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(71) Applicant: **TACCHELLA MACCHINE S.p.A.**
I-15011 Acqui Terme (IT)

(72) Inventor: **Tacchella, Claudio**
15011 Acqui Terme (IT)

(74) Representative: **Bongiovanni, Simone et al**
Studio Torta S.r.l
Via Viotti 9
I-10121 Torino (IT)

(54) Vertical-axis grinding machine

(57) A grinding machine having a workpiece support and rotation device (3) for supporting and rotating a workpiece (4) for grinding about a vertical first axis B; and at least one grinding head (6) having at least one rotary grinding wheel (7; 7a, 7b, 7c) movable to and from the workpiece to remove surface portions of and so grind the workpiece (4).

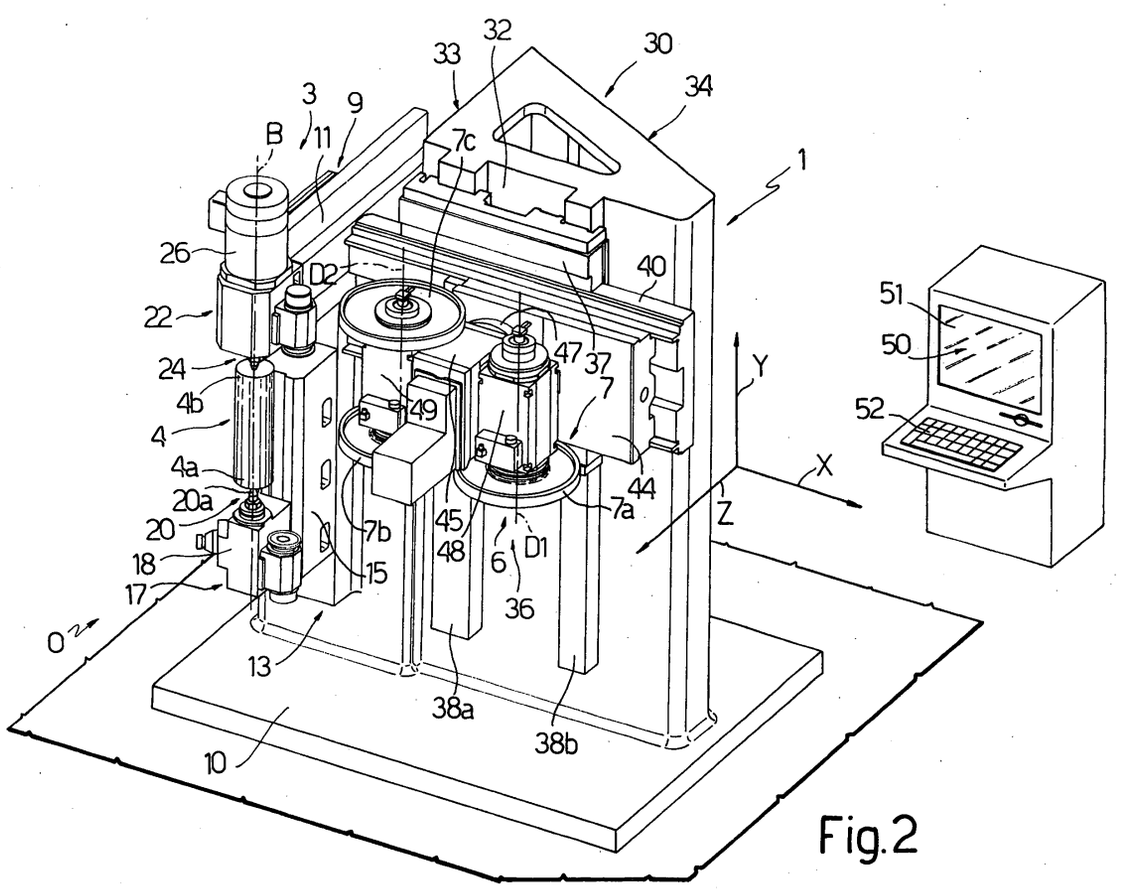


Fig.2

EP 1 371 448 A1

Description

[0001] The present invention relates to a vertical-axis grinding machine.

[0002] Grinding machines are known (as shown in Figure 1) which comprise a workpiece support and rotation device for supporting and rotating a workpiece (shown by the dash line) about a horizontal axis (axis C); and at least one grinding head having at least one rotary wheel movable to and from the workpiece to remove surface portions of the workpiece rotating about horizontal axis C. The grinding head is movable reversibly to and from the workpiece along a horizontal axis (axis X) perpendicular to axis C, and reversibly along a horizontal axis Z parallel to axis C to machine different axial portions of the workpiece. The head also rotates about a vertical axis B to adjust the tilt angle of the wheel with respect to axis C and the workpiece; and the reference system is completed by a vertical axis Y perpendicular to horizontal axes X and Z.

[0003] Grinding machines of the above type, which have been known for decades, have various drawbacks, foremost of which include:

1. Considerable size horizontally.
2. A non-modular structure, so that the machine cannot be altered easily to accommodate additional accessory parts, such as additional heads.
3. Known grinding machines are designed solely for grinding, and are totally unsuitable for other machining operations, such as turning or milling.
4. Chip removal is unsatisfactory. More specifically, the chips collect at the bottom of the machine, beneath the workpiece, and may interfere with and/or damage the head actuating and/or control members.
5. Considerable size, weight and cost, by being mounted on an extremely rigid bed.
6. Known grinding machines employ one or more wheels positioned substantially facing the operator. So, to avoid injury in the event of the wheel exploding, the wheel must be shielded by a metal C-section casing, and an additional unbreakable transparent shield is also interposed between the grinding head and the operator. Though such devices provide for a fairly good degree of safety, demand nevertheless exists for further improvement.

[0004] It is an object of the present invention to provide a grinding machine designed to eliminate the drawbacks of known grinding machines.

[0005] According to the present invention, there is provided a grinding machine comprising a workpiece support and rotation device for supporting and rotating a workpiece for grinding about a first axis; and at least one grinding head having at least one rotary grinding wheel movable to and from the workpiece to remove surface portions of and so grind the workpiece;

characterized in that said workpiece support and rotation device defines a substantially vertical first axis.

[0006] A preferred, non-limiting embodiment of the invention will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows a view in perspective of a known grinding machine;
Figure 2 shows a view in perspective of a grinding machine in accordance with the teachings of the present invention;
Figure 3 shows a view in perspective of a first variation of the Figure 2 machine;
Figure 4 shows a front view of a second variation of the Figure 2 machine.

[0007] Number 1 in Figure 2 indicates as a whole a vertical-axis grinding machine in accordance with the teachings of the present invention.

[0008] More specifically, grinding machine 1 comprises a workpiece support and rotation device 3 for supporting and rotating a workpiece 4 for grinding about a first axis B; and at least one grinding head 6 having at least one rotary grinding wheel 7 movable to and from workpiece 4 to remove surface portions of and so grind workpiece 4.

[0009] According to the present invention, workpiece support and rotation device 3 defines a vertical or substantially vertical first axis B, i.e. sloping by only a few (e.g. 1-10) degrees with respect to the vertical.

[0010] More specifically, workpiece support and rotation device 3 comprises a vertical supporting structure 9 having a bottom end fixed firmly to a flat rectangular base 10, and a top end from which projects a horizontal supporting structure 11 perpendicular to vertical supporting structure 9.

[0011] Vertical supporting structure 9 is bounded at the front by a flat rectangular wall 13, along which extends a straight vertical guide 15 fixed firmly to vertical supporting structure 9.

[0012] A bottom slide 17 can be set to a predetermined number of stable positions along straight vertical guide 15.

[0013] Slide 17 is fitted with a parallelepiped-shaped body 18, which houses an elastic supporting device (not shown in detail) for supporting a centre 20 extending outside body 18, upwards towards structure 11, and coaxially with axis B.

[0014] The elastic supporting device can be set to two operating positions: a full-lock position, in which centre 20 is connected rigidly to body 18 and performs no movement along vertical axis B; and a second workpiece-support position, in which centre 20 is connected to an elastic member (not shown) housed inside body 18 and permitting a limited amount of movement (a few millimetres) of centre 20 along axis B and in opposition to the elastic member.

[0015] Centre 20 is made of metal (e.g. high-tensile

steel), terminates with a conical end 20a, and engages a bottom end 4a of workpiece 4, with the end portion of conical end 20a inserted inside a conical locating hole (not shown) formed in an end wall of workpiece 4 and coaxial with axis B.

[0016] Horizontal supporting structure 11 carries a substantially parallelepiped-shaped body 22 facing parallelepiped-shaped body 18 and supporting a known spindle 24 coaxial with axis B and which engages in known manner a top end portion 4b of workpiece 4. Parallelepiped-shaped body 22 also carries an electric motor 26 extending upwards and for rotating spindle 24 via a transmission (not shown) housed in body 22.

[0017] Grinding head 6 is carried by a guide and support structure 30 allowing head 6 a number of translation/rotation movements, including:

a linear translation movement in opposite directions along a vertical axis Y parallel to vertical axis B;
a linear translation movement in opposite directions along a horizontal axis X perpendicular to axis Y;
an angular rotation movement in opposite angular directions about an axis Z perpendicular to the plane containing axes X and Y.

[0018] More specifically, guide and support structure 30 comprises a vertical column member having a right-triangular cross section and defined by a first front rectangular wall 32 alongside and substantially coplanar with wall 13, a second lateral rectangular wall 33 perpendicular to the first wall, and a rear rectangular wall 34.

[0019] First rectangular wall 32 carries a first straight vertical guide 36, along which a first slide 37 travels along vertical axis Y. More specifically, guide 36 is defined by two spaced, parallel rails 38a, 38b extending along a central portion of front rectangular wall 32. Slide 37 is roughly parallelepiped-shaped, has two seats facing front wall 32 and housing respective rails 38a, 38b, and is moved along guide 36 by known actuating means (e.g. electric motors). First slide 37 carries a second straight guide 40 aligned with axis X and supporting a second slide 44, which is movable linearly and reversibly along second guide 40 by known actuating means (not shown). Head 6 comprises a central parallelepiped-shaped body 45 connected to a central portion of second slide 44 by an articulated joint 47 enabling central parallelepiped-shaped body 45 to move about axis Z, which is also perpendicular to second slide 44, thus forming an axis of rotation C rotating about axis Z. On a first side, central body 45 carries a first lateral parallelepiped-shaped body 48 housing the electric motor and transmission (not shown) for driving a first disk wheel 7a rotating about an axis D1 perpendicular to axis Z; and, on a second side, central body 45 carries a second lateral parallelepiped-shaped body 49 housing the electric motors and transmissions (not shown) for driving a second disk wheel 7b and a third disk wheel 7c located at opposite ends of second body 49 and both rotating about an axis D2 perpendicular to axis Z and parallel to axis D1.

[0020] In actual use, to perform a machining cycle on workpiece 4, the workpiece is placed (e.g. by means of a pickup and conveying device having a robotized arm - not shown) with bottom end 4a resting on centre 20, so that conical end 20a engages the locating hole in workpiece 4. The position of workpiece 4 is adjusted so that the axis of workpiece 4 is coincident with axis B of machine 1; spindle 24 is then connected to the top end 4b of workpiece 4 in known manner not shown; and the pickup and conveying device (not shown) releases workpiece 4 and is withdrawn so that grinding of workpiece 4 can commence.

[0021] For which purpose, an electronic control unit starts electric motor 26 to rotate workpiece 4 about axis B. At the same time or successively, the electronic unit of machine 1 also starts the electric motors controlling rotation of one or more of wheels 7a, 7b and 7c, and operates the actuators governing reversible linear movement of first slide 37 and second slide 44, and rotation of head 6 about axis Z. Head 6 can thus move and approach workpiece 4 so that at least one of wheels 7a, 7b and 7c contacts the surface of workpiece 4 to remove material and so grind workpiece 4. More specifically, the movement of slide 37 along axis Y provides for positioning the wheel at different heights and so machining different axial portions of workpiece 4; the movement of slide 44 along axis X provides for moving the wheel towards or away from the workpiece; and rotation of the head about axis Z provides for tilting the wheel plane with respect to the axis of workpiece 4, thus enabling a complete grinding cycle of the workpiece.

[0022] The advantages of the machine according to the present invention will be clear from the foregoing description.

1. Grinding machine 1 described above is horizontally compact by extending mainly vertically.
2. Grinding machine 1 according to the present invention has a modular structure, by grinding head 6 being located on a first side of workpiece support and rotation device 3. A further grinding head 6 (shown in Figure 3) can therefore be located on a second side of support and rotation device 3 to modify machine 1 easily by the addition of accessory components.
3. A head for performing other than grinding operations, e.g. turning, milling or drilling, may also be located on a second side of support and rotation device 3.
4. The chips produced by wheels 7 machining workpiece 4 drop into an area (rectangular base 10) containing no mechanical members, and therefore do not damage the machine; and a chip-removing device may even be provided for optimum chip disposal.

5. Being longitudinally small, machine 1 is mounted on a base 10 which need not be particularly rigid.
6. Wheels 7 being located alongside the rotating workpiece 4, the operator facing the workpiece (position 0 in Figure 2) is not positioned facing the wheels, thus improving operator safety in the event of a wheel exploding.

[0023] The Figure 2 machine can be controlled by an electronic unit 50 comprising a video terminal 51 and a keyboard 52, and for controlling rotation of workpiece 4 by electric motor 26, and the movement along axes X and Y and rotation about axis Z of head 6.

[0024] The electronic unit reads a number of coded instructions controlling a sequence of workpiece and head movements with respect to the above machine axes to perform a complete machining cycle. If the coded instructions are designed for a conventional machine (i. e. of the type in Figure 1), electronic unit 50 may comprise a translating circuit (software or hardware) for converting conventional grinding machine control data into machine 1 data by translating the reference systems of the two machines, whereby:

- axis Z of the conventional machine is converted to axis Y;
- axis X of the conventional machine is converted to axis X;
- axis C of the conventional machine is converted to axis B;
- axis B of the conventional machine is converted to axis C.

[0025] Clearly, changes may be made to the grinding machine as described and illustrated herein without, however, departing from the scope of the present invention.

[0026] Figure 3 shows a variation 1a of the Figure 2 machine, which comprises a workpiece support and rotation device 3 of the type described above; a grinding head 6 located on a first (right) side of workpiece support and rotation device 3, and having the structure described above; and an auxiliary grinding head 6a located on a second (left) side of workpiece support and rotation device 3.

[0027] Auxiliary grinding head 6a is carried by a guide and support structure 30a located on a second side of workpiece support and rotation device 3, and having a specular structure with respect to guide and support structure 30 described above.

[0028] Auxiliary head 6a is thus movable along a horizontal axis X1 parallel to axis X, along a vertical axis Y1 parallel to axis Y and perpendicular to axis X1, and along an axis Z1 parallel to axis Z and perpendicular to the plane containing axes X1 and Y1.

[0029] Grinding machine 1a may perform grinding operations using only one of heads 6, 6a; or both heads 6, 6a may simultaneously machine axially spaced portions of workpiece 4.

[0030] Figure 4 shows, schematically, a further variation 1b of the Figure 2 grinding machine. Machine 1b comprises a workpiece support and rotation device substantially similar to device 3, and for rotating workpiece 4 about a vertical axis B.

[0031] Grinding machine 1b comprises a number of heads 6, 6a, 6b, 6c (four in the example shown, but which may obviously differ in number) located on a first and second side of device 3. Preferably, a first number of heads (two heads 6 and 6a in the example shown) are carried by the same guide and support structure 30 on a first side of device 3, and a second number of heads (two heads 6b and 6c in the example shown) are carried by the same guide and support structure 30a on a second side of device 3. Heads 6, 6a, 6b, 6c are movable along respective horizontal axes X, X1, X2, X3 to and from workpiece 4, are movable along respective vertical axes Y, Y1, Y2, Y3 to machine different axial portions of workpiece 4, and each head 6, 6a, 6b, 6c can also rotate about a respective axis Z, Z1, Z2, Z3 perpendicular to the respective pair of axes X,Y, X1,Y1, X2,Y2, X3,Y3. In variation 1b, at least one of heads 6, 6a, 6b, 6c has at least one grinding wheel 7; and at least one of heads 6, 6a, 6b, 6c has tools 52 for performing other than grinding operations, e.g. milling and/or turning and/or drilling.

Claims

1. A grinding machine comprising a workpiece support and rotation device (3) for supporting and rotating a workpiece (4) for grinding about a first axis B; and at least one grinding head (6) having at least one rotary grinding wheel (7; 7a, 7b, 7c) movable to and from the workpiece to remove surface portions of and so grind the workpiece (4);

   characterized in that said workpiece support and rotation device (3) defines a substantially vertical first axis B.

2. A machine as claimed in Claim 1, wherein said workpiece support and rotation device (3) comprises a vertical supporting structure (9); a centre (20), which is carried by said vertical supporting structure (9), is coaxial with said vertical first axis B, and engages a first end of said workpiece (4); and a spindle (24), which is carried by said vertical supporting structure (9), is coaxial with said vertical first axis B, and engages a second end of said workpiece (4).

3. A machine as claimed in Claim 2, wherein said centre (20) is located below said spindle (24).

4. A machine as claimed in Claim 2 or 3, wherein said centre (20) is connected to an elastic supporting device which can be set to two operating positions: a first full-lock position, in which said centre (20) is

connected rigidly to said vertical supporting structure (9) and performs no movement along the vertical first axis B; and a second workpiece-support position, in which said centre (20) is connected to an elastic member to allow a limited amount of movement of said centre (20) along said vertical first axis B.

5. A machine as claimed in Claim 2, 3 or 4, wherein said vertical supporting structure comprises a straight vertical guide (15), and a slide (17) supporting said centre (20); said slide (17) being positionable in a predetermined number of stable positions along said straight vertical guide (15).

6. A machine as claimed in any one of the foregoing Claims, wherein a guide and support structure (30) allows said grinding head (6) a number of translation/rotation movements, including:

- a linear translation movement in opposite directions along a vertical axis Y parallel to said vertical first axis B;
- a linear translation movement in opposite directions along a horizontal axis X perpendicular to said vertical axis Y;
- an angular rotation movement in opposite angular directions about an axis Z perpendicular to the plane containing said horizontal and vertical axes X and Y.

7. A machine as claimed in Claim 6, wherein said guide and support structure (30) comprises:

- a vertical member supporting a first straight guide (36), and a first slide (37) movable reversibly by drive means along said first straight guide (36) and said vertical axis Y;
- a second straight guide (40) carried by said first slide (37), and a second slide (44) movable by drive means along said second straight guide (40) and said horizontal axis X; said grinding head (6) being carried by said second slide (44), and being movable angularly with respect to said second slide (44) about said axis Z.

8. A machine as claimed in Claim 6 or 7, wherein said grinding head comprises at least one grinding wheel (7a, 7b, 7c) movable angularly about an axis of rotation (D1, D2) crosswise to said axis Z.

9. A machine as claimed in Claim 8, wherein said grinding head comprises at least a first grinding wheel (7a) and at least a second grinding wheel (7b, 7c), which are movable angularly about respective first and second axes of rotation (D1, D2) spaced apart, crosswise to said axis Z, and located on opposite sides of said axis Z.

10. A machine as claimed in any one of the foregoing Claims, wherein said grinding head (6) is located on a first side of said workpiece support and rotation device (3); an auxiliary grinding head (6a) being located on a second side of said workpiece support and rotation device (3).

11. A machine as claimed in Claim 10, wherein an auxiliary guide and support structure (30a) allows said auxiliary grinding head (6a) a number of translation/rotation movements, including:

- a linear translation movement in opposite directions along a vertical axis Y1 parallel to said vertical first axis B;
- a linear translation movement in opposite directions along a horizontal axis X1 perpendicular to said vertical axis Y1;
- an angular rotation movement in opposite angular directions about an axis Z1 perpendicular to the plane containing said horizontal and vertical axes X1 and Y1.

12. A machine as claimed in any one of the foregoing Claims, wherein at least one auxiliary head (6a, 6b, 6c) performs on said workpiece machining operations other than grinding operations, and in particular milling and/or turning and/or drilling operations.

13. A machine as claimed in Claim 12, wherein a guide and support structure (30, 30a) allows said auxiliary head (6a, 6b, 6c) a number of translation/rotation movements, including:

- a linear translation movement in opposite directions along a vertical axis (Y1, Y2, Y3) parallel to said vertical first axis B;
- a linear translation movement in opposite directions along a horizontal axis (X1, X2, X3) perpendicular to said vertical axis (Y1, Y2, Y3);
- an angular rotation movement in opposite angular directions about an axis (Z1, Z2, Z3) perpendicular to the plane containing said vertical and horizontal axes.

14. A machine as claimed in any one of the foregoing Claims, wherein a guide and support structure (30) allows said grinding head (6) a number of translation/rotation movements, including:

- a linear translation movement in opposite directions along a vertical axis Y parallel to said vertical first axis B;
- a linear translation movement in opposite directions along a horizontal axis X perpendicular to said vertical axis Y;
- an angular rotation movement in opposite angular directions about an axis Z perpendicular

to the plane containing said horizontal and vertical axes X and Y;

said machine comprising a translating circuit for converting the data controlling a known grinding machine into new data usable by said machine (1), by translating the reference systems of the two machines, whereby:

- axis Z of the known machine is converted to said vertical axis Y;
- axis X of the known machine is converted to said horizontal axis X;
- axis C of the known machine is converted to said vertical first axis B;
- axis B of the known machine is converted to axis C.

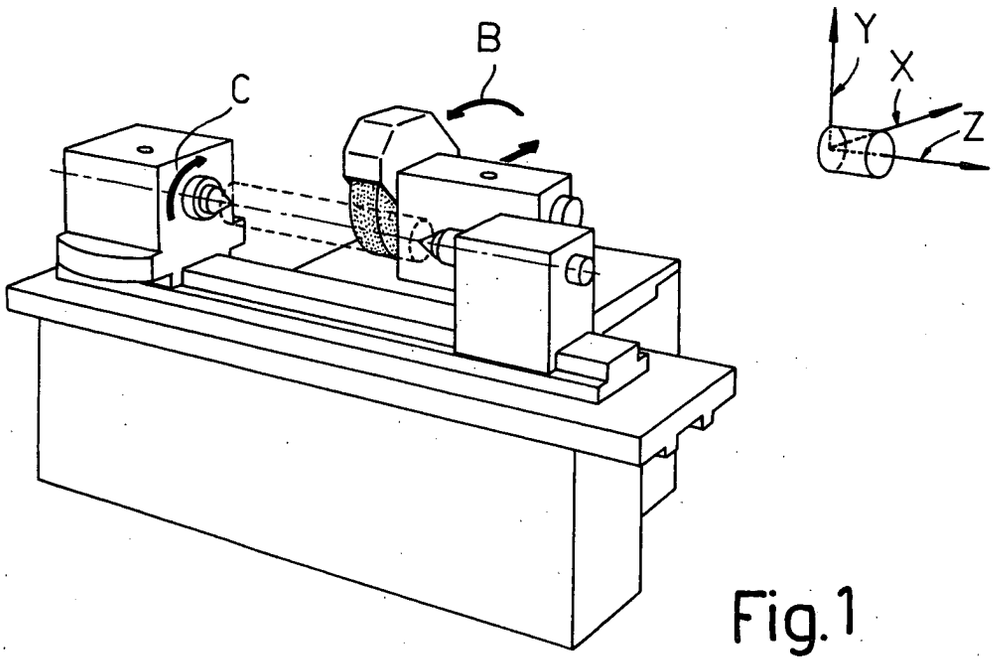
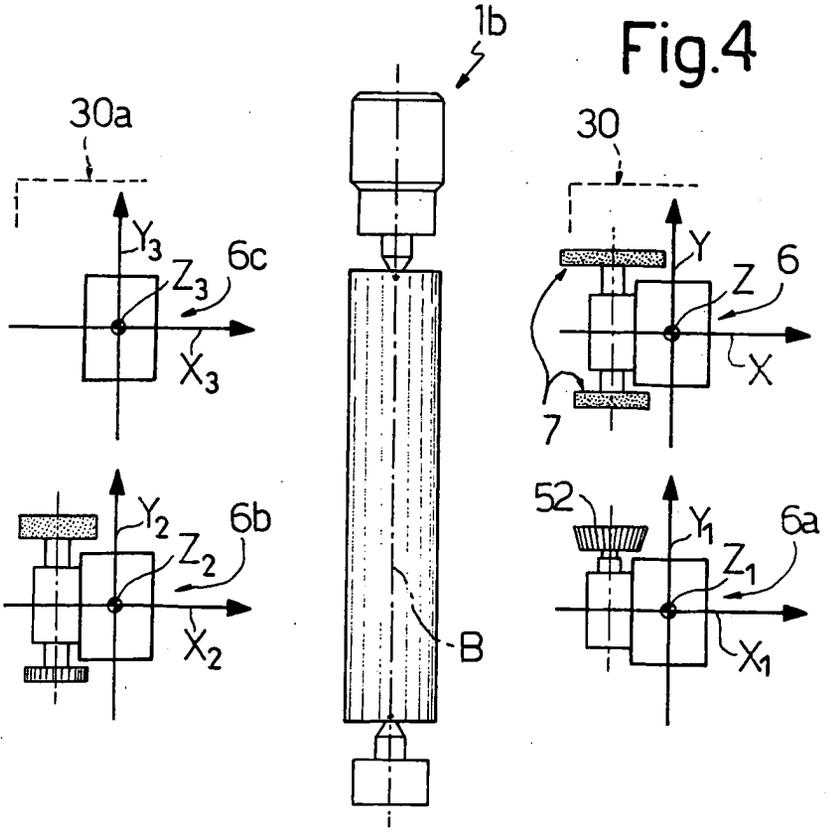


Fig.1

Fig.4



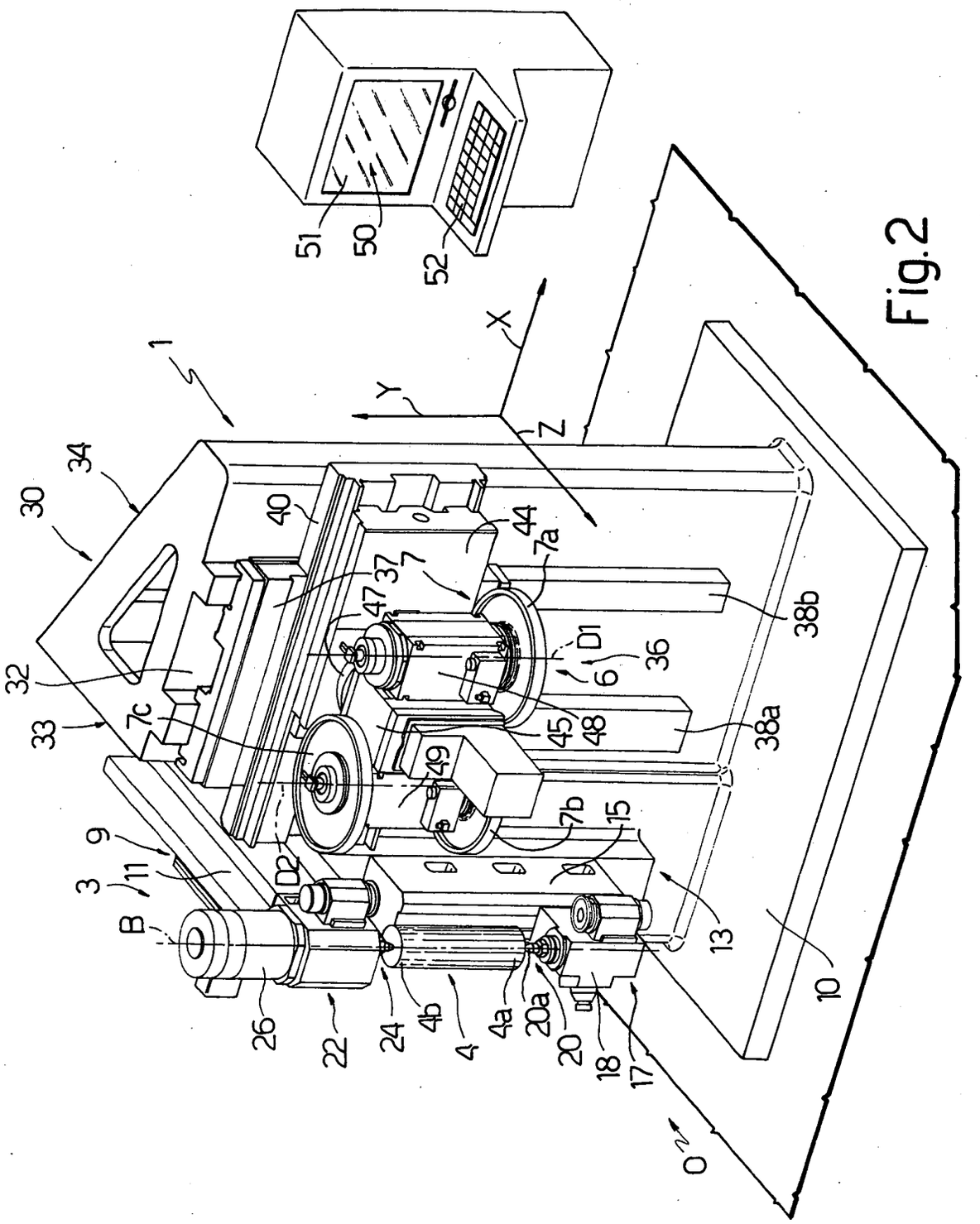

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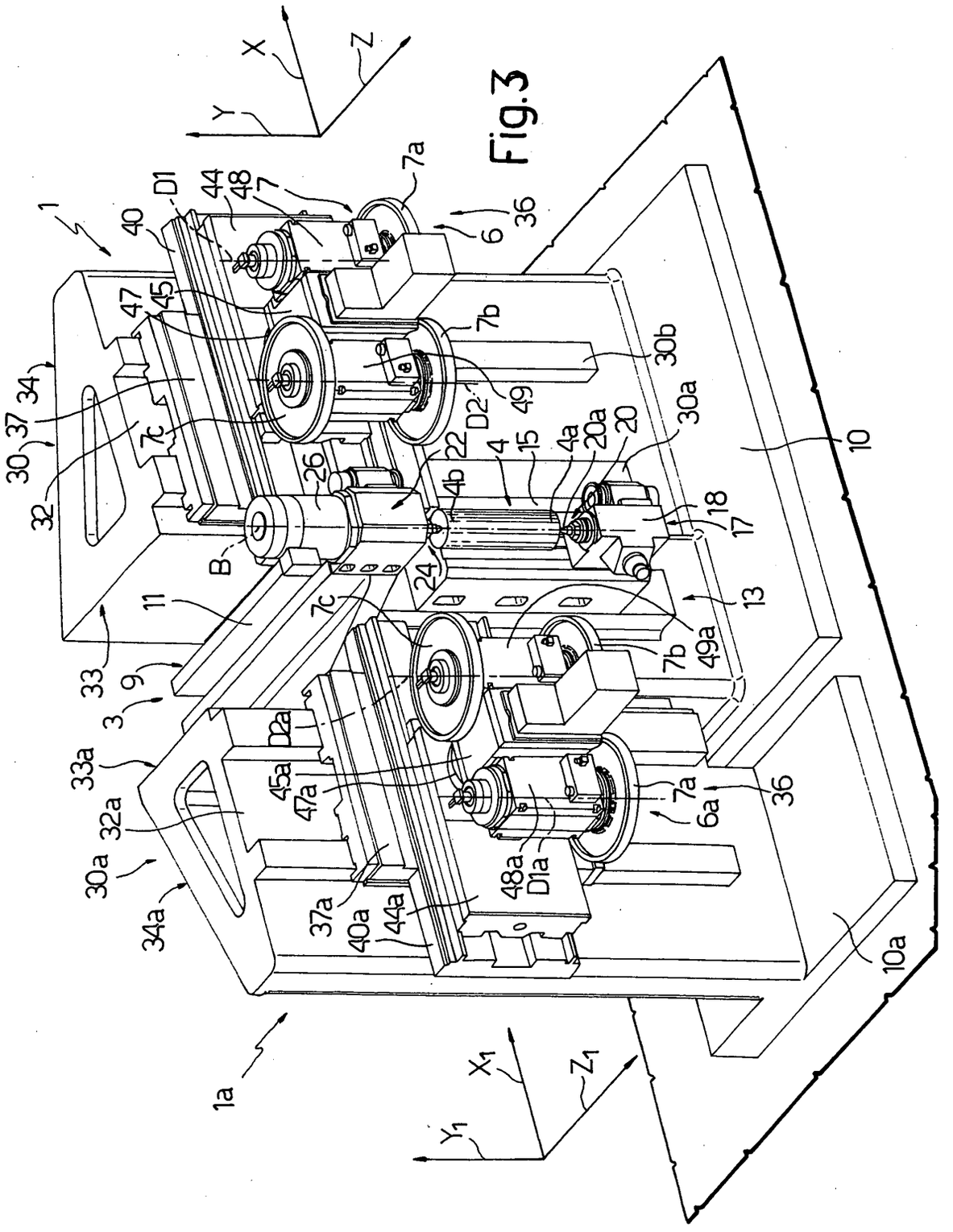
Fig.2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D1a
6a
10a
1a
X1
Z1
Y1

Fig.3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 01 3283

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	GB 544 213 A (NAT BROACH & MACH) 1 April 1942 (1942-04-01) * page 1, line 64 - page 2, line 50; figures 1,2 * -----	1-3,5-11	B24B5/04 B24B41/04

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

B24B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23 September 2003	Garella, M

CATEGORY OF CITED DOCUMENTS

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 544213 A	01-04-1942	NONE	

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