

EMERGENCY STOP DEVICE FOR ELEVATOR AND ELEVATOR

BACKGROUND OF THE INVENTION

This invention relates generally to an elevator, and more particularly to a highly-reliable emergency stop device for high-speed elevators which
5 device operates when the speed of movement of the elevator exceeds a predetermined speed, and also relates to a high-speed elevator equipped with such emergency stop devices.

It is essential for an elevator to have a
10 emergency stop device which stops an elevator cage at such an average deceleration (not more than 9.8 m/S^2 according to the standard of Japan Elevator Association) as not to injure passengers when the cage drops, for example, as a result of the cutting of drive ropes.

15 A conventional emergency stop device comprises two brake members having their sliding surfaces disposed in opposed relation to opposite sides of a guide rail, respectively. When the speed of a cage exceeds a predetermined speed, the two brake members are pressed
20 respectively against the opposite sides of the guide rail by a resilient force of a resilient member, thereby producing a braking force. With the advent of multistory buildings, elevators have been of a high-speed design and a long-stroke design. When the
25 elevator has such a high-speed and long-stroke design,

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the speed of movement and the braking distance increase at the time of emergency stop, and this arouses a new problem that the energy to be braked by the emergency stop devices increases greatly.

5 In the conventional construction, to deal with such increased braking energy, the force of pressing of the brake members against the guide rail must be increased, and therefore the resilient member must be of a larger size, which results in an increased weight of
10 the emergency stop device. The increased weight of the emergency stop device leads to the increase of the weight of the cage, and therefore the power of a drive source for driving the elevator must be increased. Moreover, because of the increased weight of the cage,
15 the number of ropes must be increased, and the diameter of these ropes must be increased. Disadvantageously, this further increases the weight. Therefore, for dealing with the higher speed and the longer stroke of the elevator, the method of pressing the brake members
20 with an increased force is not proper, and instead it is necessary to enhance sliding properties of the brake members, that is, to increase a friction coefficient and to improve wear resistance.

 A brake member is required to have the
25 following sliding properties. In an emergency stop device, there must be by all means avoided a situation in which brake members seize on a rail to abruptly stop a cage, thus injuring passengers. Therefore, the brake



member is required to have a certain degree of lubricating properties so that it will not seize and lock relative to the rail. On the other hand, in order to efficiently convert the pressing force into a braking
5 force for stopping a cage, it is necessary to provide a stable high friction coefficient over a wide speed range from a high speed to a low speed. Furthermore, where the resilient member for pressing the brake member against the rail comprises a spring having a linear
10 spring constant, the pressing force decreases with the increase of wear. Therefore, other properties that the brake member requires is wear resistance.

Generally, case iron has heretofore been used for the brake member. For example, as disclosed in
15 Japanese Patent Publication No. 50-4175, flake graphite cast iron, FC250 (Japanese Industrial Standard, that is, JIS), and nodular graphite cast iron, FCD400 (JIS) have been used. In these materials, graphite acts as a lubricating component, and therefore the locking of the
20 brake member relative to the rail does not occur, and the friction coefficient is stable. However, although FC250 and FCD400 are stable in friction coefficient, they are low in friction coefficient, and are inferior in wear resistance. Therefore, when FC250 and FCD400
25 are to be used, the pressing force of the emergency stop device must be increased, and therefore the weight of the emergency stop device is increased, which results in a problem that the weight of the cage is increased.



It has been proposed to mechanically improve the sliding properties of the brake member. For example, with respect to a method of stabilizing a friction coefficient while keeping its value high,

5 Japanese Patent Publication No. 59-35819 clearly discloses an emergency stop device in which an iron material having a good wear resistance is provided at an upper portion of a sliding surface of a brake member while a copper material stable in friction coefficient

10 is provided at a lower portion of the sliding surface. In this brake member, a lubricating component indispensable for such a brake member has not been studied, and has a problem with its reliability. Although the use of the iron material and the copper

15 material in combination has been studied in order to deal with a temperature rise of the sliding surface, the efficiency of thermal conduction between the two materials is low, and this is not effective in preventing the fusion of that portion of the sliding

20 surface of the iron material. Furthermore, if the two materials are not equal in wear resistance to each other, the upper portion and the lower portion of the brake member differ in amount of wear from each other, so that an uneven contact of the sliding surface occurs,

25 which results in a possibility that a proper braking force is not produced.

As a method of increasing the stability of a friction coefficient of a brake member at high



temperatures, there has been proposed a method of coating a thin film of a heat-resistant material on a sliding surface of the brake member, as clearly disclosed in Japanese Patent Unexamined Publication No. 5 62-269875. In this method, a study of a lubricating component indispensable for the brake member has not been made, and there is a problem with the reliability. And besides, after the thin film is worn out, the effect of preventing the fusion of the sliding surface is 10 eliminated, thus causing a problem with the reliability.

Apart from elevators, various kinds of cast irons have been used as friction materials for railway vehicles. Various kinds of cast irons for friction materials used in railway are described in Journal of 15 Japan Society of Lubrication Engineers entitled "Lubrication" (Vol. 31, No. 12 (1986), pages 845 to 850). The various kinds of cast irons for railway vehicles are used at a speed (20~35 m/s), far higher than the speed (several to 10 and several m/s) of an 20 elevator, with a surface pressure (0.02~0.1 kg/mm²) smaller than that (several to 10 kg/mm²) of the elevator. The friction material for railway is repeatedly used for a longer period of time whereas a brake member of an emergency stop device for an elevator needs only to be 25 so durable as to be used only once. Generally, sliding properties of the material depend on sliding conditions. Therefore, the various kinds of cast irons for railway vehicles do not always exhibit the same properties under



the operating condition of the elevator. Namely, a mere conversion based on the properties under the condition of use of railway vehicles is insignificant.

SUMMARY OF THE INVENTION

5 It is an object of this invention to overcome the above problems of the prior art.

 Another object of the invention is to provide an improved emergency stop device for elevators which comprises brake members disposed in opposed relation to
10 a guide rail mounted on an elevator path wall, and a resilient member for pressing the brake members against the guide rail when the speed of movement of a cage of the elevator exceeds a predetermined speed.

 A further object of the invention is to
15 provide an improved elevator which comprises a cage, a drive device for moving the cage upward and downward, and emergency stop devices operable when the speed of the cage exceeds a predetermined speed.

 According to one aspect of the present
20 invention, the ratio of a maximum force (kg), produced by a resilient member for pressing brake members against a guide rail, to a braking energy (J) required per set of emergency stop devices for stopping a cage at an average deceleration of not more than 9.8 m/s^2 is not
25 more than 0.015 kg/J .

 According to another aspect of the invention, the ratio of the weight (kg) of a set of emergency stop



devices to a braking energy (J) required per set of emergency stop devices for stopping a cage at an average deceleration of not more than 9.8 m/s^2 is not more than 0.00015 kg/J .

5 According to a further aspect of the invention, a metallic structure of a sliding surface of the brake member contains a graphite phase, a steadite phase, a cementite phase and a pearlite phase.

 According to a still further aspect of the
10 invention, a metallic structure of a sliding surface of the brake member contains a steadite phase whose area ratio is not less than 5%.

 According to a further aspect of the invention, the brake member is made of an iron alloy
15 containing 3~4 wt.% C and not less than 0.5 wt.% P.

 According to a further aspect of the invention, the brake member is made of an iron alloy containing 3~4 wt.% C, not less than 0.5 wt.% P, and not less than 2.0 wt.% of P plus Cr.

20 According to a further aspect of the invention, there is provided an elevator provided with the emergency stop devices mentioned in the above aspects.

BRIEF DESCRIPTION OF THE DRAWINGS

25 Fig. 1 is a schematic perspective view of an elevator provided with one preferred embodiment of emergency stop devices of the present invention;



Fig. 2 is a schematic view showing an emergency stop device system of the present invention for elevators;

Fig. 3 is a partly cross-sectional view of the emergency stop device taken along the line III-III of Fig. 2;

Fig. 4 is a cross-sectional view taken along the line IV-IV of Fig. 3;

Fig. 5 is a partly-broken view showing the interior of the emergency stop device;

Fig. 6 is a diagram showing the relation between the P content of the brake member of the invention and a relative mean friction coefficient, as well as the relation between this content and a relative wear rate;

Fig. 7 is a diagram showing the relation between an area ratio of steadite in a sliding surface of the brake member of the invention and a relative mean friction coefficient, as well as the relation between this area ratio and a relative wear rate;

Fig. 8 is a diagram showing the relation between the (P + Cr) content of the brake member of the invention and a relative mean friction coefficient, as well as the relation between this content and a relative wear rate;

Fig. 9 is a diagram showing the relation between the ratio of an steadite area plus an cementite area to a graphite area and a relative mean friction



coefficient, as well as the relation between this ratio and a relative wear rate;

Fig. 10 is a perspective view of one example of brake member of the invention;

5 Fig. 11 is a front-elevational view showing a portion of a sliding surface of the brake member of Fig. 10;

Fig. 12 is an enlarged, cross-sectional view of a portion of the brake member taken along the line
10 XII-XII of Fig. 11;

Fig. 13 is a front-elevational view showing a portion of a sliding surface of a modified brake member of the invention;

Fig. 14 is an enlarged, cross-sectional view
15 of a portion of the brake member of Fig. 13 taken along the line XIV-XIV of Fig. 13;

Fig. 15 is a front-elevational view showing a portion of a sliding surface of another modified brake member of the invention;

20 Fig. 16 is a diagram showing a comparison between a conventional emergency stop device and the device of the invention with respect to the relation between the ratio of a spring force P to a braking energy E and a relative mean friction coefficient;

25 Fig. 17 is a diagram showing a comparison between the conventional emergency stop device and the device of the invention with respect to the relation between the ratio of the weight W of the device to the



braking energy E and a relative mean friction coefficient;

Fig. 18 is a schematic view of another preferred embodiment of the invention in which two sets
5 of emergency stop devices are provided on an elevator;

Fig. 19 is a cross-sectional view taken along the line XIX-XIX of Fig. 18.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

One preferred embodiment of the present
10 invention will now be described with reference to Fig. 1 to 19.

Fig. 1 is a schematic view showing a moving portion of an elevator provided with one preferred embodiment of emergency stop devices of the present
15 invention. The moving portion of the elevator comprises a cage 2 movable along an elevator path for carrying passengers, a plurality of main ropes 4 connecting the cage 2 to a drive system mounted within a machine room, and emergency stop devices 1 for safely stopping the
20 cage 2 in case of emergency. Two guide rails 3 are mounted on a wall of the elevator path, and serve to guide the cage 2 when the cage moves upward and downward. The emergency stop device 1 includes a pair of brake members 9 therein between which the guide rail
25 3 is interposed, and the brake members 9 are connected by rods 8 to a governor system (more fully described later) for detecting the speed of the cage 2. In Fig.



1, in order to mainly explain the position of mounting of the emergency stop devices, those devices of the elevator not directly related to the invention, such as a door opening-closing device, a tail cord, the drive system, and those portions associated with the governor, are not illustrated.

In order to explain the operating condition of the emergency stop devices 1, the construction of the emergency stop device system is schematically shown in Fig. 2. The emergency stop device system comprises a governor 5 mounted within the machine room 50 of the elevator, a governor rope 6 for transmitting the speed of the cage 2 to the governor 5, links 7 connecting the governor rope 6 to the cage 2, and pull-up rods 8 connecting the links 7 to the emergency stop devices 1.

Fig. 3 is a schematic, partly cross-sectional view of the emergency stop device 1 taken along the line III-III of Fig. 2. In Fig. 3, the emergency stop device 1 is shown in cross-section at a right half of the guide rail 3, and is shown in front elevation at a left half of the guide rail 3. The emergency stop device 1 comprises the two brake members 9 having the guide rail 3 disposed therebetween, guide rollers 10 for guiding the movement of the brake members 9, guides 11, guide support members 12 each supporting the corresponding roller 10 and guide 11, a resilient member 13 for producing a force for pressing the brake members 9 against the guide rail 3, a frame 14, roller plates 15



each disposed on the side of the corresponding rollers 10, and fixing bolts 16 which mount the guide support members 12 on the frame 14, and guide the resilient member 13. Each of the fixing bolts 16 is mounted on
5 the frame 14 through a spring 17 and a nut 18.

The composition and structure of the brake member 9, as well as the weight and shape of the emergency stop device, will be described later in detail. A U-shaped spring is used as the resilient
10 member 13. In the emergency stop device of the present invention, the shape of the spring is not limited, and other types of springs than the U-shaped spring, such as a belleville spring and a coil spring can be used.

Fig. 4 is a fragmentary cross-sectional view
15 of the emergency stop device taken along the line IV-IV of Fig. 3. In Fig. 4, the rod 8 for pulling the brake members 9 upwardly when the emergency stop device 1 is operated is shown in cross-section. A support plate 8' is connected to the pull-up rod 8, and the brake members
20 9 are supported on the support plate 8' so as to move into and out of contact with the guide rail 3. The brake member 9 is urged against the rollers 10 by a spring (not shown). The resilient member 13 is fixed to the frame 14 by fixing bolts (not shown).

25 The operation mechanism of the emergency stop device 1 will now be described with reference to Figs. 2, 3, 4 and 5. Fig. 5 is a view explanatory of movements of the relevant parts during the operation of



the emergency stop device 1.

Explanation will now be made first with reference to Figs. 2 and 5. When the cage 2 drops at a speed higher than a predetermined speed, the number of
5 revolution of the governor 5 exceeds a predetermined level, so that an acceleration detector (not shown) provided therein operates to stop the governor 5. As a result, the movement of the governor rope 6 is also stopped; however, since the cage 2 continues to drop,
10 the links 7 are pulled upwardly relative to the governor rope, and the rods 8 connected to the links 7 are also pulled upwardly. As a result, the brake members 9 supported on the support plate 8' connected to the rod 8 are pulled upwardly.

15 Next, explanation will now be made with reference to Figs. 3 and 4. When each rod 8 is pulled upwardly, the brake members 9 move upward while guided by the roller 10 and the guide 11. When the brake member 9 moves upward a predetermined distance relative
20 to the frame 14, the interval or spacing between the pair of brake members 9 decreases since the pair of guides 11, disposed in opposed relation to the guide rail 3, are tapered, and as a result the pair of brake members 9 are brought into contact with the guide rail
25 3. When the pair of brake members 9 further move upward, a force of pressing of the brake members 9 against the guide rail 3 is produced, and at the same time a reaction force is produced, so that the legs of



the U-shaped resilient member 13 are urged away from each other by a predetermined distance through the rollers 10, the guides 11 and the guide support members 12, thereby producing a predetermined force for pressing
5 the brake members 9 against the guide rail 3. As a result, a large frictional force is produced between the guide rail 3 and each brake member 9, thereby stopping the cage 2.

Contents and results of study of the
10 composition and structure of the brake member 9 used in this embodiment will now be described below in detail.

For simulating the dropping condition of the elevator, there were conducted tests in which a disk of low carbon steel (SS400 (JIS)), which was a material for
15 the guide rail, was rotated, and each of pins, made of materials used for the brake member, was pressed into sliding contact with the surface of this disk. For simulating the operating condition of the emergency stop device, the disk was decelerated at a constant rate from
20 a predetermined rotational speed until the disk was stopped. The friction coefficient of the disk and the pin during that time was measured, and the relation between the speed and the friction coefficient was found, and further a mean friction coefficient and a
25 wear rate were calculated, thereby evaluating the materials. Conditions of the test are shown in Table 1 below.

The mean friction coefficient μ_{av} is



determined in the following manner. The friction coefficient μ depends on a sliding movement speed v , and therefore it can be expressed by an equation $\mu = \mu(v)$.

The speed v varies with time. If the distance of

5 sliding movement is represented by L , L can be expressed by an equation $L = \int v(t)dt$, and therefore the mean friction coefficient μ_{av} can be expressed by an equation $\mu_{av} = \int \mu(v)dv/L$.

The wear rate WR is expressed by an equation

10 $WR = WL/(P \times L)$ where WL represents a wear amount, P (= load/sliding area) represents a surface pressure, and L represents a sliding distance.

Table 1 Test Conditions

V_0 : Initial velocity	8~15 m/s
g : Average deceleration	9.8 m/s ²
P : Surface pressure	4~10 kg/mm ²

The above studied materials will now be described. First, various kinds of elements were added to FC250 (serving as a base) used in the conventional device, and various kinds of cast irons were prepared from these materials, and changes in structure, means friction coefficient and wear rate were examined. The composition range of the studied materials is shown in

20 Table 2.



Table 2 Composition Range of studied Materials

Element	C	Si	Mn	
wt. %	3.2~3.6	1.4~3.5	0.5~0.7	

P	Ni	Cr	Fe
0~1.6	0~4.0	0~3.0	balance

The above results were obtained by chemically analyzing samples taken at the time of casting, and show the composition range of the whole of the brake member. The effects of C, Si, Ni, Cr and P among the above
5 elements will be described further.

C is present as graphite, and serves as a lubricating component. Si and Ni have the effect of forming C into graphite. Ni also has the effect of strengthening pearlite. P forms steadite. Cr has the
10 effect of precipitating cementite and steadite. Mn serves to remove oxygen from cast iron, and has extensively been used as an additive element for cast iron.

The structure of the cast iron having the
15 above composition will now be described. FC250 has a structure in which flake graphite is precipitated in the pearlite base. When P is added to FC250, steadite of a three-component eutectic structure represented by Fe_3P - Fe_3C -Fe is precipitated. When Cr is further added,



cementite (carbide of iron) represented by Fe_3C is precipitated, and also the amount of precipitation of the steadite increases. With respect to a pearlite phase of a two-component (Fe_3C and ferrite) eutectic
5 structure in which layers of Fe_3C and ferrite are alternately arranged, when Ni is added, the pearlite phase is made finer. Further, when this element is added in a larger amount of up to about 4%, the phase is changed into a hard structure called bainite.

10 The operation and role which the above structure performs to serve as the brake member will now be described.

 The graphite phase present in the sliding surface serves as a lubricating component, and prevents
15 seizure between the guide rail and the brake member. The steadite phase is a hard phase, and serves to increase the friction coefficient and also to increase the wear resistance. The cementite phase is also a hard phase, and also serves to increase the friction
20 coefficient and to increase the wear resistance. As compared with the steadite phase, the cementite phase is less lowered in hardness at elevated temperatures, and therefore when the temperature of the sliding surface becomes high, the friction coefficient and the wear
25 resistance are less lowered.

Results of the study will now be described.

The influence of P will first be described.

The results described below were obtained when changing



the content of P while fixing the composition of the other elements. Incidentally, although the materials were prepared while fixing the composition of the other elements, an analysis indicated that there were a little
5 difference between test pieces. Including variations of the other elements, the composition is shown in Table 3. Test conditions were the same in all cases. The test conditions are shown in Table 4.

Table 3 Composition Range of studied Materials
shown in Fig. 6

Element	C	Si	Mn	
wt. %	3.4~3.6	1.4~1.6	0.5~0.7	

P	Ni	Cr	Fe
0~1.6	1.0~1.2	2.0~2.2	balance

Table 4 Test Conditions

V_0 : Initial velocity	11~12 m/s
g: Average deceleration	9.5~10.5 m/s ²
P: Surface pressure	5~7 kg/mm ²

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Fig. 6 shows the relation between the content of P and a mean friction coefficient, as well as the relation between this content and a wear rate. The mean friction coefficient and the wear rate are a relative mean friction coefficient and a relative wear rate, respectively, which are obtained by converting them into respective relative values, using the values of FC250 as a reference value (1.0). The mean friction coefficient increases with the increase of the addition amount of P, and abruptly increases when the P content exceeds about 0.5 wt.%, and reaches a generally constant value when the P content exceeds about 0.8 wt.%. The wear rate decreases with the increase of the addition amount of P, and reaches a generally constant value when the P content exceeds about 0.7 wt.%. As shown in Fig. 6, the mean friction coefficient is about 1.4~1.5 times higher than that of the conventional material, and the wear rate is about 9~10 times higher than that of the conventional material.

Fig. 7 shows the relation between an area ratio of steadite and the mean friction coefficient, as well as the relation between this area ratio and the wear rate. The area ratio of steadite was determined such that 15 photographs of the structure of the material were taken, and then the steadite portions were traced, and then the area and the area ratio were found by the use of a picture processing device (LUSEX II) (manufactured by NIRECO K.K.). The area ratio means a



ratio of the area of steadite in the range in which the picture processing was done.

The mean friction coefficient increases with the increase of the area ratio of steadite, and abruptly
5 increases when the area ratio of steadite exceeds about 5%, and reaches a generally constant value when this area ratio exceeds about 6%. The wear rate decreases with the increase of the area ratio of steadite, and reaches a generally constant value when this area ratio
10 exceeds about 6%.

Namely, by adding P to FC250 used as a material for the conventional brake member, the friction coefficient and the wear resistance can be improved greatly. When this addition amount is not less than
15 about 0.5 wt.%, marked effects are obtained, and when the addition amount is not less than about 0.7 wt.%, the effect reaches a generally constant level. However, when the amount of addition of P is more than 3 wt.%, the machineability (cutting) for the brake member is
20 deteriorated, and therefore it is preferred that the addition amount be in the range of 0.7~3 wt.%.

A further study of the structure of the materials having P added thereto has indicated that the precipitation of steadite greatly improves the friction
25 coefficient and the wear resistance. Evaluating the structure quantitatively, when the area ratio of steadite is not less than about 5%, its effect is conspicuous, and when this area ratio is not less than



about 6%, the effect reaches a generally constant level.

Next, the influence of Cr will now be described. Results described blow were obtained when changing the content of Cr while fixing the composition of the other elements, as described above for the above results. The composition range of studied materials is shown in Table 5. Test conditions are the same as shown in Table 4.

Table 5 Composition Range of studied Materials shown in Fig. 8

Element	C	Si	Mn	
wt. %	3.4~3.6	1.4~1.6	0.5~0.7	

P	Ni	Cr	Fe
0.5~0.7	1.0~1.2	0~3.0	balance

As described above, when Cr is added, cementite is precipitated. However, where steadite has been precipitated as a result of addition of P, cementite is precipitated also as one constituting part of the steadite. Therefore, the effect achieved by the addition of Cr can not be evaluated by the precipitation of the single cementite. Therefore, when P is added, it is necessary to study the effect of Cr in combination with P on the friction coefficient and wear resistance.

Fig. 8 shows the relation between the content



of P + Cr and a relative mean friction coefficient, as well as the relation between this content and a relative wear rate. The mean friction coefficient increases with the increase of the P + Cr content, and reaches a
5 generally constant value when this content exceeds about 2.0 wt.%. The wear rate decreases with the increase of the P + Cr content, and reaches a generally constant value when this content exceeds about 2.0 wt.%.
Generally, when the Cr content is more than 3.0 wt.%,
10 the machineability of the brake member is deteriorated. The effect of Cr is more conspicuous in wear resistance than in friction coefficient. Namely, if Cr is added together with P, a greater effect is achieved by the improved mean friction coefficient and wear resistance,
15 and particularly a greater effect of improving the wear resistance is obtained. The effect is conspicuous when the P + Cr content is not less than about 1.5 wt.%, and the effect reaches a constant level when this content is not less than about 2.0 wt.%. In view of the
20 machineability, a practical range of the P + Cr content is up to about 5 wt.%.

Next, the influence of C will now be described. All of the materials, used in the above study of P and Cr, contain 3.4~3.6 wt.% C, and have
25 graphite precipitated therein. The area ratio of graphite in these materials is 8.4~10.5%, and about 9.6% on the average. In order to confirm the effect of graphite, similar tests were conducted with tool carbon



steel, SK-3 (JIS), having a lower C content and a smaller area ratio of graphite.

As a result, it was found that the friction coefficient was not stable though it was high, and there was a large difference between the measurements in the tests. In some cases, the material was locked relative to a material of SS400 simulating the guide rail, and was stopped at an abrupt deceleration. Furthermore, the wear rate was markedly increased. In view of the fact that the emergency stop device plays the role of a safety device, the material inferior in reliability can not be used. From these results, it is thought that an unstable friction coefficient and a high wear rate of the carbon steel are attributable to the fact that the graphite phase is extremely small in the structure, and it is thought that the existence of the graphite phase for stabilizing the friction coefficient is indispensable for the brake member. Si is effective as an additive element for promoting the formation of C into graphite, and it is preferred that 1.4~1.6 wt.% Si be added for promoting the formation of the graphite.

In order that the brake member can have such characteristics that a high friction coefficient and a high wear resistance are compatible with a stable friction coefficient and a high reliability, we have directed our attention to the ratio of the structure, offering a sliding resistance, to the structure, offering lubrication, in the material for the brake



member. The area ratio of the steadite plus the cementite to the graphite in the various test pieces mentioned above was analyzed, and the characteristics were expressed in terms of the ratio of (the steadite
5 area + the cementite area) to the graphite area. Results thereof are shown in Fig. 9. The ratio of (the steadite area + the cementite area) to the graphite area will hereinafter be represented by "SR". The mean friction coefficient increases with the increase of SR,
10 and particularly increases markedly when SR is not less than about 0.5. The wear rate decreases with the increase of SR, and reaches a generally constant value when SR is about 1.0%.

Namely, when the ratio SR of (the steadite
15 area + the cementite area) to the graphite area is not less than about 0.5, the characteristics are stable, and also a high friction coefficient and a high wear rate can be obtained.

Next, the influence of Ni will now be
20 described. When Ni is added, the pearlite in the structure is made fine, and the overall strength is increased, and the wear resistance is improved. However, when the amount of addition of Ni is so increased that bainite is precipitated in the base, the
25 effect becomes adverse. Namely, when bainite is precipitated in the base, the friction coefficient and the wear resistance are lowered. Particularly, the wear resistance is lowered markedly. Therefore, the



precipitation of bainite must be avoided, and preferably the amount of Ni should be in the range of 1.5~4 wt.%, and more preferably in the range of 2~4 wt.%.

In view of the above findings, in order that
5 the brake member can have stable characteristics, and can have a high friction coefficient and a high wear resistance, the structure of the material preferably contains a graphite phase, a steadite phase, a cementite phase and a pearlite phase. The above results are
10 obtained not only when the material for the guide rail is SS400 but also when this material is low carbon steel.

The shape of the brake member whose material was determined based on the above findings will now be
15 described.

Fig. 10 shows the appearance of the brake member 9 of the emergency stop device which member is made of the above materials. As shown in Fig. 10, the brake member 9 has a wedge-shape, and a plurality of
20 grooves are formed in its sliding surface 9a disposed in opposed relation to the guide rail 3. Guide grooves 9b are formed in each of opposite side surfaces of the brake member 9, and these guide grooves 9b guide the movement of the brake member 9 when the brake member 9
25 is pulled upwardly in facing relation to the guide rail 3.

Details of the sliding surface 9a will now be described with reference to Figs. 11 and 12. Fig. 11 is



a front-elevational view showing a portion of the sliding surface 9a of the brake member 9, and Fig. 12 is an enlarged, cross-sectional view of a portion of the brake member taken along the line XII-XII of Fig. 11.

5 In the brake member 9, two groups of grooves 30 of a V-shaped cross-section (hereinafter referred to as "V-shaped grooves") are provided respectively at an angle of 45° and an angle of 135° with respect to the sliding direction, so that the two groups of grooves
10 perpendicularly intersect each other. As a result, the sliding surface 9a is divided by the V-shaped grooves into a plurality of sections of a square shape. In this embodiment, the case where the angle α of the V-shaped groove 30 is 90° , as well as the case wherein the angle α
15 is 60° , has been studied, and both angles are favorably effective in removing powder (hereinafter referred to as "abrasion powder"), produced as a result of abrasion, from the V-shaped grooves. In the case of the V-shaped grooves, the formation of the grooves is easy, and since
20 the cross-sectional shape of the square section is trapezoidal, this configuration has the effect of sufficiently withstanding a shearing force.

A modified brake member is shown in Figs. 13 and 14. Fig. 13 is a front-elevational view showing a
25 portion of a sliding surface 9c of the brake member 9, and Fig. 14 is an enlarged, cross-sectional view of a portion of the brake member taken along the line XIV-XIV of Fig. 13. In this brake member, two groups of grooves



32 of a generally square cross-section (hereinafter referred to as "square grooves") are provided respectively at an angle of 45° and an angle of 135° with respect to the sliding direction, so that the two groups
5 of grooves perpendicularly intersect each other. As a result, the sliding surface 9c is divided by the square grooves into a plurality of sections of a square shape. The square groove has a larger volume, and therefore can receive a larger amount of abrasion powder.

10 Another modified brake member will be described with reference to Fig. 15. Fig. 15 is a front-elevational view showing a portion of a sliding surface 9d of the brake member 9. In this brake member, three groups of square grooves are provided respectively
15 at three different angles, that is, 60° , 90° and 120° , and the sliding surface 9d is divided by these square grooves into a plurality of sections of a triangular shape. Since the sliding surface 9d is thus divided into the triangular sections, the three groups of square
20 grooves intersect, so that the abrasion powder can be removed easily.

The role of the grooves formed in the sliding surface of the brake member, as well as the effect and role of the divided sliding surface, will now be
25 described.

The plurality of grooves formed in the sliding surface rapidly remove the abrasion powder from the sliding surface, and prevent the abrasion powder or



scraps from biting into the guide rail, thus preventing an abnormal wear. When the sliding surface divided into the plurality of sections is subjected to an uneven contact, the surface pressure of the contacted portion
5 (that is, one section) of the divided sliding surface becomes extremely high, and therefore this section is worn soon, thus eliminating the uneven contact, thereby preventing an abrasive wear.

Characteristics of the emergency stop device
10 provided with the brake members produced based on the above findings will now be described.

Depending on the rated speed of the elevator (to which the emergency stop devices are to be mounted) and the weight of the cage, that is, the energy (unit:
15 joule) to be braked by the emergency stop devices, the specification of the resilient member is determined, and the overall weight (unit: kg) of the device is determined. Therefore, where the conventional device is used, naturally, the larger the braking energy
20 (hereinafter represented by E) is, the larger the force (hereinafter represented by P) of the resilient member for pressing the brake members against the guide rail needs to be, and as a result the weight (hereinafter represented by W) of the emergency stop devices
25 increases.

However, when the emergency stop device of this embodiment is used, the pressing force P can be efficiently converted into the braking force since the



friction coefficient of the brake member is high, and furthermore because of an excellent wear resistance, the sliding surface of the brake member is subjected to less wear, so that the pressing force P is less lowered.

5 Therefore, a large braking force E can be accommodated with a smaller pressing force P by the use of the emergency stops devices of a smaller weight. A comparison in braking ability between the conventional device, using FC250 for the brake member, and the device
10 of this embodiment will now be described with reference to Figs. 16 and 17.

Fig. 16 shows the relation between the ratio P/E of the pressing force P to the braking energy E and a relative friction coefficient. P/E can be greatly
15 lowered in the emergency stop device of this embodiment, as compared with the conventional device. Namely, in this embodiment, when the weight of the cage assumes two kinds of values with the speed kept constant, the P/E value is 0.013 (kg/J) and 0.009 (kg/J), and thus it
20 becomes possible to achieve the value of not more than 0.015 (kg/J) calculated based on the proper pressing force estimated from the proper weight of the cage. On the other hand, in the conventional device, the obtained value of P/E is 0.036 (kg/J).

25 Fig. 17 shows the relation between the ratio W/E of the weight W of the emergency stop devices to the braking energy E and a relative friction coefficient. W/E can be greatly lowered in the emergency stop device



of this embodiment, as compared with the conventional device. Namely, the obtained value of W/E in the conventional device is 0.00036 (kg/J), and on the other hand, when the weight assumes two kinds of values, the
5 W/E value is 0.00015 (kg/J) and 0.00009 (kg/J), and thus it becomes possible to achieve the value of not more than 0.00015 (kg/J) calculated based on the proper weight of the emergency stop devices estimated from the proper weight of the cage.

10 A further embodiment of the present invention will now be described with reference to Figs. 18 and 19.

Fig. 18 is a schematic view showing the construction of an elevator provided with modified emergency stop devices of the present invention. In
15 Fig. 18, emergency stop devices 1 are mounted on the underside of the elevator, and emergency stop devices 1' are mounted on the top of the elevator. Fig. 19 is a cross-sectional view taken along the line XIX-XIX of Fig. 18. In Fig. 19, the reference numeral 9 denotes
20 brake members (hereinafter referred to as "lower brake members") for the emergency stop devices 1, and the reference numeral 9' denotes brake members (hereinafter referred to as "upper brake member"s) for the emergency stop devices 1'. Resilient members, as shown as the U-
25 shaped springs in Figs. 3 and 4, are shown in Fig. 19 as simple springs 13 for illustration purposes.

In this embodiment, the material, described in the first embodiment and having a structure including a



graphite phase, a steadite phase, a cementite phase and a pearlite phase, was used for the lower brake members 9 and the upper brake members 9'. As a result, it has been clearly found that the braking force is increased
5 to enable applying the emergency stop devices to an elevator having a greater rated speed and a greater load. In this case, if, instead of operating the upper and lower brake members simultaneously, the lower brake members are operated after the upper brake members are
10 operated, a smooth deceleration can be obtained. If the upper brake members and the lower brake members are made of different materials, respectively, the friction coefficient can be controlled over a wide range, and the optimum braking force can be obtained in accordance with
15 the speed of movement of the elevator and the load. Table 6 shows combinations of the emergency stop devices with the brake members made of FC250 and the emergency stop devices with the brake members made of the material having a structure including a graphite phase, a
20 steadite phase, a cementite phase and a pearlite phase. The rated speed is a speed during the normal operation, and is different from the speed at which the emergency stop devices are operated.

Table 6 Combination of Brake Member Materials

Combination	Rated speed	Load	Upper brake member	Lower brake member
A	High	Large	Material of invention	Material of invention
B	Low	Medium	Material of invention	FC250

In the combination B in Table 6, the emergency stop devices of the present invention are mounted on the upper portion while the emergency stop devices with the brake members made of FC 250 are mounted on the lower
5 portion. The upper emergency stop devices with the brake members, made of the material of the present invention having such a structure that the friction coefficient is higher than that of FC250 at high temperatures, slide on the guide rails which are
10 elevated in temperature by the frictional heat produced by the braking operation of the lower emergency stop devices. With this arrangement, a more effective braking can be obtained.

Although FC250 is used as the material for the
15 brake members of the lower devices, this material is not limited to FC250 in so far as the friction coefficient and the wear rate are acceptable, and FCD400 or FCD700 may be used.

By combining the materials for the brake
20 members of the emergency stop devices of the elevator as shown in Table 6, there can be provided the type of elevator in which the braking force is optimum and stable.

Next, the operation and role of the mechanism
25 mounting two sets of emergency stop devices will now be described.

First, the manner of numbering the emergency stop devices will be described in the following. The



cage of the elevator is guided by guide rails which define the elevator path and are provided respectively on opposed walls of the elevator path. Therefore, in order that the emergency stop device will not tilt the
5 cage during the operation for abrupt stop of the cage, two emergency stop devices are provided for each of the two guide rails, respectively, and are disposed at the same level. Namely, the braking operation will never be effected by only one emergency stop device, but at least
10 two emergency stop devices are always used as a unit. Therefore, when referring to one set of emergency stop devices, two emergency stop devices are mounted on the cage of the elevator.

The braking force of the emergency stop
15 devices depends on the force for pressing the brake members, the number of the brake members, the friction coefficient of each brake member, the spring constant of the resilient member for pressing the brake members, and the wear resistance of the brake members. Therefore, by
20 providing two sets of emergency stop devices in which materials different in friction coefficient are used for their brake members, the braking force can be adjusted finely, which can not be achieved when using the same material for the brake members.

25 By using the emergency stop device of the present invention, the mean friction coefficient about 1.4~1.5 times larger than that of the conventional device, as well as the wear resistance about 9~10 times



larger than that of the conventional device, can be constantly obtained, and the elevator can be stopped with the pressing springs of a smaller size.

Furthermore, since the wear amount is about 1/10 as
5 compared with the prior art device, the spring constant of the spring to be used can be small, and therefore the spring having a small displacement amount can be used.

Therefore, despite the increased braking
energy, the weight of the emergency stop device does not
10 need to be much increased. As a result, the diameter of the main rope does not need to be increased, and the power of the drive motor does not need to be increased, and the number of passengers to be carried by the cage can be increased, and the energy to be consumed can be
15 saved. Furthermore, the reliability of the emergency stop device is high, and the safety of the passengers is ensured.

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CLAIMS:

1. In an emergency stop device for elevators comprising brake members disposed in opposed relation to a guide rail mounted on a wall of an elevator path, and a resilient member for pressing said brake members against said guide rail when the speed of a cage of said elevator exceeds a predetermined speed;

the improvement wherein a ratio of a maximum force (kg), produced by said resilient member for pressing said brake members against said guide rail, to a braking energy (J) required per set of said emergency stop devices for stopping said cage at an average deceleration of not more than 9.8 m/s^2 is not more than 0.015 kg/J.

2. In an emergency stop device for elevators comprising brake members disposed in opposed relation to a guide rail mounted on a wall of an elevator path, and a resilient member for pressing said brake members against said guide rail when the speed of a cage of said elevator exceeds a predetermined speed;

the improvement wherein a ratio of the weight (kg) of a set of said emergency stop devices to a braking energy (J) required per set of said emergency stop devices for stopping said cage at an average deceleration of not more than 9.8 m/s^2 is not more than 0.00015 kg/J.

3. In an emergency stop device for elevators comprising brake members disposed in opposed relation to





a guide rail mounted on a wall of an elevator path, and a resilient member for pressing said brake members against said guide rail when the speed of a cage of said elevator exceeds a predetermined speed;

the improvement wherein a metallic structure of a sliding surface of said brake member contains a graphite phase, a steadite phase, a cementite phase and a pearlite phase.

4. An emergency stop device according to claim 3, in which a ratio of an area of said steadite phase plus an area of said cementite phase to an area of said graphite phase is not less than 0.5.

5. In an emergency stop device for elevators comprising brake members disposed in opposed relation to a guide rail mounted on a wall of an elevator path, and a resilient member for pressing said brake members against said guide rail when the speed of a cage of said elevator exceeds a predetermined speed;

the improvement wherein a metallic structure of a sliding surface of said brake member contains a steadite phase whose area ratio is not less than 5%.

6. In an emergency stop device for elevators comprising brake members disposed in opposed relation to a guide rail mounted on a wall of an elevator path, and a resilient member for pressing said brake members against said guide rail when the speed of a cage of said elevator exceeds a predetermined speed;

the improvement wherein said brake member is





made of an iron alloy containing 3~4 wt.% C and not less than 0.5 wt.% P.

7. In an emergency stop device for elevators comprising brake members disposed in opposed relation to a guide rail mounted on a wall of an elevator path, and a resilient member for pressing said brake members against said guide rail when the speed of a cage of said elevator exceeds a predetermined speed;

the improvement wherein said brake member is made of an iron alloy containing 3~4 wt.% C, not less than 0.5 wt.% P, and not less than 2.0 wt.% of P plus Cr.

8. An emergency stop device according to any one of claims 1 to 7, in which the sliding surface of said brake member is divided into a plurality of sections.

9. An emergency stop device according to any one of claims 1 to 7, in which the sliding surface of said brake member is divided into a plurality of sections by two groups of grooves intersecting each other, said two group of grooves being disposed respectively at different angles with respect to a direction of sliding of said brake member.

10. An elevator comprising a cage, a drive device for moving said cage upward and downward, and emergency stop devices of any one of claims 1 to 9 operable when the speed of said cage exceeds a predetermined speed.

11. An elevator comprising a cage, a drive device for moving said cage upward and downward, and emergency

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stop devices operable when the speed of said cage exceeds a predetermined speed, said sets of said emergency stop devices, respectively, being mounted on upper and lower portions of said elevator and at least one set of said emergency stop devices comprising emergency stop device as claimed in any one of claims 1 to 9.

12. An emergency stop device for elevators substantially as herein described with reference to and as shown in Figures 1-17 or 18, 19 of the accompanying drawings.

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