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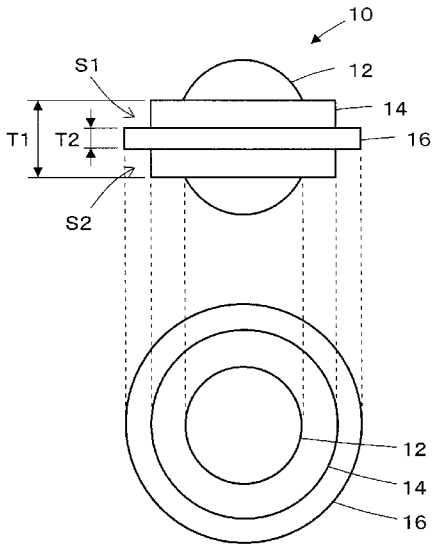
(54) Title: PREFORM FOR MOLDING AN OPTICAL ELEMENT AND METHOD OF MOLDING AN OPTICAL ELEMENT

(57) Abstract: A preform for molding an optical element comprises an element body forming portion for forming an element body including optical surfaces, an annular flange forming portion provided on a periphery of the element body forming portion and having a first thickness, and an annular rim forming portion provided on a periphery of the flange forming portion and having a second thickness that is smaller than the first thickness to form annular steps on a top face side and a bottom face side of the flange forming portion, upon deformation caused by being heated and compressed, an outer periphery of the rim forming portion abutting on an inner surface of a barrel die with the annular steps left to remain.

[Fig. 1]



WO 2011/102085 A1

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Description

Title of Invention: PREFORM FOR MOLDING AN OPTICAL ELEMENT AND METHOD OF MOLDING AN OPTICAL ELEMENT

Technical Field

[0001] The present invention relates to a preform for molding an optical element, which is an intermediate, and a method of molding an optical element using the preform in an optical element molding method whereby an optical element is molded by compression molding.

Background Art

[0002] Patent Literature 1, for example, describes a conventional method of producing an optical element such as a lens and a prism, used in optical instruments. As illustrated in Fig. 14, after producing a preform 1 from an optical material such as plastics or glass, the preform 1 undergoes heating and compression molding inside a mold 2 to produce, for example, an optical element 5 as illustrated in Fig. 15 having an optical element body 3 and a flange 4 supporting the optical element body 3.

[0003] However, conventional methods have drawbacks that an excessive or deficient quantity of the preform 1 or a misalignment of the preform 1 in the mold 2 allowed that a part of the preform 1 flows into clearances of the mold 2, i.e., gaps between the upper die 6, the lower die 7, and the barrel die 8 forming the mold 2 to permit formation of a burr B or that a part 4a of the flange 4 did not reach the barrel 8, failing to form the rim portion. In such a case, a molded optical element could not be accurately positioned in a device such as a camera.

[0004] Recent years have been seeing a growth in demand for lenses used in cameras having reduced dimensions such as, in particular, digital cameras incorporated in mobile phones and cameras used in medical equipment. These lenses used in mobile phones, medical equipment and the like are extremely small and are required to meet high optical accuracies.

[0005] Therefore, optical elements of low quality such that they do not permit accurate positioning in devices cause defects of material importance in optical accuracy.

In particular, lenses incorporated in extremely small cameras, etc. are often used in combination. Thus, burrs cause the reference surfaces for positioning the lenses to shift and make it difficult to align the optical paths of the lenses.

[0006] Patent Literature 2 and 3 describe a method of eliminating the problem of such lenses being molded with burrs. Patent Literature 2 describes adjusting the temperature of the preform and the pressure applied thereto to control the deformation speed of the

preform and hence prevent formation of burrs. Patent Literature 3 uses a method of making the linear expansion coefficients of the upper and lower dies, components of the mold from that of the barrel die, another component of the mold.

Citation List

Patent Literature

[0007] [PTL 1] JP 05-177725 A

[PTL 2] JP 8-127077 A

[PTL 3] JP 2000-326354 A

Summary of Invention

TECHNICAL PROBLEMS

[0008] These methods described in Patent Literature 2 and 3 had drawbacks that the molding conditions and the mold configurations are complicated resulted in increasing the work and costs for molding an optical element.

[0009] To overcome the above problems associated with the prior art, the present invention provides a preform for molding an optical element permitting easy and low-cost molding of a high quality optical element and a method of molding an optical element using such a preform.

SOLUTION TO PROBLEMS

[0010] A preform for molding an optical element according to the present invention comprises:

an element body forming portion for forming an element body including optical surfaces;

an annular flange forming portion provided on a periphery of the element body forming portion and having a first thickness; and

an annular rim forming portion provided on a periphery of the flange forming portion and having a second thickness that is smaller than the first thickness to form annular steps on a top face side and a bottom face side of the flange forming portion,

wherein upon deformation caused by being heated and compressed, an outer periphery of the rim forming portion abuts on an inner surface of a barrel die with the annular steps left to remain.

[0011] A method of molding an optical element according to the present invention comprises the steps of:

disposing the preform for molding an optical element of the present invention in a space enclosed by an upper die, a lower die, and a barrel die, and

deforming the preform for molding an optical element through heating and compressing so that a periphery of the rim forming portion abuts on an inner surface of a barrel die with the annular steps left to remain.

Advantageous Effects of Invention

[0012] The present invention permits molding a high-quality optical element easily and at a low cost without complicating molding conditions and mold configurations.

Brief Description of Drawings

[0013] [fig.1]Fig. 1 is a view of a preform for molding an optical element according to Embodiment 1 of the invention.

[fig.2]Fig. 2 is a sectional view illustrating a preform compression molding device for molding the preform according to Embodiment 1.

[fig.3]Fig. 3 is an enlarged sectional view illustrating a part of the compression molding device where the preform according to Embodiment 1 is correctly positioned in a cavity.

[fig.4]Fig. 4 is an enlarged sectional view illustrating a part of the compression molding device where the preform, which was in the state as shown in Fig. 3, has now been compressed.

[fig.5]Fig. 5 is a view illustrating the optical element retrieved from the compression molding device shown in Fig. 4.

[fig.6]Fig. 6 is an enlarged sectional view illustrating a part of the compression molding device where the preform according to Embodiment 1 is misaligned in the cavity.

[fig.7]Fig. 7 is an enlarged sectional view illustrating a part of the compression molding device where the preform, which was in the state as shown in Fig. 6, has now been compressed.

[fig.8]Fig. 8 is a view illustrating the optical element retrieved from the compression molding device shown in Fig. 7.

[fig.9]Fig. 9 is a lateral section of a preform according to Embodiment 2 of the invention.

[fig.10]Fig. 10 is a lateral section of a preform according to a variation of Embodiment 2.

[fig.11]Fig. 11 is a lateral section of a preform according to another variation of Embodiment 2.

[fig.12]Fig. 12 is a top plan view of a preform according to Embodiment 3 of the invention.

[fig.13]Fig. 13 is a top plan view of the preform illustrated in Fig. 12 upon completion of compression molding.

[fig.14]Fig. 14 is a sectional view of a part of a compression molding device where a conventional preform is positioned in a cavity.

[fig.15]Fig. 15 is an enlarged sectional view illustrating a part of the compression

molding device where the conventional preform has been compressed.

DETAILED DESCRIPTION OF INVENTION

[0014] EMBODIMENT 1

Fig. 1 illustrates a preform 10 for molding an optical element according to Embodiment 1 of the invention. The preform 10 comprises an element body forming portion 12 having a top face and a bottom face, both substantially spherical, for forming an element body having optical surfaces, an annular flange forming portion 14 provided on the periphery of the element body forming portion 12 and having a first thickness T1, and an annular rim forming portion 16 provided on the periphery of the flange forming portion 14 and having a second thickness T2.

The second thickness T2 of the rim forming portion 16 is smaller than the first thickness T1 of the flange forming portion 14, so that the rim forming portion 16 forms a step S1 and a step S2, both annular, on the periphery of the upper side and the lower side of the flange forming portion 14.

[0015] The material of the preform 10 for molding an optical element is not specifically limited and may be any of various optical materials such as thermoplastic resins and glass depending on the optical element to be molded.

[0016] Next, the method of molding the preform 10 into an optical element will be described.

[0017] To mold the preform 10, a preform compression molding device 30 as illustrated in Fig. 2 is used. The molding device 30 comprises a lower die 34 which is fixedly provided, and an upper die 32 which can move up and down with respect to the lower die 34. Around the lower die 34 and the upper die 32 are provided a barrel die 36 in such a manner as to surround the lower die 34 and the upper die 32. The barrel die 36 is in turn surrounded by a cylindrical spacer 38 to limit the displacement of the upper die 32.

[0018] First, the preform 10 illustrated in Fig. 1 is disposed in a cavity 40 defined by molding surfaces of the upper die 32 and the lower die 34 and the inner surface of the barrel die 36.

The preform 10 is disposed so that the top and bottom faces of the element body forming portion 12 are positioned opposite to substantial centers of the molding surfaces of the upper die 32 and the lower die 34, respectively, and heated by a heater (not shown) provided in the molding device 30.

[0019] When the preform 10 has been sufficiently heated to permit deformation, the upper die 32 is lowered toward the lower die 34 as illustrated in Fig. 3 to achieve compression molding of the preform 10, imparting to the preform 10 a shape defined by the molding surfaces of the upper die 32 and the lower die 34.

[0020] The size of the spacer 38 is previously determined according to the shape and

thickness of the optical element to be molded. The upper die 32 is lowered until it abuts on the spacer 38 to complete deformation of the preform 10 by compression and achieve shaping of the optical element.

[0021] After completion of compression and deformation of the preform 10 as illustrated in Fig. 4, the deformed preform 10 is cooled to produce an optical element. The upper die 32 is lifted up to open the mold and permit retrieval of the optical element.

[0022] Fig. 5 illustrates an optical element 20 thus produced. The optical element 20 comprises an element body 22 and an annular flange 24 disposed around the element body 22 for supporting the element body 22. Further, an annular rim portion 26 is formed on the periphery of the flange 24. To install the optical element 20 in an optical device such as a camera, the element body 22 is supported by the flange 24 and positioned by using the outer periphery of the rim portion 26.

[0023] A thickness T12 of the rim portion 26 is smaller than a thickness T11 of the flange 24, so that the rim portion 26 forms a step S11 and a step S12, both annular, on the periphery of the upper side and the lower side of the flange 24.

[0024] Next, referring to Fig. 3, described in detail is how the compression molding is achieved focusing on the molding surfaces of the upper die 32 and the lower die 34 and the inner surface of the barrel die 36.

The preform compression molding device 30, composed of several different die members, necessarily has a clearance 60 between neighboring die members, particularly between the barrel die 36 and each of the upper die 32 and the lower die 34.

[0025] After the preform 10 has been sufficiently heated to permit deformation, the upper die 32 moves down toward the lower die 34.

[0026] As the upper die 32 moves down, the element body forming portion 12 of the preform 10 is first compressed by the molding surfaces of the upper die 32 and the lower die 34. The compression deforms the preform 10 into the profile of the molding surfaces, thereby starting to mold the optical surface of the element body forming portion 12.

[0027] Secondly, the flange forming portion 14 of the preform 10 is then compressed by the molding surfaces of the upper mold 32 and the lower mold 34. This compression deforms the flange forming portion 14 into the profiles of the molding surfaces of the upper mold 32 and the lower mold 34 as the flange forming portion 14 grows thinner and radially expands toward the inner surface of the barrel die 36.

[0028] The rim forming portion 16 of the preform 10 approaches the inner surface of the barrel die 36 substantially without changing its thickness as the flange forming portion 14 expands and, because the annular steps S1 and S2 are provided on both sides, the top and bottom sides, of the flange forming portion 14, the rim forming portion 16 abuts on the inner surface of the barrel die 36 without contacting with the molding

surfaces of the upper die 32 and the lower die 34 to form the rim portion 26. In other words, the flange forming portion 14 of the preform 10 expands toward the inner surface of the barrel die 36 maintaining the annular steps S1 and S2 formed on the periphery of the top and bottom sides of the flange forming portion 14 to form the flange portion 24.

[0029] Thus, because the outer periphery of the rim forming portion 16 of the preform 10 abuts on the inner surface of the barrel die 36 without contacting with the molding surfaces of the upper die 32 and the lower die 34 to form the rim portion 26, while the flange forming portion 14 forms the flange portion 24 without abutting on the inner surface of the barrel die 36, the material of the preform 1 does not flow into the clearances 60 between the barrel die 36 and each of the upper die 32 and the lower die 34, thereby making it possible to produce the optical element 20 without burrs.

[0030] Further, even when the preform 10 of the invention is disposed slightly out of alignment with the substantial center of the molding surfaces of the upper die 32 and the lower die 34 in the cavity 40, the element body 22 having optical surfaces and the rim portion 26 for positioning the optical surfaces can be formed with precision.

[0031] Now, let us assume that the preform 10 is disposed with its center out of alignment by dX rightward with respect to the center of the molding surfaces of the upper die 32 and the lower die 34 as illustrated in Fig. 6.

[0032] As in the cases free from misalignment, the preform 10 is heated by a heater, not shown, incorporated in the molding device 30 until the preform 10 becomes deformable, whereupon the preform 10 undergoes compression molding by the upper die 32 and the lower die 34.

Similarly to the above embodiment, the element body forming portion 12 abuts on the molding surfaces of the upper die 32 and the lower die 34 and deforms as illustrated in Fig. 7 to form the element body 22 having an optical surfaces as illustrated in Fig. 8.

[0033] Because the preform 10 is disposed slightly out of alignment rightwards, the flange 24 is formed slightly out of alignment rightwards as illustrated in Fig. 8.

However, if the flange 24 may support the element body 22 and be adjusted in position together with the element body 22 in the optical axis direction, a slight misalignment of the flange 24 does not pose any problem.

Even when the preform 10 is eccentrically positioned, the reference positioning plane of the molded element body 20 is not misaligned and the optical accuracy is not affected because the rim forming portion 16 abuts on the inner surface of the barrel die 36 during compression molding to form the rim portion 26, and the peripheral surface of the rim portion 26 serves to position the element body 22, while the annular steps S1 and S2 are formed on the periphery of the top and bottom sides of the flange portion

24, respectively.

[0034] EMBODIMENT 2

Although the element body forming portion 12 of the preform 10 according to Embodiment 1 has its top and bottom surfaces made spherical, the preform 10 is not limited this way.

[0035] As illustrated in Fig. 9, when at least one of an upper die 32A and the lower die 34 has a convex molding surface 42 projecting toward the cavity 40, a preform 10A disposed in the cavity 40 preferably has a concave portion 44 having a radius of curvature that is greater than that of the convex molding surface 42. Such a configuration reduces the amount of deformation produced by compression molding and reduces distortion. Further, air trapping occurring between the molding surface 42 and the concave portion 44 can be avoided more readily.

[0036] Similarly, as illustrated in Fig. 10, when at least one of an upper die 32B and the lower die 34 has a concave molding surface 46 hollowing with respect to the cavity 40, a preform 10B disposed in the cavity 40 preferably has a convex portion 48 having a radius of curvature that is smaller than that of the concave molding surface 46. Such a configuration reduces the amount of deformation produced by compression molding and reduces distortion. Further, air trapping occurring between the molding surface 46 and the convex portion 48 can be avoided more readily.

[0037] Further, as illustrated in Fig. 11, when at least one of an upper die 32C and the lower die 34 has a flat molding surface 50, a preform 10C disposed in the cavity 40 preferably has a flat portion 52 having a smaller width and a greater height than the flat molding surface 50. Such a configuration reduces the amount of deformation produced by compression molding and reduces distortion. Further, air trapping occurring between the molding surface 50 and the flat portion 52 can be avoided more readily.

[0038] Figs. 9 to 11 specifically illustrate only the molding surfaces of the upper dies 32A, 32B, and 32C of the molding machine 30 and, as regards the preforms 10A, 10B, and 10C, only the top face of the element body forming portion.

[0039] Use of a preform for molding an optical element having a shape corresponding to the molding surfaces of the dies reduces the amount of deformation of the preform occurring during molded so that it becomes possible to manufacture an optical element that reduces the risks of occurrences of burrs and significant misalignment.

[0040] EMBODIMENT 3

The preform 10 illustrated in Fig. 1 has the flange forming portion 14 and the rim forming portion 16 both having a circular shape when seen from the upper side but the configuration thereof is not limited this way.

Fig. 12 illustrates a preform 10D for molding an optical element according to Embodiment 3. The preform 10D comprises an element body forming portion 12D having

an upper and a lower face, both substantially spherical, a flange forming portion 14D provided on the periphery of the element body forming portion 12D and having a triangular shape when seen from the upper side, and a rim forming portion 16D provided on the periphery of the flange forming portion 14D and having a triangular shape when seen from the upper side. The rim forming portion 16D forms annular steps on the periphery of both sides, the top face and the bottom face, of the flange forming portion 14D.

Upon completion of compression and deformation inside the mold of the compression molding device, the rim forming portion 16D forms three abutment portions 17 at the vertex portions of the triangle abutting on the inner surface of the barrel die 36 and three non-abutment portions 18 out of contact with the inner surface of the barrel die 36, with the annular steps left to remain, as illustrated in Fig. 13.

[0041] An optical element formed using the preform 10D comprises three rim portions corresponding to the abutment portions 17, these three rim portions serving to position the optical element. Upon completion of the compression and deformation, there are formed between the non-abutment portions 18 of the preform 10D and the inner surface of the barrel die 36 gaps where there is no resin. Therefore, even with a significant variation in the quantity of the preform 10D, a high-quality optical element free from burrs can be manufactured.

[0042] The shapes of the flange forming portion 14D and the rim forming portion 16D when seen from the upper side are not limited to a triangle and may be a quadrangle, a rhombus, a pentagon or other polygons having more angles, an ellipse, a shape of a circle from which a pair of arc-shaped segments faced opposite to each other are cut off, or any other appropriate shapes as desired.

[0043] While the element body forming portion 12 of the preform 10 illustrated in Fig. 1 has a circular shape when seen from the upper side, the configuration is not limited this way and may have any other shape as appropriate according to the optical element to be manufactured.

Reference Signs List

[0044] 10, 10A, 10B, 10C, 10D preform for molding an optical element
12, 12D element body forming portion
14, 14D flange forming portion
16, 16D rim forming portion
17 abutment portion
18 non-abutment portion
20 optical element
22 element body

24 flange
26 rim portion
30 preform compression molding device
32, 32A, 32B, 32C upper die
34 lower die
36 barrel die
38 spacer
40 cavity
42 convex molding surface
44 concave portion
46 concave molding surface
48 convex portion
50 flat molding surface
52 flat portion
60 clearance

Claims

[Claim 1] A preform for molding an optical element, the preform being disposed inside a space enclosed by an upper die, a lower die, and a barrel die and formed into an optical element through heating and compressing, the preform comprising:
an element body forming portion for forming an element body including optical surfaces;
an annular flange forming portion provided on a periphery of the element body forming portion and having a first thickness; and
an annular rim forming portion provided on a periphery of the flange forming portion and having a second thickness that is smaller than the first thickness to form annular steps on a top face side and a bottom face side of the flange forming portion,
wherein upon deformation caused by being heated and compressed, an outer periphery of the rim forming portion abuts on an inner surface of the barrel die with the annular steps left to remain.

[Claim 2] The preform for molding an optical element according to Claim 1, wherein the element body forming portion comprises an upper face and a lower face corresponding to the optical surfaces of the optical element, at least one of the upper face and the lower face having a convex surface.

[Claim 3] The preform for molding an optical element according to Claim 1, wherein the element body forming portion comprises an upper face and a lower face corresponding to the optical surfaces of the optical element, at least one of the upper face and the lower face having a concave surface.

[Claim 4] The preform for molding an optical element according to Claim 1, wherein the element body forming portion comprises an upper face and a lower face corresponding to the optical surfaces of the optical element, at least one of the upper face and the lower face having a flat surface.

[Claim 5] The preform for molding an optical element according to Claim 1, wherein when the preform is deformed through being heated and compressed, an outer periphery of the rim forming portion is formed to have abutment portions that abut on the inner surface of the barrel die and non-abutment portions that do not abut on the inner surface of the barrel die.

[Claim 6] A method of molding an optical element comprising the steps of:
disposing the preform for molding an optical element described in Claim 1 in a space enclosed by an upper die, a lower die, and a barrel die, and
deforming the preform for molding an optical element through heating and compressing so that a periphery of the rim forming portion abuts on an inner surface of the barrel die with the annular steps left to remain.

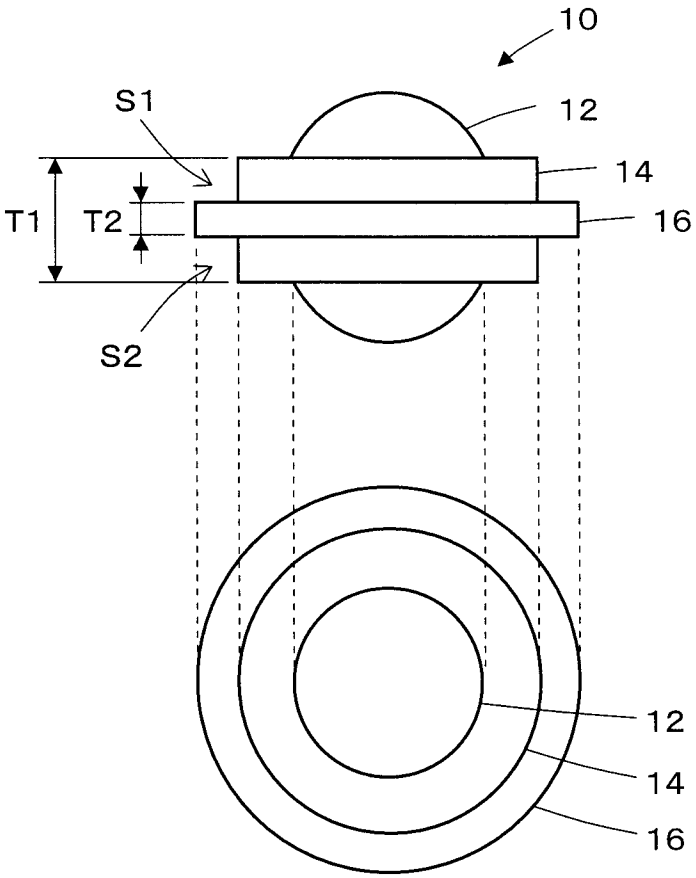
[Claim 7] The method of molding an optical element according to Claim 6, further comprising the step of:
placing a spacer between the upper and lower dies to limit an amount of deformation of the preform for forming an optical element caused by heating and compression.

[Claim 8] The method of molding an optical element according to Claim 6, wherein at least one of the upper and the lower dies has a convex molding surface projecting toward the space, and the preform for molding an optical element placed in the space has a concave portion opposite the convex molding surface.

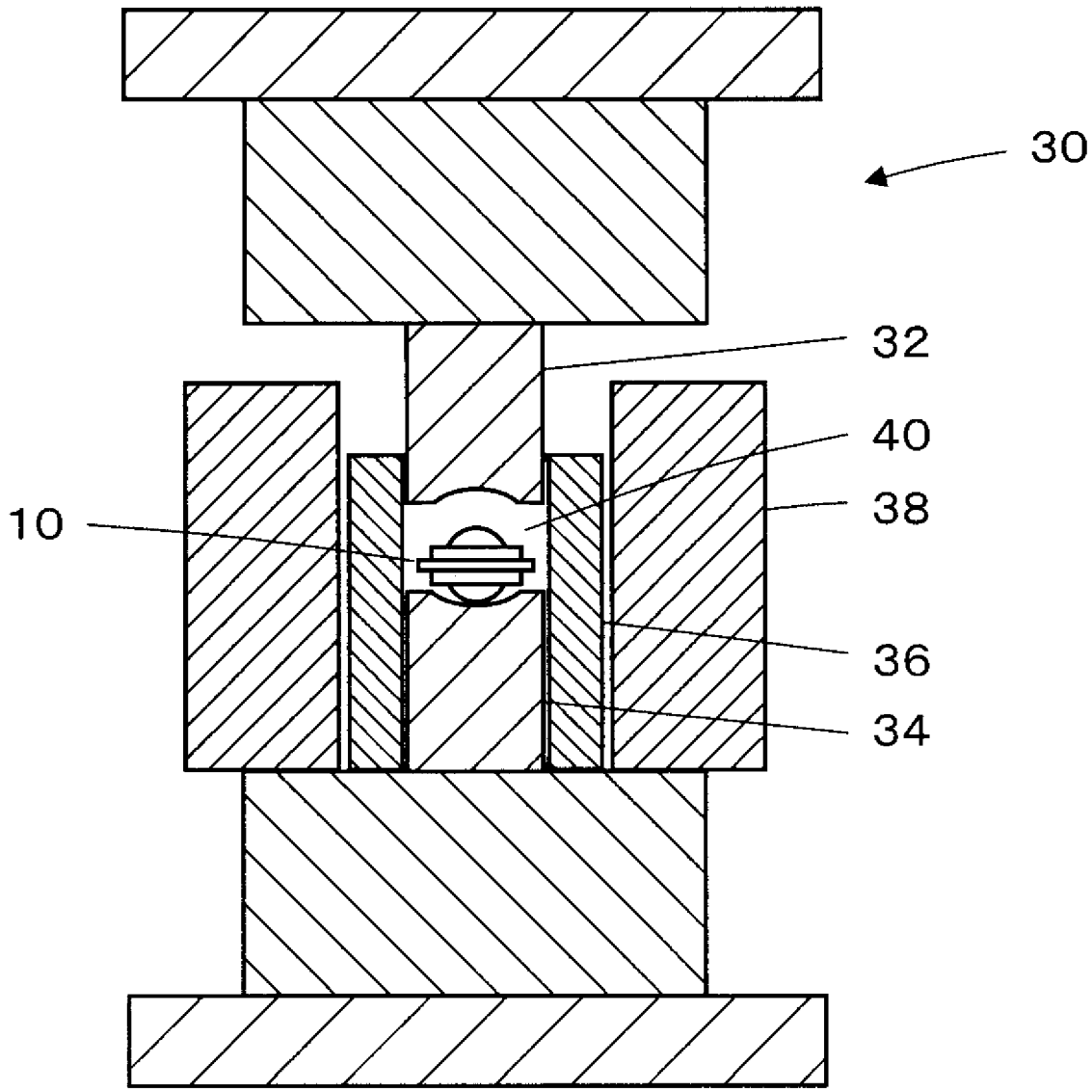
[Claim 9] The method of molding an optical element according to Claim 6, wherein at least one of the upper and the lower dies has a concave molding surface hollowing with respect to the space, and the preform for molding an optical element placed in the space has a convex portion opposite the concave molding surface.

[Claim 10] The method of molding an optical element according to Claim 6, wherein at least one of the upper and the lower dies has a flat molding surface, and the preform for molding an optical element placed in the space has a flat portion opposite the flat molding surface.

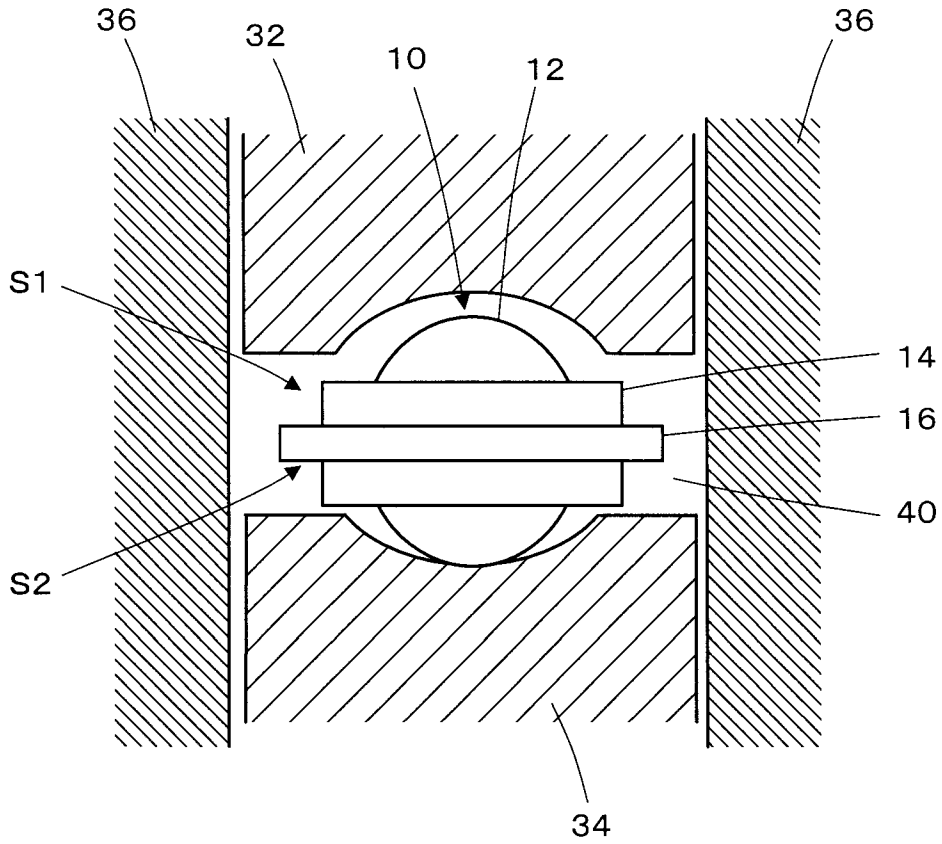
[Fig. 1]



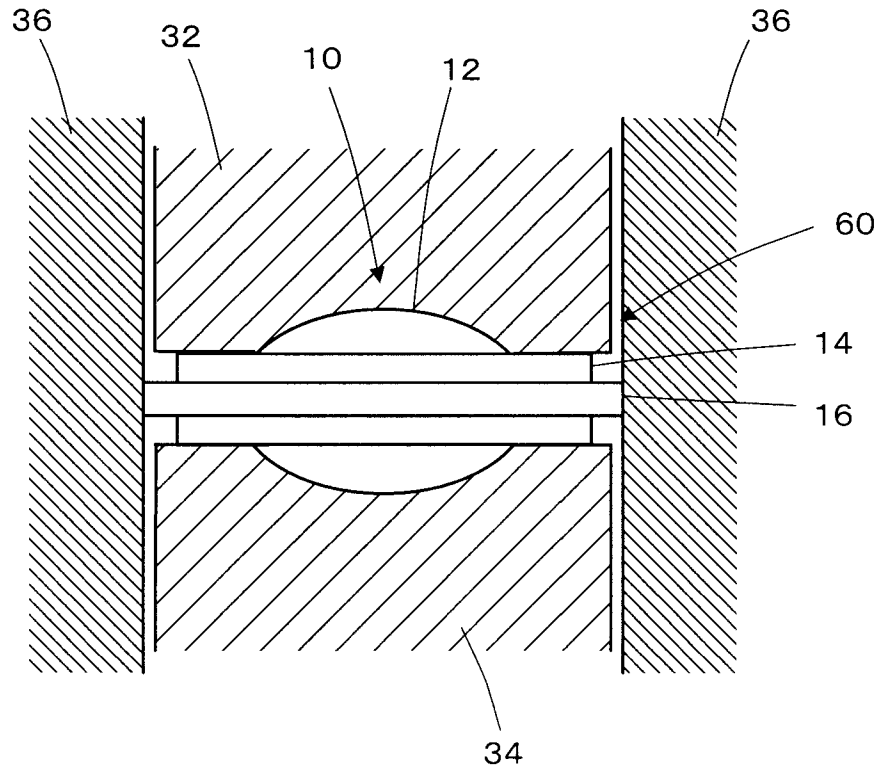
[Fig. 2]



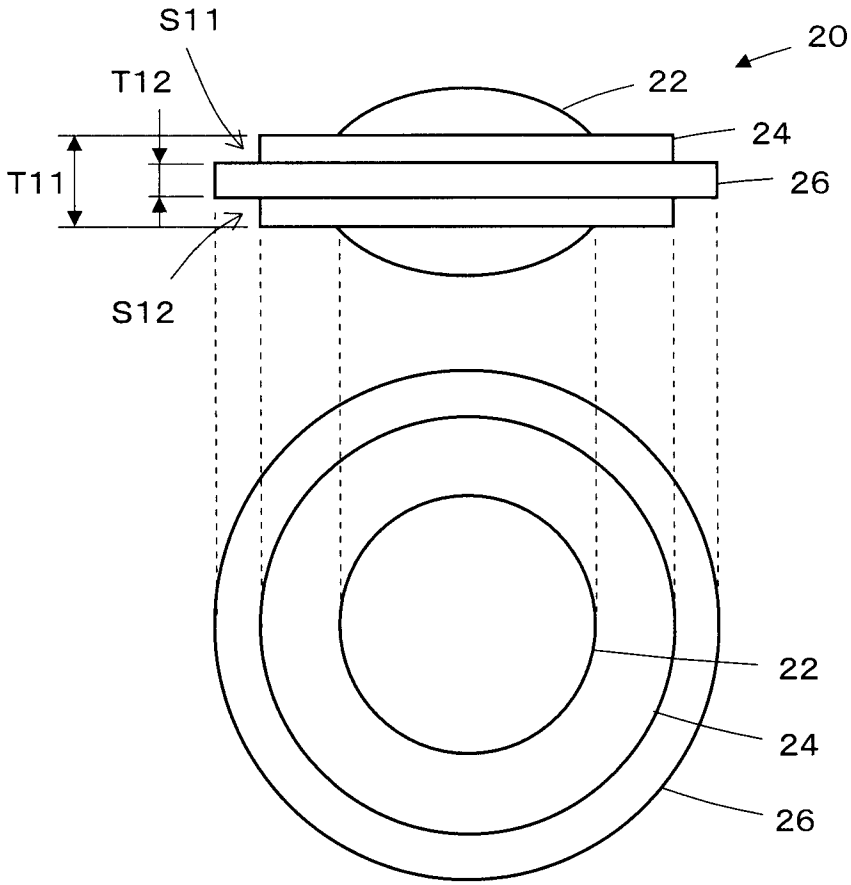
[Fig. 3]



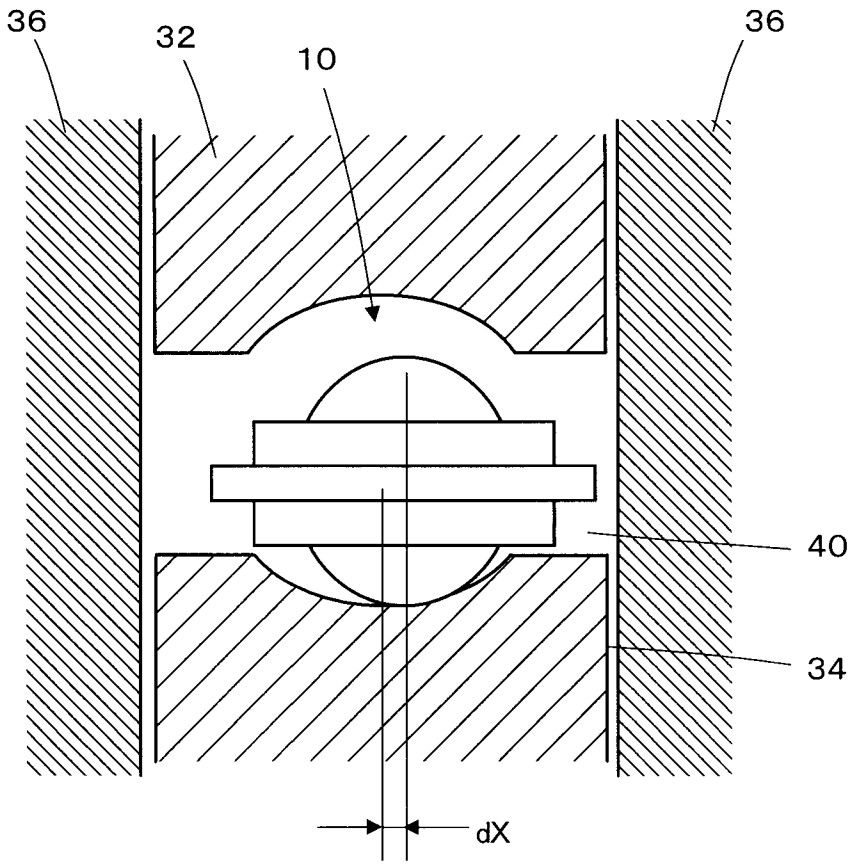
[Fig. 4]



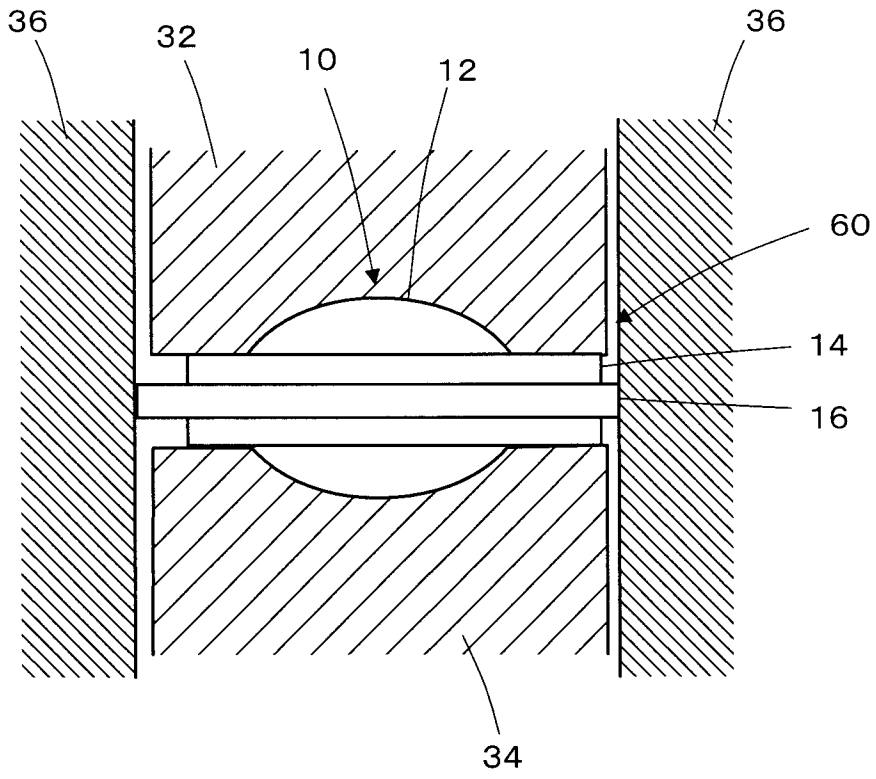
[Fig. 5]



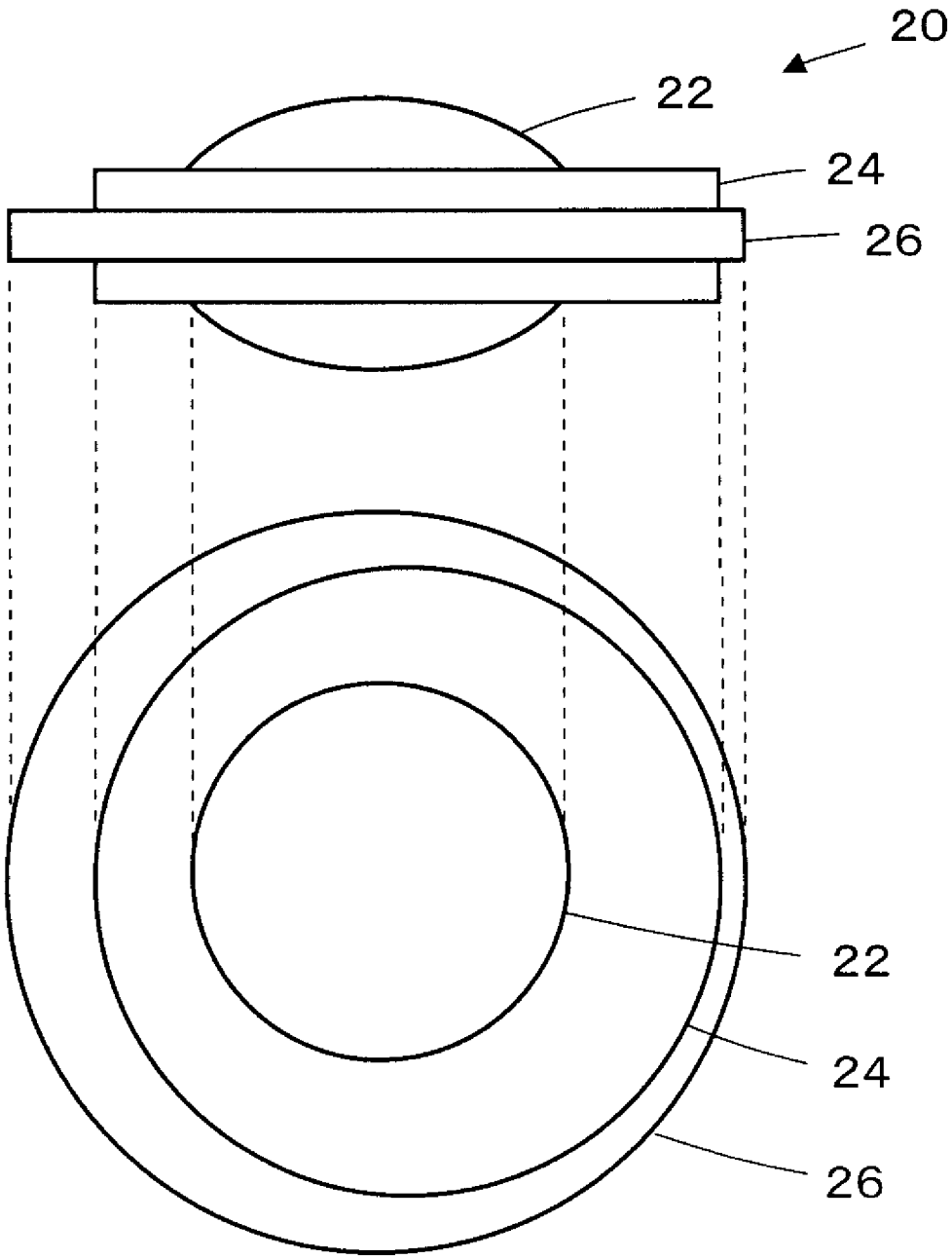
[Fig. 6]



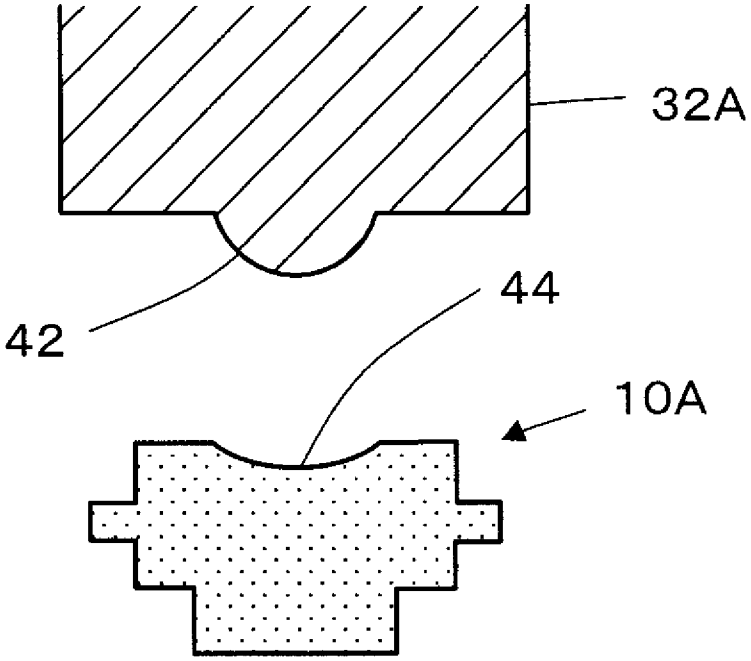
[Fig. 7]



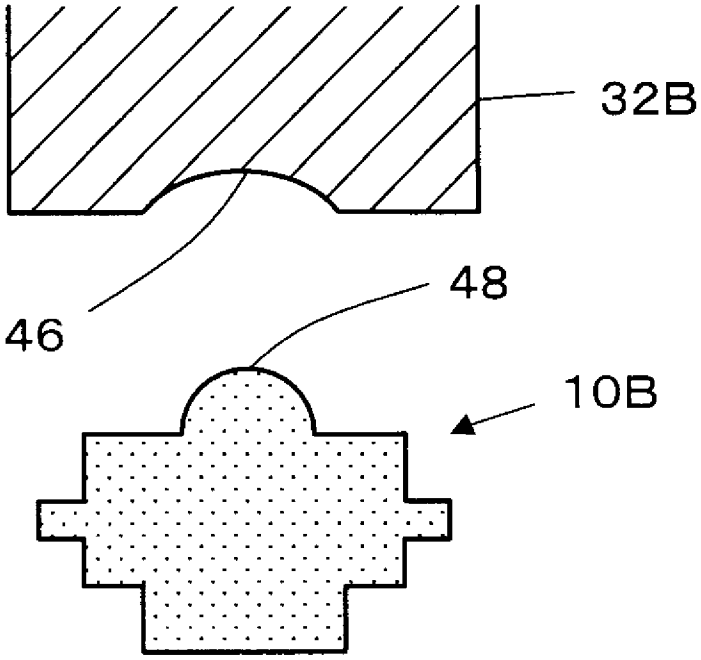
[Fig. 8]



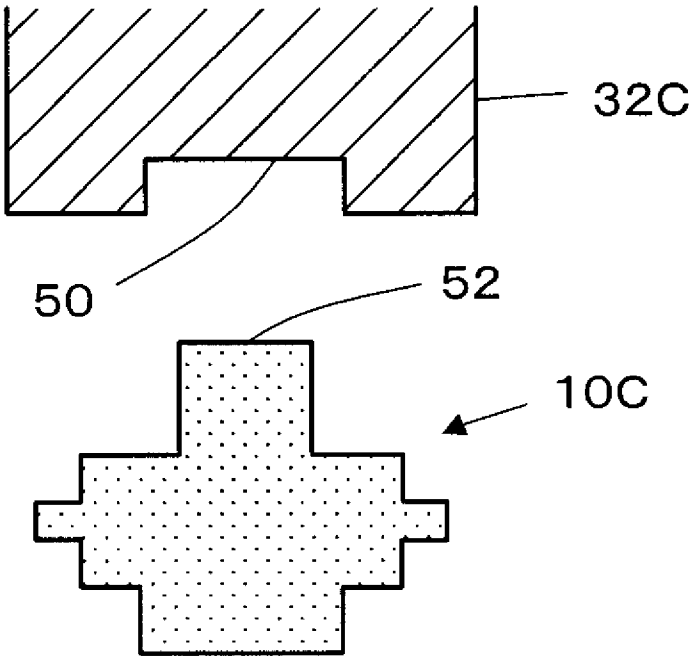
[Fig. 9]



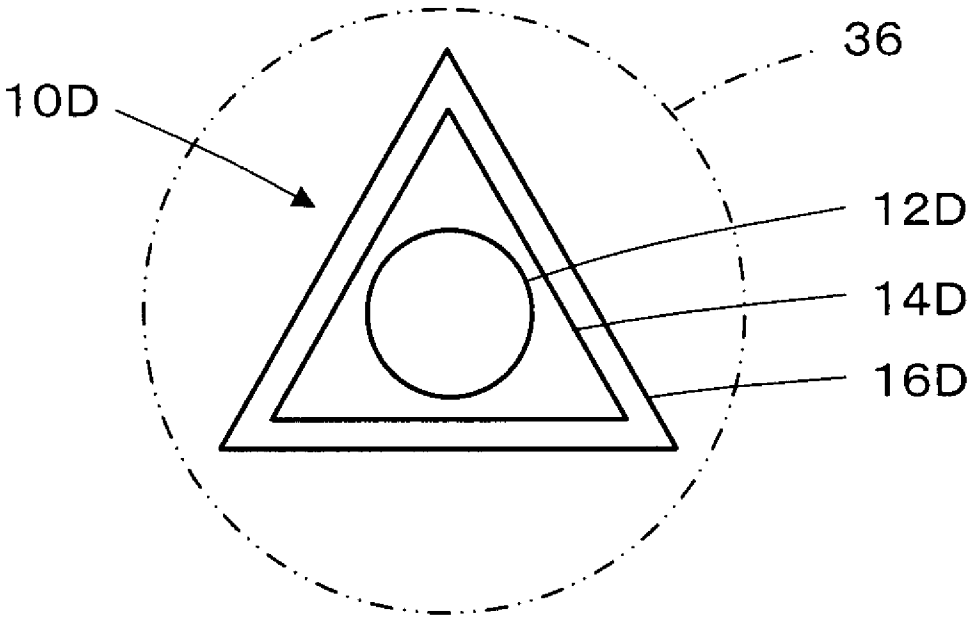
[Fig. 10]



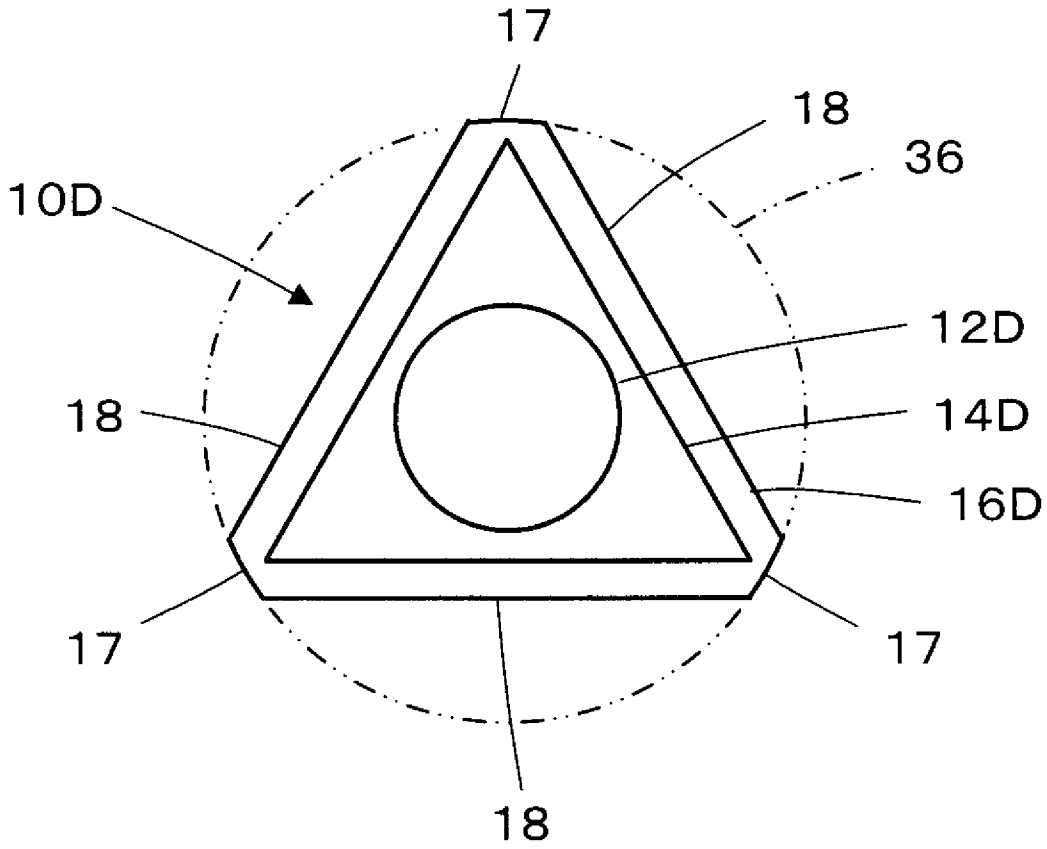
[Fig. 11]



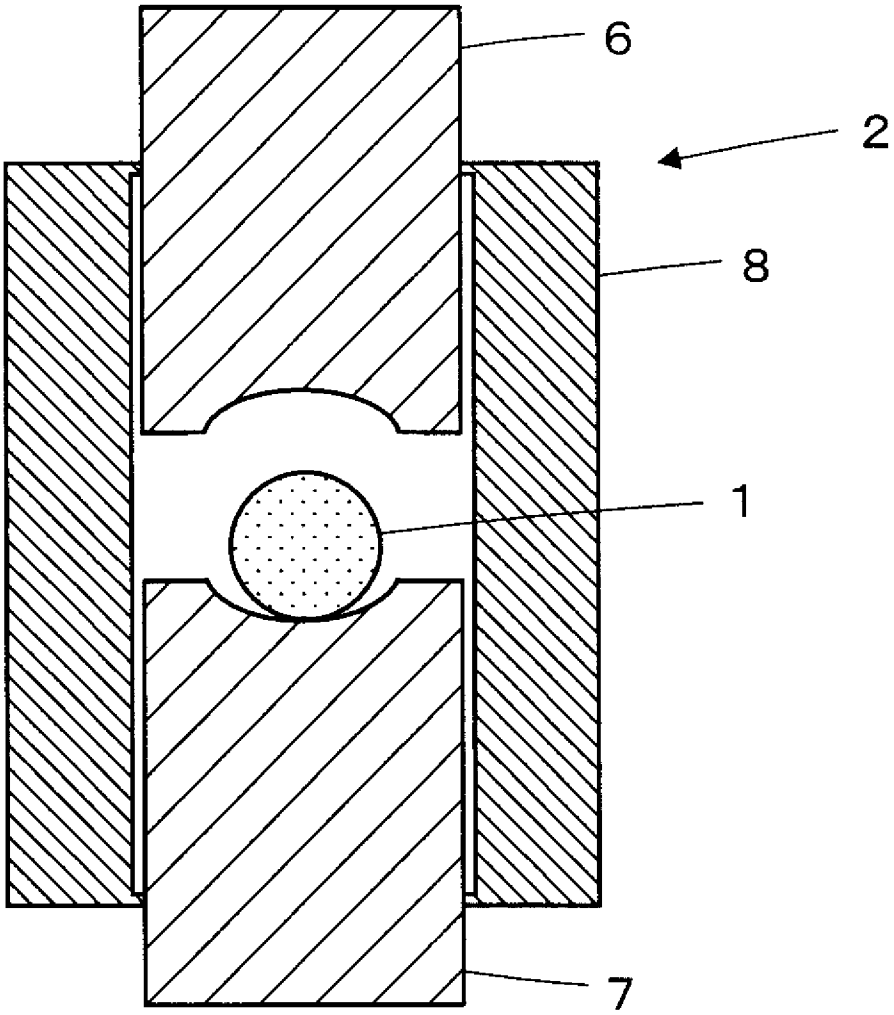
[Fig. 12]



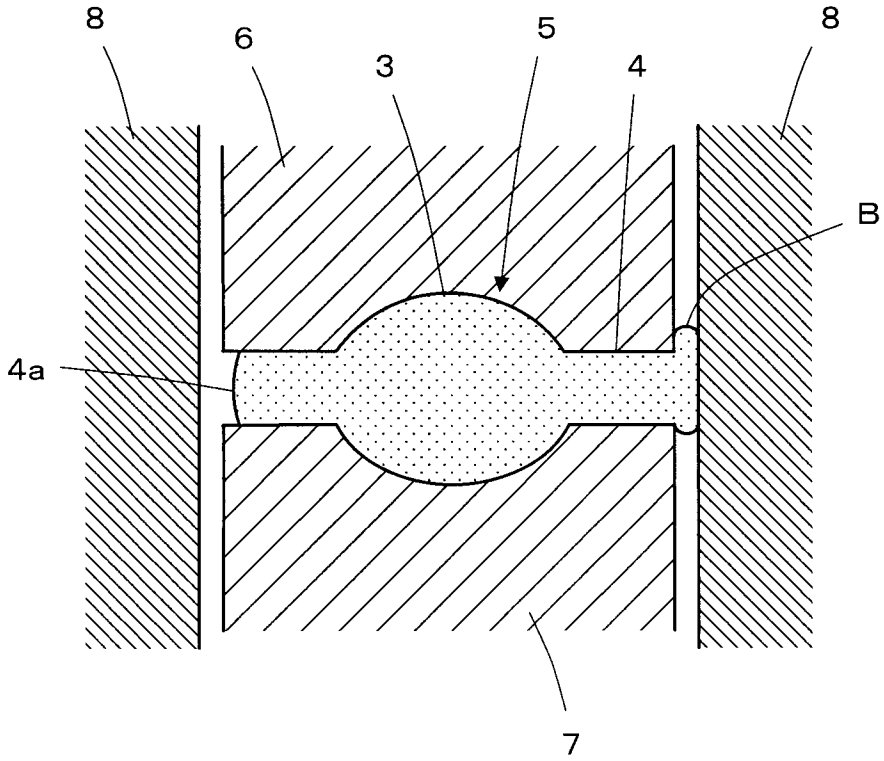
[Fig. 13]



[Fig. 14]



[Fig. 15]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2011/000433

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. B29D11/00(2006.01)i, C03B11/00(2006.01)i, G02B3/00(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)

Int.Cl. B29D11/00, C03B11/00, G02B3/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2011
Registered utility model specifications of Japan 1996-2011
Published registered utility model applications of Japan 1994-2011

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	JP 2000-313627 A (Asahi Optical Co., Ltd.) 2000.11.14, [0002],[0016]-[0023],[0037],[0051],[0052],[0063],Fig.2,Fig.3,Fig.6 (no family)	1-10
Y	JP 2007-331311 A (Fuji Photo Optical Co., Ltd.) 2007.12.27, [0016]-[0062],Fig.1-6 (no family)	1-10
Y	JP 2009-69774 A (FUJIFILM Corporation) 2009.04.02, [0083],[0084],Fig.12 & US 2010/0225013 A & EP 2188326 A & WO 2009/038222 A2 & CN 101802056 A & KR 10-2010-0074135 A	3,9
Y	JP 3003880 U (Shin-Etsu Polymer Co., Ltd.) 1994.08.24, [0005]-[0015],Fig.1-3 (no family)	4,10

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14.02.2011	22.02.2011

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