(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 114 696 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 158(3) EPC

(43) Date of publication:
11.07.2001 Bulletin 2001/28

(21) Application number: **00905312.5**

(22) Date of filing: **24.02.2000**

(51) Int Cl.[7]: **B24D 5/12**, B24D 3/00

(86) International application number:
PCT/JP00/01061

(87) International publication number:
WO 00/51789 (08.09.2000 Gazette 2000/36)

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE

(30) Priority: **26.02.1999 JP 5172899**

(71) Applicants:
- **SANKYO DIAMOND INDUSTRIAL CO., LTD.**
  Kanagawa 243-0417 (JP)
- **TOHO TITANIUM CO., LTD.**
  Chigasaki-shi, Kanagawa 253-8510 (JP)

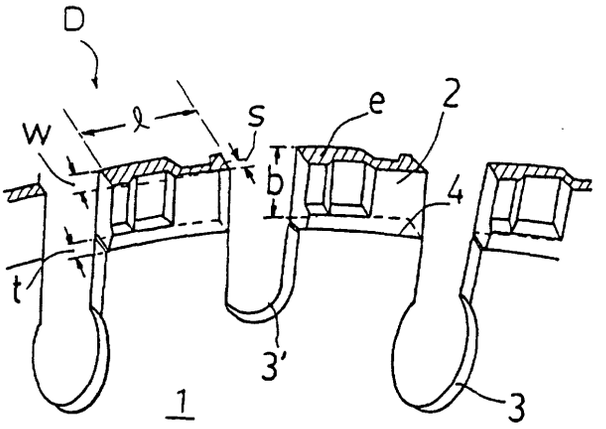
(72) Inventors:
- **Yoshida, Takuma**
  Chigasaki-shi, Kanagawa 253-0041 (JP)
- **Mashiko, Kazuhiro, 144-A-304 Miyayama**
  Kanagawa 253-0106 (JP)
- **Kobayashi, Shigeyoshi**
  Chigasaki-shi, Kanagawa 253-0087 (JP)

(74) Representative: **Pfau, Anton Konrad, Dr.**
Grünecker, Kinkeldey,
Stockmair & Schwannhäusser
Anwaltssozietät
Maximilianstrasse 58
80538 München (DE)

(54) DIAMOND SAW BLADE

(57) A diamond saw blade D includes diamond grinding stones 2 attached to the peripheral edge of a circular base plate 1. When a first value obtained through multiplication of the circumferential length of a circle having a diameter equal to the maximum outer diameter of the diamond saw blade D by the maximum thickness t of the circular base plate 1 is compared with a second value which is the total area of end surfaces e of the diamond grinding stones 2, the ratio of the second value to the first value is not less than 0.3 but not greater than 1.0.

Fig. 3



EP 1 114 696 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a diamond saw blade which exhibits excellent cutting performance and achieves a longer tool life when used for performing dry machining, such as dry grinding or dry cutting, of a hard and brittle material such as concrete or stone.

BACKGROUND ART

[0002] Conventionally, a diamond saw blade has been widely used as a tool for grinding or cutting a hard and brittle material such as stone or concrete structure. Such a diamond saw blade has a structure such that diamond grinding stones consisting of diamond abrasive grains bonded together by use of bond are attached to the outer circumferential portion of a disk-shaped metal base plate via a metal substrate called a substrate layer. The diamond saw blade is attached to a rotary tool, and then is rotated to effect grinding or cutting of a hard and brittle material.

[0003] The diamond saw blade exhibits excellent cutting performance in cutting of concrete or any other hard and brittle material, when, among other conditions, the following conditions are satisfied: a rotary tool outputs appropriate power; the diamond grinding stones contain a necessary and minimum number of diamond abrasive grains suitable for the power and the circumferential speed of the diamond saw blade; the diamond abrasive grains have sharp edges that project from the tip end of the grinding stone; and the diamond saw blade bites a workpiece deeply while the projection of the diamond abrasive grains is maintained to a possible extent, so that broken portions of the workpiece are discharged as chips at high speed.

[0004] However, the conventional diamond saw blade has a problem in that during cutting of a hard and brittle material, diamond abrasive grains at the tip end of the diamond grind stone gradually wear, break, and drop off, so that the cutting performance of the diamond saw blade gradually deteriorates.

[0005] Conventionally, the problem of deterioration in cutting performance of the diamond saw blade has been solved through adjustment of the hardness of the bond such that the bond has properties for providing a self-sharpening action. The self-sharpening action is an action such that upon diamond abrasive grains wearing or dropping off, the bond itself is caused to wear, so that the tip-end surface of the grinding stone moves inward, whereby diamond abrasive grains embedded in the bond are caused to project from the tip-end surface of the diamond grinding stone, to thereby maintain cutting performance.

[0006] However, when the bond is finished to come into a sintered state or to have a composition such that the bond has properties for easy wear to thereby provide the self-sharpening action, although cutting performance improves, the service life of the diamond saw blade is shortened due to the increased wear rate.

[0007] In contrast, when the bond is finished to come into a sintered state or to have a composition such that the bond has enhanced mechanical properties for strongly holding diamond abrasive grains, although the service life of the diamond saw blade increases, the bond becomes difficult to wear, so that the bond cannot provide the self-sharpening action. Therefore, cutting performance deteriorates as service life increases.

[0008] As described above, bond used for fabrication of diamond grinding stones of a diamond saw blade has the following two conflicting functions: (1) strongly holding effective diamond abrasive grains; and (2) wearing in accordance with the state of wear of diamond abrasive grains at the tip end in order to automatically sharpen cutting edges.

[0009] The conventional diamond saw blade can have only one of the property for providing a good cutting performance and the property for achieving a long service life. Therefore, in an exemplary case in which labor cost is high, priority is given to increasing cutting speed through improvement of the cutting performance of the diamond saw blade. By contrast, in a case in which importance is placed on the cost of a diamond saw blade itself, a diamond saw blade which has a longer service life but a somewhat deteriorated cutting performance is used. As described above, various types of diamond saw blades must be used selectively in accordance with an intended work application and conditions.

[0010] In view of the foregoing, an object of the present invention is to solve the problem that either cutting performance or service life must be sacrificed and to provide a diamond saw blade which achieves excellent cutting performance and improved durability.

DISCLOSURE OF THE INVENTION

[0011] The present invention provides a diamond saw blade in which diamond grinding stones are attached to the peripheral edge of a circular base plate, characterized in that a first value obtained through multiplication of the circumferential length of a circle having a diameter equal to the maximum outer diameter of the diamond saw blade by the maximum thickness of the circular base plate is compared with a second value which is the total area of end surfaces of the diamond grinding stones, and the ratio of the second value to the first value is not less than 0.3 but not greater than 1.0.

[0012] As described above, the diamond saw blade of the present invention requires that the ratio of the total area of the end surfaces of the diamond grinding stones to the total area of the peripheral end surface of a disk which has a circumference corresponding to a circle having a diameter equal to the maximum outer diameter of the diamond saw blade and a thickness corresponding to the maximum thickness of the circular base plate

becomes not less than 0.3 but not greater than 1.0. Through satisfaction of the requirement, the diamond saw blade can maintain an excellent cutting performance and realize a long tool life, when the diamond saw blade is used for dry grinding or cutting of hard and brittle materials such as concrete and stone.

[0013] When the diamond grinding stones are arranged on the circular base plate at a predetermined interval, the diamond saw blade preferably has the following configuration.

[0014] When the diamond grinding stones are arranged at an interval less than 3.0 mm, the ratio of the second value to the first value is preferably not less than 0.3 but not greater than 0.8, wherein the first value is obtained through multiplication of the circumferential length of a circle having a diameter equal to the maximum outer diameter of the diamond saw blade by the maximum thickness of the circular base plate, and the second value is the total area of end surfaces of the diamond grinding stones.

[0015] When the diamond grinding stones are arranged at an interval not less than 3.0 mm but less than 15.0 mm, the ratio of the second value to the first value is preferably not less than 0.4 but not greater than 0.9, wherein the first value is obtained through multiplication of the circumferential length of a circle having a diameter equal to the maximum outer diameter of the diamond saw blade by the maximum thickness of the circular base plate, and the second value is the total area of end surfaces of the diamond grinding stones.

[0016] As described above, since the diamond saw blade of the present invention can maintain an excellent cutting performance and realize a long tool life, a burdensome work for selectively using a different type of a diamond saw blade in accordance with an intended work and conditions can be eliminated. Further, a good work environment can be maintained.

[0017] Each of the diamond grinding stones preferably includes diamond abrasive grains bonded together by use of bond, and the bond preferably has a Rockwell hardness not less than HRA60 but not greater than HRA80. In this case, the bond can hold the diamond abrasive grains strongly.

[0018] Moreover, when the thickness of the diamond grinding stone is not less than 3 times the minimum grain size of diamond abrasive grains contained in the diamond grinding stone, the bond can hold the diamond abrasive grains with a proper holding force. Thus, the diamond abrasive grains are prevented from dropping off in an early stage, whereby the high cutting performance and long service life of the diamond saw blade can be maintained.

[0019] Furthermore, the concentration of the diamond abrasive grains in the diamond grinding stone with respect to the bond is preferably not less than 0.6 (ct/cm^3) but not greater than 1.4 (ct/cm^3). In this case, during cutting work performed for a workpiece, a sufficient load acts on each of the diamond abrasive grains projecting from the bond, which constitutes the diamond grinding stone 2. Therefore, a high cutting performance can be obtained.

[0020] The area of the blade-portion end surface of the diamond grinding stone is an area of a cross section which is obtained by extending the diamond grinding stone toward the peripheral direction of the circular base plate, and cutting it along a plane perpendicular to the circular base plate.

[0021] Moreover, the diamond grinding stone preferably has a shape such that at least of a portion of a surface parallel to the circular base plate is removed. In this case, chips of a workpiece are discharged from the removed portion, so that the smooth rotation of the diamond saw blade is secured.

[0022] The present invention further provides a diamond saw blade in which a diamond grinding stone is attached to the peripheral edge of a circular base plate, characterized in that a value obtained through multiplication of the maximum thickness of the diamond grinding stone by the circumferential length of the diamond grinding stone is compared with the area of the blade-portion end surface of the diamond grinding stone, and the ratio of the area of the blade-portion end surface of the diamond grinding stone to the value obtained through multiplication of the maximum thickness of the diamond grinding stone by the circumferential length of the diamond grinding stone is not less than 0.3 but not greater than 0.8.

[0023] The diamond grinding stone preferably includes diamond abrasive grains bonded together by use of bond, and the bond preferably has a Rockwell hardness not less than HRA 60 but not greater than HRA80. In this case, the bond can hold the diamond abrasive grains strongly.

[0024] Moreover, when the thickness of the diamond grinding stone is not less than 3 times the minimum grain size of diamond abrasive grains contained in the diamond grinding stone, the bond can hold the diamond abrasive grains with a proper holding force. Thus, the diamond abrasive grains are prevented from dropping off in an early stage, whereby the high cutting performance and long service life of the diamond saw blade can be maintained.

[0025] Furthermore, the concentration of the diamond abrasive grains in the diamond grinding stone with respect to the bond is preferably not less than 0.6 (ct/cm^3) but not greater than 1.4 (ct/cm^3). In this case, during cutting work performed for a workpiece, a sufficient load acts on each of the diamond abrasive grains projecting from the bond, which constitutes the diamond grinding stone 2. Therefore, a high cutting performance can be obtained.

[0026] More specifically, the area of the blade-portion end surface of the diamond grinding stone is an area of a cross section which is obtained such that the diamond grinding stone is assumed to be extended toward the peripheral direction of the circular base plate, and is cut

along a plane which is perpendicular to the circular base plate and passes through the peripheral circle of the original diamond saw blade.

[0027] Moreover, the diamond grinding stone preferably has a shape such that at least of a portion of a surface parallel to the circular base plate is removed. In this case, chips of a workpiece are discharged from the removed portion, so that the smooth rotation of the diamond saw blade is secured.

BRIEF DESCRIPTION OF DRAWINGS

[0028] FIGS. 1 and 2 are schematic views showing general diamond saw blades; FIG. 3 is a perspective view of a peripheral edge portion of the diamond saw blade of FIG. 1; FIGS. 4 to 6 are explanatory views showing examples of the diamond saw blade of the present invention; and FIGS. 7 to 9 are explanatory views showing peripheral edge portions of diamond saw blades of comparative examples.

BEST MODE FOR CARRYING OUT THE INVENTION

[0029] Embodiments of the present invention will next be described with reference to the drawings. It is to be noted that members, layout, etc. described below do not limit the present invention, and may be changed in various manners within the scope of the present invention.

[0030] A diamond saw blade D according to the present invention comprises a circular base plate 1 formed of metal, and a plurality of diamond grinding stones 2 integrally bonded to the peripheral edge of the circular base plate 1. Each of the diamond grinding stones 2 is formed of diamond abrasive grains and bond. The diamond grinding stones 2 are bonded to the circular base plate 1 via a substrate layer or are bonded directly to the circular base plate 1 through simultaneous sintering, without interposition of the substrate layer.

[0031] A specific embodiment of the diamond saw blade of the present invention will be described with reference to FIGS. 1 to 3. FIG. 1 is a schematic view showing the diamond saw blade D of the present embodiment. As shown in FIG. 1, the diamond saw blade D of the present embodiment comprises, as main structural elements, the circular base plate 1 and a plurality of the diamond grinding stones 2 attached to the periphery of the circular base plate 1.

[0032] The circular base plate 1 is a metal plate formed in a disk-like shape, and the peripheral portion is divided in the circumferential direction by means a plurality of slits 3. Each portion sandwiched by adjacent slits 3 serves as an attachment portion 4 for attachment of the diamond grinding stones 2. Further, an attachment hole la is formed at the center of the base plate 1 and is used for attachment to a rotary tool.

[0033] Although the circular base plate 1 of the present embodiment has key-shaped slits 3a and U-shaped slits 3b, the shape of the circular base plate 1 is not limited thereto. It may be the case that the circular base plate 1 includes only the key-shaped slits 3a or only the U-shaped slits 3b. Further, the shape of the slits are not limited to the key-like shape or the U-like shape and each of the slits may have an arbitrary shape.

[0034] The slits 3 formed in the diamond saw blade D enhance the cutting performance of the diamond grinding stones, and effectively remove friction heat generated between the tip end of the grinding stones and a workpiece, while securing smooth discharge of cutting chips. Thus, the slits 3 improve service life considerably. Although the diamond saw blade D shown in FIG. 1 has slits 3, needless to say, the diamond saw blade D may have a configuration such that no slits are formed, as shown in FIG. 2.

[0035] The diamond grinding stones 2 are segment-form grinding stones formed through a process in which diamond abrasive grains are bonded together by use of bond. Each of the diamond grinding stones 2 is formed into a rectangular parallelopiped having a length corresponding to that of the attachment portions 4 of the circular base plate 1. The diamond grinding stones 2 are attached to the circular base plate 1 via a metallic substrate layer by means of laser welding or any other suitable method. Alternatively, the diamond grinding stones 2 are integrally bonded to the circular base plate 1 by means of simultaneous sintering, without interposition of the substrate layer.

[0036] Further, as shown in FIG. 3, in each of the diamond grinding stones 2 of the present embodiment, a stepped portion is provided adjacent to the slit 3. The stepped portion is formed on either side surface of the diamond grinding stone 2 to extend from the slit 3 to the vicinity of the center of the diamond grinding stone 2. The depth of the stepped portion measured at the vicinity of the center is greater than that measured at the slit side. Therefore, discharge of cutting chips and radiation of friction heat can be effected effectively.

[0037] No limitation is imposed on the shape and number of the diamond grinding stones 2, and they may be changed freely depending on the size and thickness of the circular base plate 1 and the material of a workpiece.

[0038] In order to enable strong holding of diamond abrasive grains, the bond used in the present embodiment is prepared to exhibit high strength. For example, the bond is prepared such that the bond has a Rockwell hardness of HRA 60 or higher when sintered with diamond abrasive grains held therein. However, the bond is prepared such that the Rockwell hardness does not become greater than HRA80 in order to promote the self-sharpening action of the diamond abrasive grains.

[0039] When the Rockwell hardness is set to be not less than HRA65 but not greater than HRA75, the performance for holding diamond abrasive grains and the self-sharpening action are both achieved at high levels in a well-balanced manner, which is preferable.

[0040] Therefore, the present invention encompass-

es the following embodiment of the diamond saw blade; i.e., a diamond saw blade in which diamond grinding stones are fabricated through a process in which diamond abrasive grains are bonded together by use of bond; and the bond has a Rockwell hardness not less than HRA65 but not greater than HRA75.

[0041] The most important feature of the present invention resides in that the total area of blade-portion tip-end surfaces of the diamond grinding stones 2; i.e., the area obtained through multiplication of the area of the blade-portion tip-end surface of each diamond grinding stone 2 by the number of the diamond grinding stones 2, is determined to satisfy a predetermined requirement, which will be described below.

[0042] The circumferential length of a circle having a diameter equal to the maximum outer diameter c of the diamond saw blade D is multiplied by the maximum thickness t of the circular base plate 1 to obtain a first value X; and the first value X is compared with a second value Y, which is the total area of blade-portion end surfaces of the diamond grinding stones 2. The above-described requirement is such that the ratio Y/X is not less than 0.3 but not greater than 1.0.

[0043] When the result of comparison between the first value X and the second value Y shows that the ratio Y/X is not less than 0.4 but not greater than 0.9, more preferably, not less than 0.5 but not greater than 0.8, both the cutting speed and service life of the diamond saw blade D can be achieved at high levels in a well-balanced manner.

[0044] That is, the present invention encompasses the following embodiment; i.e., a diamond saw blade in which diamond grinding stones are attached to the peripheral edge of a circular base plate, wherein the circumferential length of a circle having a diameter equal to the maximum outer diameter of the diamond saw blade is multiplied by the maximum thickness of the circular base plate to obtain a first value; the first value is compared with a second value, which is the total area of end surfaces of the diamond grinding stones; and the ratio of the second value to the first value is not less than 0.4 but not greater than 0.9.

[0045] The present invention further encompasses the following embodiment; i.e., a diamond saw blade in which diamond grinding stones are attached to the peripheral edge of a circular base plate, wherein the circumferential length of a circle having a diameter equal to the maximum outer diameter of the diamond saw blade is multiplied by the maximum thickness of the circular base plate to obtain a first value; the first value is compared with a second value, which is the total area of end surfaces of the diamond grinding stones; and the ratio of the second value to the first value is not less than 0.5 but not greater than 0.8.

[0046] The above-descried requirement will be described in further detail with reference to FIGS. 1 and 3.

[0047] The maximum outer diameter c(mm) of the diamond saw blade D is the length of a line which extends between the blade-portion tip-end portion 2a of one diamond grinding stone 2 and the blade-portion tip-end portion 2a of the opposite diamond grinding stone 2 while passing through the center O of the circular base plate 1. That is, the maximum outer diameter c(mm) of the diamond saw blade D is obtained through a calculation in which the height b(mm) of the diamond grinding stone 2 (the distance between the junction between the circular base plate 1 and the diamond grinding stone 2 and the blade-portion tip-end portion of the diamond grinding stone 2) is doubled, and the resultant value is added to the outer diameter a(mm) of the circular base plate 1.

[0048] The first value X can be obtained through a calculation in which the circumferential length ($c \times \pi$)(mm) of a circle having a diameter equal to the maximum outer diameter c(mm) of the diamond saw blade D is multiplied by the maximum thickness t(mm) of the circular base plate 1; i.e., by use of the following equation:

$$X(mm^2) = c(mm) \times \pi \times t(mm).$$

[0049] The second value Y can be obtained through a calculation in which the area $e(mm^2)$ of the blade-portion end surface of each diamond grinding stone 2 is multiplied by the number y(pieces) of the diamond grinding stones 2 disposed on the diamond saw blade D; i.e., by use of the following equation:

$$Y(mm^2) = e(mm^2) \times y(pieces).$$

[0050] The diamond saw blade of the present embodiment is characterized in that when the above-mentioned first value $X(mm^2)$ is compared with the above-mentioned second value; i.e., the total area $Y(mm^2)$ of the area $e(mm^2)$ of the blade-portion end surface of each diamond grinding stone 2, the second value Y (mm^2) is not less than 30% but not greater than 100% the first value $X(mm^2)$.

[0051] That is, the following is an essential requirement:

$$0.3 \leq Y(mm^2)/X(mm^2) \leq 1.0.$$

[0052] When the ratio $Y(mm^2)/X(mm^2)$ exceeds 1.0; i.e. when the area $e(mm^2)$ of the blade-portion end surface of each diamond grinding stone 2 increases with a resultant increase in the total area $Y(mm^2)$, the cutting performance of the diamond saw blade is deteriorated. This is because the self-sharpening action does not occur effectively.

[0053] That is, the reason is that the bond is prepared to have high strength for strongly holding diamond abrasive grains. In cases, such as in the present embodiment, in which the bond is prepared to have high strength, when the total area $Y(mm^2)$ of the area $e(mm^2)$

of the blade-portion end surface of each diamond grinding stone 2 becomes excessively large, wear of the bond 2 does not proceed, so that diamond abrasive grains embedded in the bond become difficult to project, resulting in deterioration of the cutting performance.

[0054] By contrast, when the ratio $Y(mm^2)/X(mm^2)$ assumes an extremely small value of 0.3 or less; i.e. when the area $e(mm^2)$ of the blade-portion end surface of each diamond grinding stone 2 decreases excessively with a resultant excessive decrease in the total area $Y(mm^2)$, the durability of the diamond saw blade decreases.

[0055] As described above, when the Rockwell hardness of the bond is set to be not less than HRA60 but not greater than HRA80, and the ratio $Y(mm^2)/X(mm^2)$ is set to be not less than 0.3 but not greater than 1.0, more preferably, not less than 0.4 but not greater than 0.9, a state in which diamond abrasive grains greatly project from the tip-end surface of the diamond grinding stone 2 can be maintained for a long time, so that a desired cutting performance can be maintained for a long time.

[0056] Notably, as shown in FIG. 1, the diamond saw blade D is fabricated through attachment of the diamond grinding stones 2 onto the peripheral edge of the circular base plate 1. The diamond saw blade D can be classified into two types in accordance with the interval of disposition of the diamond grinding stones 2. For the diamond saw blade D of each type, a range for the ratio $Y(mm^2)/X(mm^2)$ in which excellent cutting performance and long tool life are secured is determined as follows.

[0057] For example, when the diamond grinding stones 2 are arranged at a relatively small interval, more specifically, when the diamond grinding stones 2 are arranged at an interval smaller than 3.0 mm, the size and end-face-shape of the diamond grinding stones 2 are adjusted such that the ratio $Y(mm^2)/X(mm^2)$ becomes not less than 0.3 but not greater than 0.8.

[0058] When the diamond grinding stones 2 are arranged at a relatively large interval, more specifically, when the diamond grinding stones 2 are arranged at an interval not less than 3.0 mm but less than 15.0 mm, the size and end-face-shape of the diamond grinding stones 2 are adjusted such that the ratio $Y(mm^2)/X(mm^2)$ becomes not less than 0.4 but not greater than 0.9.

[0059] That is, when the diamond grinding stones 2 are arranged at a relatively small interval, the area $e(mm^2)$ of the end surface of each diamond grinding stone 2 can be decreased more, as compared with the case in which the diamond grinding stones 2 are arranged at a large interval.

[0060] Notably, criteria other than the ratio $Y(mm^2)/X(mm^2)$ can be used for selecting the size and shape of the diamond grinding stone 2. That is, a value $Z(mm^2)$ obtained through multiplication of the maximum thickness t(mm) of the diamond grinding stone 2 by the outer circumferential length 1(mm) of the diamond grinding stone 2 is compared with the area $e(mm^2)$ of the blade-portion end surface of the diamond grinding stone 2; and when the ratio $Z(mm^2)/e(mm^2)$ is not less than 0.3 but not greater than 0.8, the diamond saw blade D is judged to secure excellent cutting performance and long tool life.

[0061] The above-described criterion is obtainment of the ratio of the actual area $e(mm^2)$ of the end surface of the diamond grinding stone 2 to a virtual area $Z(mm^2)$ obtained from the maximum thickness t(mm) of the diamond grinding stone 2 and the outer circumferential length 1 (mm) of the diamond grinding stone 2. Therefore, the present method in which the area $Z(mm^2)$ is compared with the actual area $e(mm^2)$ of the end surface of the diamond grinding stone 2 can be practiced even when the diamond grinding stone 2 does not have a rectangular end surface, specifically, a zigzagged end surface as shown in FIGS. 3 to 6.

[0062] In the above-described structure, when the value $Z(mm^2)$ obtained through multiplication of the maximum thickness t(mm) of the diamond grinding stone 2 by the outer circumferential length 1(mm) of the diamond grinding stone 2 is compared with the area e (mm^2) of the blade-portion end surface of the diamond grinding stone 2 and the ratio $Z(mm^2)/e(mm^2)$ is set to be not less than 0.4 but not greater than 0.7, the cutting speed and service life of the diamond saw blade D can be achieved at high levels in a well-balanced manner, which is preferable.

[0063] In other words, the present invention encompasses the following embodiment; i.e., a diamond saw blade in which a diamond grinding stone is attached to the peripheral edge of a circular base plate; the value obtained through multiplication of the maximum thickness of the diamond grinding stone by the outer circumferential length of the diamond grinding stone is compared with the area of the blade-portion end surface of the diamond grinding stone; and the ratio of the area of the blade-portion end surface of the diamond grinding stone to the value obtained through multiplication of the maximum thickness of the diamond grinding stone by the outer circumferential length of the diamond grinding stone is not less than 0.4 but not greater than 0.7.

[0064] Next, the hardness of the bond will be described. As described above, the Rockwell hardness of the bond is set to be not less than HRA60 but not greater than HRA80. When the Rockwell hardness becomes HRA60 or less, the holding force acting on diamond abrasive grains projecting from the tip end of the diamond grinding stone decreases, so that the diamond abrasive grains drop off within a short time, and the diamond saw blade loses its cutting capability before new grinding grains emerge due to wear of the bond; i.e., before the self-sharpening action occurs effectively. Therefore, the service life is also shortened.

[0065] By contrast, when the Rockwell hardness becomes HRA80 or greater, wear of the bond does not proceed, so that the self-sharpening action for exposing the cutting edges of diamond abrasive grains embedded in

the bond is hindered, and therefore, the high cutting performance is lost.

[0066] Moreover, when the appearance minimum thickness s(mm) of the diamond grinding stone 2; i.e., the minimum thickness as measured in the direction in which the maximum thickness w is measured as shown in FIGS. 3 and 4 is rendered not less than 3 times, preferably 4.5 times the minimum grain size of diamond abrasive grains contained in the diamond grinding stone 2, the high cutting performance and long service life of the diamond saw blade can be maintained.

[0067] When the appearance minimum thickness s (mm) of the diamond grinding stone 2 is rendered equal to or less than 3 times the minimum grain size of diamond abrasive grains; i.e., the diamond grinding stone 2 is made excessively thin, the probability of diamond abrasive grains existing at sharp edge portions of the diamond grinding stone 2 increases. At the sharp edge portions of the diamond grinding stone 2, the force for holding the diamond abrasive grains by the bond is low, which causes diamond abrasive grains to drop off in an early stage. Accordingly, the diamond saw blade cannot possess high cutting performance, and the service life of the diamond saw blade becomes shorter.

[0068] By contrast, when the appearance minimum thickness s of the diamond grinding stone 2 is rendered excessively thick as compared with the minimum grain size of diamond abrasive grains, the total area Y of the blade-portion end surfaces of the diamond grinding stones 2 becomes excessively large, so that the condition $Y(mm^2)/X(mm^2) \leq 1.0$, which is the essential requirement of the present invention, becomes impossible to satisfy. Needless to say, a diamond saw blade which does not satisfy the essential requirement does not satisfy both of high cutting performance and long service life.

[0069] Moreover, when the concentration of diamond abrasive grains in the diamond grinding stone 2; i.e., the content of diamond abrasive grains with respect to the bond is set to a range of 0.6 to 1.4 (ct/cm^3), preferably 0.8 to 1.2 (ct/cm^3), during cutting work performed for a workpiece, a sufficient load acts on each of the diamond abrasive grains projecting from the bond, which constitutes the diamond grinding stone 2. Therefore, a high cutting performance can be obtained.

[0070] That is, the present invention encompasses the following embodiment; i.e., a diamond saw blade characterized in that the concentration of diamond abrasive grains with respect to the bond is not less than 0.8 (ct/cm^3) but not greater than 1.2 (ct/cm^3).

[0071] When the concentration of diamond abrasive grains becomes excessively high, a load which acts on each abrasive grain during cutting work decreases, with the result that the performance of biting into a workpiece decreases, and thus the cutting performance decreases.

[0072] When the concentration of diamond abrasive grains becomes excessively low, the service life of the diamond saw blade is shortened. Further, in an extreme case, the number of abrasive grains at the tip end becomes absolutely insufficient, the bond comes in direct contact with the workpiece, so that cutting operation becomes impossible to effect.

[0073] Accordingly, as described above, the concentration of diamond abrasive grains in the diamond grinding stone 2 is limited to a range of 0.6 to 1.4 (ct/cm^3), preferably 0.8 to 1.2 (ct/cm^3) (weight ratio).

[0074] The present invention will now be described more specifically with reference to examples and comparative examples. However, the material, shape, size, etc. employed in the present invention are not limited thereby, and may be freely changed within the scope of the present invention.

(Example 1)

[0075] As shown in FIG. 4, a diamond saw blade D1 of the present example includes a plurality of diamond grinding stones 2 disposed along the peripheral edge of a circular base plate 1.

[0076] The circular base plate 1 of the present example includes alternatively formed key-shaped and U-shaped slits 3, and has an outer diameter (a) of 291 mm and a maximum thickness (t) of 2 mm.

[0077] Each of the diamond grinding stones 2 of the diamond saw blade D1 of the present example is formed through a process in which a pre-form for a diamond grinding stone layer and a pre-form for a substrate layer are set in a sintering mold to be adjacent to each other and are subjected to sintering under pressure. The pre-form for the diamond grinding stone layer is formed through a process in which tungsten-based bond and diamond abrasive grains having a minimum grain size of 0.3 mm are mixed and formed such that the concentration of the diamond abrasive grains after firing becomes 1.0 (ct/cm^3). The tungsten-based bond is prepared such that the Rockwell hardness of the bond portion after firing becomes HRA68.

[0078] Further, as shown in FIGS. 4 and 5, the diamond grinding stone 2 was formed such that the height (b) (length from a joint portion at which the diamond grinding stone 2 was boned to the circular base plate 1 to the blade-portion tip-end portion) was 8.0 mm; the apparent minimum thickness (s) (i.e., the minimum thickness in the direction of the maximum thickness w) was 1.6 mm; the maximum thickness (w) was 2.8; and the area of the blade-portion tip-end surface (e) was 27 mm^2.

[0079] 42 pieces of the diamond grinding stones 2 are attached to the attachment portions 4 of the circular base plate 1, each attachment portion 4 being located between the corresponding slits 3.

[0080] The circular base plate 1 and the diamond grinding stones 2 are formed to have sizes represented by the above-mentioned values. As a result, the maximum outer diameter (c) of the diamond saw blade is ob-

tained from the sum of the outer diameter (a) of the circular base plate 1 (291 mm) and the height (b) of the diamond grinding stones 2 (8.0 mm x 2). The circumferential length calculated from the maximum outer diameter (c: 307 mm) is 964 mm (= 307 mm x 3.14). The area obtained through multiplication of the circumferential length (964 mm) by the maximum thickness (t: 2 mm) of the circular base plate 1 is 1928 mm^2.

[0081] The ratio of the sum total (27 mm^2 x 42 = 1134 mm^2) of the areas of the blade-portion tip-end surfaces (e) to the above-described area value 1928 mm^2 was 0.59.

[0082] Further, the ratio of the actual area (e: 27.0 mm^2) of the end surface of diamond grinding stone to the virtual area (z: 42.0 mm^2) obtained through multiplication of the maximum thickness of the diamond grinding stone by the outer circumferential length of the diamond grinding stone was 0.64.

[0083] The diamond saw blade D1 manufactured in the above-described manner was attached to an engine cutter having a displacement of 85 cc. A concrete plate (material age: 1 year, grain size of aggregates: 20 mm, plate thickness: 60 mm) was cut in a dry state, while the engine cutter was rotated at 5000 rpm. As a result, it was confirmed that cutting operation can be performed at a high cutting speed of 1300 mm/min without generation of deflection of the circular base plate 1 or local wear of the diamond grinding stones 2. Further, it was confirmed that cutting operation can be performed over a distance of 185 m before the diamond saw blade D1 reaches the end of the service life.

(Example 2)

[0084] In the present example, the pre-form for the diamond grinding stone layer was formed through a process in which tungsten-based bond and diamond abrasive grains having a minimum grain size of 0.3 mm was mixed and formed such that the concentration of the diamond abrasive grains became 1.4 (ct/cm^3). The tungsten-based bond was prepared such that the Rockwell hardness of the bond portion after firing became HRA70.

[0085] Further, the diamond grinding stone 2 was formed to have such a shape that, as compared with the diamond grinding stone 2 shown in Example 1, the thickness was decreased by 30%, and the length was reduced by 20%, and that the area of the blade-portion tip-end surface (e) was 15.1. 42 pieces of the diamond grinding stones were welded to a circular base plate 1 having a thickness of 2.0 mm to complete a diamond saw blade D2.

[0086] The circumferential length calculated from the maximum outer diameter (c: 307 mm) is 964 mm (= 307 mm x 3.14). The area obtained through multiplication of the circumferential length (964 mm) by the maximum thickness (t: 2.0 mm) of the circular base plate 1 is 1928 mm^2.

[0087] The ratio of the sum total (15.1 mm^2 x 42 = 634 mm^2) of the areas of the blade-portion tip-end surfaces (e) to the above-described area value 1928 mm^2 was 0.33.

[0088] Further, the ratio of the actual area (e: 15.1 mm^2) of the end surface of the diamond grinding stone to the virtual area (z: 33.6 mm^2) obtained through multiplication of the maximum thickness of the diamond grinding stone by the outer circumferential length of the diamond grinding stone was 0.45.

[0089] Similar to Example 1, the diamond saw blade D2 manufactured in the above-described manner was subjected to a concrete cutting test. As a result, it was confirmed that cutting operation can be performed at a high cutting speed of 1200 mm/min and that cutting operation can be performed over a distance of 100 m before the diamond saw blade D2 reaches the end of the service life.

(Example 3)

[0090] In the present example, the pre-form for the diamond grinding stone layer was formed through a process in which tungsten-based bond and diamond abrasive grains having a minimum grain size of 0.3 mm was mixed and formed such that the concentration of the diamond abrasive grains became 1.0 (ct/cm^3). The tungsten-based bond was prepared such that the Rockwell hardness of the bond portion after firing became HRA65.

[0091] Further, as shown in FIG. 6, the diamond grinding stone 2 was formed such that the height (b) was 11.0 mm; the apparent minimum thickness (s) was 2.0 mm; the maximum thickness (w) was 3.2; and the area of the blade-portion tip end surface (e) was 90.2 mm^2. 21 pieces of the diamond grinding stones were welded to a circular base plate 1 having a thickness t of 2.2 mm to complete a diamond saw blade D3.

[0092] The circumferential length calculated from the maximum outer diameter (c: 308 mm) is 968 mm (= 308 mm x 3.14). The area obtained through multiplication of the circumferential length (968 mm) by the maximum thickness (t: 2.2 mm) of the circular base plate 1 is 2129 mm^2.

[0093] The ratio of the sum total (90.2 mm^2 x 21 = 1894 mm^2) of the areas of the blade-portion tip-end surfaces (e) to the above-described area value 2129 mm^2 was 0.89.

[0094] Further, the ratio of the actual area (e: 90.2 mm^2) of the end surface of the diamond grinding stone to the virtual area (z: 129.6 mm^2) obtained through multiplication of the maximum thickness of the diamond grinding stone by the outer circumferential length of the diamond grinding stone was 0.70.

[0095] Similar to Example 1, the diamond saw blade D3 manufactured in the above-described manner was subjected to a concrete cutting test. As a result, it was confirmed that cutting operation can be performed at a

high cutting speed of 1100 mm/min and that cutting operation can be performed over a distance of 320 m before the diamond saw blade D3 reaches the end of the service life.

[0096] Further, a cutting test was similarly performed by use of a cast-iron pipe (called "ductile cast-iron pipe 80A", the inner surface being lined with mortar, outer diameter: 93 mm). The test result indicated that cutting could be performed at high speed so that each cutting operation was completed within 24 seconds (average).

(Comparative Example 1)

[0097] As shown in FIG. 7, a diamond saw blade D4 of the present example includes a plurality of diamond grinding stones 2 disposed along the peripheral edge of a circular base plate 1.

[0098] The circular base plate 1 of the present comparative example includes key-shaped slits 3, and has a maximum outer diameter (c) of 307 mm and a maximum thickness (t) of 2 mm.

[0099] As shown in FIGS. 7 and 8, the diamond grinding stone 2 of the present comparative example was formed in a parallelopiped, and the area of the blade-portion tip end surface (e) was 103 mm^2.

[0100] 21 pieces of the diamond grinding stones 2 are attached to the attachment portions 4 of the circular base plate 1, each attachment portion 4 being located between the corresponding slits 3.

[0101] The circular base plate 1 and the diamond grinding stones 2 are formed to have sizes represented by the above-mentioned values. Therefore, the circumferential length calculated from the maximum outer diameter (c: 307 mm) of the diamond saw blade D4 is 964 mm (= 307 mm x 3.14). The area obtained through multiplication of the circumferential length (964 mm) by the maximum thickness (t: 2 mm) of the circular base plate 1 is 1928 mm^2.

[0102] The ratio of the sum total (103 mm^2 x 21 = 2163 mm^2) of the areas of the blade-portion tip-end surfaces (e) to the above-described area value 1928 mm^2 was 1.12.

[0103] Further, the ratio of the actual area (e: 103.0 mm^2) of the end surface of the diamond grinding stone to the virtual area (z: 103.0 mm^2) obtained through multiplication of the maximum thickness of the diamond grinding stone by the outer circumferential length of the diamond grinding stone is 1.00.

[0104] Similar to Example 1, the diamond saw blade D4 manufactured in the above-described manner was subjected to a concrete cutting test. The test result indicated that although wear of the diamond grinding stones 2 hardly proceeded, the cutting performance decreased gradually, so that dressing was necessary to perform whenever the concrete plate was cut over 10 m, and that the average cutting speed before performance of the dressing was 650 mm/min.

[0105] Further, as in Example 3, a cutting test was performed by use of a cast-iron pipe (called "ductile cast-iron pipe 80A", the inner surface being lined with mortar, outer diameter: 93 mm). The test result indicated that each cutting operation required 36 seconds (average).

(Comparative Example 2)

[0106] A diamond saw blade D5 of the present comparative example includes a plurality of diamond grinding stones 2 disposed along the peripheral edge of a circular base plate 1.

[0107] The circular base plate 1 of the present comparative example has the same shape as that in Example 1 and includes alternatively formed key-shaped and U-shaped slits 3, and has an outer diameter (a) of 291 mm and a maximum thickness (t) of 2 mm.

[0108] As in Example 1, each of the diamond grinding stones 2 of the present comparative example is formed such that the height (b) (length from a joint portion at which the diamond grinding stone 2 is boned to the circular base plate 1 to the blade end portion) was 8.0 mm; the apparent minimum thickness (s) was 1.6 mm; the maximum thickness (w) was 2.8; and the area of the blade-portion tip end surface (e) was 27 mm^2. 42 pieces of the diamond grinding stones 2 are attached to the attachment portions 4 of the circular base plate 1, each attachment portion 4 being located between the corresponding slits 3.

[0109] In the present comparative example, the bond of the diamond grinding stones 2 was prepared such that the Rockwell hardness after firing became HRA57.

[0110] The diamond saw blade D5 of the present comparative example was used for a cutting test performed under the same conditions as those employed in Example 1. Wear of the diamond grinding stones proceeded considerably, self-sharpening action occurred actively, and many abrasive grains dropped off. The average cutting speed was 910 mm/min, and the cutting distance before the diamond saw blade D5 reached the end of service life was 75 m.

(Comparative Example 3)

[0111] A diamond saw blade D6 of the present comparative example includes a plurality of diamond grinding stones 2 disposed along the peripheral edge of a circular base plate 1.

[0112] The circular base plate 1 of the present comparative example has the same shape as that in Example 1 and includes alternatively formed key-shaped and U-shaped slits 3, and has an outer diameter (a) of 291 mm and a maximum thickness (t) of 2 mm.

[0113] As in Example 1, 42 pieces of the diamond grinding stones 2 are attached to the attachment portions 4 of the circular base plate 1, each attachment portion 4 being located between the corresponding slits 3. However, as sown in FIG. 9, the diamond grinding

stones 2 were formed such that the apparent minimum thickness (s) (i.e., the minimum thickness (s) in the direction of the maximum thickness w) was 0.8 mm.

[0114] The diamond grinding stones 2 of the present comparative example include diamond abrasive grains of 40/50 mesh, which have the same grain size as that employed in Example 1. Therefore, the apparent minimum thickness (s) of the diamond grinding stones 2 of the present comparative example becomes about 2.7 times that of the diamond abrasive grains.

[0115] The diamond saw blade D6 of the present comparative example was used for a cutting test performed under the same conditions as those employed in Example 1. The probability of diamond abrasive grains existing at the end portions of the side surfaces of the grinding stone became extremely high, so that the high cutting performance was lost due to dropping off of the diamond abrasive grains at the end portions in an early stage. Further, wear of the diamond grinding stones 2 proceeded considerably, and the service life was shortened. The average cutting speed was 900 mm/min, and the cutting distance before the blade reached the end of service life was 40 m.

(Comparative Example 4)

[0116] A diamond saw blade D7 of the present comparative example includes a plurality of diamond grinding stones 2 disposed along the peripheral edge of a circular base plate 1. The circular base plate 1 of the present comparative example has the same shape as that used in Comparative Example 1 except that the maximum thickness (t) is 1.8 mm.

[0117] The diamond grinding stone 2 of the present comparative example has a parallelopipedonal shape as in Comparative Example 1, the thickness (w) is 2.5 mm, and the area of the blade-portion tip end surface (e) is 95 mm^2. As in Comparative Example 1, 21 pieces of the diamond grinding stones are attached to the attachment portions of the circular base plate 1, each attachment portion being located between the corresponding slits.

[0118] The circumferential length calculated from the maximum outer diameter (c: 307 mm) of the diamond saw blade D7 is 964 mm (= 307 mm x 3.14). The area obtained through multiplication of the circumferential length by the maximum thickness (t: 1.8 mm) of the circular base plate 1 is 1736 mm^2.

[0119] The ratio of the sum total (95 mm^2 x 21 = 1995 mm^2) of the areas of the blade-portion tip-end surfaces (e) to the above-described area value 1736 mm^2 was 1.15.

[0120] Further, the ratio of the actual area (e: 95.0 mm^2) of the end surface of the diamond grinding stone to the virtual area (z: 95.0 mm^2) obtained through multiplication of the maximum thickness of the diamond grinding stone by the outer circumferential length of the diamond grinding stone is 1.00.

[0121] In the present comparative example, the preform for the diamond grinding stone layer was formed through a process in which tungsten-based bond and diamond abrasive grains having a minimum grain size of 0.3 mm was mixed and formed such that the concentration of the diamond abrasive grains after firing became 0.6 (ct/cm^3). The tungsten-based bond was prepared such that the Rockwell hardness of the bond portion after firing became HRA58.

[0122] As in Example 1, the diamond saw blade D3 manufactured in the above-described manner was used for a concrete cutting test. The average cutting speed was 640 mm/min, and the cutting distance before the diamond saw blade D7 reached the end of service life was 50 m.

[0123] Further, as in Example 3, a cutting test was performed by use of a cast-iron pipe (called "ductile cast-iron pipe 80A", the inner surface being lined with mortar, outer diameter: 93 mm). The test result indicated that each cutting operation required 45 seconds (average).

INDUSTRIAL APPLICABILITY

[0124] The diamond saw blade of the present invention requires that the ratio of the total area of the end surfaces of the diamond grinding stones to the surface area value of a disk having a circumference corresponding to a circle having a diameter equal to the outer diameter of the diamond saw blade and a thickness corresponding to the maximum thickness of the circular base plate becomes not less than 0.3 but not greater than 1.0. Through satisfaction of the requirement, the diamond saw blade can maintain an excellent cutting performance and realize a long tool life, when the diamond saw blade is used for dry grinding or cutting of hard and brittle materials such as concrete and stone.

[0125] Accordingly, burdensome work for selectively using a different type of a diamond saw blade in accordance with an intended work and conditions can be eliminated. Further, since dry machining is possible, a good work environment can be maintained.

Claims

1. A diamond saw blade in which diamond grinding stones are attached to the peripheral edge of a circular base plate,
characterized in that
when a first value obtained through multiplication of the circumferential length of a circle having a diameter equal to the maximum outer diameter of the diamond saw blade by the maximum thickness of the circular base plate is compared with a second value which is the total area of end surfaces of the diamond grinding stones,
the ratio of the second value to the first value

is not less than 0.3 but not greater than 1.0.

2. A diamond saw blade according to claim 1, characterized in that

the diamond grinding stones are arranged along the peripheral edge of the circular base plate at an interval less than 3.0 mm; and

when the first value obtained through multiplication of the circumferential length of a circle having a diameter equal to the maximum outer diameter of the diamond saw blade by the maximum thickness of the circular base plate is compared with the second value which is the total area of end surfaces of the diamond grinding stones,

the ratio of the second value to the first value is not less than 0.3 but not greater than 0.8.

3. A diamond saw blade according to claim 1, characterized in that

the diamond grinding stones are arranged along the peripheral edge of the circular base plate at an interval not less than 3.0 mm but less than 15.0 mm; and

when the first value obtained through multiplication of the circumferential length of a circle having a diameter equal to the maximum outer diameter of the diamond saw blade by the maximum thickness of the circular base plate is compared with the second value which is the total area of end surfaces of the diamond grinding stones,

the ratio of the second value to the first value is not less than 0.4 but not greater than 0.9.

4. A diamond saw blade according to claim 1, characterized in that each of the diamond grinding stone includes diamond abrasive grains bonded together by use of bond, and the bond has a Rockwell hardness not less than HRA 60 but not greater than HRA80.

5. A diamond saw blade according to claim 1, characterized in that the thickness of the diamond grinding stone is not less than 3 times the minimum grain size of diamond abrasive grains contained in the diamond grinding stone.

6. A diamond saw blade according to claim 1, characterized in that the concentration of the diamond abrasive grains in the diamond grinding stone with respect to the bond is not less than 0.6 (ct/cm^3) but not greater than 1.4 (ct/cm^3).

7. A diamond saw blade according to claim 1, characterized in that the area of the blade-portion end surface of the diamond grinding stone is an area of a cross section which is obtained by extending the diamond grinding stone toward the peripheral direction of the circular base plate, and cutting the diamond grinding stone along a plane perpendicular to the circular base plate.

8. A diamond saw blade according to claim 1, characterized in that the diamond grinding stone has a shape such that at least of a portion of a surface parallel to the circular base plate is removed.

9. A diamond saw blade in which a diamond grinding stone is attached to the peripheral edge of a circular base plate, characterized in that

when a value obtained through multiplication of the maximum thickness of the diamond grinding stone by the circumferential length of the diamond grinding stone is compared with the area of the blade-portion end surface of the diamond grinding stone,

the ratio of the area of the blade-portion end surface of the diamond grinding stone to the value obtained through multiplication of the maximum thickness of the diamond grinding stone by the circumferential length of the diamond grinding stone is not less than 0.3 but not greater than 0.8.

10. A diamond saw blade according to claim 9, characterized in that the diamond grinding stone includes diamond abrasive grains bonded together by use of bond, and the bond preferably has a Rockwell hardness not less than HRA 60 but not greater than HRA80.

11. A diamond saw blade according to claim 9, characterized in that the thickness of the diamond grinding stone is not less than 3 times the minimum grain size of diamond abrasive grains contained in the diamond grinding stone.

12. A diamond saw blade according to claim 9, characterized in that the concentration of the diamond abrasive grains in the diamond grinding stone with respect to the bond is not less than 0.6 (ct/cm^3) but not greater than 1.4 (ct/cm^3).

13. A diamond saw blade according to claim 9, characterized in that the area of the blade-portion end surface of the diamond grinding stone is an area of a cross section which is obtained by extending the diamond grinding stone toward the peripheral direction of the circular base plate, and cutting the diamond grinding stone along a plane perpendicular to the circular base plate.

14. A diamond saw blade according to claim 9, characterized in that the diamond grinding stone has a shape such that at least of a portion of a surface parallel to the circular base plate is removed.

Fig. 1

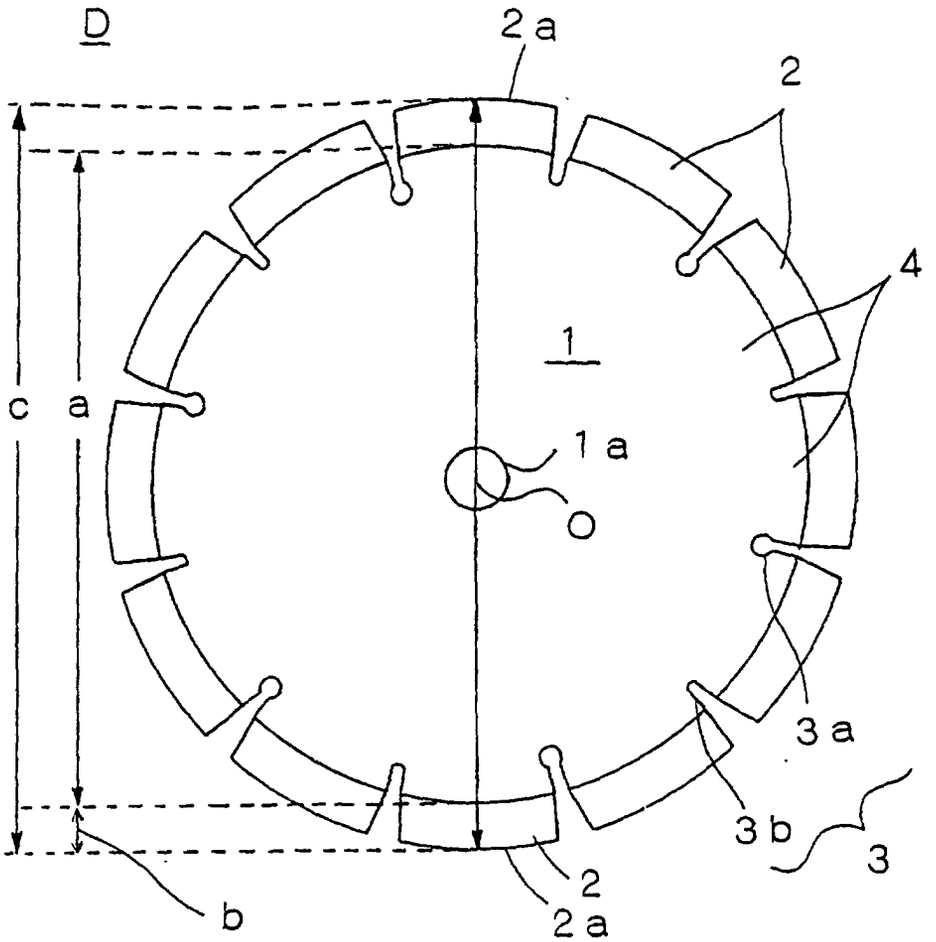


Fig. 2

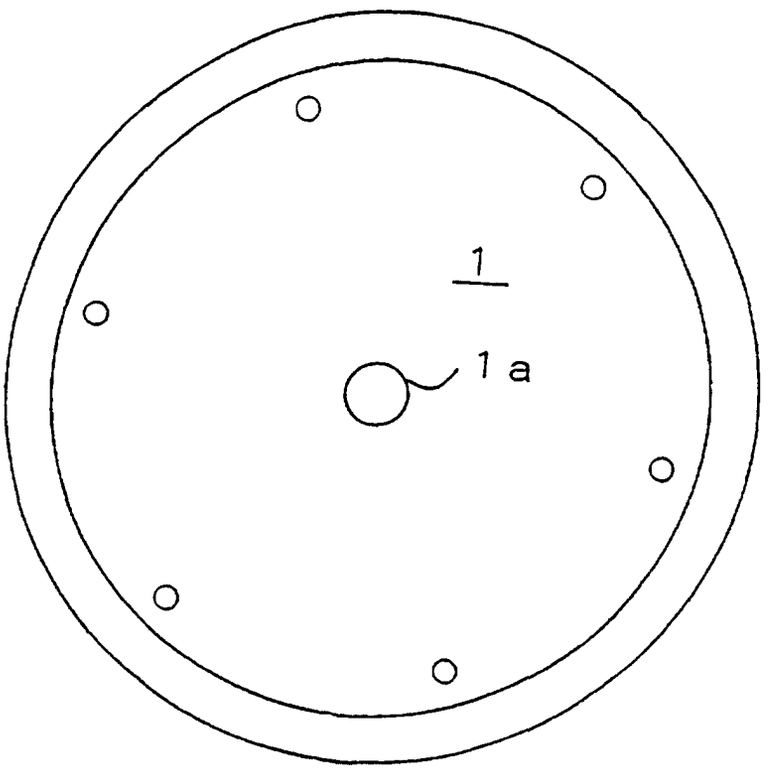


Fig. 3

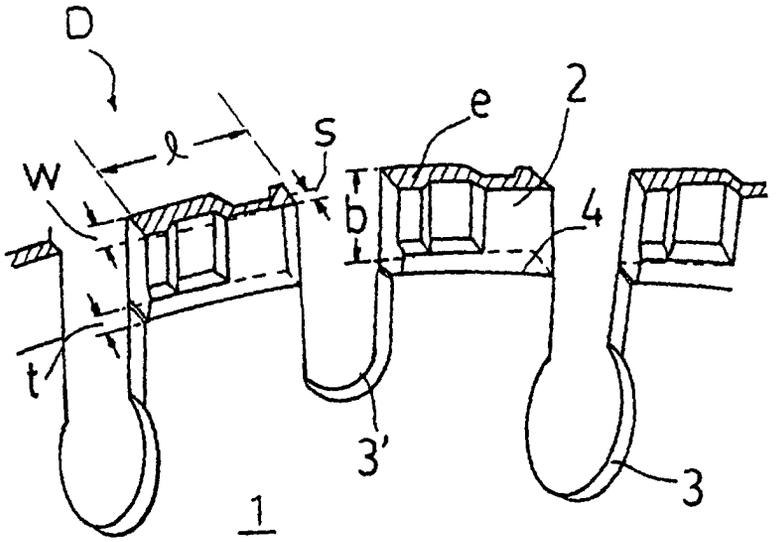


Fig. 4

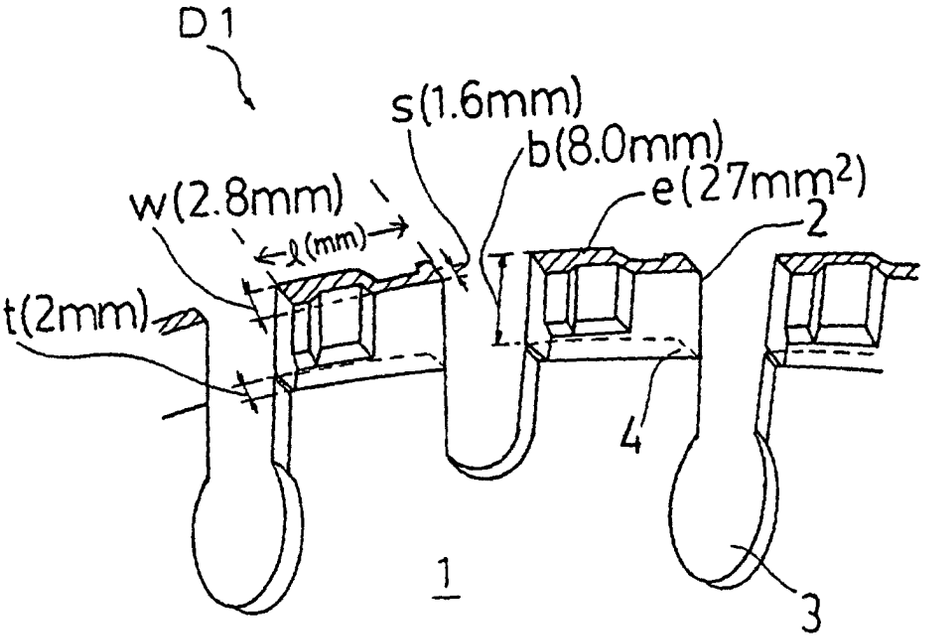


Fig.5

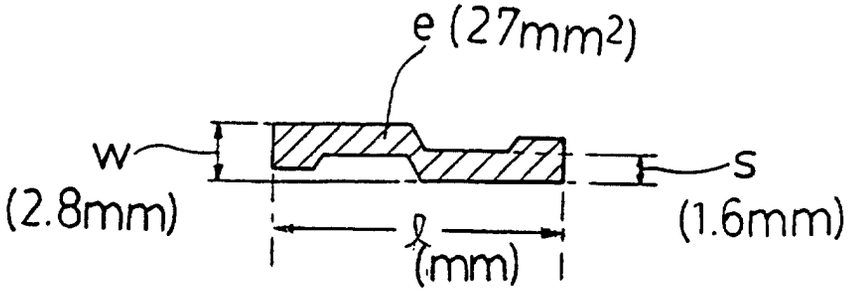


Fig. 6

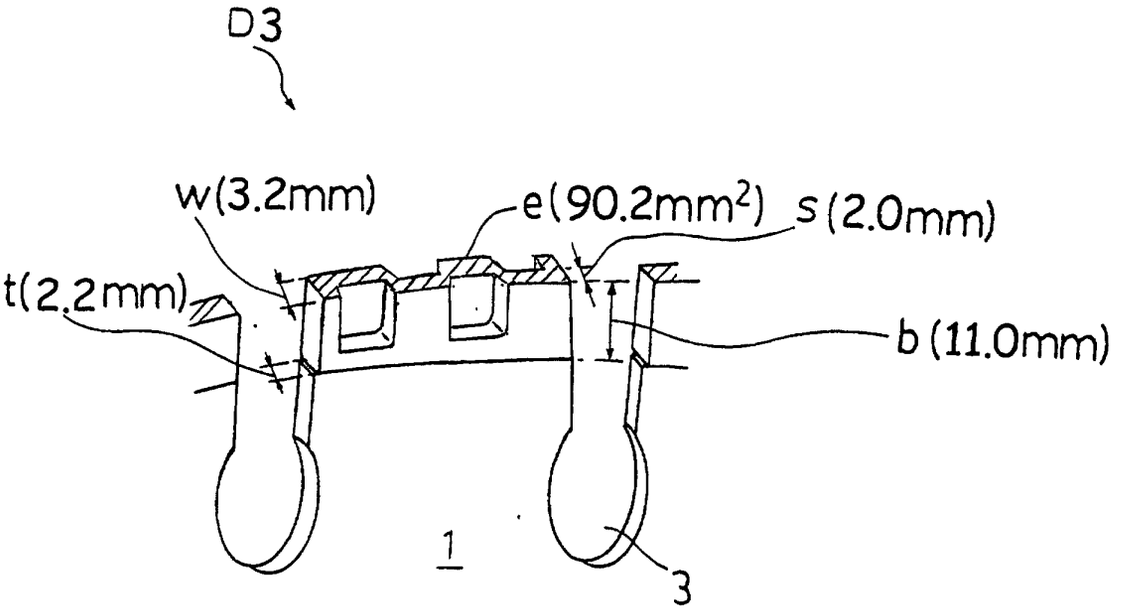


Fig. 7

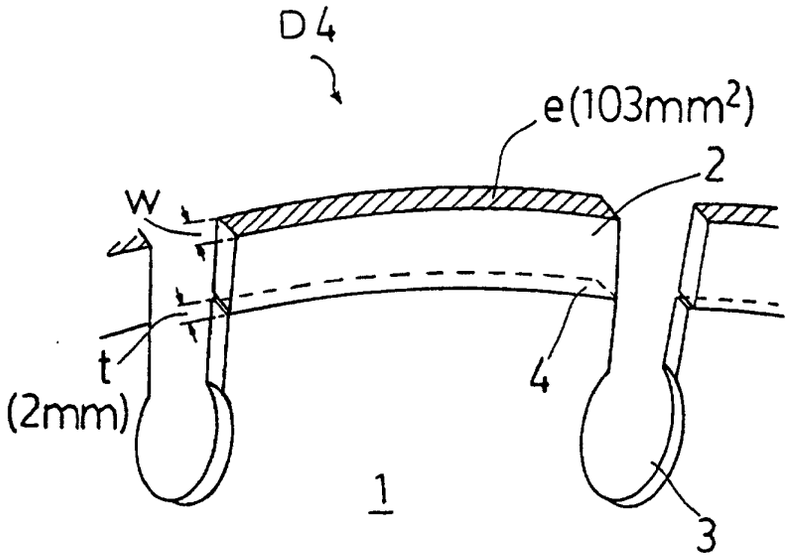


Fig. 8

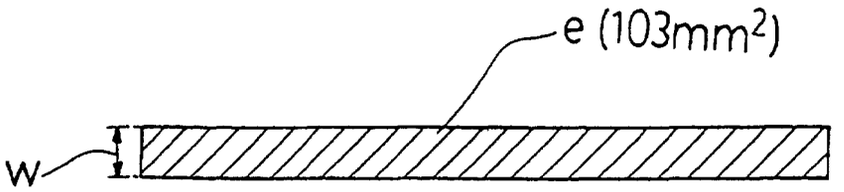
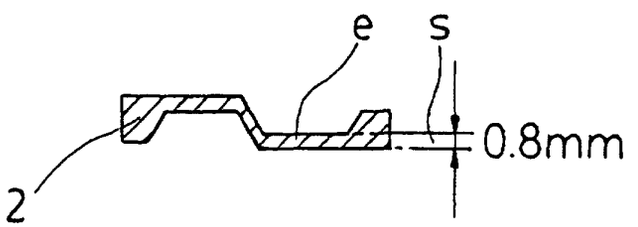


Fig. 9



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/01061

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] B24D5/12, B24D3/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] B24D5/12, B24D3/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1920-2000 Jitsuyo Shinan Toroku Koho 1996-1996
Kokai Jitsuyo Shinan Koho 1971-2000 Toroku Jitsuyo Shinan Koho 1994-2000

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB, 2281075, A (Hiroshi HASHIMOTO), 22 February, 1995 (22.02.95), page 4, line 13 to page 8, line 7; Fig. 1 & JP, 7-52051, A page 2, Column 2, line 11 to page 3, Column 3, line 13; Fig. 1 & DE, 4429920, A	1-14
Y	CD-ROM of Japanese Utility Model Application No. 64527/1993 (Laid-open No. 31266/1995) (Kabushiki Kaisha Akashiroi Kogyo), 13.June.1995(13.06.95), page 4, lines 10 to 19; Fig. 1 (Family: none)	1-14
Y	JP, 9-272857, A (DENKI KAGAKU KOGYO KABUSHIKI KAISHA), 21 October, 1997 (21.10.97), page 3, Column 3, line 10 to Column 4, line 8; Fig. 1 (Family: none)	4,10
Y	JP, 8-309664, A (Matsushita Electric Ind. Co., Ltd.), 26 November, 1996 (26.11.96), page 2, Column 2, lines 34 to 44; Fig. 6 (Family: none)	6,12

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
02 May, 2000 (02.05.00)	16.05.00
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/01061

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of Japanese Utility Model Application No. 22665/1990 (Laid-open No. 113757/1991) (Kabushiki Kaisha Sankyo Daiyamond Kogyo), 21.November.1991(21.11.91), claims of utility model; Fig. 3 (Family: none)	8,14

Form PCT/ISA/210 (continuation of second sheet) (July 1992)