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(54) **Cold rolling apparatus for an annular element, in particular a ring of a rolling bearing, and associated method.**

(57) Apparatus (1) and method for forming by rolling annular elements (2), such as rings of rolling bearings, from an annular blank workpiece (3); wherein the annular blank workpiece is sandwiched between a mandrel (4) which is axially symmetric with respect to a first axis and a forming tool (5) which is axially symmetric with respect to a second axis, arranged parallel to the first axis, which are rotating about the first and second axis; axial locking shoulders (15) are impressed on the annular blank workpiece (3) by means of a plurality of projections (14) carried by a first lateral surface (13) of the forming tool (5) which are coaxial with the second axis and are arranged mutually side by side and spaced apart in axial direction.

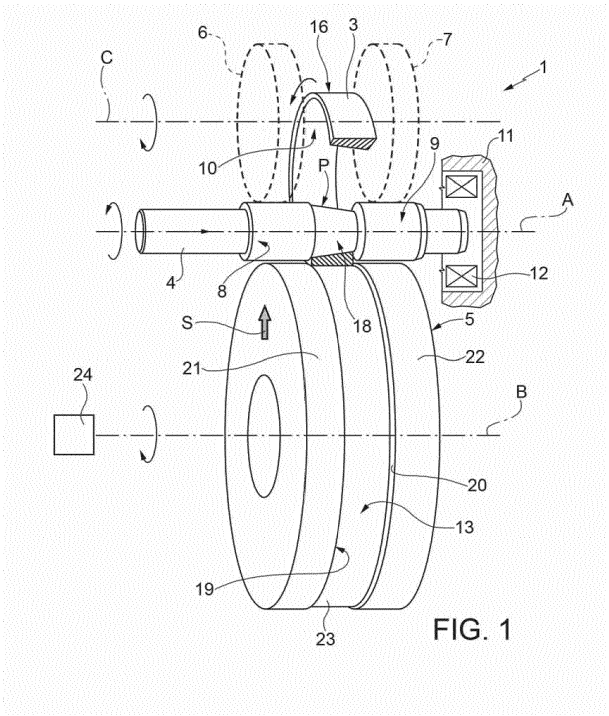


FIG. 1

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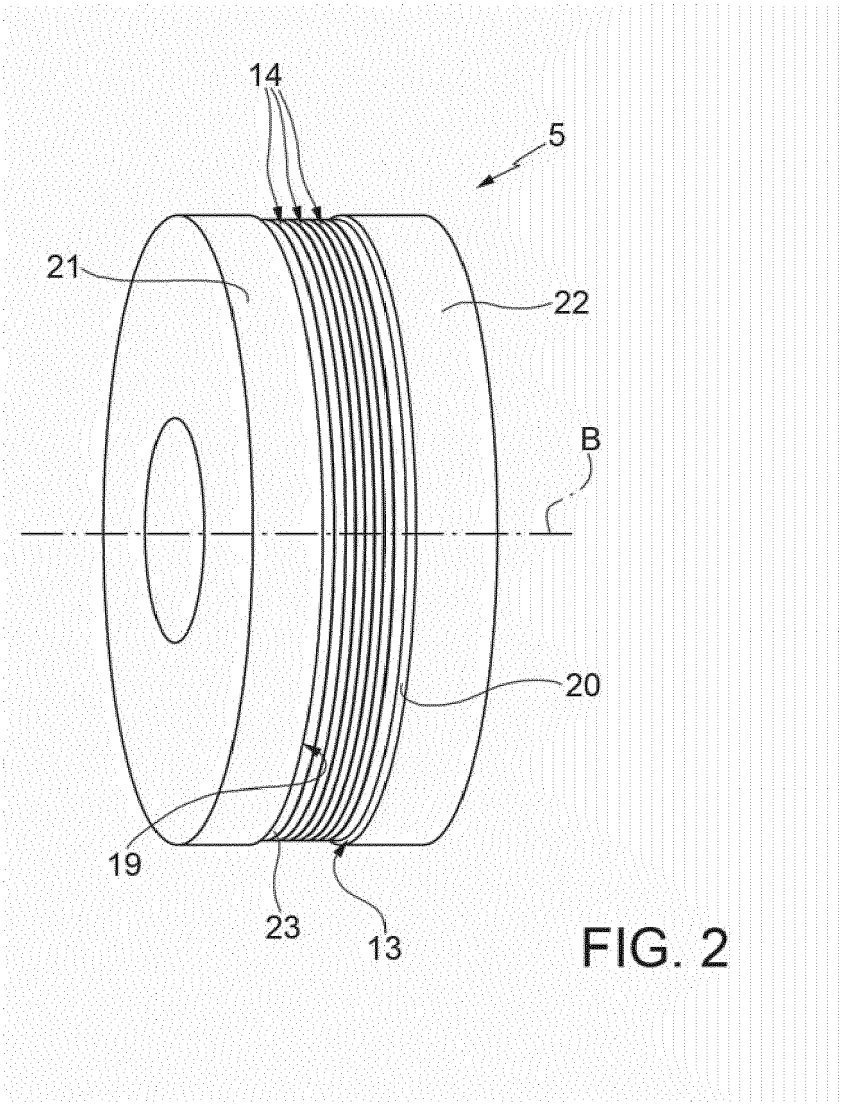


FIG. 2

## Description

### Technical field of the invention

**[0001]** The present invention relates to an apparatus for forming, by cold rolling, annular elements, in particular to obtain a radially inner surface with the desired profile of rings of rolling bearings, and to a relative method of execution using such an apparatus.

### Prior art

**[0002]** As is known, for example from EP1385651, annular elements, such as the rings of a rolling bearing or at least a part thereof carrying the rolling raceways for the rolling elements, may be advantageously formed by cold rolling, impressing a desired profile on a radially outer and/or radially inner surface of an annular blank workpiece.

**[0003]** This operation is carried out by radially sandwiching the annular blank workpiece between an axially symmetrical forming mandrel inserted axially through the annular blank workpiece, and a tool or die, also axially symmetric, arranged on an axis parallel to that of the mandrel and which is brought against a radially outer surface of the annular blank workpiece.

**[0004]** The mandrel carries on a radially outer lateral surface thereof a profile complementary to, that is, reproducing in negative, the profile to be made on a radially inner lateral surface of the annular element to be obtained; in use, the mandrel is pressed radially against the radially inner lateral surface of the blank workpiece, while the tool or die is pressed with a radially outer lateral surface thereof against the radially outer surface of the annular blank workpiece, while both the mandrel and the tool or die are brought in rotation about the respective axes thereof, dragging in rotation also the annular blank workpiece, which deforms. The radially outer lateral surface of the tool or die also has a profile complementary to that to be formed on the annular element to be obtained which, during the forming process, tapers in the radial direction and elongates in the axial direction.

**[0005]** During this roll forming process, in particular when one of the profiles to be obtained on the annular element to be formed has non-cylindrical stretches, despite the axial contrast means normally arranged on the mandrel, small axial movements of the annular element may occur in the forming step which may compromise the accuracy in obtaining the desired profiles. This problem may be present too in the method according to WO98/32556 wherein the profile to be obtained possesses projections/grooves having such a dimension that the aforementioned small axial movements can nevertheless occur.

### Summary of the invention

**[0006]** The object of the present invention is to provide an apparatus for forming by cold rolling annular elements, in particular rings of rolling bearings, without the drawbacks described above, which allows preventing even small axial movements of the element being processed, especially at the beginning of the process itself, and which is also simple, cost-effective to be made and small in size. It is also an object of the invention to provide a method for forming by rolling, starting from an annular blank workpiece, an annular element of predetermined radial profile, in particular a ring of a rolling bearing.

**[0007]** Therefore, according to the invention, there are provided an apparatus for forming by cold rolling annular elements, in particular rings of rolling bearings, and a method for forming by rolling, starting from an annular blank workpiece, an annular element having a predetermined radial profile, in particular a ring of a rolling bearing, having the features set forth in the appended claims.

### Brief description of the drawings

**[0008]** The invention will now be described with reference to the accompanying drawings, which show a non-limiting example thereof, in which:

- figure 1 schematically shows a perspective elevation and front three-quarter view of an apparatus for cold rolling annular elements, in particular rings of rolling bearings, and of a step of the method of the invention;
- figure 2 schematically shows a perspective enlarged-scale view of a tool forming part of the apparatus in figure 1, implemented according to the invention;
- figures 3 and 4 schematically show an elevation view of a detail of the apparatus in figure 1 and the tool in figure 2 before and after the execution of a step of the method of the invention on an annular element to be rolled; and
- figures 5 and 6 schematically show two further mutually alternative steps of the method of the invention.

### Detailed description

**[0009]** With reference to figures 1 and 2, reference numeral 1 indicates as a whole an apparatus for forming by cold rolling annular elements 2 (figures 5 and 6) having a predetermined radial profile, in particular rings of rolling bearings, starting from an annular blank workpiece 3 (figures 1 and 3).

**[0010]** Apparatus 1 comprises a mandrel 4 axially symmetric with respect to a first axis A and adapted to be, in use, inserted axially through and radially inside the annular blank workpiece 3, as is well shown in figure 1; apparatus 1 further comprises a forming tool 5 axially symmetric with respect to a second axis B, arranged parallel to axis A. The forming tool 5 is adapted, in use, to cooperate radially on the outside with the annular blank workpiece 3 so that the annular blank workpiece 3 remains in use sandwiched between mandrel 4 and the

forming tool 5, which rotate about the first and second axis, A and B, respectively, as clearly shown in figure 1, while the forming tool 5 applies a radial thrust S to the blank workpiece 3.

**[0011]** According to a known arrangement, mandrel 4 must be laterally supported, on the side opposite to tool 5, by a pair of receiving rollers 6 and 7 as shown with a dashed line, which idly rotate about an axis C and which cooperate with cylindrical shoulder surfaces 8 and 9 of mandrel 4 having a same diameter, so as not to create in use, as a result of thrust S, axial forces on mandrel 4. Between shoulders 8 and 9, mandrel 4 is delimited by a radial lateral surface 18 which has in a radial plane a longitudinal profile P which reproduces in negative the profile to be obtained on the blank workpiece 3 to make the finished annular element 2, in the example shown, on an inner radial surface 10 of the annular blank workpiece 3.

**[0012]** Mandrel 4 is further idly and axially supported, in a known manner and only schematically shown for simplicity, by a seat 11 provided with a bearing 12.

**[0013]** According to the main feature of the invention, the forming tool 5 has a first lateral surface 13 which faces towards mandrel 4, in the example shown the lateral surface 13 is a radially outer surface of tool 5, and which is provided with a plurality of annular projections or grooves 14, which are coaxial with axis B and are arranged mutually side by side and spaced apart in the axial direction.

**[0014]** With reference also to figures 3 and 4, the projections or grooves 14 are adapted in use to lock the annular blank workpiece against any axial movement thereof by constituting axial locking shoulders of the annular blank workpiece 3 which shoulders impress in use corresponding annular grooves or projections/protrusions 15 on a second lateral surface 16 of the annular blank workpiece 3, in the example shown a radially outer lateral surface thereof, as soon as the lateral surface 13 of the forming tool 5 is brought in cooperation with the lateral surface 16 of the blank workpiece 3 to exert the radial thrust S.

**[0015]** It is clear that the situation described applies to the case in which a predetermined radial profile P1 must be made on the radially inner lateral surface 10 of the annular blank workpiece 3, for example to obtain the rolling raceways of the finished annular element 2 when this consists of an outer ring of a rolling bearing. However, it is also clear that a dual situation may be accomplished, in which the predetermined radial profile P1 has to be made on the radially outer lateral surface 16 of the annular blank workpiece 3, for example to obtain the rolling raceways of the finished annular element 2 when this consists of an inner ring of a rolling bearing. In this case, profile P will be carried by surface 13 of the forming tool 5, while the projections or grooves 14 will be carried by the radial lateral surface 18 of mandrel 4.

**[0016]** According to the embodiment shown, the lateral surface 13 of the forming tool 5 is a cylindrical surface provided with a plurality of radial annular projections 14 having an essentially triangular profile in axial section (figures 3 and 4), which are spaced apart from one another in axial direction by a quantity greater than a maximum width W of the projections at a root or base portion 19 thereof, which is arranged flushed with the lateral surface 13.

**[0017]** The first lateral surface 13 of the forming tool 5 is delimited between two axial shoulders 19 and 20 of the forming tool 5 defined by two opposite cylindrical end stretches 21, 22 of the forming tool 5 with diameter greater than a middle stretch 23 of the forming tool 5 delimited by the lateral surface 13 and provided with the radial projections 14.

**[0018]** Moreover, according to a further feature of the invention, the central stretch 23 of the forming tool 5, delimited by the lateral surface 13, has an axial length designed so as to be greater than that of the annular blank workpiece 3 to be processed and substantially equal to the end axial length of the annular element 2 to be obtained.

**[0019]** Finally, according to a further essential feature of the invention, the radial projections 14 have a height, measured in radial direction, which is very small, of the order of magnitude of the tenths of mm, and comprised between 1 and 2 tenths of a millimeter. Projections 14 produce, in use, the formation of annular grooves 15, also deep 1 or 2 tenths of a millimeter and axially spaced apart from one another, in which projections 14 "fit" themselves while also the blank workpiece 3 is dragged in rotation by the contact with mandrel 4, thereby preventing any relative axial movement (indicated by the cross arrows in figure 4) between the blank workpiece 3 and mandrel 4, since the first instant in which tool 5 comes in contact with the blank workpiece 3. Continuing the plastic deformation step of the blank workpiece 3, this becomes thins and lengthens axially until it arrives against shoulders 19 and 20, which prevent any further axial movement of the blank workpiece 3 being processed.

**[0020]** According to the description, it is clear that the invention also relates to a method for manufacturing by rolling, starting from an annular blank workpiece 3, an annular element 2 with a predetermined radial profile P1, in particular a ring of a rolling bearing, comprising the steps of:

- axially introducing through the annular blank workpiece 3 and radially inside the annular blank workpiece 3 a mandrel 4 axially symmetrical with respect to a first axis A about which mandrel 4 rotates; and
- sandwiching the annular blank workpiece 3 between mandrel 4 and a forming tool 5 axially symmetrical with respect to a second axis B, arranged parallel to the first axis A and about which second axis B the forming tool 5 rotates, so that the forming tool 5 cooperates radially on the outside with the annular blank workpiece 3, while mandrel 4 cooperates radially on the inside with the annular blank workpiece

3, and while the mandrel and the forming tool are rotated at the same time about the first and second axis, respectively, for example by known motor means 24 schematically shown with a block for simplicity, consequently rotating the annular blank workpiece 3 as well.

**[0021]** The method according to the invention further comprises the step of forming axial locking shoulders 15 on the annular blank workpiece 3 by impressing on a lateral surface 16 of the annular blank workpiece 5 a series of annular protrusions or grooves 15 by means of a plurality of annular projections or grooves 14 carried by a lateral surface 13 of the forming tool 5 or by a lateral surface 18 of mandrel 4 as soon as the forming tool 5 begins to cooperate with the annular blank workpiece 3.

**[0022]** The step of forming axial locking shoulders 15 on the annular blank workpiece 3 is carried out by means of a first lateral surface 13 of the forming tool 5 which is a cylindrical surface provided with a plurality of radial annular projections 14 having an essentially triangular profile in axial section, which are spaced apart from one another in axial direction by a quantity greater than a maximum width W of the projections at a root or base portion 19 thereof, which is arranged flushed with the lateral surface 13.

**[0023]** Moreover, the lateral surface 13 of the forming tool 5 is pushed in cooperation against a second lateral surface 16 of the annular blank workpiece 3 during the sandwiching step of the annular blank workpiece 3 between the forming tool 5 and mandrel 4 to form profile P1 by means of the complementary profile P of mandrel 4.

**[0024]** The lateral surface 13 of the forming tool is further made so as to be delimited between two axial shoulders 19 and 20 of the forming tool 5 defined by the two opposite cylindrical end stretches 21, 22.

**[0025]** During the sandwiching step of the annular blank workpiece 3 between the forming tool 5 and mandrel 4, the axial shoulders 15 are formed first, defined by annular grooves having a triangular cross-section, on the lateral surface 16 of the annular blank workpiece 3, by means of projections 14 which "incise" on surface 16.

**[0026]** Thereafter, the annular blank workpiece 3 is plastically deformed so as to make it thin in the radial direction and elongate it in the axial direction up to bring the annular blank workpiece 3 in abutment against the axial shoulders 19, 20 of the forming tool 5, while profile P of mandrel 4 impresses profile P1 on the blank workpiece 3. The length of the annular blank workpiece 3 therefore changes, during the rolling operation, from a value L1 at the beginning of the operation to a maximum value L2 equal to the axial distance present between shoulders 19 and 20.

**[0027]** According to the method of the invention, the axial locking shoulders 15 which are formed on the annular blank workpiece 3 have a height measured in radial direction comprised only between 1 and 2 tenths of a millimeter.

**[0028]** Of course, the apparatus and the method of forming by rolling described involve that at the end of the rolling operation on the lateral surface (outer, in the example shown) of element 2 having profile P1, "streals" consisting of micro-grooves 15 remain. Therefore, the method according to the invention further comprises a step of removing the axial locking shoulders 15, i.e. grooves 15, carried out on the element 2 obtained, after removing mandrel 4 and the forming tool 5.

**[0029]** Such a removal step of the axial locking shoulders 15 is carried out by subjecting the annular element 2 substantially already finished to a processing of surface 16 for chip removal (figure 6) by means of a tool 25 or drawing of the lateral surface 16 provided with the axial locking shoulders (grooves) 15 by means of a die 26 (figure 5).

**[0030]** In both cases, a finished annular element 2 is obtained at the end, having the desired radial profile P1 and delimited by a lateral surface 16B opposite to profile P1 perfectly free of streaks, i.e. without grooves 15 which, in the initial step of the process of rolling profile P1, have allowed preventing undesired axial movements, albeit very small, of the annular blank workpiece 3.

**[0031]** Finally, it should be noted that the process which must be carried out on the lateral surface 16 provided with the "streals" or grooves 15 is not expensive, since it should be carried out anyway, even in the presence of a smooth surface 16, to be within the dimensional and geometric tolerances provided for the finished annular element 2.

## Claims

1. An apparatus (1) for forming by cold rolling annular elements (2) having a predetermined radial profile, in particular rolling bearing rings, starting from an annular blank workpiece (3), the apparatus comprising a mandrel (4) axially symmetrical with respect to a first axis (A) and adapted to be inserted, in use, axially through and radially inside the annular blank workpiece; and a forming tool (5) axially symmetrical with respect to a second axis (B), arranged parallel to the first axis, and adapted, in use, to cooperate radially on the outside with the annular blank workpiece so that the annular blank crosspiece remains sandwiched, in use, between the mandrel and the forming tool, which both rotate about the first and second axis, respectively; **characterized in that** either the forming tool (5) or the mandrel (4) have a first lateral surface (13;18) which faces the other either forming tool or mandrel, and which is provided with a plurality of annular projections or grooves (14), which are arranged reciprocally facing one another and spaced apart in axial direction; the projections or grooves (14) being adapted in use to lock the annular blank workpiece against any axial movement thereof by impressing, in use, corresponding

grooves or projections (15) on a second lateral surface (16) of the annular blank workpiece as soon as the lateral surface is taken into cooperation with the second lateral surface; the radial projections (14) having an height measured in radial direction of the order of magnitude of the tenths of mm.

**2.** An apparatus according to claim 1, **characterized in that** the first lateral surface is a cylindrical surface (13) of the forming tool (5) provided with a plurality of radial annular projections (14) having an essentially triangular profile in axial section, which are spaced apart from one another in axial direction by a quantity greater than a maximum width (W) of the projections at a root or base portion (19) thereof, which is arranged flushed with the first lateral surface (13).

**3.** An apparatus according to claim 2, **characterized in that** the first lateral surface (13) of the forming tool is delimited between two axial shoulders (19,20) of the forming tool defined by two opposite cylindrical end stretches (21,22) of the forming tool with diameter greater than a middle stretch (23) of the forming tool delimited by the first lateral surface (13) and provided with the radial projections (14).

**4.** An apparatus according to claim 3, **characterized in that** the middle stretch (23) of the forming tool, delimited by said first lateral surface, is designed such as to have an axial length (L2) equal to substantially the final axial length of the annular element (2) to be obtained.

**5.** An apparatus according to one of the claims from 2 to 4, **characterized in that** the height of the radial projections (14) measured in radial direction is comprised between 1 and 2 tenths of a millimeter.

**6.** A method for manufacturing by rolling, starting from an annular blank workpiece (3), an annular element (2) with a predetermined radial profile, in particular a ring of a rolling bearing, comprising the steps of:

- axially introducing through the annular blank workpiece and radially inside the annular blank workpiece a mandrel (4) axially symmetrical with respect to a first axis (A) about which the mandrel rotates; and
- sandwiching the annular blank workpiece between the mandrel and a forming tool (5) axially symmetrical with respect to a second axis (B), arranged parallel to the first axis and about which second axis the forming tool rotates, so that the forming tool (5) cooperates radially on the outside with the annular blank workpiece, while the mandrel (4) cooperates radially on the inside with the annular blank workpiece, and the mandrel and the forming tool are rotated at the same time about the first and second axis (A,B), respectively, consequently rotating the annular blank workpiece as well; **characterized in that** it further comprises the step of forming axial locking shoulders (15) on the annular blank workpiece (3) by impressing on a lateral surface (16) of the annular blank workpiece a series of annular protrusions or grooves (15) by means of a plurality of annular grooves or projections (14) carried by a lateral surface (13) of the forming tool (5) or of the mandrel (4) as soon as the forming tool starts to cooperate with the annular blank workpiece; the radial projections (14) having an height measured in radial direction of the order of magnitude of the tenths of mm.

**7.** A method according to claim 6, **characterized in that** the step of forming axial locking shoulders (15) on the annular blank workpiece is carried out by means of a first lateral surface (13) of the forming tool (5) which is a cylindrical surface provided with a plurality of radial annular projections (14) having essentially triangular profile in axial section, which are spaced apart from one another by a quantity greater than a maximum width (W) of the projections at a root or base portion (19) thereof, which is arranged flushed with the first lateral surface (13); the first lateral surface of the forming tool being pushed into cooperation against a second lateral surface of the annular blank workpiece during the step of sandwiching of the annular blank workpiece between the forming tool and the mandrel.

**8.** A method according to claim 7, **characterized in that** the first lateral surface (13) of the forming tool is delimited between two axial shoulders (19,20) of the forming tool defined by two opposite cylindrical end stretches (21,22) of the forming tool of diameter larger than a middle stretch (23) of the forming tool delimited by the first lateral surface and provided with radial projections (14); during the step of sandwiching of the annular blank workpiece and the mandrel the axial shoulders (15) being firstly formed on the second lateral surface (16) of the annular blank workpiece and then the annular blank workpiece (3) being plastically deformed so as to make it thinner in radial direction and elongate it in axial direction to abut the annular blank workpiece against the axial shoulders (19,20) of the forming tool.

**9.** A method according to one of the claims from 6 to 8, **characterized in that** the height of the axial locking shoulders (15) which are formed on the annular blank workpiece measured in radial direction is comprised between 1 and 2 tenths of a millimeter.

**10.** A method according to any one of the claims from 6

to 9, **characterized in that** it further comprises the step of removing the axial locking shoulders (15) after having removed the mandrel (4) and the forming tool (5).

**11.** A method according to claim 10, **characterized in that** the step of removing the axial locking shoulders (15) is carried out by subjecting the finished annular element to machining (2) by chip forming or drawing of the lateral surface (16) provided with the axial locking shoulders (15) .

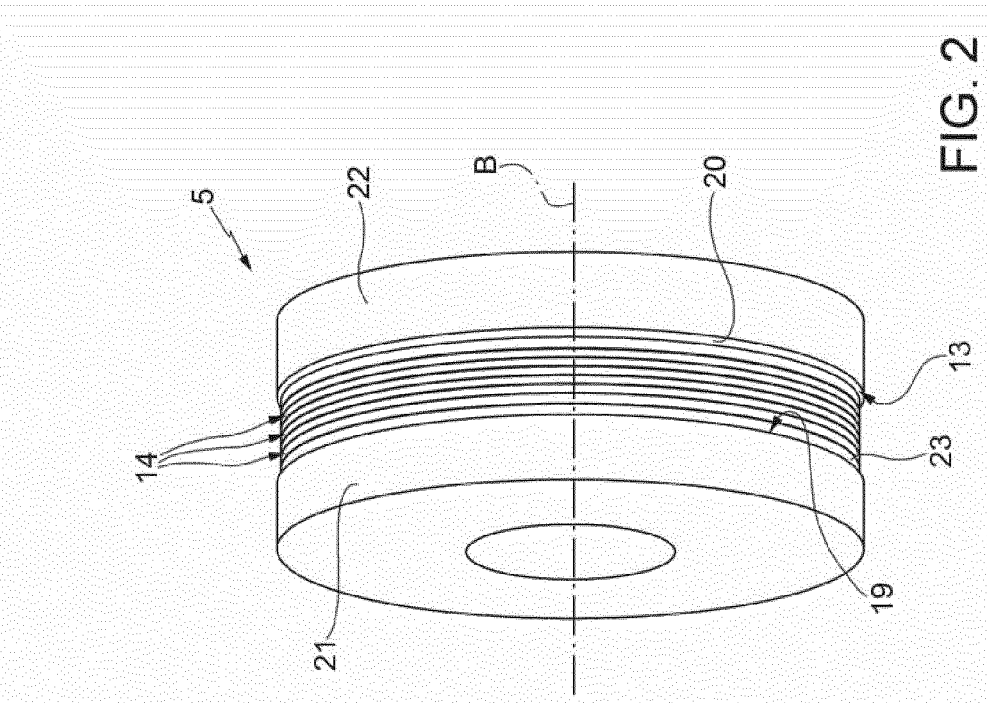
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FIG. 2

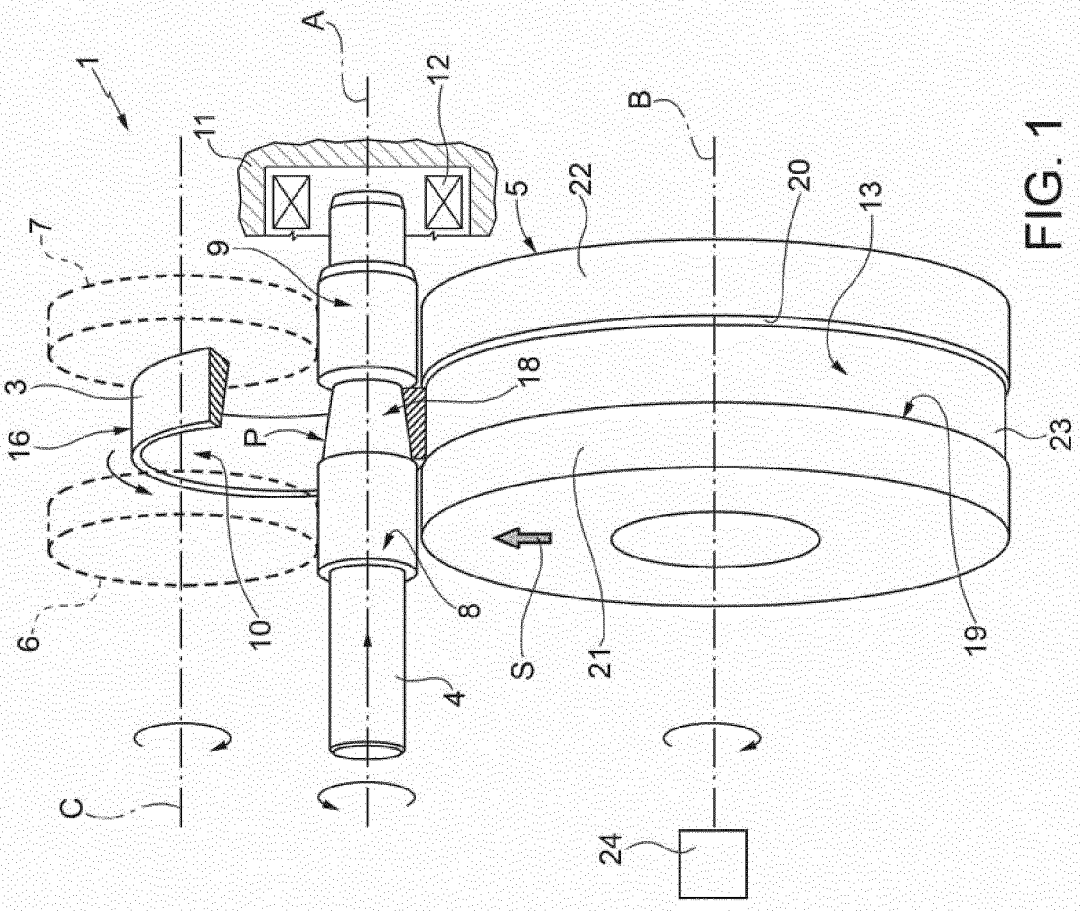
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FIG. 1

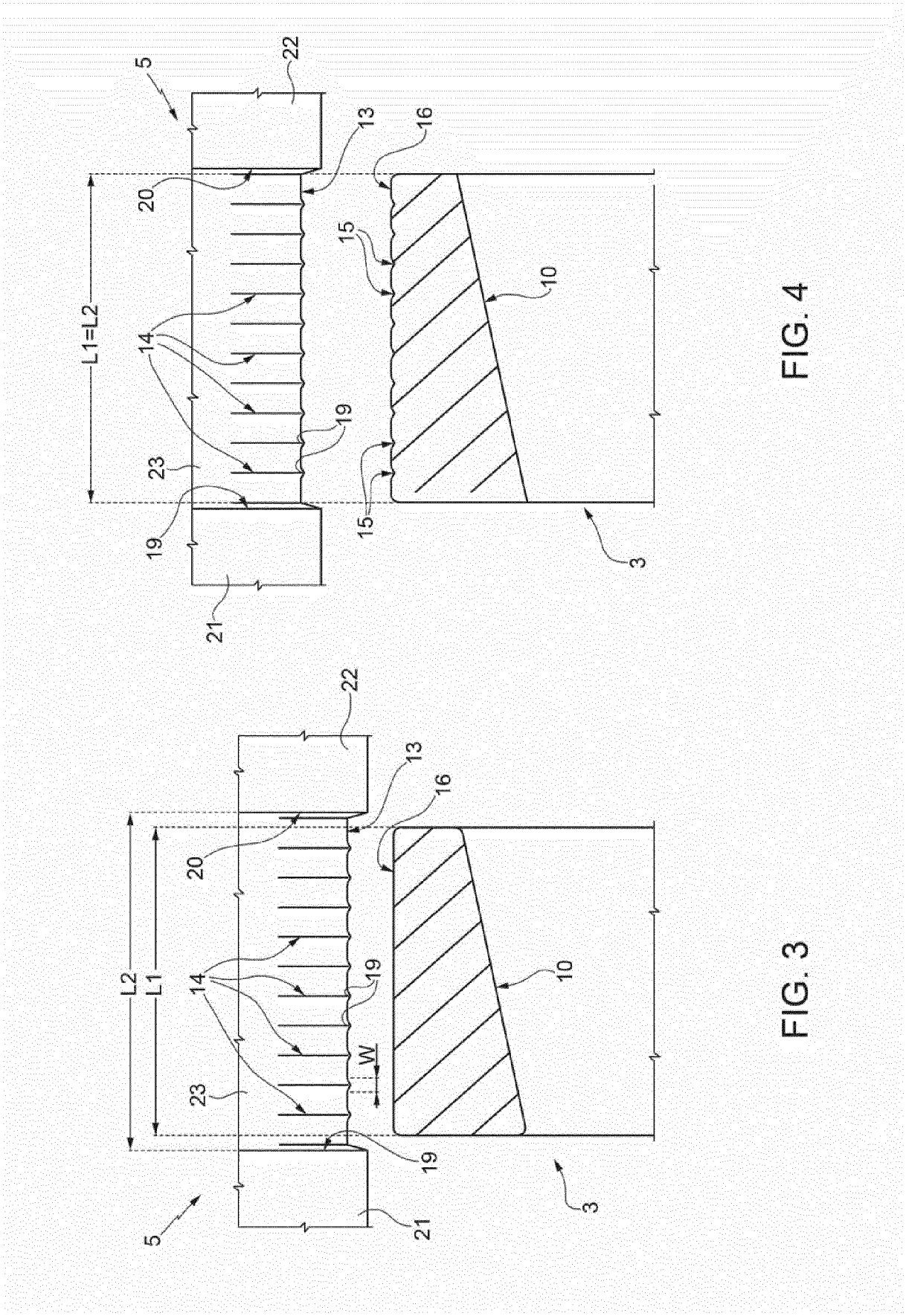
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FIG. 4

FIG. 3

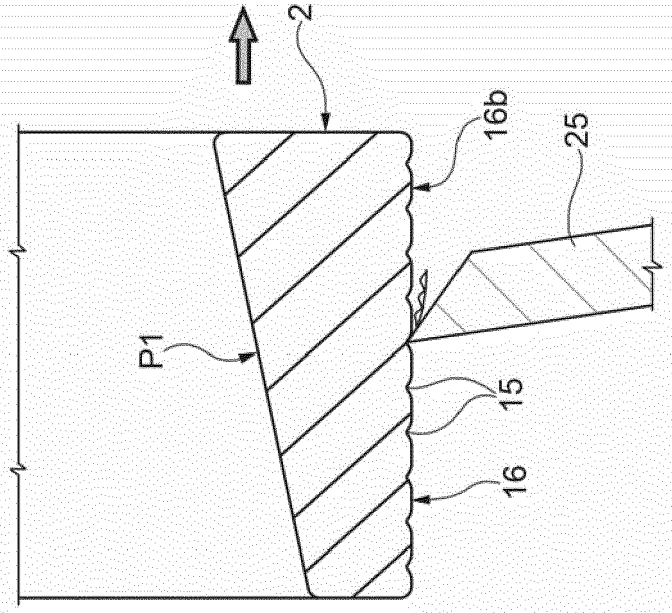


FIG. 6

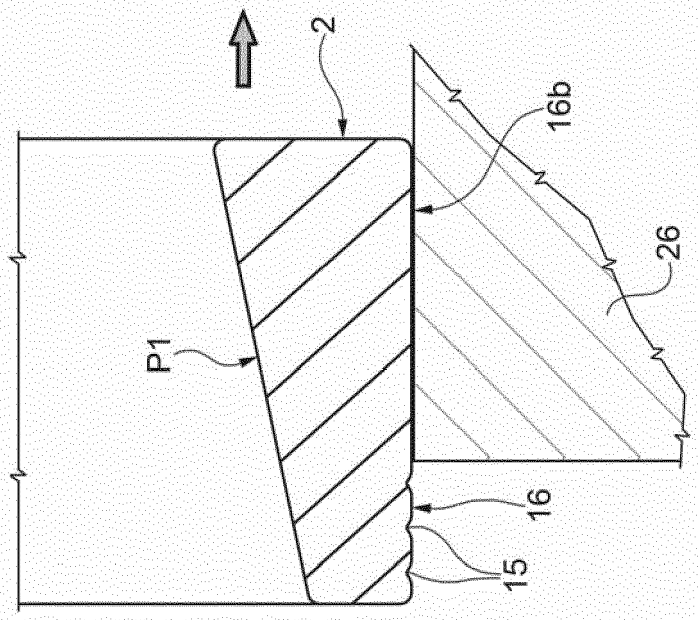


FIG. 5

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# EUROPEAN SEARCH REPORT

Application Number
EP 14 19 5153

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
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| A | * page 7, paragraph 2 - page 8, paragraph 1; figure 2 * | 3-5,8-11 | ADD. B21H1/06 B21H7/18 |
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| A | * paragraph [0010] - paragraph [0020]; figures 1,2,4 * | 2-5,7-11 | |
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TECHNICAL FIELDS SEARCHED (IPC)

B21H

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| Munich | 27 May 2015 | Ritter, Florian |

CATEGORY OF CITED DOCUMENTS

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27-05-2015

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## REFERENCES CITED IN THE DESCRIPTION

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