(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 803 867 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
19.11.2014 Bulletin 2014/47

(51) Int Cl.:
F04D 29/66 *(2006.01)*

(21) Application number: **14161532.8**

(22) Date of filing: **25.03.2014**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **14.05.2013 GB 201308596**

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(54) **Balancing method**

(57) A method is provided of balancing a set of retaining and locking plates (3, 5) used to retain a row of gas turbine engine aerofoil blades (1) in attachment to a rotor disc (7). The method includes: (i) providing a weighing plate (109) having a circular track (115); (ii) providing a non-rotating, static balancing apparatus capable of detecting unbalance in the weighing plate; (iii) positioning the weighing plate on the static balancing apparatus, and positioning the set of retaining and locking plates on the track in an arrangement corresponding to a possible arrangement for the set of plates in use in the engine; and (iv) repositioning the retaining and locking plates on the track to arrive at a balanced arrangement for the set of plates.

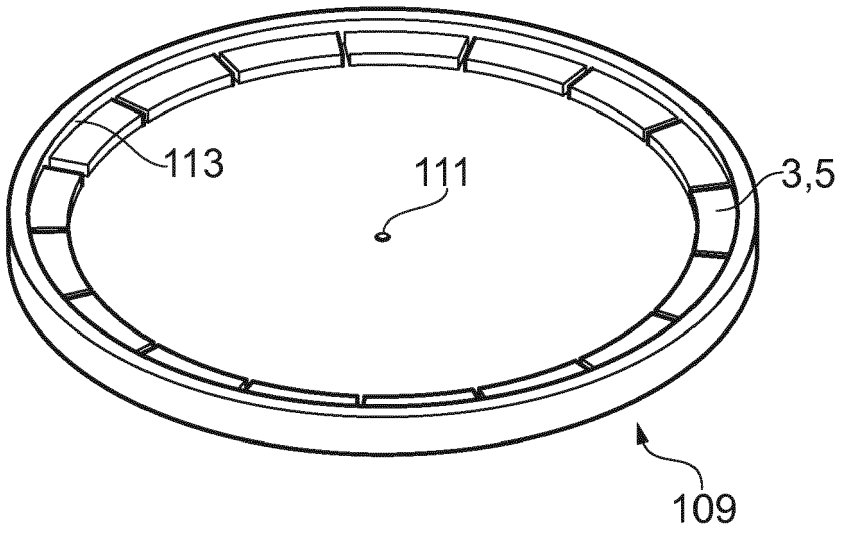

FIG. 4

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Description

Field of the Invention

[0001] The present invention relates to a method for balancing parts for a gas turbine engine, and more specifically to a method for balancing a set of retaining and locking plates used to retain a row of gas turbine engine aerofoil blades in attachment to a rotor disc.

Background of the Invention

[0002] Retaining plates are common to many gas turbine designs and are used to prevent axial movement of aerofoil blades such as turbine blades. For example, Fig. 1 shows a perspective view of gas turbine aerofoil blades 1 attached to a rotor disc 7. The aerofoil blades 1 have root fixings (not shown) that are slidable into corresponding slots formed in the disc 7. Retaining plates 3 are then used to retain the aerofoil blades 1 in attachment to the disc 7. The retaining plates 3 themselves are held in place with locking plates 5, which are smaller in circumferential extent than the retaining plates, have a different mass per unit arc, and have a deformed profile for assembly reasons. The retaining and locking plates may locate at one side in a grooved rim around the disc and at the other side in a similar grooved rim in the inner platforms of the blades.

[0003] The retaining and locking plates are required to be balanced. Unbalance occurs when a mass centre of a rotor is different from its running centre axis. Units of unbalance are mass times radius. If a mass added to a certain position on a part being balanced shifts the mass centre into the running axis so that the part is in balance, the unbalance unit of the part is the mass of correction multiplied by the applied radius. The retaining and locking plates are thus balanced when the mass centre of the plates coincides with the running centre of the disc.

[0004] A conventional method for balancing a set of retaining/locking plates uses software to distribute the plates into a pattern of even distribution based on the masses of the individual plates. If the unbalance of the complete set of plates is outside certain pre-defined limits, the software swaps the positions of individual masses until the desired result is achieved. Further balancing in a rotating balancing machine may be required to reduce unbalance to within the pre-defined limits.

[0005] A disadvantage of the software method is that it assumes that the plates are evenly circumferentially distributed. Almost invariably, however, this is not the case as the locking plates are usually a different size to the retaining plates. Further, the software method does not take account of the typically different mass per unit arc of the locking plates.

Summary of the Invention

[0006] It would be desirable to have an alternative method for balancing retaining and locking plates.

[0007] Accordingly, a first aspect of the present invention provides a method of balancing a set of retaining and locking plates used to retain a row of gas turbine engine aerofoil blades in attachment to a rotor disc, the aerofoil blades having root fixings which are slidable into corresponding slots formed in the disc, the retaining plates being positioned in a circumferential row at a rim of the disc to prevent the root fixings sliding out of the slots, and the locking plates being introduced into the circumferential row between pairs of retaining plates to lock the retaining plates in position, the method including:

providing a weighing plate having a circular track corresponding to the position of the circumferential row at the rim of the disc;
providing a non-rotating, static balancing apparatus capable of detecting unbalance in the weighing plate;
positioning the weighing plate on the static balancing apparatus, and positioning the set of retaining and locking plates on the track in an arrangement corresponding to a possible arrangement for the set of plates in the circumferential row at the rim of the disc; and
repositioning the retaining and locking plates on the track to arrive at a balanced arrangement for the set of plates which reduces unbalance produced by the set of plates to below a predetermined threshold.

[0008] Advantageously, this method can compensate for angular differences between plates, and facilitates their fast and easy balancing.

[0009] A second aspect of the invention provides a method of building a section of a gas turbine engine including:

performing the method of the first aspect;
providing a row of gas turbine engine aerofoil blades which are attached to a rotor disc by sliding root fixings of the aerofoil blades into corresponding slots formed in the disc; and
positioning the set of retaining and locking plates in a circumferential row at a rim of the disc to prevent the root fixings sliding out of the slots, the set of plates having the balanced arrangement in the circumferential row.

[0010] Optional features of the invention will now be set out. These are applicable singly or in any combination with any aspect of the invention.

[0011] The circular track may be defined at one edge by a circular abutment shoulder against which the retaining and locking plates can be located. Such a simple arrangement facilitates redistribution of the retaining and locking plates into a final, balanced, configuration for use in the turbine.

[0012] Conveniently, the method may further include measuring cold build expansion gaps formed between

the retaining plates when positioned on the track. The retaining plates can then be shortened, if necessary, to increase the expansion gaps.

[0013] The retaining plates may have a different mass per unit arc than the locking plates. The retaining plates may additionally or alternatively have a different circumferential extent than the locking plates.

[0014] The aerofoil blades may be turbine blades or compressor blades.

Brief Description of the Drawings

[0015] Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:

Fig. 1 shows a perspective view of gas turbine aerofoil blades attached to a rotor disc and prevented from moving axially by retaining and locking plates;

Fig. 2 shows a longitudinal cross-section through a ducted fan gas turbine engine;

Fig. 3 shows a plan view of retaining and locking plates located in a circular track of a weighing plate;

Fig. 4 shows a perspective view of the weighing plate of Fig. 3; and

Fig. 5 shows a cross-section view of the weighing plate of Fig. 3.

Detailed Description and Further Optional Features of the Invention

[0016] With reference to Fig. 2, a ducted fan gas turbine engine is generally indicated at 10 and has a principal and rotational axis X-X. The engine comprises, in axial flow series, an air intake 11, a propulsive fan 12, an intermediate pressure compressor 13, a high-pressure compressor 14, combustion equipment 15, a high-pressure turbine 16, an intermediate pressure turbine 17, a low-pressure turbine 18 and a core engine exhaust nozzle 19. A nacelle 21 generally surrounds the engine 10 and defines the intake 11, a bypass duct 22 and a bypass exhaust nozzle 23.

[0017] During operation, air entering the intake 11 is accelerated by the fan 12 to produce two air flows: a first air flow A into the intermediate pressure compressor 13 and a second air flow B which passes through the bypass duct 22 to provide propulsive thrust. The intermediate pressure compressor 13 compresses the air flow A directed into it before delivering that air to the high pressure compressor 14 where further compression takes place.

[0018] The compressed air exhausted from the high-pressure compressor 14 is directed into the combustion equipment 15 where it is mixed with fuel and the mixture combusted. The resultant hot combustion products then expand through, and thereby drive the high, intermediate and low-pressure turbines 16, 17, 18 before being exhausted through the nozzle 19 to provide additional propulsive thrust. The high, intermediate and low-pressure turbines respectively drive the high and intermediate pressure compressors 14, 13 and the fan 12 by suitable interconnecting shafts.

[0019] As discussed above in relation to Fig. 1, retaining 3 and locking 5 plates are used to prevent axial movement of the aerofoil blades of e.g. the high, intermediate and low-pressure turbines 16, 17, 18. However, such plates can be used to retain other types of blades, such as the aerofoil blades of e.g. the intermediate and high-pressure compressors 13, 14. The retaining plates 3 are positioned in a circumferential row at a rim of the rotor disc 7 to prevent the root fixings of the blades sliding out of the slots formed in the disc, the radially inner edge of each retaining plate locating in a circular groove formed in the disc, and the radially outer edge of each retaining plate locating in a circular groove formed in the blade platforms. The locking plates 5 are introduced into the circumferential row between pairs of retaining plates 3 to lock the retaining plates 3 in position, the inner and outer edges of each locking plate also locating in the aforementioned grooves.

[0020] Fig. 3 shows a weighing plate 109 suitable for use in balancing the set of retaining 3 and locking 5 plates, Fig. 4 shows a perspective view of the weighing plate 109, and Fig. 5 shows a cross-section view of the weighing plate 109. The weighing plate 109 is pancake-shaped and has a circular track 115 (best shown in Fig. 5) for receiving the plates. The circular track 115 corresponds to the position of the circumferential row of the set of plates 3, 5 in use at the rim of the disc 7, e.g. as illustrated in Fig. 1.

[0021] The circular track 115 replicates the running radius of the set of plates 3, 5 so that the unbalance of the plates 3, 5 can be determined. The circular track 115 may be defined by a circular abutment shoulder 113 which corresponds to the position of the circular groove in which the outer edges of the plates are located in use, as shown in Figs. 4 and 5. Conveniently, the plates 3, 5 can then be located against the abutment shoulder 113. This simple arrangement facilitates repositioning of the plates 3, 5 into different arrangements.

[0022] The weighing plate 109 is placed on a non-rotating static balancing machine (e.g. a non-rotating vertical balancing machine available from Universal Balancing Ltd), preferably with the centre 111 of the weighing plate 109 (which corresponds to the axis of rotation of the rotor disc 7) located centrally on the machine. The machine has instrumentation such that it can detect the unbalance of the plates 3, 5 with respect to the centre 111 of the weighing plate 109.

[0023] Any unbalance in the set of plates 3, 5 located on the circular track 115 is indicated by the balancing machine e.g. by way of a display. The unbalance can then be corrected by manually repositioning the plates

3, 5 around the track 115. The unbalance may be considered to be corrected and a balanced arrangement achieved when the unbalance falls below a predetermined threshold. The threshold can be set so that further balancing in a rotating balancing machine is unnecessary. The threshold is typically determined by the unbalance limits of the rotor, which are a function of its mass properties and service speed.

[0024] To build the corresponding section of a gas turbine engine, aerofoil blades 1 are attached to a rotor disc 7 by sliding root fixings of the aerofoil blades into corresponding slots formed in the disc. The edges of the retaining 3 and locking 5 plates are then located in their respective grooves in the balanced arrangement at the rim of the disc, to prevent the root fixings sliding out of the slots.

[0025] As illustrated in Figs. 1 and 3, the locking plates 5 generally have a smaller circumferential extent than the retaining plates 3. Further the locking plates 5 may have a different mass per unit arc. The angular difference between the retaining plates 3 and the locking plates 5 is illustrated in Fig. 3, by the difference between angles A and B. The approach to balancing described above using the circular weighing plate 109 and the non-rotating static balancing machine automatically compensates for this angular difference and for differences in the mass per unit arc of the plates 3, 5.

[0026] The weighing plate 109 can also be used for checking that the retaining plate 3 have sufficient cold build expansion gaps therebetween. If necessary, the circumferential lengths of one or more of the plates 3 can be reduced by machining to increase their respective expansion gaps.

[0027] While the invention has been described in conjunction with the exemplary embodiments described above, many equivalent modifications and variations will be apparent to those skilled in the art when given this disclosure. Accordingly, the exemplary embodiments of the invention set forth above are considered to be illustrative and not limiting. Various changes to the described embodiments may be made without departing from the spirit and scope of the invention.

Claims

1. A method of balancing a set of retaining (3) and locking (5) plates used to retain a row of gas turbine engine aerofoil blades (1) in attachment to a rotor disc (7), the aerofoil blades having root fixings which are slidable into corresponding slots formed in the disc, the retaining plates being positioned in a circumferential row at a rim of the disc to prevent the root fixings sliding out of the slots, and the locking plates being introduced into the circumferential row between pairs of retaining plates to lock the retaining plates in position, the method including:

   providing a weighing plate (109) having a circular track (115) corresponding to the position of the circumferential row at the rim of the disc;
   providing a non-rotating, static balancing apparatus capable of detecting unbalance in the weighing plate;
   positioning the weighing plate on the static balancing apparatus, and positioning the set of retaining and locking plates on the track in an arrangement corresponding to a possible arrangement for the set of plates in the circumferential row at the rim of the disc; and
   repositioning the retaining and locking plates on the track to arrive at a balanced arrangement for the set of plates which reduces unbalance produced by the set of plates to below a predetermined threshold.

2. The method of claim 1, wherein the retaining plates have a different mass per unit arc than the locking plates.

3. The method of claim 1 or 2, wherein the retaining plates have a different circumferential extent than the locking plates.

4. The method of any one of the previous claims, wherein the circular track is defined at one edge by a circular abutment shoulder (113) against which the retaining and locking plates can be located.

5. The method of any one of the previous claims, further including:

   measuring cold build expansion gaps formed between the retaining plates when positioned on the track.

6. A method of building a section of a gas turbine engine including:

   performing the method of any one of the previous claims;
   providing a row of gas turbine engine aerofoil blades which are attached to a rotor disc by sliding root fixings of the aerofoil blades into corresponding slots formed in the disc; and
   positioning the set of retaining and locking plates in a circumferential row at a rim of the disc to prevent the root fixings sliding out of the slots, the set of plates having the balanced arrangement in the circumferential row.

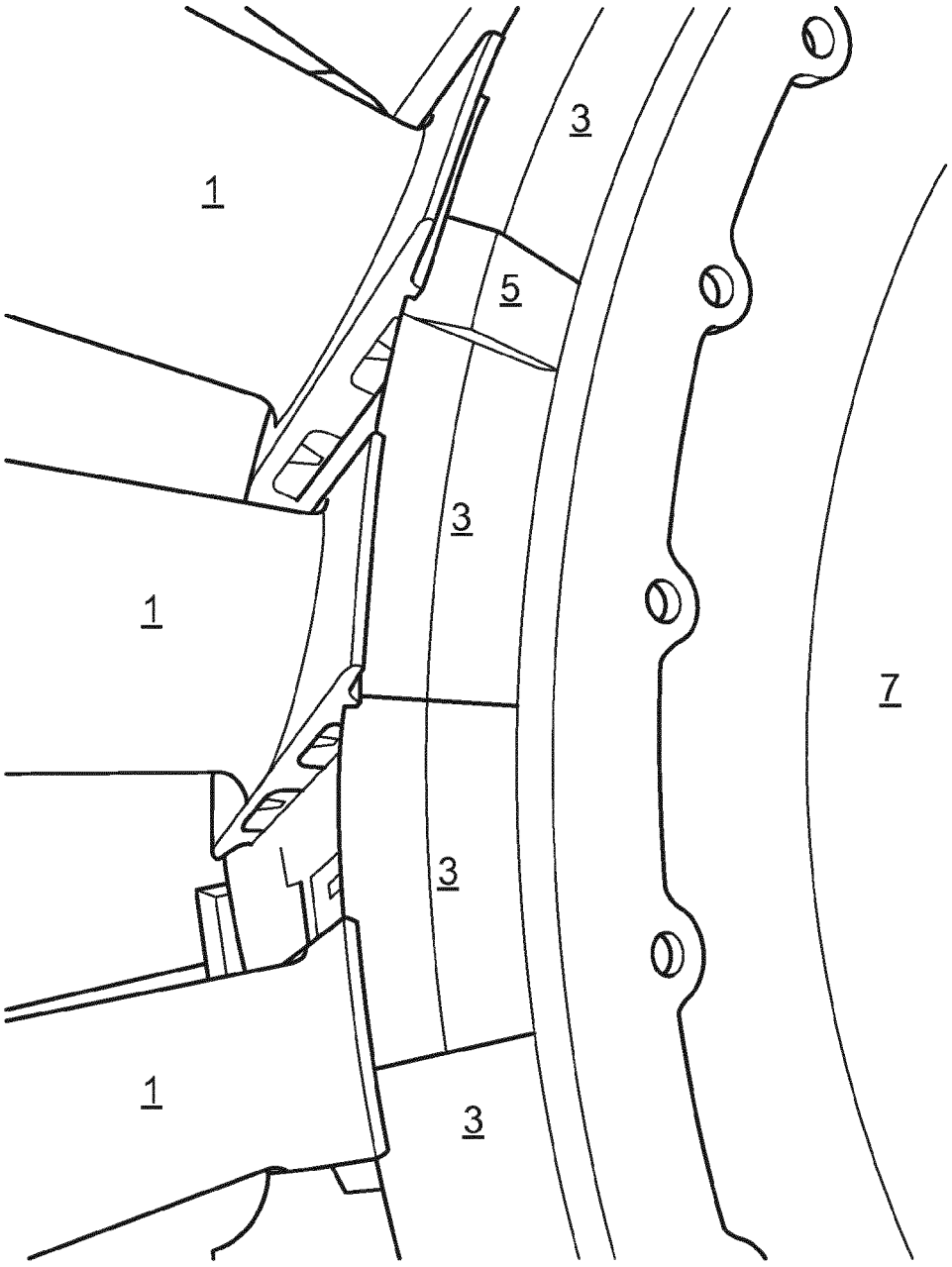

FIG. 1

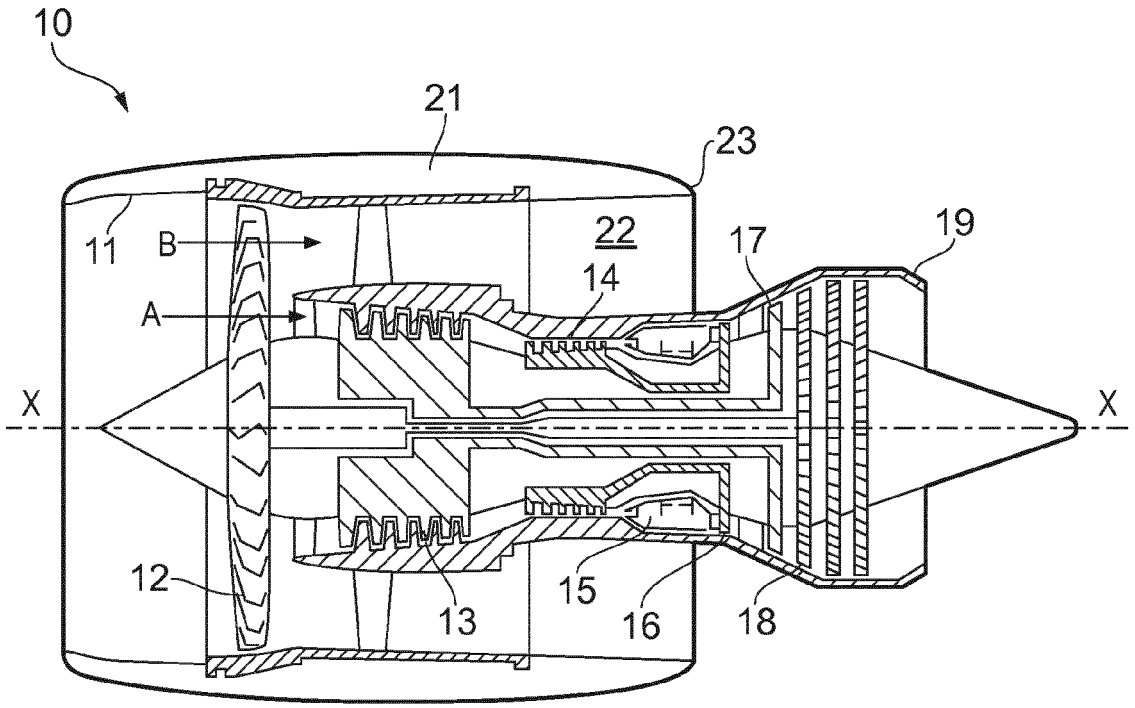

FIG. 2

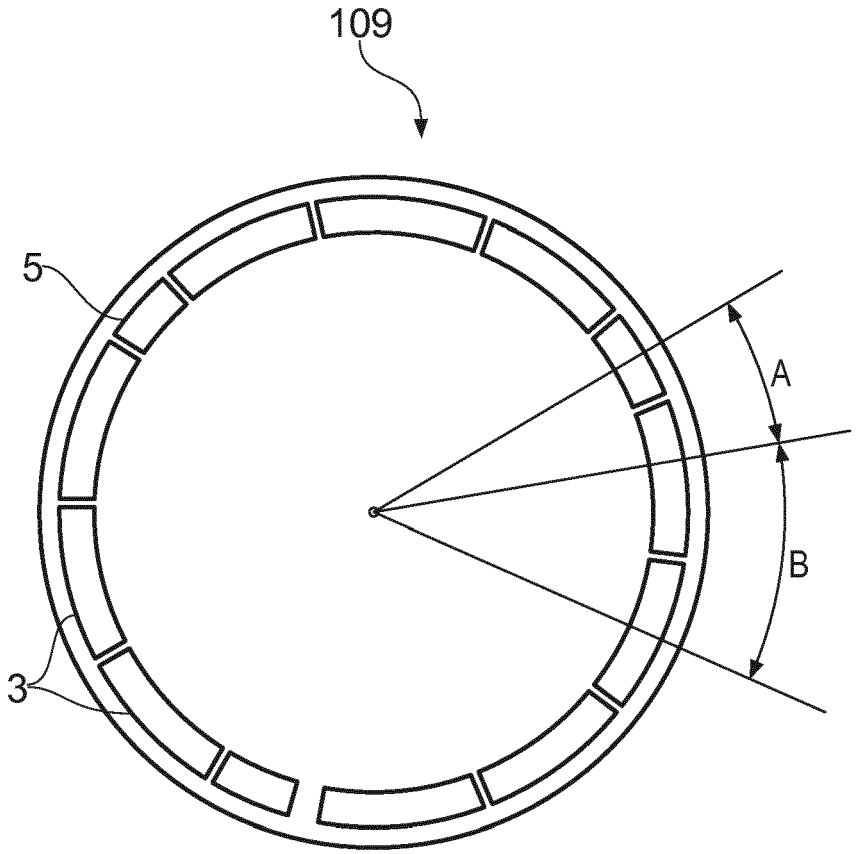

FIG. 3

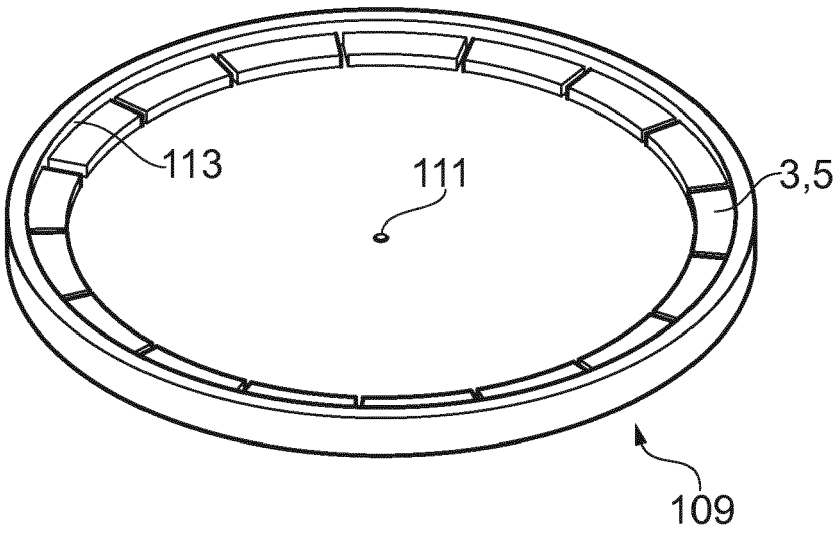

FIG. 4

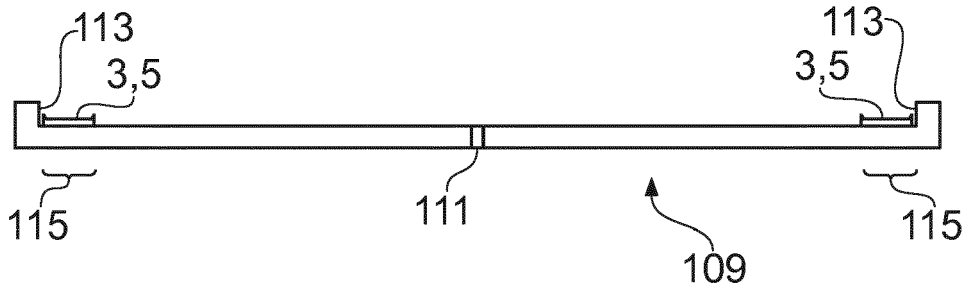

FIG. 5