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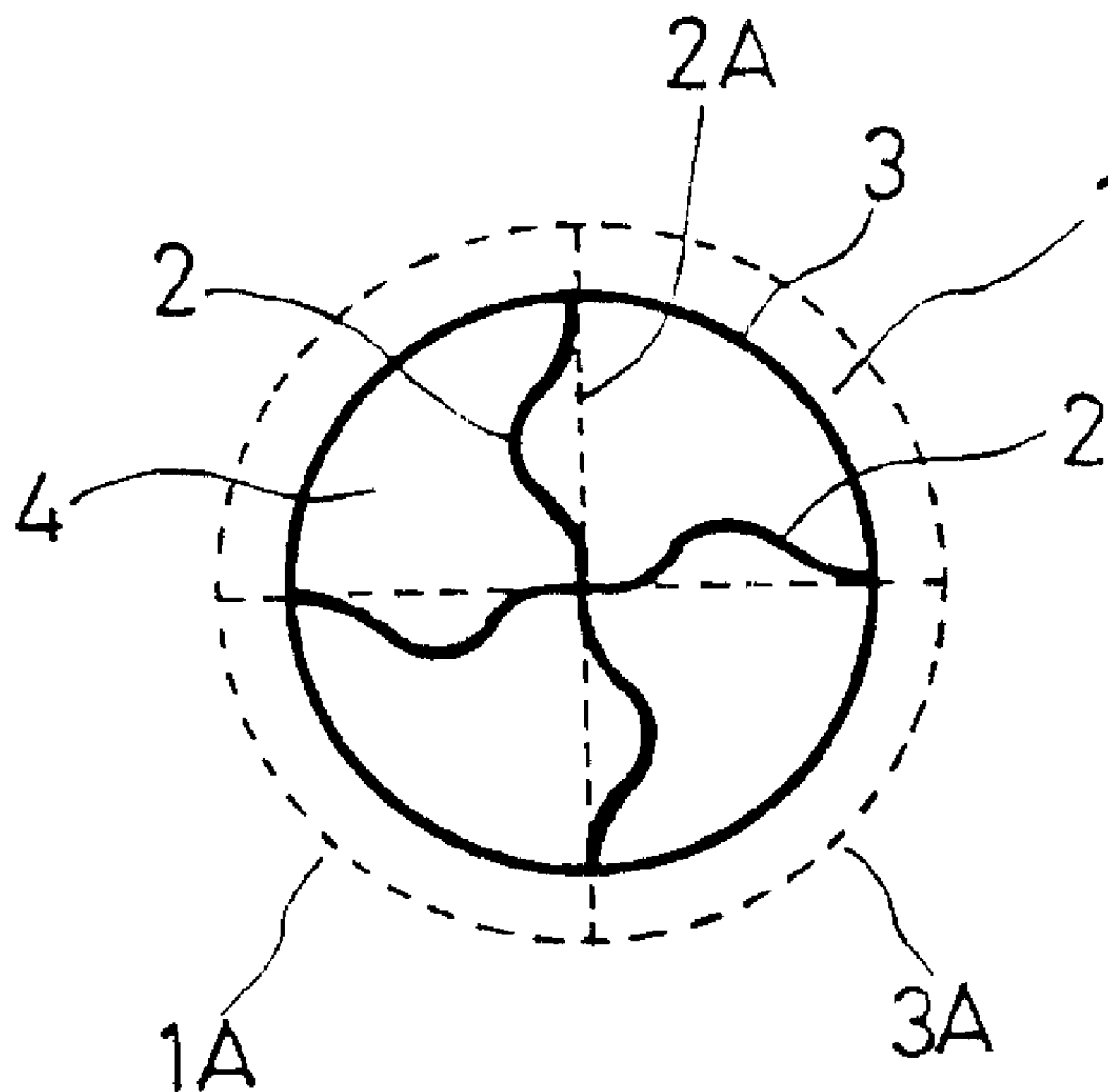
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(54) Titre : **MATERIAUX D'ALUMINIUM A EXTRUDER POUR RENFLEMENT HYDRAULIQUE ET METHODE DE FORMAGE DE RENFLEMENT HYDRAULIQUE AVEC CES MATERIAUX**

(54) Title: **ALUMINUM EXTRUSION MATERIAL FOR HYDRAULIC BULGE FORMING AND HYDRAULIC BULGE FORMING METHOD USING THE EXTRUSION MATERIAL**



(57) **Abrégé/Abstract:**

An aluminum extrusion material for hydraulic bulge forming, which can produce hydraulic bulge forming components possessing highly reliable and sufficient strength and rigidity capable of withstanding not only a static load, but also a twist load and dynamic load is provided. Also provided is a hydraulic bulge forming method using the aluminum extrusion material for hydraulic bulge forming as a raw material. The aluminum extrusion material is hollow and used as a material for hydraulic bulge forming. The material is characterized by having a partition wall radially crossing the hollow part of the extrusion material, wherein the partition wall is provided with an allowance in length to become flat when the hollow part is formed into a prescribed shape by hydraulic bulge forming.

ABSTRACT OF THE DISCLOSURE

An aluminum extrusion material for hydraulic bulge forming, which can produce hydraulic bulge forming components possessing highly reliable and sufficient strength and rigidity capable of withstanding not only a static load, but also a twist load and dynamic load is provided. Also provided is a hydraulic bulge forming method using the aluminum extrusion material for hydraulic bulge forming as a raw material. The aluminum extrusion material is hollow and used as a material for hydraulic bulge forming. The material is characterized by having a partition wall radially crossing the hollow part of the extrusion material, wherein the partition wall is provided with an allowance in length to become flat when the hollow part is formed into a prescribed shape by hydraulic bulge forming.

TITLE OF THE INVENTION

ALUMINUM EXTRUSION MATERIAL FOR HYDRAULIC BULGE FORMING
AND HYDRAULIC BULGE FORMING METHOD USING THE EXTRUSION
MATERIAL

5

BACKGROUND OF THE INVENTIONField of the Invention

The present invention relates to an aluminum extrusion material for hydraulic bulge forming, particularly to an aluminum extrusion material suitable for aluminum structural components for vehicles processed by hydraulic bulge forming, and to a hydraulic bulge forming method using the aluminum extrusion material. In the present invention, aluminum includes pure aluminum for industrial use and aluminum alloys.

15 Description of Background Art

Hydraulic bulge forming is a technology for forming hollow materials in a prescribed shape. In hydraulic bulge forming, a hollow material such as a metal tube, a tubular material, or the like is set in a pair of metal molds, a fluid such as oil and water, for example, is fed to the hollow material under low pressure, and cylinders are inserted into the hollow material from both ends while discharging air from the hollow material to seal both ends. The pressure applied to the inside of the hollow material and the cylinder insertion pressure are controlled to form the hollow material into a desired shape. In some hydraulic bulge forming methods, hollow materials are formed using only the hydraulic pressure without providing the

cylinder insertion pressure.

Hydraulic bulge forming, which is also called hydro forming or hydrostatic bulge forming, can freely deform the cross-sectional configuration of a hollow material, enabling
5 the hollow material to be formed into an integral object with a variety of shapes. Therefore, hydrostatic bulge forming can not only decrease production costs for various parts due to reduction of the number of the parts to be manufactured, but also increase reliability of the strength of the formed objects.
10 For this reason, hydrostatic bulge forming is being widely accepted as a forming method for pipe-shaped structural parts for vehicles.

Components obtained from a hollow material by deforming the circumference by applying hydraulic pressure to the inside
15 of the hollow material or components formed by tube expansion, in the case where the hollow material is a tube, possess sufficient reliability in terms of strength to static loads. However, because the components are hollow, the strength to a twist load or a dynamic load caused by a collision, for example,
20 is not sufficient. It is difficult to maintain cross-sectional shape when such a load is applied.

The present invention has been achieved to solve the above-described problems in conventional hydraulic bulge forming using a hollow material, particularly aluminum tubular
25 extrusion material. An object of the present invention is, therefore, to provide an aluminum extrusion material for hydraulic bulge forming, which can produce hydraulic bulge

forming components possessing highly reliable and sufficient strength and rigidity against not only a static load, but also a twist load and dynamic load. Another object is to provide a hydraulic bulge forming method using the aluminum extrusion material for hydraulic bulge forming.

SUMMARY OF THE INVENTION

To achieve the above object, the aluminum extrusion material for hydraulic bulge forming of claim 1 of the present invention is an hollow aluminum extrusion material used as a material for hydraulic bulge forming characterized by having a partition wall radially crossing the hollow part of the extrusion material, wherein the partition wall has an allowance in length to become flat when the hollow part is formed into a prescribed shape by hydraulic bulge forming.

In the aluminum extrusion material for hydraulic bulge forming of claim 1, the aluminum extrusion material for hydraulic bulge forming of claim 2 is characterized by having a partition wall with a thickness of 0.5-1.5 times the thickness of the surrounding wall of the hollow aluminum extrusion material.

The hydraulic bulge forming method of claim 3 of the present invention is characterized by feeding a fluid to the hollow part of the aluminum extrusion material for hydraulic bulge forming of claim 1 or claim 2, used as a raw material, applying pressure to the fluid to form the surrounding wall of the extrusion material in a desired shape, and, at the same time,

flattening the partition wall.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a cross-sectional view of the aluminum
5 extrusion material for hydraulic bulge forming of the present
invention before and after forming.

Figure 2 is another cross-sectional view of the aluminum
extrusion material for hydraulic bulge forming of the present
invention before and after forming.

10 Figure 3 is another cross-sectional view of the aluminum
extrusion material for hydraulic bulge forming of the present
invention before and after forming.

Figure 4 is yet another cross-sectional view of the
aluminum extrusion material for hydraulic bulge forming of the
15 present invention before and after forming.

Figure 5 is still another cross-sectional view of the
aluminum extrusion material for hydraulic bulge forming of the
present invention before and after forming.

Figure 6 is yet another cross-sectional view of the
20 aluminum extrusion material for hydraulic bulge forming of the
present invention before and after forming.

Figure 7 is a cross-sectional view of the aluminum
extrusion material for hydraulic bulge forming with a flat
partition wall before and after forming.

25 Figure 8 is another cross-sectional view of the aluminum
extrusion material for hydraulic bulge forming with a flat
partition wall before and after forming.

DETAILED DESCRIPTION OF THE INVENTION AND PREFERRED EMBODIMENT

The aluminum extrusion material for hydraulic bulge forming of the present invention is an hollow aluminum extrusion material used as a material for hydraulic bulge forming characterized by having a partition wall radially crossing the hollow part of the extrusion material, wherein the partition wall is previously provided with an allowance in length to become flat when the hollow part is formed into a prescribed shape by hydraulic bulge forming.

Examples of the cross section of the hollow aluminum extrusion material for hydraulic bulge forming in the present invention are shown in Figures 1-6. In Figures 1-6, a material in the shape of a tube is shown as a hollow aluminum extrusion material (hereinafter referred to as "hollow material") 1. The hollow material 1 is provided with a partition wall 2 crossing a hollow space 4. The partition wall 2 is formed integral with a surrounding wall 3 of the hollow material 1.

When the tube is expanded by hydraulic bulge formation, the surrounding wall 3 of the hollow material 1 is deformed as shown by the broken line 3A, whereby the partition wall 2 becomes flattened as shown by the broken line 2A. Specifically, the partition wall 2 is previously provided with an allowance in length, so that when the hollow material 1 becomes a prescribed shape by the hydraulic bulge forming, the partition wall 2 may become flattened. The length of the allowance is determined according to the degree of molding.

There are no specific limitations to the shape of the partition wall 2. Desired shapes for flattening the surplus length are bent shapes (Figures 1-2), curved shape (Figures 5-6), and cornice shapes (Figures 3-4). After the hydraulic bulge formation, the partition wall 2 becomes flattened and functions as a support for the surrounding wall 3. As a result, the tube 1A formed by hydraulic bulge formation becomes strong, capable of withstanding a static load from the outside, a dynamic load from the outside such as a collision, a twisting load, and the like.

In the embodiment shown in Figure 6, a tubular hollow material 1 with a round cross-section is formed into a tube with an oval cross-section, whereby the surrounding wall 3 is deformed as shown by the broken line 3B and the partition wall 2 is flattened into a plane, with the length of the surrounding wall 3 remaining the same as the length of the surrounding wall 3B. This is an example in which the length along the circumference does not change. All embodiments shown in Figures 1-6 are hollow materials with a round cross-section. In the present invention, however, the cross-section of the hollow material need not be necessarily round. Hollow materials with a variety of cross-sections can be used as a raw material to produce formed products with a variety of cross-sections by the hydraulic bulge forming.

The thickness of the partition wall 2 is preferably 0.5-1.5 times the thickness of the surrounding wall 3 of the hollow material. If less than 0.5 time, the partition wall is

easily broken during expansion of the tube. Even if the partition wall can be expanded without becoming broken, it is difficult to form a sufficiently strong support for the surrounding wall 3. If the thickness is more than 1.5 times, a required surplus length is available only with difficulty when forming the hollow material by extrusion.

Now, an embodiment for forming a material by hydraulic bulge forming using the above-described hollow material will be explained. A hollow material used as a raw material is set on the female mold on a fixed board. The mold is then closed by placing the male mold onto the female mold by pushing using an embossing cylinder. Then, a fluid such as oil or water is charged into the hollow space of the hollow material under low pressure. The axial indenting cylinder on the right and left sides of the hollow material is advanced to seal both ends.

The hollow material is formed to become the shape of the mold, while adjusting the pressure applied to the hollow space and the forwarding pressure of the cylinder, to deform the surrounding wall to the shape as shown in Figures 1-6, for example, and, at the same time, the partition wall is flattened, whereby a hydraulic bulge formed part with a prescribed shape can be obtained.

EXAMPLES

The present invention is described below by examples and comparative examples to demonstrate the effects of the present invention. These examples illustrate only one of the

embodiments of the present invention, which should not be construed as limiting the present invention.

Example 1

Hollow aluminum extrusion materials (6063 alloy, thermal refining: 0 material) with an external diameter of 60.5 mm and thickness of 3 mm, having cross-sectional shapes shown in Figures 1-5, were prepared by port hole extrusion.

Products were formed from the resulting hollow aluminum extrusion materials (test materials No. 1-7) by hydraulic bulge forming using a mold with a tube expansion rate of 29-30%, while adjusting the internal pressure and the cylinder axial indentation. The cross-sectional dimensions of the hydraulic bulge forming products after molding were measured. The results are shown in Table 1.

As shown in Table 1, in the products formed from the test materials No. 1-7 by hydraulic bulge forming of the present invention, the surrounding walls were expanded without rupturing as shown by the broken line 3A in Figures 1-5. Also, plane partition walls shown by the broken line 2A in Figures 1-5 were formed.

Table 1

Test material	1	2	3	4	5	6	7
Cross-section of the material	Fig. 1	Fig. 2	Fig. 3	Fig. 4	Fig. 5	Fig. 5	Fig. 5
Before forming							
Circumference (mm)	190	190	190	190	190	190	190
External diameter (mm)	60.5	60.5	60.5	60.5	60.5	60.5	60.5
Partition wall thickness (mm)	3	3	3	3	4.5	3	1.5
Before forming							
Circumference (mm)	248	248	248	248	248	248	248
External diameter (mm)	78.7	78.7	78.4	78.6	78.5	78.6	78.6
Tube expansion (%)	30	30	30	30	30	30	30

Comparative Example 1

5 Hollow aluminum extrusion materials (6063 alloy, thermal refining: O material) with an external diameter of 60.5 mm and thickness of 3 mm, having a cross-sectional shape shown in Figures 7-8, were prepared by port hole extrusion.

10 Products were formed from the resulting hollow aluminum extrusion materials (test material Nos. 8-10) by hydraulic bulge forming using a mold with a tube expansion rate of 30%, while adjusting the internal pressure and the cylinder axial indentation. The cross-sectional dimensions of the hydraulic bulge forming products after molding were measured. The

15 results are shown in Table 2.

20 As shown in Table 2, in the hydraulic bulge forming using the test materials No. 8-10, the partition walls could not have been sufficiently deformed although they have expanded from 60.5 mm to 68.3 mm. The surrounding walls 3, shown in broken lines 3C in Figures 7 and 8, protruded in the circumferential

direction between the partition walls 2, resulting in a rupture before the circumference of the material came into contact with the internal wall of the mold.

5

Table 2

Test material	8	9	10
Cross-section of the material	Fig. 7	Fig. 7	Fig. 8
Before forming			
Circumference (mm)	190	190	190
External diameter (mm)	60.5	60.5	60.5
Partition wall thickness (mm)	3	1.5	3
After forming			
Circumference (mm)	243	235	225
External diameter (mm)	67.8	68.3	62.5

Note: External diameter after forming: External diameter D of the partition wall (See Fig. 7)

An aluminum extrusion material for hydraulic bulge forming, which can produce hydraulic bulge forming components possessing highly reliable and sufficient strength and rigidity capable of withstanding not only a static load, but also a twist load and dynamic load is provided by the present invention. Also provided is a hydraulic bulge forming method using the aluminum extrusion material for hydraulic bulge forming as a raw material.

Since the products are formed by extrusion processing, the aluminum extrusion material for hydraulic bulge forming is advantageous in terms of production costs and, therefore, is suitable as a material of aluminum structural components for

vehicles to be processed by hydraulic bulge forming.

High hardness components can be obtained by processing and curing using hydraulic bulge forming even in the case where a soft material with excellent formability is used as the
5 aluminum extrusion material for hydraulic bulge forming.

WHAT IS CLAIMED IS:

1. A hollow aluminum extrusion material for hydraulic bulge forming characterized by having a partition wall radially crossing the hollow part of the extrusion material, wherein the partition wall is provided with an allowance in length to become flat when the hollow part is formed into a prescribed shape by hydraulic bulge forming.

2. The hollow aluminum extrusion material for hydraulic bulge forming of claim 1, wherein the partition wall has a thickness of 0.5-1.5 times the thickness of the peripheral wall of the hollow aluminum extrusion material.

3. The hydraulic bulge forming method characterized by feeding a fluid to the hollow part of the aluminum extrusion material for hydraulic bulge forming of claim 1 or claim 2, used as a raw material, applying pressure to the fluid to form the peripheral wall of the extrusion material in a desired shape, and, at the same time, flattening the partition wall.

25

Fig. 1

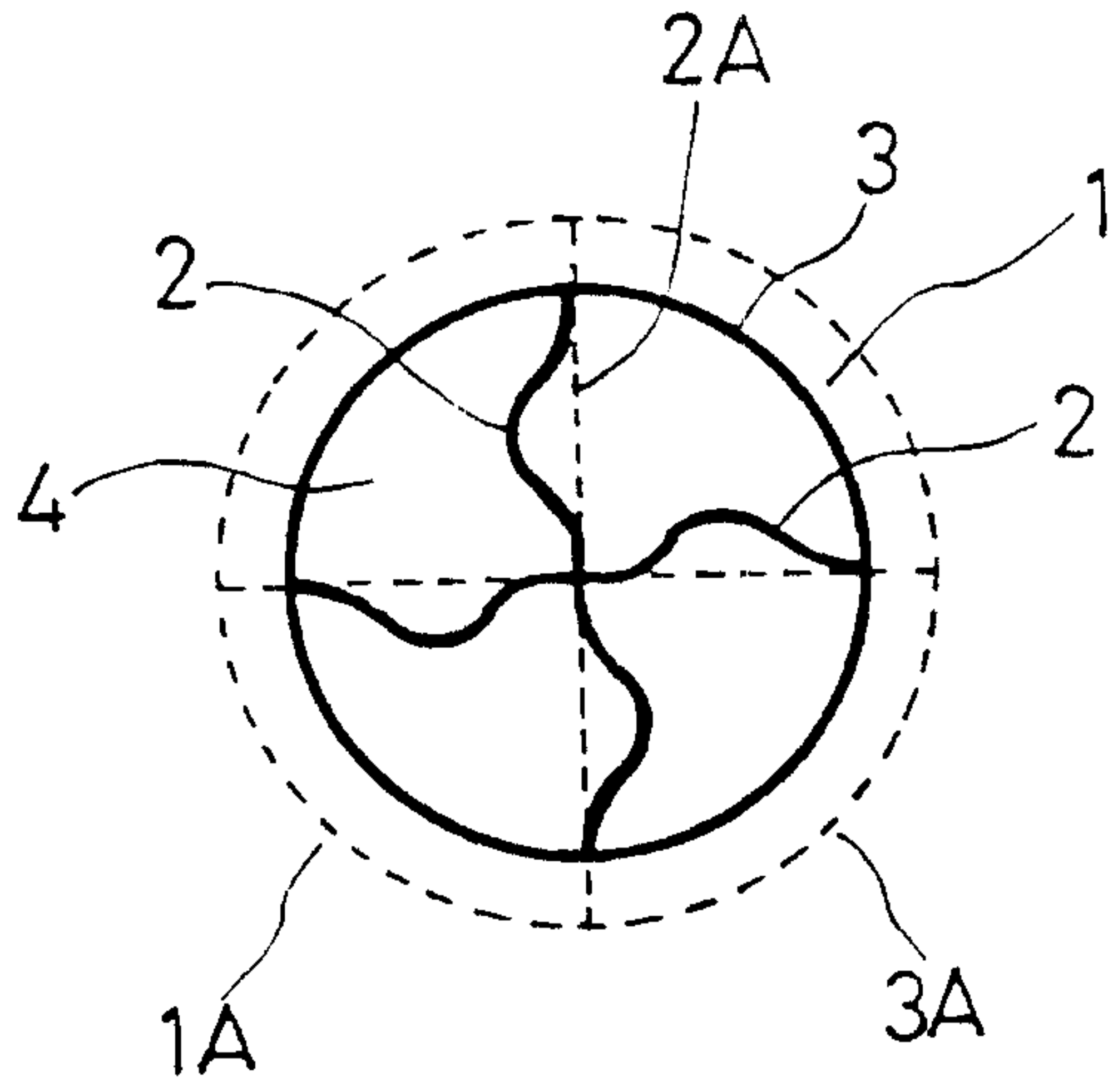


Fig. 2

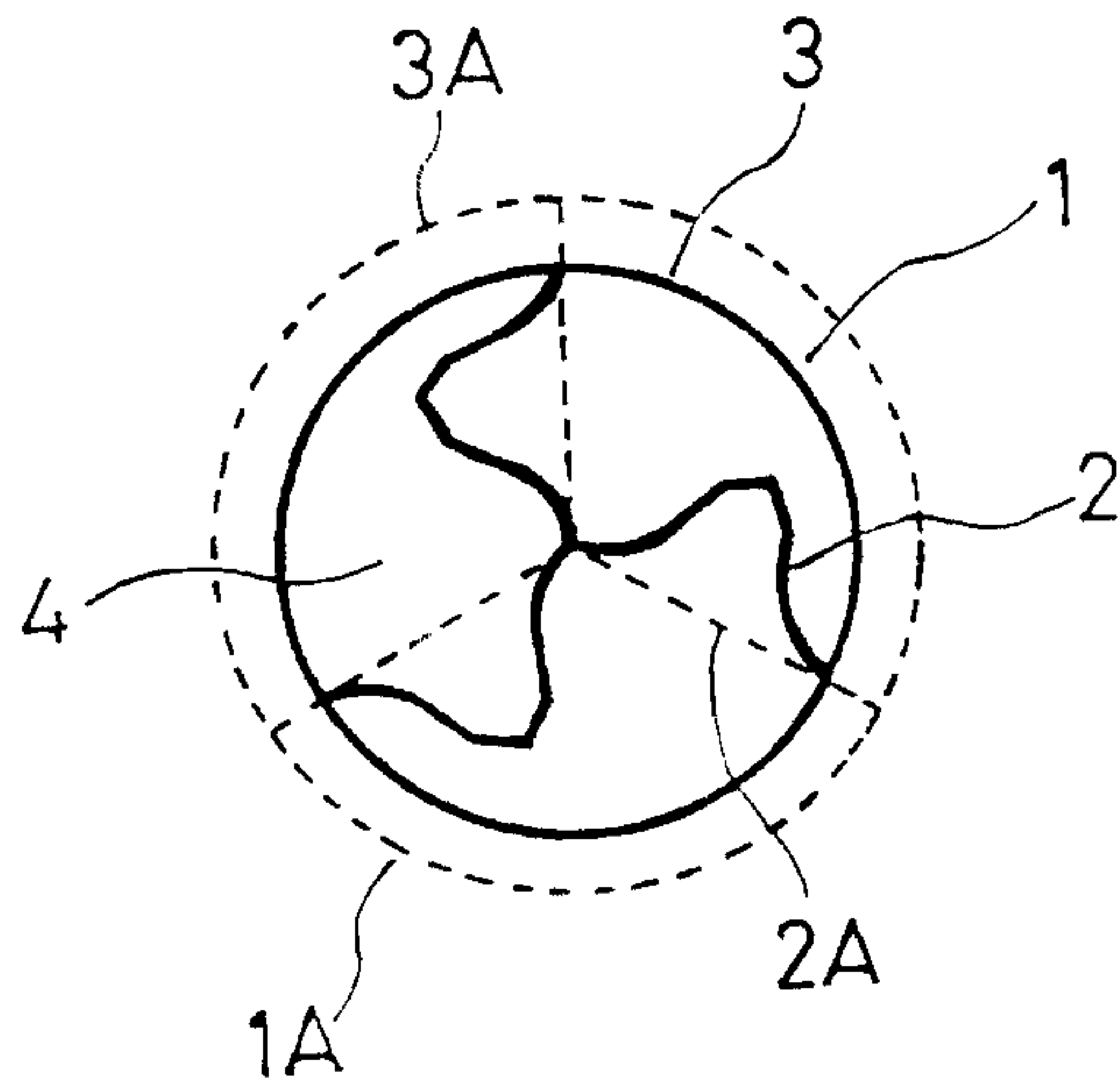
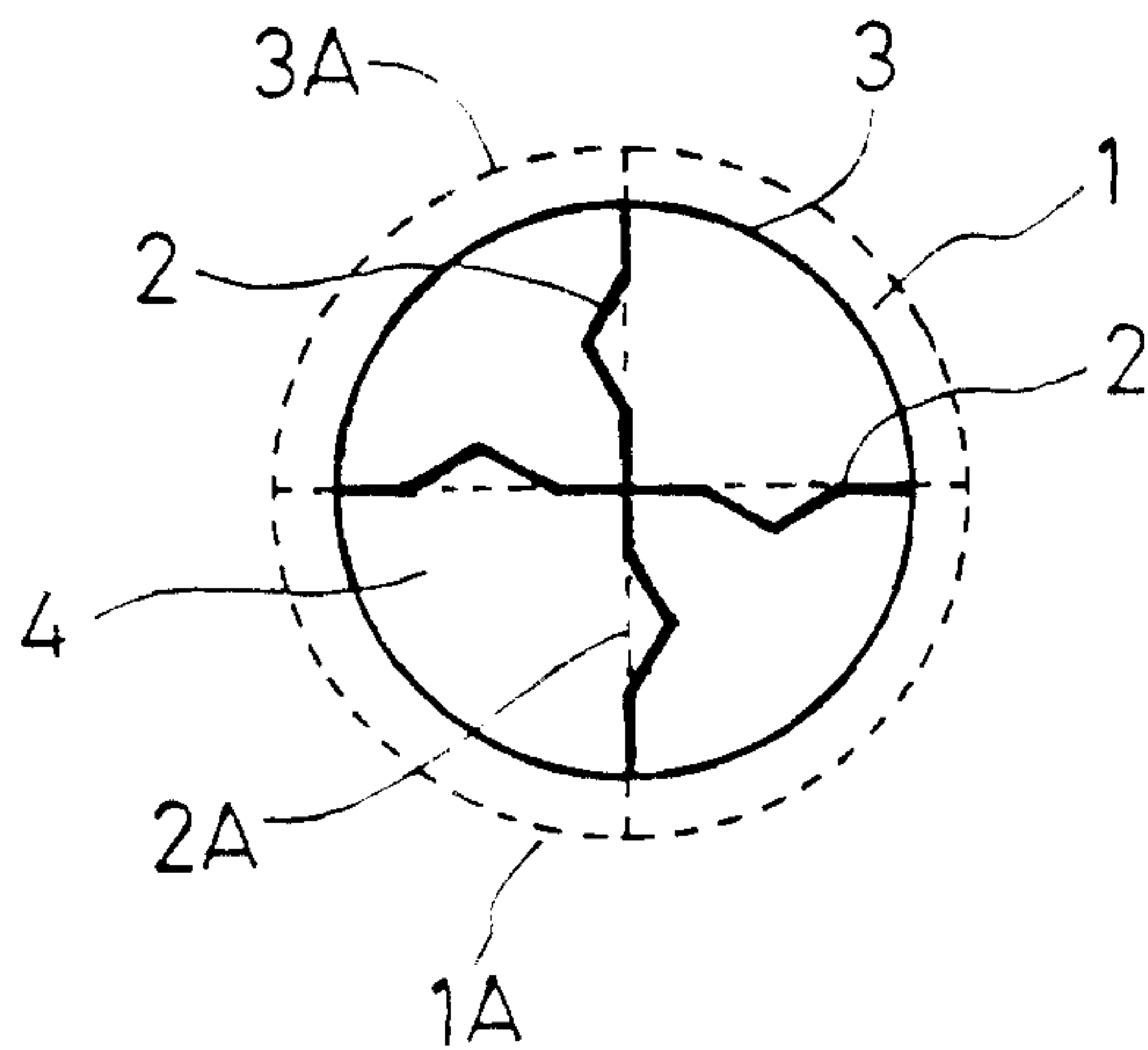


Fig. 3



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Fig. 4

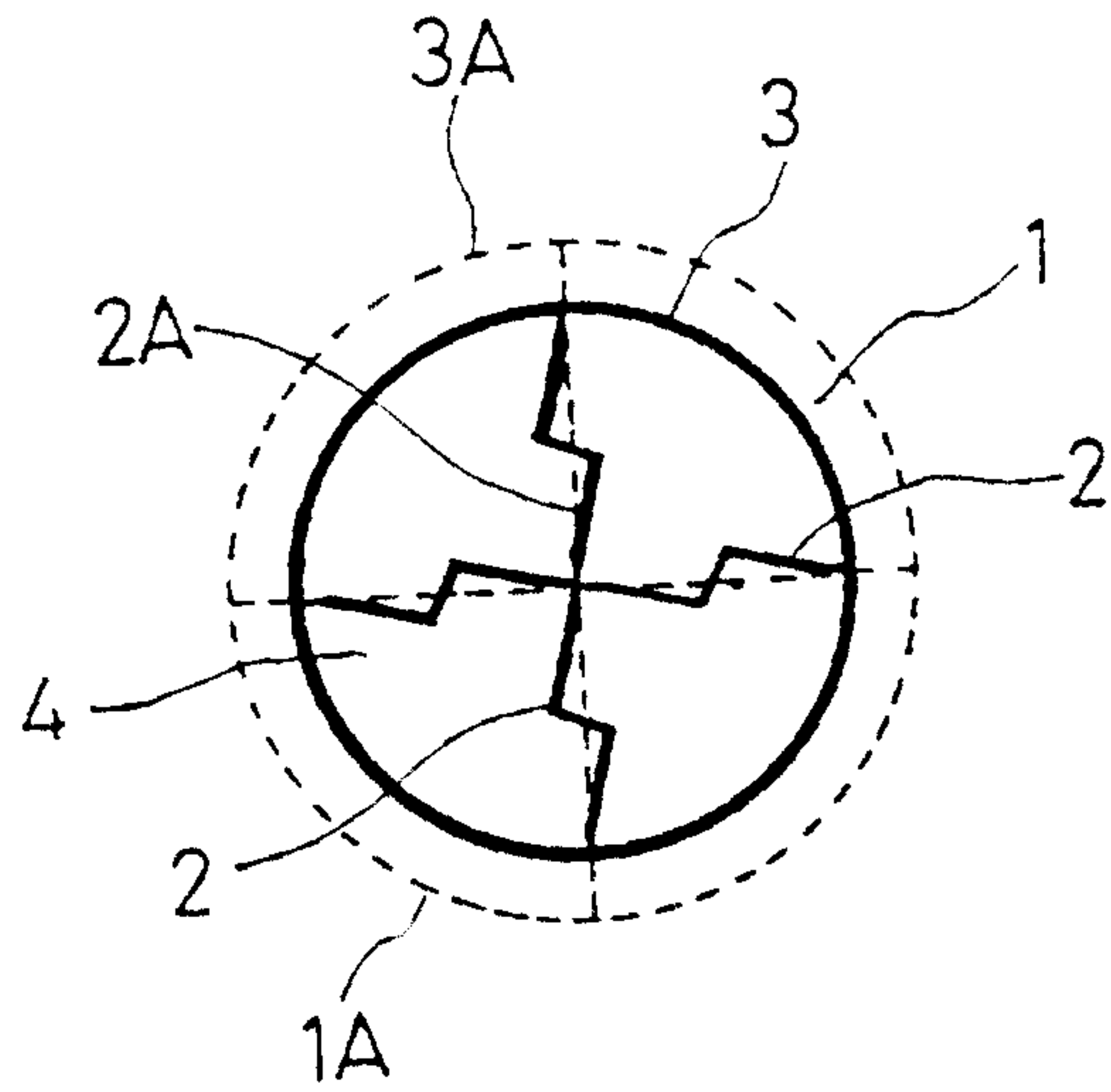


Fig. 5

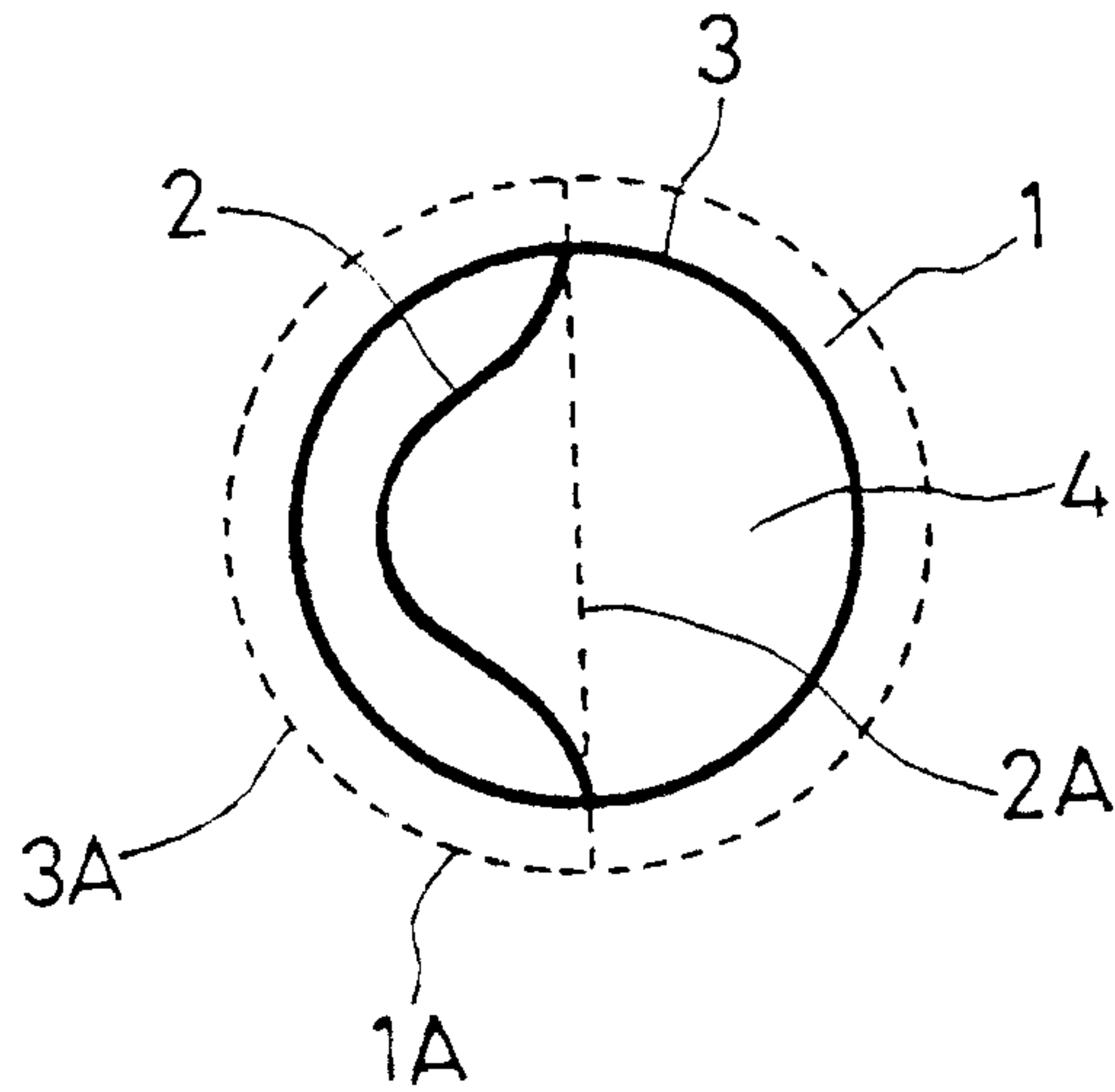
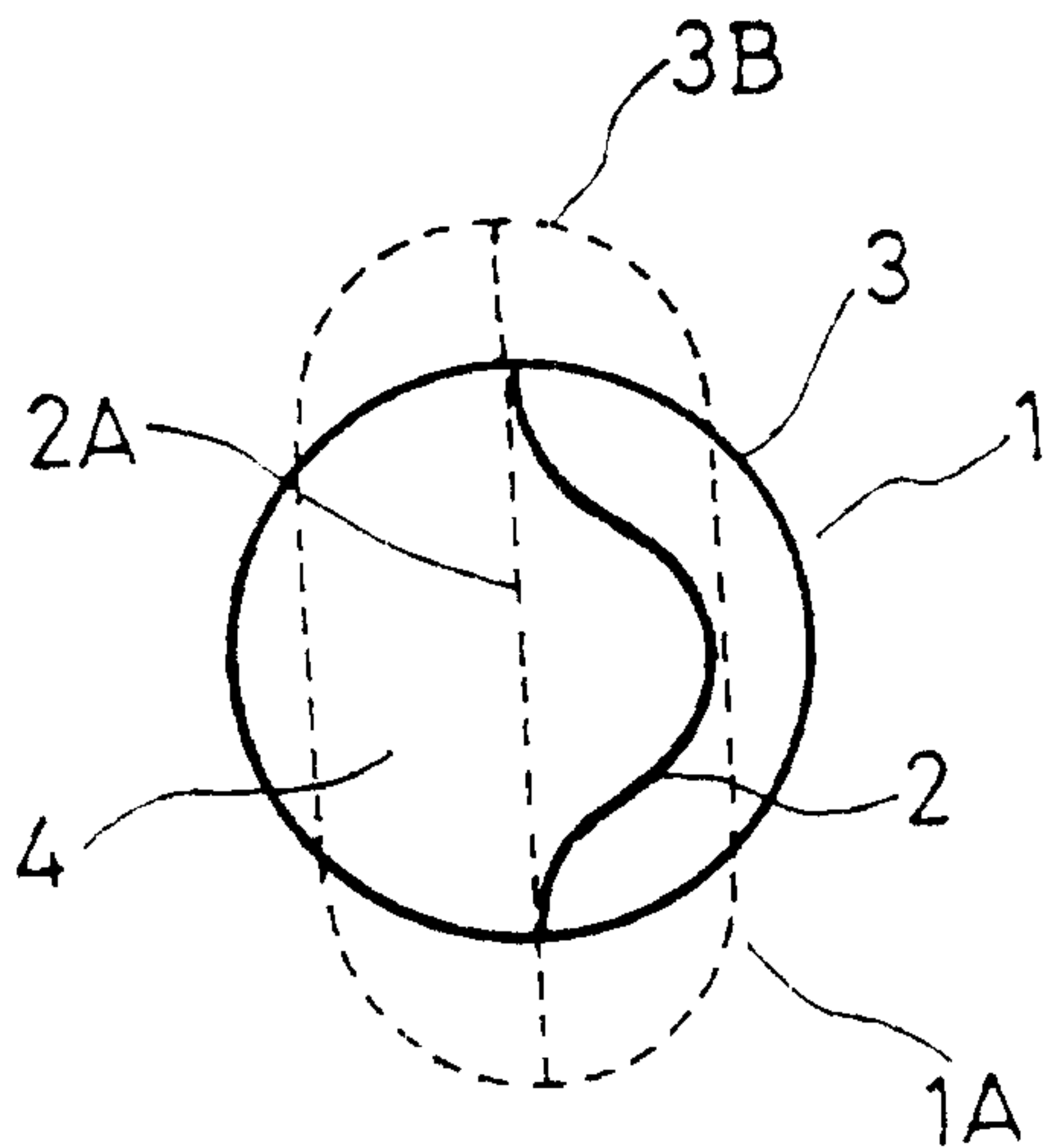


Fig. 6



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Fig. 7

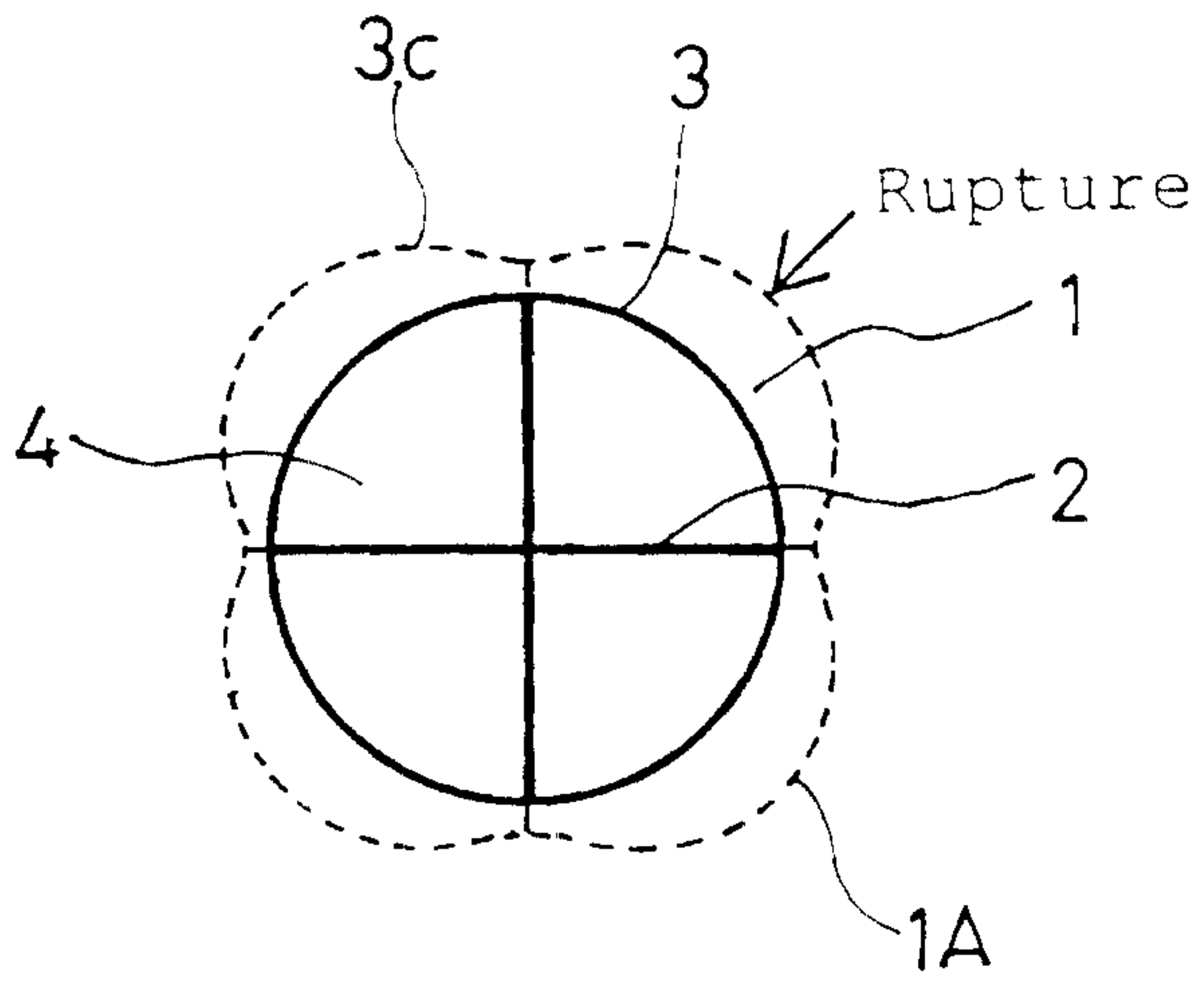
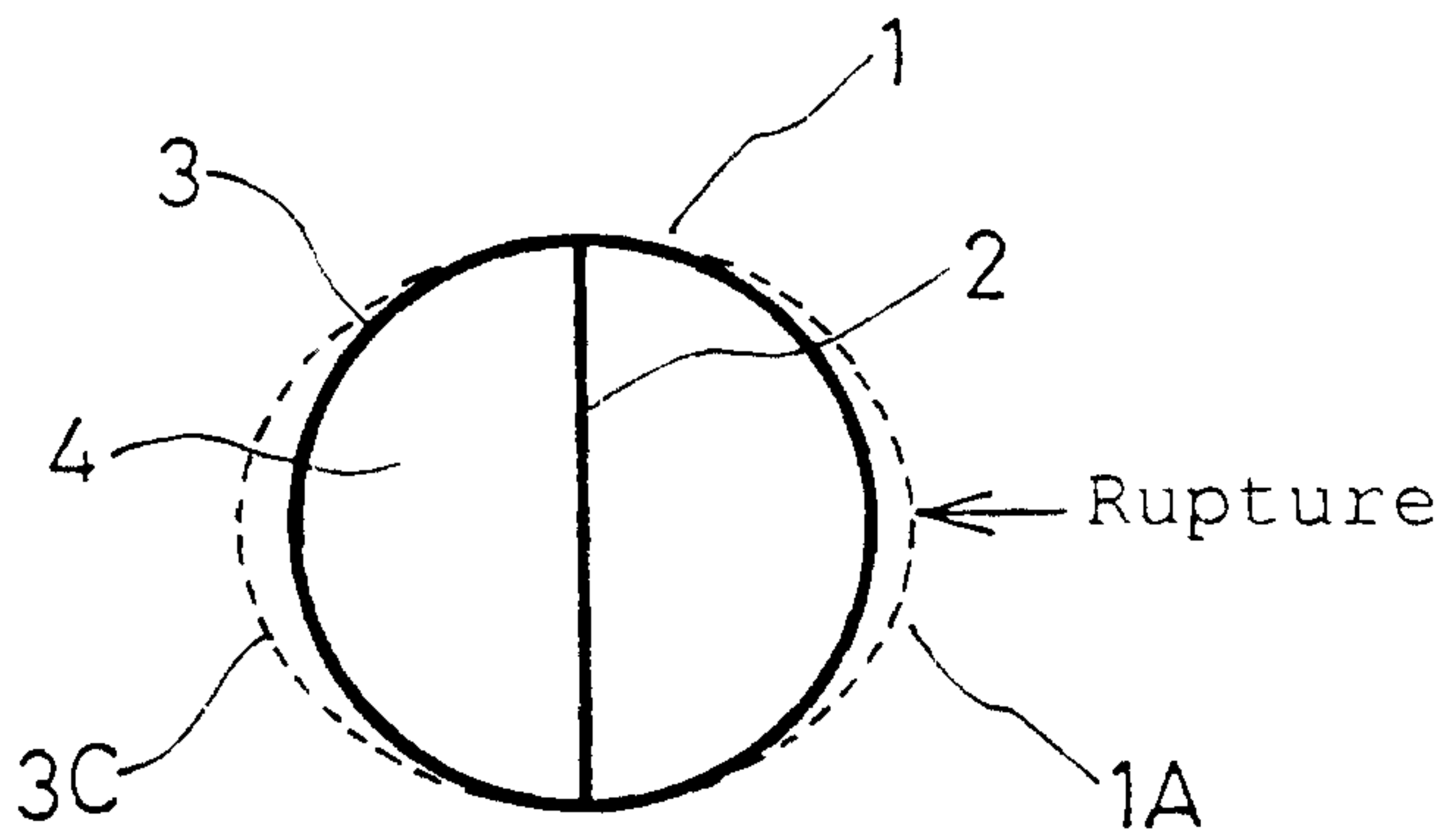


Fig. 8



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