(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 025 464 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
18.02.2009 Bulletin 2009/08

(51) Int Cl.:
B24B 13/01 *(2006.01)* ***B23C 3/16*** *(2006.01)*

(21) Application number: **07425525.8**

(22) Date of filing: **10.08.2007**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC MT NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK RS

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Remarks:
A request for correction of the description and claims has been filed pursuant to Article 14(2) EPC. A decision on the request will be taken during the proceedings before the Examining Division (Guidelines for Examination in the EPO, A-V, 3.).

(54) Sander / polishing head

(57) The present invention concerns a machining head (1) for sanding and/or polishing flat and/or curved surfaces (S) with constant or variable curvature. The machining head comprises a main body (2) which can be connected to a machine tool, preferably a numerical control machine with six axes, and a plurality of abrasive elements (3) designed to interact with the surfaces (S) to be machined, supported at the lower portion of the main body (2) and which can move along a first vertical direction (Y). Advantageously, the abrasive elements (3) are aligned along a second horizontal direction (Z) and are translated along the second direction (Z) by actuation means. The invention furthermore concerns a process for operation of the machining head (1).

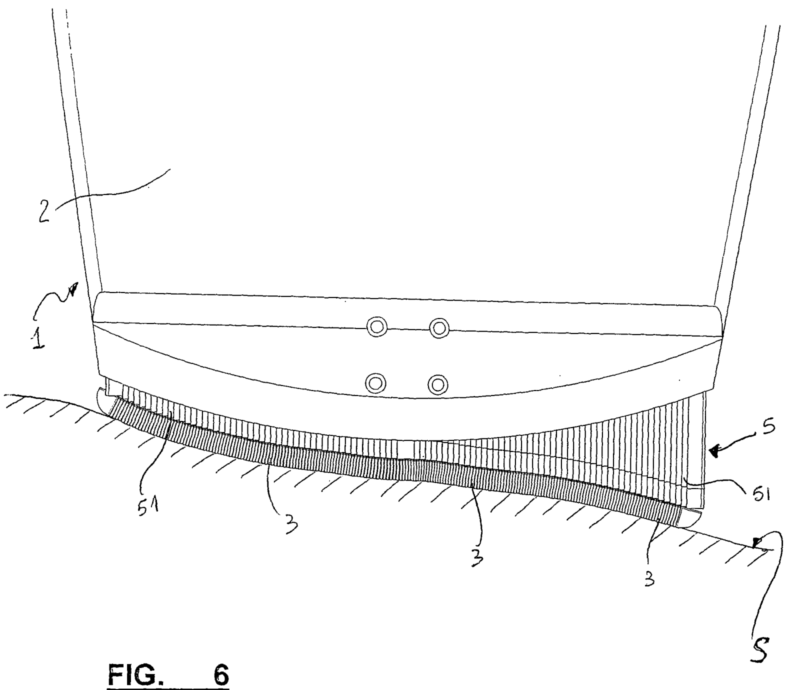

FIG. 6

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Description

[0001] The present invention concerns a machining head for machine tools for the sanding and polishing of surfaces; in particular it concerns a sander and/or polisher head for machining curved surfaces.

[0002] Machine tools for polishing and/or sanding flat surfaces, for example vertical or horizontal, have been available on the market for some time now. In general, said machines are provided with means for moving machining heads designed to interact with the surface to be polished/sanded. The heads are provided with one or more abrasive elements which slide over the surface being machined.

[0003] Normally the machining heads are circular and are rotated around their axis. The machine tools move the machining head on the surface to be sanded, according to the required path. All the sanding and/or polishing phases can be performed with automatic machine tools, for example numerical control machines, with obvious positive effects in terms of machining speed, process quality and throughput.

[0004] The current machine tools do not permit fully automated sanding and/or polishing of curved surfaces. In other words, the automatic machine tools available on the market are not as effective in machining curved surfaces as they are in machining flat surfaces. In general the sanding and polishing of curved surfaces is still performed by skilled workers by means of manual tools such as orbital sanding machines, hand sanders, abrasive paper, etc..

[0005] By way of example, polishing and/or sanding of curved fibreglass components, intended for the construction of hulls of vessels, is performed manually by skilled workers by means of circular or orbital sanders, with abrasive paste or abrasive paper. Polishing of curved metal sheets, for example for vehicle bodywork or for use in the building trade for the construction of curved panels, is also performed manually.

[0006] In addition to being costly, the manual operations do not permit high production levels and do not guarantee a constant quality level in the long term, i.e. the quality of the manual work depends heavily on the skill and experience of the operator.

[0007] Some technical solutions have been proposed which aim to automate the polishing and sanding of curved surfaces, but with poor results in terms of versatility.

[0008] JP 10151557 describes a machining head for machines for the sanding and polishing of curved surfaces, for example made of vitreous material. The machining head comprises a drive shaft, for transmission of the rotary movement, to which a convex supporting plate is joined having a constant radius of curvature. The lower surface of the supporting plate is coated in a layer of deformable material to which a plurality of abrasive cylindrical elements are connected. When the machining head is operating, the base of each cylindrical element slides over the curved surface to be sanded or polished. The layer of deformable material permits small movements of each cylindrical element along its axis. The disadvantage is that the curvature of the surface to be machined and the curvature of the machining head must necessarily correspond, so that all the abrasive cylindrical elements interact with the surface being machined and remain substantially perpendicular to the surface during machining.

[0009] JP 9066469 describes a machining head for curved surfaces which, with respect to the solution of JP 10151557, permits the treatment of surfaces having different and/or variable curvatures on different parts of the same surface. The head comprises a drive shaft, for transmission of the rotary movement, to which a hollow supporting element is connected. Abrasive elements are connected to the lower wall of the hollow supporting element, in particular they run, each along their axis, in holes purposely obtained in the bottom wall of the supporting element. The hollow supporting element can be filled with a liquid which exerts a hydrostatic pressure on the upper surface of the abrasive elements. When the machining head is used to polish or sand a curved surface, the pressure exerted on each abrasive element by the liquid contained in the supporting element balances the force exerted by the curved surface on said abrasive element. The result is that the abrasive elements move in their respective seats, positioning themselves at a height corresponding to the curvature of the surface being machined at a given point. In other words, the movement of each abrasive element in its seat depends on the balance created between the pressure exerted by the fluid and the force exerted by the surface being machined. This solution has proved to be relatively ineffective, since the abrasive elements move slowly in their respective seats, limiting the machining speed. A further drawback of the solution according to JP 9066469 is represented by the fact that the dynamics of the machining head are such that the abrasive elements, due to interaction with the surface to be machined, oscillate around the position of equilibrium, with evident disadvantages in terms of quality of the surface finish of the machined part.

[0010] The need for a machining head that permits sanding and/or polishing of curved surfaces, having a locally variable curvature, with high speeds and high quality standards has been felt for some time now.

[0011] The object of the present invention is to make available a machining head for machine tools for the sanding and polishing of flat and curved surfaces which effectively solves the problems of the traditional solutions, at the same time being highly accurate and versatile.

[0012] A further object of the present invention is to make available a machining head for sanding and/or polishing machines by means of which the configuration of the abrasive elements can be adapted, point by point, rapidly and with extreme precision, to the curvature of the surface being machined.

[0013] These and further objects are obtained by the present invention which concerns a machining head as claimed in claim 1 for machine tools for sanding and/or polishing flat and curved surfaces.

[0014] The machining head according to the present invention is used for sanding and/or polishing flat and/or curved surfaces with constant or variable curvature. Said surfaces can be made of different materials, for example metal, plastic, fibreglass, glass, wood, rock, stone, marble, resins, stucco, etc..

[0015] The machining head comprises a main body that can be connected to an external machine tool, a plurality of abrasive elements designed to interact with the surface being machined, supported at the lower portion of the main body and which can be moved along a first vertical direction. Advantageously, the abrasive elements are aligned along a second horizontal direction and the head comprises means for moving the abrasive elements along said second direction.

[0016] According to the preferred embodiment of the present invention, the main body of the machining head is designed to be connected to a machine tool with six axes (movements with six degrees of freedom), i.e. a machine able to move the head independently along six axes (three translation axes and three rotation axes), for example a CNC machine, of the type for CAD-CAM machining.

[0017] The abrasive elements are abrasive strips, for example made of metal, ceramic or other material with diamond, corundum etc. coating, arranged side by side, perpendicular to the second horizontal direction. In other words, the abrasive elements are abrasive strips positioned on top of one another, perpendicular to the second horizontal direction, to form a pack. The abrasive strips come into contact with the surface being machined, each at the relative lower end, or at the level of a portion coated with abrasive material or powders. In particular, the abrasive strips move along the second perpendicular direction and remove material from the surface being machined.

[0018] According to a first embodiment of the invention, each abrasive strip is laterally hinged in a deformable guide housed in the main body of the machining head, at the level of its lower portion. The connection between each abrasive strip and the deformable guide is such that the strips can oscillate around the relative pin, with respect to the guide, when subject to stress in the two directions along the above-mentioned second direction.

[0019] The stress acting on the abrasive elements is generated by interaction between the free lower ends of the abrasive strips and the surface to be polished and/or sanded. When the end of an abrasive strip runs on the surface to be machined along the second direction, in one of the two directions, said end removes material from the surface below. Movement of the abrasive strips is obtained by providing the machining head with appropriate means for controlling translation of all the abrasive strips along the second horizontal direction, alternately in the two ways. In other words, the machining head comprises means for moving the abrasive strips alternately along the second direction, as will be described in detail below.

[0020] Preferably, the deformable guide is made of a plurality of laminar plates stacked along the second horizontal direction and held together by at least one tie rod. The laminar plates can be made of plastic, but are preferably made of a metallic material. In this configuration the abrasive strips are connected to the main body of the machining head by interposition of the laminar plates, which are also stacked perpendicularly to the second direction. The tie rod is a metal cable which crosses each of said laminar plates and keeps them pressed against each other. The means for controlling translation of the abrasive strips comprise a drive shaft which eccentrically engages a carriage to which the guide consisting of the laminar plates is connected. In other words the translatory movement is transmitted to the abrasive strips indirectly, via a carriage, which is also housed in the main body of the machining head. The carriage can be alternately translated in a seat obtained inside the main body along the second horizontal direction. The coupling between the carriage and the drive shaft is such that the rotary movement of the shaft is converted into the reciprocating translatory movement of the carriage.

[0021] In a second embodiment of the machining head according to the present invention, the abrasive strips are directly connected to one another to form a flexible chain, or belt, housed in the main body. The chain, or belt, consisting of the abrasive strips is rotated clockwise or anticlockwise along the second horizontal direction. In other words, alternatively to the deformable guide, the machining head can be provided with a belt or chain consisting of the same abrasive strips, which slides along the second direction, in contact with the surface to be machined. Alternatively, the abrasive strips can be detached from one another but coupled to a supporting belt or chain, for example made of plastic, metal or rubber, which can be rotated clockwise/anticlockwise to translate said abrasive strips along said second direction.

[0022] In general, in both the first and second embodiment, the machining head comprises means for locally adjusting the height of the laminar plates of the deformable guide or the height of one or more portions of the belt/chain along the first vertical direction. In other words, both the deformable guide and the belt/chain can be locally height adjusted (the external deformable guide locally height-connects the belt/chain), with the effect of adapting the vertical position of the abrasive strips to the curvature of the surface being machined over which they slide.

[0023] In other words, the abrasive strips together with the deformable guide or the belt/chain form a tool for sanding/polishing flat and/or curved surfaces which is in turn deformable to adapt to the curvature of said surfaces. By adjusting the vertical position of one or more laminar plates or of one or more portions of the belt/chain, the form of the pack of abrasive strips adapts to the curvature of the surface below being machined.

[0024] The vertical position of the abrasive elements, i.e. the position of the abrasive strips, is regulated by adjustment means housed in the main body of the machining head. In particular, the means for adjustment of the height comprise a plurality of linear actuators each of which is connected to one or more laminar plates of the deformable guide or to a portion of the supporting belt/chain or of the belt/chain consisting of the abrasive strips.

[0025] In general, operation of the machining head is characterised according to claim 10.

[0026] The sanding and/or polishing of surfaces comprises the phases of:

- translating the machining head along a third horizontal direction, perpendicular to the second horizontal direction and to the first vertical direction, to move the abrasive elements, i.e. the abrasive strips, over the surface being machined;
- simultaneously controlling movement of the abrasive elements along the second horizontal direction to remove material from the surface being machined;
- adjusting the height of the abrasive elements along the first vertical direction to locally adapt the position of each abrasive element to the curvature of the surface being machined. The phase of adjusting the vertical position of the abrasive elements is in practice performed by operating the linear actuators connected to the deformable guide or to the belt/chain.

[0027] In particular, in operation of the machining head according to the first embodiment, during the relative movement between the head and the surface being machined in the third direction, an external control unit, for example that of the CNC machine tool, operates the means for adjusting the height of the abrasive elements, compensating for the local variations in curvature of the surface. In other words, while the machining head is moved by the relative machine tool over the surface to be machined, along the third direction, and the abrasive elements oscillate along the second direction due to the alternating movement of the carriage to which the deformable guide is connected, the linear actuators are operated by the control unit, continuously, to vary the vertical position of the deformable guide and, therefore, to vary the vertical position of the abrasive elements, maintaining practically constant contact pressure between each element and the surface. In this way the deformable tool consisting of the abrasive elements and the guide adapts to the form of the surface being machined, thus optimising the action of the abrasive elements and guaranteeing high quality polishing and sanding.

[0028] In operation of the machining head according to the second embodiment, simultaneously with the relative movement between the head and the surface being machined in the third direction, an external control unit, for example of the electronic type, operates the linear actuators, independently of one another, to adjust the height of the individual portions of the belt or chain, compensating for the local variations in curvature of the surface and maintaining practically constant contact pressure between each abrasive element and the surface being machined. While the machining head is moved by the relative machine tool over the surface to be machined, along the third direction, and the abrasive elements, i.e. the abrasive strips, are translated along the second direction by the rotary movement of the relative belt, or chain, the linear actuators are operated independently of one another by the control unit, continuously, to vary the vertical position of one or more portions of the same belt/chain and, therefore, to vary the vertical position of the abrasive elements. In this way the deformable belt/chain consisting of the abrasive elements adapts to the form of the surface being machined, optimising the action of the abrasive elements and guaranteeing high quality polishing and sanding.

[0029] In both the first and second embodiment of the machining head according to the present invention, the linear actuators that adjust the vertical position of the various portions of the flexible guide or belt/chain are operated by the external control unit, of the electronic type, on the basis of data stored or on the basis of a feedback control in relation to the geometry of the surface being machined or, preferably, the control unit operates the linear actuators on the basis of information, contained in an electronic file generated by a CAM system, concerning the geometry of the surface being machined. The control unit acquires from this file the information concerning the curvature of the portions of the surface being machined and controls the actuators of the machining head, independently of one another, to adjust their working range and, therefore, the position of the individual groups of abrasive strips to compensate for the height variations of the surface, due to the different curvatures between the portion being machined and the portion about to be intercepted or machined.

[0030] Due to its considerable versatility, the machining head according to the present invention permits extremely effective polishing and/or sanding of flat and/or curved surfaces, also with curvatures varying locally between the various portions of the same surface. Furthermore, by providing the deformable tool, i.e. the guide or the belt/chain with the abrasive strips, with a V profile, it is possible to effectively sand and/or polish also the corners or edges of the surfaces being machined. The machining head is therefore particularly suited to treating large curved surfaces such as, for example, the outer surfaces of hulls of vessels, or the outer surfaces of vehicles, etc.

[0031] Further aspects and advantages of the present invention will become clearer from the following description, provided for illustrative non-limiting purposes with reference to the accompanying schematic drawings, in which:

- figure 1 is a lateral view of a first embodiment of the machining head according to the present invention, in a first configuration;
- figure 2 is an overhead view of the machining head shown in figure 1;
- figure 3 is a front view of the machining head shown in figure 1;
- figure 4 is an A-A longitudinal section view of the machining head shown in figure 2;
- figure 5 is a B-B cross section view of the machining head shown in figure 3;
- figure 6 is an enlarged front view of the machining head shown in figure 1, in a second configuration;
- figure 7 is a diagram of a detail of a second embodiment of the machining head according to the present invention;
- figure 8 is a schematic view of the detail shown in figure 7.

[0032] Figure 1 shows a machining head **1** according to the present invention, which can be combined with machine tools for polishing and/or sanding of surfaces, both flat and curved. The machining head **1** comprises a main body **2** for coupling with an external machine tool, for example by means of a tang **21.**

[0033] The machining head **1** is provided with a plurality of abrasive elements **3** designed to come into contact with the surface to be machined. In general, the abrasive elements **3** are provided in the lower portion of the main body **2.**

[0034] The function of each abrasive element **3** is to remove material from the surface being machined to obtain polishing or sanding. Figure 1 is a lateral view of the machining head **1,** therefore only one abrasive element **3** is visible.

[0035] Figure 2 illustrates the machining head from above, showing the portion **21** engaging with the machine tool and a drive shaft **4.**

[0036] The machining head **1** is designed to be moved over a surface **S** along a direction/path **X** (in one of the two ways) which for the sake of simplicity will be defined horizontal, but which is substantially parallel to the surface **S.**

[0037] The abrasive elements **3** are height-adjustable, i.e. the position of the abrasive elements **3** can be adjusted along a first vertical direction **Y,** indicated in figure 1. Preferably the first vertical direction **Y** is perpendicular to the horizontal direction **X.**

[0038] Figure 3 shows a front view of the machining head **1,** in a first configuration in which the abrasive elements **3** are positioned at the same height with respect to the vertical **Y.** This configuration is suitable for machining of the flat surface **S.** The abrasive elements **3** have, in general, an elongated form and when the machining head **1** is operative, they remain in contact with the surface **S,** each at its lower end.

[0039] As shown in figures 1 and 3, the abrasive elements **3** are aligned along a second horizontal direction **Z.** Preferably the abrasive elements **3** are laminar elements made of metal, or ceramic or even plastic, coated in abrasive material, for example diamond or corundum powder. The abrasive strips **3** are stacked in the second horizontal direction **Z,** to form a pack of abrasive elements.

[0040] Figure 3 shows a front view of the machining head **1.** The upper portion (or tang) **21** for connection to an external machine tool, preferably CNC, more preferably of the CAD/CAM type, the main body **2** and the abrasive elements **3** in contact with a flat surface **S** are visible. The abrasive strips **3** are stacked in direction **Z,** i.e. aligned one on top of the other with respect to the second horizontal direction **Z.** In general, in the present invention the abrasive strips **3** are height-adjustable, i.e. the position of the strips along the vertical direction **Y** can be adjusted within a certain interval to compensate for any variations in curvature of the surface **S.** The position of each abrasive strip **3** can be adjusted in the vertical direction **Y,** but preferably the configuration of the strips **3** is modified by varying the vertical position of separate groups of strips **3.**

[0041] In the first embodiment of the head **1,** shown in figures 1-6, the abrasive strips **3** are connected to the main body **2** of the machining head by interposition of a deformable guide **5.** The guide **5** develops substantially in direction **Z** and is at least partly housed in the main body **2** of the head 1.

[0042] Figures 4 and 5 show respectively a longitudinal section, i.e. along the line **A-A** of figure 2, and a transverse section, i.e. along the line **B-B** of figure 3, of the machining head **1.** The "pack" of abrasive strips **3** can be seen supported by the guide **5,** which protrudes partially beyond the lower edge of the main body **2** of the head **1.** The guide 5 in turn consists of a plurality of laminar plates **51** stacked in direction **Z** to form another "pack". The plates **51** are held together by at least one tie rod **10** (figures 1 and 5), i.e. a flexible metal cable which keeps the plates **51** pressed against one another in the relative seat obtained in the main body **2.** The head **1** comprises a plurality of linear actuators **52, 53, 54, 55, 56,** each of which are connected to a group of laminar plates of the guide 5. The linear actuators **52-56** are driven by respective motors **M,** also housed in the main body **2,** preferably in its upper portion, via levers and/or transmissions **6.** Via the linear actuators **52-56** it is possible to modify the vertical position of one or more metal plates **51** and, consequently, to modify the vertical position, along the direction **Y,** of the respective abrasive strips **3.**

[0043] Figures 3 and 4 show the machining head **1** in a first configuration, with the abrasive elements **3** located against a flat surface **S.**

[0044] In figure 4, the motors **M** for operation of the actuators **52-56** can be seen. The motors **M** are fixed to internal supports **22** and **23** of the main body 2. For example, the motors **M** can be gearmotors with flexible connection to encoder. The levers or transmissions **6** can be of various types. What matters is that the levers/transmissions **6** transform the mechanical work of the relative motor **M** into a vertical actuation movement in direction **Y.** In other words, by controlling the function of the motors **M,** the vertical range in direction **Y** of the actuators **52-56** is regulated indirectly via the levers/transmissions **6.** Preferably, the actuators **52-56** are linear recirculating ball guides, suitable for transmitting vertical movements.

[0045] Each actuator **52-56** is fixed integral with one or more laminar plates **51** of the deformable guide **5.** In the embodiment shown in figure 4, each actuator **52-56** is connected to one group of ten laminar plates **51.**

[0046] In the configuration shown in figures 3 and 4, the deformable guide **5** is straight, i.e. the plates **51** are aligned in direction **Z** and all have the same height in direction **Y.** Also the abrasive elements **3,** connected to the guide **5,** are aligned in direction **Z** and all have the same height. Operation of the actuators **52-56** will now be described with reference to figure 3 comparing it with figure 6.

[0047] Figure 6 is a front view, enlarged, of the lower portion of the machining head **1,** shown in a second configuration, i.e. in action on a curved surface **S,** having a locally variable radius of curvature. When the machining head **1,** moving in the horizontal direction **X** (perpendicular to the plane of the drawing), is set to work on the curved surface **S** shown in figure 6, the actuators **52** and **53** reduce their range, raising the respective groups of laminar plates **51,** i.e. recalling a part of the deformable guide **5** towards the main body **2** of the head **1.** Analogously, the actuators **55** and **56** increase their range, pushing the remaining part of the guide **5** towards the outside of the body **2.** In the example shown, the actuator **54** remains at a standstill. The result is that the deformable guide **5,** and therefore also the abrasive elements **3** connected to it, assume the profile of the curved surface **S.** In other words, the actuators **52-56** move the abrasive elements **3** vertically, locally compensating for the variations in curvature of the surface **S** being machined. If the surface **S** has a raised or convex area, or has an edge or a corner, when some of the abrasive elements **3** are working in said area, the respective actuators raise the corresponding laminar plates **51,** varying the profile of the guide **5** and maintaining practically constant contact pressure between the abrasive elements **3** and the surface **S.** If the surface **S** has a depression, when some of the abrasive elements **3** are working in said depression, the respective actuators lower the corresponding laminar plates **51,** varying the profile of the guide **5** and maintaining practically constant contact pressure between the abrasive elements **3** and the surface of the depression.

[0048] Control of the motors **M** and actuators **52-56** is performed by a control unit of the machining head **1.** The control unit is preferably the control unit of the numeric control machine to which the head **1** is connected. The control unit operates on the basis of the geometric specifications relative to the surface **S,** stored in a memory unit. For example, the control unit processes the geometric data relative to the surface **S** stored in electronic file. Preferably, the CAM system of the machine generates the electronic file on the basis of a CAD type file. On the basis of the data contained in the electronic file, the control unit controls the motors **M** and the actuators **52-56** to move the abrasive elements **3** vertically when necessary to compensate for any variations, also local, in the curvature of the surface **S.**

[0049] Alternatively, operation of the motors **M** and actuators **52-56** is regulated on the basis of a feedback control relative to the curvature of the surface **S.** For example, the machine tool or the machining head 1 can be provided with optical sensors able to identify the curvature of the surface **S** in different points upstream of the head **1**, which moves in direction **X,** and able to generate a signal that can be processed by the control unit for regulation of the actuators **52-56.**

[0050] Figure 5 shows the preferred form of the abrasive elements **3,** i.e. the strips made of metal, plastic with abrasive coating, or ceramic. Preferably, said abrasive strips **3** have a rounded lower portion, designed to come into contact with the surface **S** although, in general, the lower portion can have a different shape according to requirements, for example it can be rectangular, triangular, etc.. The abrasive strips **3** have a generally rectangular upper portion, in which the connection with the deformable guide **5** is provided. In particular, the pin **7** of each metal strip **3** is supported by a plurality of spheres **8** which act as bearings and create a seat in which the pin **7** can rotate around its axis (axis **X**) and can run in direction **Z.**

[0051] The connection formed by the pin **7** and the spheres 8 permits the oscillation of an abrasive strip **3** around the axis of the pin, in the two ways, along the horizontal direction **Z,** i.e. the direction of development of the pack of abrasive elements **3,** and/or a slight translation of said strip **3** in the guide **5,** again along the direction **Z** and in the two ways.

[0052] The abrasive and/or polishing effect of the surface **S** is obtained when the abrasive strips **3** move in direction **Z,** with respect to the guide **5,** while the machining head **1** moves forward in direction **X.**

[0053] The pack formed by the abrasive strips **3** is held together by at least one tie rod **9,** preferably at least two tie rods **9,** i.e. metal cables that cross all the abrasive strips and keep them pressed one against the other. The ends of the metal cables are preferably provided with adjustable registers, via which it is possible to increase or reduce the force on the tie rods **9** and, therefore, increase or reduce the play between the strips **3.** The tie rods **9** are flexible and do not obstruct height-adjustment of the position of the individual abrasive strips **3;** at the same time they permit oscillation of the strips **3** each around its related pin **7.** It will be clear to a person skilled in the art that when the strips **3** oscillate in direction **Z,** the angle between consecutive strips **3** can vary, i.e. the strips **3** can slant differently according to the variations in curvature of the surface **S** (note the different inclination of the strips **3** with respect to the vertical **Y** and also with respect to the plates **51** of the guide **5,** in figure 6). The laminar plates **51** of the deformable guide **5,** on the other hand, can move only in a vertical direction, without slanting with respect to the vertical **Y.** In other words, the guide 5 can deform vertically, while the pack of abrasive strips **3** can "deform" both vertically and in direction **Z.**

[0054] The machining head **1** is provided with means for translating the abrasive elements **3,** i.e. the strips, in direction **Z** during forward movement of said head **1** in direction **X.** In the embodiment shown in figures 1-6, the head **1** comprises a drive shaft **4** suitable for receiving a rotary movement from the machine tool on which the head **1** is mounted, or driven by a motor **M** mounted on the head **1.** The shaft 4 eccentrically engages a carriage **11.** The carriage **11** transforms the rotary movement of the shaft **4** into an alternating translation movement, in direction **Z,** of the pack of abrasive strips **3.** The carriage **11** is directly or indirectly connected to the abrasive elements **3,** and transmits to the latter the alternating translation movement in direction **Z.** In the example shown in figure 4, the carriage **11** is directly coupled to one single abrasive strip **3** and the latter transmits the movement to the remaining strips **3** of the pack, due also to the action of the tie rod **9.**

[0055] When the shaft **4** is rotating, the carriage **11** pushes the abrasive strips **3** forward and back in direction **Z.** The strips **3** remove material from the surface **S,** sanding and/or polishing it, moving like bristles while the head 1 is translated in direction **X.**

[0056] Operation of the sanding and/or polishing head **1** is simple. The head is translated in direction **X** on the surface **S.** Simultaneously the shaft **4,** rotating, operates the carriage **11** which transmits the alternating translation movement to the pack of abrasive strips **3,** which therefore run along direction **Z,** in the two directions, with respect to the guide **5.** The abrasive strips remove material from the surface **S,** for example they remove a surface layer, polishing and sanding said surface **S.** When the head **1** encounters a portion of the surface **S** with different curvature from the portion previously machined, or there is an edge or protrusion, the control unit operates the motors **M** and the actuators **52-56** to vertically deform the guide **5,** i.e. to independently vary the vertical position (along **Y)** of the metal plates **51** of the guide **5** and therefore adapt the height of the abrasive elements **3** to the new curvature of the surface **S.** In other words, the control unit processes the electronic files provided by the CAM system, relative to the geometry of the surface **S,** and operates the actuators **52-56** to raise or lower, independently, individual groups of abrasive strips **3** when necessary to compensate for variations in the curvature of the surface **S,** as in the example shown in figure 6.

[0057] Figures 7 and 8 refer to a second embodiment of the machining head **1** according to the present invention. In particular, said figures show a base drawing of a different embodiment of the deformable guide. The reference numbers identify the same components shown in figures 1-6. The abrasive elements **3,** which in this version can differ in form and type with respect to the elements **3** shown previously, are coupled to form a chain or an elastic belt **12,** or are themselves connected to an elastic belt or a supporting chain **12,** made of rubber for example. The belt, or chain, **12** is elastically deformable and housed in the main body **2** of the head **1.** The belt/chain **12,** which replaces the guide **5** of the first embodiment, runs around wheels **13, 14, 17** at least one of which is a drive wheel, while the others are driven. The belt/chain **12** is therefore rotated, clockwise or anticlockwise, in a continuous rotary movement. The diagram of figure 7 is based on a continuous clockwise rotation as indicated by the arrow **R.** A system for compensating the length of the belt/chain **12** is provided. Said system comprises a tensioner **16** and a wheel **15** for contact with the belt/chain **12,** and is shown in figure 8 from above.

[0058] The number of actuators is higher than in the first embodiment: ten units **52-61.** Each actuator **52-61** acts independently on a section of the belt/chain **12** to vary the position in the vertical direction **Y.** For example, the belt/chain can slide on a foot or in a ring of the actuators **52-61.** The reference letter **S'** indicates in figure 7 a hypothetical flat surface, while the reference letter **S** indicates the curved surface being machined. By independently adjusting the actuators **52-61** it is possible to locally deform the belt/chain **12** to adapt the profile to the curvature of the surface to be machined, whether flat **S'** or curved **S** with variable curvature between different areas of the surface.

[0059] The machining head **1** according to the present invention, in both the first and second embodiment, permits extremely effective polishing and/or sanding of flat and/or curved surfaces **S,** also having locally variable curvatures between the various portions of the same surface, or surfaces with edges, for example the surfaces of hulls of vessels, or the sheet metal of vehicle bodywork etc.

[0060] The head **1** is extremely reliable and permits automation of polishing/sanding of curved surfaces, today performed manually by skilled workers. The machining phases currently required to obtain a finished product, i.e. sanded or polished, are, in the following order:

A) prototyping
B) machining with machining centre (milling cutter)
C) roughing
D) semi-finishing
E) finishing
F) sanding (by hand using: orbital sander, hand sander, abrasive paper)
G) polishing (by hand with abrasive paper, polishing paste, etc., applied with felts)
H) pressing
I) machining with machining centre (milling cutter)
J) roughing

K) semi-finishing
L) finishing
M) sanding (by hand using: orbital sander, hand sander, abrasive paper)
N) polishing (manual)
O) the pressed parts are finished by hand to eliminate imperfections/defects and may be manually surfaced and sanded/polished.

[0061] The head 1 according to the present invention permits automation of phases **F, G, M, N, O,** with numerical control machines, with obvious reduction in machining times and, therefore, reduction in costs.

Claims

1. Machining head (1) for sanding and/or polishing flat and/or curved surfaces (S) with constant or variable curvature, comprising a main body (2) which can be connected to a machine tool, a plurality of abrasive elements (3) designed to interact with said surfaces (S), supported at the lower portion of said main body (2) and which can move along a first vertical direction (Y), **characterised in that** said abrasive elements (3) are aligned along a second horizontal direction (Z) and **in that** it comprises means for translating said abrasive elements (3) along said second direction (Z).

2. Machining head as claimed in claim 1, **characterised in that** said abrasive elements (3) are abrasive strips arranged side by side, perpendicular to said second horizontal direction (Z).

3. Machining head as claimed in claim 2, **characterised in that** each of said abrasive strips (3) is laterally hinged in a deformable guide (5) in the first vertical direction (Y) only, at least partly housed in said main body (2), and **in that** it comprises means (4, 11) for controlling the translation of said abrasive strips (3) along said second horizontal direction (Z), alternately in the two ways.

4. Machining head as claimed in claim 3, **characterised in that** each of said abrasive strips (3) oscillates freely around the relative pin (7) and with respect to said deformable guide (5), along said second horizontal direction (Z).

5. Machining head as claimed in claim 3 or 4, **characterised in that** said deformable guide (5) is made of a plurality of laminar plates (51), sliding in said first vertical direction (Y), stacked along said second horizontal direction (Z) and held together by at least one tie rod (10).

6. Machining head as claimed in claim 5, **characterised in that** said tie rod (10) is a metal cable which crosses each of said laminar plates (51).

7. Machining head as claimed in one of the claims 3-6, **characterised in that** said means for controlling the translation comprise a drive shaft (4) which eccentrically engages a carriage (11) to which said abrasive strips (3) are directly or indirectly connected, said carriage (11) being alternately translatable along said second horizontal direction (Z).

8. Machining head as claimed in claim 2, **characterised in that** said abrasive strips (3) are connected to one another to form a chain or to an elastic belt (12), or each of said abrasive strips (3) is connected to a chain or an elastic belt (12) of said main body (2), wherein said chain or elastic belt (12) is rotated clockwise or anticlockwise along said second horizontal direction (Z).

9. Machining head as claimed in one of the claims 3-7, **characterised in that** it comprises means (M, 52-56, 6) to independently adjust the height of one or more of said laminar plates (51) or of a portion of said belt along said first vertical direction (Y).

10. Machining head as claimed in claim 9, **characterised in that** said height-adjustment means comprise a plurality of linear actuators (52-56), housed in said main body (2), each of which is connected to one or more laminar plates (51), or to a portion of said belt/chain (12), and is operated independently from the other actuators.

11. Process for sanding and/or polishing of surfaces by means of the machining head according to any one of the preceding claims 1-9, comprising the phases of:

- translating said machining head (1) along a third horizontal direction (X), perpendicular to said second horizontal direction (Z), to move said abrasive elements (3) over the surface (S) being machined;
- controlling movement of said abrasive elements (3) along said second horizontal direction (Z) to remove material from said surface being machined (S);
- adjusting the height of said abrasive elements (3) along the first vertical direction (Y) to locally adapt the position of each abrasive element (3) to the curvature of the surface being machined (S).

12. Process as claimed in claim 11, **characterised in that** the phase of adjusting the height of the abrasive elements (3) provides adjustment of the vertical range of said linear actuators (52-56).

13. Process as claimed in claim 11 or claim 12, **characterised in that** said phase of controlling the movement of the abrasive elements (3) provides the activation of said carriage (11) with reciprocating translation motion along said second horizontal direction (Z), or rotation of said belt/chain (12).

14. Process as claimed in claim 13, **characterised in that** inversion of the translation direction of said carriage causes oscillation of each of said abrasive strips (3) around the relative pin (7).

15. Use of the machining head (1) as claimed in any one of the preceding claims 1-9 for the sanding and/or polishing of flat and/or curved surfaces (S) made of metal, plastic, fibreglass, glass, wood, stone, marble, resin or stucco elements.

16. Use of the machining head (1) as claimed in any one of the preceding claims 1-9 for the sanding and/or polishing of curved surfaces (S).

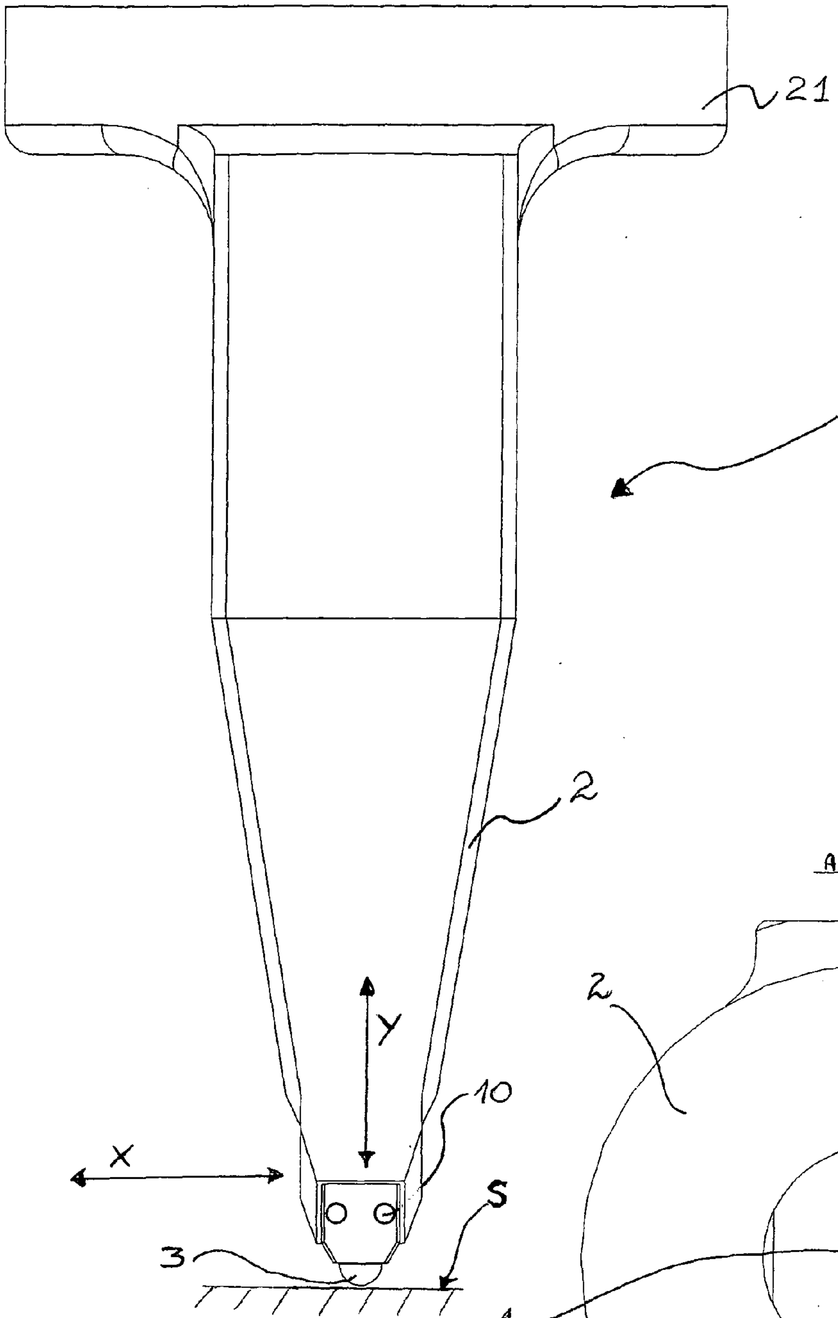

FIG. 1

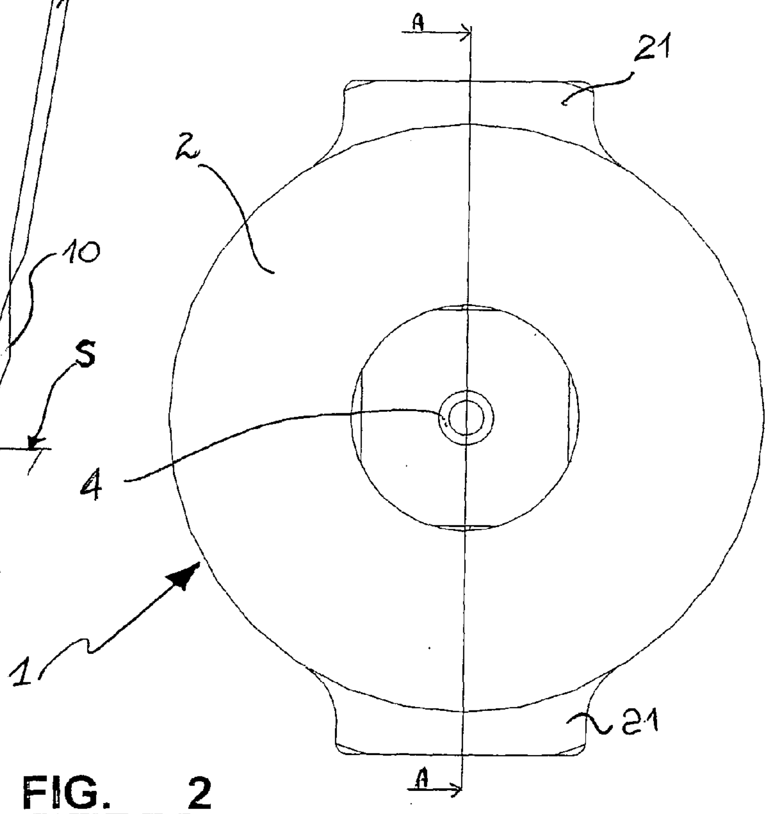

FIG. 2

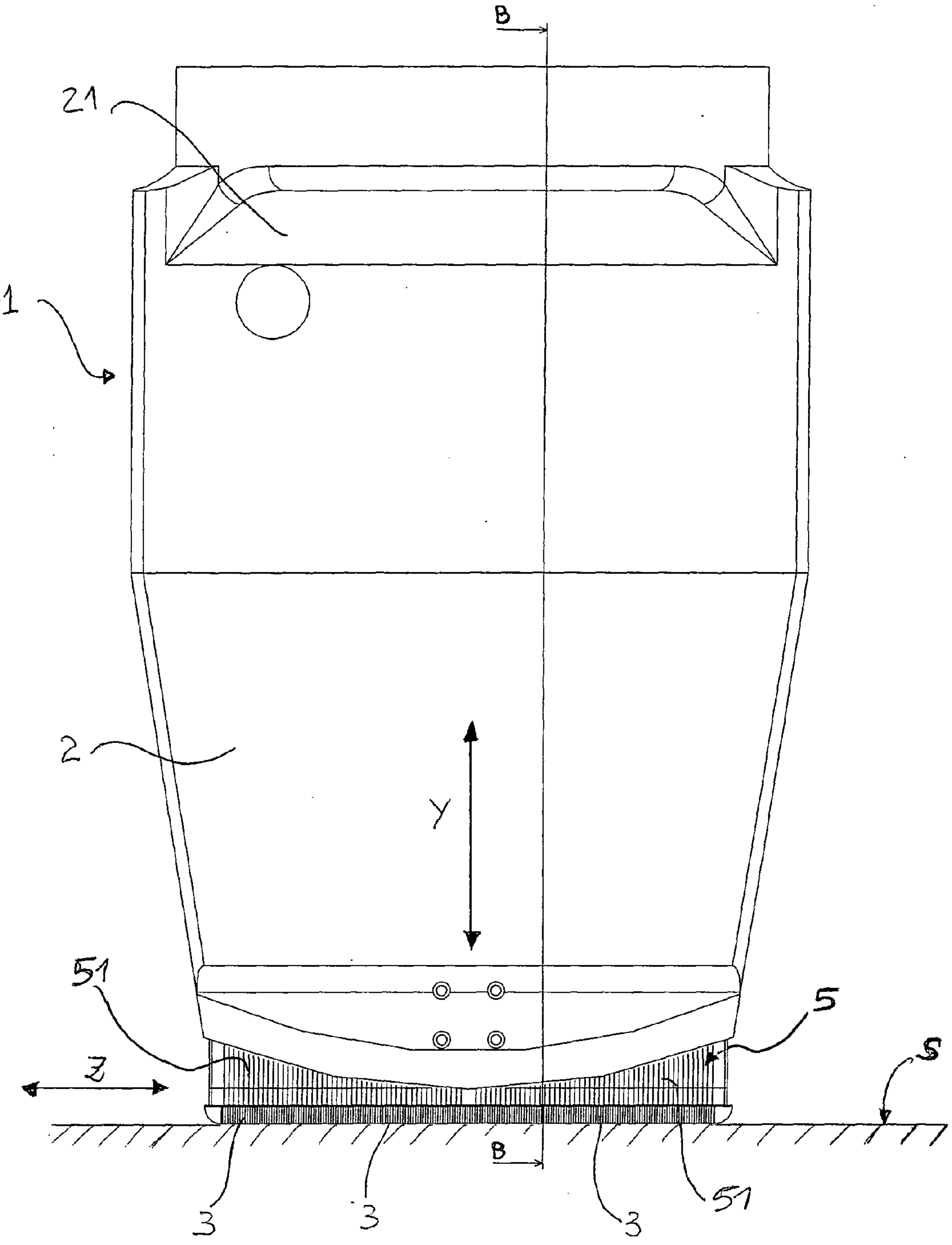

FIG. 3

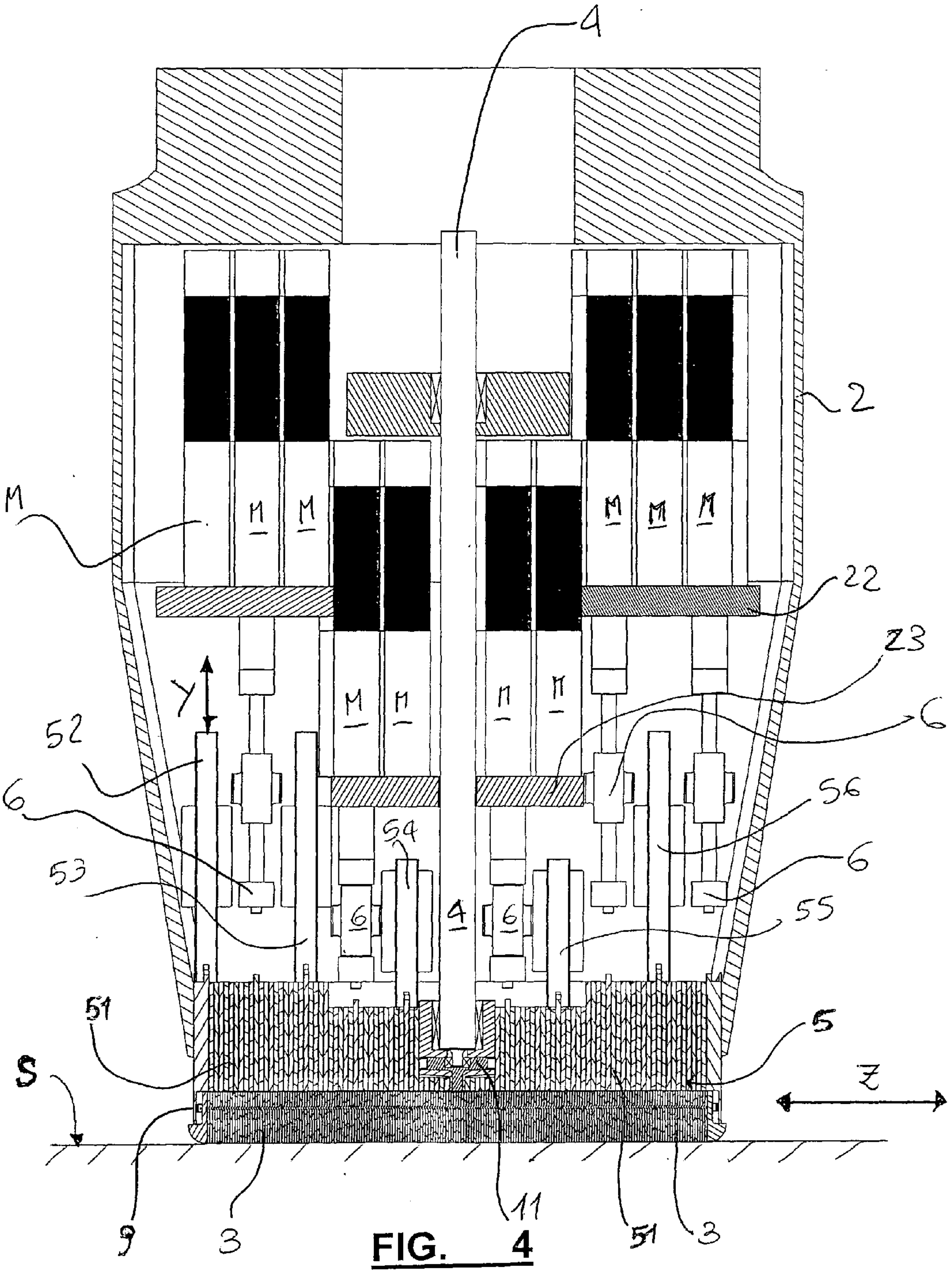

FIG. 4

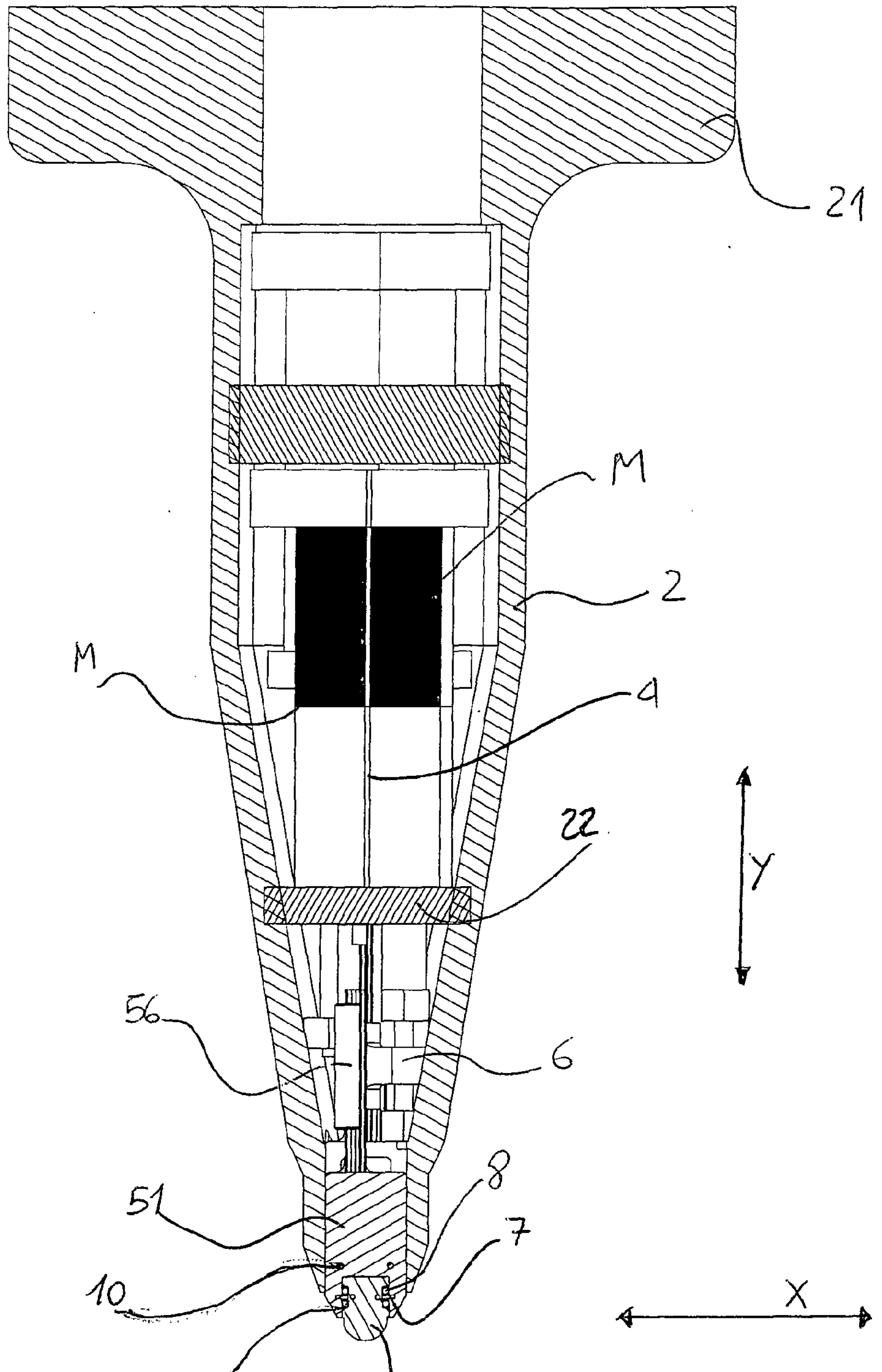

FIG. 5

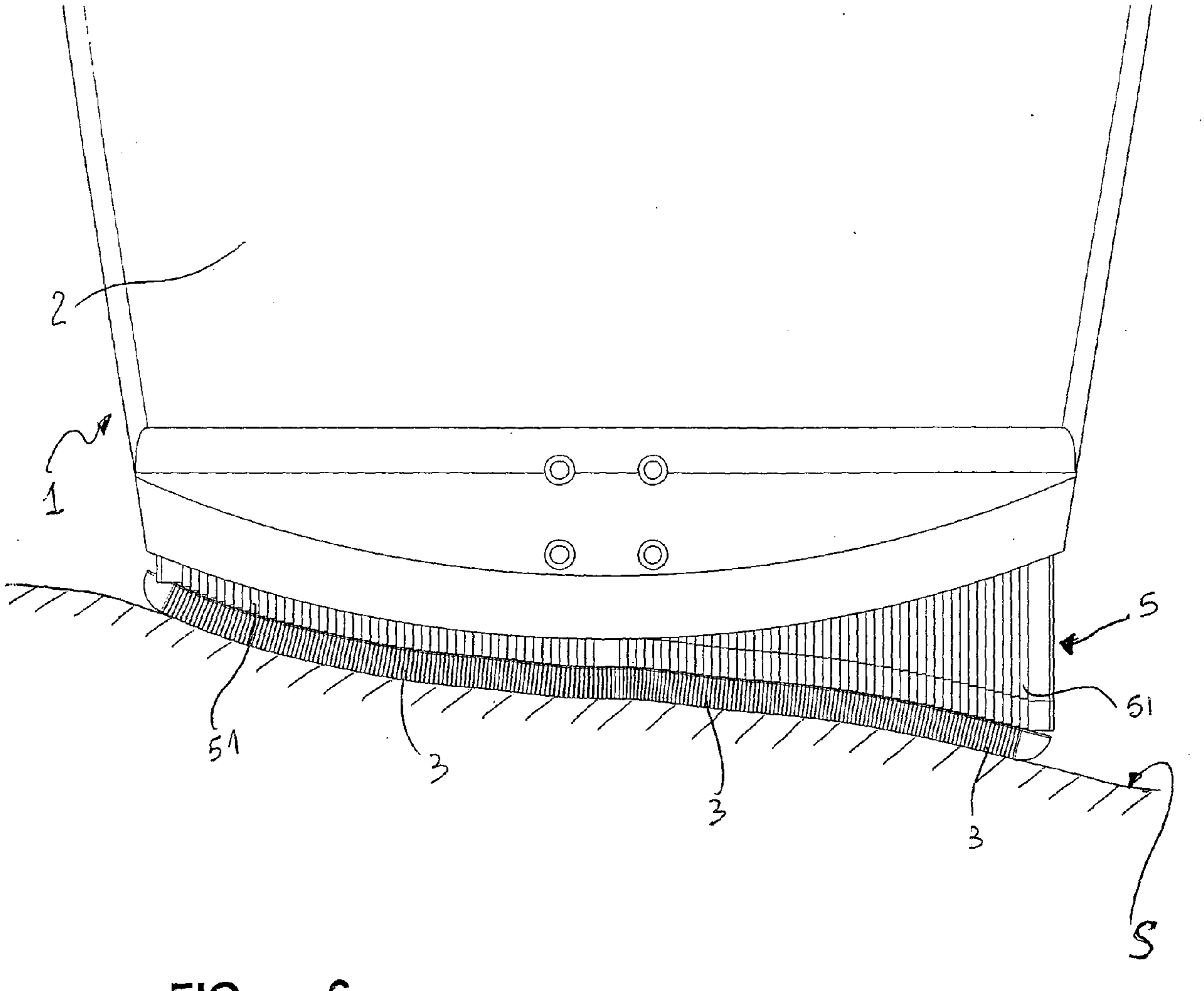

FIG. 6

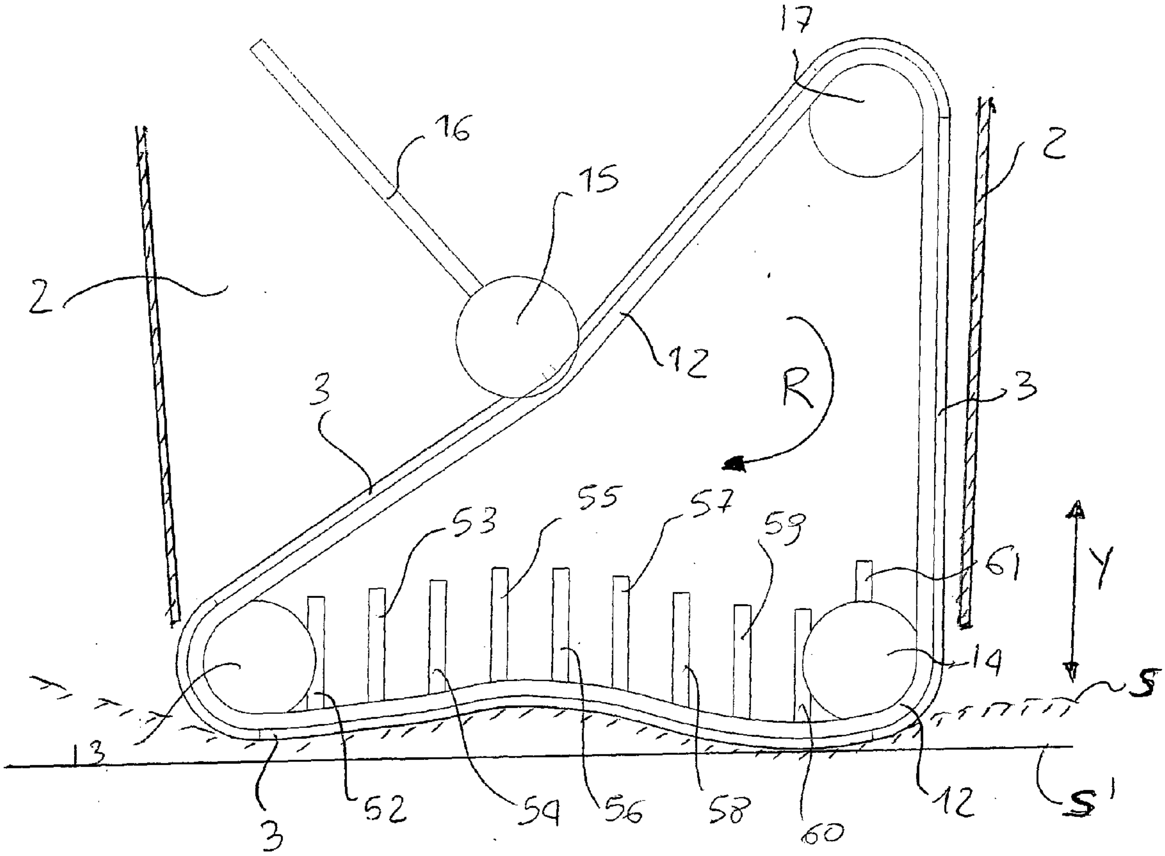

FIG. 7

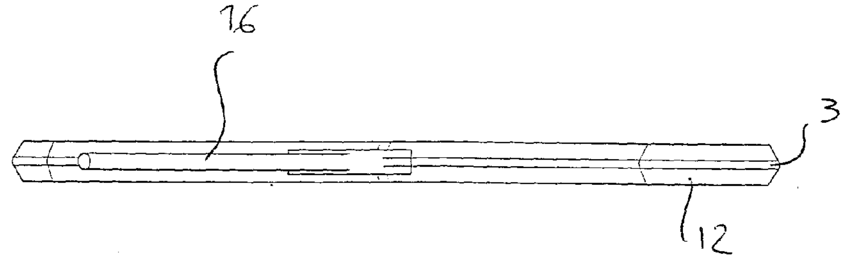

FIG. 8

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 42 5525

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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D,A	JP 09 066469 A (NISSHIN STEEL CO LTD) 11 March 1997 (1997-03-11) * abstract *		

TECHNICAL FIELDS SEARCHED (IPC)

B24B
B23C
B24D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	6 February 2008	Koller, Stefan

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06-02-2008

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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