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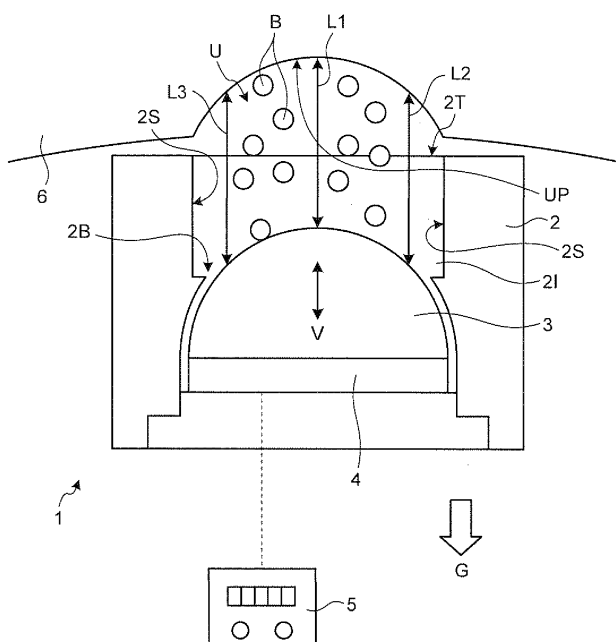
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(54) **SHOT PEENING DEVICE AND OSCILLATOR FOR SHOT PEENING**

(57) A shot peening apparatus 1 includes a storage container 2 that stores therein shots B for shot peening. The storage container 2 moves toward a shot-peening treated region U and shot-peens a treated region surface UP. The shot peening apparatus 1 includes an oscillator

3. An oscillating unit 4 is mounted to the oscillator 3, in order to impart kinetic energy to the shots B stored in a container inside 2I. The outer shape of the oscillator 3 is formed in a shape matching the shape of a treated region surface UP of the treated region U.

FIG.1



Description

TECHNICAL FIELD

[0001] The present invention relates to shot peening.

BACKGROUND ART

[0002] Shot peening is a type of cold working, and makes shots, which are metal or non-metal balls, impact on a metal surface at a high speed to generate compressive stress on the metal surface to improve fatigue strength thereof against repeated loads. For example, to improve fatigue strength of a welded joint in a pressure vessel of a chemical plant or a reactor vessel, shot peening is applied thereto. Patent Document 1 discloses an ultrasonic shot peening apparatus that shot-peens a J-weld between a bottom surface of a reactor vessel head and a nozzle stub, and surfaces near the J-weld. Patent Document 2 discloses a tip tool guide apparatus that is brought into a water chamber of a steam generator of nuclear power generation equipment, and guides a tip tool, such as a shot peening head, along a necessary region.

[0003]

[Patent Document 1] Japanese Patent Application Laid-open No. 2006-346775 (0015, Fig. 2, Fig. 3)

[Patent Document 2] Japanese Patent Application Laid-open No. 2007-181909

DISCLOSURE OF INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0004] In the technology disclosed in Patent Document 1, a planar oscillator is used to accelerate shots. When the shape of a treated region is flat or almost flat, a distance between the surface of the oscillator and the surface of the treated region is substantially constant. Therefore, the number of times the shots impact on the surface of the treated region per unit of time is substantially constant regardless of positions on the surface of the treated region.

[0005] When a treated region is a concave portion or a convex portion, however, the distance between the surface of the oscillator and the surface of the treated region differs depending on the position on the surface of the treated region. Therefore, the number of times the shots impact on the surface of the treated region per unit of time is dependent on the positions on the surface of the treated region. Accordingly, unevenness of shot peening may occur.

[0006] In particular, when the treated region that is a concave portion is positioned in the direction that gravity works, the distance between the surface of the oscillator and the surface of the treated region differs depending on the position on the surface of the treated region. As

a result, the shots bouncing off the surface of the treated region fail to reach the oscillator, therefore, shot peening may not be continuously performed.

[0007] The present invention is made in consideration of the above, and an object of the present invention is to realize at least one of: suppressing unevenness of shot peening, and performing shot peening without fail regardless of the shape of a treated region.

10 MEANS FOR SOLVING PROBLEM

[0008] According to an aspect of the present invention, a shot peening apparatus includes: a kinetic energy imparting unit that imparts kinetic energy to shots; and an oscillator that is formed in a shape matching a shape of a shot-peening treated region, that is directly or indirectly provided with the kinetic energy imparting unit, and that transfers oscillation of the kinetic energy imparting unit to the shots.

[0009] According to another aspect of the present invention, an oscillator for shot peening is formed in a shape matching a shape of a shot-peening treated region, is directly or indirectly provided with a kinetic energy imparting unit imparting kinetic energy to shots, and transfers oscillation of the kinetic energy imparting unit to the shots.

[0010] Thus, even when the treated region is a concave portion or a convex portion, the distance between the surface of the oscillator and the surface of the treated region can be constant regardless of the position on the surface of the treated region. Therefore, the number of times the shots impact on the surface of the treated region per unit of time is substantially constant regardless of the position on the surface of the treated region. As a result, unevenness of the shot peening treatment can be suppressed. Also, in this shot peening apparatus, the distance between the surface of the oscillator and the surface of the treated region is set so that the shots return to the oscillator against gravity. Thus, shots bouncing off the surface of the treated region can reach the oscillator without fail, although the treated region includes a concave portion in the direction of gravitational force. Shot peening can be thus applied continuously without fail.

[0011] Advantageously, in the shot peening apparatus, the oscillator is formed in a convex shape or a concave shape. Also, advantageously, in the shot peening apparatus, a surface of the oscillator is formed to have a curved surface.

[0012] When a shot-peening treated region is in a convex shape or a concave shape, a problem is likely to arise in that the distance between the surface of an oscillator and the surface of the treated region is different depending on the position on the surface of the treated region. In many cases, the surface is a curved surface when the treated region is a convex portion or a concave portion. By forming the shape of the oscillator in a convex shape or a concave shape having a curved surface thereon, the oscillator can be applied for general purposes.

EFFECT OF THE INVENTION

[0013] The present invention can realize at least one of suppressing shot peening unevenness and performing shot peening without fail regardless of the shape of a treated region.

BRIEF DESCRIPTION OF DRAWINGS

[0014]

[Fig. 1] Fig. 1 is a schematic of an entire structure of a shot peening apparatus according to an embodiment of the present invention.

[Fig. 2] Fig. 2 is a perspective view illustrating the shape of an oscillator included in the shot peening apparatus illustrated in Fig. 1.

[Fig. 3] Fig. 3 is a schematic of an entire structure of a shot peening apparatus using a planar oscillator.

[Fig. 4] Fig. 4 is an exemplary schematic of shot peening using the shot peening apparatus according to the embodiment, when a treated region is positioned in the direction that gravity works.

[Fig. 5] Fig. 5 is a schematic of an entire structure of a shot peening apparatus according to a first modification of the embodiment.

[Fig. 6] Fig. 6 is a schematic of an entire structure of a shot peening apparatus according to a second modification of the embodiment.

[Fig. 7] Fig. 7 is an enlarged schematic of an oscillator included in the shot peening apparatus according to the second modification of the embodiment.

EXPLANATIONS OF LETTERS OR NUMERALS

[0015]

- 1, 1a shot peening apparatus
- 2 storage container
- 21 container inside
- 6 metallic structure
- B shots

BEST MODE(S) FOR CARRYING OUT THE INVENTION

[0016] The present invention will now be explained in detail with reference to the attached drawings. The best mode(s) for carrying out the invention (hereinafter, embodiments) are not intended to limit the scope of the present invention in any way. Structural elements disclosed in the embodiments below include those that can be easily imagined by those in the art, those that are substantially the same, and those in the scope of so-called equivalents.

[0017] The present invention is suitable for shot-peening a surface having a concave or a convex portion.

[0018] The present invention is not limited to shot

peening of a weld. Moreover, the present invention can be generally applied to anything that requires shot peening, such as an internal or an outer surface of a nozzle stub located at an inlet or an outlet of a steam generator, a pipe for a fluid, or a pressure vessel used in a power generating facility; and applications of the present invention is not especially limited as well.

[0019] One of the features of the present embodiment is to make the outer shape of an oscillator match the shape of the surface of a shot-peening treated region. On the oscillator, a kinetic energy imparting unit that imparts kinetic energy to shots is directly or indirectly mounted, and the oscillator transfers motions of the kinetic energy imparting unit to the shots. A shot peening apparatus according to the present embodiment will now be explained.

[0020] Fig. 1 is a schematic of an entire structure of the shot peening apparatus according to the present embodiment. Fig. 2 is a perspective view illustrating the shape of an oscillator included in the shot peening apparatus illustrated in Fig. 1. This shot peening apparatus 1 includes a storage container 2 that stores therein shots B to be used for shot peening. The storage container 2 moves toward a shot-peening treated region U and performs shot peening to the surface (treated region surface) UP of the treated region U. In the present embodiment, shot peening is performed on a metallic structure 6, such as a nozzle stub located at an inlet or an outlet of a steam generator in a reactor vessel.

[0021] The storage container 2 is a container with a bottom, and has a container opening 2T that is an opening that faces the treated region U. A part of the storage container 2 that lies opposite to the container opening 2T is a bottom 2B of the storage container 2. A space surrounded by the bottom 2B of the storage container 2 and an inner side wall 2S of the storage container 2 is an inside (container inside) 2I of the storage container 2, and stores therein the shots B for use in shot peening. Steel balls, non-ferrous metal balls, and nonmetallic balls such as ceramic balls, are used as the shots B, and an appropriate type of the shots B is used depending on a material or a usage condition of the treated region U. Upon performing shot peening, the distance between the treated region U and the container opening 2T of the storage container 2 is set so that the shots B do not leak out between the treated region U and the storage container 2.

[0022] On the bottom 2B, the kinetic energy imparting unit that accelerates the shots B to impart thereto energy required for shot peening is provided. In the present embodiment, the kinetic energy imparting unit includes an oscillating unit 4 and an oscillator for shot peening (hereinafter, an oscillator) 3. The oscillating unit 4 oscillates at a certain frequency and at certain amplitude to accelerate the shots B, and uses a piezoelectric element, for example, a piezoelectric element. The oscillator 3 transfers oscillation of the oscillating unit 4 to the shots B. The oscillating unit 4 is mounted on the oscillator 3 directly or

indirectly. In the present embodiment, the oscillating unit 4 is directly mounted on the oscillator 3. However, the oscillating unit 4 can be mounted indirectly to the oscillator 3, for example, with an oscillation transfer member interposed therebetween.

[0023] An oscillating unit controller 5 is connected to the oscillating unit 4, in order to give the oscillating unit electronic signals at a certain frequency and make the oscillating unit oscillate at a certain frequency cycle. The oscillation controller 5 drives the oscillating unit 4 of the kinetic energy imparting unit at a certain frequency cycle (for example, frequency in the ultrasonic range). Accordingly, the oscillator 3 that comes into contact with the shots B oscillates at a certain frequency cycle in the direction parallel to the direction from the oscillator 3 to the container opening 2T (indicated by an arrow V in Fig. 1), and the shots B are accelerated toward the container opening 2T.

[0024] Accordingly, the shots B are shot toward the container opening 2T, shot onto the treated region surface UP of the treated region U, thereby applying compressive stress to the treated region surface UP. The shot peening apparatus 1 performs shot peening on the treated region U with ultrasonic shot peening. In terms of strict performance management, ultrasonic shot peening is preferably used in the present embodiment, while shot peening is not limited to ultrasonic shot peening.

[0025] As illustrated in Fig. 1, the outer shape of the oscillator 3 is formed to match the surface shape of the treated region U, that is, the treated region surface UP of the treated region U. In the present embodiment, the treated region U is a concave portion prepared by removing a hemisphere portion from the surface of the metallic structure 6. The shape of the treated region surface UP is, therefore, hemispherical concave. At least a part of the outer shape of the oscillator 3 is formed to match the treated region surface UP so that it is in a hemisphere shape as illustrated in Fig. 1 and Fig. 2. In the present embodiment, the shape of the treated region UP is transcribed to at least a part of the outer shape of the oscillator 3.

[0026] Therefore, the shot peening apparatus 1 can keep the distance between the surface of the oscillator 3 and the treated region surface UP (hereinafter, shots flight distance) substantially constant even if the treated region U is a concave portion, regardless of the position on the treated region U. In the example illustrated in Fig. 1, the shots flight distances L1, L2, and L3 from different positions on the oscillator 3 become substantially the same.

[0027] Fig. 3 is a schematic of an entire structure of a shot peening apparatus using a planar oscillator. This shot peening apparatus 101 illustrated in Fig. 3 includes a planar oscillator 103 on which a vibrator 104 is mounted. The oscillator 103 has a flat surface that comes into contact with shots B. The oscillator 103 oscillates at a certain frequency cycle toward the direction parallel to the direction from the oscillator 103 to a container open-

ing 102T (indicated by an arrow V direction in Fig. 3), and accelerates the shots B toward the container opening 102T.

[0028] When the treated region U is formed in a concave shape by hollowing the surface of the metallic structure 6, the distance between the surface of the oscillator 3 and the surface of the treated region UP (shots flight distance) differs depending on the position on the treated region UP as a result of performing shot peening with the shot peening apparatus 101 illustrated in Fig. 3. In the example illustrated in Fig. 3, a shots flight distance LA to the treated region U at the deepest portion is the greatest, and the shots flight distance LA becomes smaller as the treated region U becomes shallower. For example, shots flight distances LB and LC near the outer rim of the treated region U in a concave shape spherically hollowed are smaller than the shots flight distance LA to the treated region U at the deepest portion.

[0029] In shot peening, the number of times the shots B impact on the treated region surface UP per unit of time becomes smaller as the distance between the oscillator 3 and the treated region surface UP is greater under the same speed of the shots B. Because of this, shot peening unevenness occurs depending on the position on the treated region surface UP, therefore, some region remains unsatisfactorily treated. When the treated region is a concave portion or a convex portion, shots flight distances differ depending on the position on the surface of the treated region as a result of using the oscillator 103 having a flat surface coming into contact with the shots B, such as the shot peening apparatus 101 illustrated in Fig. 3. This may lead to excessive or unsatisfactory treatment, therefore, shot peening unevenness occurs.

[0030] In the present embodiment, the outer shape of the oscillator 3 (the shape of a portion with which shots B come into contact) included in the shot peening apparatus 1 is shaped to match the shape of the surface of the treated region U, that is, the treated region surface UP of the treated region U. The shots flight distances can be kept substantially constant regardless of the positions on the treated region surface UP, whereby unevenness of shot peening treatment can be suppressed. When the treated region U is a concave portion, as illustrated in Fig. 1, the outer shape of the oscillator 3 is shaped in a hemisphere to match the shape of the treated region surface UP. The shots flight distances can, therefore, be kept substantially constant regardless of the positions on the treated region surface UP, whereby unevenness of shot peening treatment can be suppressed.

[0031] Fig. 4 is an exemplary schematic of shot peening using the shot peening apparatus according to the present embodiment, when a treated region is positioned in the direction that gravity works. As illustrated in Fig. 4, when a concave portion, that is, the treated region U formed on the metallic structure 6 is on a gravity working direction G side, the surface of the oscillator 3 that comes into contact with the shots B is placed toward the gravity working direction G. The oscillator 3 oscillates in an arrow

V direction. The shots B are accelerated toward the treated region U that is on the gravity working direction G side, and shot onto the treated region U.

[0032] The shots B shot onto the treated region U bounce off the treated region surface UP and return to the oscillator 3, are accelerated thereon by the oscillator 3, and shot again onto the treated region U. When the treated region U is on the gravity working direction G side, the shots B return to the oscillator 3 against gravity. Like in the shot peening apparatus 101 illustrated in Fig. 3, when using the oscillator 103 having a surface coming into contact with shots B that is flat, the shots flight distances differ depending on the position on the treated region surface UP of the treated region U that is a concave portion. Moreover, when the oscillator 103 is used, at some portions having large shots flight distances, the shots B bouncing off the treated region surface UP may fail to return to the oscillator 103. Therefore, shot peening cannot be performed.

[0033] In the present embodiment, when the treated region U is a concave portion, as illustrated in Fig. 4, the outer shape of the oscillator 3 is shaped in a hemisphere to match the shape of the treated region surface UP. Therefore, the shots flight distances can be constant regardless of the position on the treated region surface UP. In this case, the shots flight distances are set so that the shots B can reach the oscillator 3 against gravity when bouncing off the treated region surface UP. Therefore, the shots B can reach the oscillator 3 without fail regardless of the position on the treated region surface UP in the shot peening apparatus 1. Shot peening is thus performed without fail.

[0034] Fig. 5 is a schematic of an entire configuration of a shot peening apparatus according to a first modification of the present embodiment. The configuration of a shot peening apparatus 1a according to the modification is substantially the same as that of the shot peening apparatus 1 (see Fig. 1), but different in the outer shape of an oscillator 3a. Specifically, a portion of the oscillator 3a coming into contact with the shots B has a hemispherical concave shape. A hemispherical convex portion of the metallic structure 6 is a treated region U with the shot peening apparatus 1a. The outer shape of the oscillator 3a (a portion with which the shots B come into contact) included in the shot peening apparatus 1a matches the shape of the surface of treated region U, that is, the treated surface UP of the treated region U.

[0035] Shots flight distances L1, L2, and L3 at different positions on the treated region surface UP can be kept substantially constant, therefore, the unevenness of the shot peening treatment is suppressed. In the present modification, because the treated region U is a convex portion, as illustrated in Fig. 5, the outer shape of the oscillator 3a is hemispherical concave to match the shape of the treated region surface UP. Accordingly, the shots flight distances can be constant regardless of the positions on the treated region surface UP, thereby suppressing the unevenness of the shot peening treatment.

[0036] Fig. 6 is a schematic of an entire structure of a shot peening apparatus according to a second modification of the present embodiment. Fig. 7 is an enlarged schematic of an oscillator included in the shot peening apparatus according to the second modification of the present embodiment. This shot peening apparatus 1b according to the modification has a structure substantially the same as that of the shot peening apparatus 1 (see Fig. 1), but different in the outer shape of an oscillator 3b that is formed step-wise.

[0037] As illustrated in Fig. 6, the outer shape of the oscillator 3b (a portion with which the shots B come into contact) included in the shot peening apparatus 1b is formed step-wise, and matches the shape of the surface of the treated region U, that is, the treated region surface UP of the treated region U. In the present modification, the treated region U is a concave portion prepared by removing a hemisphere portion from the metallic structure 6. The shape of the treated region surface UP is, therefore, hemispherical concave. The outer shape of the oscillator 3b is formed step-wise and in a convex shape.

[0038] As illustrated in Fig. 7, the outer shape of the oscillator 3b according to the modification is in a step-wise shape, by piling up a plurality of planar board parts 3b1 to 3b6 having different areas in a descending order in their areas. In the modification, the board parts 3b1 to 3b2 are circular plates. Accordingly, the outer shape of the oscillator 3b is formed in a step-wise shape by piling up the board parts 3b1 to 3b6 that have different diameters from each other in a descending order in their diameters. The diameters of the board parts 3b1, 3b2, 3b3, 3b4, 3b5, and 3b6 are D1, D2, D3, D4, D5, and D6, respectively ($D1 > D2 > D3 > D4 > D5 > D6$). The board parts 3b1 to 3b6 can be made of individual members and integrated together to make the oscillator 3b, or all the board parts 3b1 to 3b6 are integrally constituted to make the oscillator 3b.

[0039] The oscillator 3b oscillates in an arrow V direction illustrated in Fig. 6. In the present embodiment, by forming the outer shape of the oscillator 3b in a step-wise shape, flat surfaces perpendicular to the oscillation direction (arrow V direction in Fig. 6) of the oscillator 3b are formed at step-wise portions. Amplitude of the oscillator 3b becomes the same at the flat surfaces, therefore, the shots B on the flat surfaces are accelerated by the same amount. Accordingly, unevenness of the kinetic energy of the shots B that impact on the treated region surface UP is suppressed, therefore, unevenness of the shot peening treatment can be suppressed.

[0040] In the present embodiment and its modifications, the outer shape of the oscillator that transfers motions of the kinetic energy imparting unit imparting kinetic energy to the shots matches the shape of the surface of the treated region. By doing so, even when the treated region is a concave portion or a convex portion, the distance between the surface of the oscillator and the surface of the treated region can be constant regardless of

the position on the surface of the treated region. Therefore, the number of times the shots impact on the surface of the treated region per unit of time is substantially constant regardless of the position on the surface of the treated region. As a result, unevenness of the shot peening treatment can be suppressed. 5

[0041] In the present embodiment and its modifications, the distance between the surface of the oscillator and the surface of the treated region is set so that the shots return to the oscillator against gravity. In the present embodiment, because the distance between the surface of the oscillator and the surface of the treated region is substantially constant regardless of the position on the surface of the treated region, even though the treated region includes a concave portion toward a direction of gravitational force, shots bouncing off the surface of the treated region can reach the oscillator without fail. Shot peening can be thus applied continuously without fail. 10 15

INDUSTRIAL APPLICABILITY 20

[0042] As described above, the shot peening apparatus according to the present invention is useful for shot peening treatment, more specifically, for shot-peening a treated region of a concave portion or a convex portion. 25

Claims

1. A shot peening apparatus comprising: 30
 - a kinetic energy imparting unit that imparts kinetic energy to shots; and
 - an oscillator that is formed in a shape matching a shape of a shot-peening treated region, that is directly or indirectly provided with the kinetic energy imparting unit, and that transfers oscillation of the kinetic energy imparting unit to the shots. 35
2. The shot peening apparatus according to claim 1, wherein the oscillator is formed in a convex shape or a concave shape. 40
3. The shot peening apparatus according to claim 2, wherein a surface of the oscillator is formed to have a curved surface. 45
4. An oscillator for shot peening, wherein the oscillator is formed in a shape matching a shape of a shot-peening treated region, is directly or indirectly provided with a kinetic energy imparting unit imparting kinetic energy to shots, and transfers oscillation of the kinetic energy imparting unit to the shots. 50 55

FIG.1

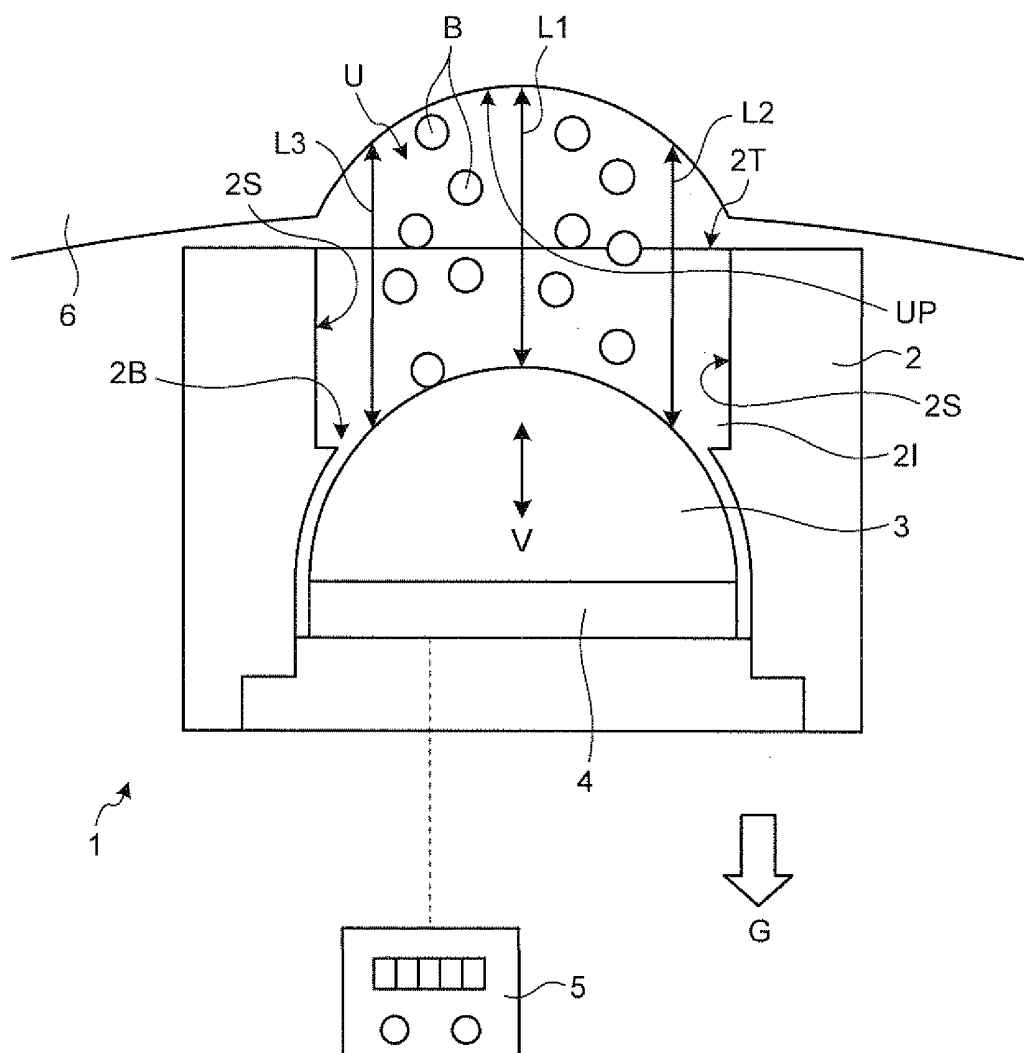


FIG.2

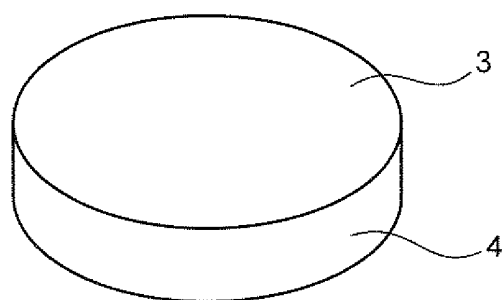


FIG.3

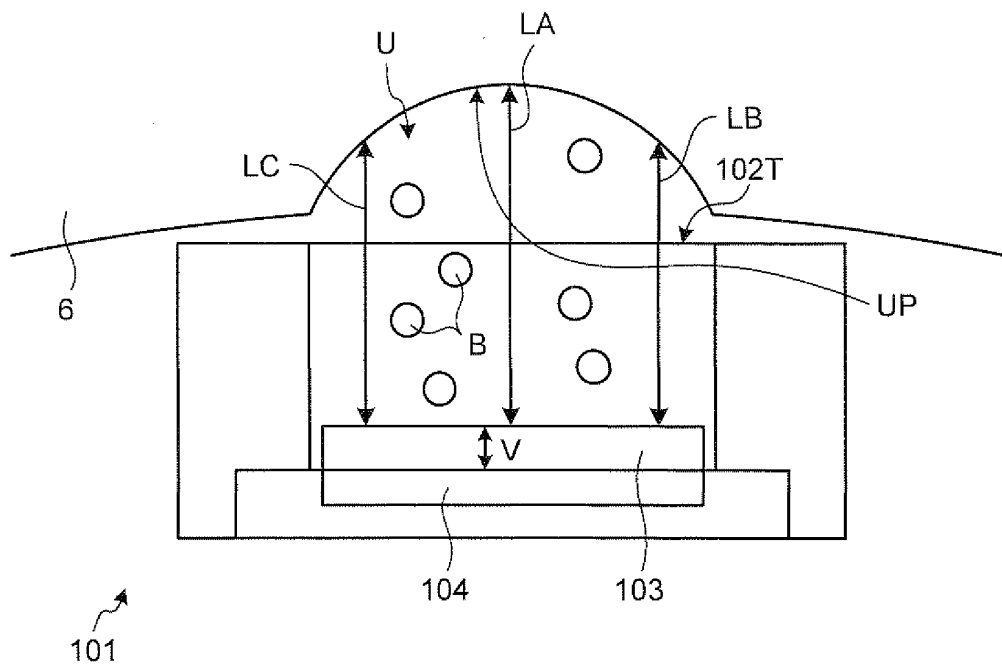


FIG.4

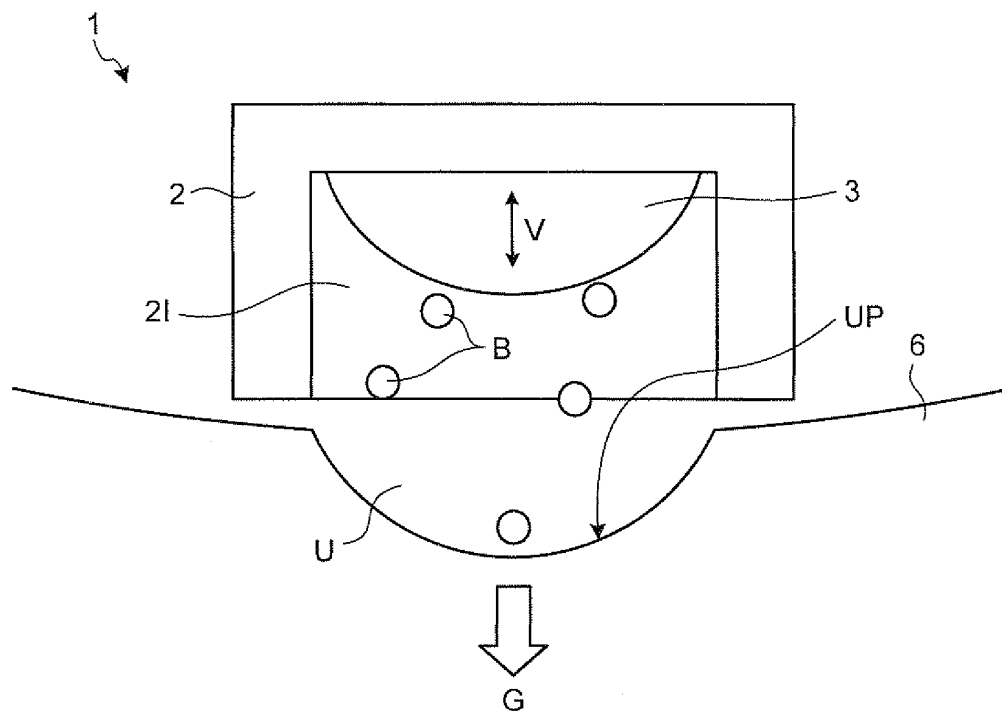


FIG.5

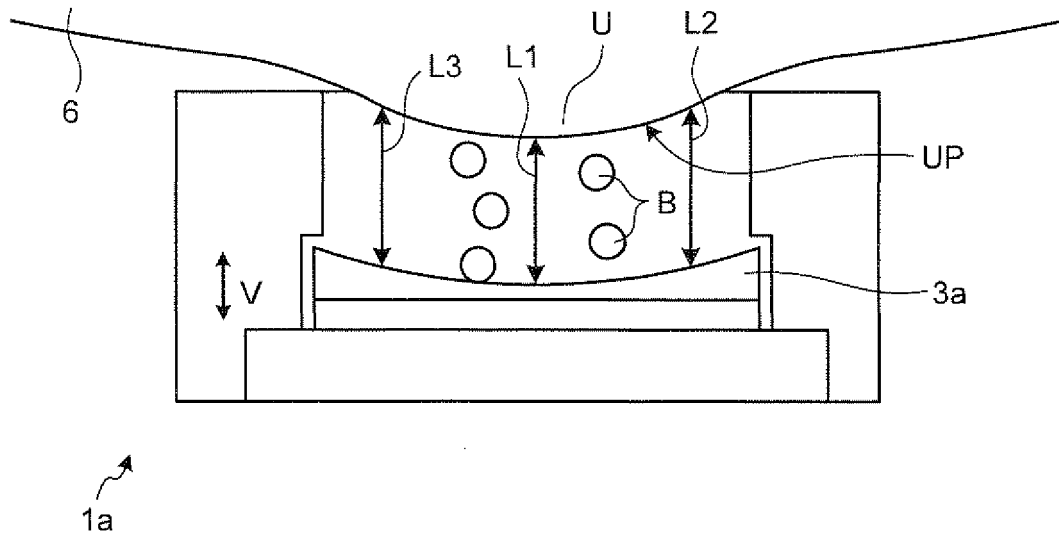


FIG.6

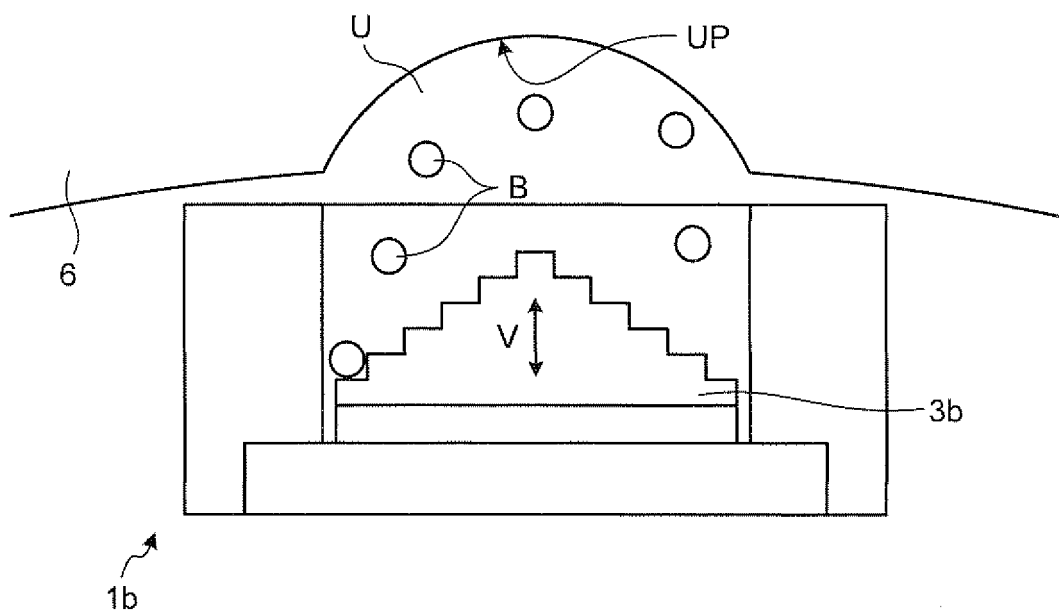
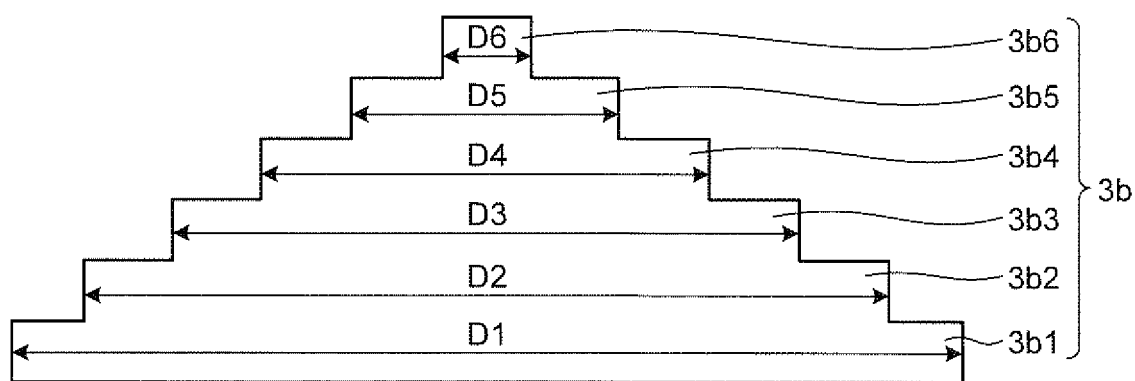


FIG.7



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/054207

A. CLASSIFICATION OF SUBJECT MATTER B24C5/06(2006.01) i, B24B1/04(2006.01) i, B24B31/00(2006.01) i, B24C5/08 (2006.01) i		
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) B24C5/06, B24B1/04, B24B31/00, B24C5/08		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2009 Kokai Jitsuyo Shinan Koho 1971-2009 Toroku Jitsuyo Shinan Koho 1994-2009		
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.
X A	JP 2006-346775 A (Mitsubishi Heavy Industries, Ltd., Toyo Seiko Co., Ltd.), 28 December, 2006 (28.12.06), Claims 1, 2; all drawings (Family: none)	1, 4 2, 3 1-4
A	JP 2006-281406 A (NHK Spring Co., Ltd., Toyo Seiko Co., Ltd.), 19 October, 2006 (19.10.06), Claims 1, 4; all drawings (Family: none)	1-4
☒ 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 application or patent 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 20 May, 2009 (20.05.09)		Date of mailing of the international search report 02 June, 2009 (02.06.09)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/054207

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2001-18126 A (Sonats-Societe des Nouvelles Applications des Techniques de Surfaces), 23 January, 2001 (23.01.01), All pages; all drawings & US 6343495 B1 & EP 1038977 A1 & DE 60019998 D & DE 60019998 T & FR 2791293 A & CA 2301986 A & AT 295431 T & CA 2301986 A1	1-4

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Patent documents cited in the description

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- JP 2007181909 A [0003]