US010385802B2

(12) United States Patent
Nakaji

(10) **Patent No.: US 10,385,802 B2**
(45) **Date of Patent: Aug. 20, 2019**

(54) **PISTON OF INTERNAL COMBUSTION ENGINE**

(71) Applicant: **SUBARU CORPORATION**, Tokyo (JP)

(72) Inventor: **Takayuki Nakaji**, Tokyo (JP)

(73) Assignee: **SUBARU CORPORATION**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/622,621**

(22) Filed: **Jun. 14, 2017**

(65) **Prior Publication Data**

US 2018/0080407 A1 Mar. 22, 2018

(30) **Foreign Application Priority Data**

Sep. 16, 2016 (JP) 2016-181372

(51) **Int. Cl.**

F02F 3/26 (2006.01)
F02F 3/28 (2006.01)
F02B 23/10 (2006.01)

(52) **U.S. Cl.**

CPC ***F02F 3/26*** (2013.01); ***F02B 23/10*** (2013.01); ***F02F 3/28*** (2013.01); *F02B 2023/106* (2013.01); *Y02T 10/125* (2013.01)

(58) **Field of Classification Search**

CPC F02F 3/28; F02F 3/26
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,028,662	B2 *	4/2006	Tsuchida	F02B 17/005 123/276
7,770,556	B2	8/2010	Kihara et al.	
2011/0120410	A1	5/2011	Gue et al.	
2011/0203544	A1 *	8/2011	Katou	F02B 23/10 123/193.6

(Continued)

FOREIGN PATENT DOCUMENTS

CN	201835910	U	5/2011
CN	102080604	A	6/2011
CN	202031716	U	11/2011

(Continued)

OTHER PUBLICATIONS

Japanese Office Action dated Jan. 30, 2018, in Japanese Patent Application No. 2016-181372 (11 pages—Japanese with English machine translation).

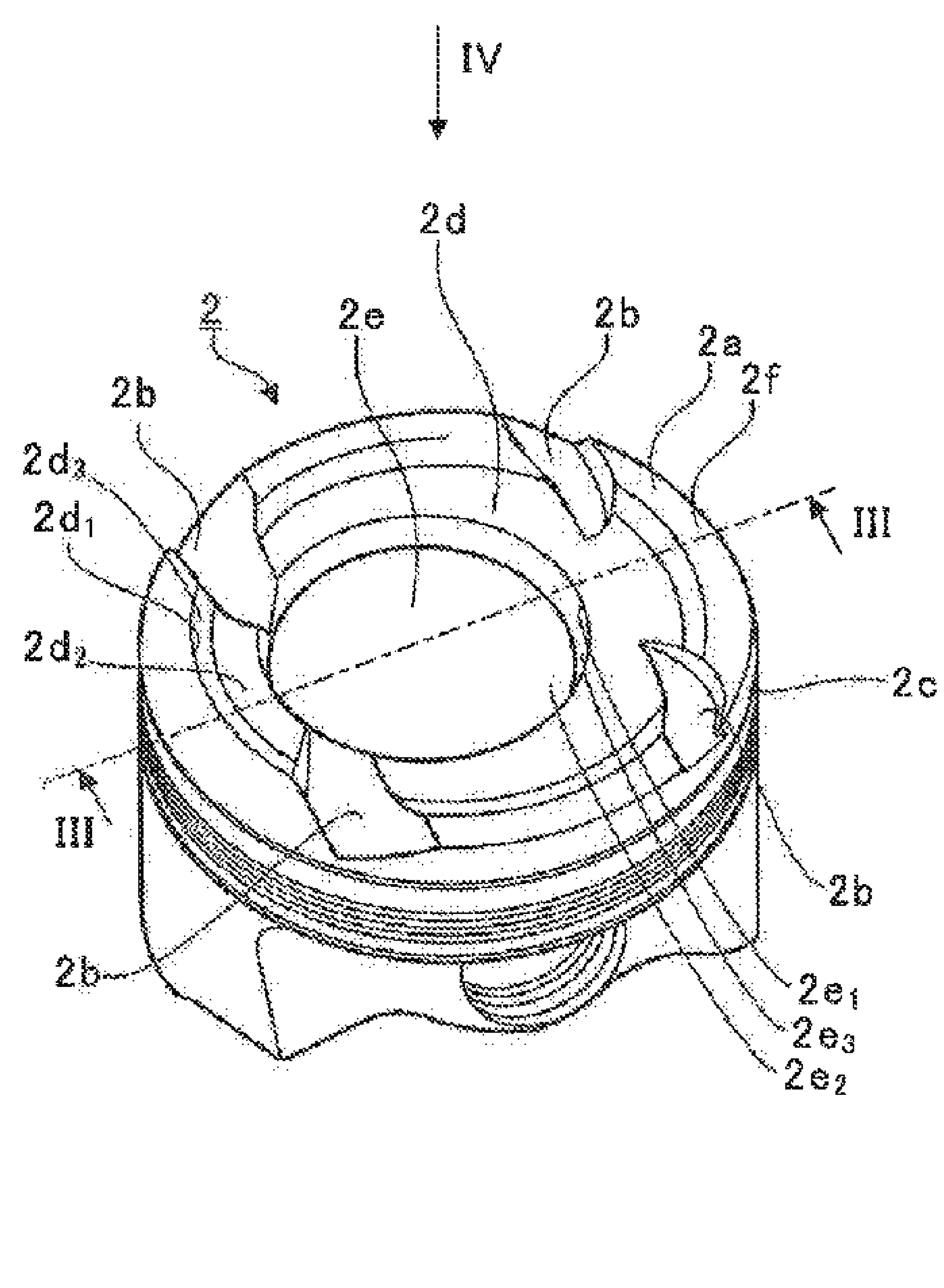
(Continued)

Primary Examiner — Kevin A Lathers
(74) *Attorney, Agent, or Firm* — Smith, Gambrell & Russell, LLP

(57) **ABSTRACT**

A piston of an internal combustion engine includes a crown surface, a first cavity, and a second cavity. The crown surface forms an internal wall surface of a combustion chamber. The first cavity is a depression provided in the crown surface. The second cavity is a depression provided inside the first cavity. The first cavity includes an upstream portion located upstream of the second cavity in a flow direction of a tumble flow flowing along the crown surface and a downstream portion located downstream of the second cavity in the flow direction. The upstream portion extends further in the flow direction than the downstream portion.

4 Claims, 6 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

2016/0177864 A1 6/2016 Sasaki et al.

FOREIGN PATENT DOCUMENTS

CN	203189138	U		9/2013
CN	105324570	A		2/2016
JP	2003-113717	A	*	4/2003
JP	2005-140006	A		6/2005
JP	2005-171814	A		6/2005
JP	2006-052663	A		2/2006
JP	2008-157197	A		7/2008
JP	2009-024683	A		2/2009
JP	2009-46985			3/2009
JP	2013-181493	A		9/2013

OTHER PUBLICATIONS

Office Action received in Chinese Patent Application No. 201710619160 dated Feb. 11, 2019 (6 pages in Chinese with machine translation).

* cited by examiner

FIG. 1

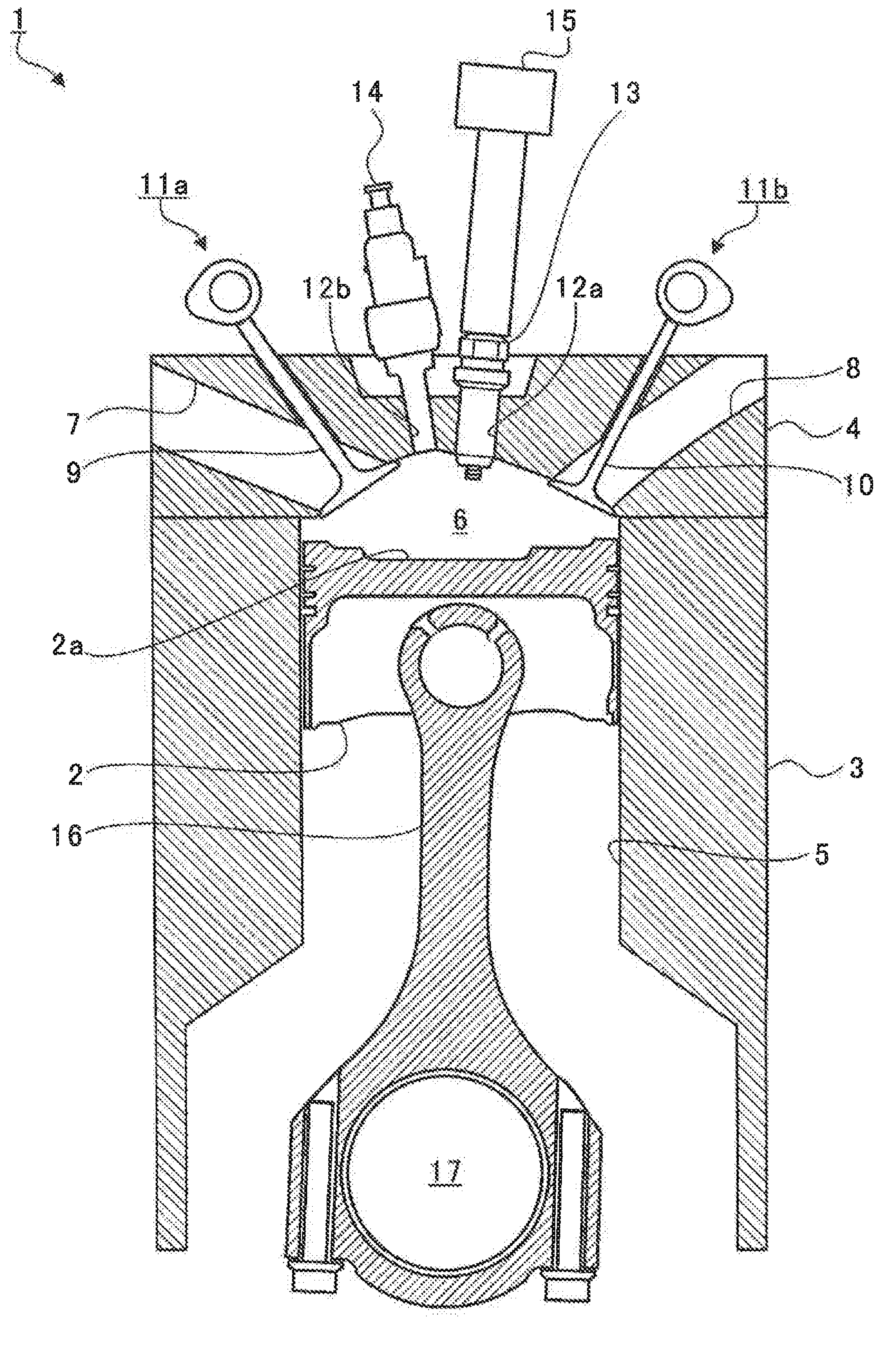


FIG. 2

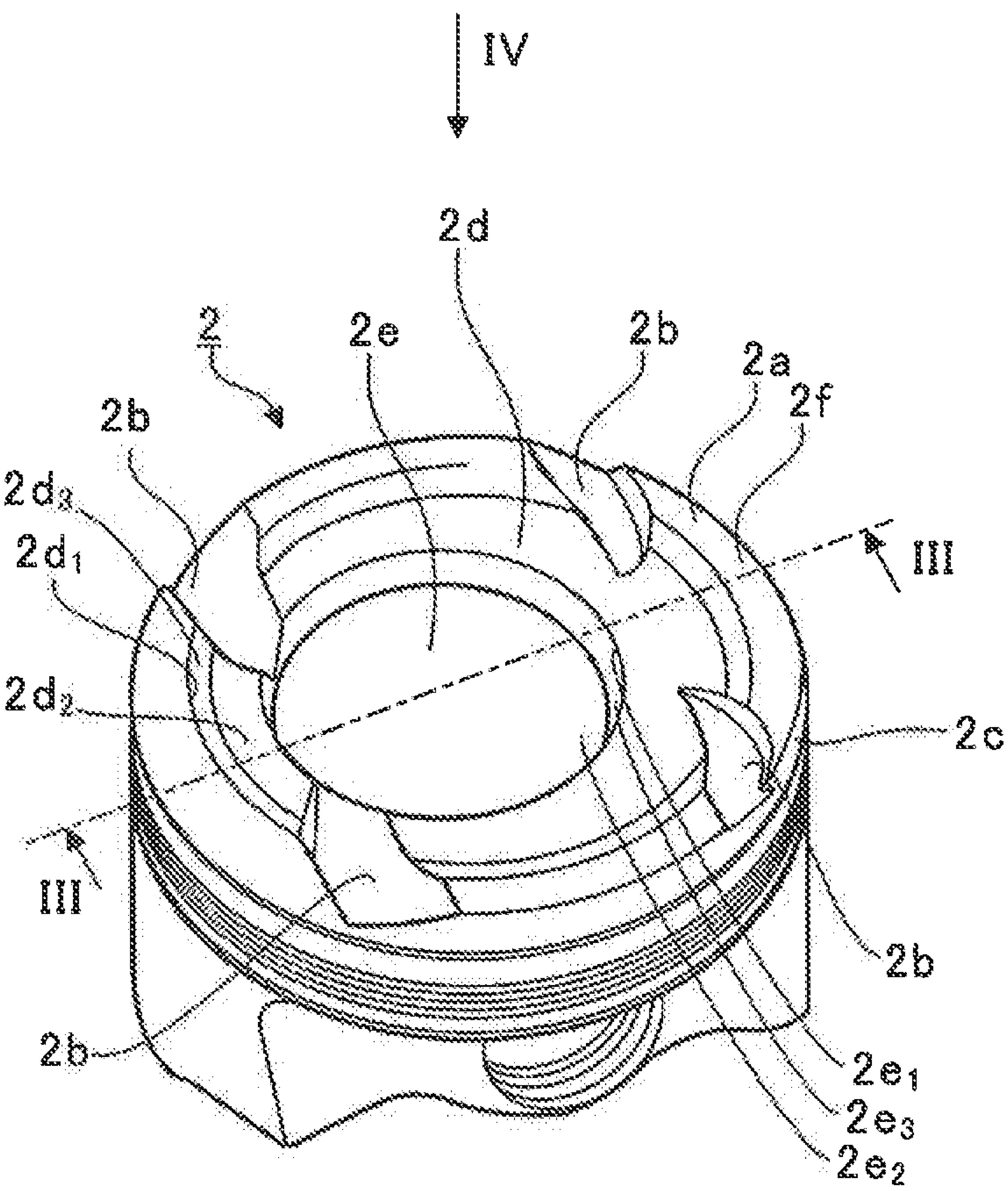


FIG. 3A

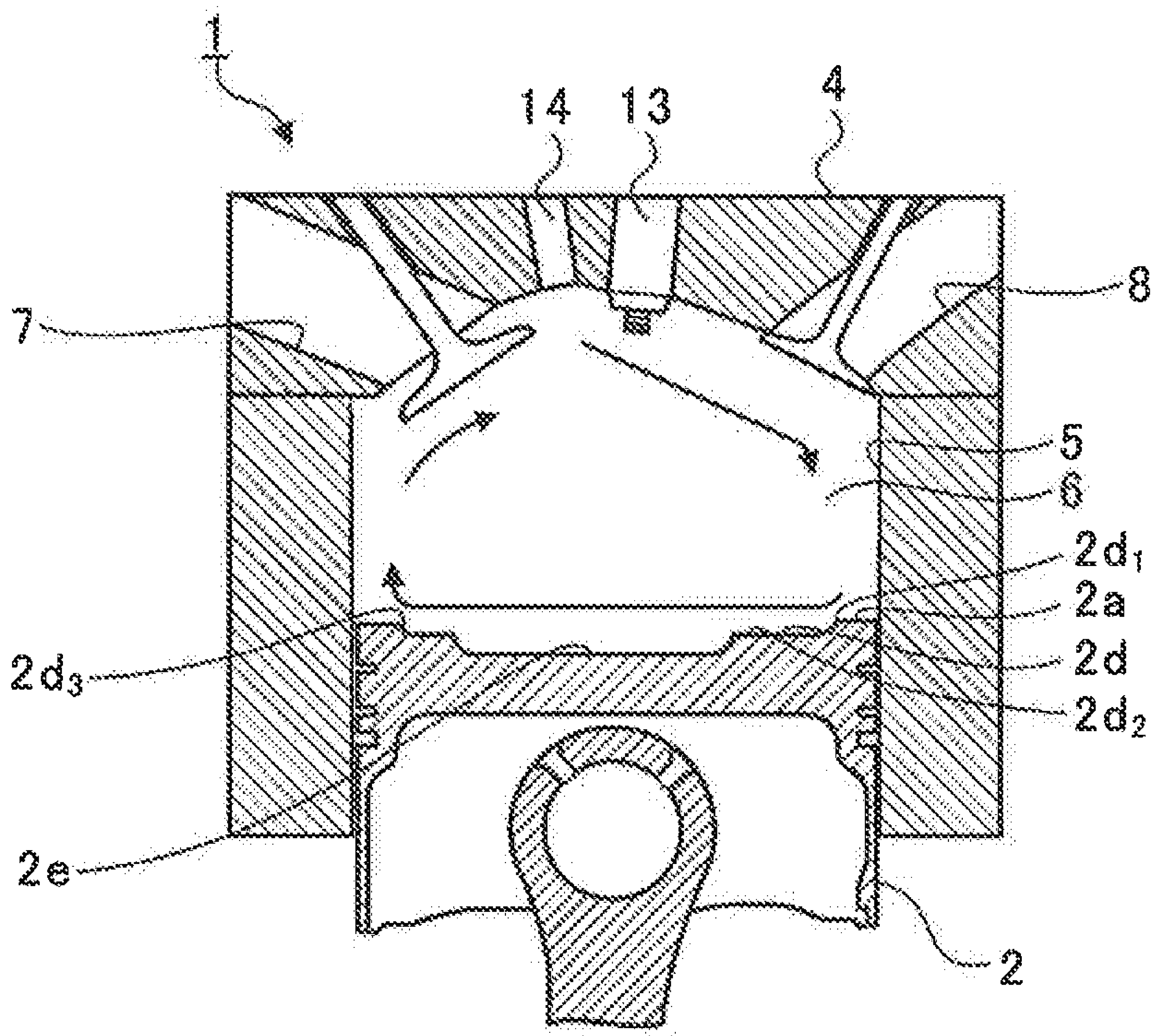

1
14
13
4
7
8
5
6
2d1
2a
2d
2d2
2d3
2e
2

FIG. 3B

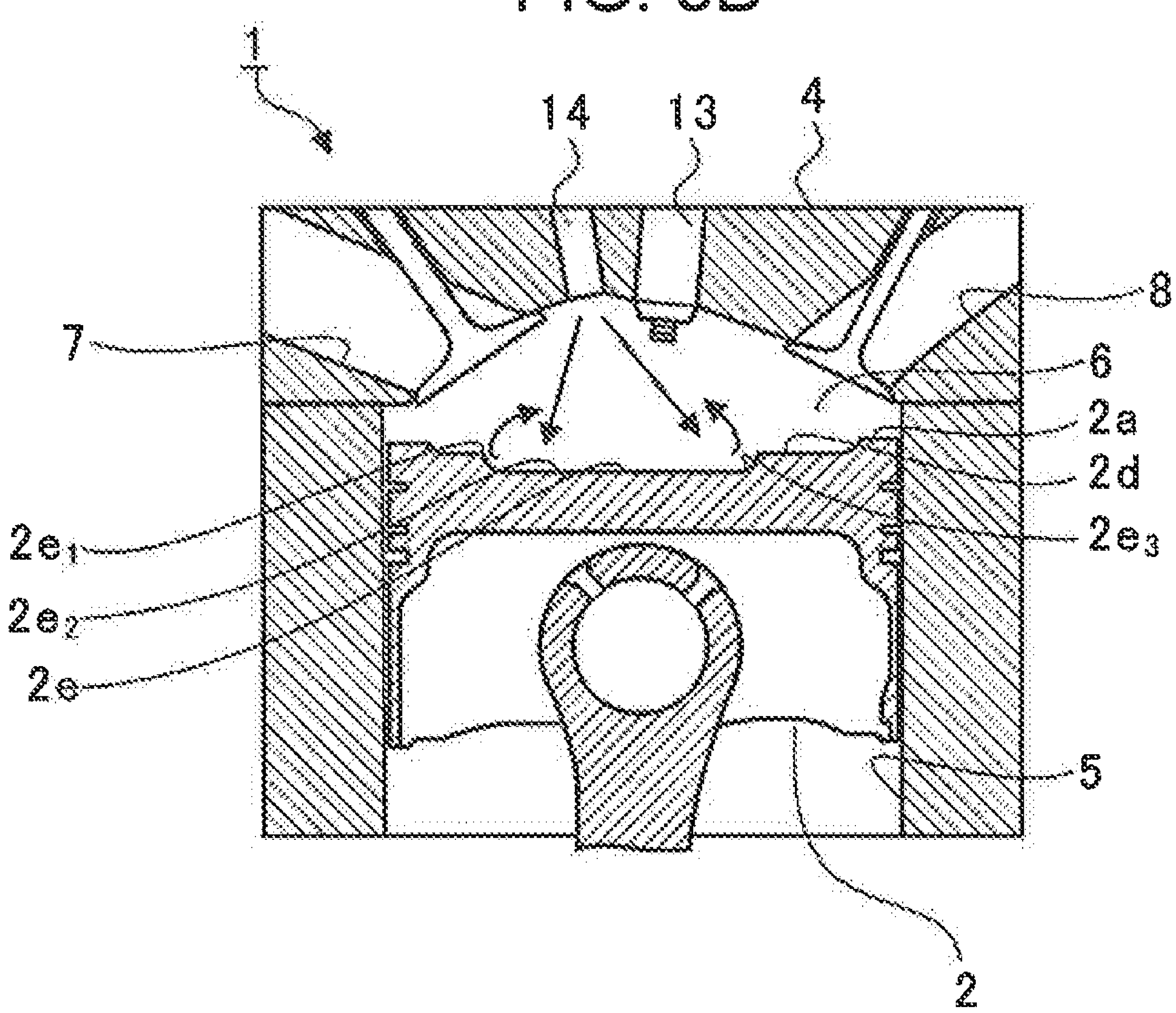

1
14
13
4
8
7
6
2a
2d
2e1
2e3
2e2
2e
5
2

FIG. 4

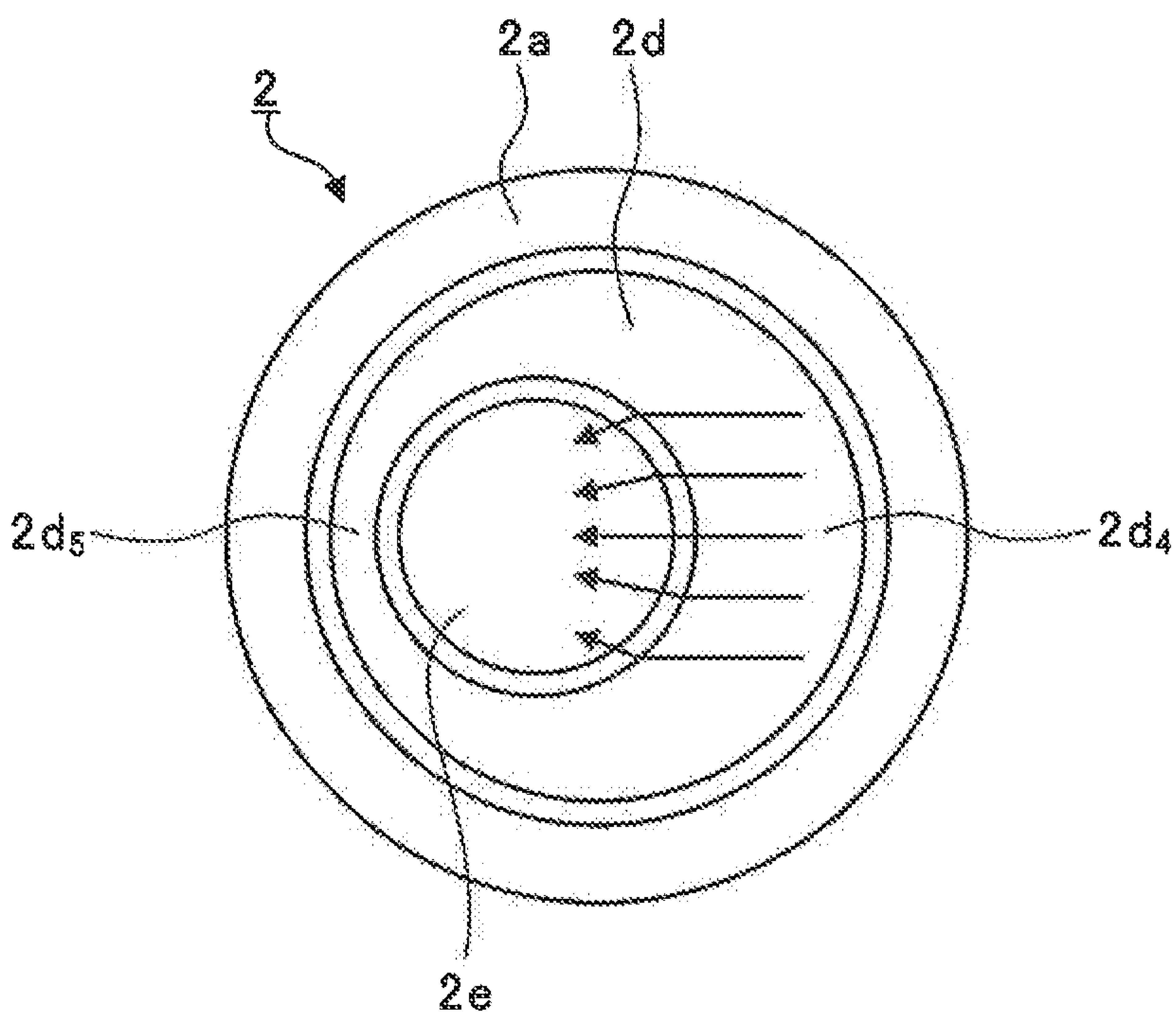


FIG. 5A

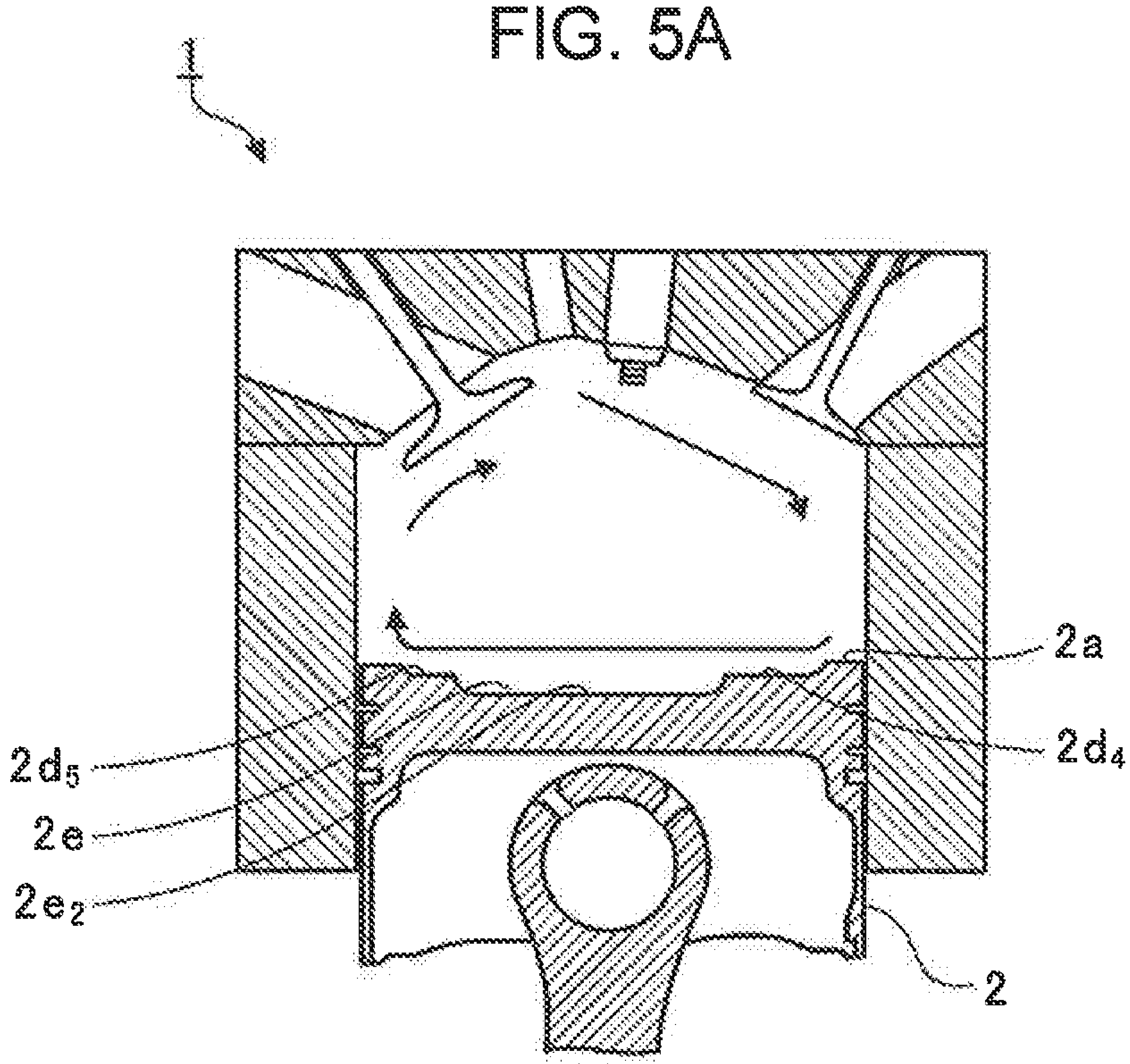


FIG. 5B

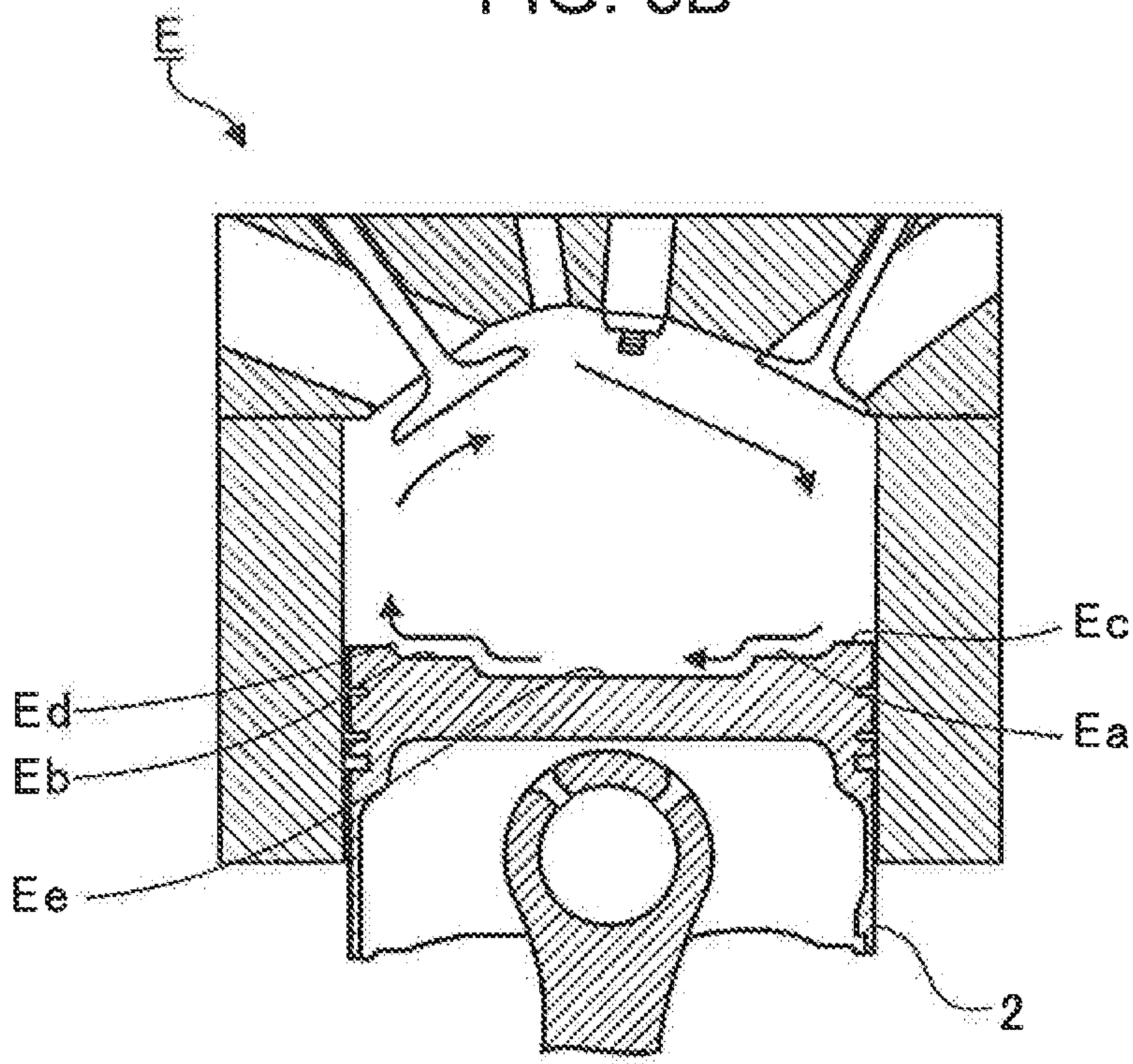


FIG. 6

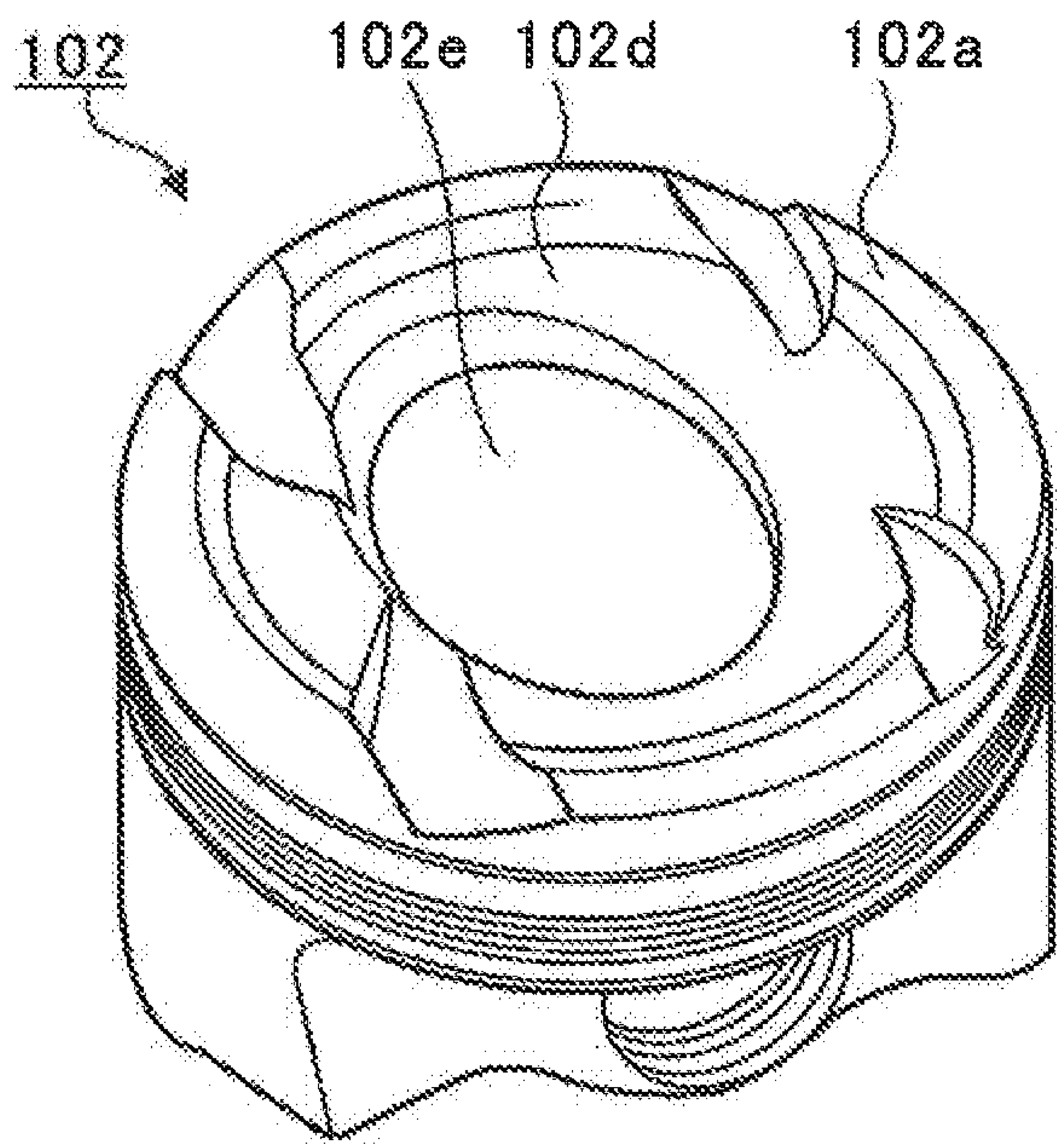
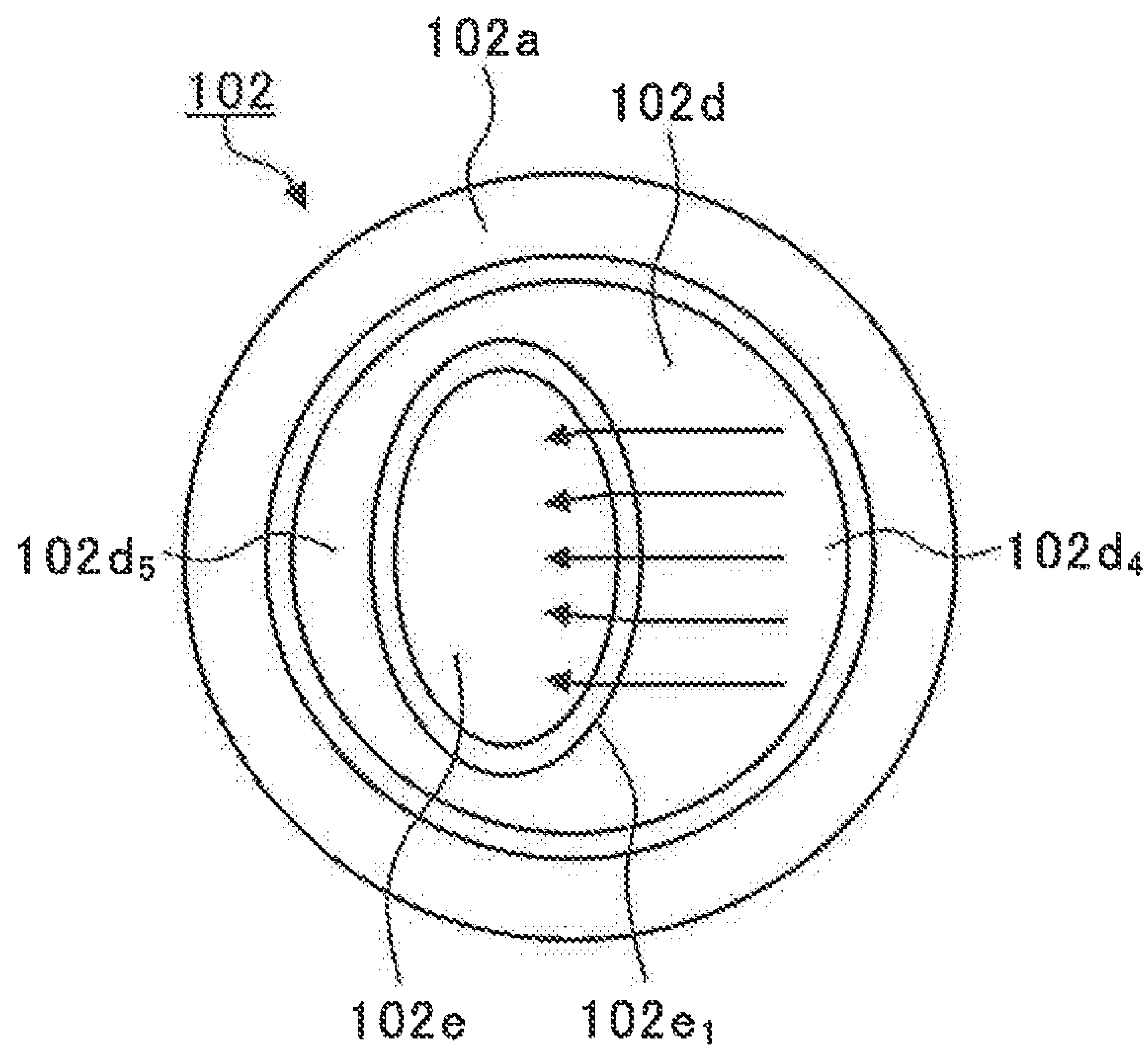


FIG. 7



PISTON OF INTERNAL COMBUSTION ENGINE

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority from Japanese Patent Application No. 2016-181372 filed on Sep. 16, 2016, the entire contents of which are hereby incorporated by reference.

BACKGROUND

1. Technical Field

The present invention relates to a piston of an internal combustion engine whose crown surface has a cavity.

2. Related Art

Pistons whose crown surfaces have cavities have been proposed. For instance, Japanese Unexamined Patent Application Publication (JP-A) No. 2008-157197 discloses a technology in which a crown surface of a piston is provided with two cavities and the two cavities are selectively utilized, that is, an injector is directed to one of the cavities during full-load operation and directed to the other cavity during cold start.

JP-A No. 2009-46985 discloses a technology in which a crown surface of a piston has a cavity that follows a tumble flow and an interior of the cavity is provided with a damper portion that reduces the tumble strength of tumble flow partially so that the tumble strength is made uniform.

An engine operates in a stratified lean burn mode under a low load condition and in a homogeneous combustion mode under an increased load condition. In order to realize the stratified lean burn mode, a cavity that guides sprayed fuel to an ignition plug is provided as described in JP-A No. 2008-157197. In order to realize the homogeneous combustion mode, a cavity is provided so as to follow tumble flow as described in JP-A No. 2009-46985.

When part of tumble flow of sprayed fuel enters, of two cavities provided in the foregoing manner, the cavity formed to guide sprayed fuel to the ignition plug, the incoming tumble flow reduces a flow speed, resulting in a non-uniform flow speed of the tumble flow and therefore degraded quality of the tumble flow.

SUMMARY OF THE INVENTION

It is desirable to provide an internal combustion engine piston that makes it possible to inhibit the deterioration of quality of tumble flow resulting from a non-uniform flow speed caused by crown cavities that guide fuel to an ignition plug.

A first aspect of the present invention provides a piston of an internal combustion engine that includes a crown surface configured to form an internal wall surface of a combustion chamber, a first cavity that is a depression provided in the crown surface, and a second cavity that is a depression provided inside the first cavity. The first cavity includes an upstream portion located upstream of the second cavity in a flow direction of a tumble flow flowing along the crown surface and a downstream portion of the first cavity located downstream of the second cavity in the flow direction. The upstream portion extends further in the flow direction than the downstream portion.

The second cavity may have an elliptical shape whose short axis lies in the flow direction.

A second aspect of the invention provides a piston of an internal combustion engine which includes a crown surface configured to face a combustion chamber, a first cavity that is a depression provided in the crown surface, and a second cavity that is a depression provided in the first cavity and that has an elliptical shape whose short axis lies in a flow direction of a tumble flow flowing along the crown surface.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic illustrative diagram of an engine (internal combustion engine).

FIG. **2** is a perspective view of a crown surface side of a piston.

FIGS. **3**A and **3**B are diagrams for describing functions of a first cavity and a second cavity.

FIG. **4** is a front view of a crown surface of the piston.

FIGS. **5**A and **5**B are diagrams for describing a function resulting from the length of an upstream portion.

FIG. **6** is a perspective view of the crown surface side of a piston according to a modification.

FIG. **7** is a front view of the crown surface of the piston according to the modification.

DETAILED DESCRIPTION

Preferred examples of the present invention will be described hereinafter with reference to the accompanying drawings. Dimensions, materials, other concrete numerical values, and the like indicated in conjunction with examples of the invention are merely illustrative for the purpose of facilitating the understanding of the invention and are not intended to limit the invention unless otherwise specified. In this specification and the accompanying drawings, elements that have substantially the same functions and configurations are referred to using the same characters and are not redundantly described and, furthermore, elements not directly relevant to the invention are omitted from the drawings.

FIG. **1** schematically illustrates an engine **1** (internal combustion engine) in a schematic sectional view taken along a center axis of a piston **2** of the engine **1**. FIG. **1** as well as FIGS. **3**A and **3**B and FIGS. **5**A and **5**B described later illustrate an intake port **7** and an exhaust port **8**, which will be described later, for the sake of easy understanding. However, actual configurations are not necessarily the same as illustrated. For instance, an intake port **7** and an exhaust port **8** are provided at each one of the near and far sides of the plane of the section indicated in each of FIGS. **1**, **3**A, **3**B, **5**A, and **5**B. The engine **1** is a four-stroke engine that undergoes cycles of an intake stroke, a compression stroke, a combustion stroke, and an exhaust stroke and includes a cylinder block **3**, a cylinder head **4**, and the piston **2** as illustrated in FIG. **1**.

The cylinder block **3** has a cylinder **5** in which the piston **2** is freely slidably housed. The cylinder block **3** may have one or more than one cylinder **5**.

The cylinder head **4** is coupled to a surface of the cylinder block **3** which includes an end of the cylinder **5**. In the engine **1**, a space defined by the cylinder **5** formed in the cylinder block **3**, a crown surface **2**a of the piston **2**, and the cylinder head **4** forms a combustion chamber **6**. That is, the crown surface **2**a of the piston **2** forms a portion of an internal wall surface of the combustion chamber **6**.

The cylinder head **4** has one or more than one (e.g., two) of each of an intake port **7** and an exhaust port **8** that communicate with the combustion chamber **6**. The cylinder head **4** is also provided with an intake valve **9** and an exhaust valve **10**.

The intake valve **9** is disposed in the cylinder head **4** so that a distal end of the intake valve **9** is positioned between the intake port **7** and the combustion chamber **6**. The intake valve **9** is moved by a cam mechanism **11***a* so that the intake port **7** communicates with and is closed to the combustion chamber **6**. The exhaust valve **10** is disposed in the cylinder head **4** so that a distal end of the exhaust valve **10** is positioned between the exhaust port **8** and the combustion chamber **6**. The exhaust valve **10** is moved by a cam mechanism **11***b* so that the exhaust port **8** communicates with and is closed to the combustion chamber **6**.

The cylinder block **3** houses an ignition plug **13** and an injector **14**. The cylinder block **3** has, at different positions, communicating portions **12***a* and **12***b* that are holes that communicate with the combustion chamber **6**. A distal end of the ignition plug **13** is inserted into the communicating portion **12***a*. A distal end of the injector **14** is inserted into the communicating portion **12***b*. The distal end of the injector **14** is positioned in the vicinity of a center of the combustion chamber **6** (so-called center injection).

A coil device **15** is attached to a rear end of the ignition plug **13** (an opposite end thereof to the combustion chamber **6**). The coil device **15** houses a primary coil and a secondary coil. As the magnetic field produced by the primary coil changes according to changes in the electric power supplied thereto from a battery or the like, an electromotive force is induced in the secondary coil. The electromotive force induced in the secondary coil is delivered to the ignition plug **13**, so that the ignition plug **13** produces a spark discharge.

In the engine **1**, after the injector **14** injects fuel at a predetermined timing, the fuel is ignited by the ignition plug **13**. Such combustion causes the piston **2** to move back and forth in the cylinder **5**, and the back-and-forth motion of the piston **2** is converted into rotational motion of a crankshaft **17** via a connecting rod **16**.

FIG. **2** is a perspective view of a crown surface **2***a* side of the piston **2**. As illustrated in FIG. **2**, a crown surface **2***a* has four recesses **2***b*. Each recess **2***b* extends from an outer peripheral surface **2***c* of the piston **2** to a radially inner side. The recesses **2***b* avoid interference of the piston **2** with the distal end of the intake valve **9** and the distal end of the exhaust valve **10** when the piston **2** is at the top dead center.

The piston **2** further has a first cavity **2***d* and a second cavity **2***e*. The first cavity **2***d* and the second cavity **2***e* are depressions formed in the crown surface **2***a*. The first cavity **2***d* and the second cavity **2***e* of the crown surface **2***a* of the piston **2**, when viewed from the front (viewed from the cylinder head **4** side), are substantially circular.

The first cavity **2***d* in the crown surface **2***a* is more depressed (further separated from the cylinder head **4**) than a top surface **2***f* which is located furthest toward the cylinder head **4** side, that is, nearest to the cylinder head **4**, in the crown surface **2***a*. Furthermore, the first cavity **2***d* is located further toward the radially inner side than the top surface **2***f* in the crown surface **2***a*, That is, the first cavity **2***d* is separated from the outer peripheral surface **2***c* of the piston **2**, In the first cavity **2***d*, an outer periphery **2***d***1** and a bottom surface **2***d***2** are connected by a curved surface **2***d***3**.

The second cavity **2***e* is a depression that is formed inside the first cavity **2***d* and that is deeper than the first cavity **2***d*. The second cavity **2***e* is separated radially inward from the outer periphery **2**d_1 of the first cavity **2***d*. Furthermore, similarly to the first cavity **2***d*, the second cavity **2***e* has an outer periphery **2**e_1 and a bottom surface **2**e_2 that are connected by a curved surface **2**e_3.

Of the four recesses **2***b*, two recesses **2***b* (two recesses on the right in FIG. **2**) extend from the outer peripheral surface **2***c* of the piston **2** into an interior of the first cavity **2***d* and are separated from the second cavity **2***e*. Of the four recesses **2***b*, the other two recesses **2***b* (the recesses on the left in FIG. **2**) extend from the outer peripheral surface **2***c* of the piston **2** into an interior of the second cavity **2***e* through the interior of the first cavity **2***d*.

FIGS. **3**A and **3**B are diagrams for describing functions of the first cavity **2***d* and the second cavity **2***e* and are schematic sectional views of the engine **1** taken along a center axis of the piston **2**, illustrating surroundings around the combustion chamber **6**. Furthermore, the sectional views of the piston **2** shown in FIGS. **3**A and **3**B are taken along line in FIG. **2**.

As indicated by arrows in FIG. **3**A, intake gas that flows from the intake port **7** into the combustion chamber **6** during the intake stroke flows toward a lower right portion of the combustion chamber **6** (a portion at the exhaust port **8** side and the crown surface **2***a* side of the piston **2**) in FIG. **3**A. After that, the intake gas is guided along an exhaust port **8** side inner wall of the cylinder **5**, flows along the crown surface **2***a* to the left side in FIG. **3**A (to the intake port **7** side), and is guided along an intake port **7** side inner wall of the cylinder **5** and returns to the upper side (the cylinder head **4** side) in FIG. **3**A. In this manner, in the engine **1**, intake gas forms tumble flows.

As illustrated in FIG. **3**A, the center of curvature of the curved surface **2**d_3 of the first cavity **2***d* is located above the top surface **2***f* of the piston **2**. The curved surface **2**d_3 on the right side in FIG. **3**A (on the exhaust port **8** side) functions as a guide that guides intake gas flowing downward to the right to the left side along the first cavity **2***d*. The curved surface **2**d_3 on the left side in FIG. **3**A (on the intake port **7** side) functions as a guide that guides intake gas flowing to the left side along the first cavity **2***d* to an upper side.

In this manner, the first cavity **2***d* functions as a guide that facilitates formation of tumble flow. In the engine **1**, forming tumble flow realizes the rapid combustion of fuel caused by a strong turbulence produced when the tumble flow breaks, so that fuel economy and combustion stability can be improved.

As illustrated in FIG. **3**B, the second cavity **2***e* is formed at a location that faces the injector **14**. The center of curvature of a curved surface **2**e_3 of the second cavity **2***e* is located above the bottom surface **2**d_2 relative to the piston **2**.

Fuel sprayed in, for instance, a conical shape (radial shape), from the injector **14** moves toward a bottom surface **2**e_2 of the second cavity **2***e* and then is guided by the curved surface **2***e*; toward the ignition plug **13** provided next to the injector **14**. Specifically, the second cavity **2***e* guides sprayed fuel to the ignition plug **13**. Therefore, in the engine **1**, a mixture having a high concentration of fuel is formed in the vicinity of the injector **14**, for instance, during low load operation, so that it becomes possible to realize stratified lean burn.

As described above, the piston **2** is provided with the first cavity **2***d* that facilitates formation of tumble flow and the second cavity **2***e* that guides fuel to the ignition plug **13** are provided. However, when tumble flow enters the second cavity **2***e*, the incoming tumble flow reduces a flow speed, resulting in a non-uniform flow speed of the incoming tumble flow and the tumble flow not entering the second cavity **2***e*. This results in deteriorated quality of tumble flow.

Therefore, the piston **2** is configured to stop tumble flow from entering the second cavity **2***e*.

FIG. **4** is a front view of the crown surface **2***a* of the piston **2** viewed as indicated by an arrow IV in FIG. **2**. FIG. **4** omits illustration of the recesses **2***b* in order to facilitate the understanding. In FIG. **4**, arrows indicate tumble flow flowing along the crown surface **2***a*. As illustrated in FIG. **4**, tumble flow moves along the crown surface **2***a* from the right side to the left side in FIG. **4** (from the exhaust port **8** side to the intake port **7** side).

A region in the first cavity **2***d* which is closer to the right side in FIG. **4** than the second cavity **2***e* will be referred to as "upstream portion $2d_4$". That is, the upstream portion $2d_4$ is a region in the first cavity **2***d* which is closer to the exhaust port **8** side than the second cavity **2***e*. Furthermore, a region in the first cavity **2***d* which is closer to the left side in FIG. **4** than the second cavity **2***e* will be referred to as "downstream portion $2d_5$". That is, the downstream portion. $2d_5$ is a region in the first cavity **2***d* which is closer to the intake port **7** side than the second cavity **2***e*.

The upstream portion $2d_4$ extends further in the flow direction of tumble flow flowing along the crown surface **2***a* (in the left-right direction in FIG. **4**) than the downstream portion $2d_5$. In other words, while the first cavity **2***d* is provided substantially at the center of the crown surface **2***a*, the second cavity **2***e* is offset from the center of the crown surface **2***a* to the intake port **7** side.

FIGS. **5**A and **5**B are diagrams for describing the function resulting from the length of the upstream portion $2d_4$. FIG. **5**A illustrates the engine **1** of this example while FIG. **5**B illustrates an engine E of a comparative example. As illustrated in FIG. **5**B, the engine E of the comparative example has an upstream portion. Ea and a downstream portion Eb that have substantially equal lengths in the flow direction of tumble flow flowing on a crown surface Ec. In other words, in the engine E of the comparative example, both the first cavity Ed and the second cavity Ee are formed substantially at the center of the crown surface Ec.

In the engine E of the comparative example, although tumble flow flows along the upstream portion Ea, the length of the upstream portion Ea is insufficient, so that the tumble flow reaches the second cavity Ee before being sufficiently urged to flow leftward. Therefore, the tumble flow enters the second cavity Ee and reduces a flow speed.

In contrast, in the example of the invention, since the upstream portion $2d_4$ is long as illustrated in FIG. **5**A, tumble flow flowing along the upstream portion $2d_4$ is sufficiently urged to flow leftward before reaching the second cavity **2***e*. Therefore, the tumble flow reaching the second cavity **2***e* has a high flow speed and therefore separates from the crown surface **2***a*, so that the tumble flow keeps flowing leftward without entering the second cavity **2***e*.

Because the tumble flow does not enter the second cavity **2***e* but keeps a distance from the second cavity **2***e*, the tumble flow is less subject to the viscosity of gas present in the vicinity of the bottom surface $2e_2$ of the second cavity **2***e*, so that the slowing down of part of the tumble flow is avoided. Thus, the tumble flow can be inhibited from having a non-uniform flow speed and therefore can be inhibited from deteriorating in quality.

FIG. **6** is a perspective view of a crown surface **102***a* side of a piston **102** according to a modification. In the foregoing example, the first cavity **2***d* and the second cavity **2***e* of the crown surface **2***a* of the piston **2** are substantially circular when viewed from the front (viewed from the cylinder head **4** side). In this modification, as illustrated in FIG. **6**, a first cavity **102***d* is substantially circular but a second cavity **102***e* is substantially elliptical.

FIG. **7** is a front view of the crown surface **102***a* of the piston **102** according to the modification. In FIG. **7**, arrows indicate tumble flow flowing along the crown surface **102***a*. As illustrated in FIG. **7**, in the modification, similar to the foregoing example, an upstream portion $102d_4$ extends further in the flow direction of tumble flow moving along the crown surface **102***a* (the left-right direction in FIG. **7**) than a downstream portion $102d_5$.

Furthermore, the second cavity **102***e* has a substantially elliptical shape with its short axis lying in the flow direction of tumble flow (the left-right direction in FIG. **7**). The long axis of the elliptical second cavity **102***e* is orthogonal to the flow direction of tumble flow.

In the case where the second cavity **102***e* is elliptical, the upstream portion $102d_4$ can be reliably made longer than in the case where the second cavity **102***e* is circular provided that the second cavities **102***e* in the two cases are designed to have equal volumes. That is, when a second cavity **102***e* that is elliptical and a second cavity **102***e* that is circular of the crown surfaces **102***a* in these two cases have equal areas when viewed from the front, since the short axis of the elliptical second cavity **102***e* is shorter than the diameter of the circular second cavity **102***e*, a long upstream portion $102d_4$ can be secured in the case where the circular second cavity **102***e* is provided. As a result, as in the foregoing example, tumble flow flowing along the upstream portion $102d_4$ is sufficiently urged to flow leftward and then reaches the second cavity **102***e*, so that, due to its flow speed, the tumble flow separates from the crown surface **102***a* and does not enter the second cavity **102***e*. Hence, the tumble flow can be effectively inhibited from having a non-uniform flow speed and therefore can be inhibited from deteriorating in quality.

Furthermore, when tumble flow reaches the second cavity **102***e* and separates from the crown surface **102***a*, the tumble flow tends to turn to directions orthogonal to tangents to the outer periphery $102e_1$ of the second cavity **102***e*. Specifically, as indicated by arrows in FIG. **7**, tumble flows flowing near two ends of a long axis of the elliptical second cavity **102***e* (upper and lower ends of the long axis in FIG. **7**) change their directions slightly toward the center of the elliptical second cavity **102***e*.

For instance, since the second cavity **102***e* is elliptical, the curvature of the outer periphery $102e_1$, from which tumble flow separates, is larger than in the case where the second cavity **102***e* is circular (provided that the aforementioned areas of the second cavities **102***e* are equal). Therefore, tumble flows change their directions toward the center of the elliptical second cavity **102***e* only to a small degree. In consequence, tumble flow is not disturbed and therefore is inhibited from deteriorating in quality.

As described above, the example and the modification can inhibit tumble flow from having a non-uniform flow speed and therefore from deteriorating in quality due to the cavities that guide fuel to the ignition plug.

While the preferred examples of the present invention have been described with reference to the drawings, it is apparent that these examples and the like do not limit the present invention. It is apparent to a person having ordinary skill in the art that other various modifications and the like can be conceived within the scope of the invention described in the claims and it can be understood that such modifications are naturally included within the technical scope of the invention.

For instance, in the foregoing example and modification, tumble flow flows clockwise after moving downward to the right from the intake port **7** in FIG. **3**A. However, tumble flow may flow counterclockwise in FIG. **3**A. Specifically, tumble flow, after flowing from the intake port **7** to a lower side in FIG. **3**A, may move to the right side and then move toward the exhaust port **8**. In the case where tumble flow flows counterclockwise in FIG. **3**A in this manner, an upstream portion **2**d_4, **102**d_4 is in a region in the first cavity **2***d*, **102***d* which is closer to the intake port **7** side than the second cavity **2***e*, **102***e*. A downstream portion **2**d_5, **102**d_5 is a region in the first cavity **2***d*, **102***d* which is closer to the exhaust port **8** side than the second cavity **2***e*, **102***e*.

The present invention can be used for internal combustion engine pistons whose crown surfaces have cavities.

The invention claimed is:

1. A piston of an internal combustion engine, comprising:

a crown surface configured to both form an internal wall surface of a combustion chamber and to receive a tumble flow along the crown surface;

a first cavity that is a depression provided in the crown surface; and

a second cavity that is a depression provided inside the first cavity, wherein

the first cavity includes an upstream portion located upstream of the second cavity in a flow direction of the tumble flow flowing along the crown surface and a downstream portion located downstream of the second cavity in the flow direction, the upstream portion extending farther in the flow direction than the downstream portion, and

wherein the second cavity has a curved wall surface extending between a more centralized region of the second cavity and up to a border region with the first cavity

wherein the crown surface has a radial outer surface extending radially inward from an outer periphery of the crown surface to a border location with the first cavity, and the first cavity has a curved surface extending between a more centralized region of the first cavity and up to a border region with the radial outer surface of the crown surface, and

said piston further comprising a plurality of recesses spaced circumferentially about the crown surface, with at least one recess extending through the radial outer surface and to the first cavity, and at least one other recess extending through the radial outer surface, within the first cavity, and to the second cavity.

2. The piston according to claim **1**, wherein the second cavity has an elliptical shape whose short axis lies in the flow direction.

3. A piston of an internal combustion engine, comprising:

a crown surface configured to both form an internal wall surface of a combustion chamber extending along a first axis and to receive a tumble flow along the crown surface;

a first cavity that is a depression provided in the crown surface; and

a second cavity that is a depression provided inside the first cavity, wherein

the first cavity includes an upstream portion located upstream of the second cavity in a flow direction of the tumble flow flowing along the crown surface and a downstream portion located downstream of the second cavity in the flow direction, the upstream portion extending farther in the flow direction than the downstream portion, and

wherein the crown surface has a radial outer surface extending radially inward from an outer periphery of the crown surface to a border location with the first cavity, and wherein the first cavity has a curved wall surface extending between a more centralized region of the first cavity and up to a border region with the radial outer surface, and

said piston further comprising a plurality of recesses spaced circumferentially about the crown surface, with at least one recess extending through the radial outer surface and to the first cavity, with at least one other recess extending through the radial outer surface, within the first cavity, to the second cavity.

4. The piston according to claim **3**, wherein the second cavity has an elliptical shape whose short axis lies in the flow direction.

* * * * *