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(54) **A DRESSING APPARATUS AND A METHOD FOR DRESSING A GRINDING WHEEL WITH THE DRESSING APPARATUS**

(57) The present invention relates to a dressing apparatus (100) for dressing a grinding wheel (10) and a method for dressing the grinding wheel (10) with such a dressing apparatus (100), whereas the dressing apparatus (100) comprises a dressing disc (11), which dressing disc (11) is configured to interact with the grinding wheel (10) in order to perform a dressing operation of

the grinding wheel (10), and whereas the dressing apparatus comprises a spindle unit (12) for rotating the dressing disc (11). According to the invention, the dressing apparatus (100) further comprises an oscillation generator (13) to cause an oscillation movement in the dressing disc (11) while dressing the grinding wheel (10).

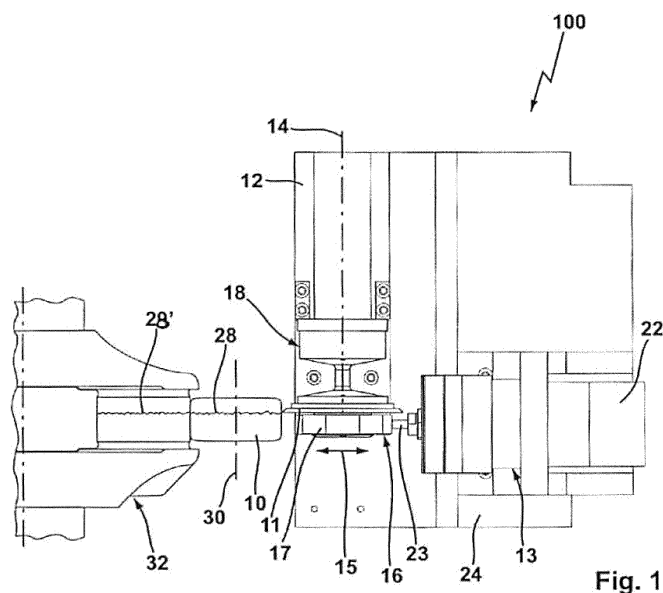


Fig. 1

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Description

[0001] The present invention relates to a dressing apparatus for dressing a grinding wheel, whereas the dressing apparatus comprises a dressing disc, which dressing disc is configured to interact with the grinding wheel in order to perform a dressing operation of the grinding wheel, and whereas the dressing apparatus comprises a spindle unit for rotating the dressing disc. Furthermore, the invention relates to a method for dressing a grinding wheel with such a dressing apparatus.

PRIOR ART

[0002] EP 1 754 569 A1 discloses a dressing apparatus for dressing a grinding wheel whereas the dressing apparatus comprises a dressing tool which is configured to interact with the grinding wheel in order to perform a dressing operation of the grinding wheel. The dressing tool is received on an oscillating generator to cause an oscillation movement in the dressing tool when the dressing tool interacts with the grinding wheel. Due to the oscillation movement in the dressing tool the surface of the grinding wheel can be dressed more efficiently, and the binding of the abrasive grain within the composite material of the grinding wheel can locally be damaged. This leads to a more exact dressing effect with lower dressing forces and a reduced wearing of the dressing tool. The oscillation generator is provided with an ultrasonic sonotrode.

[0003] EP 0 048 356 B1 discloses a method of dressing a grinding wheel with a dressing apparatus, and the dressing apparatus comprises a dressing disc which is configured to interact with the grinding wheel, and the grinding wheel comprises diamond or cubic crystalline boron nitride as an abrasive. The interaction with the grinding wheel is to perform a dressing operation of the grinding wheel and whereas the dressing apparatus comprises a spindle unit for rotating the dressing disc. Moreover, the dressing apparatus comprises an auxiliary dressing tool.

[0004] It is known in the prior art that a profiling of a grinding wheel can be generated with a dressing disc, and either the dressing disc features the profiling in the own dressing surface which profile can be imaged to the surface of the grinding wheel, or the dressing operation is performed with a movement of the dressing wheel, which movement reproduces the required profile on the grinding surface of the grinding wheel. In particular when the grinding parts which are ground with the grinding wheel, e.g. parts for internal combustion engines as crankshafts, connecting rods, camshafts and the like, patterns in the range of microns are requested on the ground surfaces. For example, it is benefit to implement a pattern in the surface of main journals or hub journals of a crankshaft in order to improve the lubrication behavior in the bearings. In the prior art, these patterns in the range of microns have been applied in the surface with

a separate operating step up to now.

DISCLOSURE OF INVENTION

[0005] It is an objective of the present invention to develop a controlled, accurate and economic-feasible process for dressing grinding wheels and to develop a dressing apparatus for dressing grinding wheels, which improve the dressing behavior and which is suited to implement a micro pattern into the surface grinding part which is ground with the grinding wheel.

[0006] This objective is achieved by a dressing apparatus according to the preamble of claim 1 and a method according to the preamble of claim 10 in conjunction with the inventive features of the present invention. A preferred embodiment of the invention is defined in the sub-claims.

[0007] According to the invention, the dressing apparatus further comprises an oscillation generator to cause an oscillation movement in the dressing disc while dressing the grinding wheel.

[0008] The core of the invention is the application of an oscillation generator to cause an oscillation movement in the dressing disc, and the oscillation movement is generated with a movement behavior suited to reproduce a pattern on the dressing surface of the dressing disc. When the dressing disc gets into contact the dressing part, either in a simultaneous process during the grinding of the grinding part or in a subsequent step when the grinding wheel is used to grind the grinding part, and this pattern in the dressing disc can be imaged onto the grinding wheel and thus imaged onto the grinding part simultaneously or in a subsequent step. Experiences show that with grinding of automotive components, e.g. crankshafts or camshafts, with a vibration of the dressing tool during the dressing process this oscillation movement could lead to the generation of surface pattern on the grinding wheel to be further transferred to the grinding part. The transference of the surface pattern from the grinding wheel to the grinding part depends on the speed ratio between the grinding wheel and the grinding part. This leads to the advantage that already with the grinding of the grinding part the pattern can be implemented into the surface of the grinding part. A separate, subsequent step to implement the pattern into to the surface of the grinding part is not necessary. Accordingly, the inventive dressing apparatus is suited to combine a usual grinding process with a pattern process of the surface of the grinding wheel and simultaneously and subsequently in the surface of the grinding part.

[0009] Another core idea of the dressing apparatus is the rotating of the dressing disc simultaneous to the exciting of the dressing disc with the oscillation movement caused by the oscillation generator. This leads to a superposition of the surface movement in circumferential direction relative to the grinding wheel and a radial movement relative to the grinding wheel caused by the oscillation. This overlap of at least two movements are suited

to generate the required pattern in the surface of the grinding wheel.

[0010] It is another advantage of the dressing apparatus that the dressing disc is rotatable by means of the spindle unit in a rotation axis, whereas the oscillation movement is caused in an oscillation direction which is oriented perpendicular to the rotation axis. This means that the oscillation movement is performed a radial direction of the dressing disc and when the dressing disc interacts with the grinding wheel, the oscillation direction is also directed radial to the grinding wheel.

[0011] Moreover, the dressing disc is received in a bearing arrangement comprising a bearing frame, whereas the bearing frame features an elastic movability in the oscillation direction in order to allow the oscillation movement of the dressing disc. The bearing frame can be made of a metallic material and a special shaft section of the bearing frame enables the dressing disc to perform the oscillation movement.

[0012] According to yet another embodiment, the coupling of the spindle unit with the dressing disc comprises a shaft element, whereas the shaft element comprises a spindle coupling section and a dressing disc coupling section, whereas in between these coupling sections the shaft element features a flexible section in order to allow a lateral displacement of the dressing disc coupling section relative to the spindle coupling section. This leads to the advantage that the dressing disc can be excited with the oscillation movement and at the same time the dressing disc can be rotated by the spindle unit. The shaft element can be made of a metallic material and the flexible section can be made e.g. with a radial contraction shape section having a lower lateral stiffness.

[0013] According to a preferred embodiment the oscillation generator comprises at least one piezo element or at least one package of multi piezo elements. The piezo element or the package of piezo elements are suited to generate an oscillation movement in the range of ultrasonic, and this movement can be transferred onto the dressing disc. The oscillation generator is coupled to the bearing frame by means of an exciting element, which exciting element is formed to transform the oscillation movement from the oscillation generator to the bearing frame. Because the dressing disc is received within the bearing frame, the oscillation movement is transferred from the bearing frame to the dressing disc.

[0014] The exciting element is directly coupled to the piezo element or package of piezo elements and forms the moving part of the oscillation generator. The exciting element can form a cylinder shaft and the tip of the exciting element can advantageously be connected to the bearing frame in an articulated manner.

[0015] According to yet another embodiment, the dressing apparatus features a support table, whereas the spindle unit, the oscillation generator and the bearing arrangement are commonly arranged on the support table. The spindle unit can additionally feature a bearing support, to which the spindle unit is mounted and the

bearing support is mounted to the support table.

[0016] According to another improvement, the support table is received on a grinding table in such a manner that the support table is linear movable relative to the grinding table in a moving direction, whereas the moving direction is aligned with the rotation axis of the spindle unit. This enables the support table and thus the spindle unit, the oscillation generator and the bearing arrangement with the dressing disc to be moved relative to the grinding wheel in the axial direction of the rotation axis of the spindle unit.

[0017] The dressing apparatus comprises a control unit, whereas the control unit is performed to control at least the spindle unit and the oscillation generator in order to generate a defined pattern on the grinding wheel. If the support table is optional movable in the moving direction by means of a moving unit this moving unit can also be controlled by the control unit.

[0018] The present invention is also directed to a method for dressing a grinding wheel with a dressing apparatus, whereas the dressing apparatus comprises a dressing disc, which dressing disc interacts with the grinding wheel in order to perform a dressing operation of the grinding wheel, and whereas the dressing apparatus comprises a spindle unit which rotates the dressing disc. According to the invention the method comprises the further steps of providing an oscillation generator, and an oscillation movement in the dressing disc is caused with the oscillation generator while dressing the grinding wheel and a defined pattern is generated on the grinding wheel by means of a defined oscillation movement of the oscillation disc.

[0019] According to another advantage, this method is performed by controlling at least one piezo element or at least one package of multiple of piezo elements, which piezo elements are part of the oscillation generator and are performed to cause the oscillation movement, e. g. in the range of ultrasonic. The controlling is advantageously performed with a control unit.

[0020] Another advantage of the method relates to a grinding part which is provided, whereas the grinding wheel interacts with the grinding part and whereas the caused pattern in the grinding wheel is transferred to the grinding part.

[0021] The transfer can be performed simultaneously when the grinding wheel interacts with the grinding part and when the dressing disc at the same time dresses the grinding wheel and is excited by the oscillation generator with the oscillation movement. However, the dressing disc can perform the dressing process on the grinding wheel, excited by the oscillation generator in a first step and the grinding wheel can transfer the pattern to the grinding part during the grinding process in a second step.

[0022] According to yet another advantage of the method, the spindle unit and the oscillation generator are controlled by a control unit, whereas in the control unit operates a program to reproduce a defined pattern on the

grinding wheel by means of a defined control of the oscillation movement with the oscillation generator and/or the operation of the spindle unit. In particular with the control unit the rotation speed of the spindle unit can be correlated with the oscillation movement of the oscillation generator. If the dressing apparatus is movable in a moving direction relative to the grinding wheel, this movement can also be controlled by the control unit and can be correlated with the rotating speed of the spindle unit and the oscillation movement of the oscillation generator.

[0023] The abrasive material for the grinding wheel preferably comprises diamond or cubic crystalline boron nitride due to the higher hardness, strength and abrasion resistance of the material, which preserves the defined pattern for a superior time when compared to other known materials.

[0024] The afore-mentioned components as well as the claimed components and the components to be used in accordance with the invention in the described embodiment are not subject to any special exceptions with respect to their size, shape, material selection and technical concept such that the selection criteria known in the pertinent field can be applied without limitations.

PREFERRED EMBODIMENT OF THE INVENTION

[0025] Additional details, characteristics and advantages of the object of the invention are disclosed in the sub-claims and the following description of the respective figures, which show preferred embodiments in an exemplary fashion of the subject matter according to the invention in conjunction with the accompanying figures, in which show

Fig. 1 a top view of the dressing apparatus;

Fig. 2 a perspective view of the dressing apparatus and

Fig. 3 a side view of the dressing apparatus.

[0026] Fig. 1 and Fig. 2 show the dressing apparatus 100 according to the present invention, and Fig. 1 shows a top view and Fig. 2 shows a perspective side view of said dressing apparatus 100.

[0027] The dressing apparatus 100 is thought for dressing a grinding wheel 10, which is according to Fig. 1 shown in contact with a crankshaft which forms a grinding part 32. According to the invention the dressing apparatus 100 is suited to induce a defined pattern 28 on the grinding surface of the grinding wheel 10, and when the grinding wheel 10 interacts with a grinding part 32, e.g. shown as a crankshaft, with the grinding machining of the grinding part 32 by means of the grinding wheel 10 the defined pattern 28' can be reproduced on the surface of the grinding part 32. The inventive features of the dressing apparatus 100 in order to apply such a defined pattern 28, 28' on the surface of the grinding wheel 10

and/or additionally on the surface of a grinding part 32, the dressing apparatus 100 features the following structure as described below.

[0028] For dressing the grinding wheel 10 a dressing disc 11 is arranged and connected to a spindle unit 12, and when the spindle unit 12 is operating, the dressing disc 11 rotates in a rotation axis 14. The dressing disc 11 may comprise diamond crystals for example. The dressing disc 11 is received in a bearing arrangement 16, which comprises a bearing frame 17. The bearing frame 17 is designed to perform an oscillation movement in an oscillation direction 15, which oscillation direction 15 is arranged perpendicular to the rotation axis 14. In order to exercise an oscillation movement in the bearing frame 17 and thus in the dressing disc 11, the dressing apparatus 100 comprises an oscillation generator 13. The oscillation generator 13 may comprise a piezo element 22 or a package of multiple of piezo elements, and when the piezo elements 22 are activated, an exciting element 23 performs the oscillation movement in the oscillation direction 15 and the exciting element 23 is coupled to the bearing frame 17. Accordingly, the bearing frame 17 performs the oscillation movement in the oscillation direction 15 caused by the oscillation generator 13, and with the oscillating of the bearing frame 17 the dressing disc 11 performs the same oscillation movement.

[0029] The oscillation movement is performed in the rotation plane of the dressing disc 11, and this oscillation direction 15 is oriented perpendicular to a grinding wheel axis 30 of the grinding wheel 10.

[0030] The dressing apparatus 100 comprises a support table 24, which is e.g. movable received on a grinding table 25 as shown in Fig. 2. In order to arrange the support table 24 onto the grinding table 25, the support table 24 comprises clamps 31. The spindle unit 12 is arranged on the support table 24 with a bearing support 29. The oscillation generator 13 is arranged on the support table 24 as well as the bearing arrangement 16. The interconnection between the dressing disc 11 and the spindle unit 12 forms a shaft element 18, comprising a flexible section to allow the oscillation movement of the dressing disc 11 while the spindle unit 12 is resting on the bearing support 29.

[0031] As in particular shown in fig. 2, the dressing apparatus 100 further comprises a control unit 27 for controlling the spindle unit 12 and the oscillation generator 13. As not shown in detail, the moving of the support table 24 on the grinding table 25 in the moving direction 26 can be caused by a moving unit, which also can be controlled by the control unit 27.

[0032] The oscillation movement of the bearing frame 17 in the oscillation direction 15 is indicated with dashed lines and arrows, and the bearing frame 17 comprises a shaft section 34 which forms a flexible movability of the upper part of the bearing frame 17 relative to a base section 35, which is inflexible mounted to the support table 24.

[0033] Fig. 3 shows a side view of the dressing appa-

ratus 100 with the spindle unit 12 for rotating the dressing disc 11 in the rotation axis 14 and in the background the oscillation generator 13 is shown for exciting the dressing disc 11 via the bearing arrangement 16 with an oscillation movement in the oscillation direction 15. The oscillation direction 15 runs perpendicular to the rotation axis 14.

[0034] In order to allow a lateral movement of the bearing arrangement 16 and thus the dressing disc 11 relative to the rotation axis 14 the shaft element 18 between the spindle unit 12 and the dressing disc 11 comprises a flexible section 21. The flexible section 21 is arranged in between a spindle coupling section 19 and a dressing disc coupling section 20, and the spindle coupling section 19 remains in the rotation axis 14 and the dressing disc coupling section 20 performs the same oscillation movement in the oscillation direction 15 as the dressing disc 11. This lateral movement is enabled with the flexible section 21 of the shaft element 18.

List of numerals

[0035]

| | | |
|-----|--------------------------------|--|
| 100 | dressing apparatus | |
| 10 | grinding wheel | |
| 11 | dressing disc | |
| 12 | spindle unit | |
| 13 | oscillation generator | |
| 14 | rotation axis | |
| 15 | oscillation direction | |
| 16 | bearing arrangement | |
| 17 | bearing frame | |
| 18 | shaft element | |
| 19 | spindle coupling section | |
| 20 | dressing disc coupling section | |
| 21 | flexible section | |
| 22 | piezo element | |
| 23 | exciting element | |
| 24 | support table | |
| 25 | grinding table | |
| 26 | moving direction | |
| 27 | control unit | |
| 28 | defined pattern | |
| 28' | defined pattern | |
| 29 | bearing support | |
| 30 | grinding wheel axis | |
| 31 | clamp | |
| 32 | grinding part | |
| 33 | bearing part | |
| 34 | shaft section | |
| 35 | base section | |

Claims

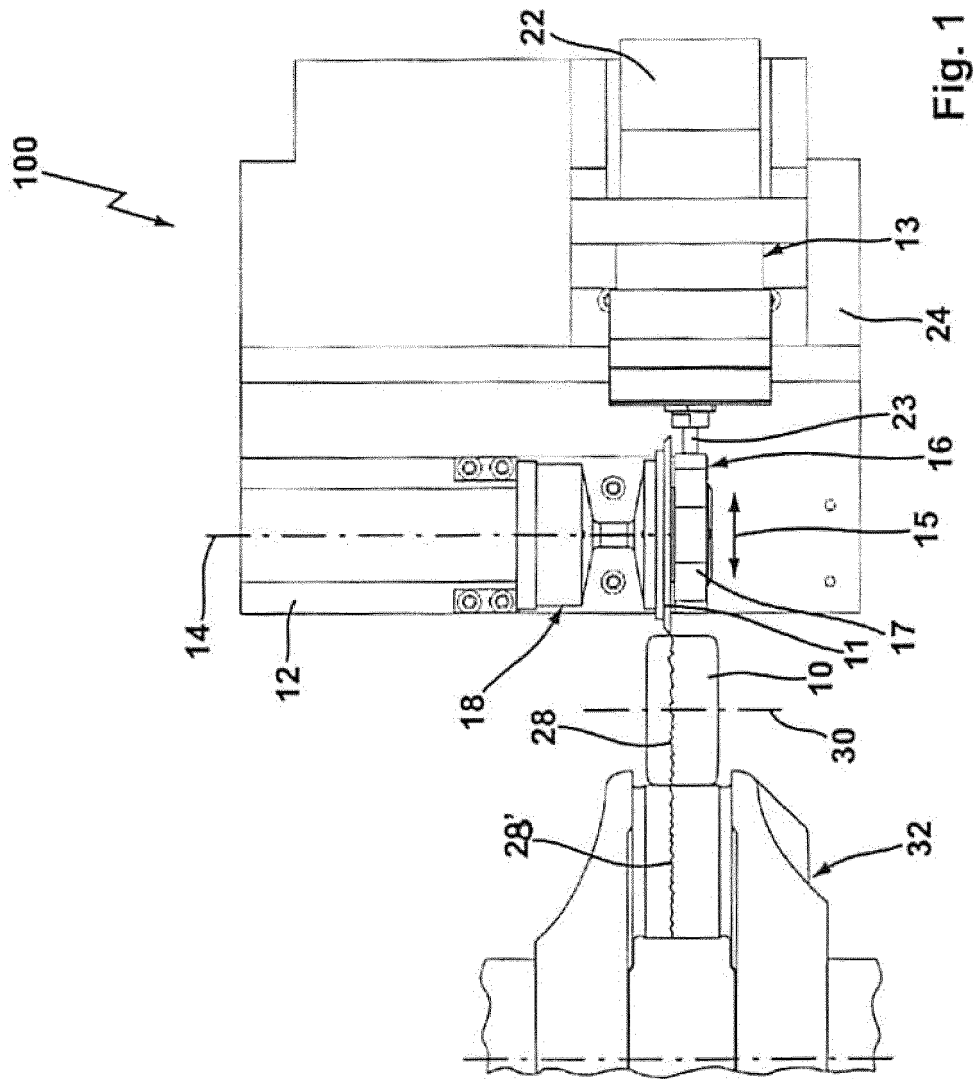
1. A dressing apparatus (100) for dressing a grinding wheel (10), whereas the dressing apparatus (100) comprises a dressing disc (11), which dressing disc

(11) is configured to interact with the grinding wheel (10) in order to perform a dressing operation of the grinding wheel (10), and whereas the dressing apparatus comprises a spindle unit (12) for rotating the dressing disc (11),

characterized in that the dressing apparatus (100) further comprises an oscillation generator (13) to cause an oscillation movement in the dressing disc (11) while dressing the grinding wheel (10).

2. A dressing apparatus (100) according to claim 1, **characterized in that** the dressing disc (11) is rotatable by means of the spindle unit (12) in a rotation axis (14), whereas the oscillation movement is caused in an oscillation direction (15) which is oriented perpendicular to the rotation axis (14).
3. A dressing apparatus (100) according to claim 1 or 2, **characterized in that** the dressing disc (11) is received in a bearing arrangement (16) comprising a bearing frame (17), whereas the bearing frame (17) features an elastic movability in the oscillation direction (15) in order to allow the oscillation movement in the dressing disc (11).
4. A dressing apparatus (100) according to one of the previous claims, **characterized in that** the coupling of the spindle unit (12) with the dressing disc (11) comprises a shaft element (18), whereas the shaft element (18) comprises a spindle coupling section (19) and a dressing disc coupling section (20), whereas in between the coupling sections (19, 20) the shaft element (18) features a flexible section (21) in order to allow a lateral displacement of the dressing disc coupling section (20) relative to the spindle coupling section (19).
5. A dressing apparatus (100) according to one of the previous claims, **characterized in that** the oscillation generator (13) comprises at least one piezo element (22) or at least one package of multiple of piezo elements.
6. A dressing apparatus (100) according to one of the previous claims, **characterized in that** the oscillation generator (13) is coupled to the bearing frame (17) by means of an exciting element (23), which exciting element (23) is formed to transmit the oscillation movement from the oscillation generator (13) to the bearing frame (17).
7. A dressing apparatus (100) according to one of the previous claims, **characterized in that** the dressing apparatus (100) features a support table (24), whereas the spindle unit (12), the oscillation generator (13) and the bearing arrangement (16) are commonly arranged on the support table (24).

8. A dressing apparatus (100) according to claim 7,
characterized in that the support table (24) is received on a grinding table (25) in such a manner that the support table (24) is linear movable relative to the grinding table (25) in a moving direction (26), whereas the moving direction (26) is aligned with the rotation axis (14) of the spindle unit (12). 5
9. A dressing apparatus (100) according to one of the previous claims,
characterized in that the dressing apparatus (100) comprises a control unit (27), whereas the control unit (27) controls the spindle unit (12) and the oscillation generator (13) in order to generate a defined pattern (28) on the grinding wheel (10). 10 15
10. A dressing apparatus (100) according to one of the previous claims,
characterized in that the dressing apparatus (100) features a grinding wheel (10) whereas the abrasive material for the grinding wheel (10) comprises diamond or cubic crystalline boron nitride. 20
11. A method for dressing a grinding wheel (10) with a dressing apparatus (100), whereas the dressing apparatus (100) comprises a dressing disc (11), which dressing disc (11) interacts with the grinding wheel (10) in order to perform a dressing operation of the grinding wheel (10), and whereas the dressing apparatus comprises a spindle unit (12) which rotates the dressing disc (11), and whereas the method comprises at least the following steps: 25 30
- providing an oscillation generator (13),
 - causing an oscillation movement in the dressing disc (11) with the oscillation generator (13) while dressing the grinding wheel (10) and
 - generating a defined pattern (28) on the grinding wheel (10) by means of an defined oscillation movement of the dressing disc (11). 35 40
12. A method according to claim 11,
characterized in that a grinding part (32) is provided, whereas the grinding wheel (10) interacts with the grinding part (32) and whereas the caused pattern in the grinding wheel (10) is transferred to the grinding part (32). 45
13. A method according to claim 11 or 12,
characterized in that the spindle unit (12) and the oscillation generator (13) are controlled by a control unit (27), whereas in the control unit (27) operates a program to reproduce a defined pattern (28) on the grinding wheel (10) by means of a defined control of the oscillation movement with the oscillation generator (13) and/or the operation of the spindle unit (12). 50 55



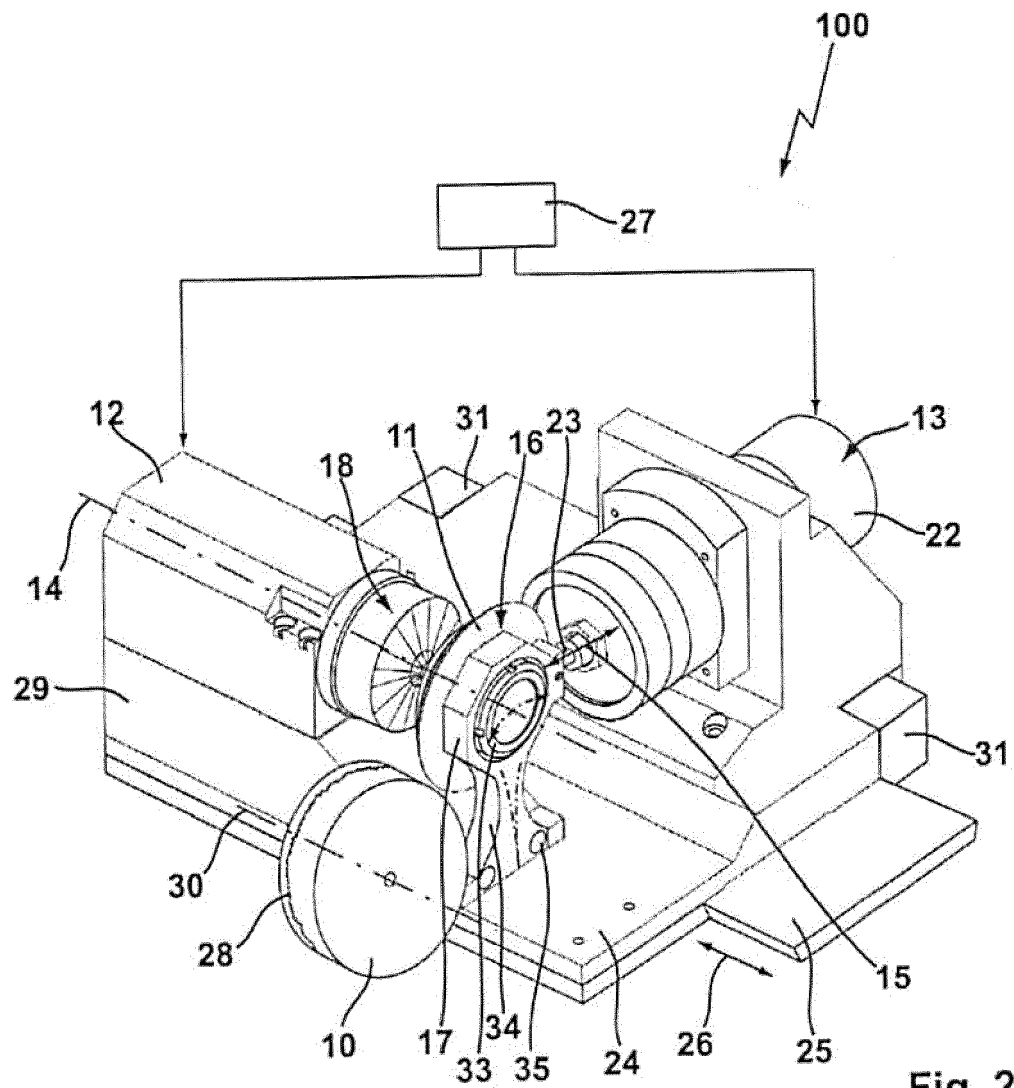
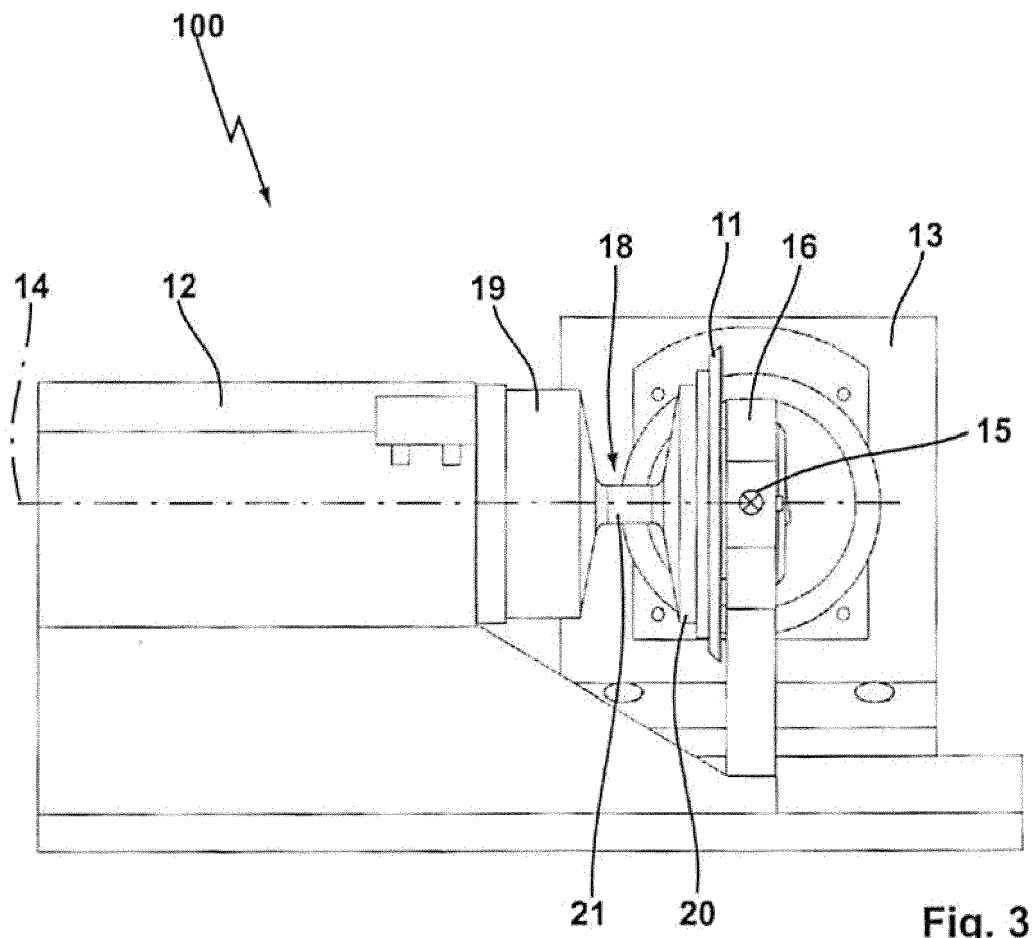


Fig. 2





EUROPEAN SEARCH REPORT

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| DOCUMENTS CONSIDERED TO BE RELEVANT | | | |
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| Place of search Munich | | Date of completion of the search 4 September 2018 | Examiner Kornmeier, Martin |
| 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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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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