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(71) Applicant: **Kureha Seiko Co., Ltd.**
Osaka-shi, Osaka 555 (JP)

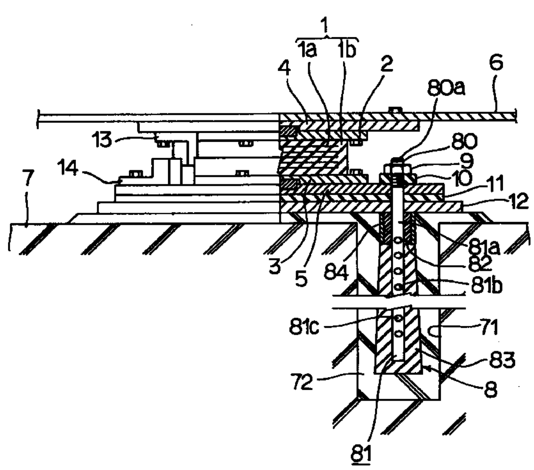
(72) Inventors:
- **Kamon, Tadashi**
c/o Kureha Seiko Co., Ltd.
Osaka-shi, Osaka 555 (JP)
- **Kawakami, Akira**
Hyogo 653 (JP)
- **Kishida, Hiroo**
Osaka 580 (JP)

(74) Representative: **VOSSIUS & PARTNER**
Siebertstrasse 4
81675 München (DE)

(54) Earthquake-resistant anchor bolt, mounting structure using the same and post-processing for the anchor bolt

(57) In an earthquake-resistant anchor bolt, a mounting structure using the same and a post-processing method for the anchor bolt, not only the vibration absorbing characteristics in the horizontal and vertical (lift) direction are superior but also the mounting strength of the object to be mounted to the base may be enhanced without curvature even if the structure is subjected to large lateral load due to the earthquakes. In the earthquake-resistant anchor bolt, a first support member (82) having a high compression elasticity is fixed to an outer circumference of a neck portion of a bolt body to be embedded in the base. A second support member (83) having a lower compression elasticity than that of the first support member is fixed to an outer circumference of a base portion inward of the neck portion of the bolt body. A fastening member has a threaded portion around which the fastening member is screwed at the bolt end portion.

Fig.1



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Description

The present invention relates to an earthquake-resistant anchor bolt for use in supporting a bridge beam or a building or installing a machinery such as machine tools on a base. The present invention also relates to a mounting structure using the anchor bolt and a post-process for the anchor bolt.

Conventionally, in the case where bridge beams or buildings are to be supported on the base or the machinery such as machine tools are to be installed on the base, anchor bolts made of metal are used, bodies of the anchor bolts are embedded in the base, objects to be mounted such as bridge beams, buildings or machine tools are fitted around tip end portions of the anchor bolts, and fastening members such as nuts are screwed around threaded portions of the tip end portions of the bolts, thus mounting the objects to be mounted are installed on the base.

In the case where the anchor bolts are embedded in the base, the following two methods are known. In a preprocess method, the anchor bolts are disposed in advance in a mold frame together with reinforcements, and thereafter, concrete is cast into the mold frame to form the base. In a post-process method, mount holes are formed by cutting at the predetermined position on the base made of concrete and formed in advance, or mount holes are formed by mold drawing upon casting the concrete, the anchor bolts are inserted into the mount holes and thereafter, cement mortar or resin mortar (adhesives) are filled therein.

The preprocess method has an advantage that the embedding step for the anchor bolts is facilitated, but has a disadvantage that the positioning precision for the anchor bolts would not be high. In the current situation, discord or misalignment in position between the bolt holes formed in the objects to be mounted and the anchor bolts has frequently occurred. On the other hand, in the post-process method, after the anchor bolts are held exactly in place in the mount holes formed in the base and then the cement mortar or resin mortar is filled therein. Accordingly, this method is superior in positional precision for the anchor bolts.

However, irrespective of either the preprocess method or the post-process method for the embedding step for the anchor bolts, in the case where the objects to be mounted are mounted on the base by using the above-described anchor bolts, since the anchor bolts are made of metal and low in elasticity, there have been problems that vibration dampening or absorbing effects would be low when the above-described objects to be mounted are subjected to vibrations in the horizontal direction and the vertical (lift) direction due to load fluctuations or drive of a machinery.

Therefore, the present inventors et al. have heretofore proposed an anchor bolt in which a rubber member having a convex/concave corrugation on its outer surface in a spiral form is provided on an outer circumferential surface of a bolt body to be embedded in the base to thereby enhance the vibration absorption effects when the objects to be mounted are subjected to the vibration (refer to JP-A-6-135044).

However, the following disadvantage has been raised. If only the rubber member having a low compression elasticity is provided around the bolt body as described above, when the objects to be mounted and the base are subjected to a large lateral load due to earthquakes, the anchor bolts are tilted while pressing the rubber member so that the bolt body is curved from a neck portion of the bolt body embedded in the base located on the side of the objects to be mounted. As a result, it is difficult to sufficiently enhance the mounting strength of the objects to be mounted.

In view of the foregoing problems, an object of the present invention is to provided an earthquake-resistant anchor bolt, a mounting structure using the same and a post-processing method for the anchor bolt, in which not only the vibration absorbing characteristics in the horizontal and vertical (lift) direction are superior but also the mounting strength of the object to be mounted to the base may be enhanced without curvature even if the structure is subjected to large lateral load due to the earthquakes.

In order to attain this and other objects, according to the present invention, there is provided an earthquake-resistant anchor bolt characterized in that a first support member having a high compression elasticity is fixed to an outer circumference of a neck portion of a bolt body to be embedded in a base; a second support member having a lower compression elasticity than that of said first support member is fixed to an outer circumference of a base portion on the inward end side of the neck portion of the bolt body; and a threaded portion is provided at a bolt end portion to be threadedly engaged with a fastening member.

It is preferable that the compression elasticity of said first support member is not smaller than 20 kgf/mm^2 but not larger than 200 kgf/mm^2, and the compression elasticity of said second support member is not smaller than 1 kgf/mm^2 but not larger than 8 kgf/mm^2. Also, said first support member is made of synthetic resin and fixed to the bolt body during curing, and said second support member is made of rubber and fixed to the bolt body during vulcanizing. Then, a ratio of the neck portion to which said first support member is to be mounted to a length of the base portion to which said second support member is to be mounted is not smaller than 0.1 but not larger than 0.5. It is further preferable that said second support member is in the form of a truncated cone having a larger diameter at the other end than a diameter at the neck side. It is also preferable that a ring made of metal is fixed to an outer circumference of said first support member.

In the earthquake-resistant anchor bolt according to the present invention, neck portion and the base portion provided in the bolt body are embedded in the base. The object to be mounted is mounted on the base through the bolt body. When the object to be mounted or the base is subjected to a large lateral load caused by the earthquakes, it is possible to positively prevent the bolt body from bending from the neck portion by the first support member, having the high compression elasticity, provided around the outer circumference of the neck portion of the bolt body. Also, when the base or the object to be mounted is vibrated in the horizontal and vertical (lift) directions, it is possible to much positively absorb the vibration and to interrupt the vibration transmission from the object to be mounted to the base or from the base to the object to be mounted by the second support member, having the low compression elasticity, provided on the outer circumference of the base portion of the bolt body. Furthermore, when the bolt body is embedded on the base side by using fastening agents such as cement mortar, the bolt body is prevented from pulling apart from the fastening agents by the second support member and the bolt body may be firmly fixed to the base. Accordingly, it is possible to enhance the mounting strength of the object to be mounted to the base.

Also, in the mounting structure using the earthquake-resistant anchor bolt, the anchor bolt having the above-described structure is used, the bolt body is embedded in the base, the object to be mounted is fitted around the bolt end portion, and the object to be mounted is fastened to the base by the fastening member screwed around the threaded portion of the bolt end portion. In this case, it is possible to fasten the object to be mounted to the base under the condition that the elastic member interposed between the fastening member screwed around the threaded portion of the bolt end portion and the base is compressed.

In the case where the elastic member is the elastic washer fitted around the bolt body between the object to be mounted and the fastening member and the object to be mounted is fastened to the base through the elastic washer by the fastening member screwed around the threaded portion of the bolt end portion, even if the bolt body is subjected to the large lateral load, the bolt body is prevented from being bent by the first support member, and at the same time, it is possible to much more positively absorb the vibration of the object to be mounted by the second support member and the elastic washer provided on the bolt body. In addition, when the object to be mounted is slanted, the shift of the object to be mounted is absorbed to thereby reduce the stress or the object to be mounted and the base.

Also, in the case that said elastic member comprises a rubber sheet laid between the base and the object to be mounted, the object to be mounted being fastened through said rubber sheet to said base by the fastening member screwed around the threaded portion of the bolt end portion, it is possible to prevent the curvature caused by the lateral load of the bolt body with the first support member. At the same time, by the rubber sheet and the second support member provided on the bolt body, it is possible to much more absorb with secure the vibration of the object to be mounted. In addition, it is possible to well mount the object to be mounted on the base by the rubber sheet. Moreover, since it is possible to impart the elastic restoration force of the rubber sheet to the fastening member, it is possible to prevent the loosening of the fastening member and to well carry out without fail the fixture of the object to be mounted to the base by the anchor bolt.

In the accompanying drawings:

Fig. 1 is a partial cross-sectional view showing a support structure for a bridge as a mounting structure example of an object to be mounted by using an earthquake-resistant anchor bolt according to a first embodiment of the invention;

Fig. 2 is a partially enlarged cross-sectional view showing a primary part shown in Fig. 1;

Fig. 3 is a longitudinal sectional view showing a washer;

Fig. 4 is a partial cross-sectional view showing a support structure for a bridge by using an earthquake-resistant anchor bolt according to a second embodiment of the invention;

Figs. 5(a) to 5(c) are schematic cross-sectional view showing a process example according to a post-processing method for an earthquake-resistant anchor bolt according to the present invention;

Figs. 6(a) to 6(c) are schematic cross-sectional view showing another process example according to the post-processing method for an earthquake-resistant anchor bolt according to the present invention;

Figs. 7(a) to 7(c) are schematic cross-sectional view showing a conventional anchor bolt, a rubber provided anchor bolt according to the prior invention, and an anchor bolt according to the present invention, respectively, for various comparison tests;

Fig. 8 is a drawing showing bending stress distributions of each part of the three kinds of anchor bolts; and

Figs. 9(a) to 9(c) are graphs showing the fatigue test results of the three kinds of anchor bolts shown in Figs. 7(a) to 7(c).

A typical embodiment of the present invention will now be described with reference to Figs. 1 through 3.

Fig. 1 shows a mounting structure in the case where a bridge beam is supported on a base as a mounting structural example of an object to be mounted by using anchor bolts according to the present invention. In Fig. 1, a plurality of iron plates 1a are laminated at a predetermined interval in the vertical direction. The overall iron plates 1a are molded with a rubber member 1b into a cylindrical or rectangular pillar elastic support 1. An upper flange 2 and a lower flange 3 are coupled integrally with the elastic support 1 on the upper and lower sides, respectively, by vulcanization or the like. A sole plate 4 and a base plate 5 are coupled on the respective upper and lower flanges 2 and 3 by bolts. A bridge beam 6 and the base plate 5 which is an object to be mounted are fixed to the sole plate 4 and a base 7 made of concrete, respectively.

Also, an anchor bolt 8 is embedded in the base 7 under the condition that its tip end portion 80 projects upwardly. A planar rubber sheet (elastic member) 11 made of chloroprene rubber or the like and an adjustment plate 12 made of a steel plate are laid between the base plate 5 and the base 7. The anchor bolt 8 is caused to pass through the rubber sheet 11 and the adjustment plate 12 upwardly above the base plate 5. A fastening member such as a nut 9 is screwed around a threaded portion 80a of the tip end portion 80 of the anchor bolt 8 extending upwardly from the base plate 5 through an elastic washer (elastic member) 10. Thus, the base plate 5 is fixed to the base 7.

More specifically, a mounting hole 71 is formed in the base 7, the mounting hole 71 is embedded, and a well known non-shrinkable cement mortar 72 is cast so as to cover a predetermined region including a portion on which the adjustment plate 12 is to be loaded on the base 7. The above-described anchor bolt 8 is embedded through the cement mortar material 72 so that its tip end portion 80 projects beyond the above-described cement mortar material 72. The anchor bolt 8 is fixed and supported by using the above-described non-shrinkable cement mortar material 72 so that a gap is not formed between the cement mortar material 72 and the concrete material for the base 7 after drying the mortar material 72. Thus the degradation in structural strength may be prevented.

Then, as is apparent from Fig. 2, in the anchor bolt 8, a first support member 82 having a high compression elasticity (hard) is mounted around a neck portion 81a of the bolt body 81, i.e., an outer circumference of the portion 81a, located at a position in the vicinity of the mounting portion for the base plate 5 on the upper side of the bolt body 81 embedded in the above-described cement mortar material 72. A second support member 83 having a lower compression elasticity (softer) than the first support member 82 is applied over the outer circumference of the base portion 81b embedded to reach a deep portion of the above-described cement mortar material 72, located on the lower side of the above-described neck portion 81a.

A ratio of a length B of the base portion 81b on which the second support member 83 is to be applied, to a length of a length A of the neck portion 81a on which the first support member 82 is mounted is preferably in the range of $0.1 \leqq A/B \leqq 0.5$. If the ratio is less than 0.1, the lateral load of the neck portion 81a is not sufficiently supported by the first support member 82. On the other hand, if the ratio exceeds 0.5, the length of the second support member 83 for the base portion 81b is insufficient so that the vibration absorbing effect by the second support member 83 is degraded. For example, in the case where the bolt body 82 having a diameter of 42 mm is used, it is preferable that the length of the neck portion 81a be at about 90 mm and the length of the base portion 81b be at about 370 mm. Also, in the case where the bolt body 82 having a diameter of 42 mm is used, it is preferable that an outer diameter of the first support member 82 to be mounted around the neck portion 81a be at about 62 mm.

Also, the preferable ranges of the compression elasticities E1 and E2 (in terms of a unit of kgf/mm^2) of the above-described first support member 82 and the above-described second support member 83 are given as follows:

$$20 \leqq E1 \leqq 200$$

$$1 \leqq E2 \leqq 8$$

It is preferable to use, in particular, epoxy mortar which is thermosetting resin as material for the first support member 82 having the compression elasticity in this range and to use synthetic rubber, in particular, chloroprene rubber as material for the second support member 83.

When the compression elasticity E1 of the above-described first support member 82 is less than 20 kgf/mm^2, the effect to suppress the curvature at the neck portion 81a for supporting the lateral load to be applied to the neck portion 81a is degraded. When the compression elasticity E1 exceeds 200 kgf/mm^2, the first support member 82 becomes too hard, so that one of the vibrations of the base 7 and the base plate 5 is liable to be directly transmitted to the other through the anchor bolt 8 and the first support member 82. Also, when the compression elasticity E2 of the second support member 83 is less than 1 kgf/mm^2, the second support member 83 becomes too soft, the slant or tilt of the anchor bolt 8 is excessive due to the lateral load so that the anchor bolt 8 is brought into contact with an inner wall surface of the mounting hole 71 of the base 7 and the vibration interruption effect between the base 7 and the base plate 5 would be degraded. On the other hand, when it exceeds 8 kgf/mm^2, the second support member 83 becomes too hard so that the vibration interruption effect between the base 7 and the base plate 5 by the second support member 83 is degraded.

The second support member 83 is applied over all the circumference of the base portion 81b of the anchor bolt 8 by the vulcanization. A ring 84 made of metal is fitted around the outer circumference of the neck portion 81a on the upper side of the second support member 83 after the vulcanization. The above-described epoxy resin mortar is poured into the interior of the ring to thereby form the first support member 82 between the neck portion 81a and the ring 84. Thus, the mounting step to mount the above-described first member 82 onto the neck portion 81a may readily and positively be carried out.

Also, as in the embodiment shown in Fig. 2, it is preferable to embed the above-described ring 84 in the cement mortar material 72 while the ring 84 is being mounted on the above-described neck portion 81a. Thus, it is possible to further enhance the mechanical strength of the above-described neck portion 81a against the lateral load through the above-described first support member 82 and the ring 84.

Furthermore, in the embodiment shown, the second support member 83 having a conical trapezoidal shape with the upper portion having a smaller diameter and the lower portion having a larger diameter is mounted around the outer circumference of the base portion 81b. Thus, when the anchor bolt is embedded into the cement mortar member 72, even if the vertical load is applied to the anchor bolt 8, it is possible to prevent the bolt 8 from being pulled apart outwardly from the cement mortal member 72 and to further enhance the strength of fixture of the bolt 8 to the base 7. At this time, in the case where the bolt body 81 having the diameter of 42 mm is used, preferably, the diameter of the upper side of the second support member 83 is 62 mm and the diameter of the lower side of the second support member 83 is 100 mm.

Also, a number of recesses 81c are formed from the neck portion 81a to the base portion 81b of the bolt body 81. With such recesses 81c, it is possible to firmly mount the above-described support member 82 and second support member 83 through the recesses 81c to the above-described neck portion 81a and the base portion 81b.

As shown in Fig. 3, the above-described elastic washer 10 is composed, in combination, of a rubber member 10a made of chloroprene rubber or the like, a stainless steel plate 10b disposed on an upper surface of the rubber member 10a, a tetrafluoroethylene resin coating layer 10c formed on the upper surface of the stainless steel plate 10b, and a stainless plate 10d provided on the lower surface of the above-described rubber member 10a. The elastic washer 10 has a through-hole 10e through which the anchor bolt 8 is caused to pass.

Also, when the above-described elastic support 1 is shifted beyond the predetermined range in the horizontal direction, a first stopper 13 and a second stopper 14 which are in contact with each other are mounted on the sole plate 4 and the base plate 5 in facing relation. Thus, a damage due to a large deformation in the horizontal direction of the above-described support 1 by the respective stoppers 13 and 14 may be avoided.

In the case where the anchor bolt having the structure described above is inserted into the base 7 shown in Fig. 1 and the above-described bridge beam 6 is mounted in place, the horizontal and vertical vibrations of the bridge beam 6 and the base 7 due to the fluctuations of the loads applied to the bridge or the earthquakes are well absorbed without fail by the second support member 83 provided on the base portion 81b of the above-described bolt body 81 together with the elastic support 1. The vibrations are well prevented without fail from being transmitted to the base 7 and/or the bridge beam 6.

Also, when the bridge beam 6 is subjected to the lateral load and largely shifted in the horizontal direction by the earthquakes or loads, the above-described first stopper 13 is brought into contact with the second stopper 14. The shift exceeding this is transmitted from the two stoppers 13 and 14 through the base plate 5 to the anchor bolt 8 so that a bending stress generates in the anchor bolt 8. In this case, since the shift of the anchor bolt 8 is absorbed by the above-described second support member 83, the stress of the anchor bolt 8 is reduced.

Even if the bridge beam 6 or the base 7 is subjected to the further larger lateral load by the earthquakes, since the first support member 82 having the high compression elasticity is mounted around the outer circumference of the neck portion 81a of the above-described bolt body 81 and the ring 84 is provided therearound, the first support member 82 and the ring 84 cause the above-described bolt body 81 to slant largely to thereby prevent the curvature of the neck portion 81a without fail. At the same time, the cement mortar material 72 is prevented from being damaged around the neck portion 81a. For this reason, the mounting strength of the bridge beam 6 to the base 7 may be enhanced by the anchor bolt 8.

Moreover, since the base plate 5 is fastened to the base 7 by the nut 9 through the elastic washer 10, the vibration of the bridge beam 6 or the base 7 may be well absorbed without fail by the second support member 83 of the anchor bolt 8 and the above-described elastic washer 10. When the bridge beam 6 is slanted or shifted in the horizontal direction by the load of the bridge beam 6 or the earthquakes, its shift is absorbed and the excessive stress may be prevented from being generated in the anchor bolt 8. In addition, when the above-described nut 9 is fastened to the anchor bolt 8, since the above-described elastic washer 10 is elastically deformed, an elastic restoration force of the elastic washer 10 is given to the nut 9 to thereby prevent the nut 9 from being loosened.

Also, the rubber sheet 11 laid between the base plate 5 and the base 7 exhibits the same effect as that of the above-described elastic washer 10 to absorb or dampen the vibrations and shifts of the bridge beam 6 and/or the base 7 and to prevent the loosening of the nut 9.

Fig. 4 shows a second embodiment of an earthquake-resistant anchor bolt 8 according to the present invention. In Fig. 4, the first support member 82 made of synthetic resins and mounted on the neck portion 81a of the anchor bolt 8 is structured in a double form composed of an inner layer 82a having a relatively low compression elasticity (soft) and an outer layer 82b having a relatively high compression elasticity (hard). For example, the two layers 82a and 82b are formed of the materials whose compression elasticities are made different from each other to some extent in epoxy resin mortar component. In the same way, also, the second support member 83 mounted on the base portion 81b of the anchor bolt 8 is structured in a double form composed of an inner layer 83a having a relatively low compression elasticity and an outer layer 83b having a relatively high compression elasticity. The two layers 83a and 83b are made of materials whose compression elasticities are caused to be different from each other by changing the components of the chloroprene rubber.

With such a structure, the "hardness" of the first support member 82 and the second support member 83 is well adjusted so as to further effectively attain the attenuation of vibration and to suppress the excessive slant of the anchor bolt 8.

Incidentally, in the foregoing embodiments, the case where the bridge beam 6 is mounted on the base 7 has been explained. However, for example, it is apparent that the invention may be applied without any difficulty to the case where the anchor bolt is mounted on buildings or machinery such as machine tools.

Subsequently, the case where the invention is applied to the so-called post-process method for the earthquake-resistant anchor bolt will now be described with reference to Figs. 5 and 6. In this case, although the anchor bolt 8a before the process is fixed to the second support member 83 made of rubber to the base portion 81b of the bolt body 81 by the vulcanisation, the first support member 82 has not yet been well fixed to the neck portion 81a on the way for completion of the products, it should be understood that the anchor bolt 8 having the above-described earthquake-resistance and in which the first support member 82 has been fixed to the neck portion 81a after the completion of the post-process method according to the invention is completed.

First of all, the first post-process method shown in Fig. 5 is composed of the following steps 1 to 4.

The first step is to form the mounting hole 71 by mold-drawing or cutting to the base 7 made of concrete (see Fig. 5(I)). In forming the mounting hole 71 by the mold-drawing, when the base 7 is formed by casting the concrete into the mold frame, the draw mold frame is provided in a position corresponding to the mounting hole 71 in advance, and the draw mold frame is removed to form the hole after the concrete is semi-solidified or solidified. Also, in order to form the above-described mounting hole 71 by cutting, a concrete drill is used. A diameter of this mounting hole 71 is three times larger than a diameter of the bolt body 81. A depth thereof is set to a depth which is longer about twice of the diameter of the bolt body 81 than the length of the bolt body 81.

In a second step, under the condition that the above-described anchor bolt 8a is fitted coaxially to the neck portion 81a with the ring 84a having an inner diameter larger than a diameter of the bolt body 81 and a lower end opening of the ring 84a is closed by an upper end face of the second support member 83, the anchor bolt 8a is held at a predetermined position of the above-described mounting hole 71 (see Fig. 5(II)).

In a third step, the non-shrinkable cement mortar material 72 is filled in a space defined between the above-described mounting hole 71 and the second support member 83 and the ring 84a (see Fig. 5(III)).

In a fourth step, the above-described ring 84a is removed after the above-described cement mortar material 72 becomes hard so that it may self-hold its shape (see Fig. 5 (IV)). The fluidized first support member 82 made of material having a higher compression elasticity than that of the second support member 83 after the solidification is filled in a space between the neck portion 81a of the bolt body 81 and the cement mortar material 72 (see Fig. 5(V)). It is most preferable to use the epoxy resin mortar having the thermosetting property as the first support member 82. Here, it is preferable that the above-described ring 84a has a length projecting from the upper face of the cement mortar material 72 so that the ring 84 may readily be removed from the cement mortal material 72 and it is divided to three segments which may be removed inwardly. In this case, it is preferable to form convex/concave corrugations on an outer surface of the ring 84a so that the convex/concave corrugations are formed on the inner wall surface of the cement mortar material 72 corresponding to the neck portion 81a after the above-described ring 84a has been removed.

Through the fourth step, the cement mortal material 72 is cured and hardened, and after the epoxy resin mortar has been cured as the first support member 82, as described above, the earthquake-resistant anchor bolt 8 of the present invention is kept under the condition that it is embedded in the base 7.

A second post-process method will be explained with reference to Fig. 6, in which the earthquake-resistant anchor bolt 8, to which the ring 84 made of metal is fixed to the outer circumference of the first support member 82 fixed to the neck portion 81a of the above-described bolt body 81, is embedded to the base 7.

This post-process method is composed of first through fourth steps.

The first step is the same as described above (see Fig. 6(I)).

In a second step, the point different from the first post-process method shown in Fig. 5 is that under the condition that the metal ring 84 is mounted on the outer circumferential portion of the neck portion 81a of the bolt body 81, the upper end of the ring 84 is set at a length so as not to project from the upper surface of the base 7 (see Fig. 6(II)).

The third step is the same as described above (see Fig. 6(III)). In this case, it is preferable to transfer to the next step after the non-shrinkable cement mortar material 72 filled in the space between the above-described mounting hole 71 and the second support member 83 and the ring 84 is completely cured.

In a fourth step, the point different from the first post-process method shown in Fig. 5 is that under the condition that the first support member 82 kept under the fluidized condition and made of material higher in the compression elasticity after the curing than that of the second support member 83 is filled in the space between the neck portion 81a of the bolt body 81 and the inner surface of the ring 84 under the condition that the above-described ring 84 is left as it is (see Fig. 6(IV)).

The earthquake-resistant anchor bolt 8 produced through the above-described post-process method is shown in Figs. 1 and 2.

Finally, comparison results showing the validity of the earthquake-resistant anchor bolt according to the present invention will be explained.

As shown in Figs. 7(a) to 7(c), samples used in the comparison tests were three kinds of conventional anchor bolt 8A, improved type anchor bolt 8B (described in the specification of the above-described Japanese Patent Application No. Hei 7-54407), and anchor bolt 8C according to the present invention. Incidentally, in any of the three kinds of bolt body structure, since the structure is the same as that of the bolt body 81 according to the present invention, the same reference numerals are used to indicate the like members or components in the following description.

First of all, as shown in Fig. 7(a), the conventional type anchor bolt 8A had a steel member of SS400 (Japanese Industrial Standards, rolled steel material for general structure) with a diameter of 42 mm and a length of 630 mm. A length of the bolt body 81 embedded in the base 7 was 485 mm and a length of the tip end portion 80 was 145 mm. The threaded portion 80a was formed at the tip end portion 80. Eight oblong recesses 81c were formed at an interval of 50 mm on the four surfaces on the circumference of the bolt body 81. The bolt body was inserted into the mounting hole 71 formed in the base 7 and having the diameter of 150 mm and the depth 565 mm. The hole 71 was filled with the cement mortar material 72.

Also, in the improved type anchor bolt 8B as shown in Fig. 7(b), a support member 83B made of chloroprene rubber and provided with a spiral groove having a pitch of 60 mm, a width of 30 mm and a depth of 30 mm on a cylindrical outer circumference of a cylinder having an outer diameter of 120 mm was fixed to an outer circumference of a bolt member 81 which was the same as that of the above-described conventional anchor bolt 8A at the same time with the vulcanization. In this anchor bolt 8B, the bolt body 81 was inserted into the mounting hole 71 which was the same as that described above and was filled with the cement mortar material 72.

Also, as shown in Fig. 7(c), in the anchor bolt 8C according to the present invention, the first support member 82 made of epoxy resin and the second support member 83 made of chloroprene rubber were fixed to portions corresponding to the neck portion 81a and the base portion 81b, respectively, around the outer circumference of the bolt body 81 which was the same as the conventional anchor bolt 8A. Incidentally, the first support member 82 had an outer diameter of 62 mm and a length of 90 mm. The second support member 83 was composed of a truncated conical portion having an outer diameter of 62 mm on the side of the neck portion 81a, an outer diameter of 100 mm on the other side, and a length of 365 mm and a cylindrical portion fixed to the end portion of the base portion 81b with a diameter of 100 mm and a length of 60 mm. These portions were fixed to the base portion 81b at the same time with the vulcanization. In this anchor bolt 8C, the bolt body 81 was inserted into the mounting hole 71 in the same way as described above and embedded in the cemented mortar material 72.

A position of each sample to which the shearing stress was applied was at the end portion 80 of the anchor bolt at the position of 10 mm from the surface of the base 7. Also, the tension stress was applied to the threaded portion 80a through the nut 9. Also, a plurality of strain gauges were attached at a predetermined interval in the axial direction to the bolt body 81 of the respective anchor bolts. A signal thereof was detected through lead lines connected thereto so that the shearing stress at each part could be measured.

First of all, the result of the measurement of the tension spring constant of each anchor bolt is shown in Table 1. The tension spring constant (ton/mm) was obtained by dividing the tension load by the shift amount. From the result, it was understood that the constant of the anchor bolt 8C according to the present invention and the improved type anchor bolt 8B was about 1/250 in comparison with the conventional anchor bolt 8A, and the anchor bolt according to the invention and the improved bolt were very elastic against the tension stress (in the vertical (lift) direction) and were superior in absorption of vibration in the vertical (lift) direction.

Table 1

Result of Measurement of Tension Spring Constant		
samples	spring constant (ton/mm)	tension load
conventional type (8A)	71.4	24 ton or more
improved type (8B)	0.27	16 ton
invention (8C)	0.32	18 ton or more

Also, the result of the shearing constant of each anchor bolt is shown in Table 2. The shearing spring constant (ton/mm) was obtained by dividing the shearing load by the shift amount. From the result, it was understood that the value of the anchor bolt 8C according to the invention was substantially the same as that of the conventional anchor bolt 8A, and with the anchor bolt according to the present invention, it was possible to obtain the mounting strength against the lateral load which was substantially the same as the conventional anchor bolt 8A. On the other hand, the value of the improved type anchor bolt 8B was one tenth or less of the anchor bolt 8C according to the invention and the conventional anchor bolt 8A, and the shift amount against the lateral load was larger. When the object to be mounted is fixed in place, the improved type anchor bolt was unstable and unsuitable in function of the anchor bolt.

Table 2

Result of Measurement of Shearing Spring Constant		
samples	spring constant (ton/mm)	shearing load
conventional type (8A)	1.83	18 ton
	5.32	23 ton or more
improved type (8B)	0.24	20 ton
invention (8C)	4.42	23 ton or more

Also, Fig. 8 shows the result of measurement of the shearing stress distribution (per one ton) of each anchor bolt. The dotted line (• • • o • • •) of the graph indicates the shearing stress distribution of the conventional anchor bolt 8A, the one-dot and dash line (- • -△- • -) indicates the shearing stress distribution of the improved type anchor bolt 8B and the solid line (-□-) indicates the shearing stress distribution of the anchor bolt 8C according to the present invention. The original point of the horizontal axis of the graph corresponds to the surface of the base, and the plus side represent the distance inwardly from the surface of the base along the bolt body.

From this result, it was inferred that the peak of the shearing stress was located in the vicinity of the surface of the base in the conventional anchor bolt 8A, and the portion in the vicinity of the surface layer of the cement mortar or the base would first be damaged. In contrast, the peak of the shearing stress of the anchor bolt 8C according to the invention was located at a position by about 100 mm inwardly from the surface of the base, and the distribution was curved gradually inwardly therefrom. It was inferred that, as described above, the damage or fracture would hardly occur in the vicinity of the surface layer of the cement mortar material or the base. On the other hand, the peak of the shearing stress of the improved type anchor bolt 8B was very large and the shearing stress was distributed at a high value inwardly from the surface layer portion of the base. Thus, the bolt body would be liable to be bent in the middle thereof.

Finally, Table 3 and Fig. 9(a), 9(b) and 9(c) show the fatigue test measurement result of each anchor bolt. Here, the shearing yield value of the bolt body (8313 kgf) was regarded as the 100% load. On this basis, the 50% load (4126 kgf) and the 75% load (6235 kgf) were determined. A predetermined number of fatigue tests were first carried out at the 50% load for each anchor bolt. Subsequently, a predetermined number of fatigue tests were carried out at the 75% load, and finally, the fatigue tests were carried out at the 100% load until the bolt was broken down. Incidentally, for the improved type anchor bolt 8B, the fracture occurred at the 75% load and therefore the tests at 100% load were not carried out. Incidentally, Figs. 9(a), 9(b) and (c) show the relation between the repeated number of the tests and the loads of the conventional anchor bolt 8A, the improved type anchor bolt 8B and the anchor bolt 8C according to the present invention, respectively. The sign x in the figures indicates the fracture.

Table 3

Fatigue Test Measurement Result			
sample	load	test number	note
conventional type (8A)	50%	20,000	
	75%	10,000	
	100%	3,580	fracture
improved type (8B)	50%	10,000	
	75%	1,150	fracture
invention (8C)	50%	10,000	
	75%	10,000	
	100%	11,000	fracture

From the above-described fatigue test measurement result, with respect to the total number of the repeated fatigue tests up to the fracture, the number of the anchor bolt 8C according to the present invention (31,000) was somewhat smaller than that of the conventional type anchor bolt 8A (33580) but the number of the conventional anchor bolt 8A was larger by 10,000 in the low load fatigue test of 50% load number. Also, the number of the anchor bolt 8C according to the present invention was larger by 7,500 in number up to the fracture in the 100% load tests which were the high load fatigue tests. From the results, it would be possible to conclude that the anchor bolt 8C according to the present invention was much superior to the conventional anchor bolt 8A in fatigue tests. On the other hand, it was understood that the improved type anchor bolt 8B was broken down at 1,150 tests with the 75% load and the durability was quite low.

In view of the overall results of the tests, the anchor bolt 8C according to the present invention may effectively absorb the vibrations in the horizontal and the vertical lift directions caused by the earthquakes or the like to thereby suppress the damage of the object to be mounted and the base at a minimum level, and provided with mounting strength and durability equal to or more excellent than those of the conventional anchor bolt 8A.

Various details of the invention may be changed without departing from its spirit nor its scope. Furthermore, the foregoing description of the embodiments according to the present invention is provided for the purpose of illustration only, and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

Claims

1. An earthquake-resistant anchor bolt characterized in that a first support member having a high compression elasticity is fixed to an outer circumference of a neck portion of a bolt body to be embedded in a base; a second support member having a lower compression elasticity than that of said first support member is fixed to an outer circumference of a base portion on the inward end side of the neck portion of the bolt body; and a threaded portion is provided at a bolt end portion to be threadedly engaged with a fastening member.

2. The earthquake-resistant anchor bolt according to claim 1, wherein the compression elasticity of said first support member is not smaller than 20 kgf/mm^2 but not larger than 200 kgf/mm^2, and the compression elasticity of said second support member is not smaller than 1 kgf/mm^2 but not larger than 8 kgf/mm^2.

3. The earthquake-resistant anchor bolt according to claim 1 or 2, wherein said first support member is made of synthetic resin and fixed to the bolt body during curing, and said second support member is made of rubber and fixed to the bolt body during vulcanizing.

4. The anchor bolt according to claim 1, 2 or 3, wherein a ratio of the neck portion to which said first support member is to be mounted to a length of the base portion to which said second support member is to be mounted is not smaller than 0.1 but not larger than 0.5.

5. The anchor bolt according to any of claims 1 to 4,
   wherein said second support member is in the form of a truncated cone having a larger diameter at the other

end than a diameter at the neck side.

6. The anchor bolt according to any of claims 1 to 5,
wherein a ring made of metal is fixed to an outer circumference of said first support member.

7. A mounting structure using an earthquake-resistant anchor bolt according to any of claims 1 to 6, characterized in that the bolt body is embedded in the base; an object to be mounted is fitted at the bolt end portion; and the object to be mounted is fastened to the base by the fastening member screwed around the threaded portion of the bolt end portion.

8. The mounting structure
according to claim 7, wherein the object to be mounted is fastened to the base under the condition that an elastic member interposed between the fastening member screwed around the threaded portion of the bolt end portion and the base is compressed.

9. The mounting structure
according to claim 8, wherein said elastic member comprises an elastic washer fitted around the bolt body between the object to be mounted and said fastening member, the object to be mounted being fastened through said elastic washer by the fastening member screwed around the threaded portion of the bolt end portion.

10. The mounting structure
according to claim 8, wherein said elastic member comprises a rubber sheet laid between the base and the object to be mounted, the object to be mounted being fastened through said rubber sheet to said base by the fastening member screwed around the threaded portion of the bolt end portion.

11. A post-processing method for an earthquake-resistant anchor bolt in particular according to any of claims 1 to 6, comprising the following steps of:

(a) forming a mounting hole by applying a mold drawing or cutting process to a base made of concrete;

(b) holding the anchor bolt in the mounting hole in place, said anchor bolt having a bolt body wherein a second support member having a low compression elasticity is mounted on an outer circumference of a base portion located inwardly of a neck portion of the bolt body and having a threaded portion at a bolt end portion around which a fastening member is screwed, under the condition that a ring having an inner diameter larger than a diameter of the bolt body is coaxially fitted around the neck portion and a lower opening of the ring is closed by an upper end of the second support member;

(c) filling cement mortar material having non-shrinkable characteristics in a space between the mounting hole and the second support member; and

(d) filling a first support member, kept under a fluidized condition and made of material having a higher compression elasticity after curing than that of the second support member, in a space between the neck portion of the bolt body and cement mortar material by removing the ring after curing in such a state that the cement mortar material at least self-holds its shape, or in the space between the neck portion of the bolt body and the inner surface of the ring under the condition that the ring is left intact.

Fig.1

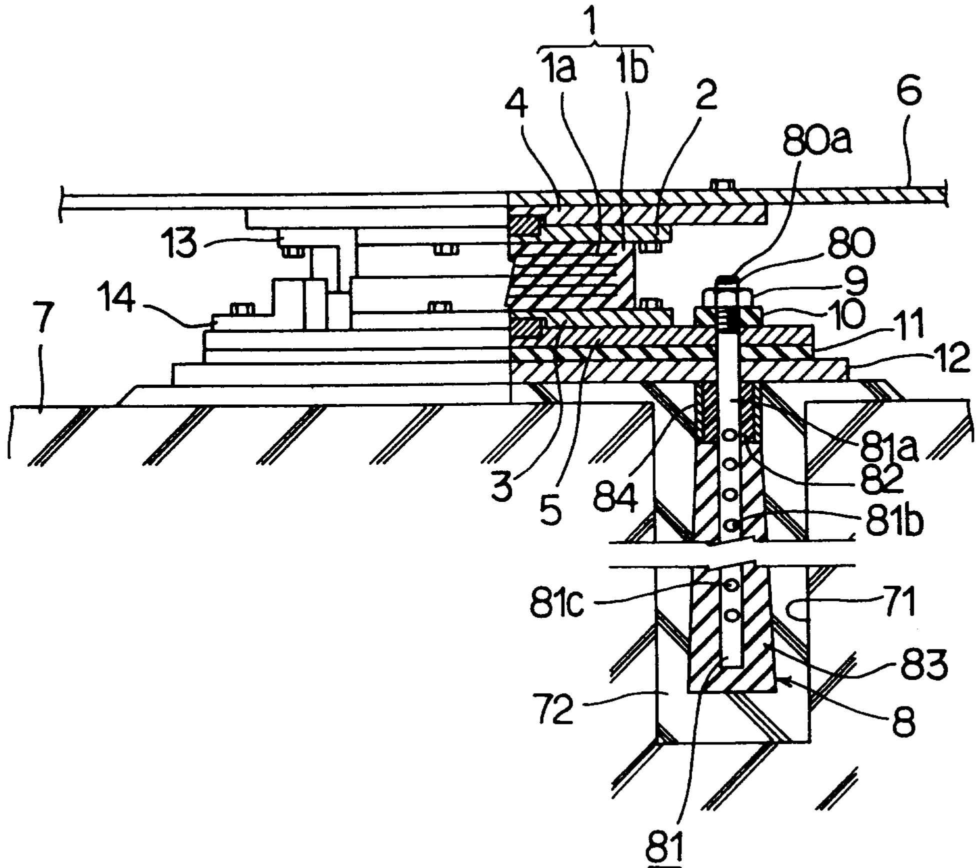


Fig. 2

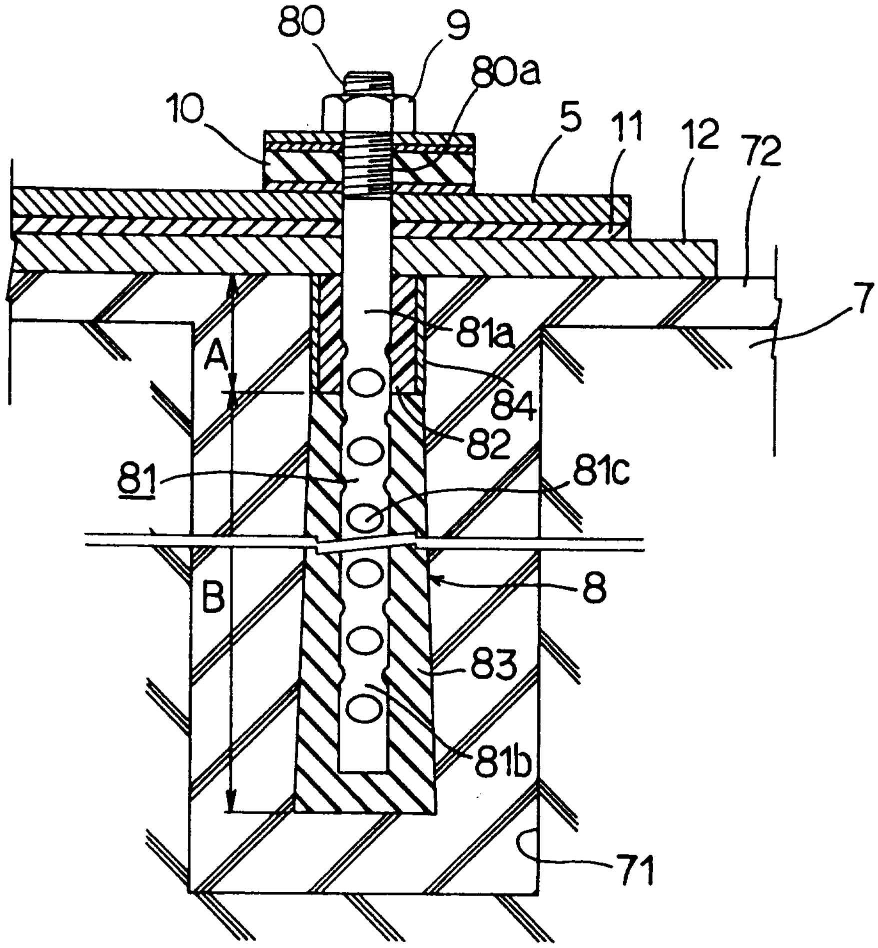
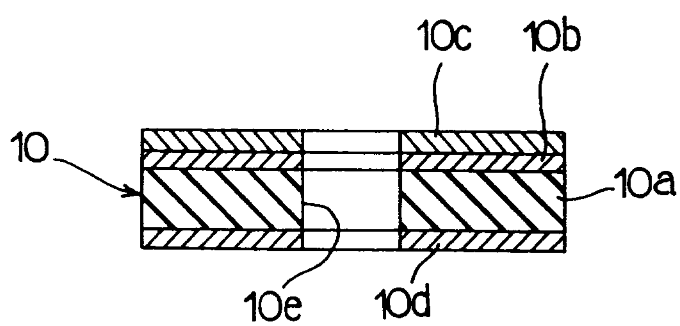

80
9
80a
10
5
11
12
72
7
81a
A
84
82
81
81c
8
B
83
81b
71

Fig. 3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10a
10e
10d

Fig, 4

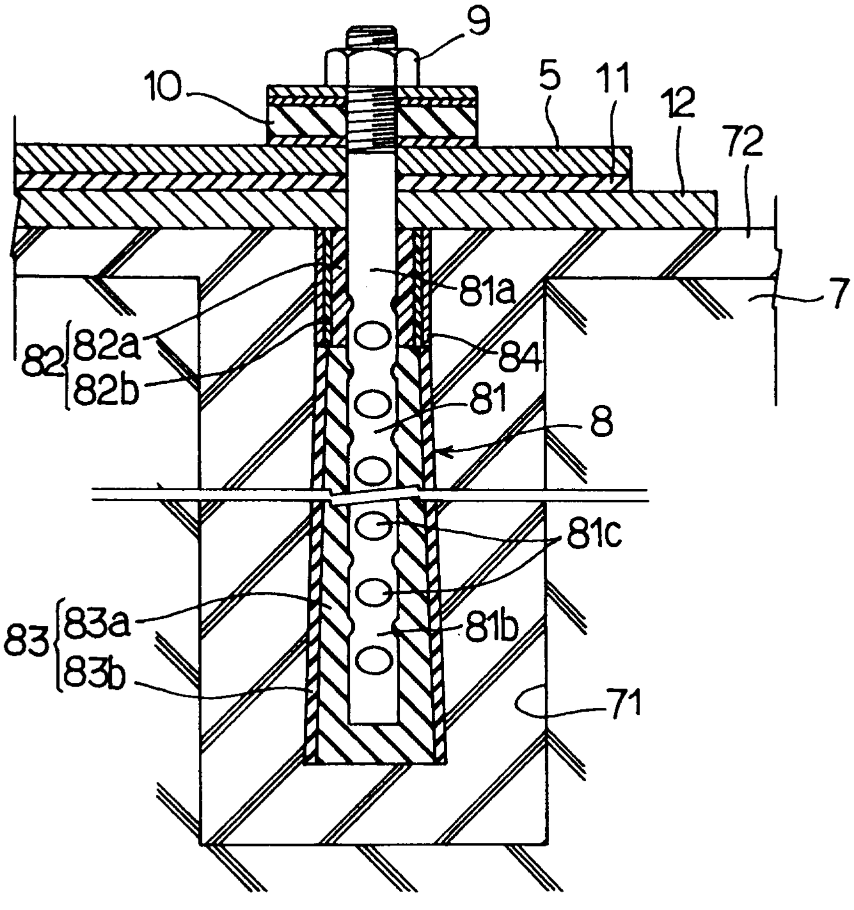
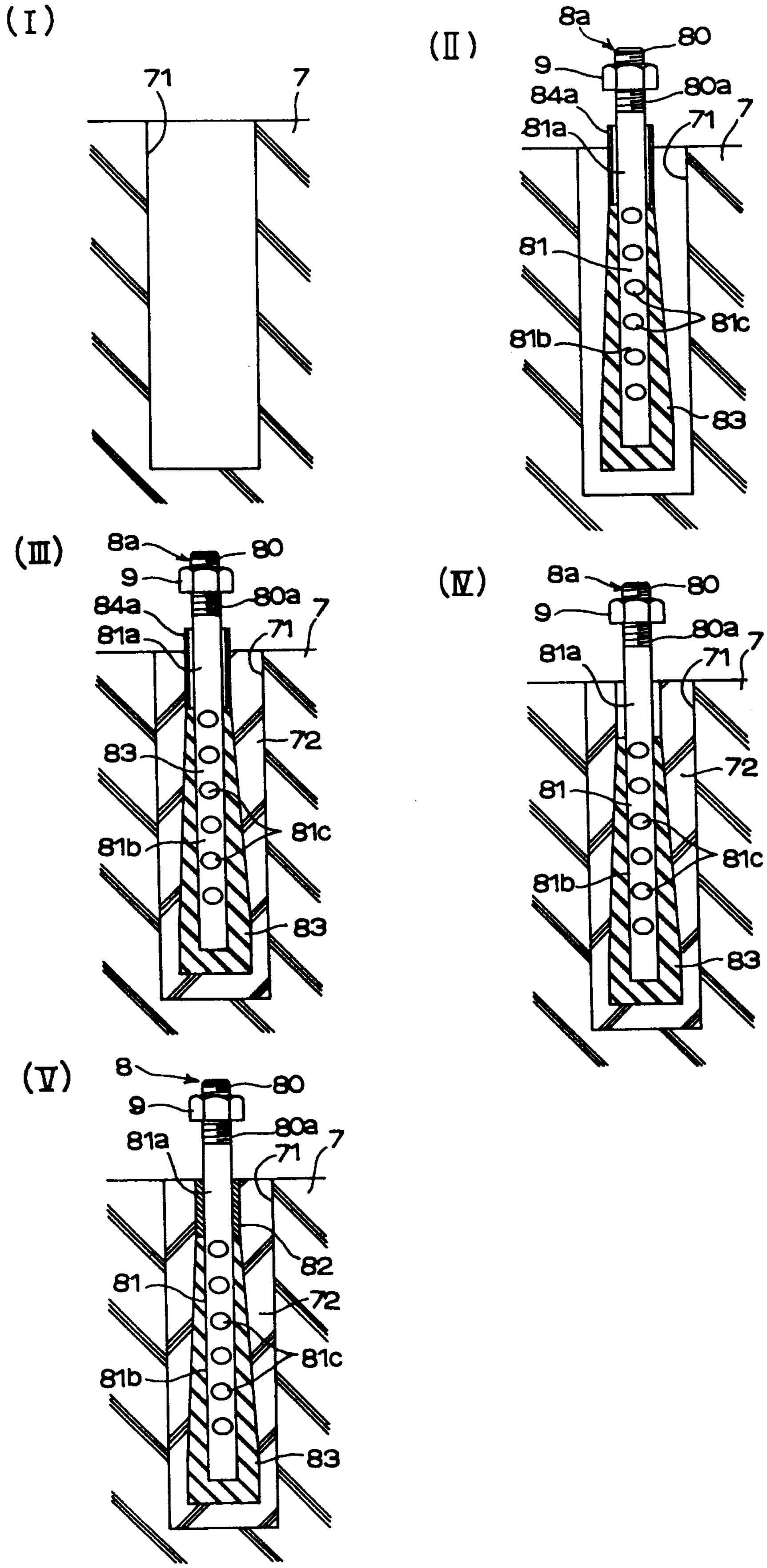


Fig. 5


(I)
71
7
(II)
8a
80
9
80a
84a
81a
71
7
81
81c
81b
83
(III)
8a
80
9
80a
84a
81a
71
7
72
83
81c
81b
83
(IV)
8a
80
9
80a
81a
71
7
72
81
81c
81b
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(V)
8
80
9
80a
81a
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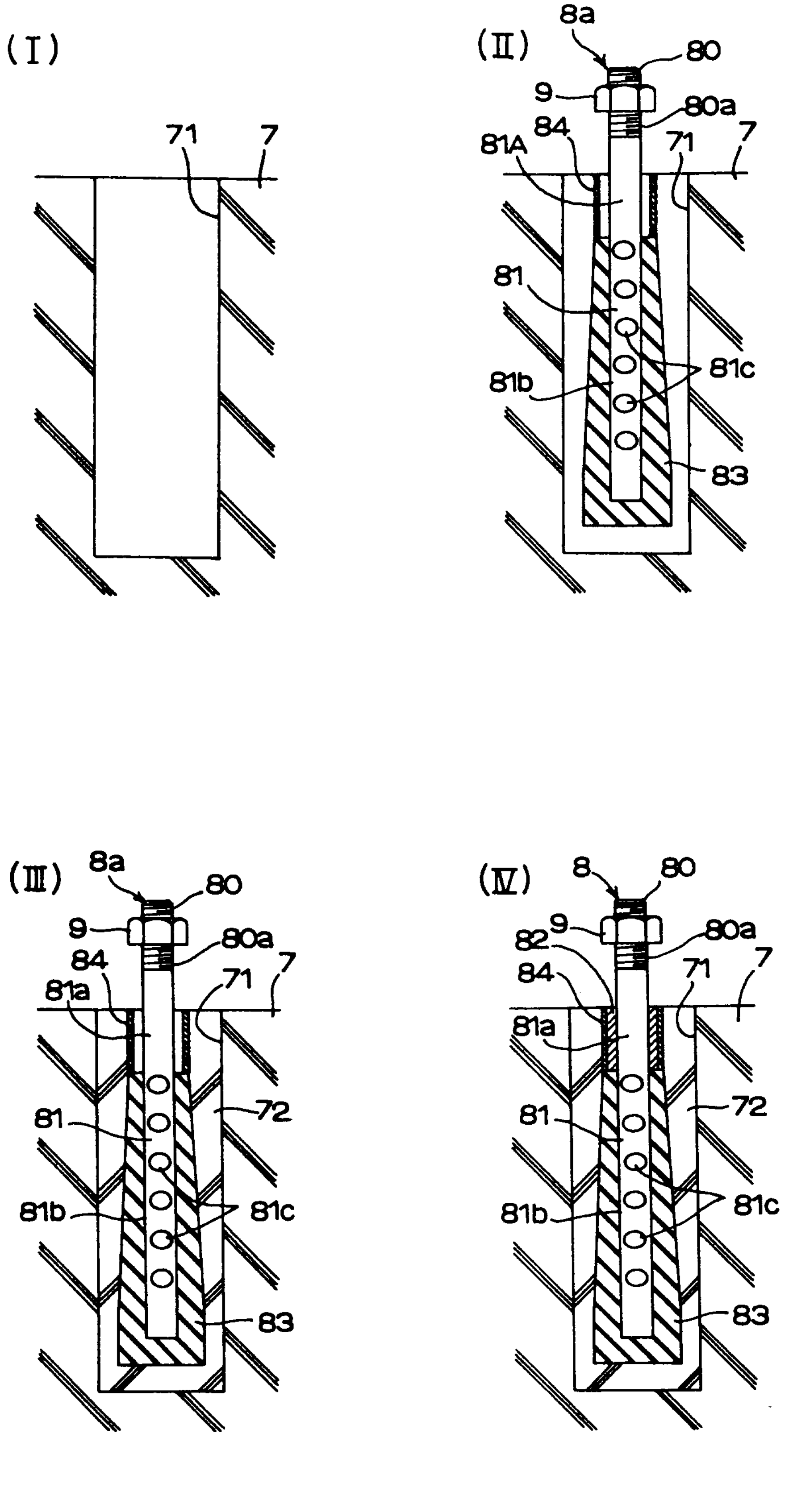
7
82
81
72
81c
81b
83

Fig, 6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81a
71
7
81
72
81b
81c
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(IV)
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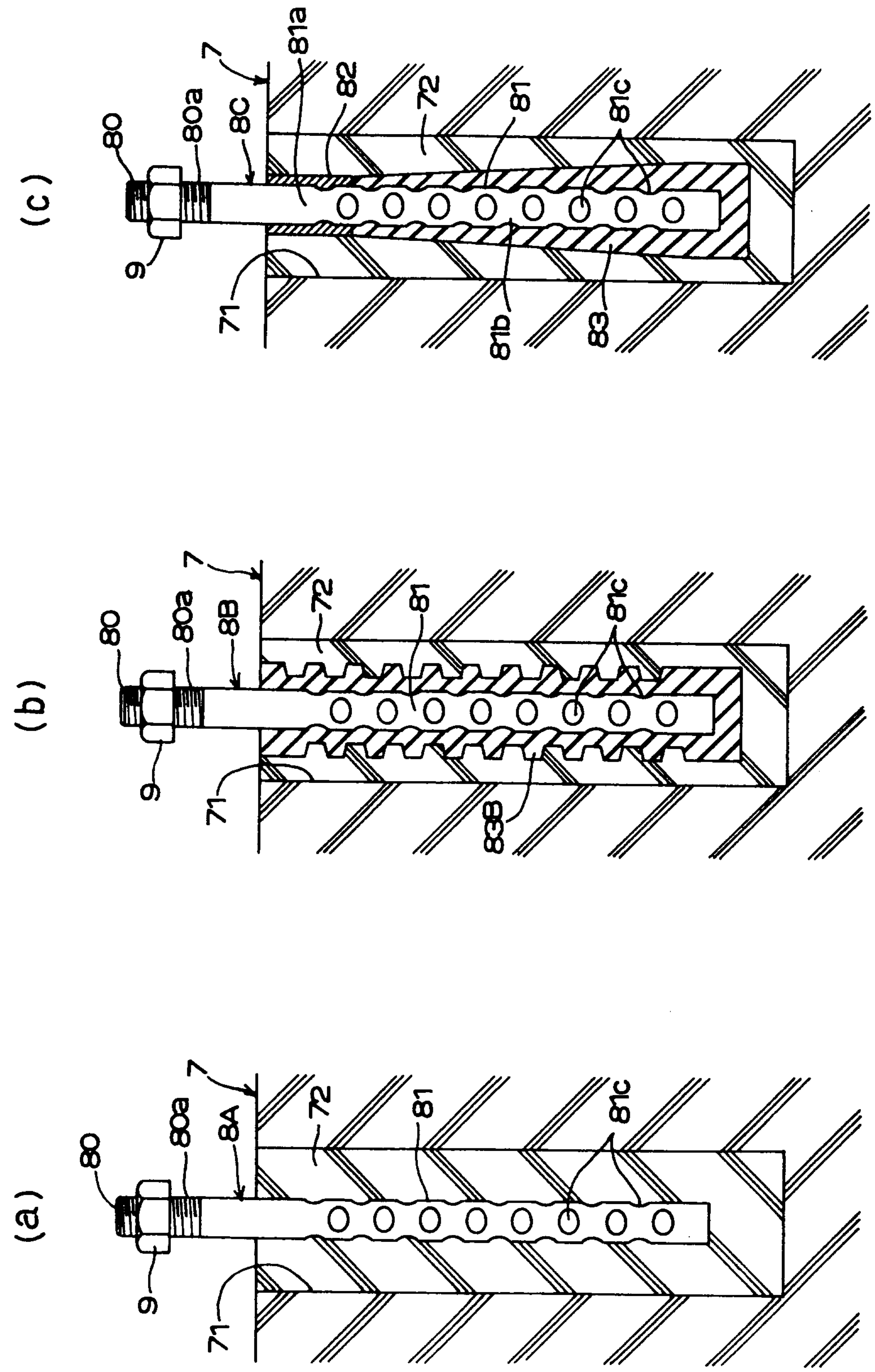
81a
81
72
81b
81c
83

Fig. 7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80a
8A
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72
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8B
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81c
9
71
83B
(c)
80
80a
8C
7
81a
82
72
81
81c
9
71
81b
83

Fig.8

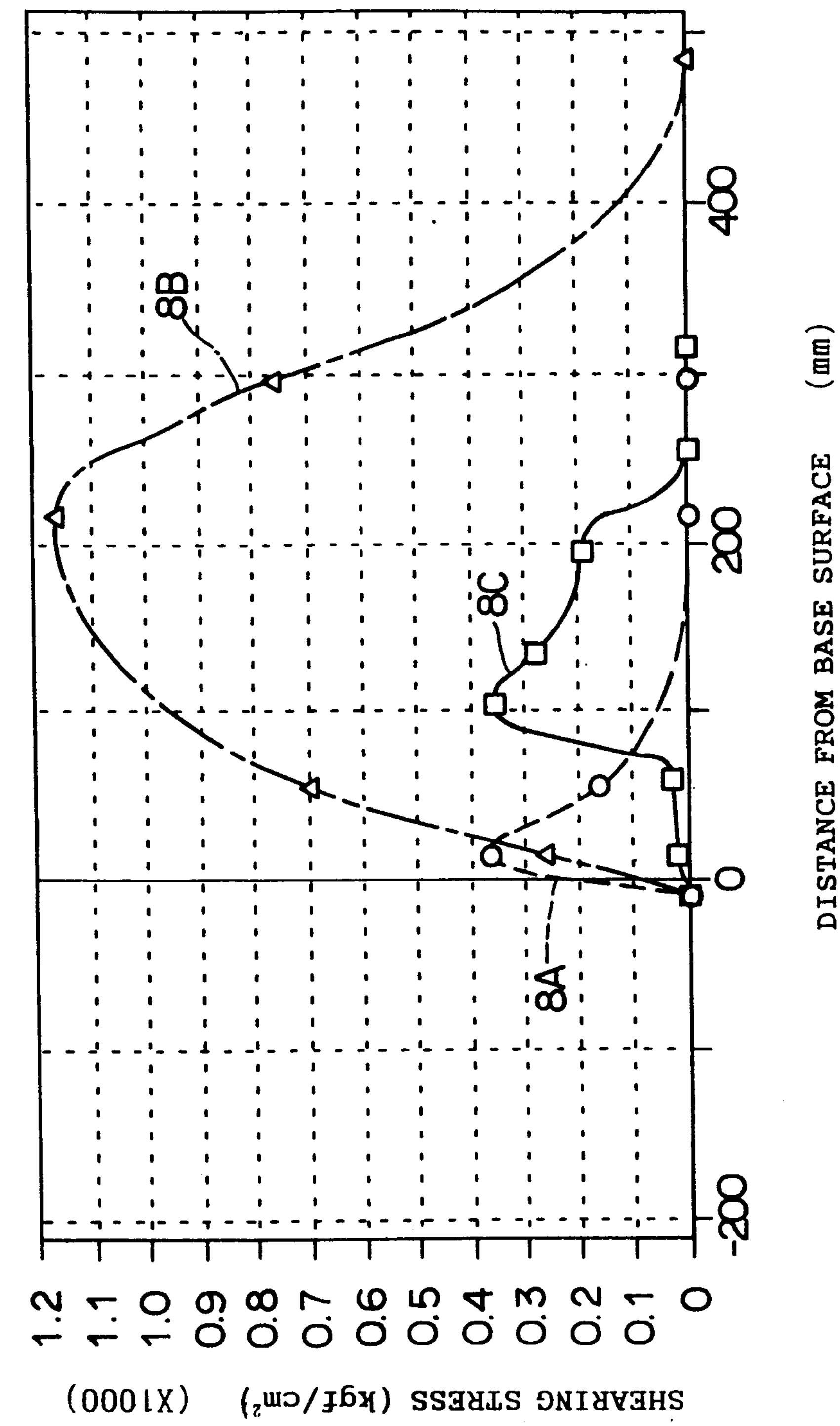
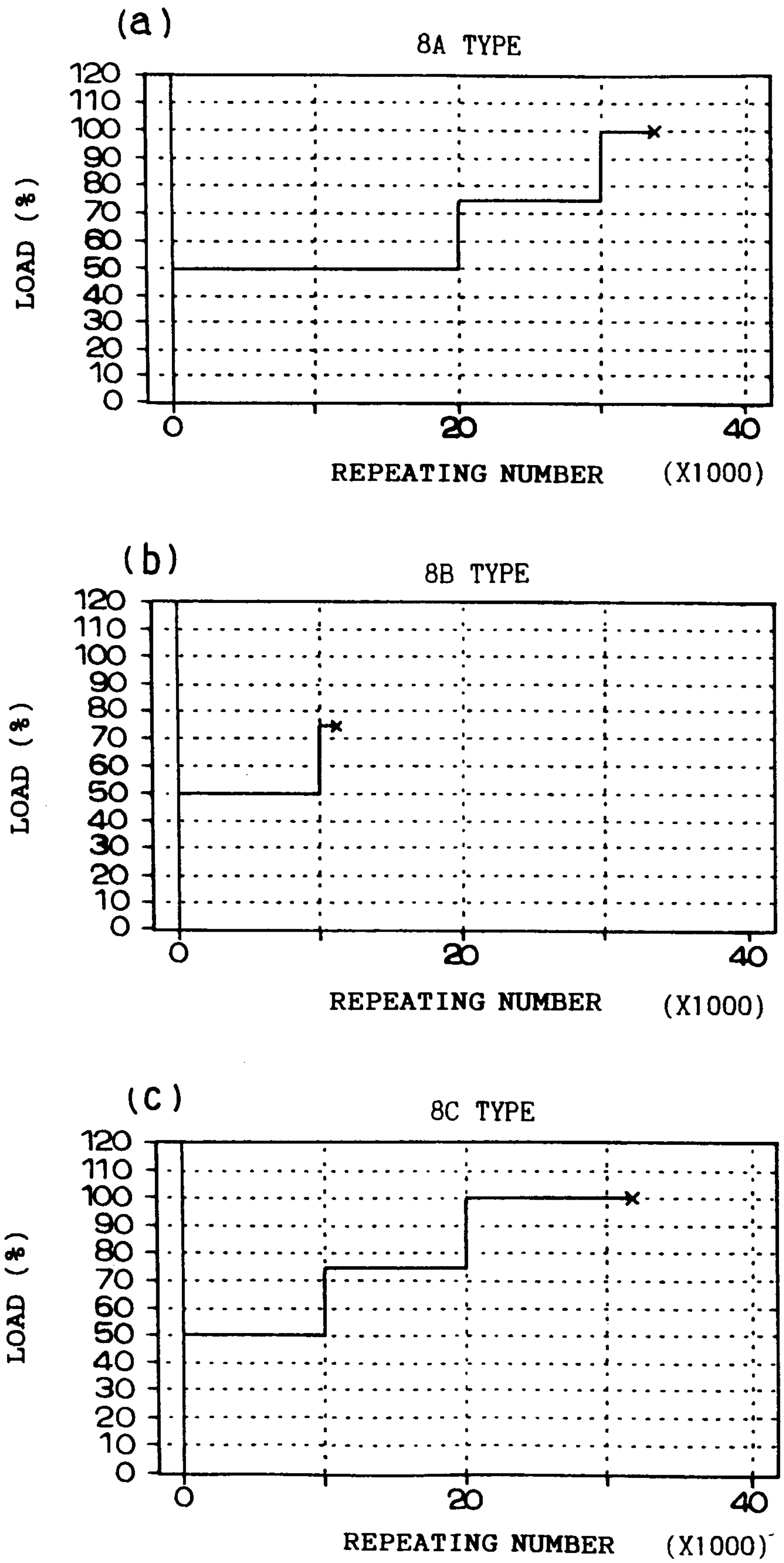

8A
8B
8C
-200
0
200
400
DISTANCE FROM BASE SURFACE (mm)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
SHEARING STRESS (kgf/cm²) (X1000)

Fig. 9


(a)
8A TYPE
LOAD (%)
REPEATING NUMBER (X1000)
(b)
8B TYPE
LOAD (%)
REPEATING NUMBER (X1000)
(c)
8C TYPE
LOAD (%)
REPEATING NUMBER (X1000)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 10 8927

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y A	US-A-4 875 808 (KELLISON) * column 2, line 36 - column 3, line 7; figures 1-3 *	1,7 5,8-10 2-4,11	E02D27/34 E02D27/44 E04H9/02 E01D19/04
Y	EP-A-0 433 170 (JEAN MULLER INTERNATIONAL) * column 2, line 53 - column 4, line 6; figures 1,2 *	8-10	
Y	US-A-4 642 964 (KELLISON) * column 4, line 3 - column 6, line 63; figures 1-4 *	5	
A	US-A-3 829 540 (COX) * column 3, line 15-32; figures 1,2 *	3	
A	US-A-4 707 956 (SATO) * column 3, line 7 - column 6, line 14; figures 1-11 *	6	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

E02D
E04H
E01D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23 August 1996	Kergueno, J

CATEGORY OF CITED DOCUMENTS

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