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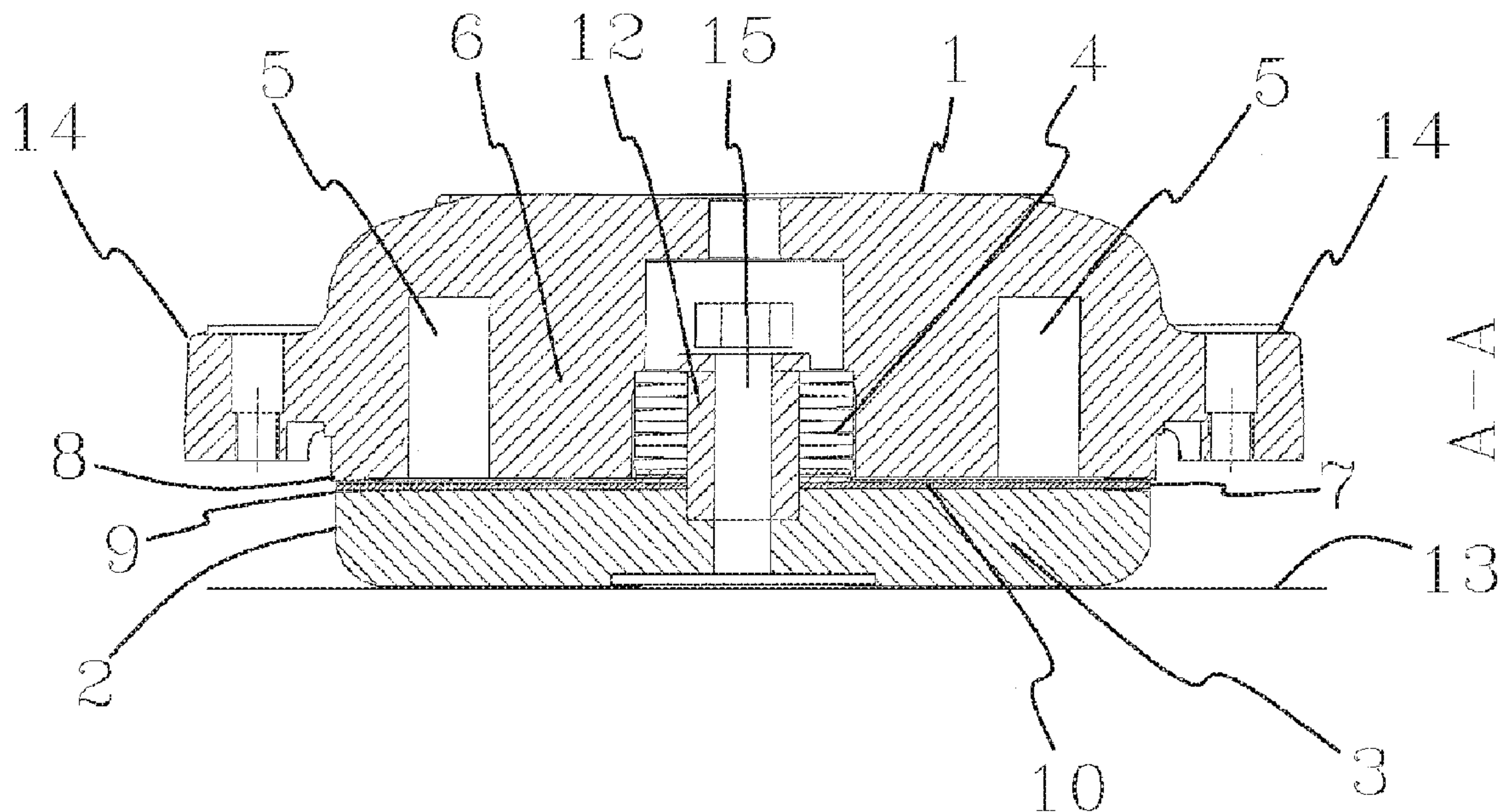


Fig. 1

(57) **Abrégé/Abstract:**

The invention relates to an electromagnetic brake and a method for making an electromagnetic brake. The electromagnetic brake comprises a frame part (1), an armature part (2) movably mounted on the frame part and having a magnetic core (3), one or more spring elements (4) for activating the brake by moving the said armature part (2) forwards, an electromagnet (5) fitted to the frame part (1) and arranged to release the brake by pulling the said armature part (2) backwards by resisting the said one or more spring elements (4), and a planar, elastically bendable damping plate (7) fitted to be bent when the armature part (2) is moving and, while being bent, to produce a damping force (F_d) resisting the bending to dampen brake noise.



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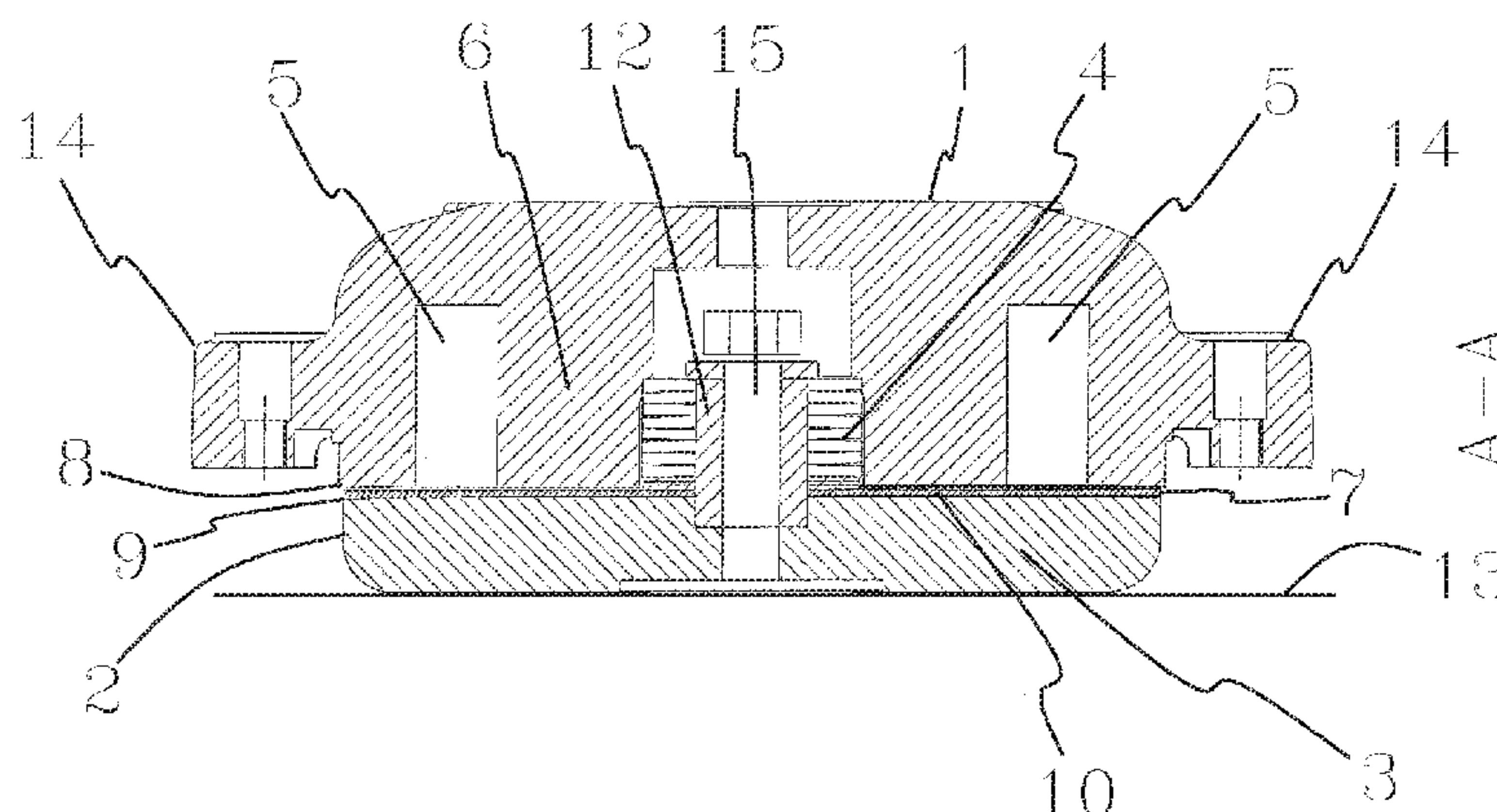


Fig. 1

(57) Abstract: The invention relates to an electromagnetic brake and a method for making an electromagnetic brake. The electromagnetic brake comprises a frame part (1), an armature part (2) movably mounted on the frame part and having a magnetic core (3), one or more spring elements (4) for activating the brake by moving the said armature part (2) forwards, an electromagnet (5) fitted to the frame part (1) and arranged to release the brake by pulling the said armature part (2) backwards by resisting the said one or more spring elements (4), and a planar, elastically bendable damping plate (7) fitted to be bent when the armature part (2) is moving and, while being bent, to produce a damping force (F_d) resisting the bending to dampen brake noise.

A BRAKE AND A METHOD FOR MAKING A BRAKE

Field of the invention

5 The present invention relates to solutions for damping brake noise.

Background of the invention

For example, in elevator hoisting machines, the braking device generally used is a machine
10 brake which mechanically engages the rotating part of the hoisting machine. The machine
brake may be constructed e.g. as a drum brake or a disc brake. The machine brake is
activated by interrupting the supply of electric current to the electromagnet of the brake. The
machine brake usually has springs which, when the brake is activated, force an armature part
provided with a brake pad against the braking surface of the rotating part to brake the
15 motion of the rotating part of the hoisting machine.

The brake is released by supplying current to the electromagnet of the brake. Release of the
brake is effected as the electromagnet pulls the brake pad off the braking surface of the
rotating part of the hoisting machine by resisting the pushing force produced by the springs.
20 During elevator operation, the electromagnet remains connected to the power supply, so the
brake is in the released state and the elevator car can move up or down in the elevator shaft.
The elevator brake may be e.g. so implemented that the same hoisting machine comprises
two or more machine brakes.

25 When the current through the electromagnet is falling, the force applied by the spring finally
exceeds the force of attraction of the electromagnet, and the brake is activated. As a result of
the imbalance between the forces, the brake pad strikes against the braking surface of the
rotating part of the machine. When the brake is released, the electromagnet again applies to
the armature part a force opposing the spring force. When the force applied by the
30 electromagnet to the armature part reaches a level exceeding the spring force, the air gap
between the frame part and the armature part is closed and the armature part strikes against

the frame part.

The impact occurring between the metallic brake parts upon activation or release of the brake may produce disturbing noise. There have been attempts to eliminate the noise problem by adding e.g. in the air gap between the frame part and the armature part a separate
5 damper which in the released state of the brake prevents direct contact between the metal surfaces of the frame part and the armature part. The damper can be made from elastic material, such as rubber or polyurethane; the damper can also be implemented as a spring designed for this purpose, such as a helical spring or diaphragm spring.

10 The air gap between the frame part and the armature part may vary due e.g. to the manufacturing tolerances of the damper. The force of attraction of the electromagnet is reduced as the airgap is increased, which means that releasing the brake / keeping the brake in the released state requires an increased amount of electric current. Generally speaking, power losses in the coil of the electromagnet are increased with the increase of the airgap,
15 and as the power losses are increased, the operating temperature of the brake also rises.

The damping power produced by the damper may also decline in the course of the service life of the brake; for example, the damping power of a damper made of polyurethane may gradually fall due to a high temperature. Again, the damping power of a spring may decline
20 due to fatigue, among other things. Decline of the damping power involves a deterioration of the functional capacity of the damper, i.e. its ability to dampen the noise of the brake.

Object of the invention

25 The object of the invention is to provide solutions to the drawbacks referred to above and presented below in the description of the invention. To achieve this object, the invention discloses an electromagnetic brake according to claim 1, a brake according to claim 3 and a method according to claim 13 for making a brake. Preferred embodiments of the invention are described in the sub-claims. Inventive embodiments and inventive combinations of
30 different embodiments are also presented in the description part of the application and in the drawings.

Brief description of the invention

The electromagnetic brake of the invention comprises: a frame part, an armature part
5 movably mounted on the frame part and having a magnetic core, one or more spring
elements for activating the brake by moving the said armature part forwards, an
electromagnet fitted to the frame part and arranged to release the brake by pulling the said
magnetic core and with it the armature part backwards by resisting the said one or more
spring elements, and additionally an elastically flexible damping plate having a planar shape
10 when in its rest position, said damping plate being fitted to be bent by the action of the force
moving the armature part. The damping plate is further fitted to resist bending with a
damping force that dampens the brake noise when the force moving the armature part is
bending the damping plate.

15 The invention also relates to a brake, which comprises a frame part, an armature part
movably mounted on the frame part, an air gap between frame part and armature part
counterfaces disposed facing towards each other, and additionally an elastically flexible
damping plate fitted in the air gap and having a planar shape when in its rest position, said
damping plate being fitted to resist bending with a damping force damping the brake noise.
20 At least one of the aforesaid counter-faces has a non-planar shape designed to flex the
damping plate.

The damping plate of the invention is fitted to be flexed preferably so that the edge portion
of the damping plate is bent with respect to the middle portion of the damping plate. The
25 damping plate of the invention having a planar shape when in its rest position makes it
possible to apply the damping force uniformly over the area of the brake, so that the motion
of the armature part can be controlled more accurately and within smaller tolerances than in
prior-art solutions. Uniform distribution of the damping force also means that point-like
damping forces are reduced, the magnitude of the damping force increases and the brake can
30 be so designed that the motion of the armature part will be very short. The short armature
part movement makes it possible for the kinetic energy bound in the armature part

movement to be reduced; as the kinetic energy is reduced, the brake noise is also damped. Moreover, the damping plate of the invention can be so designed that the damping force will grow rapidly when the damping plate is flexed, even if the total flexure of the damping plate is small. By virtue of the small total flexure, the fatigue imposed on a damping plate made of e.g. spring steel is low in spite of repeated flexing, which means that the operating time of the damping plate and consequently the service life of the brake will be very long.

In a preferred embodiment of the invention, the damping force is proportional to the degree of flexure of the damping plate. In a preferred embodiment of the invention, when the brake is being released, the damping force increases strongly as the armature part is approaching the frame part of the brake, thereby effectively dissipating the kinetic energy of the armature part and producing a resistance against contact between frame part and armature part.

In a preferred embodiment of the invention, the damping plate is fitted in an air gap between the frame part and armature part counterfaces disposed facing towards each other. In a preferred embodiment of the invention, the damping plate is made of magnetizable material, preferably spring steel. Such a damping plate reduces the effective air gap of the magnetic circle of the brake, thus allowing the required force of attraction between the electromagnet and the magnetic core to be produced by a reduced magnetizing current of the electromagnet. At the same time, power losses in the electromagnet are also reduced; on the other hand, this also makes it possible to reduce the size of the magnetizing coil, e.g. the amount of copper wires in the magnetizing coil.

In a preferred embodiment of the invention, one of the aforesaid counterfaces has a concave shape to flex the damping plate. To provide a concave counterface, it is possible to machine in the counterface e.g. a cutout, whose depth determines the magnitude of the flexure of the damping plate. In a preferred embodiment of the invention, one of the aforesaid counterfaces has a convex shape to flex the damping plate. To provide a convex counterface, it is possible to machine in the counterface e.g. a bulge or bevel, whose height / inclination determines the magnitude of the flexure of the damping plate. The area of action of the damping force as well as its magnitude with respect to the path of motion of the

armature part can be precisely defined from the geometry of the counterface / counterfaces, so the damping solution achieved is very accurate in respect of both manufacturing and adjustment tolerances, thus permitting a short armature part movement and at the same time a small air gap between the counterfaces to be achieved.

5

The brake of the invention is preferably a machine brake for an elevator, escalator or travelator.

The method of the invention for making a brake comprises forming for the brake a frame
10 part and an armature part movably supported on the frame part, forming counterfaces disposed oppositely to each other on the frame part and armature part, forming an elastically flexible damping plate which has a planar shape when in its rest position and which, when being flexed, produces a force resisting the flexing to dampen the brake noise, and fitting the damping plate in the air gap between the counterfaces in the brake.

15

In a preferred embodiment of the invention, one of the aforesaid counterfaces is formed in a concave shape to flex the damping plate.

In a preferred embodiment of the invention, one of the aforesaid counterfaces is formed in a
20 convex shape to flex the damping plate.

In a preferred embodiment of the invention, the damping plate is fitted to be engaged between the armature part and the frame part to flex the damping plate. The damping plate may be in contact with both the armature part and the frame part through the entire length of
25 the armature part movement or, on the other hand, the damping plate may be disengaged from the armature part and/or frame part in a portion of the range of movement of the armature part.

The damping plate may be implemented in many different forms; the damping plate may be
30 e.g. of a round (discoid) or square shape. The stiffness of the damping plate and therefore the force resisting the flexing of the damping plate can be adjusted, besides via choice of

material, also e.g. by varying the thickness of the damping plate. The flexing of the damping plate can be so implemented that the edge portion of the damping plate is bent by the same amount at every point relative to the middle portion, on the other hand, the flexing may also be so implemented that only two opposite edges of the plate are bent relative to the middle
 5 portion of the plate. The damping plate is preferably made of non-compressible material, such as metal.

The above summary, as well as the additional features and advantages of the invention to be described hereinafter, will be better understood from the following description of different
 10 embodiments of the invention, which is not to be interpreted as a restriction of the field of application of the invention.

Brief description of the figures

- | | | |
|----|------------------|--|
| 15 | Fig. 1 | represents a machine brake according to the invention for an elevator hoisting machine |
| | Fig. 2 | represents the machine brake of Fig. 1 in top view |
| | Fig. 3 | represents a brake damping plate used in the machine brake of Figs. 1 and 2 |
| 20 | Figs. 4a, 4b, 4c | present more detailed illustrations of some possible geometric designs of the counterfaces in the electromagnetic brake of the invention |
| | Fig. 5 | visualizes a graph of the damping force F_d as a function of flexure x of the damping plate |

25

Detailed description of preferred embodiments of the invention

In Fig. 1, the machine brake for an elevator hoisting machine presented in Fig. 2 is shown in cross-sectional view along line A – A. The frame part 1 of the machine brake is secured
 30 by mounting lugs 14 to the stationary machine frame of the hoisting machine. The frame part 1 is provided with an electromagnet, which comprises a magnetizing coil 5 and a coil

core 6 made of iron. The armature part 2 of the machine brake is movably secured to the frame part 1 with a bolt 15 and a sleeve 12 around the bolt 15, so that the armature part 2 can move along a determined path relative to the frame part 1. By moving the sleeve 12 along the bolt 15, it is also possible to adjust the distance of movement of the armature part 2, thereby adjusting the air gap 10 between the armature part 2 and the frame part 1. Springs 4 apply a pushing force between the frame part 1 and the armature part 2, so that the brake is activated to brake the motion of the rotating part of the hoisting machine when the springs 4 press the armature part 2 against the brake drum 13 of the rotating part of the hoisting machine. The range of action of the springs 4 is so designed that the pushing force generated by the springs 4 is constant with respect to the path of the armature part 2 or that only a small change in the pushing force occurs when the position of the armature part 2 changes. The brake is released by supplying current to the magnetizing coil 5 of the electromagnet; the current flowing in the coil 5 produces a force of attraction between the coil core 6 and the magnetic core 3 of the armature part made of magnetizable material, thus pulling the armature part 2 out of contact with the brake drum 13 by counteracting the pushing force of the springs 4.

When the brake is released and the armature part 2 starts moving towards the frame part 1, the force of attraction applied to the armature part 2 by the electromagnet begins to grow, because the air gap 10 between the coil core 6 and the magnetic core 3 in the brake magnetic circuit begins to decrease at the same time. The problem is that, due to the increasing force of attraction, the kinetic energy of the armature part 2 tends to grow high, which would result in a noisy impact of the armature part 2 against the frame part 1 of the brake.

25

To solve this problem, a damping plate 7 made of spring steel has been fitted in the air gap 10 between the coil core 6 and the magnetic core 3, see Fig. 1. The coil core 6 counterface 8 adjacent to the air gap 10 has been made somewhat concave, and, correspondingly, the magnetic core 3 counterface 9 of the armature part adjacent to the air gap has been made somewhat convex. Consequently, as the armature part 2 is moving towards the frame part 1 when the brake is being released, the damping plate 7 tends to

30

bend in such manner that the edge portion 16 of the damping plate is bent relative to the middle portion 17. The damping plate resists bending with force F_d , which is proportional to the magnitude of the flexure x , see Fig. 5. The force F_d grows rapidly as the flexion advances and the armature part 2 is approaching the frame part. The force also acts in the
5 opposite direction relative to the motion of the armature part 2, so the force F_d tends to resist contact between the counterfaces 8, 9 of the frame part 1 and armature part 2, thereby effectively damping the disturbing noise produced by the impact between the armature part 2 and the frame part 1.

10 Fig. 3 represents the circular damping plate 7 used in the machine brakes of Figs. 1 and 2, depicted in top view. The diameter of the damping plate 7 is substantially equal to the diameter D of the frame part 1 and armature part 2 counterfaces 8, 9 adjacent to the air gap 10, see Fig. 1. The flexing of the damping plate 7 takes place in such a way that the rim portion 16 of the damping plate is bent with respect to the middle portion 17. Thus,
15 the force F_d applied by the damping plate 7 is evenly distributed over the entire length of the rim portion 16 and, on the other hand, in the middle portion 17 of the damping plate the force is distributed uniformly over a maximal area; consequently, the pressure applied to the surfaces pressed against each other when the damping plate 7 is bent remains low. Moreover, the damping plate 7 largely fills the air gap 10 between the frame part 1 and the
20 armature part 2. As the damping plate 7 is made of magnetizable material, the effective air gap of the magnetic circle of the brake is reduced, the reluctance of the magnetic circle is reduced and the current requirement of the magnetizing coil 5 is reduced as well. The damping plate 7 is provided with a hole 11 in which the bolt 15 and sleeve 12 are placed, so that, together with the springs 4 pressing against the damping plate 7, they center the
25 damping plate 7 in position in the air gap 10.

Figs. 4a, 4b and 4c visualize a few geometric designs that can be used in shaping the counterfaces 8, 9 of the coil core 6 and magnetic core 3 of the brake, adjacent to the air gap. In the figures, certain features, such as convexity /concavity of the counterface, are
30 exaggerated to visualize the working principle.

In the solution of Fig. 4a, the coil core 6 counterface 8 adjacent to the air gap 10 has been beveled into a concave shape and the magnetic core 3 counterface 9 adjacent to the air gap 10 has been beveled into a convex shape, in such manner that the bevel angles α are equal in both counterfaces. In the solution of Fig. 4b, the coil core 6 counterface 8 adjacent to the air gap 10 has been beveled into a concave shape while the magnetic core 3 counterface 9 adjacent to the air gap 10 is flat; however, in this case, the diameter D' of the magnetic core 3 counterface 9 is substantially smaller than the diameter D of the coil core 6 counterface 8 and that of the damping plate 7. In the solution of Fig. 4c, the damping plate 7 has been pre-tensioned from its rest position so that the damping plate 7 is in a slightly bent position even when the brake is in the activated state. "Rest position" of the damping plate 7 thus refers to a position in which the damping plate 7 is in a non-flexed state (Figs. 4a, 4b).

The solutions of Figs. 4a – 4c could also be implemented the other way round, by employing an arrangement where the magnetic core 3 counterface 9 adjacent to the air gap 10 is concave and the coil core 6 counterface 8 adjacent to the air gap 10 in the embodiments of Figs. 4a and 4c is convex, and where the coil core 6 counterface 8 adjacent to the air gap 10 in the embodiment of Fig. 4b is flat and has a smaller diameter than the diameter D of the magnetic core 3 counterface 9 adjacent to the air gap 10 and that of the damping plate 7.

It is obvious to a person skilled in the art that different embodiments of the invention are not limited to the examples described above, but that they may be varied within the scope of the claims presented below.

It is further obvious to the skilled person that the damping solution of the invention is applicable for use both in drum brakes and in disc brakes.

CLAIMS

1. An electromagnetic brake, comprising:
 - 5 a frame part (1);
 - an armature part (2) movably mounted on the frame part and having a magnetic core (3);
 - one or more spring elements (4) for activating the brake by moving the said armature part (2) forwards;
 - 10 an electromagnet (5) fitted to the frame part (1) and arranged to release the brake by pulling the said armature part (2) backwards by resisting the said one or more spring elements (4);
 - characterized in that the brake comprises a planar, elastically bendable damping plate (7) fitted to resist bending with a damping force (F_d) damping the
15 brake noise when the force moving the armature part (2) is bending the damping plate (7).
2. A brake according to claim 1, characterized in that the damping plate (7) is fitted in an air gap (10) between the frame part (1) and armature part (2) counterfaces (8, 9) disposed facing towards each other.
- 20 3. A brake, comprising:
 - a frame part (1);
 - an armature part (2) movably mounted on the frame part;
 - an air gap (10) between frame part (1) and armature part (2) counterfaces (8, 9) disposed facing towards each other;
 - 25 characterized in that the brake comprises a planar, elastically bendable damping plate (7) fitted in the air gap (10) and adapted to resist bending with a damping force (F_d) damping the brake noise;
 - and that at least one of the aforesaid counterfaces (8, 9) is non-planar to bend the damping plate (7).
- 30 4. A brake according to any one of the preceding claims, characterized in that the damping force (F_d) is proportional to the magnitude of the flexure (x) of the

damping plate (7).

5. According to any one of the preceding claims, characterized in that the damping plate (7) is fitted to bend when the brake is being released.

6. A brake according to any one of the preceding claims, characterized in that the damping force (F_d) produced by the damping plate (7) is applied to resist contact between the counterfaces of the frame part (1) and armature part (2).

7. A brake according to any one of claims 2 – 6, characterized in that one of the said counterfaces (8, 9) is concave to bend the damping plate (7).

8. A brake according to claim 7, characterized in that one of the said counterfaces (8, 9) is convex to bend the damping plate (7).

9. A brake according to any one of the preceding claims, characterized in that the damping plate (7) is made of spring steel.

10. A brake according to any one of the preceding claims, characterized in that the brake is a machine brake for an elevator, escalator or travelator.

11. A brake according to any one of the preceding claims, characterized in that the damping plate (7) is provided with a hole (11) for centering the damping plate (7) in position.

12. A brake according to any one of claims 2 – 11, characterized in that the diameter of the damping plate (7) is substantially equal to the diameter (D) of the counterface (8, 9).

13. A method for making a brake, in which method:

- a frame part (1) and an armature part (2) movably supported on the frame part are formed for the brake
- counterfaces (8, 9) disposed opposite to each other are formed on the frame part (1) and on the armature part (2)

characterized in that:

- a planar, elastically flexible damping plate (7) is formed, which, when being bent, produces a force (F_d) resisting the bending so as to dampen brake noise
- the damping plate (7) is fitted in an air gap (10) between the counterfaces (8, 9) in the brake.

14. A method according to claim 13, characterized in that

- one of the counterfaces (8, 9) is formed in a concave shape to bend the damping plate (7).

15. A method according to claim 14, characterized in that

- one of the counterfaces (8, 9) is formed in a convex shape to bend the damping plate (7).

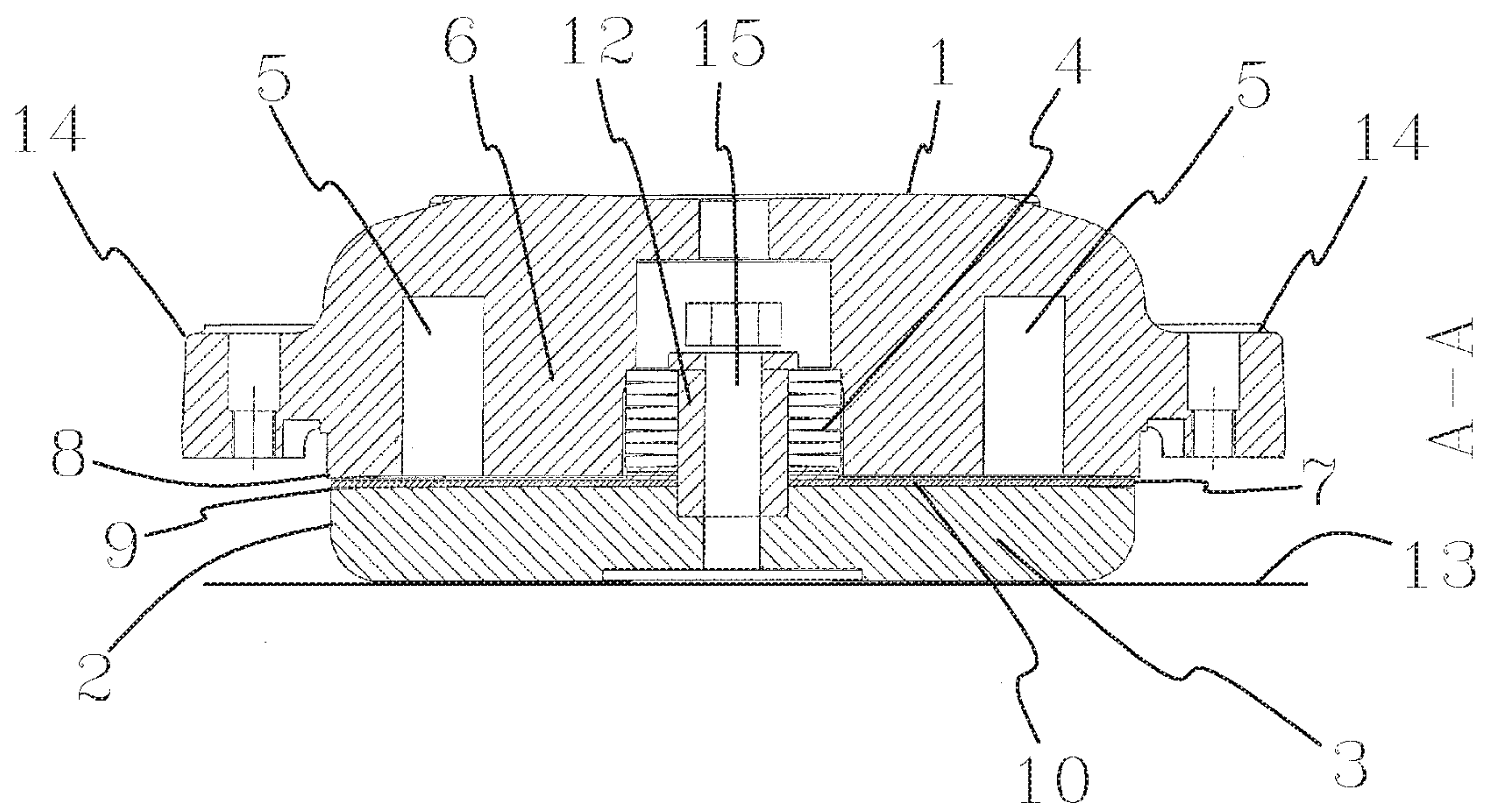


Fig. 1

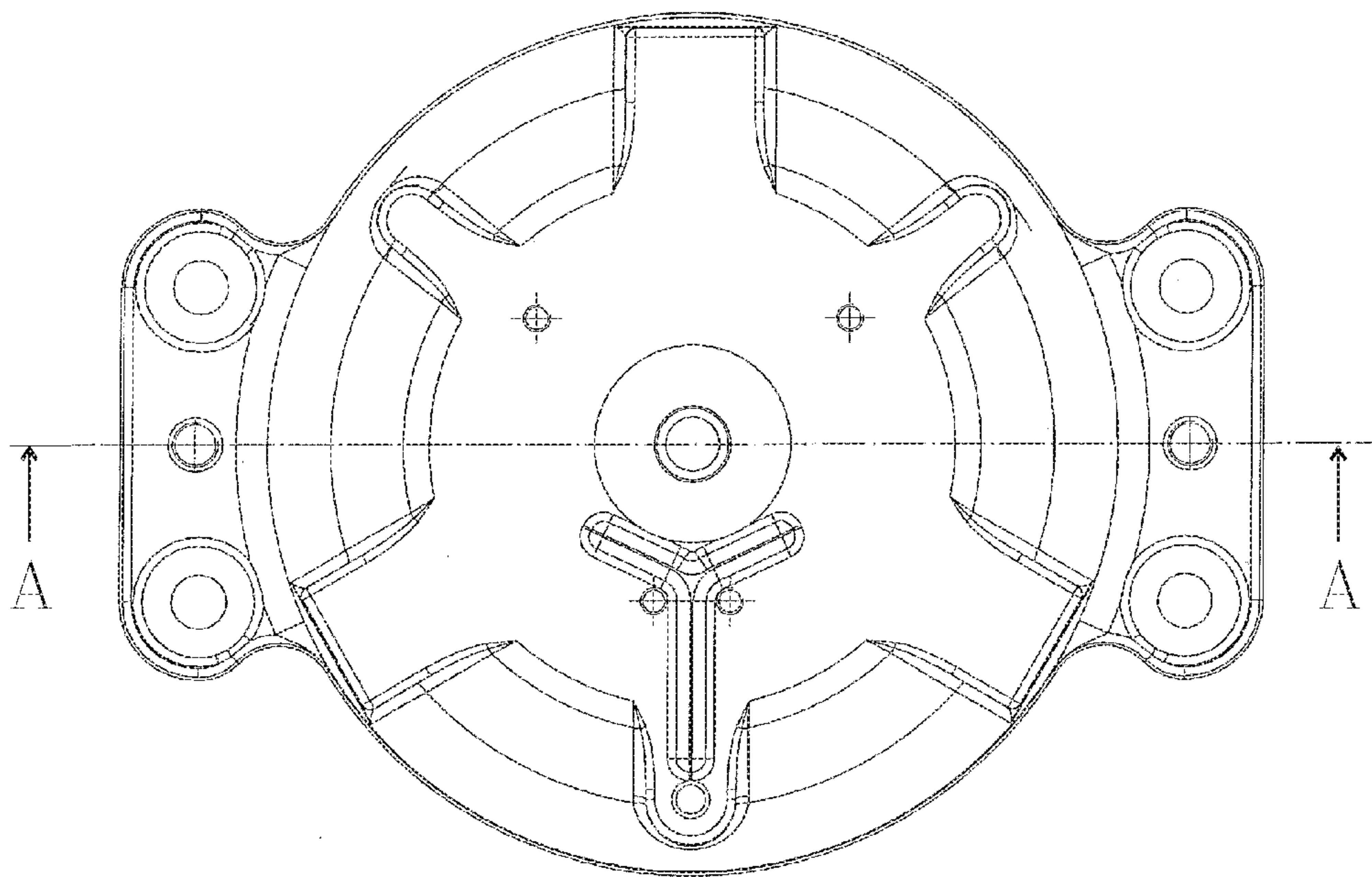


Fig. 2

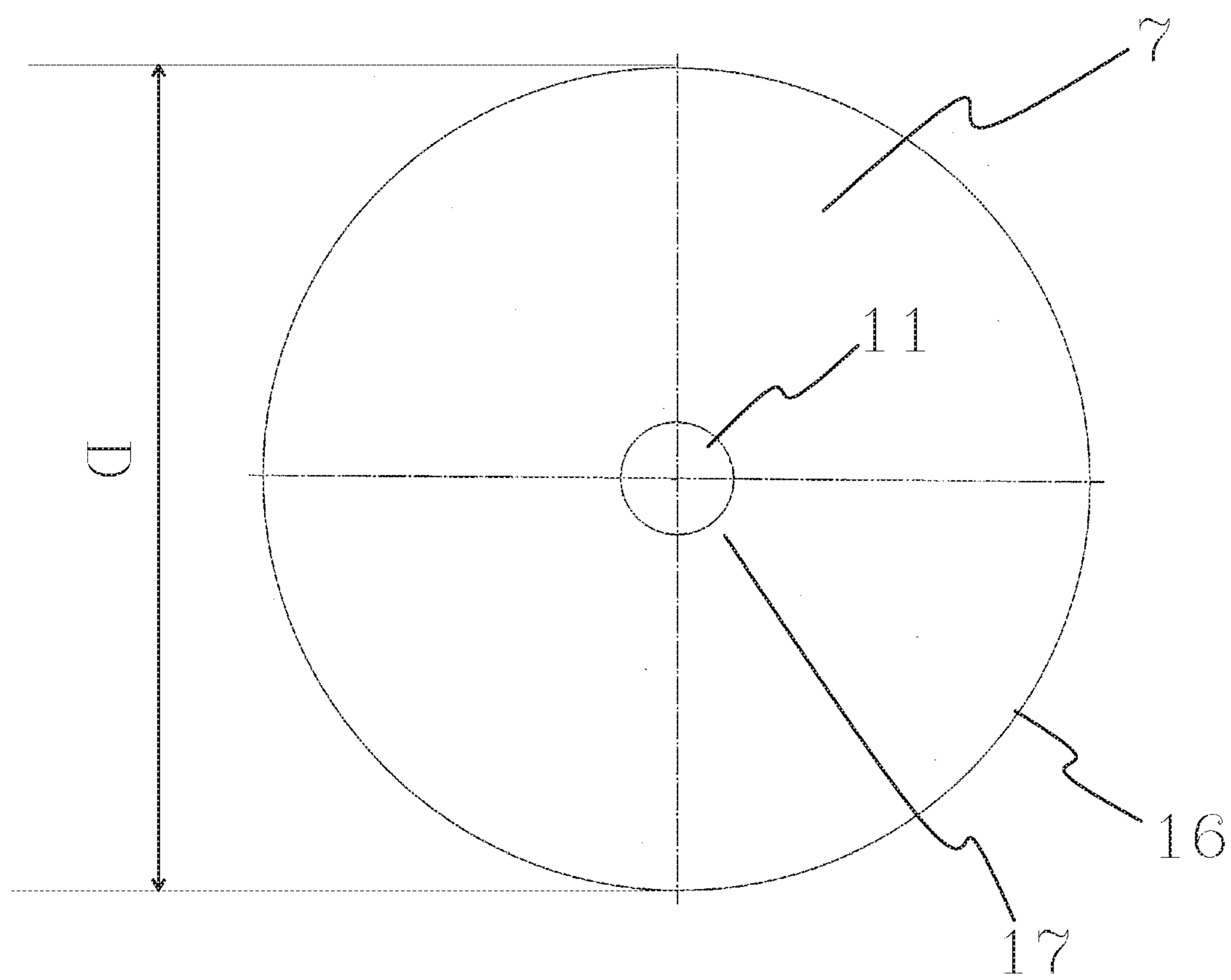


Fig.3

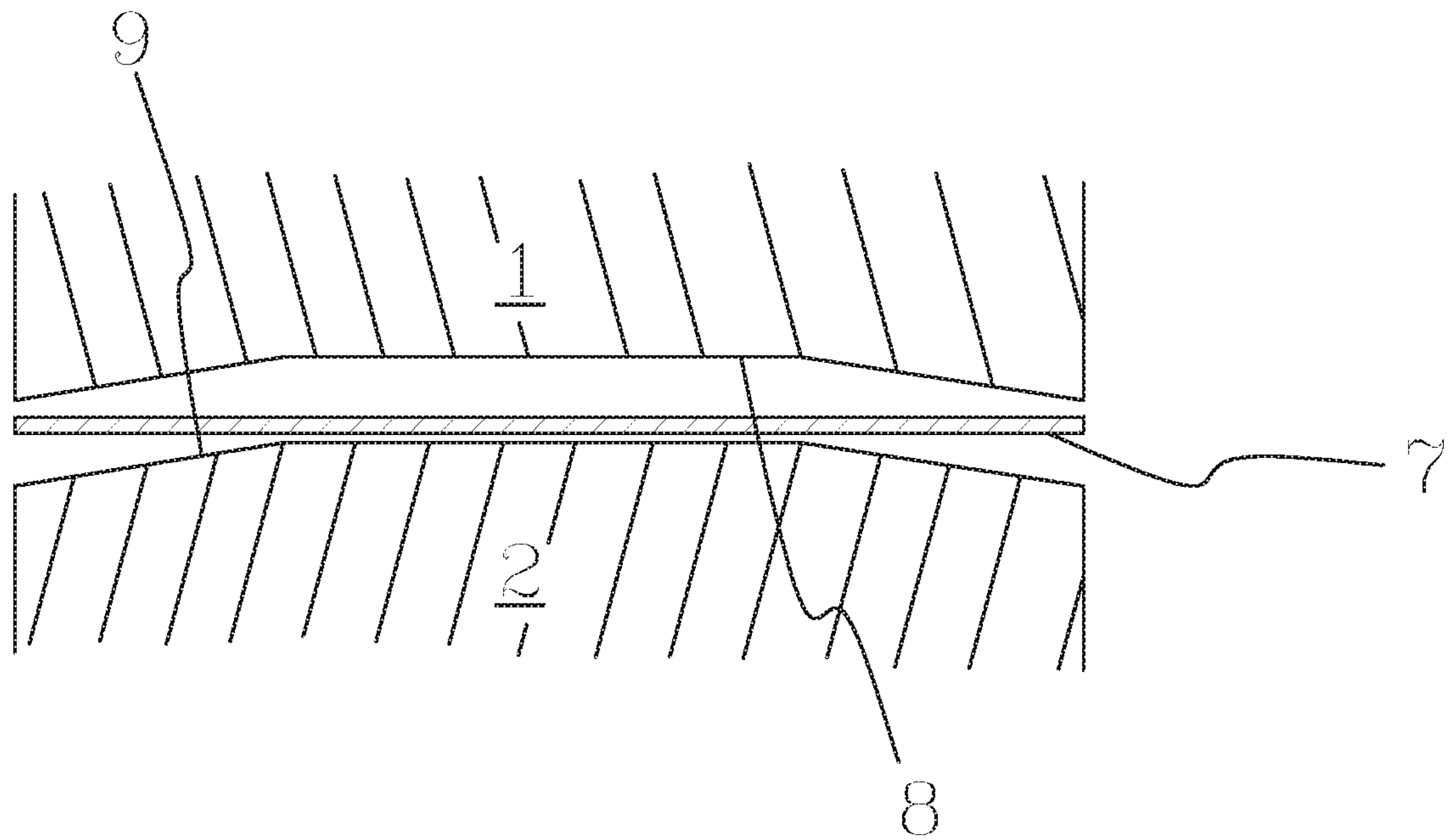


Fig.4a

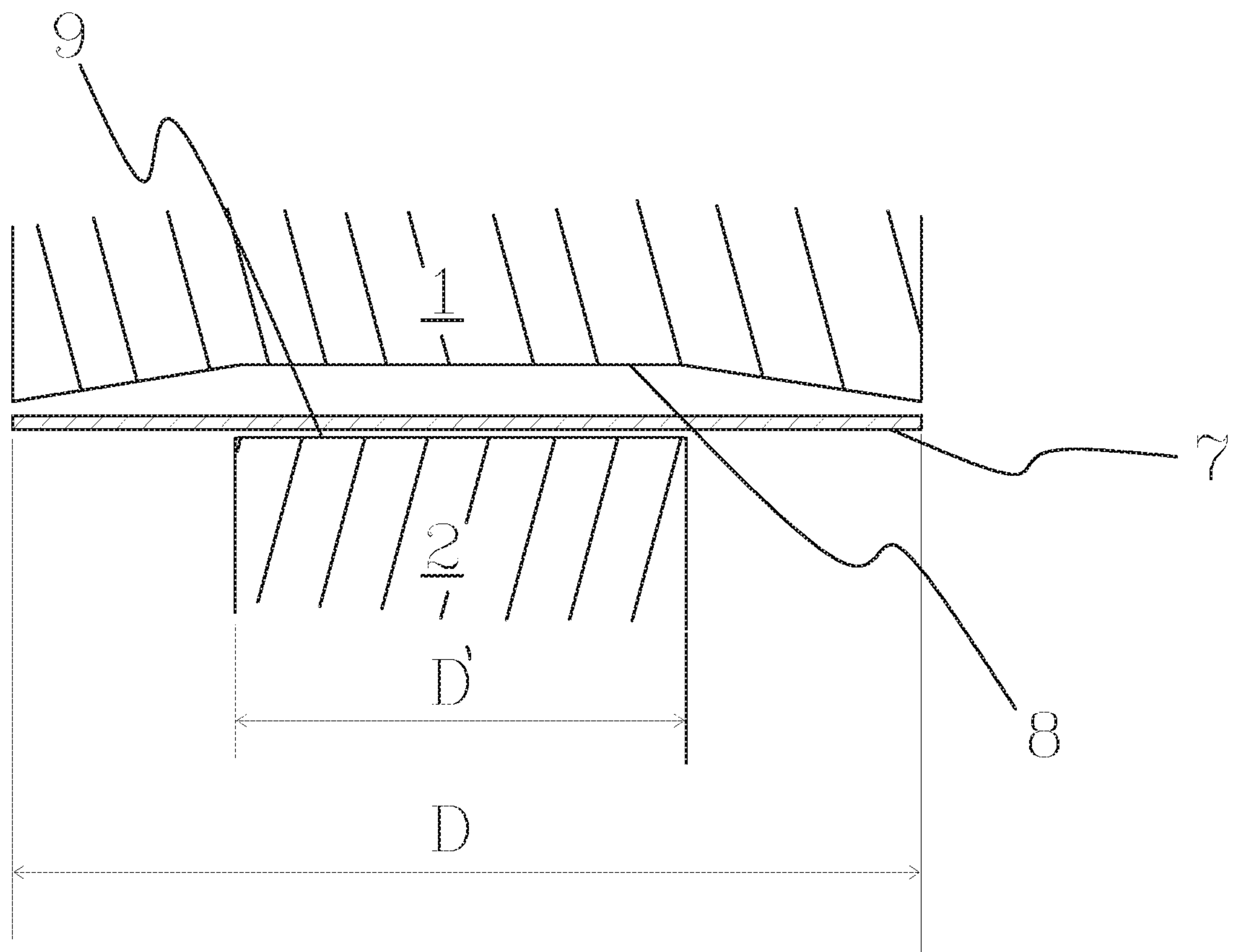


Fig.4b

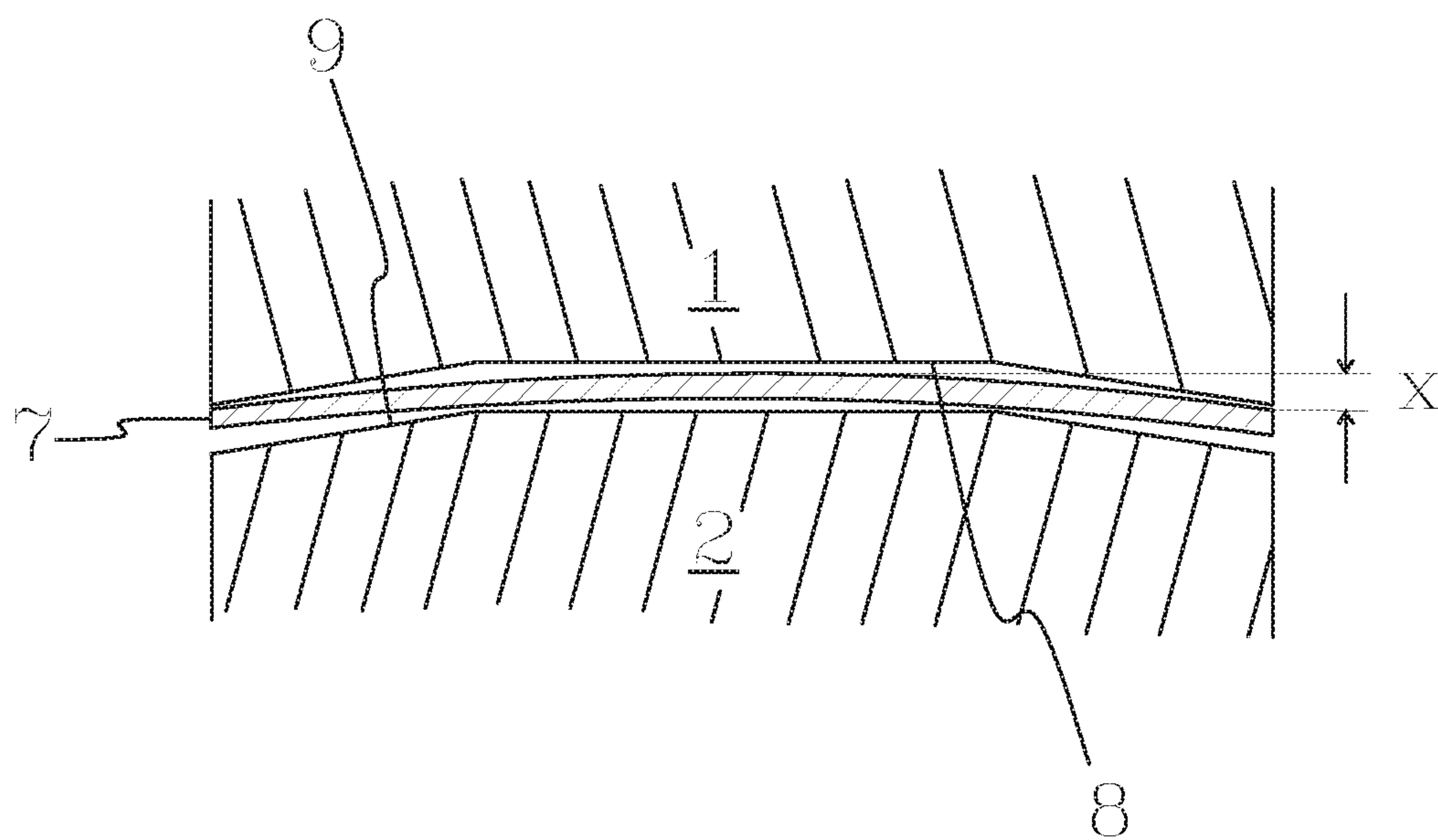


Fig.4c

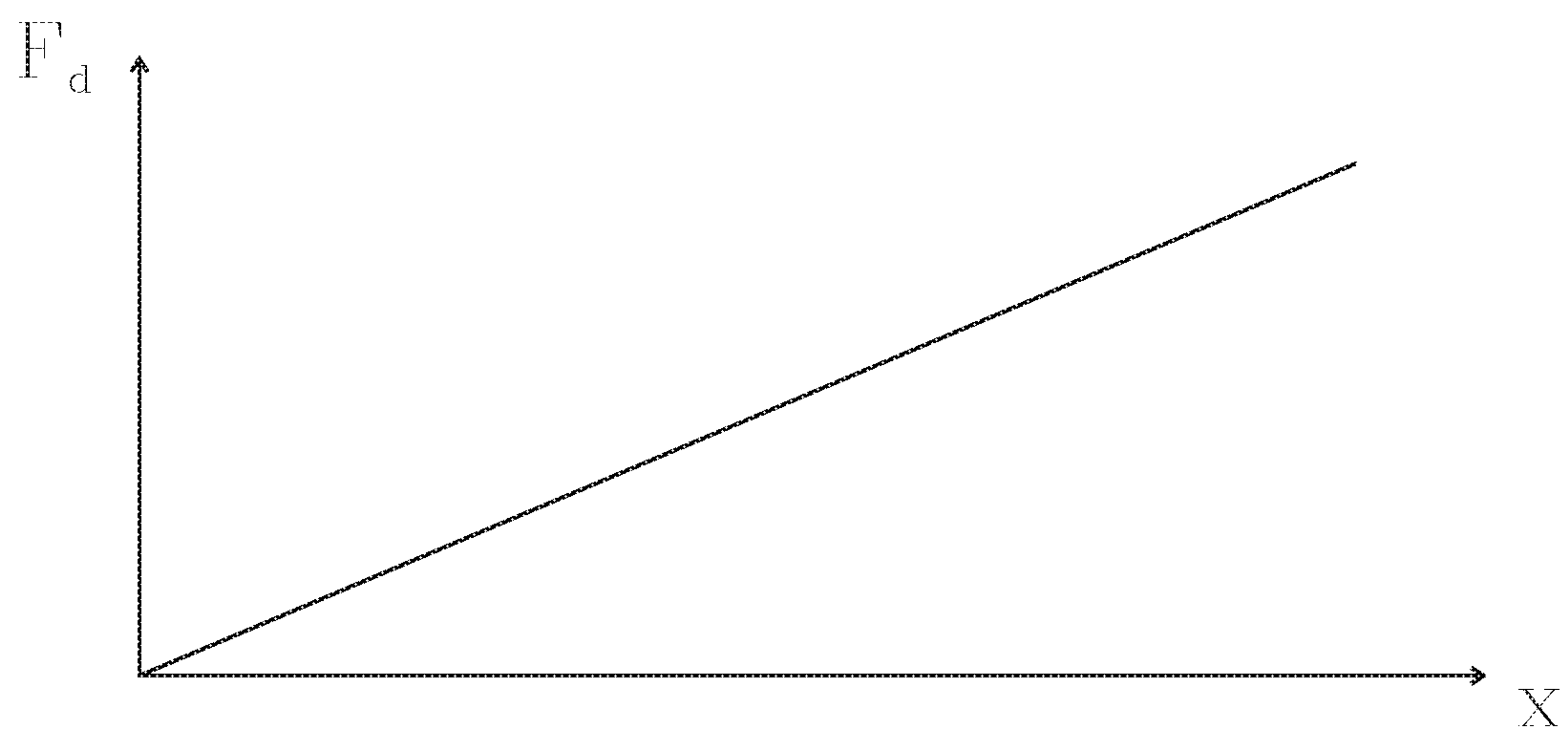


Fig.5

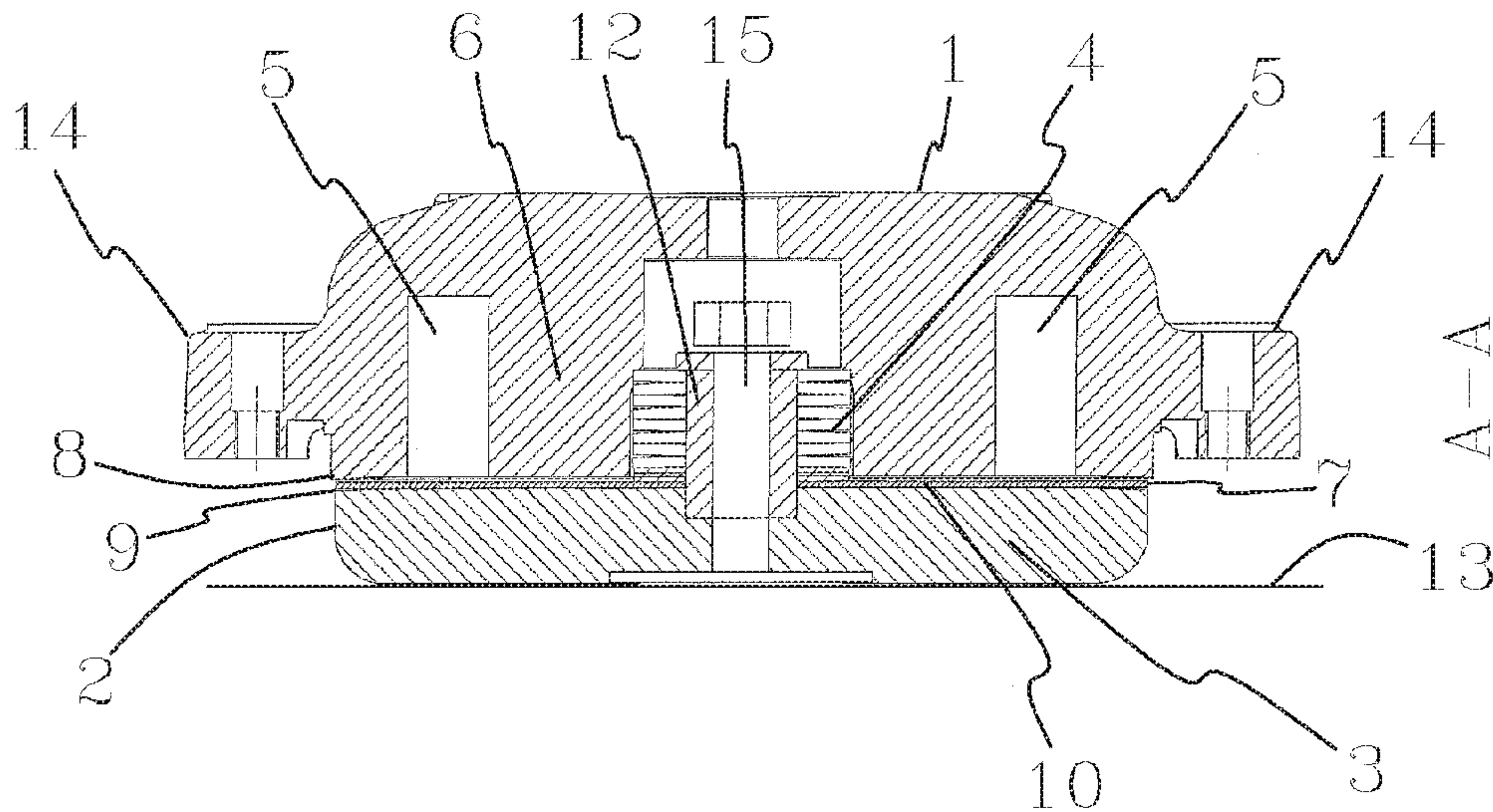


Fig. 1