the light refraction.

[Fig. 10] Fig. 10 is a table showing characteristics of resin materials.

[Fig. 11] Fig. 11 includes drawings showing a mounting method of the illuminating system 10 on the refrigerator 1.

[Fig. 12] Fig. 12 includes drawings showing examples of the shape of the inner wall 13.

[Fig. 13] Fig. 13 includes drawings showing countermeasures about the light reflection according to a second embodiment.

[Fig. 14] Fig. 14 is a front view of the refrigeration compartment 2 including a supply opening 26.

[Fig. 15] Fig. 15 is a drawing of the lamp cover 15 having the supply opening 26.

[Fig. 16] Fig. 16 includes driving circuit diagrams.

[Fig. 17] Fig. 17 includes drawings showing examples of an operation panel provided on the door of the refrigerator.

[Fig. 18] Fig. 18 is a drawing of a flashing example of the LED 9.

[Fig. 19] Fig. 19 is a drawing showing the relationship between the brightness and the lighting period.

[Fig. 20] Fig. 20 is a drawing showing the relationship between the self-check abnormal information and the duty ratio adjustment.

[Fig. 21] Fig. 21 is a front view of a refrigerator 1A according to a fifth embodiment.

[Fig. 22] Fig. 22 includes drawings showing the illumination with the LEDs 9 in the refrigeration compartment 2.

[Fig. 23] Fig. 23 includes drawings showing the illumination within the refrigeration compartment 2 according to a sixth embodiment.

[Fig. 24] Fig. 24 includes drawings showing the illumination

within the refrigeration compartment 2 according to a seventh embodiment.

[Fig. 25] Fig. 25 is a drawing showing control when the illuminating system 10 is arranged on one inner wall 13.

[Fig. 26] Fig. 26 is a plan view of a refrigeration compartment 2 according to an eighth embodiment.

[Fig. 27] Fig. 27 includes drawings showing light reflection measures according to the eighth embodiment.

[Fig. 28] Fig. 28 includes drawings showing the shapes of the recess 13A.

[Fig. 29] Fig. 29 includes drawings showing the arrangement of the LEDs 9 according to a ninth embodiment.

[Reference Numerals]

[0077]

1: refrigerator, 2: refrigeration compartment, 3: interchangeable compartment, 4: vegetable compartment, 5: freezing compartment, 6: hinged door, 7: pull out door, 8: loading shelf, 9: LED, 10: illuminating system, 11: door pocket, 12: optical axis, 13: inner wall, 13A: recess, 13B: curved part, 13C: high reflection material, 13D: inclination part, 13E: plural inclination part, 14: claw, 15, 17, 25: lamp cover, 15A: lens unit, 16: printed circuit board, 18: original optical axis, 19: relay, 20: transistor, 21: operation panel, 22: liquid crystal display, 23: abnormal display LED, 24: door switch, 26: supply opening, 27: partition plate, 100: controlling means.

[Name of Document] CLAIMS

[Claim 1]

A refrigerator comprising:

a storage compartment having a space, which is openable to/closable from an exterior space via a door, for accommodating storage goods;

one or a plurality of loading shelves for zoning the storage compartment into a plurality of storage spaces in a vertical direction; and

an illuminating system in that a plurality of light-emitting diodes are arranged on a side wall of the storage compartment in the vertical direction at positions adjacent to the door from the loading shelf for illuminating the storage compartment,

wherein on a plane parallel to the loading shelf, the plurality of light-emitting diodes of the illuminating system are directed such that an angle of an optical axis of the light-emitting diodes defined by the side wall is larger than 60° as well as the light from the light-emitting diodes in the optical axial direction is not allowed to directly enter the loading shelf.

[Claim 2]

The refrigerator according to Claim 1, further comprising a lamp cover arranged to face a proceeding direction of light emitted from the light-emitting diodes and having a lens unit for expanding an illuminating range in the storage compartment by refracting the light emitted from the light-emitting diodes.

[Claim 3]

The refrigerator according to Claim 2, wherein the lamp cover is arranged such that light in the optical axial direction enters the lens unit.

[Claim 4]

The refrigerator according to Claim 2 or 3, wherein the lamp cover is provided with a claw for assembling the illuminating system.

[Claim 5]

The refrigerator according to anyone of Claims 1 to 4, wherein the plurality of light-emitting diodes are accommodated within a recess formed on the side wall.

[Claim 6]

The refrigerator according to Claim 5, wherein on a plane parallel to the loading shelf, instead of the angle of the optical axis of the light-emitting diodes defined by the side wall being larger than 60° , the plurality of light-emitting diodes accommodated in the recess are directed such that the angle of the optical axis of the light-emitting diodes defined by the side wall is smaller than 30° .

[Claim 7]

The refrigerator according to Claim 5 or 6, wherein the recess is formed such that the door opened is illuminated with part of the light reflected at a concave surface of the recess.

[Claim 8]

The refrigerator according to any one of Claims 5 to 7, wherein a high reflection material is added on the entire or part of the concave surface of the recess.

[Claim 9]

The refrigerator according to any one of Claims 1 to 8, further comprising controlling means for determining abnormality in the refrigerator,

wherein the controlling means flashes the light-emitting diodes for displaying the abnormality.

[Claim 10]

The refrigerator according to any one of Claims 1 to 8, further comprising controlling means for determining operational conditions and abnormality in the refrigerator,

wherein the controlling means changes the luminous intensity of the light-emitting diodes for displaying the operational conditions and/or the abnormality.

[Claim 11]

The refrigerator according to any one of Claims 1 to 10, wherein the door for opening/closing the storage compartment is to be double doors hinged on both right and left side walls, respectively, and the light-emitting diodes of the illuminating system are arranged on both the right and left side walls, respectively, the light-emitting diodes arranged on the side wall hinged to the opened door are turned on to emit light.

[Claim 12]

The refrigerator according to any one of Claims 1 to 10, wherein the door for opening/closing the storage compartment is to be double doors hinged on both right and left side walls, respectively, and the light-emitting diodes of the illuminating system are arranged on both the right and left side walls, respectively, the light-emitting diodes arranged on the side wall opposite to the wall hinged to the opened door are turned on to emit light.

[Claim 13]

The refrigerator according to any one of Claims 1 to 10, wherein the door for opening/closing the storage compartment is to be double doors hinged on both right and left side walls, respectively, the light-emitting diodes of the illuminating system are arranged on at least one of the side walls, and luminous intensity of the light-emitting diodes is changed based on the door opened.

[Claim 14]

The refrigerator according to any one of Claims 1 to 13, wherein the number of the light-emitting diodes arranged on upper and lower parts of the illuminating system is increased larger than that on the other part.