

DESCRIPTION

HEAT-GENERATING ELEMENT COVER WITH EXCELLENT
HEAT ABSORPTIVITY, SURFACE-TREATED METAL SHEET
THEREFOR AND THEIR APPLICATIONS

5

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a product having excellent heat absorptivity and, more specifically, the present invention relates to a metal or nonmetallic cover enclosing inside thereof a component that generates heat, such as motor, electronic part, heater and battery, and a surface-treated metal sheet as a material for the cover. The present invention also relates to a refrigerator using the above-described material sheet having excellent heat absorptivity, and a portable device (mobile device), an in-vehicle device and a case therefor, which prevents elevation of temperature by coating a highly heat-absorptive coating material on the inner side of the case. The portable device and in-vehicle device include a cellular phone, a notebook computer, a PDA, in-vehicle battery case, vehicle navigation system, vehicle audio device and in-vehicle control equipment.

25

BACKGROUND ART

Conventionally, metal sheets such as a steel sheet and aluminum sheet have been used for the exterior plates of home electric appliances or for the cover materials of inner parts. These metal sheets are required to have performances such as corrosion resistance and design property, and therefore, are usually surface-treated before use. Examples of such metal sheets include a galvanized steel sheet excellent in a corrosion resistance, a galvanized steel sheet with chromate coating, and a precoated metal sheet previously applied with a coating and thereby imparted with design property.

35

Additional performances required of these metal

sheets are fingerprint resistance, earthing or grounding property, working and scuffing resistance, and the like. To satisfy these requirements, various surface-treated steel sheets have been developed.

5 For example, Japanese Examined Patent Publication (Kokoku) No. 4-14191 discloses a technique, for improving corrosion resistance and fingerprint resistance, where an organic composite layer composed of an aqueous organic resin adjusted by adding colloidal sol having a specific
10 fine particle size is formed on a plated steel sheet coated with chromate. Also, Japanese Unexamined Patent Publication (Kokai) No. 5-65666 discloses a technique of applying a coating material containing a wax and a
15 lubricant on a steel sheet and thereby improving the working and scuffing property and Kokai No. 10-16128 discloses a technique of coating a chromate-treated metal surface with a layer controlled in the surface roughness and the layer thickness and thereby imparting fingerprint resistance and earthing or grounding property.

20 Furthermore, nonmetallic materials such as plastic are also used for the exterior plates of home electric appliances or for the cover material of inner parts.

 With recent popularization of computers and computerization of home electric appliances, a large
25 number of components working as a heat source, such as motors and electronic parts, are used inside the computer or the home electric appliance. The heating value of such a heat source is also increasing. Therefore, the outside plate of products or the cover material of inner
30 parts is required to have a property of suppressing the heat generated in the inside or releasing the heat with high efficiency. The heat-generating element cover for home electric appliances is further required to have electrical conductivity for earthing or grounding.

35 In order to prevent the elevation of temperature inside the electronic equipment containing an electronic component, a technique of providing a heat radiation fin

in the electronic device, providing a heat radiation opening in the electronic device case or forcedly performing cooling with a fan inside the electronic device has been heretofore employed.

5 The electronic equipment is weak against heat and when the temperature is elevated, it causes malfunction or reduction in the performance. Therefore, heat radiation and cooling are important. In recent years, higher integration and finer wiring are being demanded
10 and used and a measure against reduction in performance, due to elevation of temperature, such as malfunction and lowered working speed, is becoming more important. Particularly, in the case of a portable device (mobile device), small-size electronic equipment or an in-vehicle
15 device used outdoors and exposed to heat generated by an engine or the like, it is very important to prevent heat generated due to self-heating of an internal and heat-generating electronic component or a battery from accumulating within the equipment case and elevating the
20 temperature of the electronic equipment or battery.

 A technique heretofore predominantly employed for the heat radiation from electronic equipment cases is to form an opening for releasing heat or to form the case from a heat transferring material. Also, a method of
25 applying a coating material having good radiating property to the outer side of the case and thereby enhancing the heat radiation has been proposed.

 As for conventional techniques similar to the present invention, Japanese Unexamined Patent Publication
30 (Kokai) No. 11-340639 discloses a method of applying a layer containing an infrared absorbent to the inside surface of an outer housing for electronic equipment, in which a TV receiver or other portable information device is enclosed.

35 As such, various methods have been proposed or employed for the cooling or heat radiation of electronic equipment, however, the construction material of the case

for portable or in-vehicle devices is often restricted in view of appearance, reduction in weight or the like. Furthermore, for realizing downsizing and higher performance, more efficient cooling or heat radiation is being demanded.

In light of these requirements, a first object of the present invention is to develop a technique of imparting excellent heat absorptivity to a metal or nonmetallic heat-generating element cover or a surface-treated metal sheet and provide a metal or nonmetallic heat-generating element cover and a surface-treated metal sheet, which are favored with excellent heat absorptivity.

In connection with the first object, a second object of the present invention is to develop a technique of imparting excellent heat absorptivity to a outside plate and provide a refrigerator having excellent thermal efficiency and a production method for efficiently producing a refrigerator having excellent heat absorptivity.

A third object of the present invention is to provide a case, more improved in a heat radiation property, which is used for portable or in-vehicle devices containing a heat-generating electronic component, and provide a portable or in-vehicle device with such a case.

DISCLOSURE OF THE INVENTION

As a result of extensive investigations, the present inventors have found that when a substance having high heat absorptivity is applied to the inside surface of a metal-made and nonmetal-made cover for a heat source of a home electric appliance, the temperature inside the heat source cover is lower compared with the case of not applying a substance having high heat absorptivity.

The present invention has been accomplished based on this finding and the gist of the present invention

resides in the following.

5 (1) A heat-generating element cover having excellent heat absorptivity, comprising a heat-generating element cover body having coated at least on the inner surface thereof a heat-absorptive layer of which entire emissivity measured at a temperature in a range of 80°C to 200°C is 0.70 or more in the wave number region of 600 to 3,000 cm^{-1} .

10 (2) The heat-generating element cover having excellent heat absorptivity as described in (1) above, wherein the heat-absorptive layer comprises 100 parts by mass of a binder solid content and from 10 to 150 parts by mass of a heat-absorptive pigment.

15 (3) The heat-generating element cover having excellent heat absorptivity as described in (1) and (2) above, wherein the heat-absorptive layer comprises from 1 to 20 parts by mass of a carbon having a particle size of less than 0.1 μm and from 1 to 140 parts by mass of a carbon having a particle size of 0.1 to 50 μm per 100 parts by mass of the binder solid content and in the heat-absorptive layer, the total of a carbon having a particle size of less than 0.1 μm and a carbon having a particle size of 0.1 μm to 50 μm is from 10 to 150 parts by mass.

25 (4) The heat-generating element cover having excellent heat absorptivity as described in (1) to (3) above, wherein the heat-absorptive layer comprises 100 parts by mass of a binder solid content, from 10 to 150 parts by mass of a heat-absorptive pigment and from 1 to 150 parts by mass of an electrically conducting pigment.

30 (5) The heat-generating element cover having excellent heat absorptivity as described in (4) above, wherein the heat-absorptive pigment is a carbon black having an average particle size of 1 to 100 nm, the electrically conducting pigment comprises a flaked metal Ni having an average particle size of 0.5 to 50 μm and a

chained metal Ni, and the mass ratio of flaked metal Ni/chained metal Ni is from 0.1 to 6.

5 (6) The heat-generating element cover having excellent heat absorptivity as described in (2) to (5) above, wherein the electrically conducting pigment is ferrosilicon.

10 (7) The heat-generating element cover having excellent heat absorptivity as described in (1) above, wherein the heat-absorptive layer comprises 100 parts by mass of a binder solid content and from 5 to 150 parts by mass of ferrosilicon.

(8) The heat-generating element cover as described in (1) to (7) above, wherein the heat-generating element cover body is made of a metal.

15 (9) The heat-generating element cover as described in (1) to (7) above, wherein the heat-generating element cover body is made of a nonmetal.

20 (10) A surface-treated metal sheet having excellent heat absorptivity, comprising a metal sheet or plated metal sheet having coated at least on one surface thereof a heat-absorptive layer of which entire emissivity measured at a temperature in a range of 80°C to 200°C is 0.70 or more in the wave number region of 600 to 3,000 cm^{-1} .

25 (11) The surface-treated metal sheet having excellent heat absorptivity as described in (10) above, wherein the heat-absorptive layer comprises 100 parts by mass of a binder solid content and from 10 to 150 parts by mass of a heat-absorptive pigment.

30 (12) The surface-treated metal sheet having excellent heat absorptivity as described in (10) or (11) above, wherein the heat-absorptive layer comprises from 1 to 20 parts by mass of a carbon having a particle size of less than 0.1 μm and from 1 to 140 parts by mass of a
35 carbon having a particle size of 0.1 to 50 μm per 100 parts by mass of the binder solid content and in the

heat-absorptive layer, the total of a carbon having a particle size of less than 0.1 μm and a carbon having a particle size of 0.1 μm to 50 μm is from 10 to 150 parts by mass.

5 (13) The surface-treated metal sheet having excellent heat absorptivity as described in (10) to (12) above, wherein the heat-absorptive layer comprises 100 parts by mass of a binder solid content, from 10 to 150 parts by mass of a heat-absorptive pigment and from 1 to 10 150 parts by mass of an electrically conducting pigment.

 (14) The surface-treated metal sheet having excellent heat absorptivity as described in (13) above, wherein the heat-absorptive pigment is a carbon black having an average particle size of 1 to 100 nm, the 15 electrically conducting pigment comprises a flaked metal Ni having an average particle size of 0.5 to 50 μm and a chained metal Ni, and the mass ratio of flaked metal Ni/chained metal Ni is from 0.1 to 6.

 (15) The surface-treated metal sheet having 20 excellent heat absorptivity as described in (12) to (14) above, wherein the electrically conducting pigment is ferrosilicon.

 (16) The surface-treated metal sheet having excellent heat absorptivity as described in (10) above, 25 wherein the heat-absorptive layer comprises 100 parts by mass of a binder solid content and from 5 to 150 parts by mass of ferrosilicon.

 (17) A refrigerator having excellent thermal efficiency, comprising an exterior plate having coated on 30 the inside surface thereof a heat-absorptive layer of which entire emissivity measured at a temperature in a range of 80°C to 200°C or more is 0.70 or more in the wave number region of 600 to 3,000 cm^{-1} .

 (18) The refrigerator having excellent thermal 35 efficiency as described in (17) above, wherein the heat-absorptive layer comprises from 10 to 150 parts by mass

of a carbon per 100 parts by mass of the binder solid content.

5 (19) The refrigerator having excellent thermal efficiency as described in (18) or (19) above, wherein the heat-absorptive layer comprises from 1 to 50 parts by mass of an electrically conducting metal powder per 100 parts by mass of the binder solid content.

10 (20) The refrigerator having excellent thermal efficiency as described in (17) to (19) above, wherein the heat-absorptive layer comprises from 1 to 20 parts by mass of a carbon having a particle size of less than 0.1 μm and from 1 to 140 parts by mass of a carbon having a particle size of 0.1 to 50 μm per 100 parts by mass of the binder solid content and in the heat-absorptive layer, the total of a carbon having a particle size of
15 less than 0.1 μm and a carbon having a particle size of 0.1 μm to less than 50 μm is from 10 to 150 parts by mass and the dry layer thickness is 1 μm or more.

20 (21) A refrigerator having excellent thermal efficiency characterized in that the heat-generating element cover as described in to any one of (1) to (9) above is used as an exterior plate.

25 (22) A refrigerator having excellent thermal efficiency characterized in that the surface-treated metal sheet as described in any one of (10) to (16) above is used as an exterior plate, in which the heat-absorptive layer of said metal sheet is disposed as an inner surface.

30 (23) The refrigerator having excellent thermal efficiency as described in (17) to (22) above, wherein a clear layer or a layer comprising a color pigment is coated on the outer side of the metal-made exterior plate.

35 (24) A method for producing a refrigerator having excellent heat absorptivity, comprising previously

coating the heat-absorptive layer as described in any one of (17) to (20) above on one surface of a flat metal sheet and a clear or color pigment-containing layer on another surface to produce a precoated metal sheet having high heat absorptivity, cutting and working the metal sheet, and then assembling the metal sheet into a refrigerator.

(25) A portable or in-vehicle device, containing a heat-generating electronic component and being enclosed in a case having inside thereof a heat-absorptive layer, the heat-absorptive layer comprising

(A) 100 parts by mass of a binder solid content, from 1 to 20 parts by mass of a carbon having a particle size of less than 0.1 μm , and from 1 to 140 parts by mass of a carbon having a particle size of 0.1 to 50 μm , with the total of a carbon having a particle size of less than 0.1 μm and a carbon having a particle size of 0.1 μm to 50 μm being from 10 to 150 parts by mass;

(B) 100 parts by mass of a binder solid content, from 10 to 150 parts by mass of a heat-absorptive pigment and from 1 to 150 parts by mass of an electrically conducting pigment, the heat-absorptive pigment being a carbon black having an average particle size of 1 to 100 nm and the electrically conducting pigment comprising a flaked metal Ni having an average particle size of 0.5 to 50 μm and a chained metal Ni, with the mass ratio of flaked metal Ni/chained metal Ni being from 0.1 to 6;

(C) 100 parts by mass of a binder solid content, from 10 to 150 parts by mass of a heat-absorptive pigment and from 5 to 150 parts by mass of ferrosilicon; or

(D) 100 parts by mass of a binder solid content and from 5 to 150 parts by mass of ferrosilicon.

(26) A portable or in-vehicle device characterized in that a case for a portable or in-vehicle device containing an electronic component which generates heat

is the heat-generating element cover as described in any one of (1) to (9) above.

5 (27) A portable or in-vehicle device characterized in that a case for a portable or in-vehicle device containing an electronic component which generates heat is made by processing the surface-treated metal sheet as described in any one of (10) to (16) above.

10 (28) The portable or in-vehicle device as described in any one of (25) to (27) above, wherein the case is made of an Mg alloy or an Al alloy.

(29) A portable or in-vehicle device case having a heat-absorptive layer as described in (25) above.

BRIEF DESCRIPTION OF THE DRAWINGS

15 Fig. 1 is a view showing a constitution of a metal-made heat-generating element cover or case having excellent heat absorptivity of the present invention.

Fig. 2 is a view showing a mode of the measuring box for measuring the heat absorptivity.

20

MODE FOR CARRYING OUT THE INVENTION

(Metal or Nonmetallic Heat-Generating Element Cover and Surface-Treated Metal Sheet)

25 In the present invention, the heat-generating element is not particularly limited and includes all components which generate heat, such as motor, electronic part, heater and battery. The heat-generating element cover is used for the purpose of covering, enclosing or housing such a heat-generating element.

30 The heat-absorptive heat-generating element cover of the present invention is described below mainly by referring to a metal sheet-made heat-generating element cover, however, the present invention is not limited thereto and the same applies to the nonmetal-made heat-generating element cover.

35

It is known that heat is one part of electromagnetic waves diverged from a material body and when radiant heat

rays enter into a material body, some are reflected, some other are transmitted and the remaining portions are absorbed (see, for example, Nishikawa and Fujita, "Kikai Kogaku Kiso Koza, Dennetsu Kogaku (Elementary Course of Mechanical Engineering, Electrothermal Engineering)",
5 Rikogaku Sha, p289, (1983)).

When radiant heat rays enter into a metal sheet, a surface-treated metal sheet or a nonmetal material, the thermal radiant ray is scarcely transmitted and
10 therefore, the thermal radiant ray is reflected or absorbed.

Here, when radiant heat rays generated from a heat-generating element enter into the inner surface of a heat-generating element cover, if many radiant heat rays
15 entered are reflected within the cover, heat is accumulated inside the heat-generating element cover and the temperature within the cover elevates.

Therefore, in order to lower the temperature within the heat source cover, radiant heat rays must be
20 prevented from reflecting inside the cover. The present inventors have made extensive studies, as a result, it has been found that when the inside of the cover is coated with a layer having high heat absorptivity, the reflection of radiant heat rays can be prevented.

25 With respect to the method for examining the absorptivity of radiant heat rays entered into the surface of a metal sheet, a nonmetal material or the like, a reflection method using an infrared spectrophotometer is well known, however, in the case
30 where the metal sheet or nonmetal material has a rough surface, the entered radiant heat rays are irregularly reflected and the absorptivity cannot be obtained with high precision in the measurement by this method.

According to the Kirchhoff's law regarding thermal
35 radiation, the absorptivity and the emissivity of a material body become the same at a fixed temperature (see, for example, Nishikawa and Fujita, "Kikai Kogaku

Kiso Koza, Dennetsu Kogaku (Elementary Course of Mechanical Engineering, Electrothermal Engineering)", p290, (1983)), Rikogaku Sha).

5 Based on this knowledge, the present inventors have
made extensive investigations and, as a result, it has
been found that when a surface-treated metal sheet
obtained by previously coating at least one surface of a
metal sheet or a plated metal sheet with a heat-
absorptive layer having an entire emissivity of 0.70 or
10 more in the wave number region of 600 to 3,000 cm^{-1} as
measured at a temperature in a range of 80°C to 200°C is
formed to produce a cover while laying the surface coated
with the heat-absorptive layer on the inner side of the
heat-generating element cover and a heat-generating
15 element is covered with the cover, the temperature inside
the cover is lower as compared with the case of covering
the heat-generating element with a cover produced from a
metal sheet where the inner surface of the cover is not
coated with a heat-absorptive layer. Similarly, it has
20 been also found that when a heat-generating element is
covered with a nonmetallic material-made cover where the
inner surface thereof is applied with a heat-absorptive
layer having an entire emissivity of 0.70 or more in the
wave number region of 600 to 3,000 cm^{-1} as measured at a
25 temperature in a range of 80°C to 200°C, the temperature
inside the cover is lower as compared with the case of
covering the heat-generating element with a cover where
the inner surface of the cover is not coated with a heat-
absorptive layer.

30 The absorption of radiant rays in the wave number
region at a frequency of less than 600 cm^{-1} or exceeding
3,000 cm^{-1} has a very small effect on the reduction of
temperature within the cover and, therefore, the
emissivity including the radiant rays having these wave
35 number regions is inadequate. Furthermore, if a heat-
absorptive layer having an entire emissivity of less than
0.70 in the wave number region of 600 to 3,000 cm^{-1} is

coated, the effect of reducing the temperature within the cover is small and this is inadequate.

Fig. 1 shows a constitution of a metal or nonmetallic heat-generating element cover having excellent heat absorptivity of the present invention. The metal or nonmetallic heat-generating element cover of the present invention is characterized in that the cover is composed of a metal sheet or nonmetallic material 1 and the inner surface of the cover is coated with a heat-absorptive layer 2. In the Figure, 3 is a heat-generating element. When a heat-absorptive layer 2 is previously coated on a flat metal or nonmetal sheet and the metal or nonmetal sheet is worked to produce a metal or nonmetallic heat-generating element cover, the working efficiency in the production is improved and therefore, this is preferred.

If the surface coated with the heat-absorptive layer of the metal sheet or nonmetallic material does not constitute the inner surface of the heat-generating element cover, the effect of reducing the temperature within the heat-generating element cover cannot be obtained. The heat-absorptive layer may be coated not only on the inner surface of the heat-generating element cover but also on the outer side. When coated also on the outer side, the temperature of the metal or nonmetallic heat-generating element cover itself is lower due to the effect of heat radiation equivalent to the heat absorption and therefore, this is more preferred.

The metal sheet or nonmetallic material constituting the metal or nonmetallic heat-generating element cover having excellent heat absorptivity of the present invention is succeeded in securing the heat absorptivity by coating at least one surface of a metal sheet, a plated metal sheet or a nonmetallic material with a heat-absorptive layer composed of a) 100 parts by mass of a binder solid content and b) from 10 to 150 parts by mass of a heat-absorptive pigment and having an entire emissivity of 0.70 or more in the wave number region of

600 to 3,000 cm^{-1} as measured at a temperature in a range of 80°C to 200°C.

5 The heat-absorptive pigment may be a generally known pigment such as carbon, charcoal and graphite, or may be a commercially available pigment. Among these heat-absorptive pigments, carbon black is preferred because the particle size is very small and this pigment disperses widely in the layer. Carbon black having a particle size of 1 to 100 nm is more preferred.

10 The present inventors have further found that for elevating the entire emissivity of the layer coated on a metal sheet or a nonmetallic material and thereby enhancing the heat absorptivity, it is effective to add carbon to the layer and mask the metal sheet or
15 nonmetallic material with such a substance. Here, carbon may be a generally known carbon such as carbon black, charcoal and graphite. In order to mask the metal sheet or nonmetallic material with carbon, a carbon having a smaller particle size must be added in a large amount.
20 If a carbon having a small particle size is added in a slight amount, the masking effect is small, whereas in the case of carbon having a large particle size, if the carbon is added in a large amount, a gap is generated between carbon particle and carbon particle and the
25 masking effect decreases. However, if carbon having a small particle size is added in a large amount, the viscosity of the coating solution containing a binder solid content and the carbon is increased and this causes problems, such as, for example, the workability in
30 coating decreases or fine carbon particles dispersed in the coating solution are aggregated in time to bring about gelling of the coating solution. The present inventors have extensively studied to solve these problems, as a result, have been found that the above-
35 described problems can be solved by using a carbon having a small particle size of less than 0.1 μm and a carbon

having a large particle size of 0.1 to 50 μm in combination. When these carbons are used in combination, a fine particle carbon is dispersed in the gap between carbons of large particle size dispersed in the layer and therefore, even if a fine particle carbon is not added in a large amount, the masking of metal sheet or nonmetallic material with carbon is improved and the heat-absorptive effect is exerted.

In a preferred embodiment of the present invention accomplished based on this finding, the heat-absorptive layer comprises from 1 to 20 parts by mass of a carbon having a particle size of less than 0.1 μm and from 1 to 140 parts by mass of a carbon having a particle size of 0.1 to 50 μm per 100 parts by mass of a binder solid content and in the heat-absorptive layer, the total of a fine particle carbon having a particle size of less than 0.1 μm and a large particle carbon having a particle size of 0.1 μm to 50 μm is from 10 to 150 parts by mass and the layer thickness is 1 μm or more. The lower limit of the particle size of the fine particle carbon is not particularly specified, however, if the particle size is 0.1 μm or more, a gap is readily generated between carbon particle and carbon particle and this carbon disadvantageously fails to play a role as a fine particle carbon. If the amount of the fine particle carbon added is less than 1 part by mass, the effect of masking the metal sheet or nonmetallic material is inferior to give poor heat absorptivity and this is improper, whereas, if the amount added exceeds 20 parts by mass, the coating solution may be increased in the viscosity or gelled in time and this is improper. If the particle size of the large particle carbon is less than 0.1 μm , the carbon fails to play a role as the large particle carbon and shows the same behavior as the fine particle carbon and therefore, this is improper, whereas if the particle size

of the large particle carbon exceeds 50 μm , the coatability in coating the coating solution containing the carbon may decrease or the layer after coating may have bad appearance and therefore, this is improper. A preferred particle size of the large particle carbon is 0.1 μm to 30 μm , more preferably 0.1 μm to 10 μm . If the amount of the large particle carbon added is less than 1 part by mass, the heat absorptivity deteriorates, whereas if it exceeds 140 parts by mass, the layer becomes brittle and poor in the workability and this is improper. If the total amount of fine particle carbon and large particle carbon added is less than 10 parts by mass, the heat absorptivity deteriorates, whereas if it exceeds 150 parts by mass, the layer becomes brittle and poor in the workability or the coating solution is increased in the viscosity and shows poor workability in coating and therefore, this is improper. If the layer thickness of the heat-absorptive layer is less than 1 μm , the layer becomes poor in the heat absorptivity and therefore, this is improper.

In one preferred embodiment, the metal sheet or nonmetallic material constituting the metal or nonmetallic heat-generating element cover having the excellent heat absorptivity of the present invention succeeds in ensuring heat absorptivity and electrical conductivity by coating at least one surface of a metal sheet, a plated metal sheet or a nonmetallic material with a heat-absorptive layer comprising a) 100 parts by mass of a binder solid content, b) from 10 to 150 parts by mass of a heat-absorptive pigment and c) from 1 to 150 parts by mass of an electrically conducting pigment and having an entire emissivity of 0.70 or more in the wave number region of 600 to 3,000 cm^{-1} as measured at a temperature in a range of 80°C to 200°C.

The electrically conducting pigment may be a known pigment such as flaked metal Ni, chained metal Ni,

granular metal Al, scaly metal Al and stainless steel powder, or may be a commercially available pigment. Metals in general readily reflect heat to inhibit the heat absorption of the heat-absorptive pigment. However, 5 metal Ni has a property of less inhibiting the heat absorption of the heat-absorptive pigment as compared with other metal pigments. In particular, a chained metal Ni is preferred because the area of reflecting heat within the layer is small due to the chained state and 10 the heat absorption is less inhibited.

However, use of only the chained metal Ni gives poor electrical conductivity and therefore, a flaked metal Ni and a chained metal Ni are preferably used in combination. In this case, the mass ratio of flaked 15 metal Ni/chained metal Ni is preferably from 0.1 to 6 because excellent heat absorptivity and excellent electrical conductivity are attained.

The flaked metal Ni is large in the area of reflecting heat within the layer and readily inhibits the 20 heat absorption. Therefore, if the mass ratio of flaked metal Ni/chained metal Ni is less than 0.1, the electrical conductivity deteriorates, whereas if it exceeds 6, the heat absorptivity deteriorates.

The electrically conducting pigment is preferably 25 ferrosilicon because the emissivity of the heat-absorptive layer is improved and, at the same time, the corrosion resistance is improved in the case of the surface-treated metal sheet. The ferrosilicon is excellent not only in the electrical conductivity but 30 also in the heat absorptivity and can serve concurrently as the electrically conducting pigment and the heat-absorptive pigment, so that even if added alone, the heat absorptivity and the electrical conductivity both can be ensured.

35 If the amount of the heat-absorptive pigment added is less than 10 parts by mass per 100 parts by mass of the binder solid content, the entire emissivity of the

metal sheet as measured at a temperature in a range of 80°C to 200°C becomes less than 0.70 in the wave number region of 600 to 3,000 cm^{-1} and this is improper.

5 As the amount of the heat-absorptive pigment added per 100 parts by mass of the resin solid content is larger, the emissivity becomes higher and this is more preferred. However, if the amount added exceeds 150 parts by mass, the layer becomes brittle and low in the impact resistance or the workability on working the metal
10 sheet decreases and this is improper.

The layer thickness of the heat-absorptive layer may be freely selected as needed but is suitably from 1 to 50 μm in the case of a metal sheet and from 1 to 1000 μm in the case of a nonmetal material. If the layer thickness
15 is less than 1 μm , the entire emissivity of the metal sheet or nonmetallic material as measured at a temperature in a range of 80°C to 200°C hardly reaches 0.70 or more in the wave number region of 600 to 3,000 cm^{-1} . If it exceeds 50 μm in the case of a metal sheet,
20 the layer disadvantageously decreases in the workability. If it exceeds 1000 μm in the case of a nonmetal material, the heat absorption is saturated and is economically disadvantageous. When the electrical conductivity is considered, 1 μm to less than 10 μm is more preferred.

25 The binder constituting the heat-absorptive layer of the present invention may be a generally known binder for layers such as an inorganic layer formed by a resin or a sol-gel method and an inorganic/organic composite layer formed by a sol-gel method. The resin is suitably used
30 in the form of a coating material or the like, because the handling is easy and the layer formation is facilitated.

The resin may be a generally known resin such as polyester resin, urethane resin, acrylic resin, epoxy
35 resin, melamine resin and vinyl chloride resin. The

resin may be either thermoplastic type or thermosetting type.

Several species of these resins may be used in combination, if desired. This resin is not particularly specified but must be appropriately selected as needed, because the performance of layer, such as workability, adhesion and hardness, varies depending on the kind, molecular weight and glass transformation temperature T_g of resin.

The resin which is cured using a crosslinking agent is not particularly specified but must be appropriately selected as needed, because the performance of layer, such as workability, adhesion and hardness, varies depending on the kind and amount added of crosslinking agent, and the kind and amount added of catalyst at the crosslinking reaction.

When the resin used is solid, this may be heat-melted, dissolved in an organic solvent or pulverized into a powder. A water-soluble resin or an emulsion-type resin obtained by water dispersion may also be used. Furthermore, the resin may be an ultraviolet (UV)-curable resin or an electron beam (EB)-curable resin.

According to the knowledge of the present inventors, for example, solvent-type melamine curable polyester resins, solvent-type isocyanate curable polyester resins, and water dispersion-type acryl emulsion resins are preferred. In particular, the following are more preferred, however, these are only examples and the present invention is not limited thereto.

In the case of the solvent-type melamine curable polyester resin, the polyester resin preferably has a molecular weight of 2,000 to 30,000 in terms of the number average molecular weight and a T_g of -10 to 70°C . The amount of the melamine resin added is preferably from 5 to 70 parts by mass per 100 parts by mass of the polyester resin.

If the molecular weight of the polyester resin is

less than 2,000, the workability of layer decreases, whereas if it exceeds 30,000, too high viscosity disadvantageously results when the resin is dissolved in a solvent. If the Tg of the polyester resin is less than
5 -10°C, a layer is not formed and this is improper, whereas if it exceeds 70°C, the layer is too hard and poor in the workability and therefore, this is improper. If the amount of melamine resin added is less than 5 parts by mass per 100 parts by mass of polyester, the
10 layer is uncured and this is improper, whereas if it exceeds 70 parts by mass, the layer is too hard and poor in the workability and therefore, this is improper.

The polyester resin used may be a commercially available product in general, such as "VILON" produced by
15 Toyobo Co., Ltd. and "DESMOFEN", produced by Sumitomo Bayer Urethane Co., Ltd. The melamine resin used may also be a commercially available product in general, such as "CYMEL" and "MYCOAT" produced by Mitsui Cytec Ltd., and "PEKKAMIN" and "SUPER-PEKKAMIN" produced by Dai-
20 Nippon Ink & Chemicals, Inc.

In the case of the solvent-type isocyanate curable polyester resin, the polyester resin preferably has a molecular weight of 2,000 to 30,000 in terms of the number average molecular weight and a Tg of -10 to 70°C.
25 The amount of isocyanate added is preferably an amount of giving $[\text{NCO group equivalent of isocyanate}]/[\text{OH group equivalent of polyester resin}] = 0.8 \text{ to } 1.2$.

If the value of $[\text{NCO group equivalent of isocyanate}]/[\text{OH group equivalent of polyester resin}]$ is
30 less than 0.8 or exceeds 1.2, the layer is liable not to be cured at the layer formation. If the molecular weight of the polyester resin is less than 2,000, the layer becomes poor in the workability, whereas if it exceeds 30,000, a too high viscosity disadvantageously results
35 when the resin is dissolved in a solvent. If the Tg of the polyester resin is less than -10°C, a layer is not formed and this is improper, whereas if it exceeds 70°C,

the layer becomes excessively hard and poor in the workability and therefore, this is improper.

5 The polyester resin used may be a commercially available product in general, such as "VILON" produced by Toyobo Co., Ltd. and "DESMOFEN", produced by Sumitomo Bayer Urethane Co., Ltd.

10 The isocyanate used may also be a commercially available product in general, such as "SUMIDULE" and "DESMODULE" produced by Sumitomo Bayer Co., Ltd. and "TAKENATE" produced by Mitsui Takeda Chemical.

15 The water dispersion-type acryl emulsion resin may be a generally known emulsion resin or a commercially available product. In the water dispersion-type acryl emulsion, a resin having good adhesive property, such as generally known epoxy resin, may be added.

20 The kind and amount added of the epoxy resin affect the performance of the layer and therefore, these can be appropriately selected as needed. An aqueous resin such as water dispersion-type acryl resin is more preferred, because high workability is attained in the coating of layer and a problem that a volatile organic solvent is released into the atmosphere is not generated and, as a result, enhancement of an exhaust duct in the coating equipment or a combustion facility for the volatile organic solvent is not necessary.

25 In the heat-absorptive layer of the present invention, in addition to the heat-absorptive pigment and electrically conducting pigment, a color pigment and a rust-preventive pigment or a rust inhibitor may be used in combination.

30 The color pigment may be a generally known color pigment including inorganic pigments and organic pigments such as titanium oxide (TiO_2), zinc oxide (ZnO), zirconium oxide (ZrO_2), calcium carbonate (CaCO_3), barium sulfate (BaSO_4), alumina (Al_2O_3), kaolin clay, carbon black and iron oxide (Fe_2O_3 , Fe_3O_4).

The rust-preventive pigment may be a generally known

chromium-base rust-preventive pigment such as strontium chromate and calcium chromate, or a generally known non-chromium rust-preventive pigment or rust inhibitor such as zinc phosphate, zinc phosphite, aluminum phosphate, aluminum phosphite, molybdate, phosphomolybdate, vanadic acid/phosphoric acid mixed pigment, silica, and a Ca-adsorbed silica called calcium silicate.

Particularly, in the case where the base metal of the metal sheet of the present invention is a readily corroding metal such as steel sheet or plated steel sheet, a rust-preventive pigment or a rust inhibitor is preferably added, because the metal sheet of the present invention is enhanced in the corrosion resistance.

In considering the recent environmental problem, a non-chromium rust-preventive pigment or rust inhibitor is more preferred. The non-chromium rust-preventive pigment or rust inhibitor may be a reagent or a commercially available product.

Examples of the commercially available rust-preventive pigment include zinc phosphate-base rust-preventive pigments "EXPERT-NP500" and "EXPERT-NP530" produced by Toho Ganryo, zinc phosphite-base rust-preventive pigments "EXPERT-NP1500", "EXPERT-NP1530", "EXPERT-NP1600" and "EXPERT-NP1700" produced by Toho Ganryo, aluminum polyphosphates "K-WHITE Series" produced by Teika, molybdate-base pigments and phosphomolybdate-base pigments "SHER-WHITE Series" produced by Sherwin Williams, gas-phase silicas "AEROSIL Series" produced by Nippon Aerosil and Degussa, colloidal silicas "SNOWTEX Series" produced by Nissan Chemical, and Ca-adsorbed silicas "SHELDEX-Series" produced by Grace.

The color pigment and the rust-preventive pigment or rust inhibitor must be appropriately selected as needed, because the emissivity and the workability, appearance, corrosion resistance and other performances of the layer greatly differ according to their kind, amount added and particle size.

In the heat-absorptive layer of the present invention, a leveling agent, a pigment dispersant, a wax and the like, which are generally known, may be added, if desired. The kind and amount added of these additives
5 are not particularly specified and may be appropriately selected as needed. Particularly, the wax is effective, for example, in improving the formability on forming the surface-treated metal sheet of the present invention or in preventing flawing of the heat-absorptive layer.

10 The heat-absorptive layer of the present invention can be formed on the surface of a metal sheet or a nonmetallic material by forming the layer components including the binder into a generally known coating material form and applying the coating material.

15 Examples of the coating material form include a solvent-type coating material obtained by dissolving a resin in a solvent, an aqueous coating material obtained by forming a resin into an emulsion and dispersing it in water or the like, a powder coating material obtained by
20 pulverizing a resin into powder, a slurry powder coating material obtained by pulverizing a resin into powder and dispersing it in water or the like, an ultraviolet (UV)-curable coating material, an electron beam (EB)-curable coating material, a film laminate, and a form where a
25 resin is melted and then coated.

The coating method is not particularly limited and a generally known coating method may be employed, such as roll coating, roller curtain coating, curtain flow coating, air spray coating, airless spray coating, brush
30 coating and die coater coating. A dip coating or an inkjet coating may be also used.

Before coating the heat-absorptive layer on a metal sheet, the metal sheet is preferably pretreated so as to enhance the adhesion of layer to the metal sheet. When
35 this pretreatment is applied, the adhesive property of heat-absorptive layer and the corrosion resistance of metal sheet are advantageously improved.

When the layer is tightly attached without applying a pretreatment for coating, this is more preferred, because the coating pretreatment step can be dispensed with. The coating pretreatment may be a generally known treatment such as chromate-coating treatment, chromate electrolysis treatment, zinc phosphate treatment, zirconia treatment and titania treatment.

In recent years, a non-chromate pretreatment based on an organic compound such as resin has been developed and when the non-chromate pretreatment based on resin is used, the load on the environment is reduced and therefore, this is more preferred.

Examples of the non-chromate pretreatment based on an organic compound such as resin include the techniques described in Japanese Unexamined Patent Publication (Kokai) Nos. 09-828291, 10-251509, 10-337530, 2000-17466, 2000-248385, 2000-273659, 2000-282252, 2000-265282 and 2000-167482. These and other known techniques can be used.

A non-chromate pretreatment already available on the market may also be used. Depending on the kind and amount attached of the pretreatment, the adhesive property of the heat-absorptive layer and the corrosion resistance of the metal sheet greatly differ, therefore, the pretreatment must be appropriately selected according to necessity.

The metal sheet of the present invention is used for producing a metal-made heat-generating element cover through working and therefore, may be sufficient if it is a metal material which can be worked, and a generally known metal material may be used. The metal material may also be an alloy material. Examples thereof include steel, aluminum, titanium, copper and magnesium alloy. Among these, aluminum and copper having a high heat conductivity are preferred, because the heat absorbed is uniformly dispersed within the metal and the metal can be protected from local heating. The surface of these

materials may be plated.

Examples of the plating include zinc plating, aluminum plating, copper plating and nickel plating. An alloy plating may also be used. In the case of steel sheet, a generally known steel sheet or plated steel sheet can be used, such as cold-rolled steel sheet, hot-rolled steel sheet, hot-dip galvanized steel sheet, electrogalvanized steel sheet, hot-dip galvanized steel sheet, aluminum-plated steel sheet, aluminum-zinc alloyed plated steel sheet and stainless steel sheet.

In particular, a steel sheet plated with an alloy of iron and zinc, such as hot-dip galvanized steel sheet, is preferred because this plated steel sheet itself has high heat absorptivity and when coated with a heat-absorptive layer, the heat absorptivity is more enhanced. Also, when a steel sheet plated with a metal having high heat conductivity, such as aluminum and copper, is coated with a heat-absorptive layer, this is more preferred, because the heat absorbed is uniformly dispersed through the plated layer on the metal surface and the metal can be protected from local heating. The steel sheet plated with a metal having high heat conductivity, such as aluminum and copper, is advantageous not only in that the heat conductivity is improved but also in that the strength and formability of the steel sheet are maintained and because the plated steel sheet is less expensive than the sole use of the metal having high heat conductivity, such as aluminum and copper, the production cost can be reduced.

Before the coating pretreatment is applied, the metal sheet can be subjected to a normal treatment such as warm water washing, alkali degreasing and acid washing. The working method, in the production of a metal-made heat-generating element cover by forming the metal, may be a generally known working method. Examples thereof include forging, casting, stamping, bending, drawing, bulging and roll forming. A precoating system

of previously coating the heat-absorptive layer on the metal sheet and then forming the metal sheet brings high production efficiency and is more preferred.

5 The nonmetal material used in the present invention is any inorganic or organic material other than a metal material, and may be plastics, resins, ceramics, porcelain, cement, as well as naturally-occurring materials. Further, the resin may be any known resins including acrylic resins, vinyl chloride resins, HIPS-
10 based resins, ABS-based resins and polycarbonate-based resins. Also, the ceramics may be any known ceramics including alumina-based, aluminum nitride-based, barium titanate-based, and strontium titanate-based ceramics.

15 In the case of a nonmetallic material, the surface of the nonmetallic material, on which the heat-absorptive layer is coated, may be subjected to a generally known chemical conversion treatment to coarsen the roughness, if desired, so that the adhesion of the heat-absorptive layer can be improved.

20 The applications of the heat-generating element excellent in its heat absorption and the material therefor of the present invention include audio-visual equipment such as VTR, audio equipment, a DVD, a television, a liquid crystal television, a plasma display
25 and a plasma display tuner, and their peripherals; a personal computer, a notebook-type personal computer and a personal computer peripherals such as an optical disc and hard disc drive; mobile equipment such as a cellular phone and an electronic notebook; household electric
30 products such as a refrigerator, an air conditioner outdoor machine, an air conditioner indoor machine, a washing machine, and a lighting appliance; a battery casing, a vehicle-mounted battery casing, a vehicle-mounted electronic parts and equipment, a vehicle
35 navigation system, a vehicle audio device, an automatic vending machine, an exchange machine, ticket- or prepaid card-vending machine, etc. In addition, outer covers,

inside part plates or substrates, inside- or outside-
electronic parts coverings, and product inside- or
outside-control equipment are preferable applications.

5 A refrigerator and portable and in-vehicle devices
to which the heat-generating element cover of the present
invention and the material therefor are applied as well
as their effects which were confirmed are described in
detail below.

(Refrigerator)

10 Inside a refrigerator, a large number of components
working as heat sources, such as a motor and electronic
parts, are used. Particularly, with the recent progress
of computerization of refrigerators, heat generated from
those heat sources is liable to accumulate inside the
15 refrigerator and elevate the internal temperature. When
the temperature inside the refrigerator is elevated, a
larger quantity of electric power is necessary for
lowering the temperature within the cold compartment and,
accordingly, the life of motor or electronic parts is
20 shortened. In recent years, demand for a reduction in
the electric power consumption of electric products such
as refrigerator is increasing in view of the ecology.

As a result of extensive investigation, the present
inventors have found that when a substance having high
25 heat absorptivity is applied to a metal material surface
on the inner side of the exterior plate of a
refrigerator, the temperature in the vicinity of a heat
source such as motor is lowered as compared with the case
where a substance having high heat absorptivity is not
30 applied.

Assuming that the exterior plate constituting the
refrigerator is a heat-generating element cover, those
described above regarding the heat-generating element
cover and the heat-absorptive layer can entirely apply to
35 the exterior plate of the refrigerator of the present
invention and the heat-absorptive layer coated on the
inner surface of the exterior plate. Therefore, their

description is omitted here.

The refrigerator of the present invention may have the same structure and interior as those of known refrigerators except that a specific heat-absorptive layer is coated on the inner surface of the exterior plate.

When a colored layer or a clear layer is coated on the outer surface of the exterior plate of the refrigerator of the present invention, a designed appearance can be imparted and this is more preferred. In order to improve the corrosion resistance in the case of the metal sheet and enhance the design property, this colored or clear layer is preferably composed of a multilayer layer where a rust-preventive layer containing a rust-preventive pigment is used for the lowermost layer, a colored layer containing a color pigment is provided thereon and if desired, a clear layer is further coated on the colored layer.

In the process of assembling the refrigerator, static electricity is generated on the surface layer of a metal sheet used for the outside plate of the refrigerator due to friction with the belt conveyer or other transportation instrument and this causes a problem that dust or motes adhere to the surface of the metal sheet in the assembly line. To solve this problem, the static electricity accumulated on the layer surface must be removed by imparting electrical conductivity to the layer. The heat-absorptive layer coated on the inner side of the exterior plate of the refrigerator of the present invention preferably contains, in addition to the above-described carbons, from 1 to 50 parts by mass of an electrically conducting metal powder per 100 parts by mass of the binder solid content, whereby the layer can have electrical conductivity and this can solve the problem that dust or mote adhere due to static electricity in the process of assembling the refrigerator. The constitution where electrical

conductivity is imparted to the heat-absorptive layer is described above.

5 In the production of the refrigerator of the present invention, when the heat-absorptive layer of the present invention is previously coated on one surface of a metal sheet to produce a precoated metal sheet having high heat absorptivity and the precoated metal sheet is cut and then assembled into a refrigerator while laying the heat-absorptive layer on the inner side of the exterior plate,
10 the working efficiency is elevated and this is preferred.

The working method used in producing a precoated metal sheet previously coated with a heat absorptive layer and then cutting, working and assembling it at the production of the refrigerator having high heat
15 absorptivity of the present invention may be a generally known working method. Examples thereof include stamping, bending, drawing, bulging and roll forming.

(Portable Device and In-Vehicle Device)

20 The present invention has been accomplished based on the finding that when the highly heat-absorptive coating material of the present invention is coated on the inner surface of a case for an electronic device containing an electronic component or battery which generates heat, the elevation of temperature inside the electronic device can
25 be remarkably suppressed.

In the present invention, the portable device (mobile device) and the in-vehicle device are not particularly limited and include a cellular phone, a notebook computer, a PDA, an in-vehicle battery, vehicle
30 navigation system equipment, vehicle audio device and vehicle control equipment.

The heat-generating electronic component is not particularly limited and includes electronic components such as a CPU element, an MPU element, a DSP element, an
35 electronic integrated circuit and a resistance. The battery may be a known one.

The material constituting the case for the portable

or in-vehicle device of the present invention is also not particularly limited but examples thereof include an Mg alloy case, an Al alloy case, a steel case, a case made of other metal, and a plastic case. Among these, an Mg alloy case, an Al alloy case and a steel case are useful.

In one embodiment, the heat-absorptive layer of the portable or in-vehicle device case comprises 100 parts by mass of a binder solid content, from 1 to 20 parts by mass of a carbon having a particle size of less than 0.1 μm , and from 1 to 140 parts by mass of a carbon having a particle size of 0.1 to 50 μm , and in the heat-absorptive layer, the total of a carbon having a particle size of less than 0.1 μm and a carbon having a particle size of 0.1 μm to 50 μm is from 10 to 150 parts by mass.

In a second embodiment, the heat-absorptive layer comprises 100 parts by mass of a binder solid content, from 10 to 150 parts by mass of a heat-absorptive pigment and from 1 to 150 parts by mass of an electrically conducting pigment, the heat-absorptive pigment is carbon black having an average particle size of 1 to 100 nm, the electrically conducting pigment is composed of a flaked metal Ni having an average particle size of 0.5 to 50 μm and a chained metal Ni, and the mass ratio of flaked metal Ni/chained metal Ni is from 0.1 to 6.

In a third embodiment, the heat-absorptive layer comprises 100 parts by mass of the binder solid content, from 10 to 150 parts by mass of a heat-absorptive pigment, and from 10 to 150 parts by mass of ferrosilicon.

In a fourth embodiment, the heat-absorptive layer comprises 10 to 150 parts by mass of ferrosilicon, per 100 parts by mass of the binder solid content.

The specific contents of the heat-absorptive layer in each embodiment are fundamentally the same as those described above regarding the heat-generating element

cover and, therefore, a specific description is omitted here. The heat-generating element cover which has been explained before may be used as a case for a portable device or for an in-vehicle device.

5 The highly heat-absorptive layer of the present invention can be formed on the case surface by forming the layer components including the binder into a generally known coating material form and applying the coating material. Examples of the coating material form
10 include a solvent-type coating material obtained by dissolving a resin in a solvent, an aqueous coating material obtained by forming a resin into an emulsion and dispersing it in water or the like, a powder coating material obtained by pulverizing a resin into powder, a
15 slurry powder coating material obtained by pulverizing a resin into powder and dispersing it in water or the like, an ultraviolet (UV)-curable coating material, an electron beam (EB)-curable coating material, a film laminate, and a form where a resin is melted and then coated.

20 The thickness of the high heat absorptive layer is preferably from 1 to 1000 μm . If it is less than 1 μm , the heat absorption decreases and it is not suitable. If it exceeds 1000 μm , the heat absorption is saturated and, it is not economically preferable. A more preferable
25 thickness is from 10 to 500 μm . From 1 μm to less than 10 μm is more preferred to secure the electrical conductivity.

 The highly heat-absorptive layer of the present invention is generally coated on the case after the case
30 is formed, but in the case of a sheet material, the highly heat-absorptive layer may be coated before the formation of the case.

 In the present invention, the surface coated with the heat-absorptive layer is the inner side of an
35 electronic component case or a battery case, whereby the temperature inside the electronic device case is

decreased.

The constitution of the case having excellent heat absorptivity of the present invention may be the same as that shown in Fig. 1. The case of the present invention is characterized in that the case is composed of, for example, an Mg alloy sheet 1 and the inner surface of the case is coated with a high absorptive layer 2. In the Figure, 3 is a heat-generating electronic component or a battery.

If the surface coated with a highly heat-absorptive layer is not the inner surface of the case, the effect of lowering the temperature within the electronic device case cannot be obtained. However, the highly heat-absorptive layer may be coated also on the outer side of the case, in addition to the inner surface. When the highly heat-absorptive layer is coated also on the outer side, the heat absorbed in the metal sheet as the heat-generating element case is readily released due to the effect of heat radiation equivalent to the heat absorption and the temperature of the case itself is lower, therefore, this is preferred.

On the outer side of the case, a colored layer may be coated to impart a designed appearance. The colored layer may be composed of a multilayer layer where, in the case of a metal-made case, a rust-preventive layer containing a rust-preventive pigment is used for the lowermost layer and a colored layer containing a color pigment is provided thereon. In this case, the colored organic layer (in the case of a multilayer layer, including the rust-preventive layer) itself has a certain level of heat radiation property and therefore, is preferably coated to a thickness of 10 μm or more in total so as to lower the temperature of the case.

EXAMPLES

The method for preparing a heat-absorptive layer coating material used in experiments is described in

detail below.

"VILON GK140" (number average molecular weight: 13,000, Tg: 20°C, produced by Toyobo Co., Ltd.), which is a commercially available organic solvent-soluble
5 amorphous polyester resin (hereinafter referred to as a "polyester resin"), was dissolved in an organic solvent (obtained by mixing SOLVESSO 150 and cyclohexanone at 1:1 by mass).

To this polyester resin dissolved in the organic
10 solvent, 15 parts by mass of CYMEL 303 produced by Mitsui Cytec Ltd., which is a commercially available hexa-methoxy-methylated melamine and, then, 0.5 parts by mass of "CATALYST 6003B" produced by Mitsui Cytec Ltd., which is a commercially available acidic catalyst, were added
15 per 100 parts by mass of the solid content of the polyester resin and the resulting solution was stirred to obtain a melamine curable polyester-base clear coating material (hereinafter referred to as "polyester/melamine (type)").

In order to examine the effect of resin, the
20 polyester resin dissolved in the organic solvent was blended with "SUMIDULE BL3175" produced by Sumitomo Bayer Urethane Co., Ltd., which is a commercially available blocked isocyanate based on HDI, to have an [NCO group
25 equivalent of isocyanate]/[OH group equivalent of polyester resin] ratio of 1.0. Thereafter, a reaction catalyst "TK-1" produced by Mitsui Takeda Chemical was added to a concentration of 0.05% based on the resin solid content to obtain an isocyanate-curable polyester-
30 base clear coating material (hereinafter referred to as a "polyester/isocyanate (type)").

Separately, a commercially available epoxy resin was added to a commercially available water dispersion-type acryl emulsion resin in an amount of 5 mass% as the solid
35 content to obtain a water dispersion-type acryl emulsion/epoxy clear coating material (hereinafter referred to as a "waterborne acryl").

Furthermore, a commercially available ordinary temperature drying-type solvent-base clear coating material (hereinafter referred to as "ordinary temperature-drying solvent-base") and a commercially available ordinary temperature drying-type waterborne clear coating material (hereinafter referred to as "ordinary temperature-drying waterborne coating material") were prepared.

To each clear coating material obtained or prepared, a heat-absorptive pigment, an electrically conducting pigment and a rust-preventive pigment were added, if desired. Then, the mixture was stirred to obtain a heat-absorptive layer coating material. Details of each coating material obtained are shown in Tables 1 to 4.

TABLE 1 (1/3)

Coating Material No.	Species of Binder	Heat-Absorptive Pigment		Electrically Conducting Pigment		Other Pigment Added	
		Species of Pigment Added	Entire Amount of Pigment Added (*1)	Species of Pigment Added	Entire Amount of Pigment Added (*1)	Species of Pigment Added	Entire Amount of Pigment Added (*1)
Coating Material 1-1	polyester/melamine	carbon black (*2)	10	flaked Ni/chained Ni (*6)	10	not added	-
Coating Material 1-2	polyester/melamine	carbon black (*2)	15	flaked Ni/chained Ni (*6)	10	not added	-
Coating Material 1-3	polyester/melamine	carbon black (*2)	100	flaked Ni/chained Ni (*6)	10	not added	-
Coating Material 1-4	polyester/melamine	carbon black (*2)	150	flaked Ni/chained Ni (*6)	10	not added	-
Coating Material 1-5	polyester/melamine	carbon black (*2)	200	flaked Ni/chained Ni (*6)	10	not added	-
Coating Material 1-6	polyester/melamine	charcoal powder (*3)	10	flaked Ni/chained Ni (*6)	10	not added	-
Coating Material 1-7	polyester/melamine	graphite powder (*4)	10	flaked Ni/chained Ni (*6)	10	not added	-
Coating Material 1-8	polyester/melamine	carbon black (*2)	15	flaked Ni/chained Ni (*6)	0.1	not added	-
Coating Material 1-9	polyester/melamine	carbon black (*2)	15	flaked Ni/chained Ni (*6)	1	not added	-
Coating Material 1-10	polyester/melamine	carbon black (*2)	15	flaked Ni/chained Ni (*6)	150	not added	-
Coating Material 1-11	polyester/melamine	carbon black (*2)	15	flaked Ni/chained Ni =0.05 (*12)	10	not added	-
Coating Material 1-12	polyester/melamine	carbon black (*2)	15	flaked Ni/chained Ni (*7)	10	not added	-
Coating Material 1-13	polyester/melamine	carbon black (*2)	15	flaked Ni/chained Ni =0.1 (*8)	10	not added	-
Coating Material 1-14	polyester/melamine	carbon black (*2)	15	flaked Ni/chained Ni (*13)	10	not added	-

TABLE 1 (2/3)

Coating Material No.	Species of Binder	Heat-Absorptive Pigment		Electrically Conducting Pigment		Other Pigment Added	
		Species of Pigment Added	Entire Amount of Pigment Added (*1)	Species of Pigment Added	Entire Amount of Pigment Added (*1)	Species of Pigment Added	Entire Amount of Pigment Added (*1)
Coating Material 1-15	polyester/melamine	carbon black (*2)	15	Al powder (*9)	10	not added	-
Coating Material 1-16	polyester/melamine	carbon black (*2)	15	stainless steel powder (*10)	10	not added	-
Coating Material 1-17	polyester/melamine	carbon black (*2)	15	ferrosilicon (*11)	10	not added	-
Coating Material 1-18	polyester/melamine	electrically conducting carbon black (5*)	15	flaked Ni/chained Ni =6 (*6)	10	not added	-
Coating Material 1-19	polyester/melamine	-	-	ferrosilicon (*11)	30	not added	-
Coating Material 1-20	polyester/isocyanate	carbon black (*2)	15	flaked Ni/granular Ni =6	15	not added	-
Coating Material 1-21	waterborne acryl emulsion	carbon black (*18)	15	flaked Ni/granular Ni =6	15	not added	-
Coating Material 1-22	polyester/melamine	carbon black (*2)	10	flaked Ni/chained Ni =6 (*6)	10	gas phase silica (*14)	5
Coating Material 1-23	polyester/melamine	carbon black (*2)	10	flaked Ni/chained Ni =6 (*6)	10	calcium silicate (*15)	30
Coating Material 1-24	polyester/melamine	carbon black (*2)	10	flaked Ni/chained Ni =6 (*6)	10	aluminum tripolyphosphate (*16)	30
Coating Material 1-25	waterborne acryl emulsion	carbon black (18*)	10	flaked Ni/chained Ni =6	10	colloidal silica (*17)	5
Coating Material 1-26	polyester/melamine	carbon black (*2)	5	flaked Ni/chained Ni =6 (*6)	10	not added	-

TABLE 1 (3/3)

Coating Material No.	Species of Binder	Heat-Absorptive Pigment		Electrically Conducting Pigment		Other Pigment Added	
		Species of Pigment Added	Entire Amount of Pigment Added (*1)	Species of Pigment Added	Entire Amount of Pigment Added (*1)	Species of Pigment Added	Entire Amount of Pigment Added (*1)
Coating Material 1-27	polyester/melamine	carbon black (*2)	15	flaked Ni/chained Ni =6 (*6)	200	not added	-
Coating Material 1-28	polyester/melamine	carbon black (*2)	30	flaked Ni/chained Ni =6 (*7)	10	not added	-
Coating Material 1-29	polyester/melamine	carbon black (*2)	15	not added	-	not added	-
Coating Material 1-30	polyester/melamine	carbon black (*2)	18	not added	-	calcium silicate (*15)	10
Coating Material 1-31	polyester/melamine	carbon black (*2)	19	not added	-	aluminum triphosphate	10
Coating Material 1-32	polyester/isocyanate	carbon black (*2)	20	flaked Ni/chained Ni =6 (*7)	10	not added	-
Coating Material 1-33	polyester/melamine	not added	-	not added	-	not added	-
Coating Material 1-34	polyester/melamine	carbon black (*2)	5	not added	-	not added	-
Coating Material 1-35	polyester/melamine	carbon black (*2)	200	not added	-	not added	-
Coating Material 1-36	polyester/melamine	not added	-	not added	-	titanium oxide (*19)	15

TABLE 2 (1/3)

Coating Material No.	Species of Binder	Fine Particle Carbon		Large Particle Carbon		Entire Amount of Carbon Added (*1)	Other Pigment Added	
		Species of Pigment Added	Entire Amount of Pigment Added (*1) (parts by mass)	Species of Pigment Added	Entire Amount of Pigment Added (*1) (parts by mass)		Species of Pigment Added	Entire Amount of Pigment Added (*1) (parts by mass)
Coating Material 2-1	polyester/melamine	fine particle carbon (*2)	3	large particle carbon A (*3)	10	13	not added	-
Coating Material 2-2	polyester/melamine	fine particle carbon (*2)	10	large particle carbon A (*3)	10	20	not added	-
Coating Material 2-3	polyester/melamine	fine particle carbon (*2)	20	large particle carbon A (*3)	10	30	not added	-
Coating Material 2-4	polyester/melamine	fine particle carbon (*2)	5	large particle carbon A (*3)	5	10	not added	-
Coating Material 2-5	polyester/melamine	fine particle carbon (*2)	5	large particle carbon A (*3)	20	25	not added	-
Coating Material 2-6	polyester/melamine	fine particle carbon (*2)	5	large particle carbon A (*3)	50	55	not added	-
Coating Material 2-7	polyester/melamine	fine particle carbon (*2)	5	large particle carbon A (*3)	100	105	not added	-
Coating Material 2-8	polyester/melamine	fine particle carbon (*2)	5	large particle carbon A (*3)	140	145	not added	-
Coating Material 2-9	polyester/melamine	fine particle carbon (*2)	5	large particle carbon B (*20)	20	25	not added	-

TABLE 2 (2/3)

Coating Material No.	Species of Binder	Fine Particle Carbon		Large Particle Carbon		Entire Amount of Carbon Added (*1)	Other Pigment Added	
		Species of Pigment Added	Entire Amount of Pigment Added (parts by mass)	Species of Pigment Added	Entire Amount of Pigment Added (parts by mass)		Species of Pigment Added	Entire Amount of Pigment Added (parts by mass)
Coating Material 2-10	polyester/isocyanate	fine particle carbon (*2)	5	large particle carbon A (*3)	20	25	not added	-
Coating Material 2-11	polyester/melamine	fine particle carbon (*2)	5	large particle carbon A (*3)	20	25	electrically conducting pigment (*6)	10
Coating Material 2-12	polyester/melamine	fine particle carbon (*2)	5	large particle carbon A (*3)	20	25	electrically conducting and rust-preventive pigment (*11)	10
Coating Material 2-13	polyester/melamine	fine particle carbon (*2)	5	large particle carbon A (*3)	20	25	rust-preventive pigment A (*15)	10
Coating Material 2-14	polyester/melamine	fine particle carbon (*2)	5	large particle carbon A (*3)	20	25	rust-preventive pigment B (*16)	10
Coating Material 2-15	polyester/melamine	fine particle carbon (*2)	30	large particle carbon A (*3)	10	40	not added	-
Coating Material 2-16	polyester/melamine	fine particle carbon (*2)	5	large particle carbon A (*3)	180	190	not added	-
Coating Material 2-17	polyester/melamine	fine particle carbon (*2)	20	large particle carbon A (*3)	140	150	not added	-

TABLE 2 (3/3)

Coating Material No.	Species of Binder	Fine Particle Carbon		Large Particle Carbon		Entire Amount of Carbon Added (*1)	Other Pigment Added	
		Species of Pigment Added	Entire Amount of Pigment Added (*1) (parts by mass)	Species of Pigment Added	Entire Amount of Pigment Added (*1) (parts by mass)		Species of Pigment Added	Entire Amount of Pigment Added (*1) (parts by mass)
Coating Material 2-18	polyester/melamine	fine particle carbon (*2)	5	large particle carbon C (*21)	20	30	not added	-
Coating Material 2-19	polyester/melamine	fine particle carbon (*2)	-	large particle carbon A (*3)	10	10	not added	-
Coating Material 2-20	polyester/melamine	fine particle carbon (*2)	0.5	large particle carbon A (*3)	10	10.5	not added	-
Coating Material 2-21	polyester/melamine	fine particle carbon (*2)	5	not added	-	5	not added	-
Coating Material 2-22	polyester/melamine	fine particle carbon (*2)	5	large particle carbon A (*3)	0.5	10.5	not added	-
Coating Material 2-23	polyester/melamine	not added	-	not added	-	-	aluminum powder (*9)	20
Coating Material 2-24	polyester/melamine	not added	-	not added	-	-	titanium oxide (*19)	20
Coating Material 2-25	polyester/melamine	fine particle carbon (*2)	15	large particle carbon A (*3)	15	30	not added	-
Coating Material 2-26	polyester/melamine	fine particle carbon (*2)	15	large particle carbon A (*3)	85	100	not added	-

TABLE 3 (1/2)

Coating Material No.	Coating Material	Heat-Absorptive Pigment		Electrically Conducting Pigment	
		Species of Pigment Added	Entire Amount of Pigment Added (*1)	Species of Pigment Added	Entire Amount of Pigment Added (*1)
Coating Material 3-1	ordinary temperature-drying solvent-base	carbon black (*2)	10	flaked Ni/chained Ni =6 (*6)	10
Coating Material 3-2	ordinary temperature-drying solvent-base	carbon black (*2)	15	flaked Ni/chained Ni =6 (*6)	10
Coating Material 3-3	ordinary temperature-drying solvent-base	carbon black (*2)	100	flaked Ni/chained Ni =6 (*6)	10
Coating Material 3-4	ordinary temperature-drying solvent-base	carbon black (*2)	150	flaked Ni/chained Ni =6 (*6)	10
Coating Material 3-5	ordinary temperature-drying solvent-base	carbon black (*2)	200	flaked Ni/chained Ni =6 (*6)	10
Coating Material 3-6	ordinary temperature-drying solvent-base	charcoal powder (*3)	10	flaked Ni/chained Ni =6 (*6)	10
Coating Material 3-7	ordinary temperature-drying solvent-base	graphite powder (*4)	10	flaked Ni/chained Ni =6 (*6)	10
Coating Material 3-8	ordinary temperature-drying solvent-base	carbon black (*2)	15	flaked Ni/chained Ni =6 (*6)	0.1
Coating Material 3-9	ordinary temperature-drying solvent-base	carbon black (*2)	15	flaked Ni/chained Ni =6 (*6)	1
Coating Material 3-10	ordinary temperature-drying solvent-base	carbon black (*2)	15	flaked Ni/chained Ni =6 (*6)	150
Coating Material 3-11	ordinary temperature-drying solvent-base	carbon black (*2)	15	flaked Ni/chained Ni =0.05 (*12)	10
Coating Material 3-12	ordinary temperature-drying solvent-base	carbon black (*2)	15	flaked Ni/chained Ni =1 (*7)	10
Coating Material 3-13	ordinary temperature-drying solvent-base	carbon black (*2)	15	flaked Ni/chained Ni =0.1 (*8)	10

TABLE 3 (2/2)

Coating Material No.	Coating Material	Heat-Absorptive Pigment		Electrically Conducting Pigment	
		Species of Pigment Added	Entire Amount of Pigment Added (*1)	Species of Pigment Added	Entire Amount of Pigment Added (*1)
Coating Material 3-14	ordinary temperature-drying solvent-base	carbon black (*2)	15	flaked Ni/chained Ni =7 (*13)	10
Coating Material 3-15	ordinary temperature-drying solvent-base	carbon black (*2)	15	Al powder (*9)	10
Coating Material 3-16	ordinary temperature-drying solvent-base	carbon black (*2)	15	stainless steel powder (*10)	10
Coating Material 3-17	ordinary temperature-drying solvent-base	carbon black (*2)	15	ferrosilicon (*11)	10
Coating Material 3-18	ordinary temperature-drying solvent-base	electrically conducting carbon black (*5)	15	flaked Ni/chained Ni =6 (*6)	10
Coating Material 3-19	ordinary temperature-drying solvent-base	-	-	ferrosilicon (*11)	30
Coating Material 3-20	ordinary temperature-drying waterborne coating material	carbon black (*14)	15	flaked Ni/granular Ni =6	15
Coating Material 3-21	ordinary temperature-drying solvent-base	carbon black (*2)	5	flaked Ni/chained Ni =6 (*6)	10
Coating Material 3-22	ordinary temperature-drying solvent-base	carbon black (*2)	15	flaked Ni/chained Ni =6 (*6)	200

TABLE 4 (1/2)

Coating Material No.	Fine Particle Carbon		Large Particle Carbon		Entire Amount of Carbon Added (*1)	Other Pigment Added	
	Species of Pigment Added	Entire Amount of Pigment Added (*1) (parts by mass)	Species of Pigment Added	Entire Amount of Pigment Added (*1) (parts by mass)		Species of Pigment Added	Entire Amount of Pigment Added (*1) (parts by mass)
Coating Material 4-1	fine particle carbon (*2)	3	large particle carbon A (*3)	10	13	not added	-
Coating Material 4-2	fine particle carbon (*2)	10	large particle carbon A (*3)	10	20	not added	-
Coating Material 4-3	fine particle carbon (*2)	20	large particle carbon A (*3)	10	30	not added	-
Coating Material 4-4	fine particle carbon (*2)	5	large particle carbon A (*3)	5	10	not added	-
Coating Material 4-5	fine particle carbon (*2)	5	large particle carbon A (*3)	20	25	not added	-
Coating Material 4-6	fine particle carbon (*2)	5	large particle carbon A (*3)	50	55	not added	-
Coating Material 4-7	fine particle carbon (*2)	5	large particle carbon A (*3)	100	105	not added	-
Coating Material 4-8	fine particle carbon (*2)	5	large particle carbon A (*3)	140	145	not added	-
Coating Material 4-9	fine particle carbon (*2)	5	large particle carbon B (*20)	20	25	not added	-
Coating Material 4-10	not added	-	large particle carbon A (*3)	10	10	not added	-
Coating Material 4-11	fine particle carbon (*2)	0.5	large particle carbon A (*3)	10	10.5	not added	-
Coating Material 4-12	fine particle carbon (*2)	30	large particle carbon A (*3)	10	40	not added	-
Coating Material 4-13	fine particle carbon (*2)	5	not added	-	5	not added	-

TABLE 4 (2/2)

Coating Material No.	Fine Particle Carbon		Large Particle Carbon		Entire Amount of Carbon Added (*1)	Other Pigment Added	
	Species of Pigment Added	Entire Amount of Pigment Added (*1) (parts by mass)	Species of Pigment Added	Entire Amount of Pigment Added (*1) (parts by mass)		Species of Pigment Added	Entire Amount of Pigment Added (*1) (parts by mass)
Coating Material 4-14	fine particle carbon (*2)	5	large particle carbon A (*3)	0.5	10.5	not added	-
Coating Material 4-15	fine particle carbon (*2)	5	large particle carbon A (*3)	180	190	not added	-
Coating Material 4-16	fine particle carbon (*2)	20	large particle carbon A (*3)	140	160	not added	-
Coating Material 4-17	fine particle carbon (*2)	5	large particle carbon C (*21)	20	25	not added	-
Coating Material 4-18	not added	-	not added	-	-	aluminum powder (*9)	20
Coating Material 4-19	not added	-	not added	-	-	titanium oxide (*19)	20

In Tables 1 to 4, (*1) to (*21) are as follows.

- (*1): Parts by mass of pigment added per 100 parts by mass of resin solid content in coating material.
- 5 (*2): "TOKA BLACK #7350F" (28 nm, fine particle carbon) produced by Tokai Carbon
- (*3): "BINCHOTAN POWDER (charcoal)" produced by Cooperative Association Latest (maximum particle size: 5 μm , large particle carbon A)
- 10 (*4): A reagent graphite powder, which was further pulverized and classified to an average particle size of 10 μm by a sieving classifier, was used.
- (*5): "TOKA BLACK #5500F" (25 nm) produced by Tokai Carbon was used.
- 15 (*6): Commercially available flaked metal Ni and chained metal Ni were purchased and used by mixing these to a mass ratio of flaked Ni/chained Ni=6 (average particle size: 5 μm).
- 20 (*7): Commercially available flaked metal Ni and chained metal Ni were purchased and used by mixing these to a mass ratio of flaked Ni/chained Ni=1 (average particle size: 5 μm).
- (*8): Commercially available flaked metal Ni and chained metal Ni were purchased and used by mixing these to a mass ratio of flaked Ni/chained Ni=0.1 (average particle size: 5 μm).
- 25 (*9): "ALUMINUM POWDER 02-0005" produced by Toyo Aluminium K.K. (average particle size: 10 μm)
- 30 (*10): A commercially available stainless steel powder (average particle size: 20 μm) was used.
- (*11): Ferrosilicon No. 2 described in JIS-G2302, which was pulverized by a grinder and
- 35 classified to an average particle size of 10 μm

- by a sieving classifier, was used.
- 5 (*12): Commercially available flaked metal Ni and chained metal Ni were purchased and used by mixing these to a mass ratio of flaked Ni/chained Ni=0.05 (average particle size: 5 μm).
- 10 (*13): Commercially available flaked metal Ni and chained metal Ni were purchased and used by mixing these to a mass ratio of flaked Ni/chained Ni=7 (average particle size: 5 μm).
- (*14) "AEROSIL 300" produced by Nippon Aerosil (12 nm) was used.
- (*15): "SHELDEX C303" produced by Grace (3 μm) was used.
- 15 (*16): "K-WHITE K-105" produced by Teika (average particle size: 2.3 μm) was used.
- (*17): "SNOWTEX N" produced by Nissan Chemicals Industries, Ltd. was used (this rust-preventive pigment is a water dispersion type and therefore, the amount added shown in the Table is an amount as the solid content; particle size: 10 to 20 nm).
- 20 (*18): "AF BLACK U14" produced by Dainichiseika Color & Chemicals Mfg. Co., Ltd. (this rust-preventive pigment is a water dispersion type of resin mixture and therefore, the amount added shown in the Table is the amount of only carbon black; particle size: 10 to 50 nm).
- 25 (*19) "TIPAQUE CR-95" produced by Ishihara Sangyo Kaisha, Ltd. was used.
- 30 (*20) Reagent graphite powder was used after further pulverizing and classifying it to an average particle size of 40 μm by a sieving classifier (large particle carbon B).
- 35 (*21) Reagent graphite powder was used after further

pulverizing and classifying it to an average particle size of 60 μm by a sieving classifier (large particle carbon C).

5 All binders shown in Tables 1 to 4 are normal temperature drying type.

The Examples are described in detail below.

[EXAMPLE 1]

10 The method for preparing a heat-absorptive surface-coated sheet used in experiments is described in detail below.

A 0.6 mm-thick electrogalvanized steel sheet with both surfaces thereof being plated to an attached amount of 20 g/m^2 per one surface was dipped in an aqueous solution prepared by diluting "FC-364S" produced by Nihon
15 Parkerizing Co., Ltd., which is a commercially available alkali degreasing agent, to a concentration of 20 mass%, at a temperature of 60°C for 10 seconds and thereby degreased. Thereafter, the steel sheet was washed with water and then dried.

20 On the electrogalvanized steel sheet after degreasing, a pretreating solution was coated by a roll coater and dried with hot air under the condition of giving a peak metal temperature of 60°C.

In this experiment, "ZM1300AN" (hereinafter referred to as "chromate treatment") produced by Nihon Parkerizing
25 Co., Ltd., which is a commercially available chromate treatment, or "CT-E300" (hereinafter referred to as "non-chromate treatment") produced by Nihon Parkerizing Co., Ltd., which is a commercially available non-chromate pretreatment, was used for the pretreatment.
30

The attached amount in the chromate treatment was 50 mg/m^2 in terms of the amount of Cr attached and the attached amount in the non-chromate treatment was 200 mg/m^2 as the entire layer amount.

35 Furthermore, on the electrogalvanized steel sheet subjected to the pretreatment, a heat-absorptive layer coating material shown in Table 1 was coated by a roll

coater and dry-cured in an induction heater using a hot air blast in combination. The dry curing condition was set to give a peak metal temperature (PMT) of 230°C. The pretreating solution and heat-absorptive layer coating material were coated on one surface or both surfaces as needed to obtain specimens.

Details of each surface-coated sheet prepared are shown in Tables 5 to 8. In all of the surface-coated sheets of Tables 5 to 7, the same kind of heat-absorptive layer was coated on both surfaces under the same conditions, and in all of the surface-coated sheets of Table 8, the heat-absorptive layer was coated on only one surface and the other surface was not coated.

TABLE 5 (1/2)

No.	Species of Pretreatment	Species of Coating Material	Layer Thickness	Emissivity	Heat		Adhesion of Layer	Bending Property	Press Formability	Corrosion Resistance		Electrical Conductivity
					Absorptivity Temperature A	Temperature B				Scratch	Cut Edge	
I-1	non-chromate treatment	Coating Material 1-1	5 μ m	0.80	O	O	O	O	O	Δ	Δ	O
I-2	non-chromate treatment	Coating Material 1-2	5 μ m	0.91	O	O	O	O	O	Δ	Δ	Δ
I-3	non-chromate treatment	Coating Material 1-3	5 μ m	0.94	O	O	O	Δ	Δ	Δ	Δ	Δ
I-4	non-chromate treatment	Coating Material 1-4	5 μ m	0.95	O	O	O	Δ	Δ	Δ	Δ	Δ
I-5	non-chromate treatment	Coating Material 1-5	5 μ m	0.95	O	O	O	X	X	Δ	Δ	Δ
I-6	non-chromate treatment	Coating Material 1-6	5 μ m	0.80	O	O	O	O	O	Δ	Δ	Δ
I-7	non-chromate treatment	Coating Material 1-7	5 μ m	0.78	Δ	Δ	O	O	O	Δ	Δ	Δ
I-8	non-chromate treatment	Coating Material 1-8	5 μ m	0.81	O	O	O	O	O	Δ	Δ	X
I-9	non-chromate treatment	Coating Material 1-9	5 μ m	0.92	O	O	O	O	O	Δ	Δ	O
I-10	non-chromate treatment	Coating Material 1-10	5 μ m	0.80	O	O	O	O	O	Δ	Δ	O
I-11	non-chromate treatment	Coating Material 1-11	5 μ m	0.92	O	O	O	O	O	Δ	Δ	X
I-12	non-chromate treatment	Coating Material 1-12	5 μ m	0.92	O	O	O	O	O	Δ	Δ	Δ
I-13	non-chromate treatment	Coating Material 1-13	5 μ m	0.93	O	O	O	O	O	Δ	Δ	Δ
I-14	non-chromate treatment	Coating Material 1-14	5 μ m	0.72	Δ	Δ	O	O	O	Δ	Δ	O
I-15	non-chromate treatment	Coating Material 1-15	5 μ m	0.72	Δ	Δ	O	O	O	Δ	Δ	O
I-16	non-chromate treatment	Coating Material 1-16	5 μ m	0.73	Δ	Δ	O	O	O	Δ	Δ	O
I-17	non-chromate treatment	Coating Material 1-17	5 μ m	0.95	O	O	O	O	O	O	O	O

Example
of
Invention

TABLE 5 (2/2)

	No.	Species of Pretreatment	Species of Coating Material	Layer Thickness	Emissivity	Heat Absorptivity		Adhesion of Layer	Bending Property	Press Formability	Corrosion Resistance		Electrical Conductivity
						Temperature A	Temperature B				Scratch	Cut Edge	
Example of Invention	I-18	non-chromate treatment	Coating Material 1-18	5 μm	0.92	○	○	○	○	○	△	△	○
	I-19	non-chromate treatment	Coating Material 1-19	5 μm	0.80	○	○	○	○	○	○	○	○
	I-20	non-chromate treatment	Coating Material 1-20	5 μm	0.93	○	○	○	○	○	△	△	△
	I-21	non-chromate treatment	Coating Material 1-21	5 μm	0.91	○	○	○	○	○	○	○	△
	I-22	non-chromate treatment	Coating Material 1-22	5 μm	0.81	○	○	○	○	○	○	○	△
	I-23	non-chromate treatment	Coating Material 1-23	5 μm	0.80	○	○	○	○	○	○	○	△
	I-24	non-chromate treatment	Coating Material 1-24	5 μm	0.82	○	○	○	○	○	○	○	△
Comparative Example	I-25	non-chromate treatment	Coating Material 1-25	5 μm	0.80	○	○	○	○	○	○	○	△
	I-26	non-chromate treatment	Coating Material 1-26	5 μm	0.65	×	×	○	○	○	△	△	○
	I-27	non-chromate treatment	Coating Material 1-27	5 μm	0.65	×	×	○	×	×	△	△	○

TABLE 6

	No.	Species of Pretreatment	Species of Coating Material	Layer Thickness	Emissivity	Heat Absorptivity		Adhesion of Layer	Bending Property	Press Formability	Corrosion Resistance		Electrical Conductivity
						Temperature A	Temperature B				Scratch	Cut Edge	
Example of Invention	I-28	non-chromate treatment	Coating Material 1-2	0.5 μm	0.70	Δ	Δ	O	O	O	Δ	Δ	Δ
	I-29	non-chromate treatment	Coating Material 1-2	1.0 μm	0.85	O	O	O	O	O	Δ	Δ	Δ
	I-30	non-chromate treatment	Coating Material 1-2	10 μm	0.94	O	O	O	O	O	Δ	Δ	Δ
	I-31	non-chromate treatment	Coating Material 1-2	15 μm	0.95	O	O	O	O	O	Δ	Δ	Δ
	I-32	non-chromate treatment	Coating Material 1-2	25 μm	0.95	O	O	O	O	O	Δ	Δ	Δ
	I-33	non-chromate treatment	Coating Material 1-2	50 μm	0.95	O	O	O	Δ	Δ	Δ	Δ	Δ
	I-34	non-chromate treatment	Coating Material 1-2	70 μm	0.95	O	O	O	X	X	Δ	Δ	Δ

TABLE 7

	No.	Species of Pretreatment	Species of Coating Material	Layer Thickness	Emissivity	Heat Absorptivity		Adhesion of Layer	Bending Property	Press Formability	Corrosion Resistance		Electrical Conductivity
						Temperature A	Temperature B				Scratch	Cut Edge	
Example of Invention	I-35	chromate treatment	Coating Material 1-2	5 μ m	0.91	O	O	O	O	O	Δ	Δ	Δ
Comparative Example	I-36	none (not treated)	Coating Material 1-2	5 μ m	0.91	O	O	Δ	Δ	Δ	X	X	Δ

TABLE 8

	No.	Species of Pretreatment	Species of Coating Material	Layer Thickness	Emissivity	Heat Absorptivity		Remarks
						Temperature A	Temperature B	
Example of Invention	I-37	non-chromate treatment	Coating Material 1-2	5 μm	0.91	O	X	In the heat absorptivity test, the metal sheet was disposed such that the coated layer surface was on the inner side of the box and the non-coated surface was on the outer side.
Comparative Example	I-38	non-chromate treatment	Coating Material 1-2	5 μm	0.91	X	Δ	In the heat absorptivity test, the metal sheet was disposed such that the coated layer surface was on the outer side of the box and the non-coated surface was on the inner side.

The evaluation tests of each surface-coated sheet prepared are described in detail below.

1) Measurement of Emissivity of Surface-Coated Sheet

5 Using a Fourier transform infrared spectrophotometer "VALOR-III" manufactured by JASCO Corporation, the infrared emission spectrum in the wave number region of 600 to 3,000 cm^{-1} was measured by setting the plate temperature of the surface-coated sheet at 80°C. This spectrum was compared with the emission spectrum of a
10 standard black body to measure the entire emissivity of the surface-coated sheet. The standard black body used here was prepared by spray-coating "THI-1B Black Body Spray" available from Tacos Japan (produced by Okitsumo) on an iron sheet to a layer thickness of $30 \pm 2 \mu\text{m}$.

15 2) Heat Absorptivity Measurement Test of Surface-Coated Sheet

A measurement box shown in Fig. 2 was prepared and used for the test. The measurement box 4 was opened at the top and this opened face was covered with the
20 surface-coated sheet 5 obtained. In this state, the temperature of the heat source was controlled by a temperature controller 7 such that the temperature of the heat source 6 became 100°C, and Temperature A of a thermocouple 8 disposed in the measurement box 4 and
25 Temperature B of a thermocouple 9 attached to the outer surface of the surface-coated sheet each was measured by a digital thermometer 10.

The untreated electrogalvanized steel sheet having the same thickness as that of the surface-coated sheet to
30 be evaluated was also measured in the same manner and the measured value was compared between the surface-coated sheet prepared and the untreated electrogalvanized steel sheet and evaluated according to the following criteria.

The criteria of evaluation of Temperature A are as
35 follows.

○: [{(measured value of uncoated electrogalvanized

steel sheet) - (measured value of surface-coated sheet to be evaluated)} $\geq 4^{\circ}\text{C}$

5 Δ : [$4^{\circ}\text{C} > \{(\text{measured value of uncoated electrogalvanized steel sheet}) - (\text{measured value of surface-coated sheet to be evaluated})\} \geq 2^{\circ}\text{C}$]

X: [$2^{\circ}\text{C} > \{(\text{measured value of uncoated electrogalvanized steel sheet}) - (\text{measured value of surface-coated sheet to be evaluated})\}$]

10 The criteria of evaluation of Temperature B are as follows.

O: [$20^{\circ}\text{C} \geq \{(\text{measured value of surface-coated sheet to be evaluated}) - (\text{measured value of uncoated electrogalvanized steel sheet})\}$]

15 Δ : [$30^{\circ}\text{C} \geq \{(\text{measured value of surface-coated sheet to be evaluated}) - (\text{measured value of uncoated electrogalvanized steel sheet})\} > 20^{\circ}\text{C}$]

X: [$\{(\text{measured value of surface-coated sheet to be evaluated}) - (\text{measured value of uncoated electrogalvanized steel sheet})\} > 30^{\circ}\text{C}$]

20 3) Coated layer Adhesion Test

The heat-absorptive layer of the surface-coated sheet was cross-cut by a cutter knife to form 1-mm squares and after being pushed out 7 mm by an Erichsen tester such that the coated surface became a protrusion, a tape peeling test was performed.

25 The cross-cutting to form squares, the pushing out by the Erichsen tester and the tape peeling were performed according to the methods described in JIS-K5400.8.2 and JIS-K5400.8.5. In this test, the tape peeling test was continuously performed twice at the same position (hereinafter referred to as "tape peeling twice").

30 The evaluation after the tape peeling was performed according to the figure in the evaluation example of JIS-K5400.8.5. The rating was O when the score was 10

points, $\triangle$ when from 8 to less than 10 points, and X when less than 8 points.

4) Coated Layer Bending Test

5 The surface-coated sheet prepared was subjected to 180° bending and the coated layer damage state in the worked part was observed by a magnifier and evaluated according to the following criteria. The bending was performed by interposing 3 sheets of 0.6-mm spacer (generally called 3T bending) in an atmosphere of 20°C.

10 O: Coated layer was completely free of damage.

$\triangle$: Coated layer was partially damaged.

X: Coated layer was seriously damaged over the entire surface of the worked part.

5) Press Forming Test

15 The surface-coated sheet prepared was subjected to a cylinder drawing test using a hydraulic Erichsen-type press working tester. The cylinder drawing test was performed under the conditions of punch diameter: 50 mm, punch shoulder roundness R: 5 mm, die shoulder roundness R: 5 mm, drawing ratio: 2.3 and BHF: 1 t, by continuing
20 the working until the metal sheet was drawn and came out from the die.

The coated layer damage state in the worked part was observed by a magnifier and evaluated according to the
25 following criteria.

O: Layer was completely free of damage.

$\triangle$: Layer was partially damaged.

X: Layer was seriously damaged over the entire surface of the worked part.

30 6) Corrosion Resistance

The surface-coated sheet prepared was subjected to a salt spray test according to the method described in JIS-K5400.9.1. The salt water was sprayed on the heat-absorptive layer surface. The test time was 120 hours.

35 The specimen surface was scratched by a cutter knife. The coated layer in the scratched part was

evaluated by rating ○ when the maximum blister width in one side of the scratch was less than 2 mm, △ when from 2 mm to less than 5 mm, and X when 5 mm or more.

5 A flat sheet produced such that the burr at the cutting came to the evaluation surface side of the coated steel sheet (namely, such that upper burr was obtained) was also subjected to the above-described salt spray test and the blister width of layer from the cut edge was observed. The cut edge part was evaluated by rating ○
10 when the blister width from the cut edge was less than 2 mm, △ when from 2 mm to less than 5 mm, and X when 5 mm or more.

7) Electrical Conductivity Test

The surface-coated sheet prepared was measured on
15 the electrical conductivity of the heat-absorptive layer. The measuring method was as follows. The resistivity on the surface of the surface-coated sheet was measured by a four probe method using a resistivity meter "Loresta-EP/MCP-T360" manufactured by Mitsui Chemicals, Inc. and
20 evaluated according to the following criteria.

○: The resistivity was less than $0.1 \times 10^{-2} \Omega$.

△: The resistivity was from 0.1×10^{-2} to less than $1.0 \times 10^{-1} \Omega$.

X: The resistivity was $1.0 \times 10^{-1} \Omega$ or more.

25 The evaluation results of each surface-coated sheet prepared are described below.

The results in the evaluation of the effect of the species and amount of the pigment added to the heat-absorptive layer coated on the surface-coated sheet are
30 shown in Table 5.

In the surface-coated sheet of the present invention (Examples I-1 to I-25 of the invention), the entire emissivity measured at a temperature of 80°C is 0.70 or more in the wave number region of 600 to 3,000 cm^{-1} and
35 therefore, the heat absorptivity is high as compared with

Comparative Examples I-26 and I-27 where the emissivity is less than 0.70. This reveals that the surface-coated sheet of the present invention is suitable as a heat-generating element cover.

5 When the heat-absorptive layer of the surface-coated sheet of the present invention comprises 100 parts by mass of a binder solid content, from 10 to 150 parts by mass of a heat-absorptive pigment and from 1 to 150 parts by mass of an electrically conducting pigment, excellent
10 workability and electrical conductivity are obtained and, therefore, this is more preferred.

 When the amount of the heat-absorptive pigment added is less than 10 parts by mass (Comparative Example I-26), the emissivity is less than 0.7 to give poor heat
15 absorptivity and therefore, this is improper. When the amount of the heat-absorptive pigment added exceeds 150 parts by mass (Example I-5 of the invention), the emissivity is high but the workability such as bending property or press formability deteriorates, therefore,
20 the amount of the heat-absorptive pigment added is preferably 150 parts by mass or less.

 When the amount of the electrically conducting pigment added is less than 1 part by mass (Example I-8 of the invention), the electrical conductivity cannot be
25 ensured, therefore, the amount of the electrically conducting pigment added is preferably 1 part by mass or more. When the amount of the electrically conducting pigment added exceeds 150 parts by mass (Comparative Example I-27), the electrically conducting pigment
30 inhibits the heat absorptivity and, as a result, the emissivity is less than 0.7 to give poor heat absorptivity and at the same time, the workability of the coated layer greatly decreases, therefore, this is improper.

35 When the heat-absorptive pigment contained in the heat-absorptive layer of the surface-coated sheet of the present invention is a carbon black having an average

particle size of 1 to 100 nm and the electrically
conducting pigment is composed of a flaked metal Ni and a
chained metal Ni having an average particle size of 0.5
to 50 μm with the mass ratio of flaked metal Ni/chained
5 metal Ni being from 0.1 to 6, more excellent heat
absorptivity and electrical conductivity are provided and
therefore, this is more preferred.

When the particle size of the heat-absorptive
pigment is relatively large as in charcoal powder or
10 graphite powder (Examples I-6 and I-7 of the invention),
the emissivity is relatively low and the large heat-
absorptive pigment inhibits the electrically conducting
effect of the electrically conducting pigment to lower
the electrical conductivity, therefore, the heat-
15 absorptive pigment is more preferably a carbon black
having an average particle size of 1 to 100 nm.

When the electrically conducting pigment contained
in the heat-absorptive layer of the surface-coated sheet
of the present invention is aluminum powder or stainless
20 steel powder, the electrically conducting pigment is
liable to inhibit the heat absorptivity and the sheet
having added thereto such an electrically conducting
pigment (Examples I-15 and I-16 of the invention) is
decreased in the emissivity.

25 An electrically conducting pigment composed of a
flaked metal Ni and a chained metal Ni having an average
particle size of 0.5 to 50 μm less inhibits the heat
absorptivity and is preferred, However, when the mass
ratio of flaked metal Ni/chained metal Ni is less than
30 0.1 (Example I-11 of the invention), the electrical
conductivity decreases and when the mass ratio of flaked
metal Ni/chained metal Ni exceeds 6 (Example I-14 of the
invention), the heat absorptivity is inhibited and the
emissivity is low. Therefore, the mass ratio of flaked
35 metal Ni/chained metal Ni is suitably from 0.1 to 6.

When the electrically conducting pigment is

ferrosilicon (Example I-17 of the invention), the emissivity does not decrease and, at the same time, the corrosion resistance of the surface-coated sheet of the present invention is improved, therefore, this is more preferred. When the heat-absorptive pigment is not added and only ferrosilicon is added (Example I-19 of the invention), the emissivity is relatively high and the electrical conductivity and corrosion resistance are excellent and, therefore, this is preferred.

When an electrically conducting carbon black is used as the heat-absorptive pigment, the electrical conductivity is enhanced and therefore, this is preferred. The surface-coated sheet of the present invention where the heat-absorptive layer contains a rust-preventive pigment in addition to the heat-absorptive pigment and electrically conducting pigment (Examples I-22 to I-25 of the invention) exhibits excellent corrosion resistance and therefore, this is more preferred.

The evaluation results of surface-coated sheets different in the thickness of the heat-absorptive layer are shown in Table 6. When the layer thickness is less than 1 μm (Example I-28 of the invention), the entire emissivity is low and when the layer thickness exceeds 50 μm , the workability of the layer is decreased, therefore, the layer thickness is preferably from 1 to 50 μm .

The evaluation results of the case where the heat-absorptive layer is treated with chromate as a pretreatment (Example I-35 of the invention) and the case where a pretreatment is not applied (Example I-36 of the invention) are shown in Table 7. Even when the kind of the pretreatment is varied, the emissivity, heat absorptivity and other layer performances are not changed.

However, the metal sheet subjected to a chromate treatment has an environmental problem due to hexavalent

chromium contained in the chromate-treated layer and therefore, a treatment not containing chromate (non-chromate treatment) is more preferred.

5 When a pretreatment is not applied, the layer adhesion and corrosion resistance are decreased, therefore, it is preferred to apply a pretreatment.

The evaluation results on the heat absorptivity when only one surface is coated with the heat-absorptive layer and the other surface is not coated are shown in Table 8.
10 The metal sheet where only one surface is coated with the heat-absorptive layer is inferior in the heat absorptivity to the metal sheet where both surfaces are coated.

In the case of coating only one surface with the
15 heat-absorptive layer, when the heat-absorptive layer is applied to the outer side of the cover covering the heat-generating element working out to a heat source (Comparative Example I-38), almost no heat-absorbing effect is obtained and therefore, this is improper.
20 (Example II)

The method for preparing a heat-absorptive surface-coated sheet used in experiments is described in detail below.

A 0.6 mm-thick electrogalvanized steel sheet with
25 both surfaces thereof being plated to an attached amount of 20 g/m² per one surface was dipped in an aqueous solution prepared by diluting "FC-364S" produced by Nihon Parkerizing Co., Ltd., which is a commercially available alkali degreasing agent, to a concentration of 20 mass%,
30 at a temperature of 60°C for 10 seconds and thereby degreased. Thereafter, the steel sheet was washed with water and then dried.

On the electrogalvanized steel sheet after degreasing, a chemical conversion treating solution was
35 coated by a roll coater and dried with hot air under the condition of giving a peak metal temperature of 60°C.

In this experiment, "ZM1300AN" (hereinafter referred

to as "chromate treatment") produced by Nihon Parkerizing Co., Ltd., which is a commercially available chromate treatment, or "CT-E300" (hereinafter referred to as "non-chromate treatment") produced by Nihon Parkerizing Co., Ltd., which is a commercially available non-chromate chemical conversion treatment, was used for the chemical conversion treatment. In the chemical conversion treatment, both surfaces of the metal sheet were treated using a roll coater and dried under the condition of giving a peak metal temperature of 60°C. The attached amount in the chromate treatment was 50 mg/m² in terms of the amount of Cr attached and the attached amount in the non-chromate treatment was 200 mg/m² as the entire layer amount.

Furthermore, on one surface of the electrogalvanized steel sheet subjected to the chemical conversion treatment (hereinafter this surface is referred to as Surface a), a heat-absorptive layer coating material shown in Table 2 was coated by a roll coater and dry-cured in an induction heater using a hot air blast in combination. The dry curing condition was set to give a peak metal temperature (PMT) of 230°C. The chemical conversion treating solution and heat-absorptive layer coating material were coated on one surface or both surfaces as needed to obtain specimens. The other surface (hereinafter, this surface is referred to as Surface b) was not coated, coated with the heat-absorptive coating material or applied with color coating. In the color coating, an undercoat paint for precoated steel sheets, "FL641 PRIMER", produced by Nippon Paint Co., Ltd. was coated to a dry thickness of 5 µm and baked at PMT of 210°C and thereon, a black metallic color topcoat paint, "FL7100", produced by Nippon Paint Co., Ltd. was further coated to a dry thickness of 15 µm and baked at PMT of 230°C.

Details of each surface-coated sheet prepared are

shown in Tables 9 to 10. In Tables 9 to 10, the thickness of the heat-absorptive layer is a thickness after drying.

TABLE 9 (1/3)

	No.	Species of Chemical Conversion Treatment	Coating Material of Surface a		Coating Material of Surface b		Emissivity	Heat Absorptivity Temperature		Adhesion	Bending Property	Press Formability	Corrosion Resistance	Electrical Conductivity	State in Aging of Heat-Absorptive Coating Material	Appearance of Heat-Absorptive Layer
			Kind	Layer Thickness	Kind	Layer Thickness		A	B							
Example of Invention	II-1	non-chromate treatment	Coating Material 2-1	5 μm	color coating material	20 μm	0.75	○	○	○	○	○	○	×	○	○
	II-2	non-chromate treatment	Coating Material 2-2	5 μm	color coating material	20 μm	0.80	○	○	○	○	○	○	×	○	○
	II-3	non-chromate treatment	Coating Material 2-3	5 μm	color coating material	20 μm	0.85	⊙	○	○	○	○	○	×	△	○
	II-4	non-chromate treatment	Coating Material 2-4	5 μm	color coating material	20 μm	0.71	○	○	○	○	○	○	×	○	○
	II-5	non-chromate treatment	Coating Material 2-5	5 μm	color coating material	20 μm	0.76	○	○	○	○	○	○	×	○	○
	II-6	non-chromate treatment	Coating Material 2-6	5 μm	color coating material	20 μm	0.86	⊙	○	○	○	○	○	×	○	○
	II-7	non-chromate treatment	Coating Material 2-7	5 μm	color coating material	20 μm	0.89	⊙	○	○	○	○	○	×	○	○
	II-8	non-chromate treatment	Coating Material 2-8	5 μm	color coating material	20 μm	0.90	⊙	○	○	△	△	○	×	○	○

TABLE 9 (2/3)

	No.	Species of Chemical Conversion Treatment	Coating Material of Surface a		Coating Material of Surface b		Emissivity	Heat Absorptivity			Adhesion	Bending Property	Press Formability	Corrosion Resistance	Electrical Conductivity	State in Aging of Heat-Absorptive Coating Material	Appearance of Heat-Absorptive Layer
			Kind	Layer Thickness	Kind	Layer Thickness		Temperature	A	B							
Example of Invention	II-9	non-chromate treatment	Coating Material 2-9	5 μm	color coating material	20 μm	0.74	○	○	○	○	○	○	○	×	○	△
	II-10	non-chromate treatment	Coating Material 2-10	5 μm	color coating material	20 μm	0.77	○	○	○	○	○	○	○	×	○	○
	II-11	non-chromate treatment	Coating Material 2-11	5 μm	color coating material	20 μm	0.74	○	○	○	○	○	△	○	○	○	○
	II-12	non-chromate treatment	Coating Material 2-12	5 μm	color coating material	20 μm	0.78	○	○	○	○	○	⊙	○	○	○	○
	II-13	non-chromate treatment	Coating Material 2-13	5 μm	color coating material	20 μm	0.75	○	○	○	○	○	⊙	×	○	○	○
Comparative Example	II-14	non-chromate treatment	Coating Material 2-14	5 μm	color coating material	20 μm	0.74	○	○	○	○	○	⊙	×	○	○	○
	II-15	non-chromate treatment	Coating Material 2-15	5 μm	color coating material	20 μm	0.88	⊙	○	○	○	○	○	×	○	○	○
	II-16	non-chromate treatment	Coating Material 2-16	5 μm	color coating material	20 μm	0.88	⊙	○	○	△	△	○	×	△	○	○

TABLE 9 (3/3)

No.	Species of Chemical Conversion Treatment	Coating of Material of Surface a		Coating of Material of Surface b		Emissivity	Heat Absorptivity			Adhesion	Bending Property	Press Formability	Corrosion Resistance	Electrical Conductivity	State in Aging of Heat-Absorptive Coating Material	Appearance of Heat-Absorptive Layer
		Kind	Layer Thickness	Kind	Layer Thickness		Temperature									
							A	B								
II-17	non-chromate treatment	Coating Material 2-17	5 μm	color coating material	20 μm	0.88	⊙	○	○	△	△	○	○	×	△	○
II-18	non-chromate treatment	Coating Material 2-18	5 μm	color coating material	20 μm	0.88	○	○	○	○	○	○	○	×	○	×
II-19	non-chromate treatment	Coating Material 2-19	5 μm	color coating material	20 μm	0.65	×	○	○	○	○	○	○	×	○	○
II-20	non-chromate treatment	Coating Material 2-20	5 μm	color coating material	20 μm	0.66	×	○	○	○	△	○	○	×	○	○
II-21	non-chromate treatment	Coating Material 2-21	5 μm	color coating material	20 μm	0.65	×	○	○	○	△	○	○	×	○	○
II-22	non-chromate treatment	Coating Material 2-22	5 μm	color coating material	20 μm	0.65	×	○	○	○	○	○	○	×	○	○
II-23	non-chromate treatment	Coating Material 2-23	5 μm	color coating material	20 μm	0.45	×	○	○	○	○	○	○	○	○	○
II-24	non-chromate treatment	Coating Material 2-24	5 μm	color coating material	20 μm	0.55	×	○	○	○	○	○	○	×	○	○

TABLE 10

	No.	Species of Chemical Conversion Treatment	Coating of Material of Surface a		Coating of Material of Surface b		Emissivity	Heat Absorptivity			Bending Property	Press Formability	Corrosion Resistance	Electrical Conductivity	State in Aging of Heat-Absorptive Coating Material	Appearance of Heat-Absorptive Layer
			Kind	Layer Thickness	Kind	Layer Thickness		Absorptivity								
								A	B							
Comparative Example	II-25	non-chromate treatment	Coating Material 2-2	0.5 μm	color coating material	20 μm	0.60	X	O	O	O	O	X	X	O	O
	II-26	non-chromate treatment	Coating Material 2-2	1 μm	color coating material	20 μm	0.69	Δ	O	O	O	O	Δ	X	O	O
	II-27	non-chromate treatment	Coating Material 2-2	3 μm	color coating material	20 μm	0.75	O	O	O	O	O	Δ	X	O	O
	II-28	non-chromate treatment	Coating Material 2-2	5 μm	Coating Material 2-2	5 μm	0.76	O	O	O	O	O	O	X	O	O
Example of Invention	II-29	non-chromate treatment	Coating Material 2-2	5 μm	not coated	-	0.76	O	Δ	O	O	O	O	X	O	O
	II-30	chromate treatment	Coating Material 2-2	5 μm	color coating material	20 μm	0.76	O	O	O	Δ	Δ	O	X	O	O
	II-31	not treated	Coating Material 2-2	5 μm	color coating material	20 μm	0.76	O	O	X	X	X	O	X	O	O
	II-32	non-chromate treatment	not coated	-	Coating Material 2	5 μm	0.10	X	O	-	-	-	X	X	-	-

The evaluation tests of each surface-coated sheet prepared are described in detail below.

1) Measurement of Emissivity of Surface-Coated Sheet

5 Same as in Example I, but in this experiment, the emissivity on Surface a of the surface-coated sheet prepared was measured.

2) Heat Absorptivity Measurement Test of Surface-Coated Sheet

10 Same as in Example I, but the evaluation was made according to the following criteria. The criteria of evaluation of Temperature A are as follows. In this experiment, the surface-coated sheet prepared was disposed such that surface was to the inner side (heat source side) of the measurement box.

15 ◎: $\{(\text{measured value of uncoated electrogalvanized steel sheet}) - (\text{measured value of surface-coated sheet to be evaluated})\} \geq 4^{\circ}\text{C}$

○: $\{4^{\circ}\text{C} > (\text{measured value of uncoated electrogalvanized steel sheet}) - (\text{measured value of surface-coated sheet to be evaluated})\} \geq 3^{\circ}\text{C}$

△: $\{3^{\circ}\text{C} > (\text{measured value of uncoated electrogalvanized steel sheet}) - (\text{measured value of surface-coated sheet to be evaluated})\} \geq 2^{\circ}\text{C}$

25 ×: $\{2^{\circ}\text{C} > (\text{measured value of uncoated electrogalvanized steel sheet}) - (\text{measured value of surface-coated sheet to be evaluated})\}$

The criteria of evaluation of Temperature B are as follows.

30 ○: $\{20^{\circ}\text{C} \geq (\text{measured value of uncoated surface-coated sheet evaluated}) - (\text{measured value of electrogalvanized steel to be sheet})\}$

△: $\{(\text{measured value of uncoated surface-coated sheet evaluated}) - (\text{measured value of electrogalvanized steel to be sheet})\} > 20^{\circ}\text{C}$

35 3) Coated Layer Adhesion Test

Same as in Example I, provided that the adhesion on the side a was evaluated in this test.

4) Layer Bending Test

5 Same as in Example I, but in this experiment, Surface a was disposed to be the outer side of the worked part and the evaluation was performed by observing the layer damage state in the worked part of Surface a.

5) Press Forming Test

10 Same as in Example I, but in this experiment, Surface a was disposed to be the outer side of the worked part and the evaluation was performed by observing the layer damage state in the worked part of Surface a.

6) Corrosion Resistance

15 The surface-coated sheet prepared was subjected to a salt spray test according to the method described in JIS-K5400.9.1. The salt water was sprayed on Surface a of the specimen. The test time was 72 hours. The state of white rust generation was observed in the plane part and the end face part of the Surface a side and rated ◎ when
20 white rust was generated neither in the plane part nor in the end face part, ○ when white rust was slightly generated in the end face part but was scarcely generated in the plane part, △ when white rust was generated in the end face part and partially generated also in the
25 plane part, and × when white rust was generated over the entire surface of end face part and plane part.

7) Electrical Conductivity Test

Same as in Example I, but in this experiment, the test was performed on surface a.

30 8) Observation of State in Aging of Heat-Absorptive Coating Material

35 The heat-absorptive coating material applied to Surface a of the metal sheet was left stand at an ordinary temperature for one month and thereafter, the state of coating solution was observed with an eye and evaluated as follows.

○: No change as compared with the state when the coating solution was prepared.

△: The viscosity increased as compared with the state when the coating solution was prepared.

5 ×: The coating solution was gelled or solidified as compared with the state when the coating solution was prepared.

9) Appearance of Heat-Absorptive Layer

10 The appearance of layer coated on the metal sheet in the Surface a side was observed with an eye and evaluated as follows.

○: Smooth appearance.

15 △: The pigment added was slightly larger than the layer thickness and therefore, a small irregularity was observed on the layer surface.

 ×: The pigment added was very larger than the layer thickness and therefore, heavy irregularity was observed on the layer surface.

20 The evaluation results are described in detail below.

 In the surface-coated sheet of the present invention, a heat-absorptive layer which comprises from 1 to 20 parts by mass of a carbon having a particle size of less than 0.1 μm and from 1 to 140 parts by mass of a
25 carbon having a particle size of 0.1 to 50 μm per 100 parts by mass of the binder solid content and in which the total of a carbon having a particle size of less than 0.1 μm and a carbon having a particle size of 0.1 μm to 50 μm is from 10 to 150 parts by mass, is coated to a dry
30 thickness of 1 μm or more, whereby a surface-treated metal sheet having high heat absorptivity can be obtained.

 In the case of producing a heat-generating element cover using the surface-coated sheet of the present
35 invention, the heat-absorptive layer must be the inner

side of the heat-generating element cover. When the heat-absorptive layer of the present invention is coated only on the outer side of the heat-generating element cover (Comparative Example II-32), the temperature inside the cover (Heat Absorptivity, Temperature A) is scarcely lower and therefore, this is improper.

In the heat-absorptive layer of the surface-coated sheet of the present invention, when the entire emissivity measured at a temperature of 80°C is less than 0.70 in the wave number region of 600 to 3,000 cm^{-1} (Example II-26 of the invention), the temperature inside the cover (Heat Absorptivity, Temperature A) is scarcely lower and therefore, the heat-absorptive layer preferably has an entire emissivity of 0.70 or more.

When an electrically conducting pigment is added to the heat-absorptive layer of the present invention (Example II-11 of the invention), electrical conductivity is imparted and this is preferred for uses where the heat-generating element cover is required to have earthing or grounding property or the like. When a rust-preventive pigment is added to the heat-absorptive layer of the present invention (Examples II-13 and II-14 of the invention), the corrosion resistance is improved and therefore, this is preferred for uses where corrosion resistance is required. When ferrosilicon having both corrosion resistance and electrical conductivity is added to the heat-absorptive layer of the present invention (Example II-12 of the invention), electrical conductivity is imparted and moreover, the corrosion resistance is improved, therefore, this is more preferred. When the heat-absorptive layer is coated only in the inner side of the heat-generating element cover and the outer side is not coated, the temperature inside the cover (Heat Absorptivity, Temperature A) is low, revealing excellent heat absorptivity, however, the temperature of the metal sheet itself (Heat Absorptivity, Temperature B) is high. Therefore, it is more preferred to coat the heat-

absorptive layer in the inner side of the heat-generating element cover and also coat the heat-absorptive layer of the present invention or a generally known color coating in the outer side to a thickness of 10 μm or more.

5 (EXAMPLE III)

The method for preparing a heat-absorptive surface-coated sheet used in the experiments is described in detail below.

10 A 0.6 mm-thick hot-dip galvanized steel sheet (GA) with both surfaces thereof being plated to a plating attached amount of 60 g/m² per one surface was dipped in an aqueous solution prepared by diluting "FC-364S" produced by Nihon Parkerizing Co., Ltd., which is a commercially available alkali degreasing agent, to a
15 concentration of 20 mass%, at a temperature of 60°C for 10 seconds and thereby being degreased and thereafter, the steel sheet was washed with water and then dried. Also, a 0.6 mm-thick aluminum-plated steel sheet (AL SHEET) with both surfaces thereof being plated to a
20 plating attached amount of 60 g/m² per one surface and an aluminum sheet (AL) were dipped in an aqueous solution prepared by diluting "FC-315" produced by Nihon Parkerizing Co., Ltd., which is a commercially available alkali degreasing agent for aluminum, to a concentration
25 of 40 mass%, at a temperature of 70°C for 10 seconds and thereby degreased and thereafter, the steel sheet was washed with water and then dried.

On the plated steel sheet or the aluminum sheet after degreasing, a chemical conversion treating solution
30 was coated by a roll coater and dried with hot air under the condition of giving a peak metal temperature of 60°C.

In this experiment, "CT-E300" produced by Nihon Parkerizing Co., Ltd., which is a commercially available non-chromate chemical conversion treatment, was used for
35 the chemical conversion treatment. In the chemical conversion treatment, both surfaces of the metal sheet were treated using a roll coater and dried under the

condition of giving a peak metal temperature of 60°C.
The attached amount in the chromate treatment was 50
mg/m² in terms of the amount of Cr attached and the
attached amount in the non-chromate treatment was 200
5 mg/m² as the entire layer amount.

Furthermore, on one surface of the plated steel
sheet subjected to the chemical conversion treatment
(hereinafter this surface is referred to as surface a),
Coating Material 1-2 shown in Table 1 of Example I was
10 coated by a roll coater and dry-cured in an induction
heater using hot blast in combination. The dry curing
condition was set to give a peak metal temperature (PMT)
of 230°C. The chemical conversion treating solution and
heat-absorptive layer coating material were coated on one
15 surface or both surfaces as needed to obtain specimens.
The other surface (hereinafter, this surface is referred
to as surface b) was applied with color coating. In the
color coating, an undercoat paint for precoated steel
sheets, "FL641 PRIMER", produced by Nippon Paint Co.,
20 Ltd. was coated to a dry thickness of 5 μm and baked at
PMT of 210°C and thereon, a black metallic color topcoat
paint, "FL7100", produced by Nippon Paint Co., Ltd. was
further coated to a dry thickness of 15 μm and baked at
PMT of 230°C.

25 Details of each surface-coated sheet prepared are
shown in Table 11. In Table 11, the thickness of the
heat-absorptive layer is the thickness after drying.

The evaluation tests of each prepared surface-coated sheet are described in detail below.

1) Measurement of Emissivity of Surface-Coated Sheet

Same as in Example II.

5 2) Heat Absorptivity Measurement Test of Surface-Coated Sheet

Same as in Example II.

3) Coated Layer Adhesion Test

Same as in Example II.

10 4) Layer Bending Test

Same as in Example II.

5) Press Forming Test

Same as in Example II.

6) Corrosion Resistance

15 Same as in Example II.

7) Electrical Conductivity Test

Same as in Example II.

The evaluation results are described in detail below.

20 In the surface-coated sheet of the present invention, when the metal stock sheet is iron-zinc alloy plated steel sheet such as hot-dip galvanized steel sheet (Example III-1 of the invention), the emissivity is more elevated and this is preferred. Furthermore, when
25 the metal stock sheet is a material having high heat conductivity, such as aluminum (Example II-3 of the invention), or a sheet obtained by plating a steel on such a material (Example III-2 of the invention), heat diverges within the metal sheet or on the metal sheet
30 surface to give uniform heat on the surface of the metal material sheet and therefore, this is more preferred.
(EXAMPLE IV)

35 The method for preparing a heat-absorptive surface-coated sheet used in experiments is described in detail below.

On a sheet-like alumina-based ceramic (hereinafter referred to as a ceramic sheet), a heat-absorptive layer

coating material shown in Table 3 was coated by a bar coater and dried at an ordinary temperature for about 24 hours. Here, specimens were prepared by applying the coating material onto both front and back surfaces or only onto one surface as needed.

5 Details of each surface-coated sheet prepared are shown in Tables 12 to 14. In all of the surface-coated sheets of Tables 12 and 13, the same kind of heat-absorptive layer was coated on both surfaces under the same conditions, and in all of the surface-coated sheets of Table 14, the heat-absorptive layer was coated on only one surface and the other surface was not coated.

10

TABLE 12

	No.	Species of Coating Material	Layer Thickness	Emissivity	Heat Absorptivity	Impact Strength	Electrical Conductivity
Example of Invention	IV-1	Coating Material 3-1	5 μ m	0.80	O	O	O
	IV-2	Coating Material 3-2	5 μ m	0.91	O	O	Δ
	IV-3	Coating Material 3-3	5 μ m	0.94	O	O	Δ
	IV-4	Coating Material 3-4	5 μ m	0.95	O	X	Δ
	IV-5	Coating Material 3-5	5 μ m	0.95	O	X	Δ
	IV-6	Coating Material 3-6	5 μ m	0.80	O	O	Δ
	IV-7	Coating Material 3-7	5 μ m	0.78	Δ	O	Δ
	IV-8	Coating Material 3-8	5 μ m	0.81	O	O	X
	IV-9	Coating Material 3-9	5 μ m	0.92	O	O	O
	IV-10	Coating Material 3-10	5 μ m	0.80	O	O	O
	IV-11	Coating Material 3-11	5 μ m	0.92	O	O	X
	IV-12	Coating Material 3-12	5 μ m	0.92	O	O	Δ
	IV-13	Coating Material 3-13	5 μ m	0.93	O	O	Δ
	IV-14	Coating Material 3-14	5 μ m	0.72	Δ	O	O
	IV-15	Coating Material 3-15	5 μ m	0.72	Δ	O	O
	IV-16	Coating Material 3-16	5 μ m	0.73	Δ	O	O
	IV-17	Coating Material 3-17	5 μ m	0.95	O	O	Δ
	IV-18	Coating Material 3-18	5 μ m	0.92	O	O	O
	IV-19	Coating Material 3-19	5 μ m	0.80	O	O	O
	IV-20	Coating Material 3-20	5 μ m	0.91	O	O	Δ
	IV-21	Coating Material 3-21	5 μ m	0.65	X	O	O
	IV-22	Coating Material 3-22	5 μ m	0.65	X	X	O
Comparative Example							

TABLE 13

Example of Invention	No.	Species of Coating Material	Layer Thickness	Emissivity	Heat Absorptivity	Bending Property	Electrical Conductivity
	IV-23	Coating Material 3-2	0.5 μm	0.70	Δ	O	Δ
	IV-24	Coating Material 3-2	1.0 μm	0.85	O	O	Δ
	IV-25	Coating Material 3-2	10 μm	0.94	O	O	Δ
	IV-26	Coating Material 3-2	15 μm	0.95	O	O	Δ
	IV-27	Coating Material 3-2	25 μm	0.95	O	O	Δ
	IV-28	Coating Material 3-2	50 μm	0.95	O	O	Δ
	IV-29	Coating Material 3-2	70 μm	0.95	O	O	Δ

TABLE 14

	No.	Species of Coating Material	Layer Thickness	Emissivity	Heat Absorptivity	Remarks
Example of Invention	IV-30	Coating Material 3-2	5 μ m	0.91	○	In the heat absorptivity measurement test, the coated sheet was disposed such that the heat-absorptive layer surface was the inner side of the box and the non-coated surface was the outer side.
Comparative Example	IV-31	Coating Material 3-2	5 μ m	0.91	×	In the heat absorptivity measurement test, the coated sheet was disposed such that the non-coated surface was the inner side of the box and the heat-absorptive layer surface was the outer side.

The evaluation tests of each coated cover prepared are described in detail below.

1) Measurement of Emissivity of Surface-Coated Sheet Material

5 Same as in Example I.

2) Heat Absorptivity Measurement Test of Surface-Coated Sheet Material

10 Same as in Example I but, in this experiment, only the temperature of the thermocouple 8 in Fig. 2 was measured.

Also, an untreated sheet not coated with the heat-absorptive layer coating material was measured in the same manner and the measured value was compared and evaluated according to the following criteria.

15 ○: [$\{(\text{measured value of untreated sheet}) - (\text{measured value of surface-treated sheet to be evaluated})\} \geq 4^{\circ}\text{C}$]

△: [$4^{\circ}\text{C} > \{(\text{measured value of untreated sheet}) - (\text{measured value of surface-treated sheet to be evaluated})\} \geq 2^{\circ}\text{C}$]

20 ×: [$2^{\circ}\text{C} > \{(\text{measured value of untreated sheet}) - (\text{measured value of surface-treated sheet to be evaluated})\}$]

3) Electrical Conductivity Test

25 The surface-coated sheet prepared was measured on the electrical conductivity of the heat-absorptive layer. The measuring method was as follows. The surface resistivity on the layer surface was measured by a resistance measuring apparatus (SM-8220) manufactured by
30 Toa Corporation, where an electrode (SME-8310) for plate sample measurement manufactured by Toa Corporation was fixed, and evaluated according to the following criteria.

○: The surface resistivity was $1.0 \times 10^9 \Omega$ or less.

35 △: The surface resistivity was from more than 1.0×10^9 to $1.0 \times 10^{11} \Omega$.

X: The surface resistivity was more than $1.0 \times 10^{11} \Omega$.

4) Impact Resistance Test of Layer

5 The Du Pont mode impact resistance test of JIS K 5400 8.3.2 was performed. At the test, the striking die size was 1/2 inch (12.7 mm), the mass of the weight was 500 g and the height of the weight was 20 cm. After the test, the sample surface was observed with an eye and evaluated according to the following criteria.

O: Cracking or peeling of layer was not observed.

10 X: Cracking or peeling of layer was observed.

The results in the evaluation of the effect of the species and amount of the pigment added to the heat-absorptive layer coated on the surface-coated sheet are shown in Table 12. In Table 12, all are the results in a test using a sample obtained by coating a heat-absorptive layer of the same conditions on both surfaces of a nonmetallic sheet.

In the surface-coated sheet of the present invention (Examples IV-1 to IV-20 of the invention), the entire emissivity measured at any one temperature of 80°C or more is 0.70 or more in the wave number region of 600 to 3,000 cm^{-1} and therefore, the heat absorptivity is high as compared with Comparative Examples 21 and 22 where the emissivity is less than 0.70. This reveals that the surface-coated sheet of the present invention is suitable as a heat-generating element cover.

When the heat-absorptive layer of the surface-coated sheet of the present invention comprises 100 parts by mass of a binder solid content, from 10 to 150 parts by mass of a heat-absorptive pigment and from 1 to 150 parts by mass of an electrically conducting pigment and, excellent workability and electrical conductivity are obtained and therefore, this is more preferred.

When the amount of the heat-absorptive pigment added is less than 10 parts by mass (Comparative Example IV-21), the emissivity is less than 0.7 to give poor heat

absorptivity and therefore, this is improper. When the amount of the heat-absorptive pigment added exceeds 150 parts by mass (Example IV-5 of the invention), the emissivity is high but the impact strength decreases, therefore, the amount of the heat-absorptive pigment added is preferably 150 parts by mass or less.

When the amount of the electrically conducting pigment added is less than 1 part by mass (Example IV-8 of the invention), the electrical conductivity cannot be ensured, therefore, the amount of the electrically conducting pigment added is preferably 1 part by mass or more. When the amount of the electrically conducting pigment added exceeds 150 parts by mass (Comparative Example IV-22), the electrically conducting pigment inhibits the heat absorptivity, as a result, the emissivity is less than 0.70 to give poor heat absorptivity and at the same time, the impact resistance of the layer is greatly decreased, therefore, this is improper.

When the heat-absorptive pigment contained in the heat-absorptive layer of the surface-coated sheet of the present invention is a carbon black having an average particle size of 1 to 100 nm and the electrically conducting pigment is composed of a flaked metal Ni and chained metal Ni having an average particle size of 0.5 to 50 μ m at a mass ratio of 0.1 to 6, more excellent heat absorptivity and electrical conductivity are provided and therefore, this is more preferred.

When the particle size of the heat-absorptive pigment is relatively large as in charcoal powder or graphite powder (Examples IV-6 and IV-7 of the invention), the emissivity is relatively low and this heat-absorptive pigment inhibits the electrically conducting effect of the electrically conducting pigment to lower the electrical conductivity, therefore, the heat-absorptive pigment is more preferably a carbon black having an average particle size of 1 to 100 nm.

When the electrically conducting pigment contained in the heat-absorptive layer of the surface-coated sheet of the present invention is aluminum powder or stainless steel powder, the electrically conducting pigment is
5 liable to inhibit the heat absorptivity and the sheet having added thereto such an electrically conducting pigment (Examples IV-15 and IV-16 of the invention) is readily decreased in the emissivity.

An electrically conducting pigment composed of a
10 flaked metal Ni and a chained metal Ni having an average particle size of 0.5 to 50 μm less inhibits the heat absorptivity and is preferred. However, when the mass ratio of flaked metal Ni/chained metal Ni is less than 0.1 (Example IV-11 of the invention), the electrical
15 conductivity decreases and when the mass ratio of flaked metal Ni/chained metal Ni exceeds 6 (Example IV-14 of the invention), the heat absorptivity is readily inhibited and the emissivity decreases. Therefore, the mass ratio of flaked metal Ni/chained metal Ni is suitably from 0.1
20 to 6.

When the electrically conducting pigment is ferrosilicon (Example IV-17 of the invention), the emissivity does not decrease and therefore, this is more preferred. When the heat-absorptive pigment is not added
25 and only ferrosilicon is added (Example IV-19 of the invention), the emissivity is relatively high and the electrical conductivity is excellent, therefore, this is preferred.

When an electrically conducting carbon black is used
30 as the heat-absorptive pigment, the electrical conductivity is enhanced and therefore, this is preferred.

The evaluation results of surface-coated sheets different in the thickness of the heat-absorptive layer
35 are shown in Table 13. In Table 13, all are results in a test using a sample obtained by coating a heat-absorptive layer of the same conditions on both surfaces of a

nonmetallic sheet.

When the layer thickness is less than 1 μm (Example IV-23 of the invention), the entire emissivity is liable to be low, therefore, the layer thickness is preferably
5 from 1 μm or more.

The evaluation results on the heat absorptivity when only one surface is coated with the heat-absorptive layer and the other surface is not coated are shown in Table 14. In the case of coating only one surface with the
10 heat-absorptive layer, when the heat-absorptive layer is applied to the outer side of the cover covering the heat-generating element working out to a heat source (Comparative Example IV-31), almost no heat-absorbing effect is obtained and therefore, this is improper.
15 (EXAMPLE V)

The method for preparing a heat-absorptive surface-coated sheet used in experiments is described in detail below.

On an alumina-base ceramic sheet, a heat-absorptive
20 layer coating material shown in Table 4 was coated by a bar coater and dried at an ordinary temperature for about 24 hours. Details of each surface-coated sheet prepared are shown in Table 15. In all of the surface-coated sheets of Table 15, the same kind of heat-absorptive
25 layer was coated on both surfaces under the same conditions.

The evaluation tests of each surface-treated sheet prepared are described in detail below.

1) Emissivity Measurement Test of Surface-Coated Sheet
30 Same as in Example IV.

2) Heat Absorptivity Measurement Test of Surface-Coated Sheet

Same as in Example IV.

3) Impact Resistance Test of Layer

35 Same as in Example IV.

4) Observation of State in Aging of Heat-Absorptive

Coating Material

Each heat-absorptive coating material applied to the ceramic sheet was evaluated in the same manner as in Example II.

5 5) Appearance of Heat-absorptive layer

The appearance of layer coated on the ceramic sheet was observed with an eye and evaluated in the same manner as in Example II.

10 The evaluation results of the surface-coated sheet prepared are described in detail below.

As seen in Table 15, in the surface-coated sheet of the present invention, a heat-absorptive layer which comprises from 1 to 20 parts by mass of a carbon having a particle size of less than 0.1 μm and from 1 to 140 parts
15 by mass of a carbon having a particle size of 0.1 to 30 μm per 100 parts by mass of the resin solid content and in which the total of a carbon having a particle size of less than 0.1 μm and a carbon having a particle size of 0.1 to less than 50 μm is from 10 to 150 parts by mass,
20 was coated to a dry thickness of 1 μm or more, whereby a surface-coated sheet having high heat absorptivity could be obtained.

TABLE 15

	No.	Heat-Absorptive Coating Material		Emissivity	Heat Absorptivity	Impact Strength	Electrical Conductivity	State in Aging of Heat-Absorptive Coating Material	Appearance of Heat-Absorptive Layer
		Kind	Layer Thickness						
Example of Invention	V-1	Coating Material 4-1	5 μ m	0.75	O	O	X	O	O
	V-2	Coating Material 4-2	5 μ m	0.80	O	O	X	O	O
	V-3	Coating Material 4-3	5 μ m	0.85	O	O	X	Δ	O
	V-4	Coating Material 4-4	5 μ m	0.71	O	O	X	O	O
	V-5	Coating Material 4-5	5 μ m	0.76	O	O	X	O	O
	V-6	Coating Material 4-6	5 μ m	0.86	O	O	X	O	O
	V-7	Coating Material 4-7	5 μ m	0.89	O	O	X	O	O
	V-8	Coating Material 4-8	5 μ m	0.90	O	X	X	O	O
	V-9	Coating Material 4-9	5 μ m	0.74	O	O	X	O	Δ
Comparative Example	V-10	Coating Material 4-10	5 μ m	0.65	X	O	X	O	O
Example of Invention	V-11	Coating Material 4-11	5 μ m	0.66	X	O	X	O	O
	V-12	Coating Material 4-12	5 μ m	0.88	O	O	X	O	O
Comparative Example	V-13	Coating Material 4-13	5 μ m	0.65	X	O	X	O	O
	V-14	Coating Material 4-14	5 μ m	0.65	X	O	X	O	O
Example of Invention	V-15	Coating Material 4-15	5 μ m	0.88	O	X	X	Δ	O
	V-16	Coating Material 4-16	5 μ m	0.88	O	X	X	Δ	O
	V-17	Coating Material 4-17	5 μ m	0.80	O	O	X	O	X
Comparative Example	V-18	Coating Material 4-18	5 μ m	0.45	X	O	O	O	O
	V-19	Coating Material 4-19	5 μ m	0.55	X	O	X	O	O

(EXAMPLE VI)

The method for preparing a coated sheet material used in the experiments is described in detail below.

On a sheet-like polycarbonate ABS polymer alloy-base resin (hereinafter referred to as a plastic sheet),
5 Coating Material 3-2 or Coating Material 3-20 shown in Table 3 was coated by a bar coater and dried at an ordinary temperature for about 24 hours. Details of each surface-coated sheet prepared are shown in Table 16. In
10 all of the surface-coated sheets of Table 16, the same kind of heat-absorptive layer was coated on both surfaces under the same conditions.

The evaluation tests of each surface-coated sheet prepared are described in detail below.

- 15 1) Emissivity Measurement Test of Surface-Coated Sheet
Same as in Example IV.
- 2) Heat Absorptivity Measurement Test of Surface-Coated Sheet
Same as in Example IV.
- 20 3) Impact Resistance Test of Layer
Same as in Example IV.

The evaluation results of each surface-coated sheet prepared are shown in Table 16. Even when a plastic material such as resin is used for the base material, the
25 surface-coated sheet of the present invention is effective in the heat absorptivity and is suitable.

TABLE 16

	No.	Coating Material of Surface a		Emissivity	Heat Absorptivity	Impact Strength	Electrical Conductivity
		Kind	Layer Thickness				
Example of Invention	IV-1	Coating Material 3-2	5 μ m	0.91	O	O	Δ
	IV-2	Coating Material 3-20	5 μ m	0.91	O	O	Δ

(EXAMPLE VII)

The method for preparing a heat-absorptive precoated metal sheet used in the experiments is described in detail below.

5 A 0.6 mm-thick metal sheet was alkali-degreased in an aqueous solution prepared by diluting "FC4336" produced by Nihon Parkerizing Co., Ltd., which is a commercially available alkali degreasing agent, to a concentration of 2 mass%, at a temperature of 60°C and
10 thereafter, the steel sheet was washed with water and then dried. Subsequently, on the electrogalvanized steel sheet after degreasing, a chemical conversion treating solution was coated by a roll coater and dried with hot air under the condition of giving a peak metal
15 temperature of 60°C.

In this experiment, the following metal sheets were used.

GI: Hot-dip galvanized steel sheet (Z12)

GA: Galvannealed steel sheet (F08)

20 AL Sheet: Aluminum-plated steel sheet (amount of aluminum attached: 60 g/m² per one surface)

SUS: Stainless steel sheet (SUS430, surface bright finish)

 In this experiment, "ZM1300AN" (hereinafter referred
25 to as "chromate treatment") produced by Nihon Parkerizing Co., Ltd., which is a commercially available chromate treatment, or "CT-E300" (hereinafter referred to as "non-chromate treatment") produced by Nihon Parkerizing Co., Ltd., which is a commercially available non-chromate
30 pretreatment, was used for the chemical conversion treatment. In the chemical conversion treatment, both surfaces of the metal sheet were treated using a roll coater and dried under the condition of giving a peak metal temperature of 60°C. The attached amount in the
35 chromate treatment was 50 mg/m² in terms of the amount of Cr attached and the attached amount in the non-chromate treatment was 200 mg/m² as the entire layer amount.

Furthermore, on one surface of the metal sheet subjected to the chemical conversion treatment (hereinafter this surface is referred to as Surface a), a coating material selected from Tables 1 and 2 above was coated by a roll coater and dry-cured in an induction heater using hot blast in combination. The dry curing condition was set to give a peak metal temperature (PMT) of 230°C. The other surface (hereinafter, this surface is referred to as Surface b) was coated with a color coating material or a clear coating material by a roll coater. In the color coating, an undercoat paint for precoated steel sheets, "FL641 PRIMER", produced by Nippon Paint Co., Ltd. was coated by a roll coater to a dry thickness of 5 μm and baked at a PMT of 210°C and thereon, a white topcoat paint, "FL3510", produced by Nippon Paint Co., Ltd. was further coated by a roll coater to a dry thickness of 15 μm and baked at a PMT of 230°C. For the clear coating material, FL5000 CLEAR produced by Nippon Paint Co., Ltd. was coated to a thickness of 3 μm . Here, the primer coating material "FL641 PRIMER) for the color layer layer used in this experiment was, when the coating material was applied to a metal sheet subjected to chromate treatment, a chromate type having added thereto 48 mass% of strontium chromate based on the resin solid content or, when the coating material was applied to a metal sheet subjected to a non-chromate treatment, a non-chromate type having added thereto 30 mass% of calcium silicate was used.

Details of each precoated sheet prepared are shown in Table 17. In Table 17, the thickness of the heat-absorptive layer is a layer thickness after drying.

The method for preparing a refrigerator used in experiments is described in detail below.

The metal outside plate of a commercially available small-size refrigerator was disengaged. Thereafter, the precoated metal sheet obtained above, which was cut and

worked to the same shape as the disengaged metal plate, was fixed such that surface a of the precoated metal sheet was on the inner side of the refrigerator, and thereby a refrigerator was manufactured.

5 The evaluation tests of the surface-coated sheet prepared are described in detail below.

1) Measurement of Emissivity of Exterior Plate of Refrigerator

10 Using a Fourier transform infrared spectrophotometer "VALOR-III" manufactured by JASCO Corporation, the infrared emission spectrum in the wave number region of 600 to 3,000 cm^{-1} was measured by setting the plate temperature of the precoated metal sheet used for the exterior plate of the refrigerator at 80°C. This
15 spectrum was compared with the emission spectrum of a standard black body to measure the entire emissivity of the metal sheet. The standard black body used here was prepared by spray-coating "THI-1B Black Body Spray" available from Tacos Japan (produced by Okitsumo) on an
20 iron sheet to a layer thickness of $30 \pm 2 \mu\text{m}$.

 The emissivity was measured on Surface a of the precoated metal sheet prepared.

2) Test for Measurement of Temperature Inside Refrigerator

25 The refrigerator prepared was operated under normal conditions by turning on the power source and 24 hours after the start of operation, the temperature in the vicinity of a motor as a main internal heat source was measured by a digital thermometer. Here, the temperature
30 at a position 5 cm distant from the motor was measured.

 Also, the temperature inside a refrigerator fixed with a conventionally used metal outside plate (conventional metal outside plate) which had been originally fixed to the commercially available
35 refrigerator was measured under the above-described conditions. This temperature was compared with the measured temperature of the refrigerator evaluated and

rated as follows.

The criteria of evaluation of the temperature inside the refrigerator are as follows.

5 ○: [(measured value of refrigerator having conventional metal exterior plate) - (measured value of refrigerator to be evaluated)] $\geq 4^{\circ}\text{C}$

 △: [$4^{\circ}\text{C} > \{(\text{measured value of refrigerator having conventional metal exterior plate}) - (\text{measured value of refrigerator to be evaluated})\} \geq 2^{\circ}\text{C}$]

10 ×: [$2^{\circ}\text{C} > \{(\text{measured value of refrigerator having conventional metal exterior plate}) - (\text{measured value of refrigerator to be evaluated})\}$]

3) Layer Adhesion Test of Exterior Plate of Refrigerator

15 The coated layer on surface a of the precoated metal sheet prepared for use in the exterior plate of the refrigerator was cross-cut by a cutter knife to form 1-mm squares and after being pushed out 7 mm by an Erichsen tester such that surface a became the protrusion, a tape peeling test was performed.

20 The cutting to form squares, the pushing out by Erichsen and the tape peeling were performed according to the methods described in JIS-K5400.8.2 and JIS-K5400.8.5.

25 The evaluation after the tape peeling was performed according to the figure in the evaluation example of JIS-K5400.8.5. The rating was ○ when the score was 10 points, △ when from 8 to less than 10 points, and × when less than 8 points.

4) Workability of Exterior Plate of Refrigerator

30 When the precoated metal sheet prepared was worked into the outside plate of the refrigerator, the layer damage state of the worked part in the Surface a side was observed with an eye and evaluated as follows.

 ○: Coated layer was free of cracking or peeling in the worked part and had good appearance.

35 △: Small cracking and peeling were generated on the coated layer in the worked part.

X: Coated layer was peeled off almost over the entire surface of the worked part.

5) Corrosion Resistance of Exterior Plate of Refrigerator

5 The precoated metal sheet prepared for use in the exterior plate of the refrigerator was subjected to a salt spray test according to the method described in JIS-K5400.9.1. The salt water was sprayed on Surface a of the specimen. The test time was 48 hours. The state of white rust generation was observed in the plane part of the surface a side and was rated ○ when white rust was not generated in the plane part, △ when white rust was generated in the plane part but red rust was not generated, and X when white rust and red rust were generated in the plane part.

15 6) Electrical Conductivity Test of Exterior Plate of Refrigerator

The precoated steel sheet prepared for use in the exterior plate of the refrigerator was measured on the electrical conductivity of surface a. The measuring method was as follows. The resistivity on the surface of the metal sheet was measured by a four probe method using a resistivity meter "Loresta-EP/MCP-T360" manufactured by Mitsui Chemicals, Inc. and evaluated according to the following criteria.

25 ○: The resistivity was less than $0.1 \times 10^{-2} \Omega$.

△: The resistivity was from 0.1×10^{-2} to less than $1.0 \times 10^{-1} \Omega$.

X: The resistivity was $1.0 \times 10^{-1} \Omega$ or more.

30 7) Test for Examining Change in Aging of Viscosity of Heat-Absorptive Layer Coating Material

The heat-absorptive coating material used in this experiment (a coating material selected from Tables 1 and 2) was diluted with an organic solvent (obtained by mixing SOLVESSO 150 and cyclohexanone at 1:1 by mass) to adjust the entire solid content concentration (N.V.) to

50 mass%.

The initial viscosity of the coating material obtained was measured by the Ford cup No. 4 method. Furthermore, the viscosity after each coating material was left stand at an ordinary temperature for 1 week and re-stirred by a stirrer was again measured by the Ford cup No. 4 method and used as the viscosity after 1 week. The viscosities before and after standing for 1 week were compared and the increase in viscosity of each coating material prepared was evaluated as follows. The evaluation results in the test for change in aging of viscosity are shown in Table 18.

O: [(viscosity after 1 week) - (initial viscosity)]
< 20 seconds

△: $20 \leq [(viscosity \text{ after } 1 \text{ week}) - (initial \text{ viscosity})] < 50$ seconds

X: [(viscosity after 1 week) - (initial viscosity)]
 ≥ 50 seconds

TABLE 17 (1/2)

	No.	Metal Sheet	Species of Chemical Conversion Treatment	Coating Material of Surface a		Coating Material of Surface b		Emissivity	Temperature in Refrigerator	Adhesion	Workability	Corrosion Resistance	Electrical Conductivity
				Kind	Layer Thickness	Kind	Layer Thickness						
Example of Invention	VII-1	GI	non-chromate treatment	Coating Material 1-1	5 μ m	color coating material	20 μ m	0.70	Δ	O	O	Δ	O
	VII-2	GI	non-chromate treatment	Coating Material 1-2	5 μ m	color coating material	20 μ m	0.75	O	O	O	Δ	O
	VII-3	GI	non-chromate treatment	Coating Material 1-28	5 μ m	color coating material	20 μ m	0.80	O	O	O	Δ	O
	VII-4	GI	non-chromate treatment	Coating Material 1-3	5 μ m	color coating material	20 μ m	0.85	O	O	O	Δ	O
	VII-5	GI	non-chromate treatment	Coating Material 1-4	5 μ m	color coating material	20 μ m	0.85	O	O	O	Δ	O
	VII-6	GI	non-chromate treatment	Coating Material 1-29	5 μ m	color coating material	20 μ m	0.75	O	O	O	O	X
	VII-7	GI	non-chromate treatment	Coating Material 1-17	5 μ m	color coating material	20 μ m	0.78	O	O	O	O	O
	VII-8	GI	non-chromate treatment	Coating Material 1-30	5 μ m	color coating material	20 μ m	0.75	O	O	O	O	X
	VII-9	GI	non-chromate treatment	Coating Material 1-31	5 μ m	color coating material	20 μ m	0.75	O	O	O	O	X
	VII-10	GI	non-chromate treatment	Coating Material 1-32	5 μ m	color coating material	20 μ m	0.75	O	O	O	Δ	O
	VII-11	GI	chromate treatment	Coating Material 1-2	5 μ m	color coating material	20 μ m	0.75	O	O	O	O	O

TABLE 17 (2/2)

	No.	Metal Sheet	Species of Chemical Conversion Treatment	Coating of Material of Surface a		Coating of Material of Surface b		Emissivity	Temperature in Refrigerator	Adhesion	Workability	Corrosion Resistance	Electrical Conductivity
				Kind	Layer Thickness	Kind	Layer Thickness						
Example of Invention	VII-12	GI	not treated	Coating Material 1-2	5 μ m	color coating material	20 μ m	0.75	O	Δ	Δ	Δ	O
	VII-13	GA	non-chromate treatment	Coating Material 1-2	5 μ m	color coating material	20 μ m	0.90	O	O	O	Δ	O
	VII-14	EG	non-chromate treatment	Coating Material 1-2	5 μ m	color coating material	20 μ m	0.78	O	O	O	Δ	O
	VII-15	Al sheet	non-chromate treatment	Coating Material 1-2	5 μ m	clear coating material	3 μ m	0.75	O	O	O	Δ	O
	VII-16	SUS	non-chromate treatment	Coating Material 1-2	5 μ m	clear coating material	3 μ m	0.73	O	O	O	O	O
Comparative Example	VII-17	GI	non-chromate treatment	Coating Material 1-33	5 μ m	color coating material	20 μ m	0.40	X	O	O	O	X
	VII-18	GI	non-chromate treatment	Coating Material 1-34	5 μ m	color coating material	20 μ m	0.55	X	O	O	O	X
	VII-19	GI	non-chromate treatment	Coating Material 1-35	5 μ m	color coating material	20 μ m	0.85	O	O	X	O	X
	VII-20	GI	non-chromate treatment	Coating Material 1-36	5 μ m	color coating material	20 μ m	0.56	X	O	O	O	X
	VII-21	GI	non-chromate treatment	not coated	-	color coating material	20 μ m	0.56	X	-	-	X	O
Example of Invention	VII-22	GI	non-chromate treatment	Coating Material 2-25	5 μ m	color coating material	20 μ m	0.80	O	O	O	Δ	X
	VII-23	GI	non-chromate treatment	Coating Material 2-26	5 μ m	color coating material	20 μ m	0.85	O	O	O	Δ	X

TABLE 18

Species of Coating Material	Increase of Viscosity
Coating Material 1-1	○
Coating Material 1-2	○
Coating Material 1-28	△
Coating Material 1-3	×
Coating Material 1-4	×
Coating Material 1-29	○
Coating Material 1-17	○
Coating Material 1-30	○
Coating Material 1-31	○
Coating Material 1-32	○
Coating Material 1-33	○
Coating Material 1-34	○
Coating Material 1-35	×
Coating Material 1-36	○
Coating Material 2-25	○
Coating Material 2-26	△

The evaluation results are described in detail below.

5 The evaluation results are shown in Table 17. In the refrigerator of the present invention, a heat-absorptive layer having an entire emissivity of 0.70 or more in the wave number region of 600 to 3,000 cm^{-1} as measured at a certain temperature in the range from 80°C to 200°C is coated on the inside surface of the metal-made exterior plate, whereby reduction of the temperature inside the refrigerator is achieved. In the case where the emissivity of the heat-absorptive layer is less than 0.70 (Comparative Examples VII-15, VII-16, VII-18 and VII-19), the internal temperature of the refrigerator is not greatly different from that of conventional types and therefore, this is improper.

20 When the heat-absorptive layer coated on the outside plate of the refrigerator of the present invention comprises from 10 to 150 parts by mass of carbon per 100 parts by mass of the binder solid content, the emissivity of the heat-absorptive layer is 0.70 or more and therefore, this is preferred. In the case where the amount of carbon added is less than 10 parts by mass

(Comparative Examples VII-15, VII-16 and VII-18) or carbon is not coated (Comparative Example VII-19), the emissivity is less than 0.70 and therefore, this is improper. Furthermore, when the amount of carbon added exceeds 150 parts by mass (Comparative Example VII-17), the working property deteriorates and therefore, this is improper.

When an electrically conducting pigment is added to the heat-absorptive layer coated on the exterior plate of the refrigerator of the present invention, electrical conductivity is imparted and, as a result, less static electricity is generated during the assembling of the refrigerator and the problem that dust or motes adhere due to static electricity is eliminated, therefore, this is more preferred. When an electrically conducting pigment is not added (Examples VII-6, VII-8 and VII-9 of the invention), the electrically conductivity is poor.

When a rust-preventive pigment is added to the heat-absorptive layer coated on the outside plate of the refrigerator of the present invention (Examples VII-7, VII-8 and VII-9 of the invention), excellent corrosion resistance is exhibited and therefore, this is preferred. In particular, when ferrosilicon is added (Example VII-7 of the invention), not only the corrosion resistance but also the electrical conductivity are excellent and therefore, this is more preferred.

When the heat-absorptive layer coated on the exterior plate of the refrigerator of the present invention comprises from 1 to 20 parts by mass of a carbon having a particle size of less than 0.1 μm and from 1 to 140 parts by mass of a carbon having a particle size of 0.1 to 50 μm per 100 parts by mass of the binder solid content and the total of a carbon having a particle size of less than 0.1 μm and a carbon having a particle size of 0.1 μm to 50 μm is from 10 to 150 parts by mass (Examples VII-20 and VII-21 of the invention), a large

amount of carbon is added in the heat-absorptive layer but the viscosity of the heat-absorptive coating material is less elevated and therefore, this is more preferred.

5 When the exterior plate of the refrigerator of the present invention is subjected to a chemical conversion treatment before the heat-absorptive layer is coated, excellent adhesive property and workability are obtained and therefore, this is preferred. When the exterior plate is not subjected to a chemical conversion treatment
10 (Example 12 of the invention), the adhesive property or workability is inferior. Whichever chemical conversion treatment may be performed, a non-chromate treatment is more preferred than a chromate treatment in view of environmental problem.

15 (EXAMPLE VIII)

The method for preparing a heat-absorptive coated sheet used in experiments is described in detail below.

On respective inner surfaces of an aluminum alloy sheet and a magnesium alloy sheet, a heat-absorptive
20 layer coating material shown in Table 4 was coated by a bar coater and dried at an ordinary temperature for about 24 hours. Details of each surface-coated sheet prepared are shown in Table 19 (Al alloy sheet) and Table 20 (Mg alloy sheet). In all of the surface-coated sheets of
25 Tables 19 and 20, the same kind of heat-absorptive layer was coated on both surfaces under the same conditions.

The evaluation tests of each surface-treated sheet prepared are described in detail below.

30 1) Measurement of Emissivity of Surface-Coated Sheet Material

Same as in Example IV.

2) Heat Absorptivity Measurement Test of Surface-Coated Sheet Material

Same as in Example IV.

35 3) Impact Resistance Test of Layer

Same as in Example IV.

4) Observation of State in Aging of Heat-Absorptive

Coating Material

Each heat-absorptive layer coating material applied to the aluminum alloy sheet or magnesium alloy sheet was evaluated in the same manner as in Example II.

5 5) Appearance of Heat-Absorptive Layer

The appearance of layer coated on the aluminum alloy sheet or magnesium alloy sheet was observed with an eye and evaluated in the same manner as in Example II.

10 The evaluation results of the surface-coated sheet prepared are described in detail below.

As seen in Tables 19 and 20, in the surface-coated sheet of the present invention, a heat-absorptive layer which comprises from 1 to 20 parts by mass of a carbon having a particle size of less than 0.1 μm and from 1 to 15 140 parts by mass of a carbon having a particle size of 0.1 to 50 μm per 100 parts by mass of the resin solid content and in which the total of a carbon having a particle size of less than 0.1 μm and a carbon having a particle size of 0.1 to 50 μm is from 10 to 150 parts by 20 mass, was coated to a dry thickness of 1 μm or more, whereby a surface-coated sheet having high heat absorptivity could be obtained.

TABLE 19

	No.	Heat-Absorptive Coating Material		Emissivity	Heat Absorptivity	Impact Strength	Electrical Conductivity	State in Aging of Heat-Absorptive Coating Material	Appearance of Heat-Absorptive Layer
		Kind	Layer Thickness						
Example of Invention	VIII-1	Coating Material 4-1	5 μ m	0.72	O	O	X	O	O
	VIII-2	Coating Material 4-2	5 μ m	0.81	O	O	X	O	O
	VIII-3	Coating Material 4-3	5 μ m	0.84	O	O	X	Δ	O
	VIII-4	Coating Material 4-4	5 μ m	0.71	O	O	X	O	O
	VIII-5	Coating Material 4-5	5 μ m	0.77	O	O	X	O	O
	VIII-6	Coating Material 4-6	5 μ m	0.87	O	O	X	O	O
	VIII-7	Coating Material 4-7	5 μ m	0.90	O	O	X	O	O
	VIII-8	Coating Material 4-8	5 μ m	0.91	O	X	X	O	O
	VIII-9	Coating Material 4-9	5 μ m	0.73	O	O	X	O	Δ
	VIII-10	Coating Material 4-10	5 μ m	0.65	X	O	X	O	O
Comparative Example	VIII-11	Coating Material 4-11	5 μ m	0.65	X	O	X	O	O
Example of Invention	VIII-12	Coating Material 4-12	5 μ m	0.88	O	O	X	O	O
Comparative Example	VIII-13	Coating Material 4-13	5 μ m	0.63	X	O	X	O	O
	VIII-14	Coating Material 4-14	5 μ m	0.65	X	O	X	O	O
Example of Invention	VIII-15	Coating Material 4-15	5 μ m	0.89	O	X	X	Δ	O
	VIII-16	Coating Material 4-16	5 μ m	0.88	O	X	X	Δ	O
	VIII-17	Coating Material 4-17	5 μ m	0.82	O	O	X	O	X
Comparative Example	VIII-18	Coating Material 4-18	5 μ m	0.44	X	O	O	O	O
	VIII-19	Coating Material 4-19	5 μ m	0.52	X	O	X	O	O

TABLE 20

	No.	Heat-Absorptive Coating Material		Emissivity	Heat Absorptivity	Impact Strength	Electrical Conductivity	State in Aging of Heat-Absorptive Coating Material	Appearance of Heat-Absorptive Layer
		Kind	Layer Thickness						
Example of Invention	VIII-20	Coating Material 4-1	5 μ m	0.77	O	O	X	O	O
	VIII-21	Coating Material 4-2	5 μ m	0.83	O	O	X	O	O
	VIII-22	Coating Material 4-3	5 μ m	0.88	O	O	X	Δ	O
	VIII-23	Coating Material 4-4	5 μ m	0.74	O	O	X	O	O
	VIII-24	Coating Material 4-5	5 μ m	0.80	O	O	X	O	O
	VIII-25	Coating Material 4-6	5 μ m	0.87	O	O	X	O	O
	VIII-26	Coating Material 4-7	5 μ m	0.90	O	O	X	O	O
	VIII-27	Coating Material 4-8	5 μ m	0.91	O	X	X	O	O
Comparative Example of Invention	VIII-28	Coating Material 4-9	5 μ m	0.75	O	O	X	O	Δ
	VIII-29	Coating Material 4-10	5 μ m	0.64	X	O	X	O	O
	VIII-30	Coating Material 4-11	5 μ m	0.63	X	O	X	O	O
	VIII-31	Coating Material 4-12	5 μ m	0.89	O	O	X	O	O
	VIII-32	Coating Material 4-13	5 μ m	0.63	X	O	X	O	O
	VIII-33	Coating Material 4-14	5 μ m	0.62	X	O	X	O	O
	VIII-34	Coating Material 4-15	5 μ m	0.89	O	X	X	Δ	O
	VIII-35	Coating Material 4-16	5 μ m	0.88	O	X	X	Δ	O
Comparative Example of Invention	VIII-36	Coating Material 4-17	5 μ m	0.82	O	O	X	O	X
	VIII-37	Coating Material 4-18	5 μ m	0.43	X	O	O	O	O
	VIII-38	Coating Material 4-19	5 μ m	0.54	X	O	X	O	O

(EXAMPLE IX)

The method for preparing a coated sheet material used in experiments is described in detail below.

5 On a sheet-like polycarbonate ABS polymer alloy-base resin (hereinafter referred to as a plastic sheet), Coating Material 4-2 or Coating Material 4-9 shown in Table 4 was coated by a bar coater and dried at an ordinary temperature for about 24 hours. Details of each surface-coated sheet prepared are shown in Table 21. In
10 all of the surface-coated sheets of Table 21, the same kind of heat-absorptive layer was coated on both surfaces under the same conditions.

The evaluation tests of each surface-coated sheet prepared are described in detail below.

15 1) Emissivity Measurement Test of Surface-Coated Sheet

Same as in Example IV.

2) Heat Absorptivity Measurement Test of Surface-Coated Sheet

Same as in Example IV.

20 3) Impact Resistance Test of Layer

Same as in Example IV.

The evaluation results of each surface-coated sheet prepared are shown in Table 21. Even when a plastic material such as resin is used for the base material, the
25 surface-coated sheet of the present invention is effective in heat absorptivity and is suitable.

TABLE 21

	No.	Coating Material of Surface a		Emissivity	Heat Absorptivity	Impact Strength	Electrical Conductivity
		Kind	Layer Thickness				
Example of Invention	IX-1	Coating Material 4-2	5 μ m	0.91	O	O	Δ
	IX-2	Coating Material 4-9	5 μ m	0.91	O	O	Δ

(EXAMPLE X)

The method for preparing a heat-absorptive aluminum alloy sheet used in experiments is described in detail below.

5 A 0.6 mm-thick aluminum alloy sheet was dipped in an aqueous solution prepared by diluting "FC-315", produced by Nihon Parkerizing Co., Ltd., which is a commercially available alkali degreasing agent, to a concentration of 20 mass%, at a temperature of 60°C and was thereby
10 degreased. Thereafter, the alloy sheet was washed with water and dried. Thereon, "CTE-300" produced by Nihon Parkerizing Co., Ltd., which is a commercially non-chromate treatment, was further coated by a roll coater to a dry attached amount of 200 mg/m².

15 Subsequently, on the degreased aluminum alloy sheet, a heat-absorptive layer coating material shown in Table 1 was coated by a roll coater and dry-cured in an induction heater using hot blast in combination. The dry curing condition was set to give a peak metal temperature (PMT)
20 of 230°C. The heat-absorptive layer coating material was coated on one surface or both surfaces as needed to obtain specimens.

 Details of each surface-treated aluminum alloy sheet prepared are shown in Table 22. In all of the aluminum
25 alloy sheets of Table 22, the heat-absorptive layer was coated on only one surface and the other surface was not coated.

TABLE 22 (1/2)

	No.	Species of Coating Material	Layer Thickness	Emissivity	Heat		Adhesion of Layer	Bending Property	Press Formability	Corrosion Resistance		Electrical Conductivity
					Absorptivity	Temperature				Cross-Cut	End Face	
Example of Invention	X-1	Coating Material 1-1	5 μ m	0.80		O	O	O	O	Δ	Δ	O
	X-2	Coating Material 1-2	5 μ m	0.91		O	O	O	O	Δ	Δ	Δ
	X-3	Coating Material 1-3	5 μ m	0.94		O	O	Δ	Δ	Δ	Δ	Δ
	X-4	Coating Material 1-4	5 μ m	0.95		O	O	Δ	Δ	Δ	Δ	Δ
	X-5	Coating Material 1-5	5 μ m	0.95		O	O	$\times$	$\times$	Δ	Δ	Δ
	X-6	Coating Material 1-6	5 μ m	0.80		O	O	O	O	Δ	Δ	Δ
	X-7	Coating Material 1-7	5 μ m	0.78		Δ	O	O	O	Δ	Δ	Δ
	X-8	Coating Material 1-8	5 μ m	0.81		O	O	O	O	Δ	Δ	$\times$
	X-9	Coating Material 1-9	5 μ m	0.92		O	O	O	O	Δ	Δ	O
	X-10	Coating Material 1-10	5 μ m	0.80		O	O	O	O	Δ	Δ	O
	X-11	Coating Material 1-11	5 μ m	0.92		O	O	O	O	Δ	Δ	$\times$
	X-12	Coating Material 1-12	5 μ m	0.92		O	O	O	O	Δ	Δ	Δ
	X-13	Coating Material 1-13	5 μ m	0.93		O	O	O	O	Δ	Δ	Δ
	X-14	Coating Material 1-14	5 μ m	0.72		Δ	O	O	O	Δ	Δ	O
	X-15	Coating Material 1-15	5 μ m	0.72		Δ	O	O	O	Δ	Δ	O
	X-16	Coating Material 1-16	5 μ m	0.73		Δ	O	O	O	Δ	Δ	O

TABLE 22 (2/2)

	No.	Species of Coating Material	Layer Thickness	Emissivity	Heat Absorptivity		Adhesion of Layer	Bending Property	Press Formability	Corrosion Resistance		Electrical Conductivity
					Temperature					Cross-Cut	End Face	
Example of Invention	X-17	Coating Material 1-17	5 μm	0.95	○		○	○	○	○	○	△
	X-18	Coating Material 1-18	5 μm	0.92	○		○	○	○	△	○	○
	X-19	Coating Material 1-19	5 μm	0.80	○		○	○	○	○	○	○
	X-20	Coating Material 1-20	5 μm	0.93	○		○	○	○	△	△	△
	X-21	Coating Material 1-21	5 μm	0.91	○		○	○	○	○	○	△
	X-22	Coating Material 1-22	5 μm	0.81	○		○	○	○	○	○	△
	X-23	Coating Material 1-23	5 μm	0.80	○		○	○	○	○	○	△
	X-24	Coating Material 1-24	5 μm	0.82	○		○	○	○	○	○	△
	X-25	Coating Material 1-25	5 μm	0.80	○		○	○	○	○	○	△
	X-26	Coating Material 1-26	5 μm	0.65	×		○	○	○	△	△	○
Comparative Example	X-27	Coating Material 1-27	5 μm	0.65	×		○	×	×	△	△	○

The evaluation tests of each aluminum alloy sheet prepared are described in detail below.

1) Measurement of Emissivity of Aluminum Alloy Sheet

Same as in Example I.

5 2) Heat Absorptivity Measurement Test of Aluminum Alloy Sheet

Same as in Example IV.

3) Layer Adhesion Test

Same as in Example I.

10 4) Layer Bending Test

Same as in Example I.

5) Press Forming Test

Same as in Example I.

6) Corrosion Resistance

15 The aluminum alloy sheet prepared was subjected to a salt spray test according to the method described in JIS-K5400.9.1. The salt water was sprayed on the heat-absorptive layer surface. The test time was 500 hours.

20 The coated layer in the cross-cut part was evaluated by rating ○ when the maximum blister width in one side of the cross-cut was less than 2 mm, △ when from 2 mm to less than 5 mm, and X when 5 mm or more.

25 A flat sheet produced such that the burr at the cutting came to the evaluation surface side of the coated steel sheet (namely, such that upper burr was obtained) was also subjected to the above-described salt spray test and the blister width of layer from the end face was observed. The end face part was evaluated by rating ○ when the blister width from the end face was less than 2 mm, △ when from 2 mm to less than 5 mm, and X when 5 mm or more.

30 7) Electrical Conductivity Test

Same as in Example I.

35 The results in the evaluation of the effect of the species and amount of the pigment added to the heat-absorptive layer coated on the aluminum alloy sheet are

shown in Table 22.

In the aluminum alloy sheet of the present invention (Examples X-1 to X-25 of the invention), the entire emissivity measured at a temperature of 80°C is 0.70 or more in the wave number region of 600 to 3,000 cm^{-1} and therefore, the heat absorptivity is high as compared with Comparative Examples X-26 and X-27 where the emissivity is less than 0.70. This reveals that the aluminum alloy sheet of the present invention is suitable as a heat-generating element cover.

When the heat-absorptive layer of the aluminum alloy sheet of the present invention comprises 100 parts by mass of a binder solid content, from 10 to 150 parts by mass of a heat-absorptive pigment and from 1 to 150 parts by mass of an electrically conducting pigment, excellent workability and electrical conductivity are obtained and therefore, this is more preferred.

When the amount of the heat-absorptive pigment added is less than 10 parts by mass (Comparative Example X-26), the emissivity is less than 0.7 to give poor heat absorptivity and therefore, this is improper. When the amount of the heat-absorptive pigment added exceeds 150 parts by mass (Example X-5 of the invention), the emissivity is high but the workability, such as a bending property or press formability, deteriorates and, therefore, the amount of the heat-absorptive pigment added is preferably 150 parts by mass or less.

When the amount of the electrically conducting pigment added is less than 1 part by mass (Example X-8 of the invention), the electrical conductivity cannot be ensured and, therefore, the amount of the electrically conducting pigment added is preferably 1 part by mass or more. When the amount of the electrically conducting pigment added exceeds 150 parts by mass (Comparative Example X-27), the electrically conducting pigment inhibits the heat absorptivity and, as a result, the emissivity is less than 0.7 to give poor heat

absorptivity and, at the same time, the workability of the layer layer is greatly decreased, therefore, this is improper.

5 When the heat-absorptive pigment contained in the heat-absorptive layer of the aluminum alloy sheet of the present invention is a carbon black having an average particle size of 1 to 100 nm and the electrically conducting pigment comprises a flaked metal Ni and a chained metal Ni having an average particle size of 0.5
10 to 50 μm with the mass ratio of flaked metal Ni/chained metal Ni being from 0.1 to 6, more excellent heat absorptivity and electrical conductivity are provided and therefore, this is more preferred.

15 When the particle size of the heat-absorptive pigment is relatively large as in charcoal powder or graphite powder (Examples X-6 and X-7 of the invention), the emissivity is relatively low and the large heat-absorptive pigment inhibits the electrically conducting effect of the electrically conducting pigment to lower
20 the electrical conductivity, therefore, the heat-absorptive pigment is more preferably a carbon black having an average particle size of 1 to 100 nm.

When the electrically conducting pigment contained in the heat-absorptive layer of the aluminum alloy sheet
25 of the present invention is aluminum powder or stainless steel powder, the electrically conducting pigment is liable to inhibit the heat absorptivity and the alloy sheet having added thereto such an electrically conducting pigment (Examples X-15 and X-16 of the
30 invention) is decreased in the emissivity.

An electrically conducting pigment comprising flaked metal Ni and a chained metal Ni having an average particle size of 0.5 to 50 μm less inhibits the heat absorptivity and is preferred, However, when the mass
35 ratio of flaked metal Ni/chained metal Ni is less than 0.1 (Example X-11 of the invention), the electrical

conductivity decreases and when the mass ratio of flaked metal Ni/chained metal Ni exceeds 6 (Example X-14 of the invention), the heat absorptivity is inhibited and the emissivity is low. Therefore, the mass ratio of flaked metal Ni/chained metal Ni is suitably from 0.1 to 6.

When the electrically conducting pigment is ferrosilicon (Example X-17 of the invention), the emissivity does not decrease and at the same time, the corrosion resistance of the aluminum alloy sheet of the present invention is improved, therefore, this is more preferred. When the heat-absorptive pigment is not added and only ferrosilicon is added (Example X-19 of the invention), the emissivity is relatively high and the electrical conductivity and corrosion resistance are excellent, therefore, this is preferred.

When an electrically conducting carbon black is used as the heat-absorptive pigment, the electrical conductivity is enhanced and therefore, this is preferred. The aluminum alloy sheet of the present invention where the heat-absorptive layer contains a rust-preventive pigment in addition to the heat-absorptive pigment and electrically conducting pigment (Examples X-22 to X-25 of the invention) exhibits excellent corrosion resistance and therefore, this is more preferred.

The evaluation results of aluminum alloy sheets different in the thickness of the heat-absorptive layer are shown in Table 7. When the layer thickness is less than 1 μm (Example X-28 of the invention), the entire emissivity is low and when the layer thickness exceeds 50 μm , the workability of the coated layer is decreased, therefore, the layer thickness is preferably from 1 to 50 μm .

35 INDUSTRIAL APPLICABILITY

According to the present invention, a technique of

releasing heat generated inside a home electric appliance internally using a large number of components which functions as a heat source, such as motor or electronic part, is established. Furthermore, a surface-treated material suitable for releasing heat and at the same time, having excellent electrical conductivity for earthing or grounding a home electric appliance can be provided. Using this technique, the performance of home electric appliance can be enhanced and the energy consumption amount can be reduced. This technique is applied also to devices containing an electronic parts or a battery and undergoing elevation of the internal temperature, such as a cellular phone, a notebook computer, a PDA, an in-vehicle battery case, a vehicle navigation system, a vehicle audio device and in-vehicle control equipment, and there are provided effects such as enhancement of performance and reduction in the energy consumption amount. Thus, the present invention has high industrial applicability.

CLAIMS

1. A heat-generating element cover having excellent heat absorptivity, comprising a heat-generating element cover body having coated at least on the inner surface thereof a heat-absorptive layer of which entire emissivity measured at a temperature in a range of 80°C to 200°C is 0.70 or more in the wave number region of 600 to 3,000 cm^{-1} .

2. The heat-generating element cover having excellent heat absorptivity as set forth in claim 1, wherein the heat-absorptive layer comprises 100 parts by mass of a binder solid content and from 10 to 150 parts by mass of a heat-absorptive pigment.

3. The heat-generating element cover having excellent heat absorptivity as set forth in claim 1 or 2, wherein the heat-absorptive layer comprises from 1 to 20 parts by mass of a carbon having a particle size of less than 0.1 μm and from 1 to 140 parts by mass of a carbon having a particle size of 0.1 to 50 μm per 100 parts by mass of the binder solid content and in the heat-absorptive layer, the total of a carbon having a particle size of less than 0.1 μm and a carbon having a particle size of 0.1 μm to 50 μm is from 10 to 150 parts by mass.

4. The heat-generating element cover having excellent heat absorptivity as set forth in any one of claims 1 to 3, wherein the heat-absorptive layer comprises 100 parts by mass of a binder solid content, from 10 to 150 parts by mass of a heat-absorptive pigment and from 1 to 150 parts by mass of an electrically conducting pigment.

5. The heat-generating element cover having excellent heat absorptivity as set forth in claim 4, wherein the heat-absorptive pigment is a carbon black having an average particle size of 1 to 100 nm, the electrically conducting pigment comprises a flaked metal Ni and a chained metal Ni having an average particle size

of 0.5 to 50 μm , and the mass ratio of flaked metal Ni/chained metal Ni is from 0.1 to 6.

5 6. The heat-generating element cover having excellent heat absorptivity as set forth in any one of claims 2 to 5, wherein the electrically conducting pigment is ferrosilicon.

10 7. The heat-generating element cover having excellent heat absorptivity as set forth in claim 1, wherein the heat-absorptive layer comprises 100 parts by mass of a binder solid content and from 5 to 150 parts by mass of ferrosilicon.

15 8. The heat-generating element cover as set forth in any one of claims 1 to 7, wherein the heat-generating element cover body is made of a metal.

20 9. The heat-generating element cover as set forth in any one of claims 1 to 7, wherein the heat-generating element cover body is made of a nonmetal.

25 10. A surface-treated metal sheet having excellent heat absorptivity, comprising a metal sheet or plated metal sheet having coated at least on one surface thereof a heat-absorptive layer of which entire emissivity measured at a temperature in a range of 80°C to 200°C is 0.70 or more in the wave number region of 600 to 3,000 cm^{-1} .

30 11. The surface-treated metal sheet having excellent heat absorptivity as set forth in claim 10, wherein the heat-absorptive layer comprises 100 parts by mass of a binder solid content and from 10 to 150 parts by mass of a heat-absorptive pigment.

35 12. The surface-treated metal sheet having excellent heat absorptivity as set forth in claim 10 or 11, wherein the heat-absorptive layer comprises from 1 to 20 parts by mass of a carbon having a particle size of less than 0.1 μm and from 1 to 140 parts by mass of a carbon having a particle size of 0.1 to 50 μm per 100 parts by mass of the binder solid content and in the

heat-absorptive layer, the total of a carbon having a particle size of less than 0.1 μm and a carbon having a particle size of 0.1 μm to 50 μm is from 10 to 150 parts by mass.

5 13. The surface-treated metal sheet having excellent heat absorptivity as set forth in any one of claims 10 to 12, wherein the heat-absorptive layer comprises 100 parts by mass of a binder solid content, from 10 to 150 parts by mass of a heat-absorptive pigment
10 and from 1 to 150 parts by mass of an electrically conducting pigment.

 14. The surface-treated metal sheet having excellent heat absorptivity as set forth in claim 13, wherein the heat-absorptive pigment is a carbon black
15 having an average particle size of 1 to 100 nm, the electrically conducting pigment comprises a flaked metal Ni having an average particle size of 0.5 to 50 μm and a chained metal Ni, and the mass ratio of flaked metal Ni/chained metal Ni is from 0.1 to 6.

20 15. The surface-treated metal sheet having excellent heat absorptivity as set forth in any one of claims 12 to 14, wherein the electrically conducting pigment is ferrosilicon.

 16. The surface-treated metal sheet having
25 excellent heat absorptivity as set forth in claim 10, wherein the heat-absorptive layer comprises 100 parts by mass of a binder solid content and from 5 to 150 parts by mass of ferrosilicon.

 17. A refrigerator having excellent thermal
30 efficiency, comprising a metal-made exterior plate having coated on the inside surface thereof a heat-absorptive layer of which entire emissivity measured at a temperature in a range of 80°C to 200°C or more is 0.70 or more in the wave number region of 600 to 3,000 cm^{-1} .

35 18. The refrigerator having excellent thermal efficiency as set forth in claim 17, wherein the heat-

absorptive layer comprises from 10 to 150 parts by mass of a carbon per 100 parts by mass of the binder solid content.

5 19. The refrigerator having excellent thermal efficiency as set forth in claim 18 or 19, wherein the heat-absorptive layer comprises from 1 to 50 parts by mass of an electrically conducting metal powder per 100 parts by mass of the binder solid content.

10 20. The refrigerator having excellent thermal efficiency as set forth in any one of claims 17 to 19, wherein the heat-absorptive layer comprises from 1 to 20 parts by mass of a carbon having a particle size of less than 0.1 μm and from 1 to 140 parts by mass of a carbon having a particle size of 0.1 to 50 μm per 100 parts by mass of the binder solid content and in the heat-
15 absorptive layer, the total of a carbon having a particle size of less than 0.1 μm and a carbon having a particle size of 0.1 μm to 50 μm is from 10 to 150 parts by mass and the dry layer thickness is 1 μm or more.

20 21. A refrigerator having excellent thermal efficiency characterized in that the heat-generating element cover according to any one of claims 1 to 9 is used as an exterior plate.

25 22. A refrigerator having excellent thermal efficiency characterized in that the surface-treated metal sheet according to any one of claims 10 to 16 is used as an exterior plate, in which the heat-absorptive layer of said metal sheet is disposed as an inner surface.

30 23. The refrigerator having excellent thermal efficiency as set forth in any one of claims 17 to 22, wherein a clear layer or a layer comprising a color pigment is coated on the outer side of the metal-made exterior plate.

35 24. A method for producing a refrigerator having

excellent heat absorptivity, comprising previously coating the heat-absorptive layer set forth in any one of claims 17 to 20 on one surface of a flat metal sheet and a clear or color pigment-containing layer on another surface to produce a precoated metal sheet having high heat absorptivity, cutting and working the metal sheet, and then assembling the metal sheet into a refrigerator.

25. A portable or in-vehicle device, containing a heat-generating electronic component and being enclosed in a case having on the inside thereof a heat-absorptive layer, the heat-absorptive layer comprising

(A) 100 parts by mass of a binder solid content, from 1 to 20 parts by mass of a carbon having a particle size of less than 0.1 μm , and from 1 to 140 parts by mass of a carbon having a particle size of 0.1 to 50 μm , with the total of a carbon having a particle size of less than 0.1 μm and a carbon having a particle size of 0.1 μm to 50 μm being from 10 to 150 parts by mass;

(B) 100 parts by mass of a binder solid content, from 10 to 150 parts by mass of a heat-absorptive pigment and from 1 to 150 parts by mass of an electrically conducting pigment, the heat-absorptive pigment being a carbon black having an average particle size of 1 to 100 nm and the electrically conducting pigment comprising a flaked metal Ni and a chained metal Ni having an average particle size of 0.5 to 50 μm , with the mass ratio of flaked metal Ni/chained metal Ni being from 0.1 to 6;

(C) 100 parts by mass of a binder solid content, from 10 to 150 parts by mass of a heat-absorptive pigment and from 5 to 150 parts by mass of ferrosilicon; or

(D) 100 parts by mass of a binder solid content and from 5 to 150 parts by mass of ferrosilicon.

26. A portable or in-vehicle device characterized in that a case for a portable or in-vehicle device containing an electronic component which generates heat is the heat-generating element cover according to any one of claims 1 to 9.

27. A portable or in-vehicle device characterized in that a case for a portable or in-vehicle device containing an electronic component which generates heat is made by processing the surface-treated metal sheet according to any one of claims 10 to 16.

28. The portable or in-vehicle device as set forth in any one of claims 25 to 27, wherein the case is made of an Mg alloy or an Al alloy.

29. A portable or in-vehicle device case having a heat-absorptive layer, as set forth in claim 25.