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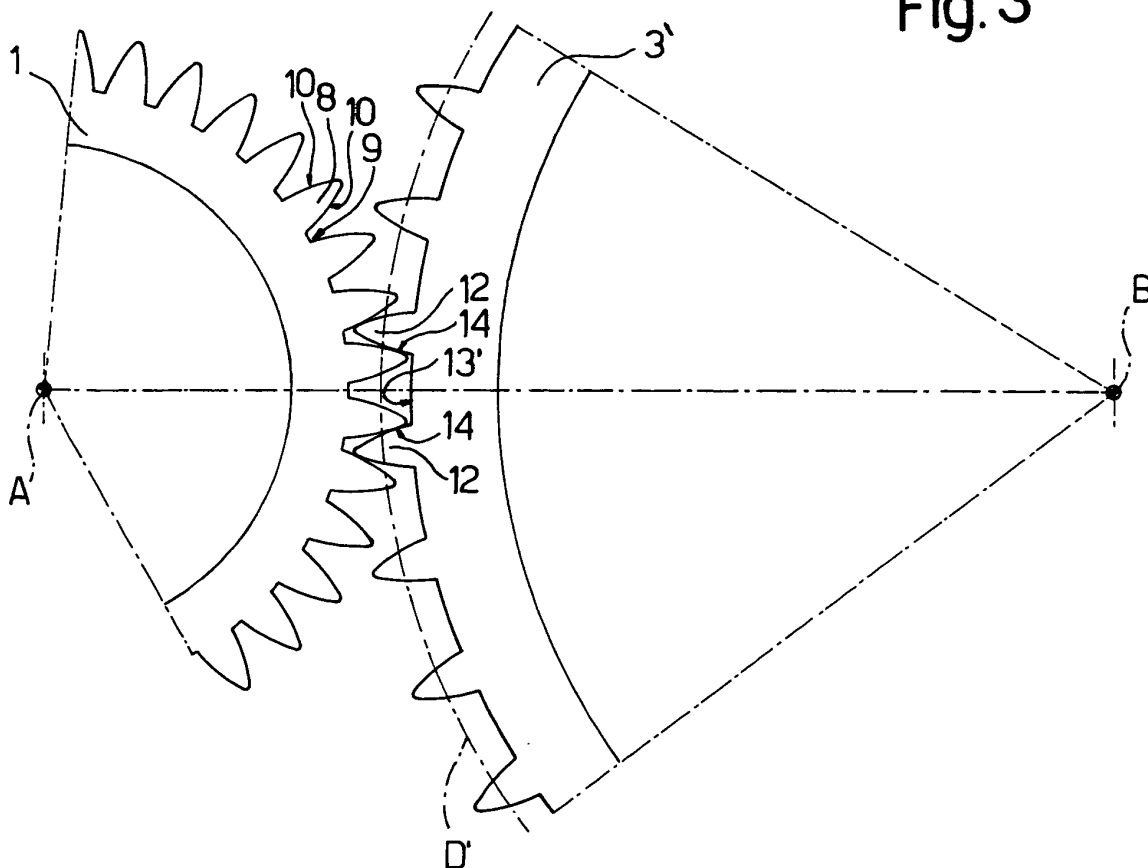
Amended claims in accordance with Rule 86 (2) EPC.

(54) Burnishing gear

(57) Described herein is a burnishing gear (3') comprising a plurality of first alternating solid elements (12) and empty elements (13') defined by a plurality of sides (14) for coupling with and densifying the surface of sec-

ond solid elements (8) alternating with second empty elements (9) carried by a sintered gear (1); each first empty element (13') can house at least two second solid elements (8).

Fig. 3



EP 1 640 085 A1

Description

[0001] The present invention relates to an improved burnishing gear for surface densification of gears obtained by sintering, referred to briefly in what follows as "sintered gears".

[0002] Known is the production of mechanical components via sintering of powders, with levels of consumption of energy and raw material lower than those required by traditional technologies. It is moreover known that the mechanical components produced by sintering of powders have values of density lower than those commonly found in components traditionally produced from massive material.

[0003] For the aforesaid reason, the use of mechanical components, and in particular of gears, produced via sintering of powders presents some limitations in the applications in which high mechanical stresses are involved or the transmission of high powers is required.

[0004] Furthermore, it is known that the gears are particularly subjected, in their surface layers, to fatigue stresses in an area corresponding to the foot and the side of the tooth and to the wear on the side of the tooth itself.

[0005] Consequently the use of burnishing gears with high hardness for increasing, by means of appropriate operations of burnishing, the surface density of sintered gears up to values close to the theoretical density of the material, for the purpose of rendering their surface layers more resistant to fatigue stresses and wear is known in the art.

[0006] An example of a machine for burnishing sintered gears which uses burnishing gears is illustrated in the U.S. patent No. US 5,711,187 and represented for convenience of description in the attached schematic Figures 1 and 2.

[0007] The above machine is designated as a whole by M and basically comprises a frame 2, on which there is designed to be mounted, in such a way that it can turn about a fixed axis A, a sintered gear 1, and a pair of burnishing gears 3, set on opposite sides of the sintered gear 1 and meshing therewith to determine its surface densification through a reduction of the distance between centres of the sintered gear 1 and the burnishing gears 3 during the operation of meshing. In particular, the burnishing gears 3 are mounted so that they can rotate at an angle about their own axes B on respective carriages 5, which are in turn able to slide along the frame 2 away from and towards the sintered gear 1.

[0008] The sintered gear 1 is provided, on its outer circumferential surface, with a plurality of alternating teeth 8 and spaces 9.

In greater detail, each tooth 8 is delimited laterally on opposite sides by respective equally extensive sides 10, which project in cantilever fashion from an outer circumferential surface of the sintered gear 1 and are radiused to one another in an area corresponding to their radially outermost ends.

[0009] The opposite ends of consecutive sides 10 are connected to one another by the outer circumferential surface of the sintered gear 1 and define a respective space 9.

[0010] In particular, in the case of sintered gears subjected to surface burnishing, on each side 10 there is provided a thickness of stock (present above all in an area corresponding to the bottom land) with respect to the nominal dimensions, i.e., design dimensions, of the sintered gear 1, designed to be compacted by the combined action of the burnishing gears 3. Like the sintered gear 1, the burnishing gears 3 have, on their respective outer circumferential surfaces, respective pluralities of teeth 12 alternating with respective pluralities of spaces 13.

[0011] In greater detail, each tooth 12 is delimited laterally on opposite sides by respective equally extensive sides 14 projecting in a cantilever fashion from the outer circumferential surface of the corresponding burnishing gear 3 and radiused to one another in an area corresponding to their radially outermost ends.

[0012] The opposite ends of consecutive sides 14 of the burnishing gear 3 itself are connected to one another by the corresponding outer circumferential surface and define a respective space 13.

[0013] The burnishing gears 3 are driven in rotation about the respective axes B by a motor, in itself known and not illustrated, of the machine M.

[0014] Furthermore, the carriages 5 are actuated by an actuator mechanism (in itself known and not illustrated herein) along respective linear guides 15 made on the frame 2 so as to enable, by bringing up each axis B to the axis A and by moving it away therefrom, the engagement/disengagement of each burnishing gear 3 to/from the sintered gear 1.

[0015] In use, the burnishing gears 3 rotate concordantly with one another about the respective axes B. Consequently, at the meshing of each burnishing gear 3 with the sintered gear 1, the latter is driven in rotation about the axis A in a direction opposite to that of rotation of the burnishing gears 3 themselves.

[0016] In particular, the aforesaid rotations about the axes B of the burnishing gears 3 occur at angular velocities such as to enable a continuous meshing with the sintered gear 1 rotating about the axis A.

[0017] Furthermore, by synchronizing the strokes of the carriages 5, the burnishing gears 3 are brought up to the sintered gear 1 until they mesh simultaneously therewith.

[0018] In greater detail, as is known in the gear sector, the aforesaid meshing is obtained when one or more teeth 12 of the burnishing gears 3 occupy the respective spaces 9 of the sintered gear 1 and, likewise, one or more teeth 8 of the sintered gear 1 occupy the respective spaces 13 of each burnishing gear 3.

[0019] More precisely, the sides 14 of the teeth 12 roll and slide on the respective sides 10 of the teeth 8 of the sintered gear 1 compacting the stock present on the sides

10 themselves and thus creating the final geometry and the profile of the teeth 8 themselves and of the respective spaces 9.

[0020] In particular, each tooth 12, in the aforesaid action of rolling and sliding on the sides 10 of the teeth 8 adjacent to a corresponding space 9, compacts and densifies the sides 10 themselves, improving their mechanical resistance to wear and fatigue.

[0021] Furthermore, the movement of the carriages 5 causes the axes B to approach progressively the axis A and causes a consequent progressive penetration of the teeth 12 of the burnishing gears 3 into the respective spaces 9 of the sintered gear 1. It follows that it is possible to regulate the depth of the stroke of each tooth 12 within the respective space 9 so as to obtain a different depth of burnishing and consequently densified surface layers of different thickness.

[0022] Furthermore, by varying the aforesaid stroke of the teeth 12 and the conformation of the latter, it is possible to densify also the bottom ends of the teeth 8 of the sintered gear 1.

[0023] Figure 2 represents, at an enlarged scale, a detail of Figure 1 illustrating the burnishing of the sides 10 of the teeth 8 of the sintered gear 1 by the sides 14 of the teeth 12 of one of the burnishing gears 3.

[0024] In particular, as is clearly visible in Figure 2, each space 13 of the aforesaid burnishing gear 3, in conditions of meshing, houses a single tooth 8 of the sintered gear 1.

[0025] In addition, as is known in the gear sector, there always exists a circumference D with its centre on the axis B along which the distance measured between two sides 14 of one and the same tooth 12 is equal to the distance measured between two consecutive sides 14 of a space 13.

[0026] The technique of surface densification, described above as known in the art, presents the following drawbacks.

[0027] In particular, it is noted that the obtaining of sintered gears 1, with the sides 10 having a shape and dimensions with tolerances that are normally necessary for their correct operation in mechanical apparatuses, is extremely problematical, frequently requiring numerous regulations and/or variations of the design of the high-hardness burnishing gears 3.

[0028] In greater detail, the presence of simultaneous contacts between a number of teeth 12 of each burnishing gear 3 and the teeth 8 of the sintered gear 1 determines an intensity of the stresses on each tooth 8 itself that is not uniform, with a maximum value in the intermediate area of the sides 10 of the tooth 8 and a minimum value at the ends of the sides 10, corresponding to the areas of start and end of meshing. Consequently, the surface densification obtainable on each tooth 8 is not uniform, with a maximum value on the intermediate area of the corresponding sides 10 and a minimum value at the ends of the sides 10 themselves. It follows that the geometry of the sides 10 of the teeth 8 departs from the

nominal dimensions and does not respect the required tolerances in terms of dimensions and shapes.

[0029] To overcome the above drawback, it is necessary to act on the geometry of the sides 14 of the teeth 12 of the burnishing gears 3 so as to generate profiles capable of determining a stress as uniform as possible on the sides 10 of the sintered gear 1 to be densified. Said profiles depart sensibly from the traditional involute profile and are frequently highly complex to obtain via numeric simulation or experimental tests.

[0030] The purpose of the present invention is to provide a burnishing gear which will enable the drawbacks specified above and linked to known burnishing gears to be overcome in a simple and economically advantageous way, and in particular will enable a homogeneous surface densification of the sintered gears to be obtained, without the need to adopt particularly complex geometries for the burnishing gears.

[0031] The aforesaid purpose is achieved by the present invention in so far as it relates to a burnishing gear made according to Claim 1.

[0032] The present invention likewise relates to a burnishing machine, as defined in Claim 3.

[0033] For a better understanding of the present invention, described in what follows is a preferred embodiment, provided purely by way of non-limiting example and with reference to the attached plate of drawings, in which:

- Figure 1 is a side view of a burnishing machine provided with burnishing gears of a known type;
- Figure 2 is a side view, at an enlarged scale, of a detail of Figure 1; and
- Figure 3 is a view corresponding to that of Figure 2 of a part of a burnishing gear according to the present invention meshing with a gear produced by sintering.

[0034] With reference to Figure 3, designated as a whole by 3' is a burnishing gear made according to the teachings of the present invention. The burnishing gear 3' is described in what follows only in so far as it differs from the burnishing gear 3; parts that are the same as or correspond to those of the burnishing gears 3, 3' are designated, where possible, by the same reference numbers.

[0035] In particular, the burnishing gear 3' is provided, on its outer circumferential surface, with a plurality of teeth 12, having the same geometry as the teeth 12 of the burnishing gears 3, and with a plurality of spaces 13' different from the spaces 13 and alternating with the teeth 12 themselves.

[0036] Advantageously, each space 13' is sized so as to be able to house, in meshing conditions, at least two teeth 8 of the sintered gear 1.

[0037] In other words, the burnishing gear 3' is obtained from the burnishing gear 3 by simply removing one tooth 12 every two. In this way, the burnishing gear 3' has a number of teeth 12 appropriately reduced with respect to that of a burnishing gear 3, given the same

radius and geometry of the teeth 12 themselves.

[0038] It follows from the above that the burnishing gear 3', unlike the burnishing gear 3, has a number of teeth 12 in simultaneous contact with the teeth 10 of the sintered gear 1, at the most equal to two, and normally comprised between one and two. In other words, if we define as "front contact ratio" the ratio l/p , where l is the length of contact between the teeth 12 and 10 and p is the pitch of the teeth 12, we obtain, in the case of burnishing gears 3', a halving of said ratio with respect to the case where known burnishing gears 3 are used.

[0039] Furthermore, the pitch between two homologous points of two consecutive teeth 12, measured along an arbitrary circumference D' with centre on the axis B, of the burnishing gear 3' is twice that of the burnishing gear 3.

[0040] Instead, two consecutive sides of each tooth 12 of the burnishing gear 3' and of the burnishing gear 3 are set at equal distances apart along an arbitrary circumference D' with centre on the axis B.

[0041] Furthermore, the distance measured along an arbitrary circumference D' with centre on the axis B between two consecutive sides 14 of a tooth 12 is smaller than the distance measured between two consecutive sides 14 of a space 13'.

[0042] On the basis of the foregoing exposition there emerge clearly the advantages that may be obtained using burnishing gears 3' made according to the present invention on the machine M.

[0043] In particular, the burnishing gear 3' enables, without either altering the geometry of the sides 14 of the teeth 12 or redesigning the entire kinematic chain that supplies the burnishing gear 3' itself, geometries to be obtained for the sides 10 of the teeth 8 having the tolerances necessary for proper operation of the sintered gear 1.

[0044] In greater detail, by reducing the number of teeth 12 of the burnishing gear 3' with respect to that of known burnishing gears 3, without varying the distance between two consecutive sides of the teeth 12, it is possible to reduce the number of teeth 12 in simultaneous contact with respective teeth 8 of the sintered gear 1. Consequently, each tooth 12 of the burnishing gear 3' exerts a substantially uniform load on the sides 10 of the teeth 8 of the sintered gear 1, enabling the surface densification to be controlled as well as possible and enabling achievement of the geometries of the sides 10 of the teeth 8 themselves contained within the prescribed tolerances in terms of dimensions and shape, limiting the number of experimental tests for definition of the best geometry of the teeth of the gears used.

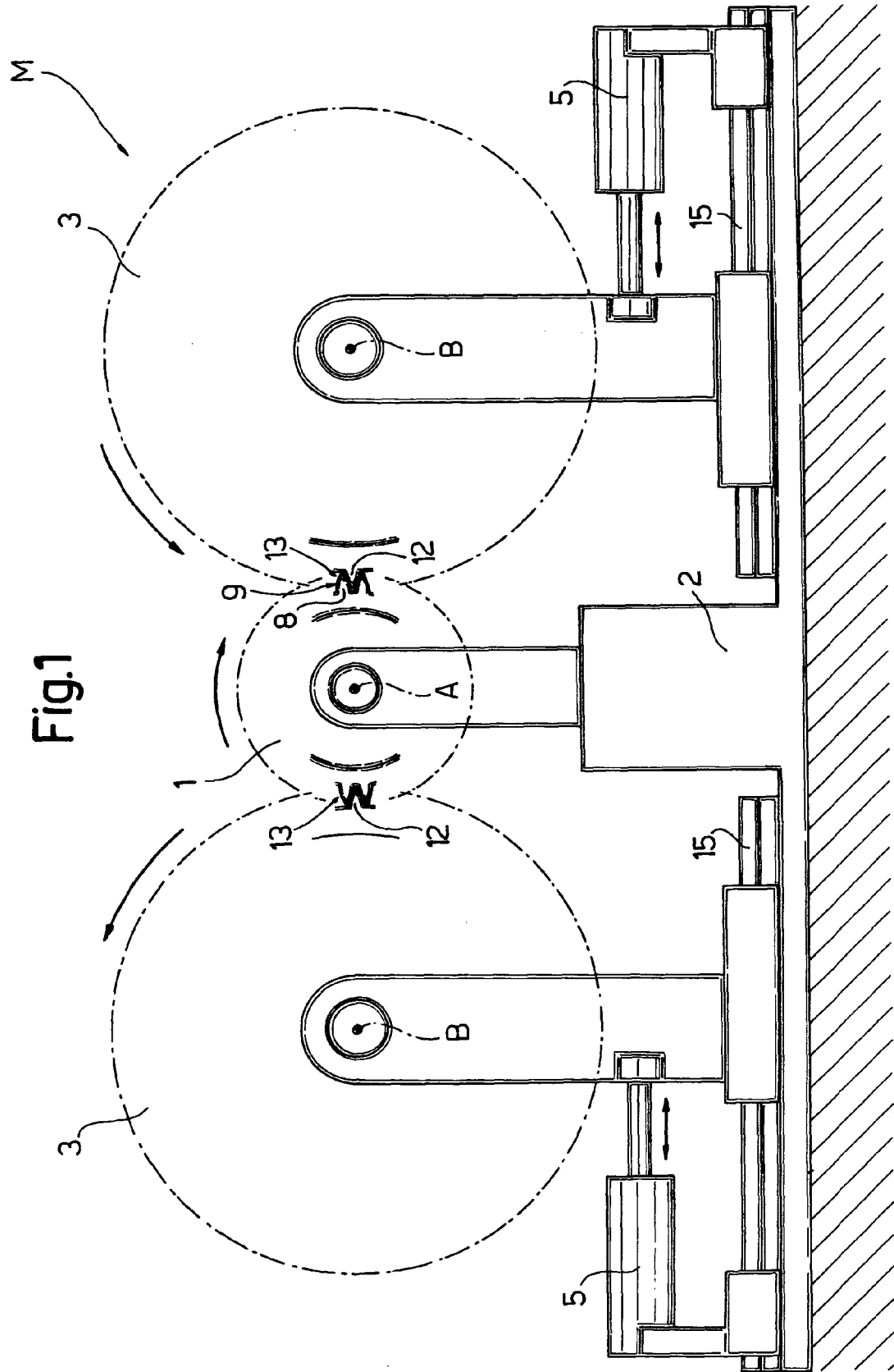
[0045] Finally, it is clear that modifications and variations can be made to the burnishing gear 3' and to the burnishing machine M described and illustrated herein, without thereby departing from the sphere of protection of the annexed claims.

Claims

1. A burnishing gear (3') comprising a plurality of first alternating solid elements (12) and empty elements (13') defined by a plurality of sides (14) for coupling with and densifying the surface of second solid elements (8) alternating with second empty elements (9) carried by a sintered gear (1), **characterized in that** each said first empty element (13') can house at least two second said solid elements (8).
2. The gear according to Claim 1, **characterized in that**, along an arbitrary circumference (D') having its centre on the axis (B) of said burnishing gear (3'), the distance between the sides (14) defining one said first solid element (12) is smaller than the distance between the consecutive sides (14) defining one said first empty element (13').
3. A burnishing machine (M) for the surface densification of sintered gears (1), **characterized in that** it comprises at least one burnishing gear (3') according to Claim 1 or Claim 2.

Amended claims in accordance with Rule 86(2) EPC.

1. A gear assembly comprising a sintered gear (1) carrying on its circumferential surface a plurality of first alternating teeth (8) and spaces (9), and a burnishing gear (3') carrying on its circumferential surface a plurality of second alternating teeth (12) and spaces (13') defined by a plurality of sides (14) for coupling with and densifying the surface of said first teeth (8); said second teeth (12) being carried integrally by and fixed to the said burnishing gear (3'); **characterized in that** each said second space (13') can house at least two first said first teeth (8).
2. The gear assembly according to Claim 1, **characterized in that**, along an arbitrary circumference (D') having its centre on the axis (B) of said burnishing gear (3'), the distance between the sides (14) defining one said second teeth (12) is smaller than the distance between the consecutive sides (14) defining one said second space (13').
3. A burnishing machine (M) for the surface densification of sintered gears (1), **characterized in that** it comprises at least one gear assembly according to Claim 1 or Claim 2.



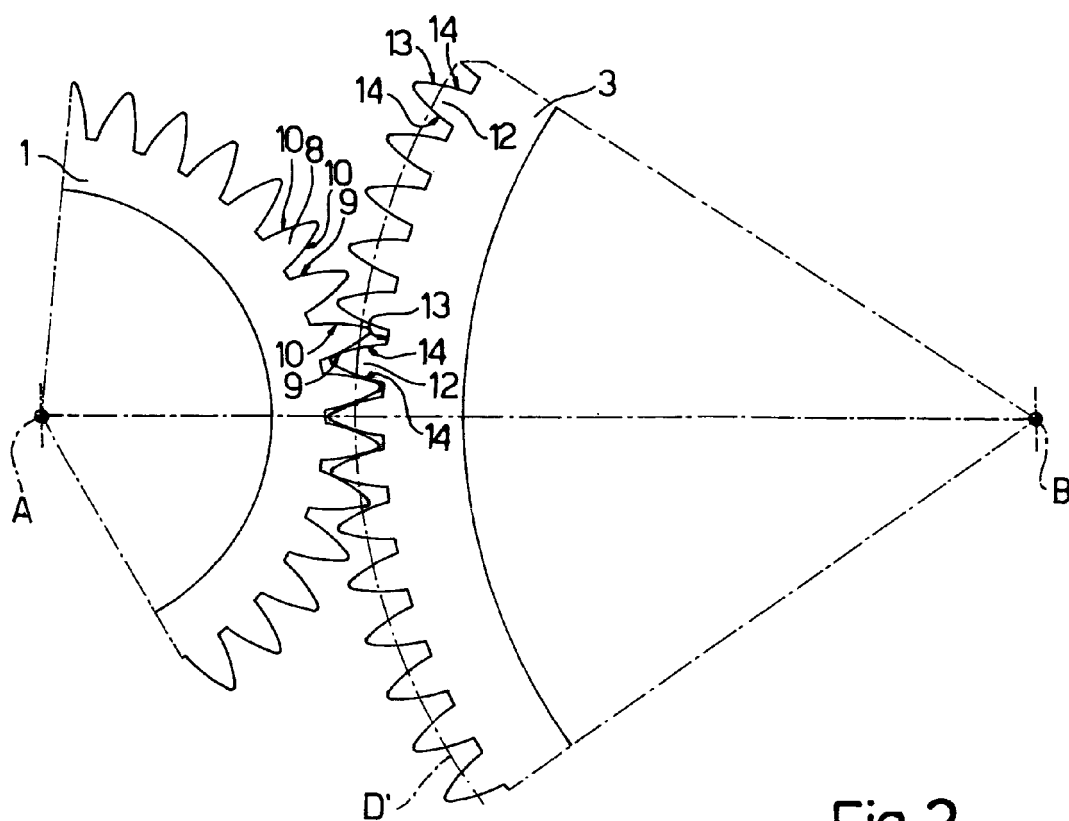
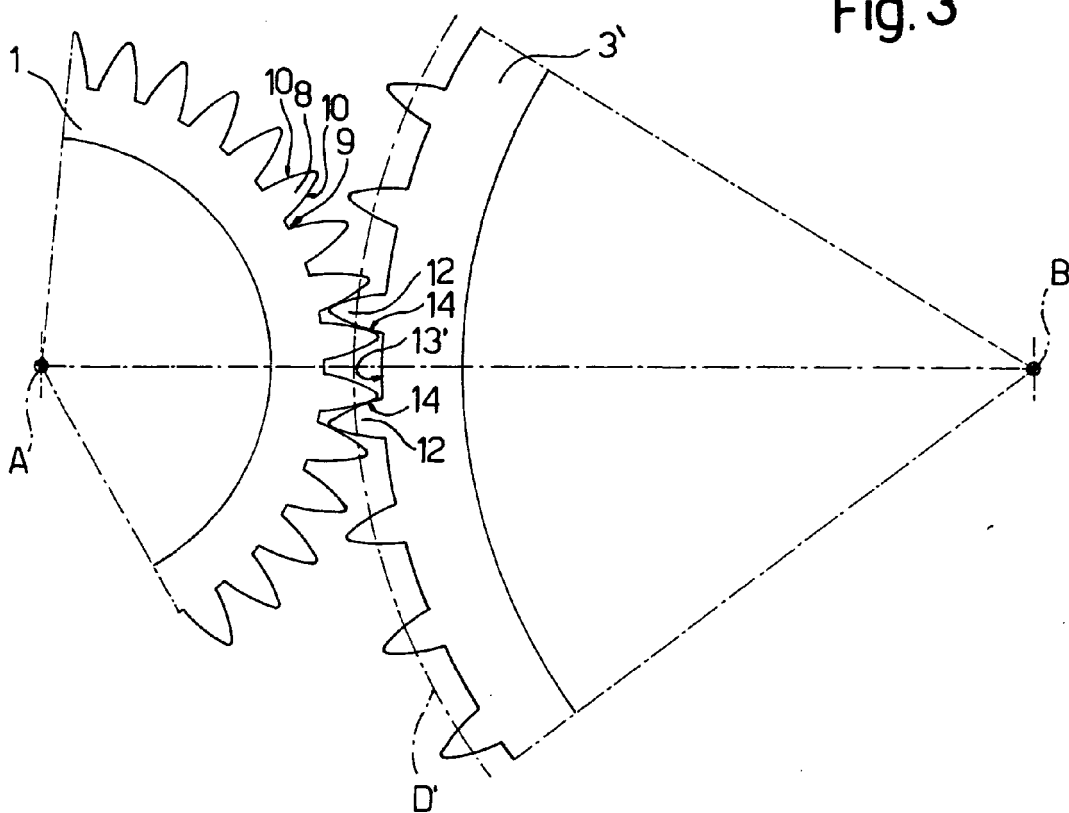


Fig. 2

Fig. 3





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EUROPEAN SEARCH REPORT

Application Number
EP 04 42 5723

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Place of search		Date of completion of the search	Examiner
The Hague		18 January 2005	Plastiras, D
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03/82 (P04C01)



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Place of search The Hague		Date of completion of the search 18 January 2005	Examiner Plastiras, D
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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