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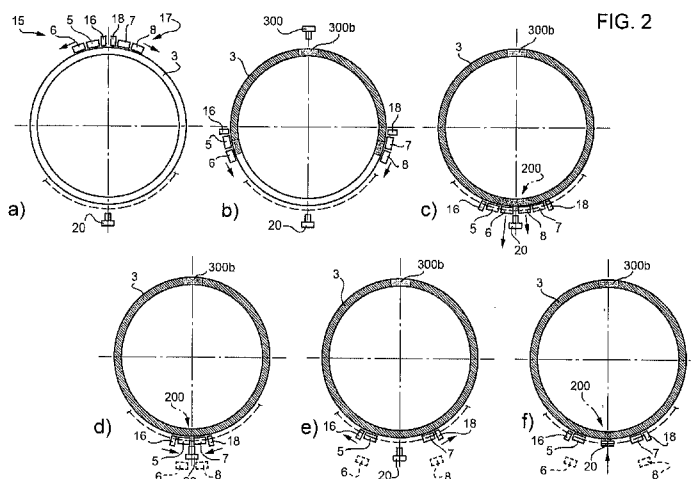
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(54) Title: METHOD AND DEVICE FOR LOCALIZED INDUCTION HARDENING OF CIRCULAR MECHANICAL COMPONENT PARTS OF LARGE - SIZE, IN PARTICULAR RINGS FOR ROLLING BEARINGS



(57) Abstract: A method and device of induction hardening of a circular mechanical component part (3), where at least four inductors (5-8) are arranged, in pairs, in tandem with respect to an annular surface (2) to be hardened, a first inductor (5) of a first pair (15) being operatively associated with a first cooling shower (16) arranged immediately adjacent to a second cooling shower (18) operatively associated with a first inductor (7) of a second pair (17). The inductors and the corresponding showers of each pair (15,17) are fed and rotated with respect to one another and to the annular surface (2) to be hardened, so that the second pair (17) of inductors leaves the first pair (15) from the side of the first shower (16) to be repositioned in tandem adjacent to the first pair (15) on the opposite side; at this point, at least two inductors (6,8) are no longer fed and are moved away from the surface (2) to be hardened, while continuing the relative rotation of the other inductors; finally, all the inductors (7,8) along with the first and second showers (16,18) are no longer fed and are moved away from a portion (200) of the surface to be hardened on which they insist at that moment, by replacing them with a third shower (20) by means of which such a portion (200) is cooled.

METHOD AND DEVICE FOR LOCALIZED INDUCTION HARDENING OF CIRCULAR MECHANICAL COMPONENT PARTS OF LARGE-SIZE, IN PARTICULAR RINGS FOR ROLLING BEARINGS

5 TECHNICAL FIELD

The present invention relates to a method and device of carrying out the localized induction hardening of large, circular mechanical component parts, in particular rings for rolling bearings.

10 BACKGROUND ART

A method is known from WO2006/087152, of carrying out the induction hardening of large bearing rings, consisting in using at least two inductors which are rotated, from a first position in which they are
15 arranged adjacent to each other, in opposite directions about the axis of the component part to be hardened, facing the surface thereof on which the heat treatment is to be performed, until they are brought to be adjacent again but on opposite side. Respective cooling
20 showers are associated with the inductors which heat the piece to be hardened.

The described method is both complex to be implemented and has a relatively low execution speed, and in order to limit the tempering of the joint zone
25 between the two half parts of the bearing ring which are hardened by each inductor (a phenomenon altering the quality of the achievable hardening profile), it

requires to use a third inductor intended to pre-heat the joint zone while the other inductors are still moving towards the same.

DISCLOSURE OF INVENTION

5 It is the object of the present invention to provide an alternative method of carrying out the heat treatment of induction hardening of rings and other similar large, circular component parts, which is effective and does not need a third inductor to pre-heat
10 the joint zone, and which improves the speed of performing the heat treatment as well as its quality.

The invention thus relates to a method of induction hardening of an annular surface of a circular mechanical component part according to claim 1.

15 The invention further relates to a device for the induction hardening of an annular surface of a circular, mechanical component part according to claim 8, which is particularly suitable for implementing the method of the invention.

20 In particular, the device of the invention comprises a plurality of inductors, each of which is provided with separate AC feeding means, cooling means for the mechanical component part, and at least one supporting and centering mandrel for the same. According
25 to the main feature of the invention, the device comprises at least four inductors arranged, in pairs, in tandem with respect to the mandrel; a first pair of

inductors comprises a first inductor operatively associated with a first cooling shower and is mounted in a relatively rotating manner with respect to the mandrel about a symmetry axis of the annular surface to be hardened, according to a first predetermined direction; the mandrel is optionally rotational about the symmetry axis of the annular surface to be hardened; and a second pair of inductors comprises a first inductor operatively associated with a second cooling shower and is mounted in a relatively rotating manner with respect to the mandrel about the symmetry axis of the annular surface to be hardened, according to a second predetermined direction opposite to the first; a third and preferably a fourth cooling showers are carried, preferably angularly integral with the mandrel, in opposite radial positions and normally away from the surface to be hardened, and are able to be selectively positioned in front of opposite portions of the surface to be hardened by rotating them on a radial plane with respect to the symmetry axis of the component part to be hardened; moreover, means are provided for moving at least two of the inductors away from the surface to be hardened, during a relative rotation between the inductors and the mandrel.

According to the method of the invention, the following steps are therefore implemented:

- arranging at least four inductors, in pairs, in

tandem with respect to the annular surface to be hardened, operatively associating a first inductor of a first pair with a first cooling shower arranged immediately adjacent to a second cooling shower
5 operatively associated with a first inductor of a second pair;

- feeding the inductors while rotating them with respect to one another and to the annular surface to be hardened, moving therewith the showers associated with
10 the first inductors of each pair, so that the second pair of inductors leaves the first pair from the side of the first shower to be repositioned adjacent in tandem to the first pair on the opposite side, while cooling the surface to be hardened, previously heated by the
15 inductors, by means of the showers associated with the first inductors, and optionally but preferably, only during the initial step of reciprocally moving away the inductors, by means of the fourth shower without operating the showers associated with the first
20 inductors;

- ceasing to feed and moving away a second inductor of each pair from the surface to be hardened, which is arranged immediately adjacent to the first inductor, when the second inductors of the first and second pairs
25 are immediately adjacent to each other, while the

relative rotation between the first inductors, the corresponding showers and the surface to be hardened continues until the first inductors of the first and second pairs are immediately adjacent to each other;

5 - ceasing to feed and either subsequently or simultaneously moving the first inductors away from a portion of the surface to be hardened on which they insist at that moment, along with the first and second showers;

10 - cooling such a surface portion to be hardened with the third shower which is positioned thereon in replacement of at least the last inductor moved away.

Thereby, the hardening rate is more than double as compared to the known art and a more constant hardening
15 profile is achieved, which may be further refined by also rotating the mandrel as necessary, when the latter is rotational; moreover, as the two pairs of inductors are symmetrical, they may be handled by means of a single portal structure, rotating them reciprocally by
20 combining two straight movements perpendicular to each other, which greatly simplifies the device structure and considerably reduces both manufacturing and installation costs.

BRIEF DESCRIPTION OF THE DRAWINGS

25 Further features and advantages of the invention will become apparent from the following description of a

non-limiting embodiment thereof, merely shown by way of example, with reference to the figures of the accompanying drawings, in which:

- figure 1 shows a schematic front view in elevation and under a three quarters perspective of a hardening device provided according to the invention; and

- figure 2 schematically shows a top plan view of the device in figure 1 in the various steps a)-f) of performing the method according to the invention.

BEST MODE FOR CARRYING OUT THE INVENTION

With reference to figures 1 and 2, numeral 1 indicates as a whole a device for the induction hardening of an annular surface 2 of a circular mechanical component part 3, such as for example a bearing ring, having a symmetry axis A.

Device 1 comprises: a plurality of inductors 5, 6, 7, 8, each of which is provided with separate AC feeding means defined by respective converters 10 of known type; cooling means for the mechanical component part 3, indicated by numeral 12 as a whole; and at least one supporting and centering mandrel or spindle 14 for the same.

According to a feature of the invention, device 1 comprises at least four inductors 5-8 arranged, in pairs, in tandem (i.e. in circumferential sequence with respect to axis A) with respect to mandrel 14, and

therefore to the component part 3 and to the annular surface 2 to be hardened.

In practice, inductors 5 and 6 form a first pair 15 of inductors, in which inductor 5 is operatively associated with a first shower 16 of the known type, for cooling the component part 3, while inductors 7 and 8 (only partially shown in figure 1) form a second pair 17 of inductors, in which inductor 7 is operatively associated with a second shower 18, of the known type, for cooling the component part 3.

According to the invention, a third cooling shower 20 for the component part 3, known per se, completes the means 12 and is carried, preferably by mandrel 14 angularly integral therewith, in a radial position with respect to axis A, which is the symmetry axis of mandrel 14 as well.

Cooling means 12 preferably also comprise a fourth shower 300 (figure 2b), for example of the same type as shower 20, preferably carried by spindle 14 in a radial position with respect to axis A, opposite to the position of shower 20.

Again according to the invention, in combination with the above description, pairs 15 and 17 of inductors 5,6 and 7,8 are relatively rotationally installed with respect to mandrel 14 about axis A, but are movable in the opposite direction; mandrel 14 is preferably rotationally mounted about axis A as well, and in this

case it is provided with driving means 21.

In practice, pair 15 of inductors 5,6 and shower 16 are carried, along with the corresponding converters 10, by respective square-like arms 22,23 which are radially and/or axially movable with respect to mandrel 14, since they are supported by a handling system on multiple axes 26, known per se. Arm 22 supports inductor 6, while arm 23 integrally supports inductor 5 and shower 16, the latter being arranged on the opposite side of inductor 6.

Conversely, pair 17 of inductors 7,8 and shower 18 are carried, along with the corresponding converters 10, by respective square-like arms 24,25 which are radially and/or axially movable with respect to mandrel 14 as well, since they are in turn supported by a handling system 26 (not shown in figure 1) which is substantially identical to that supporting arms 22,23, and are shaped so that the feeding means 10 of both the inductors 7 and 8 are arranged so as to be staggered in the radial direction with respect to the feeding means 10 of inductors 5,6, which are particularly directed towards the interior of mandrel 14 and axis A, while the feeding means 10 of inductors 5,6 are radially, outwardly directed from mandrel 14, so as to move away from axis A. Arm 25 supports inductor 8, while arm 24 integrally supports inductor 7 and shower 18, the latter being arranged on the opposite side of inductor 8.

According to one aspect of the invention, all the arms 24,25 and 22,23 are carried, e.g. by means of the respective handling systems 26 (of the slide type in the example shown), so as to be movable along the same crossbar 27 which is in turn carried so as to be movable along a pair of side members 28, so as to define a double portal structure therewith, having mandrel 14 at its centre, and thus allowing to move all together the inductors 7,8 and 5,6 with respect to axis A by means of a suitable power mechanization of known type (not described), by rotating the pair 15 and 17 of inductors at the same speed but in opposite direction about axis A, by means of a suitable combination of the two straight movements perpendicular to each other along the crossbar 27 and the side members 28 of inductors 5,6 and 7,8.

Finally, device 1 comprises means for moving away at least two of the inductors 5-8 (in this case, inductors 6 and 8), independently of each other, together or in sequence, from the surface 2 to be hardened during any relative rotation between inductors 5-8 and spindle 14. Such means are defined by the same handling system 26 and/or by powered slides 29 which allow to lift the inductors 5-8 one at a time or all at once (inductors 5 and 7 always along with the corresponding showers 16 and 18 integral therewith), preferably in a direction perpendicular to surface 2.

Third shower 20 and fourth shower 300 (the latter being optional but preferred) are both arranged in a position normally away from the surface 2 to be hardened, e.g. they are radially, overhangingly mounted
5 in diametrically opposite positions at the base of mandrel 14, and are able to be selectively positioned the shower 20 in front of a portion 200 (figures 2c and 2f) of the surface 2 to be hardened and the shower 300 in front of a portion 300b (figures 2b and 2c) of the
10 surface 2 to be hardened, which portions are in use diametrically opposed to each other, by means of a rotation in a radial plane with respect to the symmetry axis A, and a possible rotation of spindle 14, by means of a powered hinge 31 (shown in figure 1 for shower 20
15 only), for example, which allows to take them from a horizontal position (as shown in figure 1 for shower 20) to a vertical position (not shown for simplicity).

According to a non secondary aspect of the invention, inductors 5 and 7 integrally associated with
20 showers 16,18 are heating inductors and are each coupled to at least one pre-heating inductor, in this case the inductors 6 and 8; the latter have a greater circumferential length than that of the heating inductors 5 and 7 and are provided with AC feed
25 converters 10 of a higher power than that of respective AC feed converters of the heating inductors.

Figure 2 shows the various configurations from a)

to f) which may be taken by device 1 when used for implementing the various steps of the method of induction hardening of the annular surface 2 of the circular mechanical component part 3 according to the invention.

In a first (initial or starting) step of the method of the invention, the inductors 5-8 are arranged, in pairs, in tandem with respect to the annular surface 2, all adjacent to one another and with the inductors 5 and 7 of each pair 15,17 being arranged adjacent and operatively associated with showers 16 and 18; consequently, showers 16,18 are arranged immediately adjacent to each other (figure 2a). In such a step, the inductors 5-8 are substantially placed in the same radial position occupied by shower 300, which is however radially away from surface 2 and therefore does not interfere with the inductors 5-8.

In a second step (figures 2b and 2c), the inductors 5-8 are AC-fed by converters 10 independently of one another, so as to locally heat the component part 3 by induction, while being rotated relatively to one another and with respect to the annular surface 2 to be hardened about axis A, along with the corresponding showers 16,18, at the same speed but in opposite direction, so that the second pair 17 of inductors 7,8 leaves the first pair 15 from the side of the first shower 16 (figure 2b), while the first pair 15 of inductors 5,6

leaves the second pair 17 from the side of shower 18, so as to describe together and from opposite sides the majority of the circumference of the component part 3 to be then repositioned adjacent in tandem on the opposite side, i.e. with inductor 8 being immediately adjacent to inductor 6 and with showers 16,18 being arranged at the opposite ends of the "train" defined by the inductors 5-8, which are circumferentially aligned adjacent to one another (figure 2c). Simultaneously with the movement of inductors 5-8, the showers 16,18 are also immediately operated (e.g. by supplying them with water) or they are operated, according to a variant of the invention, only when they have already been moved away from the surface portion 300b, while the latter is cooled as soon as the inductors 5-8 leave it, by operating shower 300 which is taken in front of it through a radial movement, thus occupying the space left by the inductors 5-8.

During such a step, the whole portion of surface 2 is hardened (gradually shown in hatch) including portion 300b (shown in bold). The hardening is performed by pre-heating surface 2 through inductors 6,8 (shown in dotted portions), until inductors 6,8 travel over the whole surface 2 and stop adjacent to each other so that they both insist on a final portion 200 of surface 2 (figure 2c), diametrically opposite to portion 300b, which portion 200 is pre-heated as well.

In a third step, the feeding of the pre-heating

inductors 6,8 (one at a time and in sequence or simultaneously) is ceased and they are simultaneously moved away (together or in the same sequence as before) from the surface 2 to be hardened, while the relative
5 rotation between the other inductors 5,7 with the corresponding showers 16,18 and the surface 2 to be hardened (figure 2d) continues, until the inductors 5,7 are taken to insist on the portion 200 of surface 2 which is thus taken to the optimal hardening
10 temperature.

In a fourth step, the feeding of all the remaining inductors 5,7 is ceased and they are (successively or preferably simultaneously) moved away along with their corresponding showers 16,18 from the portion 200 of
15 surface 2; in particular, the inductors 5,7 may be moved away by means of slides 26 or 29, as when moving away the pre-heating inductors 6,8 from portion 200 or, more simply, by reversing the relative rotation of the pairs of inductors 15,17 with respect to surface 2, by
20 reversing the motion of crossbar 27 and slide systems 26 along the latter, so as to move away the no longer fed inductors 5,7 from portion 200 by circumferentially moving them backwards along surface 2 (figure 2e) along with the inductors 6,8 which, during this movement,
25 however remain in the previously taken position spaced from surface 2.

Thereby, portion 200 is released from the volume of

all the inductors 5-8 and, in a fifth and final step, the portion 200 which was heated by the adjacent inductors 5,7 up until a moment before, is abruptly cooled down and thus hardened by operating shower 20 (figure 2f), which is positioned on portion 200 in place of at least the last moved away inductor 5,7.

Inductors 5 and 6 are simultaneously moved away from surface 2, preferably perpendicularly thereto.

Furthermore, by rotating the third shower 20 on a radial plane with respect to the relative rotation axis A between the surface 2 to be hardened and the inductors 5-8, it is positioned on portion 200 of the surface 2 to be hardened as soon as the latter is left by inductors 7,8.

According to a final feature of the method of the invention, as already disclosed, inductors 5,7 are heating inductors and are each coupled to at least one pre-heating inductor, the inductors 6,8 respectively. These are made with a greater circumferential length than that of the heating inductors 5,7, and are fed in use with a higher power than that fed to the heating inductors 5,7.

CLAIMS

1. A method for induction hardening of an annular surface (2) of a circular mechanical component part (3),
5 characterized in that it comprises the steps of:

- arranging at least four inductors (5-8), in pairs, in tandem with respect to said annular surface to be hardened, operatively associating a first inductor (5) of a first pair (15) with a first cooling shower (16) arranged immediately adjacent to a second cooling shower (18) operatively associated with a first inductor (7) of a second pair (17);

- feeding and simultaneously rotating the inductors (5-8), relatively to each other and with respect to the annular surface (2) to be hardened, moving therewith the showers (16,18) associated with the first inductors of each pair (15,17), so that the second pair (17) of inductors leaves the first pair (15) from the side of the first shower (16) to be repositioned in tandem
15 adjacent to the first pair (15) on the opposite side, while cooling the surface (2) to be hardened, previously heated by the inductors (5-8), by means of the showers (16,18) associated with the first inductors (5,7);

- ceasing to feed and moving away from the surface
25 to be hardened a second inductor (6,8) of each pair

(15,17) arranged immediately adjacent to the first when the second inductors (6,8) of the first and second pairs are immediately adjacent to each other, while the relative rotation between the first inductors (5,7), the
5 corresponding showers (16,18) and the surface to be hardened (2) continues until the first inductors (5,7) of the first and second pairs (15,17) are immediately adjacent to each other;

- ceasing to feed and moving the first inductors
10 (5,7), either subsequently or simultaneously with respect on each other, away from a portion (200) of the surface to be hardened on which they insist at that moment, along with the first and second showers (16,18);

- cooling said surface portion (200) to be hardened
15 with a third shower (20) which is positioned thereon in replacement of at least the last inductor (5,7) moved away.

2. A method according to claim 1, characterized in that said step of feeding and simultaneously rotating
20 the inductors (5-8) relatively to each other and with respect to the annular surface to be hardened along with the corresponding showers (16,18) of each pair is carried out by keeping the annular surface (2) to be hardened stationary and rotating the inductors of the
25 first pair (15) and the first shower (16) in a first

predetermined direction about a symmetry axis (A) of the annular surface (2) to be hardened, and rotating the inductors of the second pair (17) and said second shower (18) at the same speed but in opposite direction about
5 said symmetry axis (A) of the annular surface (2) to be hardened.

3. A method according to claim 1 or 2, characterized in that during the initial step of rotating while reciprocally moving the inductors of the
10 first pair (15) away from those of the second pair (17), a portion (300b) of the surface (2) to be hardened, which has just been left by the first inductors (5,7), is cooled by means of a fourth shower (300) arranged in a position diametrically opposite to said third shower
15 (20), without actuating the showers (16,18) associated with the first inductors (5,7).

4. A method according to one of the preceding claims, characterized in that said third shower (20) is positioned on said portion (200) of the surface to be
20 hardened which has been abandoned by at least the last inductor (5,7) which has been moved away, by rotating it on a radial plane with respect to the relative rotation axis (A) between the surface to the hardened (2) and said inductors (5-8).

25 5. A method according to one of the preceding

claims, characterized in that said first inductors (5,7) of each pair (15,17) are heating inductors and are each coupled to at least one pre-heating inductor (6,8).

6. A method according to claim 5, characterized in that said pre-heating inductors (6,8) have a greater length measured in the circumferential direction than that of the heating inductors (5,7), and are fed with a higher power than that fed to the heating inductors.

7. A method according to one of the preceding claims, characterized in that said means (10) for feeding the inductors (5,6) of the first pair (15) are arranged staggered in the radial direction with respect to the means (10) for feeding the inductors (7,8) of the second pair (17); in particular, the latter are directed towards said axis (A) and the interior of a mandrel (14) supporting the component part (3) to be hardened and said third shower (20), while the means (10) for feeding the inductors (5,6) of the first pair (15) are radially, outwardly directed from the mandrel (14), so as to move away from said axis (A).

8. A device (1) for induction hardening of an annular surface (2) of a circular mechanical component part (3) comprising: a plurality of inductors, each of which is provided with separate AC feeding means (10); cooling means (12) for the mechanical component part;

and at least one supporting and centering mandrel (14) for the same; characterized in that it comprises at least four inductors (5-8) arranged in pairs, in tandem with respect to said mandrel (14); a first pair (15) of
5 inductors comprising a first inductor (5) operatively associated with a first cooling shower (16) and being mounted in a relatively rotating manner with respect to the mandrel (14) about a symmetry axis (A) of the annular surface (2) to be hardened according to a first
10 predetermined direction, the mandrel being optionally rotational about said symmetry axis (A); and a second pair (17) of inductors comprising a first inductor (7) operatively associated with a second cooling shower (18) and being mounted in a relatively rotating manner with
15 respect to the mandrel (14) about the symmetry axis (A) of the annular surface to be hardened according to a second predetermined direction opposite to the first; a third cooling shower (20) being carried, preferably by the mandrel (14), in a radial position and normally away
20 from the surface (2) to be hardened, and being able to be selectively positioned in front of a portion (200) of the surface to be hardened by rotating it on a radial plane with respect to said symmetry axis (A); means (29) being provided for moving at least two of said inductors
25 (6,8) away from the surface to be hardened (2) during a

relative rotation between the inductors (5-8) and the mandrel (14).

9. A device according to claim 8, characterized in that said first inductors (5,7) of each pair are heating inductors and are each coupled to at least one pre-heating inductor (6,8); the latter having a greater length measured in the circumferential direction than that of the heating inductors (5,7), and being provided with AC feeding converters (10) of a higher power than that of respective AC feeding converters (10) of the heating inductors (5,7).

10. A device according to claim 8 or 9, characterized in that said inductors (5-8) are carried along with said feeding means (10) for the same by respective square-like arms (22-25), which are radially and/or axially movable with respect to said mandrel (14) and are shaped so that the feeding means (10) of the inductors (7,8) of the second pair (17) are arranged staggered in the radial direction with respect to the others.

11. A device according to one of the claims from 8 to 10, characterized in that it comprises at least one fourth shower (300), of the same type of said third shower (20) and arranged in a position diametrically opposite to the latter with respect to said mandrel

(14), in a radial position and normally away from the surface (2) to be hardened, which fourth shower (300) is able to be selectively arranged in front of a portion (300b) of the surface to be hardened diametrically
5 opposite to the portion (200) of the surface to be hardened concerned in use by the third shower (20).

FIG. 1

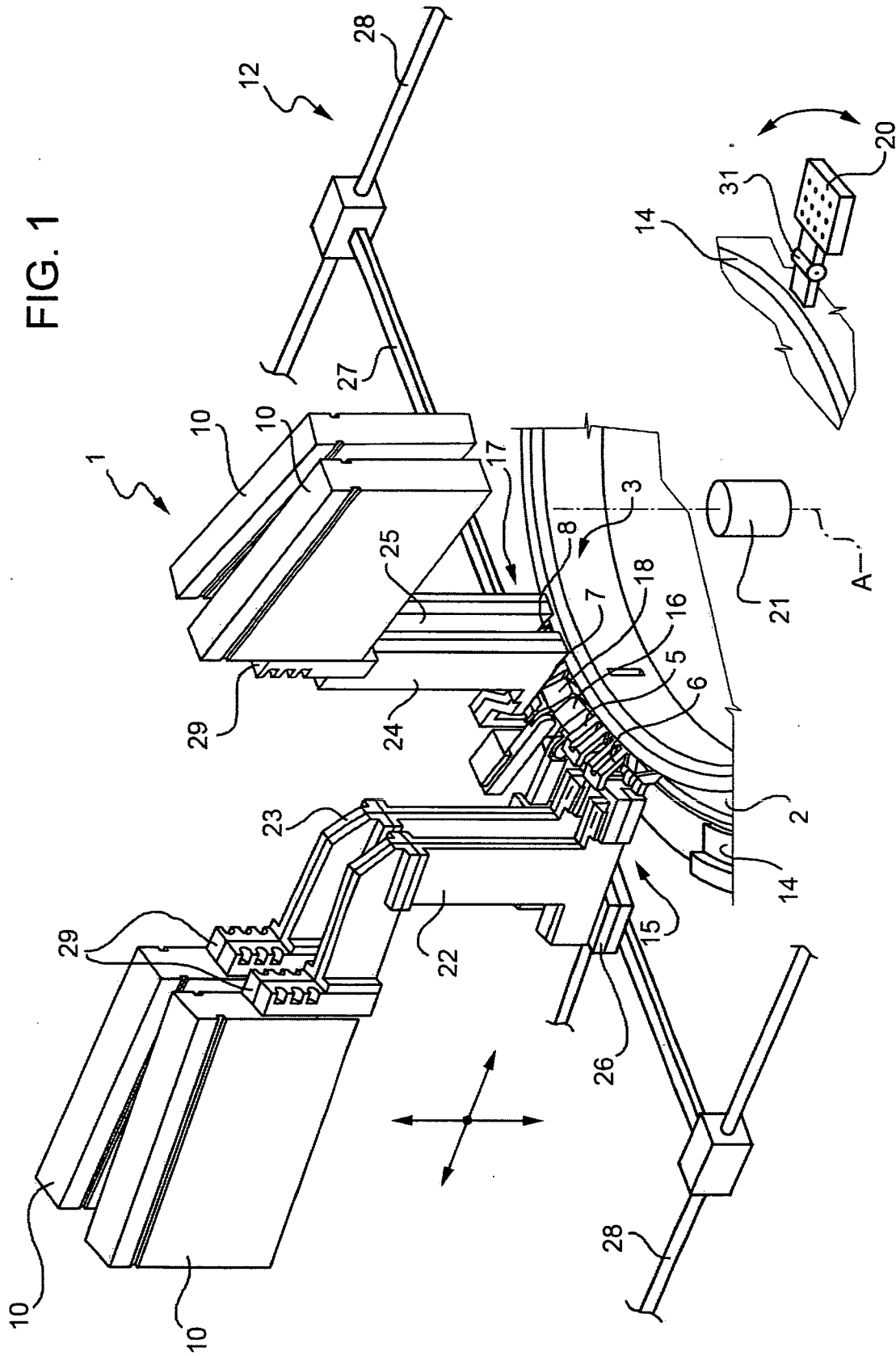
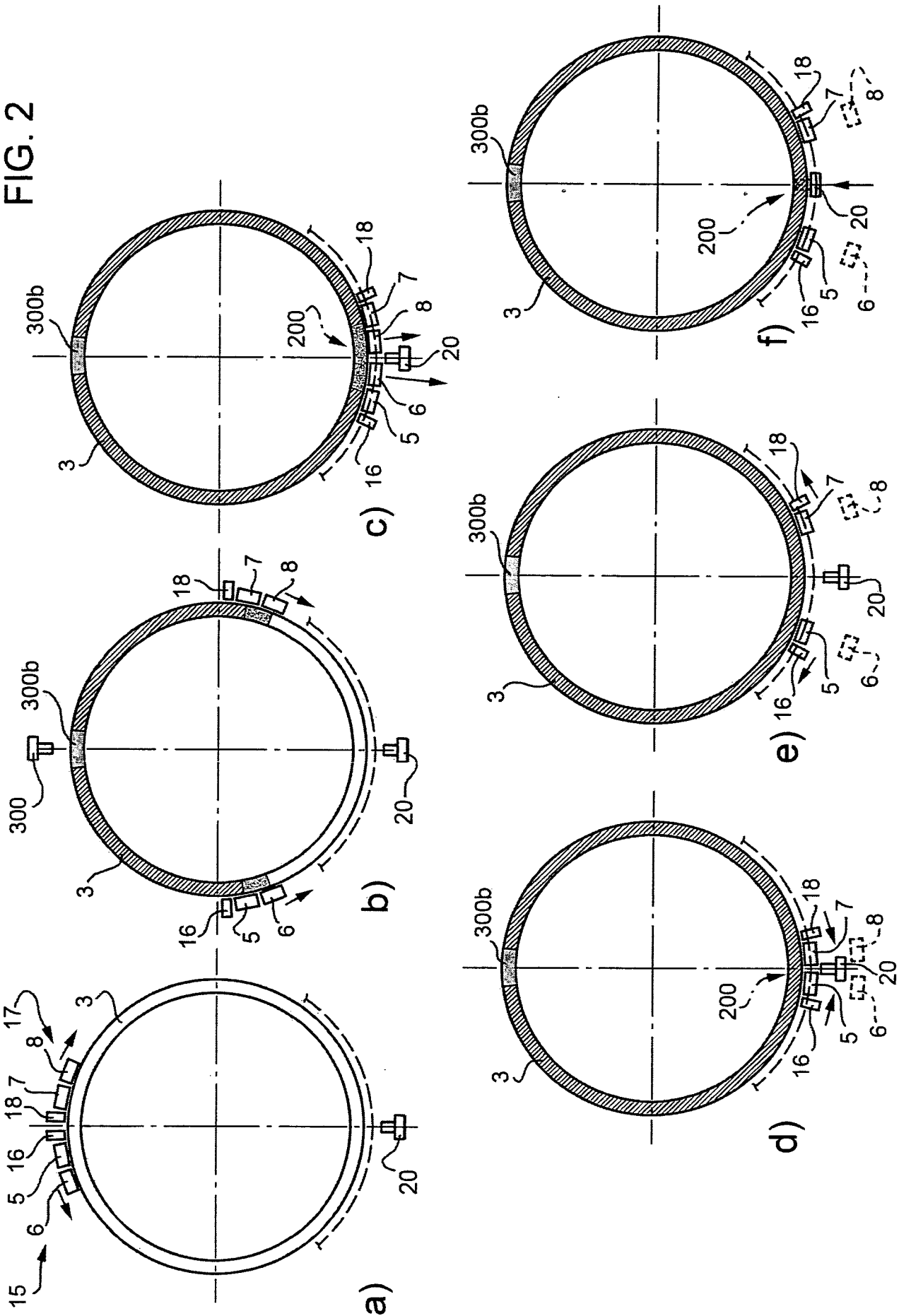


FIG. 2



INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2011/000461

A. CLASSIFICATION OF SUBJECT MATTER INV. C21D1/10 C21D1/42 C21D9/34 C21D9/40 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) C21D F16C		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, WPI Data, CHEM ABS Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 6 200326 A (NTN TOYO BEARING CO LTD) 19 July 1994 (1994-07-19) abstract; figures 1-3 paragraphs [0011], [0013], [0017] - [0019]	1,8
A	----- US 3 036 824 A (HAY DONALD A) 29 May 1962 (1962-05-29) column 2, line 5 - line 10 column 2, line 44 - column 4, line 17; figures 1-2	1-11
A	----- WO 2007/082957 A1 (SMS ELOTHERM GMBH [DE]; GEZARZICK WALDEMAR [DE]; SEITZER ANDREAS [DE];) 26 July 2007 (2007-07-26) the whole document ----- -/-	1,8
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Date of the actual completion of the international search	Date of mailing of the international search report	
20 July 2011	29/07/2011	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Gavriliu, Alexandru	

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2011/000461

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