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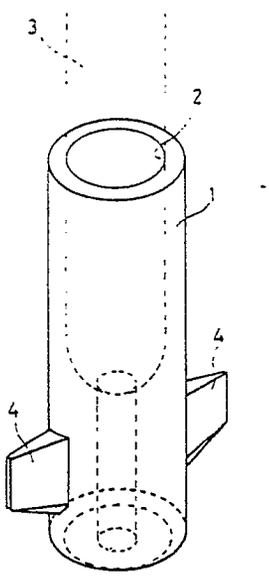
(54) Tool for forming groove in brittle object and method of fracturing same.

(57) A groove forming tool (1) having a projecting wing blade (4) whereby a crack necessary for fracturing a brittle object is formed in this material so as to extend generally in a desired direction, and a method of enabling the brittle object to be fractured along a desired line by this groove forming tool. In another method of the present invention, two free surfaces are formed to define the area of a portion to be separated by fracturing, thereby reducing the resistance to the fracturing force and enabling promotion of fracturing.

FIG. 1
(A)



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TOOL FOR FORMING GROOVE IN BRITTLE OBJECT AND METHOD OF FRACTURING SAME

BACKGROUND OF THE INVENTION

This invention relates to formation of a crack in a brittle object generally in a desired direction whereby the brittle object can be fractured along the corresponding desired line. The present invention also relates to a tool for forming a groove in a brittle object and a method of fracturing the same in which a portion to be separated by fracturing are defined by two free surfaces (facing a space) to reduce the resistance to the fracturing force and to thereby promote fracturing.

Japanese Patent No.59-53992 and Japanese Patent Laid-Open No.62-220657 disclose conventional methods of fracturing a brittle body such as rock, ground or concrete. These methods are as illustrated in Figs. 2A to 4A and Figs. 2B to 4. A conventional method is known in which a bore b is previously formed in a brittle object a and is charged with a slurry of an expansive material, and the brittle object is broken by the expansion pressure during the hydration process. Another type of method in which an explosive such as dynamite is packed in the bore b and is ignited to break the brittle object a has already been developed. In these methods, however, the bore b has a circular cross section and the break the brittle object cannot be fractured with a directionality selected in accordance with the design based on the kind, shape and restrained state of the brittle object. In particular, in a case where an expansive material is used, the time to fracture the object is increased unless the distance between bores for forming a crack is reduced. Each of these methods is based on the mechanism of creating the internal pressure of the fracturing agent to forcibly press the brittle body outwardly. Therefore, if the brittle object is very large and has a large area, its large and wide mass acts as a resistance to the fracturing force and impedes the promotion of fracturing, resulting in a difficulty in fracturing the object.

SUMMARY OF THE INVENTION

In view of these problems, an object of the present invention is to provide a tool for forming a crack in a brittle object in a desired direction and a method of fracturing this material along the corresponding desired direction.

To achieve this object, the present invention provides a tool for forming a groove in a brittle object, capable of being detachably attached to a boring shaft of a boring device such as a crawler drill, hand hammer or core drill, and having a wing blade protrusively formed on its outer peripheral surface.

The present invention also provides a method of forming a groove in a brittle object, including: forming a bore in a brittle object by that type of boring device; forming a groove in the bore in a fracturing direction by a groove forming tool capable of being detachably attached to the boring shaft of the boring device and having a wing blade protrusively formed on its outer peripheral surface; and charging the bore with a fracturing agent to fracture the brittle object with a directionality. The brittle object may be divided into smaller sections to be fractured separately in such a manner that a groove-like space is formed to define a portion of the brittle object to be separated by fracturing so that two free surfaces are formed at the periphery of this portion, thereby reducing the resistance to the fracturing force to promote fracturing.

BRIEF DESCRIPTION OF THE DRAWINGS

The attached drawings illustrate a tool for forming a groove in a brittle object and a method of fracturing the brittle object in accordance with the present invention;

Fig. 1A is a perspective view of a groove forming tool;

Fig. 1B is a perspective view of another example of the groove forming tool;

Figs. 2 to 4 are perspective views of examples of comparison between examples of the present invention and the conventional method; Figs. 2A to 4A illustrating bored states of conventional examples; Figs. 2B to 4B illustrating cracks in the conventional examples; Figs. 2C to 4C illustrating the bored states in accordance with the present invention; Figs. 2D to 4D illustrating formation of cracks in the case of the present invention; and

Figs. 5A and 5B are front views of formation of grooves defining free surfaces.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A tool for forming a groove in a brittle object and a method of fracturing the brittle object in accordance with the present invention will be described below with reference to the accompanying drawings. A groove forming tool 1 in the form of a cylinder has a hole 2 formed from its upper end to its inner portion. The groove forming tool 1 is

detachably attached to a boring shaft 3 of boring device such as a crawler drill, a hand hammer or a core drill by utilizing the hole 2. The tool 1 has a wing blade 4 protrusively formed on its outer peripheral surface. The wing blade 4 has an acute tip and has a generally triangular cross section. The wing blade 4 projects in the radial direction of the circular cross section of the tool 1. The tool 1 may have only one wing blade 4 or may have two wing blades 4 as shown in Fig. 1A or four wing blades 4 as shown in Fig. 1B. The number of wing blades 4 is not limited to these numbers and may be selected as desired according to the use.

[Operation I]

Operation of the present invention will be described below. A bore 6 having a predetermined depth is formed in a brittle object 5 by using the above-mentioned type of boring device.

The groove forming tool 1 is attached to the boring shaft 3 of the same boring device and is inserted into the bore 6 is an impact manner. Ordinarily, the boring shaft 3 of the above-mentioned crawler drill, hand hammer or core drill is designed to effect an impact action (vertical motion) as well as a rotational action and is also designed to effect both rotational and impact actions simultaneously or effect only one of these actions selected by a change-over operation. To form the bore 6 in the brittle object 5, the boring bit is attached to the boring shaft 3, and an impact action of the boring shaft 3 (boring bit) is effected while rotating the same. After the bore 6b has been formed, the groove forming tool 1 is attached in place of the boring bit and is inserted into the bore 6. At this time, the functions of the boring device can be changed over to effect the impact action alone. As the groove forming tool 1 is thereby inserted without being rotated, the wing blade 4 of the groove forming tool 1 cuts the inner surface of the bore 6, thereby forming a groove (slit) 7 in the inner surface of the bore. The groove forming tool 1 is inserted while the direction in which the wing blade 4 extends being adjusted to the direction of a crack 8 which is to be formed in the brittle object 5 so as to extend from the bore 6. After the formation of the groove has been completed, an expansive material or an explosive is packed inside the bore 6, thereby forming the crack 8 in the brittle object in a direction corresponding to the direction of the groove 7. That is, in a case where an expansive material is used, the expansive material expands with elapse of time and causes an expansion pressure inside the bore 6 so that a stress is concentrated at the groove 7, thereby breaking the brittle object 5. In a case where an explosive is used, the explosive is ignited to break the brittle object 5 from a portion in the vicinity of the groove 7. The expansive material applicable to this expanding operation may be selected from well-known expansive breaking agents, e.g., lime-, calcium sulfoaluminate-, half-baked dolomite-, magnesia-, ordinary Portland cement-blast furnace slag-bauxite-lime-, alumina cement-lime-gypsum-, and calcium aluminate-lime-gypsum- cement expanding agents, including "Bristar" (commercial name of a product of Onoda Cement Co., Ltd.). The explosive may be well-known dynamite, black powder or the like. A concrete breaker constituted by a capsule in which a chemical having a burning speed lower than that of dynamite is packed can also be used.

[Operation II]

Operation of the present invention described below generally relates to the content of the attached claim 5. As shown in Figs. 5A and 5B a groove-like space 9 is formed at a position where the area of a portion of the brittle object to be displaced by fracturing is defined. The shape of the groove-like space 9 is not specifically limited. For example, it may has a straight-line shape such as that shown in Fig. 5A or it may be curved as shown in Fig. 5B. Forming the groove-like space 9 with such a curved shape is particularly effective for tunnel construction excavation. The formation of the groove-like space 9 can be considered as formation of a free surface as described below. If the brittle object is large in size and has a large area, its large and wide mass acts as a resistance to the fracturing force and impede the promotion of fracturing, thereby making it difficult to fracture the material. To cope with this problem, the groove-like space is formed to provide a freely movable and unrestrained surface, thereby dividing the fracturing area into small unit sections. With respect to fracturing of each section, the distance between a bore 6 for fracturing this section and the groove-like space 9, i.e., the distance between the bore and the free surface is small, and the fracturing effect is therefore sufficient even if the fracturing force of an expansive material or an explosive packed as the breaking agent in the bore 6 is not so large. The groove-like space 9 may be formed by any means. However, it may be formed by the same means as the means for forming the bore and the groove 7. That is, a boring device such as a crawler drill is used to form in the brittle object 5 bores 6′ having a suitable depth. Thereafter, the groove forming tool 1 is attached to the boring shaft 3 of the same boring device and is inserted into each bore 6′ in an impact manner. More specifically, a boring bit is

attached to the boring shaft 3 of the boring device and an impact operation of the boring bit is repeated while the boring shaft 3 is being rotated, thereby forming bores 6′. Thereafter, the groove forming tool 1 is attached in place of the boring bit and is inserted into each bore 6′. At this time, the functions of the boring device are changed over to effect impact action alone, and the groove forming tool 1 is thereby inserted into each bore 6′ without being rotated, so that the wing blade 4 of the groove forming tool 1 cuts the inner surface of the bore 6′, thereby forming a groove 7′ in the inner surface of each bore 6′. The grooves 7′ are formed in such a manner that adjacent pairs of grooves 7 communicate with each other. To do so, the length of the wing blade 4 in the radial direction is selected while the bores 6′ are disposed at small intervals. After groove-like space 9 has been formed in this manner, the brittle object 5 sectioned by the groove-like space 9 is fractured in the same manner as that described in Operation I.

[Comparison Example I]

An example of comparison between the above-described conventional art and the present invention will be described below with reference to Figs. 2A to 2D. Two concrete cubes a and 5 each having 40 cm sides were prepared. As shown in Fig. 2A, a cylindrical bore b having a diameter of 42 mm and a depth of 30 cm was formed in the concrete cube a at the center thereof. As shown in Fig. 2C, a bore 6 which was the same as the bore b was formed in the concrete cube 5, and grooves 7 were formed in the fracturing direction by a groove forming tool 1 in accordance with the present invention (having an outside diameter of 40 mm, and having two wing blades 4 spaced apart from each other by 180° and each having a width of 10 mm at its root portion, a width of 2 mm at its tip, a height of 10 mm and a length of 30 mm). These bores were charged with equal amounts of the same slurry of a lime expansive fracturing agent (the above-mentioned Bristar) kneaded with 30 % water. In the example of the conventional art, as shown in Fig. 2B, three cracks 3 were formed at angles of about 120° from each other 12 hours after charging. In the case of the present invention, as shown in Fig. 2D, a generally straight crack 8 extending in the direction of the grooves was formed 8 hours after charging, and the cube was divided into two parts.

[Comparison Example II]

Another example of comparison between the above-described conventional art and the present invention will be described below with reference to Figs. 3A to 3D. Two concrete cubes a and 5 each having 60 cm sides were prepared. As shown in Fig. 3A, a cylindrical bore b having a diameter of 42 mm and a depth of 50 cm was formed in the concrete cube a at the center thereof. As shown in Fig. 3C, a bore 6 which was the same as the bore b was formed in the concrete cube 5, and grooves 7 were formed in the fracturing direction by a groove forming tool 1 in accordance with the present invention (having an outside diameter of 40 mm, and having four wing blades 4 spaced from each other by 90° and each having a width of 15 mm at its root portion, a width of 3 mm at its tip, a height of 20 mm and a length of 50 mm). These bores were charged with equal amounts of the same slurry of the above-mentioned Bristar kneaded with 30 % water. In the example of the conventional art, as shown in Fig. 3B, three cracks 3 were also formed at angles of about 120° from each other 14 hours after charging. In the case of the present invention, as shown in Fig. 3D, formation of cracks 8 started 10 hours after charging, and the cube was divided into four parts 1 hour after the start of the formation.

[Comparison Example III]

Still another example of comparison between the above-described conventional art and the present invention will be described below with reference to Figs. 4A to 4D. Two concrete cubes a and 5 each having 40 cm sides were prepared. As shown in Fig. 4A, a cylindrical bore b having a diameter of 42 mm and a depth of 30 cm was formed in the concrete cube a at the center thereof. As shown in Fig. 4C, a bore 6 which was the same as the bore b was formed in the concrete cube 5, and grooves 7 were formed in the fracturing direction by a groove forming tool 1 in accordance with the present invention (having an outside diameter of 40 mm, and having two wing blades 4 spaced from each other by 180° and each having a width of 8 mm at its root portion, a width of 1 mm at its tip, a height of 10 mm and a length of 30 mm). A concrete breaker was inserted in each bore, was enclosed by tamping with sand and was thereafter ignited. In the example of the conventional art, as shown in Fig. 4B, the cube was divided into five parts. In the case of the present invention, as shown in Fig. 4D, the cube was divided into two parts on opposite sides of the grooves 7.

As described above, the tool for forming a groove in a brittle object in accordance with the present invention is capable of being detachably attached to a boring shaft of a boring device such

as a crawler drill, hand hammer or core drill and has a wing blade protrusively formed on its outer peripheral surface. It is possible to readily form a suitable groove by using the wing blade. In the method of forming a groove in a brittle object in accordance with the present invention, a bore is formed in a brittle object by that type of boring device, a groove is formed in the bore in a fracturing direction by a groove forming tool capable of being detachably attached to the boring shaft of the boring device and having a wing blade protrusively formed on its outer peripheral surface, and a fracturing agent is packed in the bore to fracture the brittle object, thereby enabling a crack to be formed in accordance with a predetermined direction and enabling the object to be fractured along the corresponding designated line. Moreover, a stress can be concentrated to a portion in the vicinity of the groove, thereby reducing the time to fracture the object.

In addition, a groove-like space can be formed in the brittle object at the periphery of a portion thereof to be separated by fracturing, thereby forming two free surfaces whereby the resistance to the fracturing force can be reduced to promote fracturing.

The features disclosed in the foregoing description, in the claims and/or in the accompanying drawings may, both, separately and in any combination thereof, be material for realising the invention in diverse forms thereof.

Claims

1. A tool for forming a groove in a brittle object, capable of being detachably attached to a boring shaft of a boring device such as a crawler drill, hand hammer or core drill, said tool comprising a wing blade protrusively formed on its outer peripheral surface.

2. A tool for forming a groove in a brittle object according to claim 1, wherein said wing blade has a triangular cross section.

3. A method of forming a groove in a brittle object, comprising: forming a bore in a brittle object by a boring device such as a crawler drill, hand hammer or core drill; forming a groove in said bore in a fracturing direction by a groove forming tool capable of being detachably attached to the boring shaft of said boring device and having a wing blade protrusively formed on its outer peripheral surface; and charging said bore with a fracturing agent to fracture the brittle object.

4. A method of forming a groove in a brittle object according to claim 3, wherein said fracturing agent is an expansive material.

5. A method of forming a groove in a brittle object according to claim 3, wherein said fracturing agent is an explosive such as dynamite.

6. A method of forming a groove in a brittle object, comprising: forming, by a boring device such as a crawler drill, hand hammer or core drill, a bore in a portion of brittle object defined by a continuous groove-like space formed in the brittle object; forming a groove in said bore in a fracturing direction by a groove forming tool capable of being detachably attached to the boring shaft of said boring device and having a wing blade protrusively formed on its outer peripheral surface; and charging said bore with a fracturing agent to fracture the brittle object.

7. A method of forming a groove in a brittle object according to claim 6, wherein said fracturing agent is an explosive such as dynamite.

8. A method of forming a groove in a brittle object according to claim 6, wherein said fracturing agent is an explosive such as dynamite.

9. A method of forming a groove in a brittle object according to claim 6, wherein, to form said continuous groove-like space, bores are formed in the brittle object at small intervals by a boring device such as a crawler drill, hand hammer or core drill, and grooves are formed in said bores by a groove forming tool capable of being detachably attached to the boring shaft of said boring device and having a wing blade protrusively formed on its outer peripheral surface so that adjacent pairs of said grooves communicate with each other.

FIG. 1
(A)

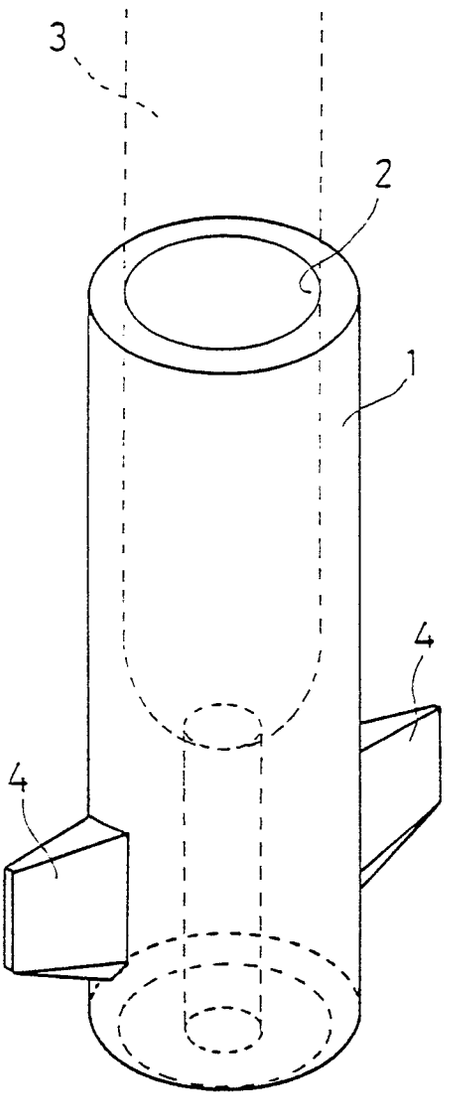


FIG. 1
(B)

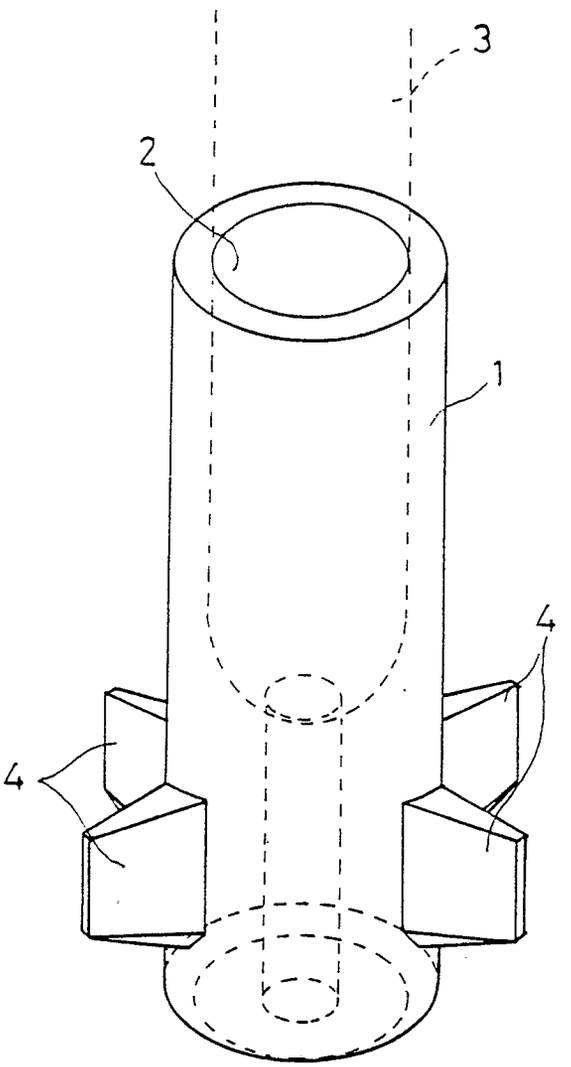


FIG. 2
(A)

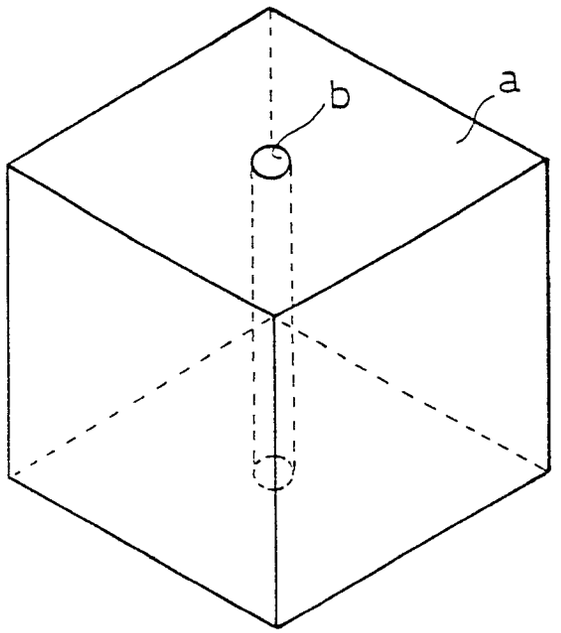


FIG. 2
(B)

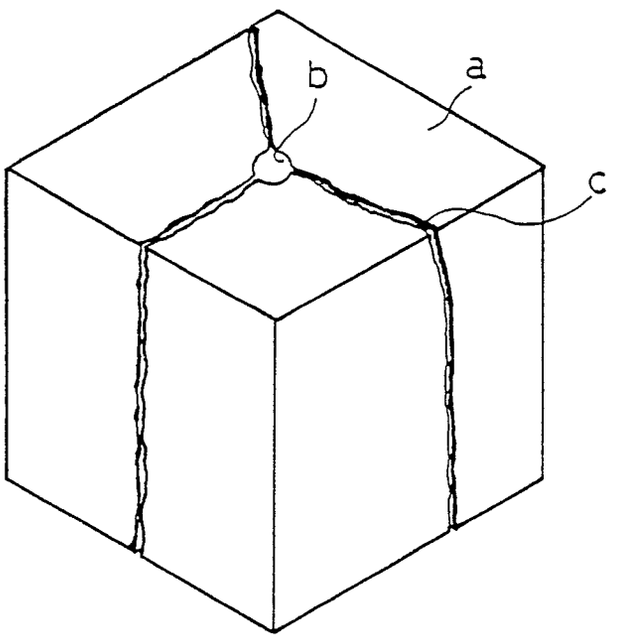


FIG. 2
(C)

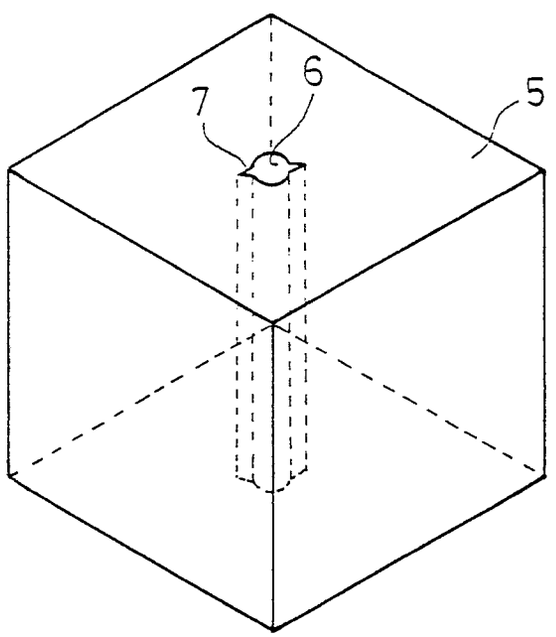


FIG. 2
(D)

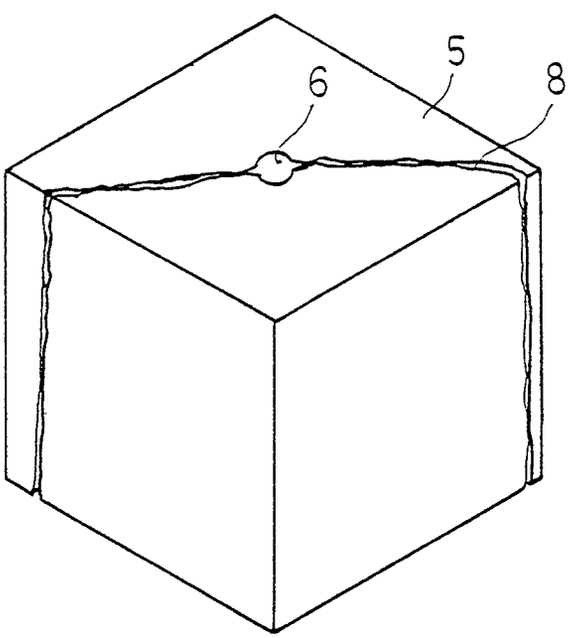


FIG. 3
(A)

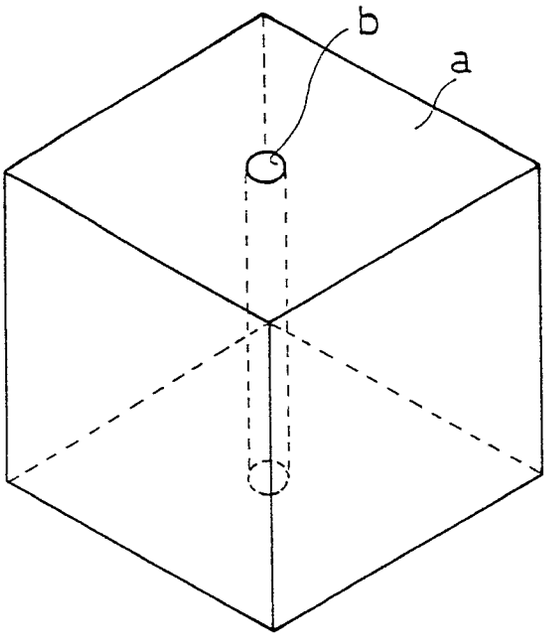


FIG. 3
(B)

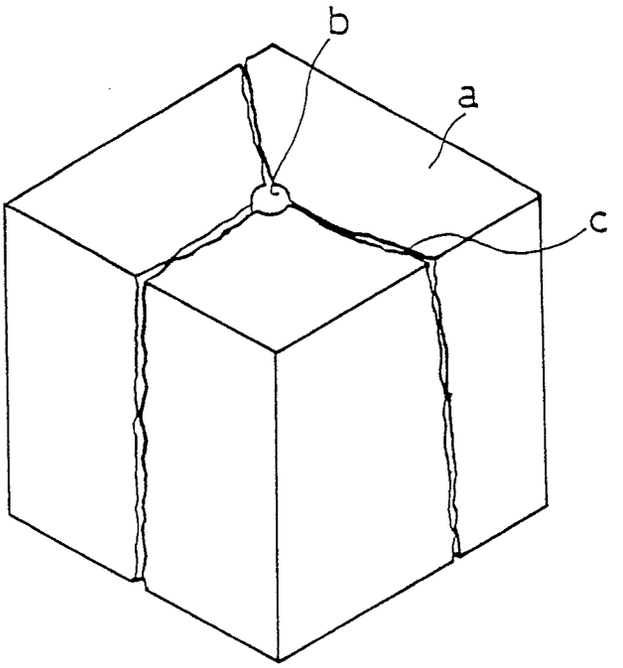


FIG. 3
(C)

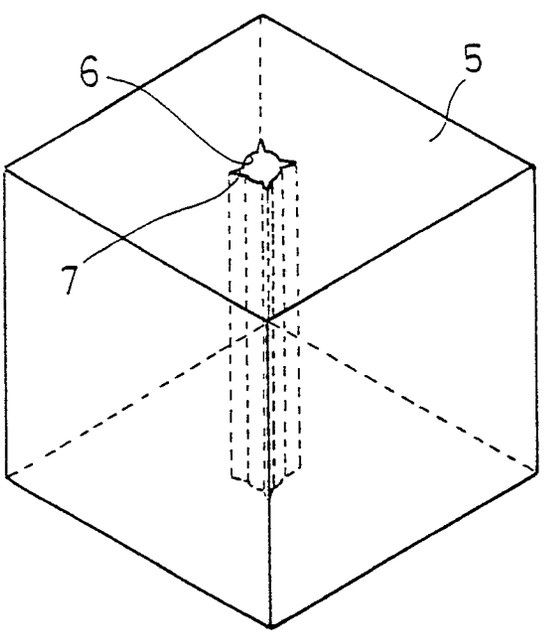


FIG. 3
(D)

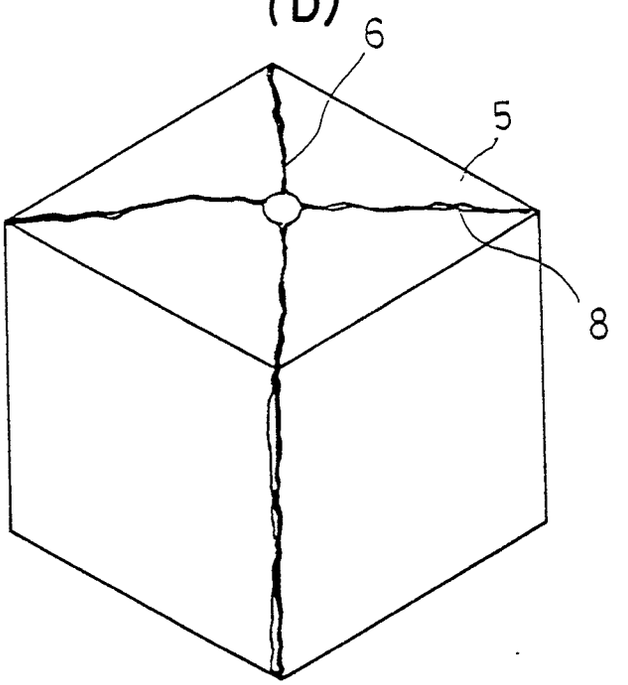


FIG. 4
(A)

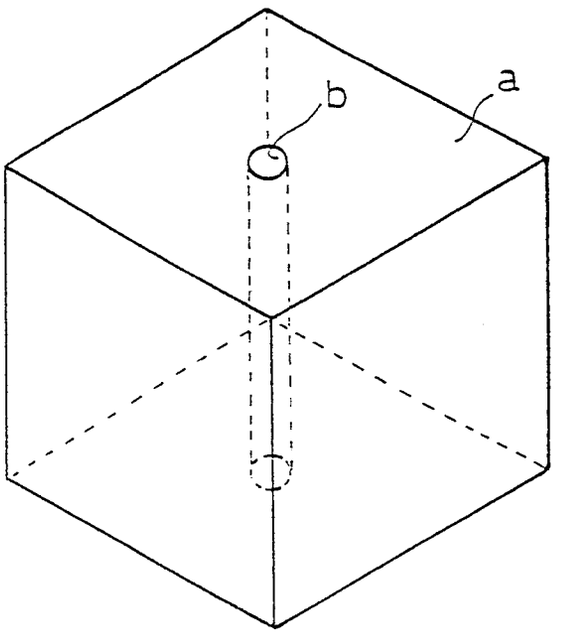


FIG. 4
(B)

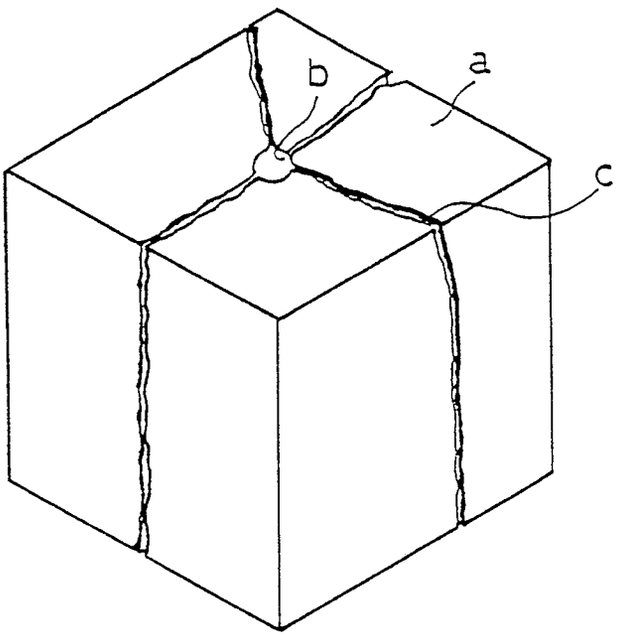


FIG. 4
(C)

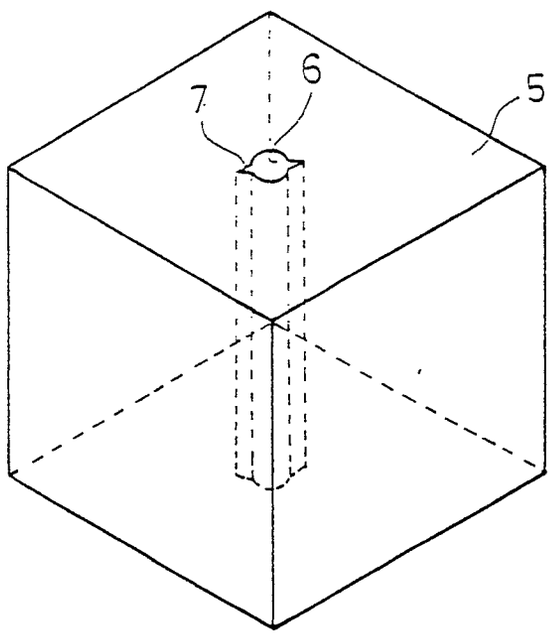


FIG. 4
(D)

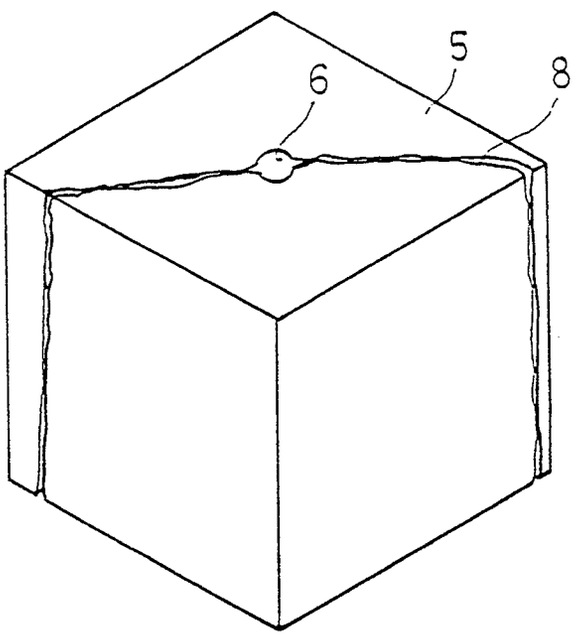


FIG. 5
(A)

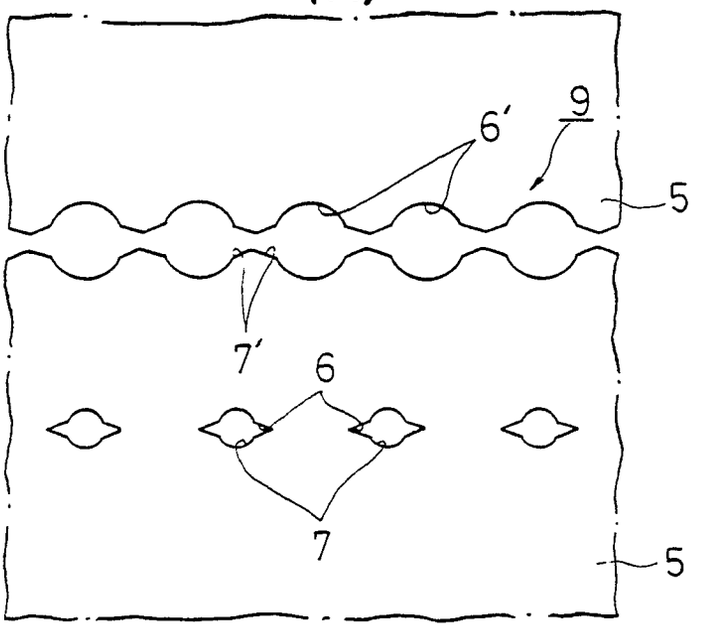
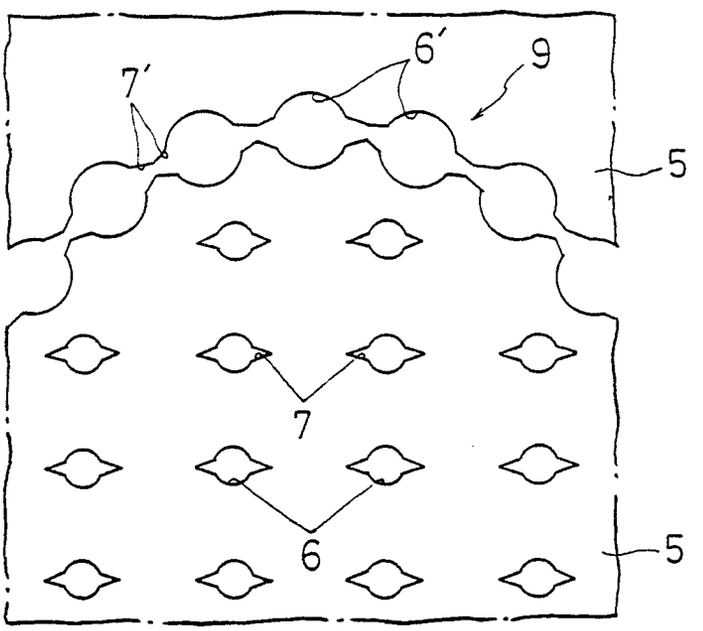


FIG. 5
(B)



European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 11 1317

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.5)
Y	FR-A-1 375 448 (STENUICK) * Page 2, column 1, last paragraph - column 2, paragraph 3; figures 5-8 *	1-3,5-9	E 21 C 37/00 B 28 D 1/00
Y	FR-E- 12 434 (ROSSI) * Claims; figures *	1-3,5-9	
A	FR-A- 405 498 (ROSSI) * Figures *	1-3,5-9	
A	US-A-4 316 583 (KAWANO et al.) * Abstract *	4	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

E 21 C
B 28 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27-09-1989	RAMPELMANN J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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L : document cited for other reasons

& : member of the same patent family, corresponding document

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