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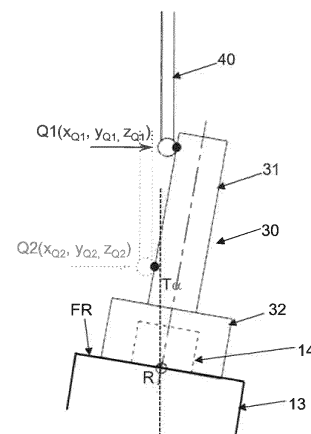
(54) METHOD FOR CALIBRATING A DRESSING SPINDLE OF A MACHINE TOOL

(57) The present invention is related to a method for calibrating a dressing spindle of a machine tool having a main spindle arranged in a machine head and the dressing spindle arranged in the machining area, wherein a grinding tool can be mounted on the main spindle and a dressing tool can be mounted on the dressing spindle and the grinding tool and the dressing tool can be moved relatively to each other for dressing the grinding tool by the dressing tool. The method comprises the following steps:

- providing a test mandrel with an elongated body and a seat;
- mounting the test mandrel on the dressing spindle by connecting the seat with the dressing spindle such that the axial axis of the body is in parallel with the rotation axis of the dressing spindle;
- measuring a plurality of positions on the body by contacting a measuring device with the body of the test mandrel at the plurality of positions;
- determining the tilt angle of the rotation axis of the dressing spindle based on the measured plurality of positions on the test mandrel by a processing unit, wherein the tilt angle is the angulation of the rotation axis of the dressing spindle with respect to the vertical direction;
- mounting a calibration sphere having a connecting portion and a jig on the top of the connecting portion on the dressing spindle, wherein the calibration sphere is concentrically arranged on the dressing spindle;
- mounting a touch probe on the main spindle;
- measuring a plurality of positions on the jig by contacting the touch probe with the jig at the plurality of

positions;

- determining the center position of the calibration sphere in accordance with the measured plurality of calibration sphere positions by the processing unit; and
- determining by the processing unit the position of a referencing point of the dressing spindle based on the determined center position of the calibration sphere, the tilt angle of the rotation axis of the dressing spindle and the dimension of the calibration sphere, wherein the referencing point is located at the center position on a referencing surface of the dressing spindle.

**Fig. 5****EP 4 491 329 A1**

Description

FIELD OF THE INVENTION

[0001] The present invention is related to a method for calibrating a dressing spindle of a machine tool.

BACKGROUND OF INVENTION

[0002] A grinding machine is a machine tool used for grinding. This process is usually applied to machine the workpieces to achieve high surface quality and high accuracy of the shape. The machine tool for grinding comprises a machine bed to hold the workpiece and a spindle for receiving a grinding tool therein. The grinding tool is the essential element to shape the workpiece by removing the material from the workpiece. Since the material of the workpiece is removed by abrasion, the grinding tool must be conditioned regularly to restore its original shape. Therefore, a dressing wheel is arranged in the grinding machine tool close to the spindle for reshaping the grinding tool. Proper dressing has a direct impact on the quality of the machined part.

[0003] As for all machine tools, kinematic calibration of the dressing wheel is essential. The position of the dressing wheel must be accurately determined. Sometimes, the dressing wheel is not arranged vertically in the machine tool. For example, in the machine tool Mikron Mill S, the rotation axis of the dressing wheel has an inclination to the vertical direction. As shown in the figures 3a and 3b, the grinding tool must be dressed laterally to fulfill the specification of the diameter and from the bottom to reshape the front face of the grinding tool. If the dressing spindle is mounted without inclination with Z axis, it is difficult to reliably reshape the front surface of the grinding tool. For this reason, the dressing spindle is mounted at an angle to the Z axis. Thus, there is an angulation between the rotation axis of the dressing wheel and the vertical direction. The angulation is normally in the range of 5 to 20 degree. The angular orientation of the dressing wheel makes difficult to measure its position precisely by standard calibration procedure.

SUMMARY OF THE INVENTION

[0004] It is an objective of this invention to provide a method for calibrating a dressing spindle of a machine tool with improved calibration accuracy. It is a further objective of the present invention to provide a method for calibrating a dressing spindle of a machine tool with simple instruments.

[0005] According to the present invention, these objectives are achieved through the features of independent claims. In addition, further advantageous embodiments follow from the dependent claims and the description.

[0006] In the present invention, a method for calibrating a dressing spindle of a machine tool is provided. The

machine tool comprises a main spindle arranged in a machine head and the dressing spindle arranged in the machining area, wherein a grinding tool is mounted on the main spindle and a dressing tool is mounted on the dressing spindle. The grinding tool and the dressing tool can be moved relatively to each other for dressing the grinding tool by the dressing tool. The method comprises the steps of: providing a test mandrel having an elongated body and a seat; mounting the test mandrel on the dressing spindle by connecting the seat with the dressing spindle such that the axial axis of the body is in parallel with the rotation axis of the dressing spindle; measuring a plurality of positions on the body by contacting a measuring device with the body of the test mandrel at the plurality of positions; determining the tilt angle of the rotation axis of the dressing spindle based on the measured plurality of positions on the test mandrel by a processing unit, wherein the tilt angle is the angulation of the rotation axis of the dressing spindle with respect to the vertical direction; mounting a touch probe on the main spindle; mounting a calibration sphere having a connecting portion and a jig on the top of the connecting portion on the dressing spindle, wherein the calibration sphere is concentrically arranged on the dressing spindle; measuring a plurality of positions on the jig by contacting the touch probe with the jig at the plurality of positions; determining the center position of the calibration sphere in accordance with the measured plurality of calibration sphere positions by the processing unit; and determining the position of a referencing point of the dressing spindle based on the determined center position of the calibration sphere, the tilt angle of the rotation axis of the dressing spindle and the dimension of the calibration sphere, wherein the referencing point is located at the center position on a referencing surface of the dressing spindle.

[0007] The machine tool may be a machine tool for grinding or for milling and grinding. It comprises a machine table, a main spindle and a dressing spindle. A workpiece can be mounted on the workpiece table which is arranged on a machine table. The main spindle is mounted on a machine head of the machine tool. A grinding tool can be mounted on the main spindle for grinding the workpiece. The machine tool comprises at least three linear axes (X, Y, Z), by which the main spindle and the machine table can be moved relatively to each other. In particular, the machine tool comprises three linear axes and at least two rotation axes.

[0008] The dressing spindle is integrated in the machine tool as well such that conditioning can be conducted directly in the same machine tool without mounting and dismounting the grinding tool to improve the machining sufficiency. The dressing tool can be mounted on the dressing spindle. When the grinding tool must be conditioned, the grinding tool and the dressing tool can be moved relatively to each other to position the grinding tool to the required position in the proximity of the dressing tool for conditioning. During conditioning, the main spindle and the dressing spindle both rotate in the opposite

direction or in the same direction and the grinding tool gets in contact with the dressing tool to be conditioned.

[0009] Depending on the kinematic of the machine tool, the dressing spindle has one or more linear axes. For example, the main spindle can be moved in Y and Z directions along with the machine head. The machine table can be moved in X direction. The dressing spindle is mounted on the machine table, in particular, on the side of the machine table can also be moved in the X direction.

[0010] To enable a proper dressing of the grinding tool, the rotation axis of the dressing tool must be slightly tilted compared to the rotation axis of the main spindle holding the grinding tool. Typically, the tilt angle is less than 20 degree.

[0011] In order to ensure an accurate final geometry of the grinding tool resulting from the dressing process, the position and the orientation of the rotation axis of the dressing spindle must be accurately determined. The determined position can be specified in the kinematic model of the machine tool. Moreover, after disturbance of the dressing spindle position e.g. exchange the dressing spindle or after transport of the machine, a geometric control is required. This means that the exact position and the tilt angle of the dressing spindle must be measured. To measure this, a touch probe applied for standard calibration can be used. However, the probing directly on the dressing tool is generally not accurate enough due to the tilt angle of the rotation axis of the dressing spindle. Additionally, only a small contact surface is available on the dressing tool for measurement by touch probe. This also cause measurement errors. The present invention provides a solution by replacing the dressing tool by dedicated test mandrels and to follow a specific calibration procedure to precisely calibrate the dressing spindle. A referencing point is defined on the dressing spindle. The goal is to precisely determine the position of this referencing point. Moreover, the calibration procedure should be simple, as complicated calibration procedure is time-consuming.

[0012] In a first step, the tilt angulation of the dressing spindle must be determined. The test mandrel having the elongated body and the seat is applied. The seat is designed to be easily and precisely mountable on the dressing spindle. The test mandrel is designed and manufactured in a way that in mounted state its axial axis is in parallel with the rotation axis of the dressing spindle. Therefore, if the tilt angulation of the body can be determined, the tilt angulation of the dressing spindle can be simply derived. The measuring device is mounted on the main spindle and moved to the proximity of the dressing spindle. At least two positions, in particular, two positions having different vertical position on the body are measured by the measuring device. The tilt angulation of the body can be determined by applying the trigonometry.

[0013] The measuring device can be a touch probe or a dial indicator. The touch probe is a preferred variant, because the measurements can be conducted automatically. When the touch probe is applied, an automatic

procedure can be programmed. The control unit controls the main spindle to move the touch probe to several defined positions of the machine tool and the measured positions are automatically stored in the control unit of the machine tool. Thus, the processing unit can be the control unit of the machine tool.

[0014] In a further step, the center position of the calibration sphere is determined. Thus, the test mandrel is replaced by the calibration sphere. The touch probe is controlled by the control unit of the machine tool to contact multiple positions for the calculation. The positions of the calibration sphere is measured by the touch probe with a defined measurement sequence. The different positions of the calibration sphere are produced by activating the main spindle movement to position the touch probe to the defined positions. From the measured calibration positions, the center position of the calibration sphere can be determined.

[0015] The determined tilt angulation and the center point of the calibration sphere are then input into the processing unit, in particular the control unit of the machine tool. Additionally, the diameter of the jig and the height of the calibration sphere are required for calculation of the position of the referencing point, thus these two parameters are also input into the control unit of the machine tool. The height of the calibration sphere provides the distance between the referencing point and the center point of the calibration sphere.

[0016] In a preferred variant, the processing unit is the control unit of the machine tool. Alternatively, the processing unit is arranged independently from the control unit of the machine tool. The processing unit can be integrated in the machine tool or at the outside of the machine tool. The processing unit can communicate with the control unit of the machine tool.

[0017] The method of the present invention can improve the accuracy in terms of determining the position of the rotation axis of the dressing tool. This again enables more accurate dressing of the grinding tool.

[0018] In some variants, three-dimensional coordinates are measured at all measuring positions.

[0019] In particular, the determined position of the referencing point is added into a kinematic compensation model, in particular the determined referencing position is automatically fed into the kinematic compensation model. Preferably, the kinematic compensation model is generated for calibration of the whole machine tool.

[0020] In order to further improve the measurement precision, the calibration sphere is first applied for determining a primary center position of the sphere before determining the tilt angulation of the dressing spindle. Therefore, before mounting the test mandrel on the dressing spindle, the calibration sphere is mounted on the dressing spindle and the touch probe measures multiple positions for calculating the primary center position of the sphere. This can obtain a rough position for the angle measurement by the test mandrel. In this variant, the calibration sphere is applied twice before and after ap-

plying the test mandrel.

[0021] The core of the present invention is to measure a reference point of the sphere as precise as possible and measure the angle using test mandrel as precise as possible. Having these two values and the known values related to the calibration sphere, the reference position of the dressing wheel can be calculated.

[0022] The present invention is related to a method for grinding a workpiece by a machine tool having a main spindle arranged in a machine head and a dressing spindle arranged in the machining area. A grinding tool can be mounted on the main spindle for grinding the workpiece mounted on the machine table. A dressing tool can be mounted on the dressing spindle and the grinding tool and the dressing tool can be moved relatively to each other for dressing the grinding tool by the dressing tool. The rotation axis of the dressing spindle has an inclination $T\alpha$ to the vertical direction comprising the steps of calibrating the dressing spindle according to the calibration method of the present invention; dressing the grinding tool by the dressing tool; and grinding the workpiece by the dressed grinding tool.

[0023] The present invention is related to a machine tool for grinding a workpiece comprising a main spindle arranged in a machine head and a dressing spindle arranged in the machining area. A grinding tool can be mounted on the main spindle for grinding the workpiece mounted on the machine table. A dressing tool can be mounted on the dressing spindle and the grinding tool and the dressing tool can be moved relatively to each other for dressing the grinding tool by the dressing tool, wherein the rotation axis of the dressing spindle has an inclination $T\alpha$ to the vertical direction.

[0024] In particular, the machine tool includes a calibration sphere and a test mandrel which can be mounted on the dressing spindle for calibrating the dressing spindle. The calibration sphere comprises a connecting portion and a jig on the top of the connecting portion, wherein the test mandrel comprises a seat and an elongated body formed on the top of the seat.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] In the following, a more particular description of the present invention is further described. The embodiments are described and explained with details with reference to accompanying drawings in which:

- Fig. 1 illustrates a side view of a machine tool having main spindle and dressing spindle;
- Fig. 2 illustrates a side view of the machining area in which the dressing spindle is mounted;
- Fig.3a illustrates schematically dressing the side surface of a grinding tool;
- Fig.3b illustrates schematically dressing the bottom

surface of the grinding tool;

- Fig.4 illustrates a schematic view of the dressing spindle;
- Fig.5 illustrates schematically test mandrel having an elongated body and a seat mounted on the dressing spindle;
- Fig.6 illustrates the trigonometry for calculation of tilt angulation;
- Fig.7 illustrates schematically a calibration sphere having a jig and a supporting element mounted on the dressing spindle; and
- Fig.8 illustrates steps of the method of the present invention.

EXEMPLARY EMBODIMENTS

[0026] Figure 1 illustrates a machine tool which is applicable for grinding. In particular, the figure 1 shows a machine tool for milling and grinding. The machine tool 1 has three linear axes X, Y and Z and two rotational axes B and C. The machine tool comprises a machine table 2 which can be moved linearly along the axis X. The linear movements along the Y and Z axes are conducted by the machine head 4. A cradle 3 is mounted on the machine table and can be rotated around the rotation axis B. The cradle includes a workpiece table 6 for mounting a workpiece thereon and the workpiece table is rotatable around the second rotation axis C. A main spindle 5 is mounted in the machine head for clamping different machining tools, for example a grinding tool therein. A dressing spindle 10 is fixedly mounted on the machine table, so it is not movable along with the workpiece table.

[0027] The figure 2 shows the arrangement of the dressing spindle depicted in the figure 1. A fixture 11 is mounted on the side surface of the machine table. The dressing spindle is mounted on the top surface of the fixture. On the top of the dressing spindle, a dressing tool 12 can be mounted for conditioning the grinding tool. As depicted in figure 2, the rotation axis of the dressing spindle 14 is not in parallel to Z direction, but having a tilt angle $T\alpha$. The reason of the tilting is shown in the figures 3a and 3b.

[0028] In order to reshape the grinding tool, not only the side surface 7a of the grinding tool but also the front surface 7b of the grinding tool must be dressed. Figure 3a shows schematically the state of dressing the side surface of the grinding tool. Figure 3b shows schematically the state of dressing the front surface of the grinding tool. For dressing, the grinding tool is mounted on the main spindle and moved closely to the dressing tool to be contacted by the dressing tool. The dressing tool is fixed mounted on the dressing spindle but rotates during the dressing. It can be clearly seen that the dressing spindle

must have a tilt angle such that the bottom surface can also be reached by the dressing tool.

[0029] Figure 4 shows a schematic view of the dressing spindle 10 which comprises a dressing spindle body 13 and a tool interface 14. The tool interface serves as an interface to clamp the dressing tool thereon and is located on the top surface of the dressing spindle body. The connecting surface of the spindle body 13 and the tool interface is defined as a referencing surface FR. The center point of the referencing surface is defined as a referencing point R. The goal of the calibration is to precisely determine the coordinate of this position and the tilt angulation of the dressing spindle. The determined values can be stored in the control unit of the machine tool for calculating the movement of the main spindle for dressing. The standard touch probe is only able to probe in an X-Y workplane and in Z-axis. Due to the inclination of the dressing spindle it is not possible to determine the position of the referencing point by the standard touch probe.

[0030] To determine the tilt angulation T_α of the dressing spindle, the grinding tool mounted on the main spindle is replaced by a touch probe 40 and the dressing tool is replaced by a test mandrel 30. As shown in figure 5, the test mandrel comprises a seat 32 for clamping it on the dressing spindle and an elongated body 31 on the seat. The seat has a cylindrical body and in its inner side a clamping interface is provided to be precisely mounted on the dressing spindle. The clamping interface is designed such that it can be coupled with the tool interface of the spindle in a simple manner. In particular, in the mounted state, the center axis of the test mandrel is in line with the rotation axis of the dressing spindle. The touch probe is controlled by the control unit of the machine tool to contact the different positions on the body and determine the tilt angle based on the measured positions.

[0031] As shown in figure 5, the touch probe is positioned close to the body and controlled by the control unit to contact for example the points Q1 and Q2 on the side surface of the body. The coordinates of the measured points Q1 and Q2, $Q1(x_{Q1}, y_{Q1}, z_{Q1})$ and $Q2(x_{Q2}, y_{Q2}, z_{Q2})$ are input into the control unit and the tilt angle of the mandrel T_α can be calculated.

[0032] As shown in figure 6, the trigonometry must be applied to calculate the tilt angulation T_α . The length a is the distance of the measured positions in Z direction, namely the difference of the two values of z_{Q1} and z_{Q2} . The length b is the distance of measured positions in Y direction, namely the difference of the two values of y_{Q1} and y_{Q2} .

[0033] In a further step, a calibration sphere is applied. The test mandrel is replaced by the calibration sphere which comprise a connecting portion 22 for clamping it on the dressing spindle and a jig 21 formed on the top of the connecting portion. The connecting portion has a cylindrical body and is provided with a clamping interface to be precisely mounted on the dressing spindle. In particular, the center axis of the calibration sphere is in line with the

rotation axis of the dressing spindle. The touch probe is controlled by the control unit of the machine tool to contact the different positions on the jig and determine the center position of the jig based on the measured positions, namely the coordinates of the point P shown in the figure 7. The distance A is known from manufacturing the calibration sphere. The diameter of the jig B is also known from manufacturing data. Since the coordinates of the center point of jig P is determined, the coordinates of the referencing point R can be determined by applying trigonometry.

[0034] The figure 8 shows the sequences of the method of the present invention. In the step S1, a touch probe is mounted on the main spindle. In the step S2, the dressing spindle is replaced by a test mandrel. In the step S3, the tilt angle of the rotation axis of the dressing spindle is determined by contacting the touch probe with the mandrel at a plurality of positions on the mandrel. In the step S4, the test mandrel is replaced by a calibration sphere. In the step S5, a plurality of positions on the calibration sphere is measured by contacting the touch probe with the calibration sphere at a plurality of positions and the measured positions are recorded. In the step S6, the center position of the calibration sphere is determined based on the plurality of calibration sphere positions by a processing unit. In the step S7, the center position of the dressing spindle is determined based on the determined center position of the calibration sphere, the tilt angle of the rotation axis of the dressing spindle and the dimension of the touch probe.

LIST OF REFERENCES

[0035]

- | | |
|----|--------------------------------|
| 1 | machine tool |
| 2 | machine table |
| 3 | cradle |
| 4 | machine head |
| 5 | main spindle |
| 6 | workpiece table |
| 7 | grinding tool |
| 7a | side surface of grinding tool |
| 7b | front surface of grinding tool |
| 8 | dressing tool |
| 10 | dressing spindle |
| 11 | fixture |
| 13 | dressing spindle body |
| 14 | tool interface |
| 20 | calibration sphere |
| 21 | jig |
| 22 | connecting portion |
| 30 | test mandrel |
| 31 | body of test mandrel |
| 32 | seat |
| 40 | touch probe |

Claims

1. A method for calibrating a dressing spindle (10) of a machine tool (1) having a main spindle (4) arranged in a machine head and the dressing spindle (10) arranged in the machining area, wherein a grinding tool can be mounted on the main spindle and a dressing tool can be mounted on the dressing spindle and the grinding tool and the dressing tool can be moved relatively to each other for dressing the grinding tool by the dressing tool, the method comprising:
 - a. providing a test mandrel (30) with an elongated body (31) and a seat (32);
 - b. mounting the test mandrel on the dressing spindle by connecting the seat with the dressing spindle such that the axial axis of the body is in parallel with the rotation axis of the dressing spindle;
 - c. measuring a plurality of positions on the body by contacting a measuring device with the body of the test mandrel at the plurality of positions;
 - d. determining the tilt angle of the rotation axis of the dressing spindle based on the measured plurality of positions on the test mandrel by a processing unit, wherein the tilt angle is the angulation of the rotation axis of the dressing spindle with respect to the vertical direction;
 - e. mounting a calibration sphere (20) having a connecting portion (22) and a jig (21) on the top of the connecting portion on the dressing spindle, wherein the calibration sphere is concentrically arranged on the dressing spindle;
 - f. mounting a touch probe (40) on the main spindle;
 - g. measuring a plurality of positions on the jig by contacting the touch probe with the jig at the plurality of positions;
 - h. determining the center position (P) of the calibration sphere in accordance with the measured plurality of calibration sphere positions by the processing unit; and
 - i. determining by the processing unit the position of a referencing point (R) of the dressing spindle based on the determined center position of the calibration sphere, the tilt angle of the rotation axis of the dressing spindle and the dimension of the calibration sphere, wherein the referencing point is located at the center position on a referencing surface (FR) of the dressing spindle.
2. The method according to claim 1, wherein the measuring device is a touch probe or a dial indicator.
3. The method according to claim 1 or 2, wherein three-dimensional coordinates are measured at all measuring positions.
4. The method according to one of claims 1 to 3, wherein the determined position of the referencing point is added into a kinematic compensation model, in particular the determined referencing position is automatically fed into the kinematic compensation model.
5. The method according to one of claims 1 to 4, wherein the touch probe is controlled by a control unit of the machine tool to conduct the measurement.
6. The method according to one of claims 1 to 5, wherein the touch probe is calibrated before conducting the measurement.
7. The method according to one of claims 1 to 6, wherein the calibration sphere is first applied for determining a primary center position before mounting the test mandrel on the dressing spindle to determine the tilt angulation of the dressing spindle.
8. The method according to one of claims 1 to 7, wherein the height of the calibration sphere is considered for determining the referencing point of the dressing spindle.
9. A method for grinding a workpiece by a machine tool having a main spindle (4) arranged in a machine head and a dressing spindle (10) arranged in the machining area, wherein a grinding tool can be mounted on the main spindle for grinding the workpiece mounted on the machine table, wherein a dressing tool can be mounted on the dressing spindle and the grinding tool and the dressing tool can be moved relatively to each other for dressing the grinding tool by the dressing tool, wherein the rotation axis of the dressing spindle has an inclination T_α to the vertical direction comprising:
 - a. calibrating the dressing spindle according to one of claims 1 to 8;
 - b. dressing the grinding tool by the dressing tool; and
 - c. grinding the workpiece by the dressed grinding tool.
10. A machine tool (1) for grinding a workpiece comprising a main spindle (4) arranged in a machine head and a dressing spindle (10) arranged in the machining area, wherein a grinding tool can be mounted on the main spindle for grinding the workpiece mounted on the machine table, wherein a dressing tool can be mounted on the dressing spindle and the grinding tool and the dressing tool can be moved relatively to each other for dressing the grinding tool by the dressing tool, wherein the rotation axis of the dressing spindle has an inclination T_α to the vertical direction.

11. The machine tool according to claim 10, wherein a control unit is provided in the machine tool and applied to conduct the steps according to claim 1.

12. The machine tool according to claim 10 or 11, where- 5
in the machine tool includes a calibration sphere and
a test mandrel which can be mounted on the dressing
spindle for calibrating the dressing spindle according
to claim 1, wherein the calibration sphere comprises 10
a connecting portion (22) and a jig (21) on the top of
the connecting portion, wherein the test mandrel (30)
comprises a seat (32) and an elongated body (31)
formed on the top of the seat.

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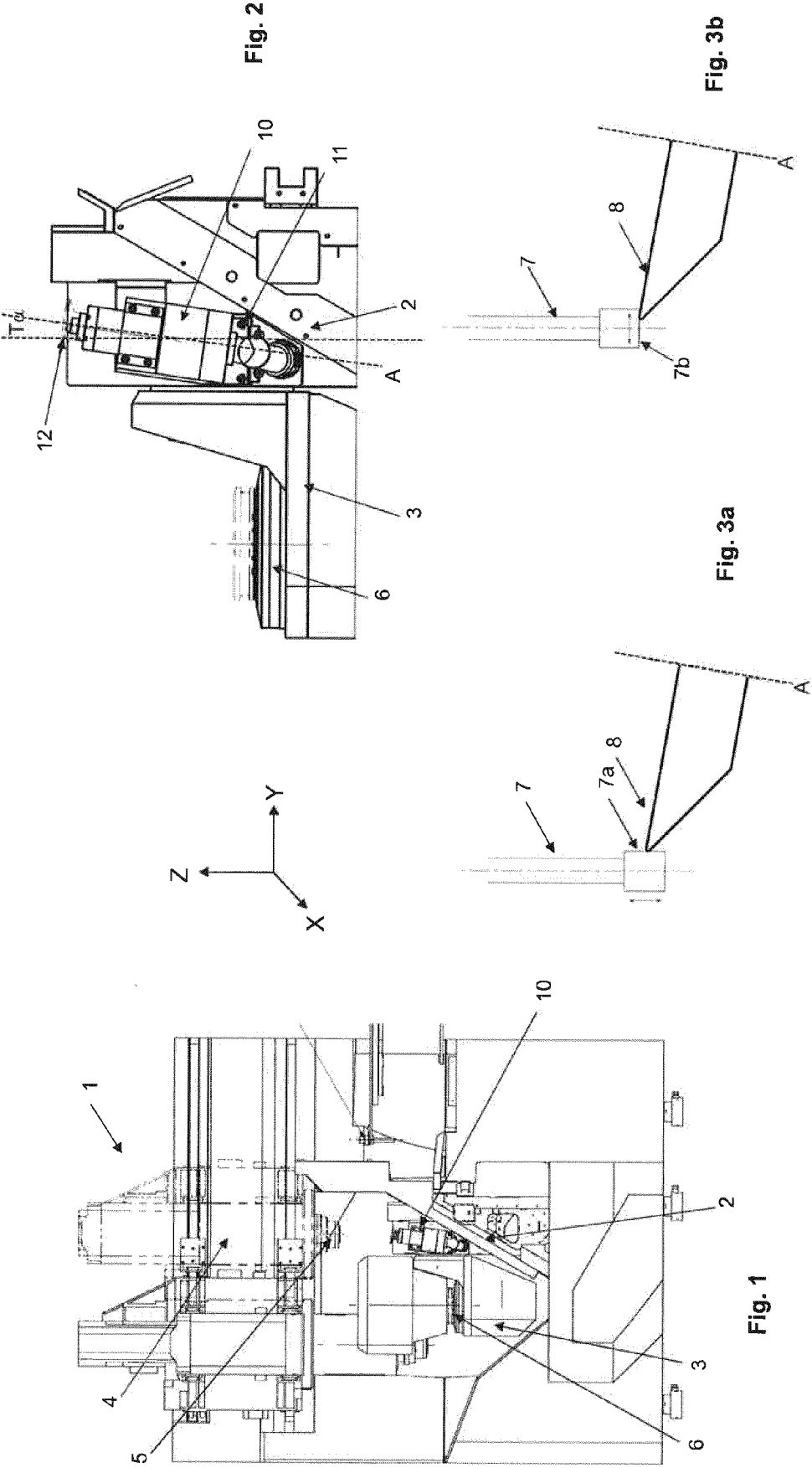
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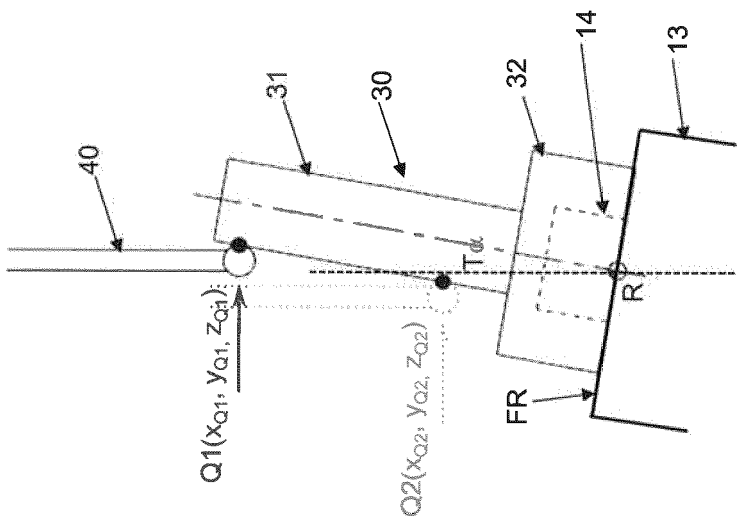


Fig. 6

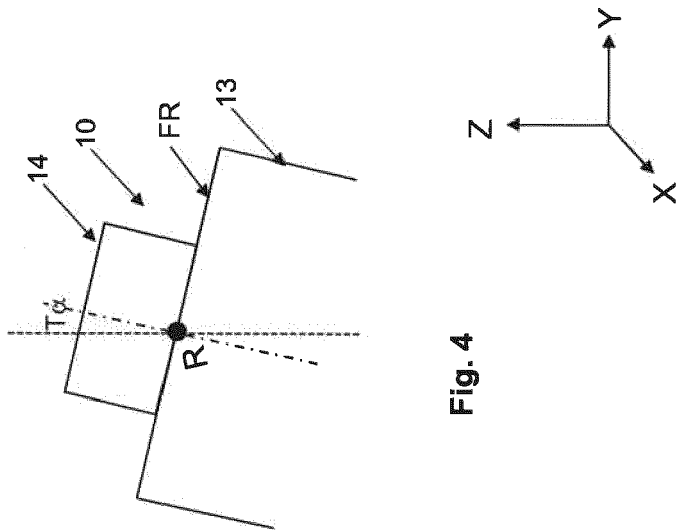


Fig. 4

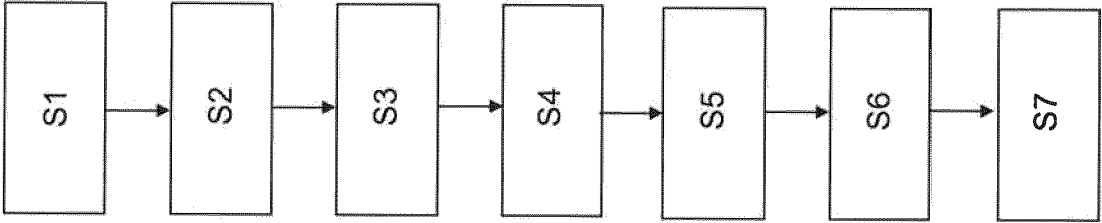


Fig. 8

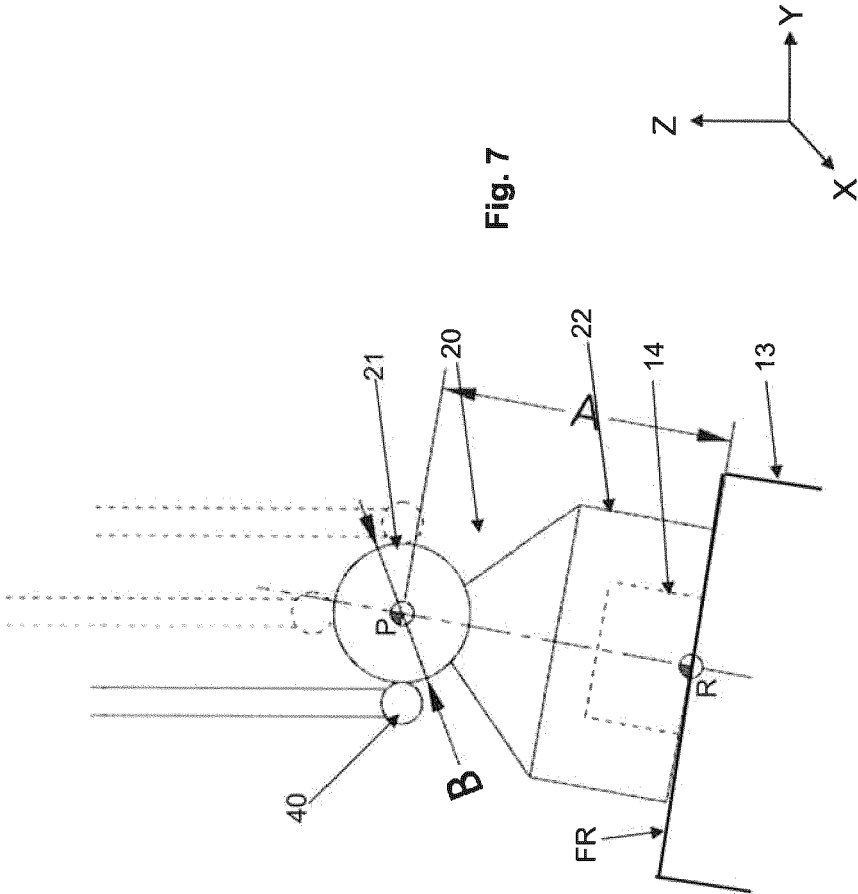


Fig. 7



EUROPEAN SEARCH REPORT

Application Number

EP 23 18 4455

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP H05 23970 A (TOSHIBA MACHINE CO LTD) 2 February 1993 (1993-02-02) * figures 1,5,7,8 *	10,12	INV. B24B53/04 B24B53/053 G01B21/22
A	-----	1-9,11	
X	GB 2 146 927 A (HAUNI WERKE KOERBER & CO KG) 1 May 1985 (1985-05-01) * page 4, line 42 - line 93; figures 2,5A,5B *	10,12	
X	GB 2 026 360 A (HAUNI WERKE KOERBER & CO KG) 6 February 1980 (1980-02-06) * figures 1,3 *	10,12	
A	EP 3 327 524 A1 (MIKRON AGIE CHARMILLES AG [CH]) 30 May 2018 (2018-05-30) * figures 1-5 *	1-12	
A	US 2009/082899 A1 (DU XIAOMING [CN] ET AL) 26 March 2009 (2009-03-26) * figures 6-10 *	1-12	TECHNICAL FIELDS SEARCHED (IPC) B24B G01B G05B
A	US 2008/114485 A1 (KATOH KOUICHI [JP] ET AL) 15 May 2008 (2008-05-15) * paragraphs [0002], [0042] - [0047]; figures 1,5-9 *	1-12	
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 16 November 2023	Examiner Kornmeier, Martin
CATEGORY OF CITED DOCUMENTS		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	
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			

EPO FORM 1503 03.82 (P04C01)

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

EP 23 18 4455

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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16-11-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP H0523970	A	02-02-1993	NONE
GB 2146927	A	01-05-1985	CH
		663923 A5	29-01-1988
		FR	2552359 A1
			29-03-1985
		GB	2146927 A
			01-05-1985
		IT	1175752 B
			15-07-1987
		JP	S6085866 A
			15-05-1985
		US	4607607 A
			26-08-1986
GB 2026360	A	06-02-1980	CH
			641994 A5
			30-03-1984
		DE	2833625 A1
			28-02-1980
		DK	314679 A
			01-02-1980
		FR	2432362 A1
			29-02-1980
		GB	2026360 A
			06-02-1980
		IT	1165274 B
			22-04-1987
		JP	S55112768 A
			30-08-1980
		US	4406275 A
			27-09-1983
EP 3327524	A1	30-05-2018	CN
			108121294 A
			05-06-2018
		EP	3327524 A1
			30-05-2018
		JP	7206037 B2
			17-01-2023
		JP	2018088250 A
			07-06-2018
		US	2018150049 A1
			31-05-2018
US 2009082899	A1	26-03-2009	NONE
US 2008114485	A1	15-05-2008	CN
			101221425 A
			16-07-2008
		JP	4902316 B2
			21-03-2012
		JP	2008119784 A
			29-05-2008
		US	2008114485 A1
			15-05-2008
		US	2011093115 A1
			21-04-2011