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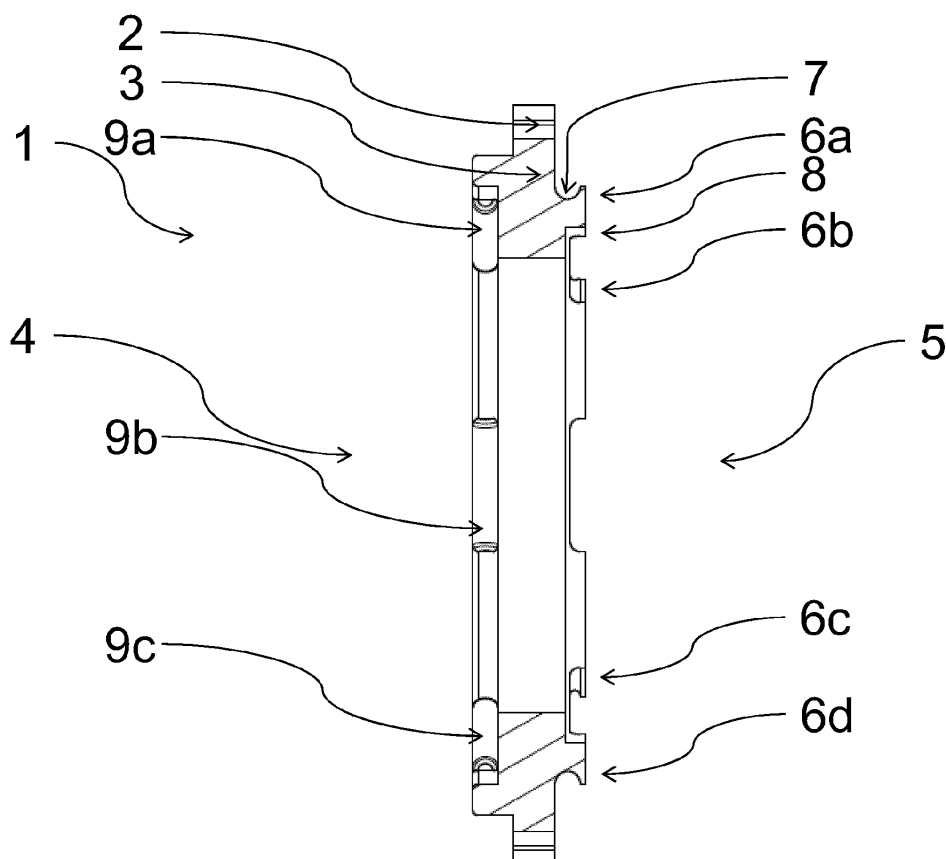
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(54) **Rotor**

(57) Rotor for a gas-turbine engine, the rotor comprising a first (1 a) and a second (1 b) rotor disc, the rotor discs (1 a, 1 b) being suitable to be joined directly, each rotor disc (1a, 1 b) is symmetric with respect to an axis of rotation common to the two rotor discs (1a, 1 b), char-

acterized in that the first rotor disc (1 a) provides an interrupted screw on one side (4), the second rotor disc (1 b) provides an interrupted screw on another side (5), said interrupted screw of the second rotor disc (1 b) reciprocates the interrupted screw of the first rotor disc (1 a).

Fig 1



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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a rotor, for example for a gas-turbine engine. More particularly, the present invention also relates to mechanical coupling between the rotor discs of the rotor.

BACKGROUND

[0002] State-of-the-art gas-turbines engines typically comprise three sections: A compressor, a combustor, and a turbine. Before entering the combustor, pressure of the working medium, typically air, is increased to approximately by the compression section. The compressed air then leaves the compression section and enters the combustor, where it is mixed with fuel and the combustion process takes place. After combustion, hot air leaves the combustor and is fed into the turbine.

[0003] A gas-turbine engine comprises a rotor. The rotor can be assembled from discs in a stack-up operation where components such as the compressor discs and the turbine discs are connected coaxially together along the axis of rotation. Various ways of connecting the discs of a rotor have been put forward. US3976399 discloses rotor discs stacked on a central connecting rod. The rotor discs of US3976399 are held in place by half-shells which are clamped together by clamping rings. US3976399 also discloses heat-shrinking rotors discs onto a central connecting rod. US7384075 discloses threaded joints between the components of a rotor. The threaded joint is additionally secured by an anti-rotation locking mechanism. US5537814 and US8100666 disclose a clamping nut and a tie shaft to axially clamp a turbine disc together with other rotor components. US4310286 discloses bolted joints to fixate the discs of a rotor.

[0004] The mechanical connections between the rotor discs of a gas-turbine engine have to meet a number of conflicting technical requirements: The rotor of a gas-turbine engine may deflect, so the axis of rotation and the center of mass of the rotor will no longer coincide. The connections between the rotors discs of a gas-turbine engine shall thus be torsionally stiff. The connections between the rotor discs of a gas-turbine engine shall be designed for a critical speed of the rotor well above the operational speed of 1500 or 15000 rpm.

[0005] The pressures inside the gas-turbine engine may be severe. The rotor of a gas-turbine engine shall be designed to withstand the corresponding stresses.

[0006] The new stack of rotor discs shall minimize the effort involved in its fabrication. In particular, the fabrication of the stack of rotor discs shall minimize the use of special tools.

[0007] Despite the aforementioned requirement of torsional stiffness, the joints between rotor discs shall allow easy and effortless removal and replacement of discs when the rotor is in stationary position. In other words,

any rotor discs shall be easily displaceable during maintenance or repair.

[0008] The present application is oriented towards providing the aforementioned needs and towards overcoming the aforementioned difficulties.

SUMMARY OF THE INVENTION

[0009] The present disclosure is about improved mechanical connections between the discs of a rotor. In order to arrive at a connection that is torsionally stiff and leakage-proof, an interrupted screw on each side of a reciprocally connected rotor disc is proposed. An interrupted screw is a screw whose surface is divided longitudinally into several blank or cutaway sections. The two rotor discs are locked together by a fraction of a turn.

[0010] After connecting the two rotor discs, the surfaces of the interrupted screw of the first rotor disc and of the reciprocally made nut of the second rotor disc align. The alignment of the two surfaces results in a connection that is torsionally stiff and allows for a critical speed of the rotor well above 1500 to 15000 rpm.

[0011] The interrupted screw on each side of the reciprocally connected rotor discs can be made of the same metals. That way, corrosion issues due to the use of dissimilar metals are eliminated.

[0012] The rotor discs can also be made of different metals, in particular of different steel alloys. A gas-turbine engine may require different alloys to be used for the rotor discs of the compressor and for the rotor discs of the combustor. The present disclosure allows rotor discs made of different metals or alloys to be connected.

[0013] To assemble a rotor, the two or more rotor discs are engaged and one rotor disc is rotated by a fraction of a turn against the other rotor disc. The rotation is carried out about the axis of rotation common to the two rotor discs. That axis will later become the axis of rotation of the rotor. As soon as the two discs are connected, yet another rotor disc is connected the stack of previously joined rotor discs by engaging said disc and the stack of rotor discs. The process continues until the assembly of the rotor is complete.

[0014] Likewise, during repair or maintenance of a rotor, a disc is removed from the stack of rotor discs by rotating it by a fraction of a turn. The direction of the rotation is now opposite to the direction when two discs were connected. The disc can then be removed from the remaining stack rotor discs. The process may continue until the stack of rotor discs has been completely disassembled.

BRIEF DESCRIPTION OF DRAWINGS

[0015] The foregoing objects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description when taken in conjunction with the accompanying drawings,

wherein:

Fig 1 is a cut-away view of a rotor disc according to the application.

Fig 2 is a three-dimensional view of one side of said rotor disc.

Fig 3 is a front view of the other side of said rotor disc.

Fig 4 is a three-dimensional view of two rotor discs before being connected.

Fig 5 is a three-dimensional view of a stack of rotor discs.

Fig 6 gives a three-dimensional view of a rotor disc according to another embodiment of the invention.

Fig 7 is a three-dimensional view of the rotor disc of Fig 6 from the other side.

Fig 8 is a three-dimensional view of connected rotor discs as per Fig 6 and Fig 7.

DETAILED DESCRIPTION OF THE INVENTION

[0016] Fig. 1 gives a cut-away view of a rotor disc 1 according to the application. The rotor disc 1 comprises a plurality of protrusions arranged along the outer circumference of the rim 3. On each of its sides 4, 5, the rotor disc 1 provides an interrupted screw. The two interrupted screws on each side 4, 5 of the rotor disc are reciprocally made, so the interrupted screw on one side 4 of a rotor disc 1 may cooperate with the interrupted screw on the opposite side 5 of another rotor disc. Fig 1 shows the interrupted screw on one side 5 of the rotor disc comprises a plurality of slots 6a, 6b, 6c, 6d. They 6a, 6b, 6c, 6d are preferably arranged evenly along the inner perimeter of the rotor disc 1, so the distance between each pair of adjacent slots is the same. The slots 6a, 6b, 6c, 6d provide clamping surfaces 7 arranged in between the slots 6a, 6b, 6c, 6d and the rim 3. The slots 6a, 6b, 6c, 6d also comprise support portions 8. The support portions 8 carry the mechanical forces applied to the slots 6a, 6b, 6c, 6d when two rotor discs are connected and/or in-service. In a preferred embodiment, the support portions 8 of each slot 6a, 6b, 6c, 6d are made of the same material as the rim 3.

[0017] On the other side 4 of the rotor disc 1, segments 9a, 9b, 9c have been arranged. Each segment on one side 4 of the rotor disc 1 reciprocates with a slot on the other side 5 of the disc 1. In a preferred embodiment, the segments 9a, 9b, 9c are arranged evenly like the slots 6a, 6b, 6c, 6d on the other side 5 of the rotor disc 1.

[0018] The segments 9a, 9b, 9c and the slots 6a, 6b, 6c, 6d are arranged so they act like plugs and sockets. In a preferred embodiment, the segments 9a, 9b, 9c can

slide into the clamping surfaces 7 provided by each slot 6a, 6b, 6c, 6d. In this embodiment, the clamping surfaces 7 of the slots 6a, 6b, 6c, 6d narrow towards one of their ends. The segments 9a, 9b, 9c narrow in the same way.

5 The segments 9a, 9b, 9c can thus slide into the clamping surfaces 7 until the surfaces of the segments 9a, 9b, 9c and the surfaces of the clamping surfaces 7 engage. A rigid connection between two adjacent discs is formed as the segments 9a, 9b, 9c eventually get wedged inside the slots 6a, 6b, 6c, 6d.

10 **[0019]** In another embodiment, the disc 1 with the slots 6a, 6b, 6c, 6d is heated before the segments 9a, 9b, 9c can slide into the slots 6a, 6b, 6c, 6d. By heating the disc 1 with the slots 6a, 6b, 6c, 6d, the material expands, so the inner diameter of each clamping surface 7 increases. 15 The segments 9a, 9b, 9c may then slide into the slots 6a, 6b, 6c, 6d. The temperatures of the slots 6a, 6b, 6c, 6d lower after introducing the segments 9a, 9b, 9c and a rigid connection providing a rotor with torsional stiffness will be formed. The segments 9a, 9b, 9c will then also exert an inward force on the clamping surfaces 7 of the slots 6a, 6b, 6c, 6d. The inward force counter-acts the centrifugal force when the rotor disc 1 rotates as part of a rotor. In other words, heat treatment will not only result 20 in torsional stiffness but also in compensation of centrifugal forces when the rotor is in service.

[0020] It should be mentioned the clamping surfaces 7 of the slots 6a, 6b, 6c, 6d as shown on Fig 1 point outwards from the axis of rotation of the disc 1. In another embodiment, the clamping surfaces 7 of the slots 6a, 6b, 6c, 6d may point inwards. This embodiment will require segments 9a, 9b, 9c whose surfaces point outwards.

[0021] Fig. 2 provides a three-dimensional view of a rotor disc 1 according to the application. This three-dimensional drawing shows the rotor disc 1 of Fig 1 viewed from one of its sides 4. Fig 2 shows a total of six segments 9a, 9b, 9c, 9d, 9e, 9f that are arranged in an equidistant manner. In this particular embodiment, the angle between two adjacent segments as measured from the axis of rotation of the rotor disc 1 would be 60°. Also, the segments 9a, 9b, 9c, 9d, 9e, 9f shown on the present Fig 2 have got the shape of bent cylinders. In other embodiments, the cross-sections of segments 9a, 9b, 9c, 9d, 9e, 9f may be triangular or square.

45 **[0022]** Fig 3 shows a front view of the rotor disc 1 of Fig 1. Fig 3 shows the rotor disc 1 of Fig 1 as viewed from its other side 5. Fig 3 shows a total of six slots 6a, 6b, 6c, 6d, 6e, 6f evenly distributed along the inner perimeter of the rotor disc 1. The slots 6a, 6b, 6c, 6d, 6e, 6f are arranged so they match with the reciprocally made segments 9a, 9b, 9c, 9d, 9e, 9f on the other side 4 of an adjacent rotor disc.

50 **[0023]** Fig 4 shows a pair of rotor discs 1a, 1b prior to them being connected. The two rotor discs 1a, 1b correspond to the discs shown on Fig 1 - 3. The first rotor disc 1a provides an arrangement of slots 6a, 6b, 6c that matches the arrangement of segments 9a, 9b, 9c of the second rotor disc 1b. In order to connect the two rotor

discs 1a, 1b, the reciprocating surfaces of the discs 1a, 1b are engaged and one disc is rotated by a fraction of a turn against the other disc. In the particular embodiment shown on Fig 4, one disc would be rotated by 60° against the other disc because there is a total six segments 9a, 9b, 9c, 9d, 9e, 9f and of six slots 6a, 6b, 6c, 6d, 6e, 6f.

[0024] The clamping surfaces 7 of the slots 6a, 6b, 6c, 6d, 6e, 6f and the surface of the segments 9a, 9b, 9c, 9d, 9e, 9f get wedged when the discs 1a, 1b are connected. In a preferred embodiment, wedged joint between the discs 1a, 1b then essentially becomes leakage-proof.

[0025] To disconnect the two discs 1a, 1b, the process as described above is reversed. Heat treatment can be used as well. The disc 1a with the slots 6a, 6b, 6c, 6d, 6e, 6f will have to be heated at a faster rate than the other disc 1b. The two discs 1a, 1b are disconnected as soon as the heat treatment yields a gap between the surfaces of the slots 6a, 6b, 6c, 6d, 6e, 6f and the surfaces of the segments 9a, 9b, 9c, 9d, 9e, 9f. Induction heating may be used for the purpose of heating disc 1a faster than the other disc 1b. The rotor discs 1a, 1b allow for easy dismantling of a rotor, since disconnection of the rotor discs 1a, 1b only requires a reversal of the above process.

[0026] While Fig 4 shows a pair of rotor discs before being joined, Fig 5 shows a stack of five rotor discs 1a, 1b, 1c, 1d, 1e that have been connected as described above. According to Fig 5 it is possible to connect a plurality of rotor discs with reciprocating interrupted screws on either side. The resulting stack of connected rotor discs will form a rotor that is torsionally stiff and whose critical speed is well beyond 1500 to 15000 rpm.

[0027] Fig 5 also indicates the stack of rotor discs provides an aperture along the common central axis of the rotor discs. The aperture common to all rotor discs allows other elements such as shafts to be arranged inside the aperture. There is thus sufficient space inside stack of rotor discs to arrange separate shafts for the compressor and for the turbine sections of a gas-turbine engine.

[0028] The rotor discs 1a, 1b, 1c, 1d, 1e shown on Fig 5 have all got the same diameters. In another embodiment, rotor discs as per this application are connected where the rotor discs differ in diameter.

[0029] Fig 6 shows a rotor disc 1 according to another embodiment of the application. The rotor disc 1 of Fig 6 comprises a protruding rim 10. The rim 10 provides a plurality of wedges 11a, 11b, 11c, 11d, 11e, 11f, 11g, 11h arranged on its sidewall. In a preferred embodiment, the wedges 11a, 11b, 11c, 11d, 11e, 11f, 11g, 11h are arranged evenly along the perimeter of the sidewall of the outer rim 10. The present Fig 6 shows a total of eight wedges. The rim 10 and the wedges 11a, 11b, 11c, 11d, 11e, 11f, 11g, 11h form an interrupted screw just as the slots 6a, 6b, 6c, 6d, 6e, 6f of Fig 3.

[0030] Fig 7 shows a rotor disc 1 with an interrupted screw that reciprocates the interrupted screw shown on Fig 6. The rotor disc 1 provides a groove 12 with a plurality

of wedges 13a, 13b, 13c, 13d, 13e, 13f, 13g, 13h along its sidewall. Those wedges replace the segments 9a, 9b, 9c, 9d, 9e, 9f shown on Fig 2. In a preferred embodiment, the wedges 11a, 11b, 11c, 11d, 11e, 11f, 11g, 11h of the protruding rim 10 and the wedges 13a, 13b, 13c, 13d, 13e, 13f, 13g, 13h of the groove 12 are made of the same materials. Different materials are also possible.

[0031] In order to connect the rotor discs shown on Fig 6 and on Fig 7, the protruding rim 10 of Fig 6 is introduced into the groove 12 shown on Fig 7. One of the discs is then rotated by a fraction of a turn against the other disc, until the outer surface of the rim 10 and the sidewall of the groove 12 wedge. The two rotor discs are then rigidly connected. Fig 8 shows two such rotor discs after having been joined. To disconnect two rotor discs, this process is reversed.

[0032] Fig 8 also shows a plurality of cooling ducts 14 that penetrate either an individual rotor disc 1 or the stack of rotor discs. The wedged connection between rotor discs avoids welded connections between discs. Since it is no longer necessary to weld the rotor discs together, any risk of accidentally blocking the cooling duct 14 during welding is eliminated and more design flexibility of cooling channels is achieved.

[0033] The process of connecting rotor discs continued rotor discs may be continued until a stack of rotor discs is formed. Fig 5 shows such a stack. Also, heat treatment as explained above may be employed in order to increase the stiffness of the connection between rotor discs and utmost utilization of the material due to residual shrink stress which acts as anti-centrifugal.

[0034] The disclosure describes a rotor made of rotor discs with interrupted screws in relation to a gas-turbine engine. In another embodiment, the same rotor and the same rotor discs form part of the rotor of a turbogenerator. Other applications such as hydro generators are also envisaged.

[0035] Although the present invention has been fully described in connection with preferred embodiments, it is evident that modifications may be introduced within the scope thereof, not considering the application to be limited by these embodiments, but by the contents of the following claims.

REFERENCE NUMBERS

[0036]

- 1 rotor disc
- 1a, 1b, 1c, 1d, 1e, 1f individual rotor discs
- 2 protrusion
- 3 rim
- 4 side of a rotor disc
- 5 side of a rotor disc
- 6 slot
- 6a, 6b, 6c, 6d, 6e, 6f individual slots
- 7 clamping surface
- 8 support portion

9 segment
 9a, 9b, 9c, 9d, 9e, 9f individual segments
 10 protruding rim
 11a, 11b, 11c, 11d, 11e, 11f, 11g, 11h wedges
 12 groove
 13a, 13b, 13c, 13d, 13e, 13f, 13g, 13h wedges
 14 cooling duct

Claims

1. Rotor comprising a first (1a) and a second (1b) rotor disc, **characterized in that** the first rotor disc (1a) provides a first interrupted screw on at least one side (4), the second rotor disc (1b) provides a second interrupted screw on at least one side (5), the second interrupted screw of the second rotor disc (1b) is connected to the first interrupted screw of the first rotor disc (1a).
2. Rotor according to claim 1, **characterized in that** each rotor disc (1a, 1b) is substantially symmetric with respect to the axis of rotation of the rotor.
3. Rotor according to claims 1 to 2, **characterized in that** the rotor discs (1a, 1b) are suitable to be connected directly to one another.
4. Rotor according to claims 1 to 3, **characterized in that** at least one of the rotor discs (1a, 1b) provides two interrupted screws on both of its sides (4, 5).
5. Rotor according to claims 1 to 4, **characterized in that** the first rotor disc (1a) provides a first interrupted screw with a protruding rim (10) with a sidewall, a first set of wedges (11a, 11b, 11c, 11d, 11e, 11f, 11g, 11h) being arranged along the sidewall of the protruding rim (10), the second rotor disc (1b) provides a second interrupted screw comprising a groove (12) with a sidewall, a second set of wedges (13a, 13b, 13c, 13d, 13e, 13f, 13g, 13h) being arranged along the sidewall of the groove (12).
6. Rotor according to claim 5, **characterized in that** the first set of wedges (11a, 11b, 11c, 11d, 11e, 11f, 11g, 11h) is evenly arranged along the sidewall of the protruding rim (10) and the second set of wedges (13a, 13b, 13c, 13d, 13e, 13f, 13g, 13h) is evenly arranged along the sidewall of the groove (12).
7. Rotor according to claims 5 to 6, **characterized in that** the first set of wedges (11a, 11b, 11c, 11d, 11e, 11f, 11g, 11h) comprises eight wedges and the second set of wedges (13a, 13b, 13c, 13d, 13e, 13f, 13g, 13h) comprises eight wedges.
8. Rotor according to claims 1 to 4, **characterized in that** the first rotor disc (1a) provides an interrupted screw comprising a plurality of slots (6a, 6b, 6c, 6d, 6e, 6f), and wherein the second rotor disc (1b) provides an interrupted screw comprising a plurality of segments (9a, 9b, 9c, 9d, 9e, 9f).
9. Rotor according to claim 8, **characterized in that** each slot (6a, 6b, 6c, 6d, 6e, 6f) comprises a clamping surface (7).
10. Rotor according to claims 8 to 9, **characterized in that** the slots (6a, 6b, 6c, 6d, 6e, 6f) of the first rotor disc (1a) are evenly arranged along the inner perimeter of the first rotor disc (1a) and the segments (9a, 9b, 9c, 9d, 9e, 9f) of the second rotor disc (1b) are evenly arranged along the inner perimeter of the second rotor disc (1b).
11. Rotor according to claims 8 to 10, **characterized in that** the first rotor disc (1a) provides six slots (6a, 6b, 6c, 6d, 6e, 6f) and the second rotor disc (1b) provides six segments (9a, 9b, 9c, 9d, 9e, 9f).
12. Gas-turbine engine with a rotor according to any of the claims 1 to 11.
13. Turbogenerator with a rotor according to any of the claims 1 to 11.
14. Method for directly joining a first (1a) and a second (1b) rotor disc, **characterized in that** the first rotor disc (1a) provides an interrupted screw on at least one side (4), the second rotor disc (1b) provides an interrupted screw on at least one side (5), the interrupted screw of the second rotor disc (1b) reciprocates the interrupted screw of the first rotor disc (1a), the method comprising connecting the first rotor disc (1a) with the second rotor disc (1b) by engaging the first interrupted screw of the first rotor disc (1a) with the second interrupted screw of the second rotor disc (1b), and rotating the first rotor disc (1a) against the second rotor disc (1b) by a fraction of a turn.
15. Method according to claim 11, **characterized in that** the size of the interrupted screw of one rotor disc (1a, 1b) is increased by heating before engaging the interrupted screws of the two rotor discs (1a, 1b).

Fig 1

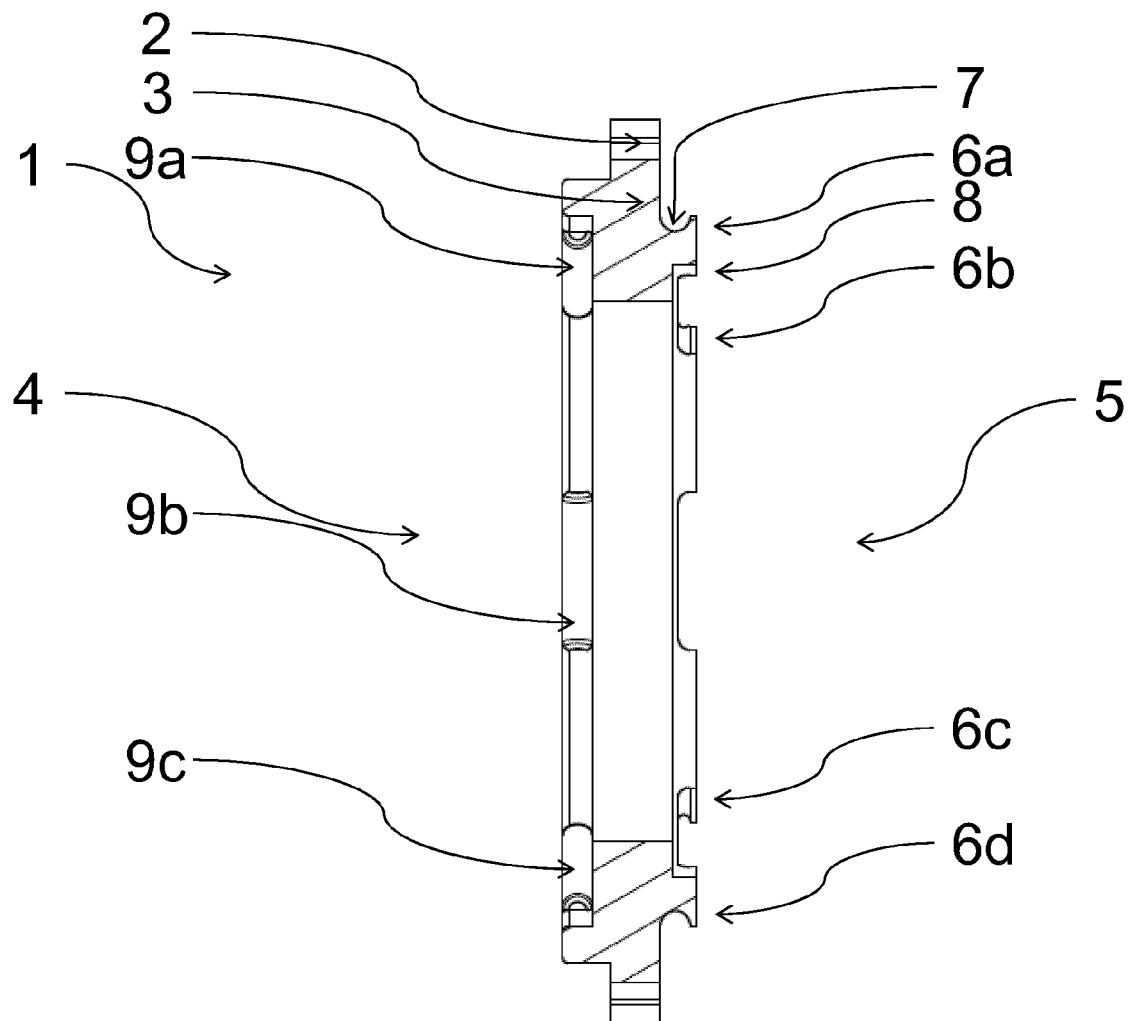


Fig 2

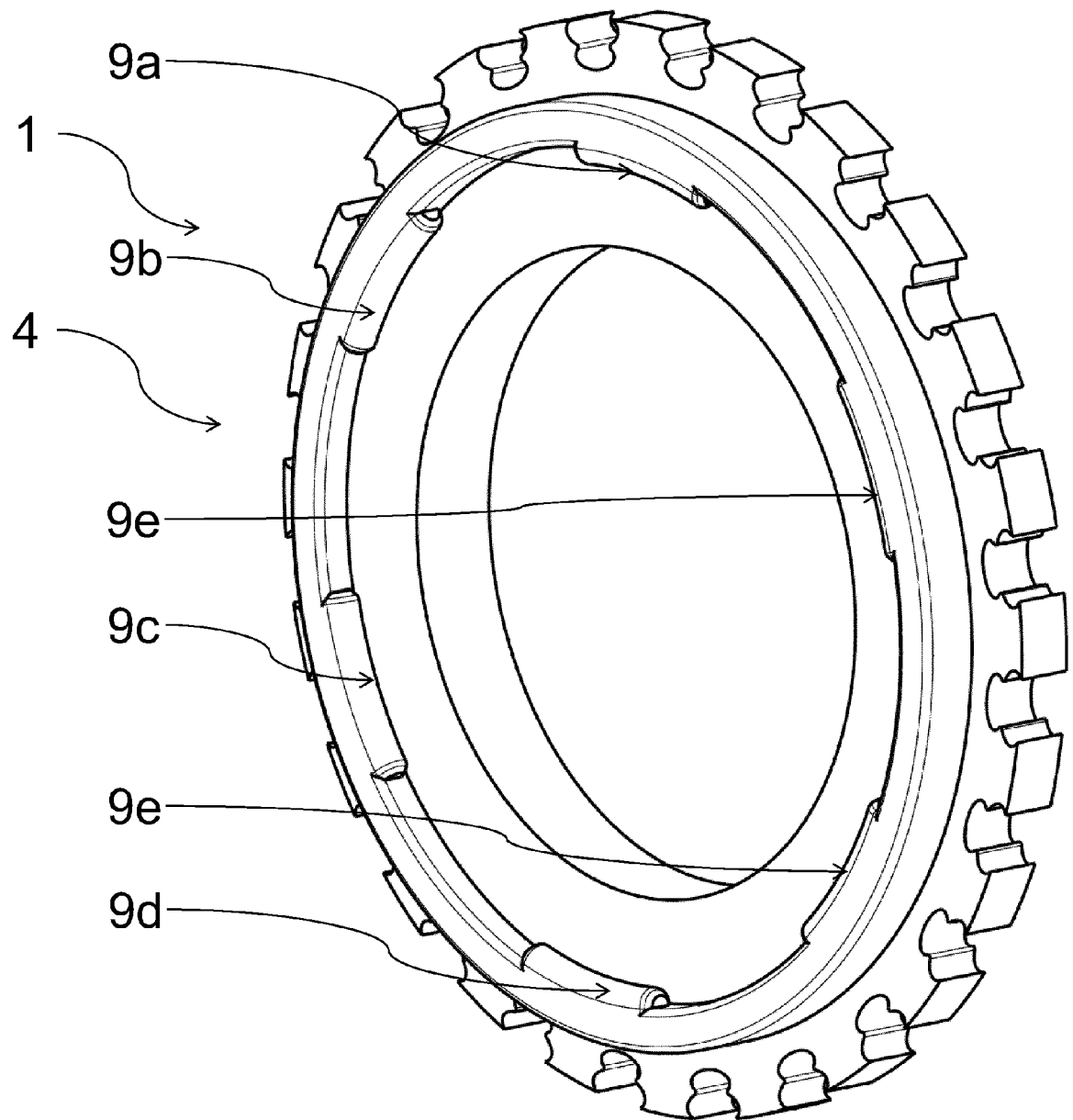


Fig 3

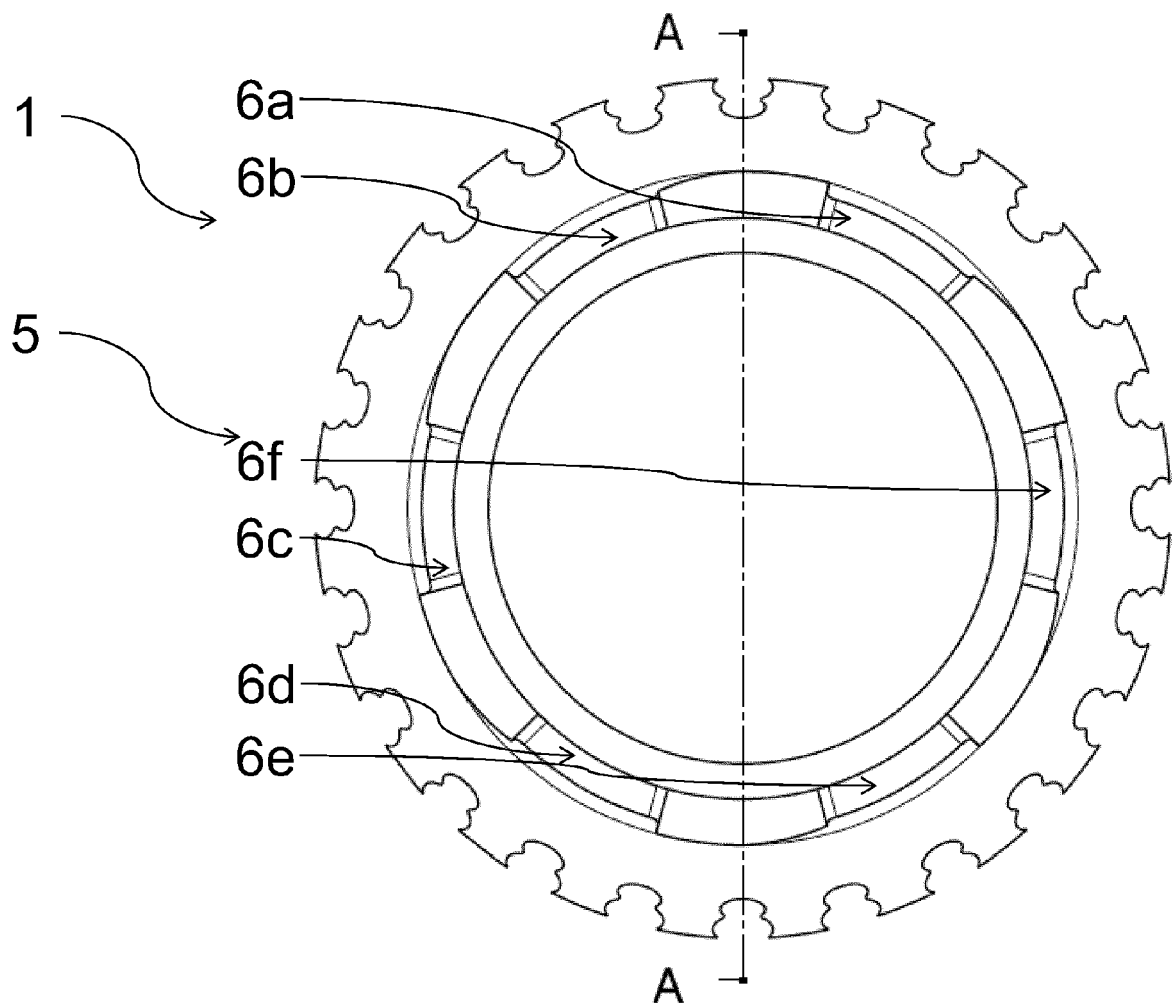


Fig 4

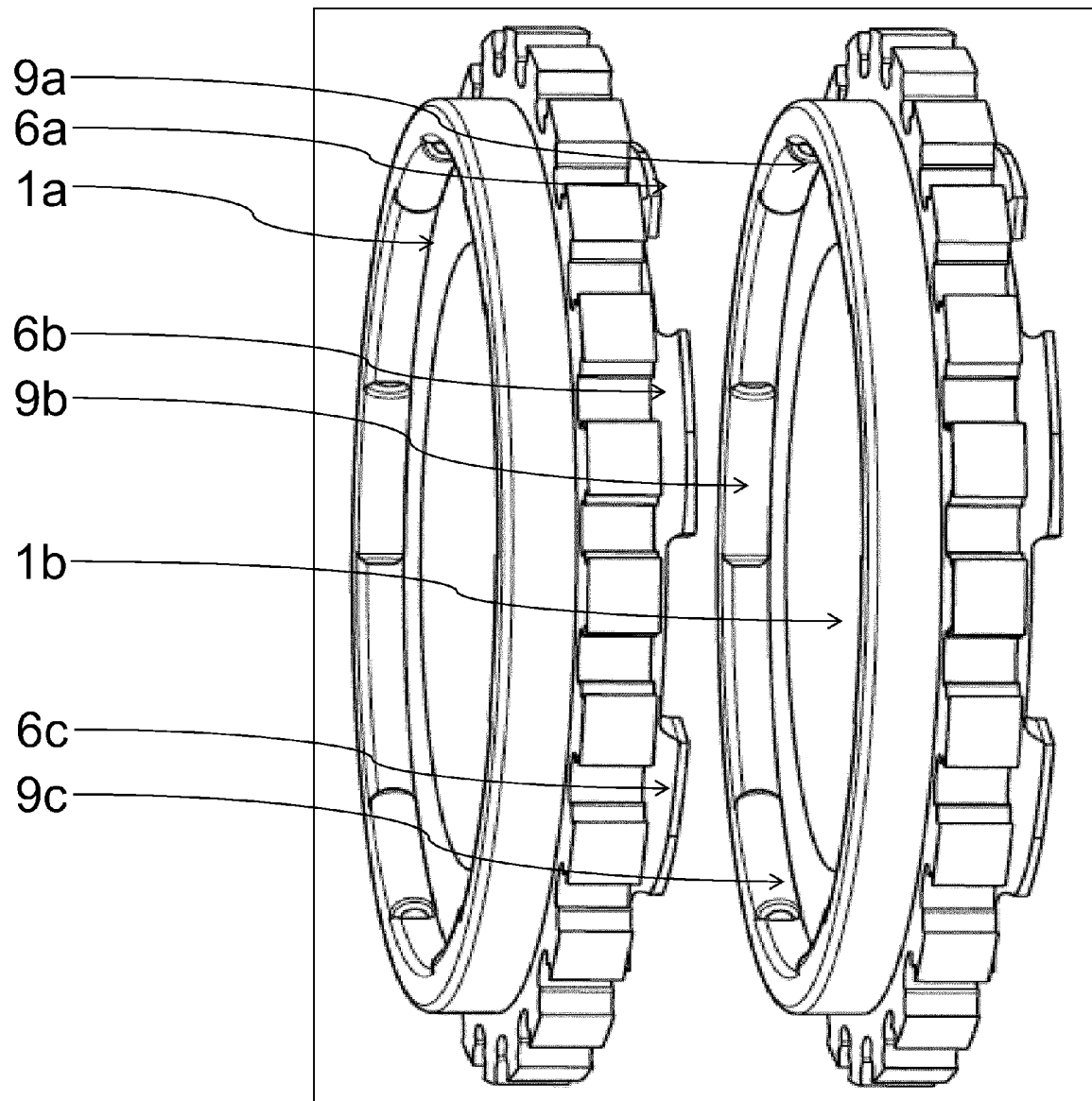


Fig 5

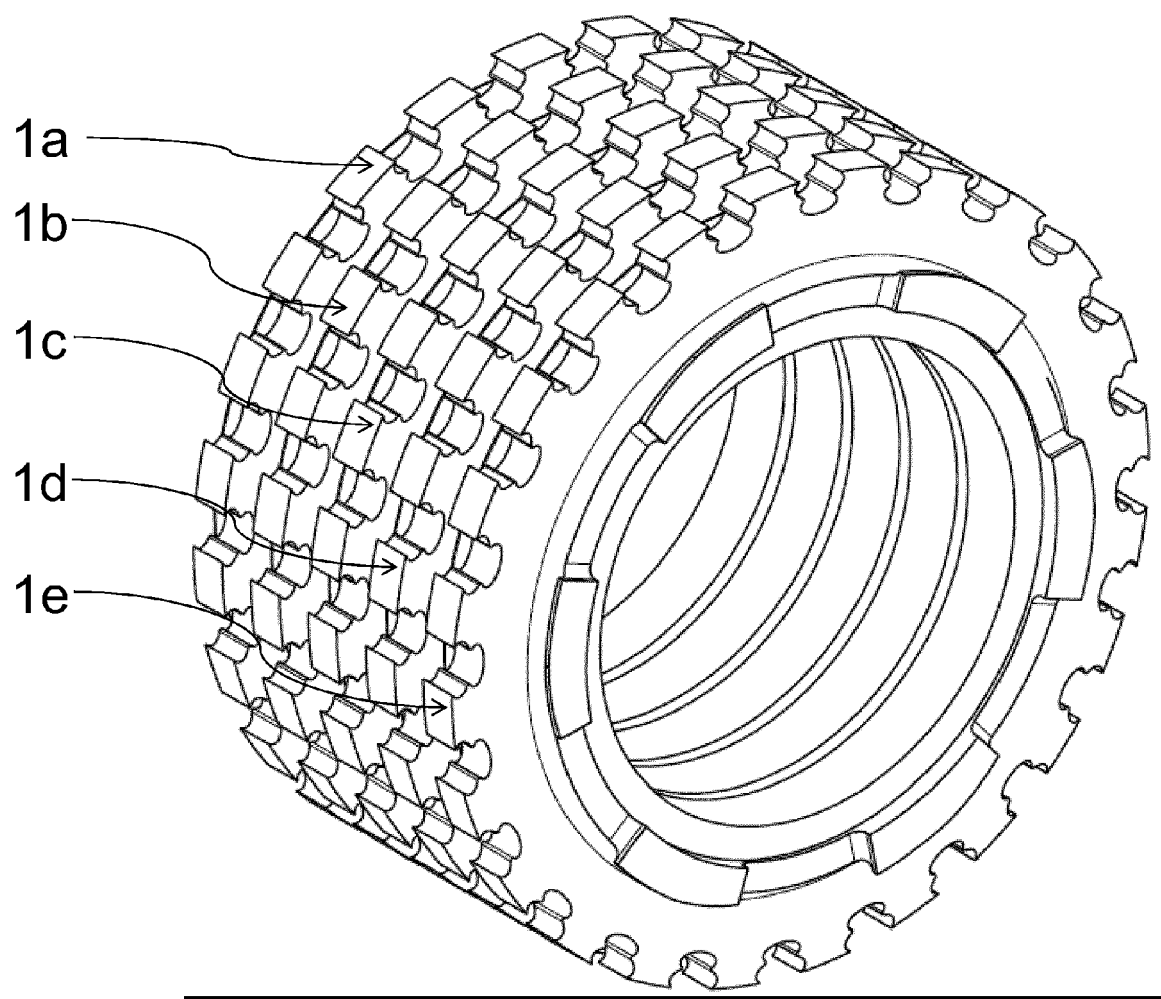


Fig 6

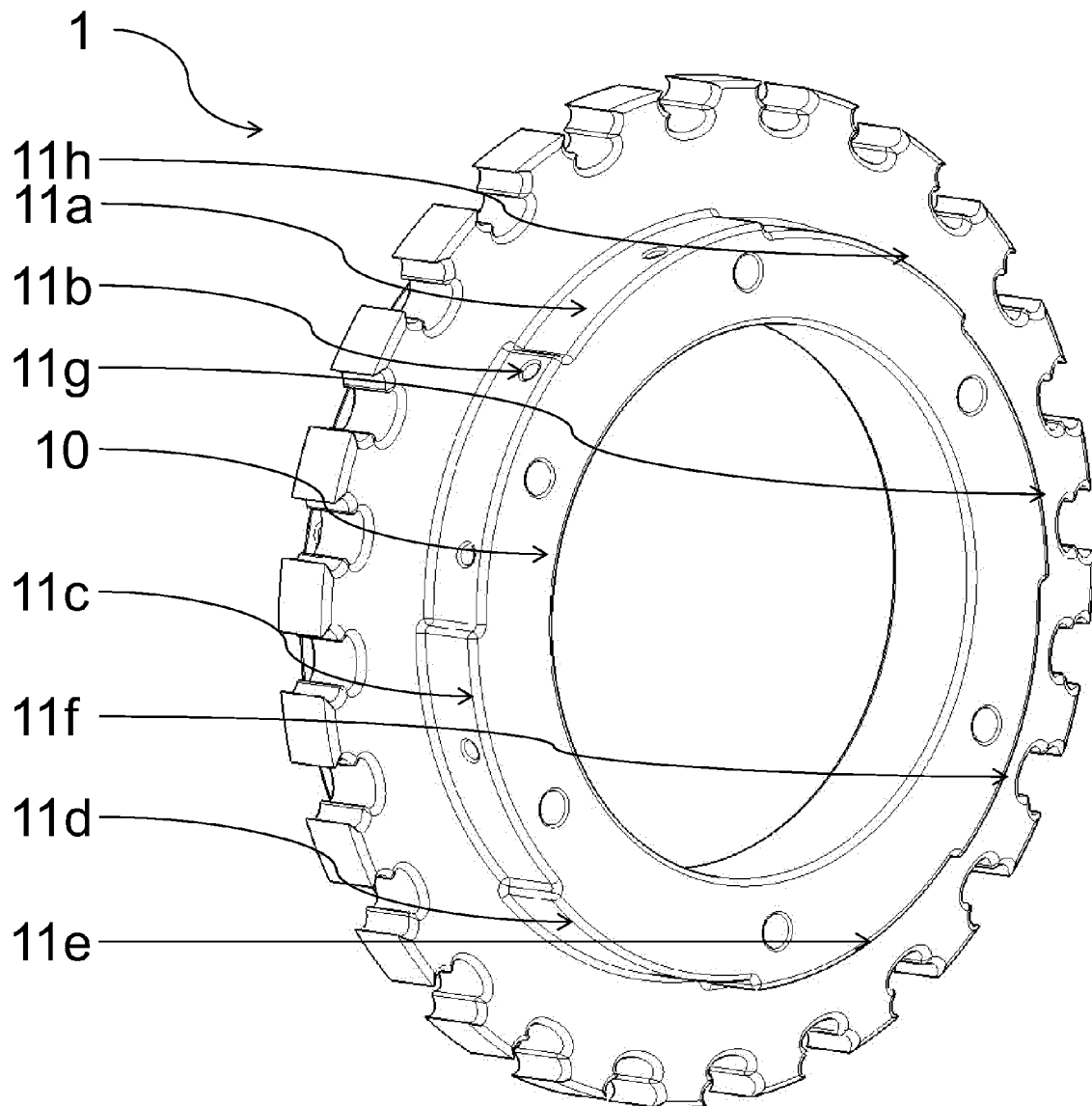


Fig 7

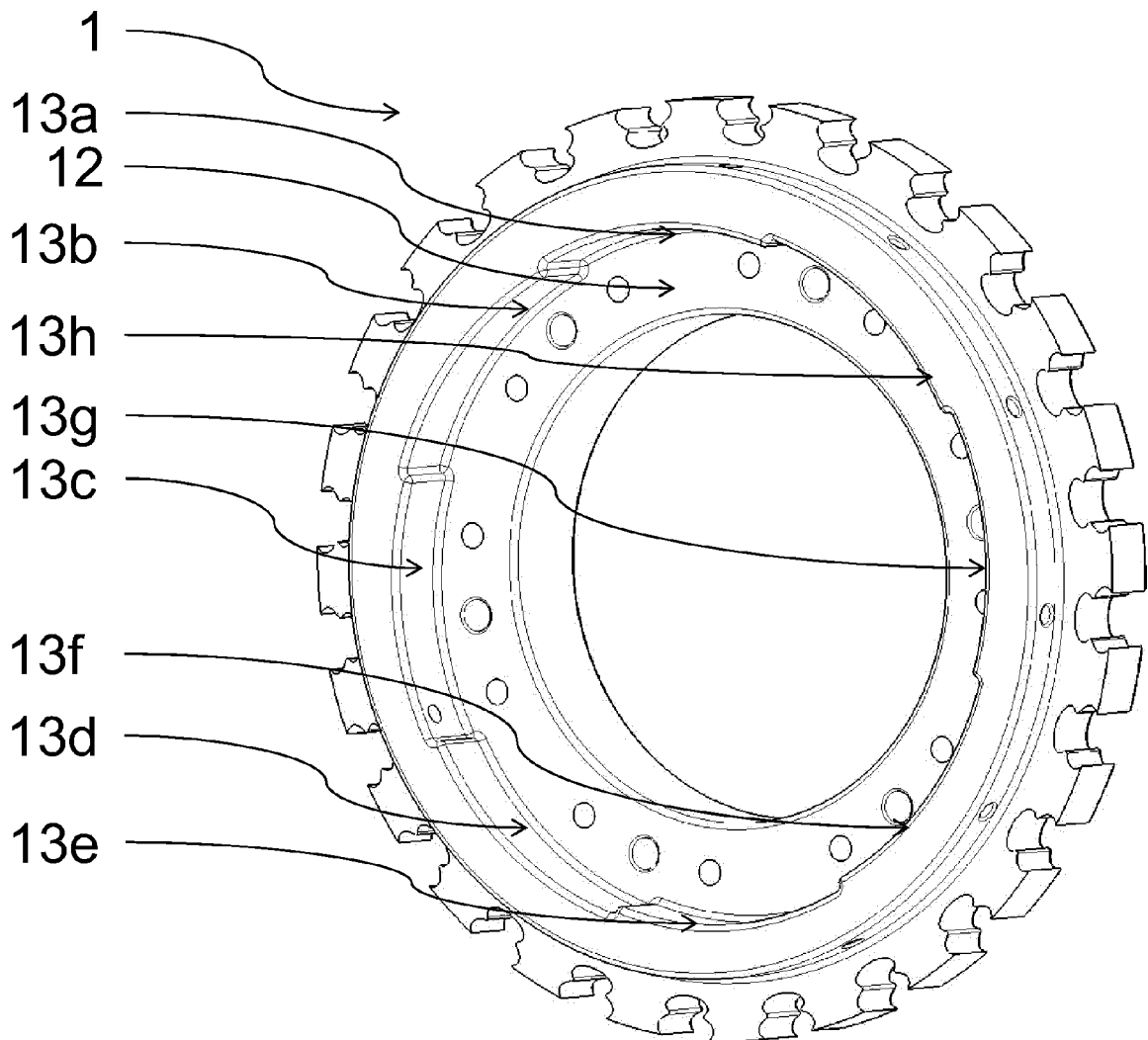
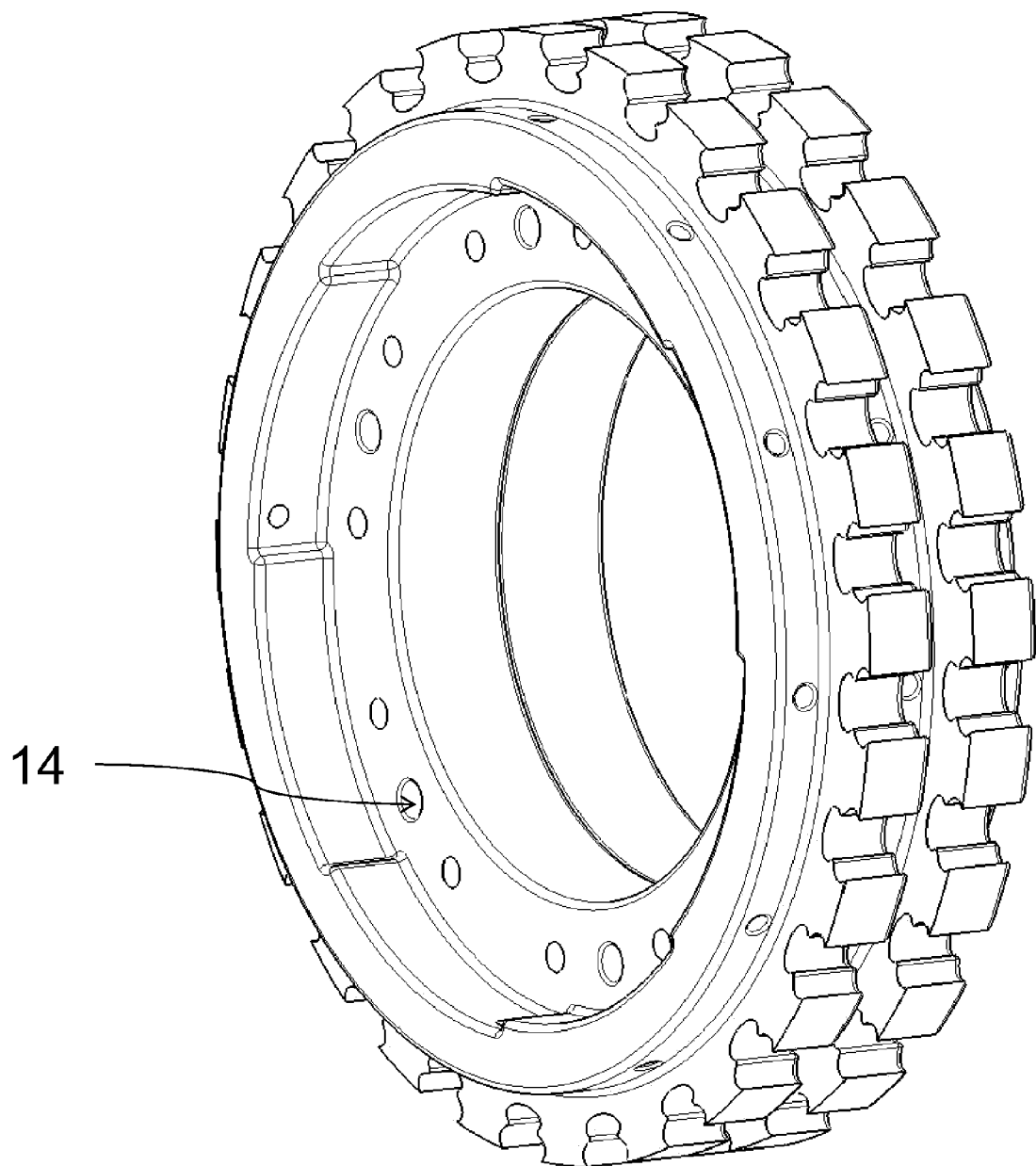


Fig 8





EUROPEAN SEARCH REPORT

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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