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

(11) **EP 4 286 121 A1**

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
06.12.2023 Bulletin 2023/49

(21) Application number: **23175342.7**

(22) Date of filing: **25.05.2023**

(51) International Patent Classification (IPC):
B26F 1/38 *(2006.01)* ***B26D 5/00*** *(2006.01)*
B26D 5/02 *(2006.01)* ***B26D 5/08*** *(2006.01)*
B26D 7/26 *(2006.01)* ***B31F 1/08*** *(2006.01)*
B26D 3/08 *(2006.01)* *B26D 7/00* *(2006.01)*
B26F 1/44 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B26F 1/38; B26D 3/08; B26D 5/00; B26D 5/02; B26D 5/08; B26D 7/26; B31F 1/08

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(30) Priority: **01.06.2022 IT 202200011690**

(71) Applicant: **SCM Group S.p.A.**
47921 Rimini (RN) (IT)

(72) Inventors:
- **SAVORELLI, Livio**
  47921 Rimini (RN) (IT)
- **D'AURIA, Marcello**
  47921 Rimini (RN) (IT)

(74) Representative: **Tiburzi, Andrea et al**
Barzanò & Zanardo Roma S.p.A.
Via Piemonte 26
00187 Roma (IT)

(54) SWIVELING OPERATING UNIT FOR SUPPORTING CUTTING TOOLS FOR SOFT SHEET MATERIALS

(57) The present invention relates to an operating unit (G) for cutting or creasing flat sheets (L) made of soft materials such as cardboard, poli-wave plastics, composite materials, comprising a supporting base (1), a rotating plate (2), rotatably coupled to said supporting base (1) about a first axis (C) to perform a first rotation (1T); a support column (3), having one end constrained to said rotating plate (2), by means of first guide means (20), wherein said support column (3) is adapted to constrain a plurality of tool holders (Wk), arranged on it with the respective operating axes (Ak) parallel to said first axis (C), and equipped with respective tools (Uk); wherein said first guide means (20) are configured to allow a translation (61), or rotation (62) first movement of said support column (3) with respect to said rotating plate (2), such that the operating axis (Ak) of one of said tool holders (W1,2, ... , k,... n) coincides with said first axis (C).

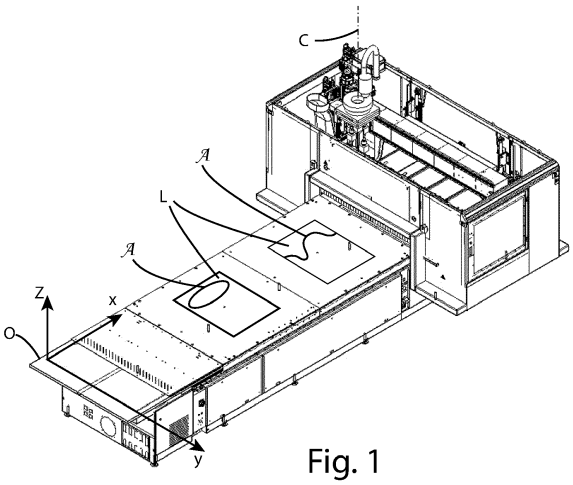

Fig. 1

EP 4 286 121 A1

Description

[0001] The present invention relates to a swiveling operating unit for supporting cutting tools for making cuts on shaped semi-finished products in thin sheets made of soft materials.

Field of invention

[0002] In more detail, the invention relates to an operating unit of the above type, designed and manufactured in particular for carrying out both cutting lines and pressing lines on materials such as cardboard, corrugated plastics, composite materials, and the like, to be performed using tools shaped respectively cutting flat plate, or flat blunt.

[0003] In these operating units, the tools are supported by relative tool holders and, through these, they are associated with the operating unit itself.

[0004] Furthermore, said operating units provide, by means of members included therein, to position the tools around the axis of the tool holder, in accordance with the curve that the tool must follow on the piece.

[0005] Said operating units are generally foreseen to be associated with a mobile translating carriage, in a machine tool, generally called *plotter* cutting, which gives the unit itself the degrees of freedom of translation necessary to perform a predetermined curve on the piece.

[0006] The operating unit object of the invention can be used to perform any other type of piece machining, during which a tool holder is constantly positioned with its axis normal to a flat surface of a piece L to be machined, and in which, moreover, it is necessary to orient, in a controlled way, the tool holder itself around its own axis.

[0007] In the following, the description will be directed in particular to the machining of pieces produced in thin sheets of soft material, which are to be cut with flat plates in the shape of a wedge-sharpened blade, or to impress without cutting with plates with a beveled edge, the latter both fixed and rolling.

[0008] However, it is clear that the present description should not be considered limited only to this specific use and to the exclusive types of objects herein referred to.

Prior art

[0009] As is well known, currently, in the field of machining thin sheets of soft material, in particular in the sector of machining cardboard sheets, but also in corrugated plastics and composite materials, machines are already made bearing relative operating units suitable for performing, along a given curve on the part, the cutting operation, or that of linear imprinting (creasing). This last operation is usually preparatory to bending the sheet without separating the parts. Among the cutting operations, the cutting with separation can be distinguished, obtained by making a full-thickness incision (full thickness), i.e. that of partial incision without separation (half thickness). In general, the geometric arrangements of the various elements necessary to obtain the correct creasing machining are similar to those applied in full-thickness cutting machining.

[0010] Said operating units, in their classic execution of the prior art, comprise a load-supporting base, which configures an element having the shape of a flat plate, vertically arranged on the machine, and on which the various tool holders are constrained, arranged side by side according to a linear array and with its axis normal to the surface of the piece being worked.

[0011] The tool holders of the prior art are similar to an elongated cylindrical cartridge, generally having a diameter of about 40 millimeters. The tool is mounted at one end of the cartridge.

[0012] When the tool is lowered and stationary on the piece, it intersects the flat surface of the piece according to a segment which, in addition to having its center on the foreseen cutting curve, is also tangent at that point to the aforementioned curve.

[0013] In the prior art, in this way, it is ensured that while the center of the oriented trace of the tool follows the foreseen cutting curve, a rotation around the axis of the tool holder can be assigned at any instant which maintains the tangency to the foreseen cutting curve.

[0014] This coordination between the position of the center of the tool-oriented trace, reached through the translations of the translating carriages of the machine and the rotation of the tool itself around the axis of the tool holder, avoids that during the cutting motion of the tool along the work curve, undesired lateral drifts of the tool take place, thus preventing consequent lacerations on the piece.

[0015] The number of tool holders which in the prior art are usually found associated with the supporting base is generally equal to three, so as to carry out most of the operations envisaged on a given batch of semi-finished products, without having to replace the tool holders on the supporting base.

[0016] Of the tool holders mounted on the supporting base, only one is placed in the operating condition, by means of a linear actuator, which selects the tool holder to be lowered with respect to the supporting base itself, until engaging the relative tool on the sheet being worked, according to an on-off mode, or under the action of a controlled linear actuator.

[0017] In the systems according to the prior art, each tool holder is associated with the supporting base in a rotatable and controlled manner, around its own axis, so as to allow any angular orientation of the relative tool.

[0018] The angular orientation of each tool holder, with respect to the supporting base, is in the systems according to the prior art, controlled with an electric motor.

[0019] Generally, in systems according to the prior art, the load- supporting base and the tool holders constrained thereto are supported on a machine tool of the type comprising a base and a work table of flat and hor-

izontal shape, suitable for clamping the sheets to be worked.

[0020] The machine tool also includes a kinematic chain made with translating carriages in series, on the last of which the supporting base is mounted, so that the machine can give it all the translations necessary to bring the axis of each tool holder on a desired point of the work curve and to adjust the depth of the pass of the tool into the piece.

[0021] However, the system just described is affected by some problems.

[0022] A first problem encountered derives from the fact that, in order to be able to continue to operate correctly, it is necessary to make each of the tool holders orientable, with respect to the supporting base, in an angularly controlled manner. This characteristic, in the embodiments of the prior art, is obtained by providing each tool holder with a relative actuator, angularly controlled. This represents an increase in production costs.

[0023] A second technical problem of the systems according to the prior art emerges when the lowering of each tool holder with respect to the supporting base is operated by a respective controlled linear axis, and not by a simple dedicated on-off actuator. Also in this case, the problem consists in an increase in costs linked to the arrangement of a controlled linear axis on each tool holder.

[0024] It therefore appears evident how all the embodiments pertaining to the prior art are onerous due to the undesired multiplication of the precision actuators, which are used both for the angular orientation around the axis of each tool holder, and for the linear translation of the lowering of the same.

Scope of the invention

[0025] In light of the above, it is, therefore, an object of the present invention to provide an operating unit for making cuts and creases on sheets of soft materials, which is free from the drawbacks described above, and which is cheap to make and simple in design.

[0026] In particular, the object of the invention is to create a group where the execution of cuts and creases in a geometrically correct way is guaranteed, minimizing the number of actuators required.

[0027] A further scope of the invention is to create an operating unit with optimized geometry, in which, even with a minimal number of controlled rotation actuators serving all the tool holders present on the operating unit, the use of coordinate calculation algorithms is avoided, due to inefficient geometries of the group, necessary to conform the translations imposed by the machine to the supporting base of the group, with the angular orientations of the working tool holder.

[0028] Another object of the invention is to provide an operating unit, which, in particular, can be easily and economically fitted on machine tools already arranged to be equipped with a head, which moves in a controlled manner along three spatial axes, and at the same time rotates in a controlled manner around an axis perpendicular to the work table.

Object of the invention

[0029] It is, therefore, a specific object of the present invention an operating unit for cutting or creasing flat sheets made of soft materials such as cardboard, poliwave plastics, composite materials, comprising a supporting base, a rotating plate, rotatably coupled to said supporting base about a first axis to perform a first rotation; a support column, having one end constrained to said rotating plate, by means of first guide means, wherein said support column is adapted to constrain a plurality of tool holders, arranged on it with the respective operating axes parallel to said first axis, and equipped with respective tools; wherein said operating unit is characterized in that said first guide means are configured to allow a translation, or rotation first movement of said support column with respect to said rotating plate, such that the operating axis of one of said tool holders coincides with said first axis.

[0030] Always according to the invention, said support column may have on its side surface a plurality of linear tracks parallel arranged to said first axis, on each of which a respective tool holder is slidingly constrained, and lockable in a respective initial, or final position, and said group may comprise at least one linear actuator, acting along at least one of said linear tracks, to command a translation of the relative tool holder from said initial position, to said final position of said linear track, wherein the respective tool is engaged, in use, on a flat plate.

[0031] Still according to the invention, said first guide means may comprise translating guide means, configuring a cross carriage, wherein the first slide of the cross carriage is slidable with respect to said rotating plate, along a first direction thereof, to perform a first stroke on first prismatic pairs, interposed between said first slide and said rotating plate, and wherein the second slide of the cross carriage is sliding, with respect to said first slide, along a second direction, transversal to said first direction, to perform a second stroke on second prismatic pairs, interposed between the second slide and the first slide.

[0032] Advantageously according to the invention, said support column may be integral, by means of its own base, to said second slide, and said first translation movement of said column support with respect to said revolving plate, on the first guide means, is made by means of one and/or both of said first stroke, second stroke.

[0033] Further according to the invention, said first guide means may comprise rotary guide means, configuring a rotoidal pair made around a second axis of said rotating plate, parallel to said first axis, and spaced by a metric dimension from it, and wherein in said rotoidal pair the first member may comprise a first disk integral with said rotating plate, and the second member may com-

prise a second disk coaxial with said first disk, and further rotatable with respect to said rotating plate, to perform a second rotation around said second axis.

[0034] Always according to the invention, said support column may substantially emulate the shape of a right prism with a regular polygonal section, and is made integral with said second disk of said rotoidal pair by means of its own base, wherein the geometric axis of said prism is arranged coincident with said second axis; said linear tracks being arranged on the lateral faces of said prism, so that each said axis respective of each said tool holder is placed at a distance from said geometric axis equal to said metric height, and wherein said first movement, of rotation of said support column with respect to said revolving plate, on said first guide means, is made by means of said second rotation.

[0035] Still according to the invention, one of said tool holders may comprise a respective tool having the shape of a flat plate, preferably made of metal, equipped with a respective active edge acting, in use, on said flat plate, and said active edge may be sharp, to perform cuts or bevel-type, to perform creasing.

[0036] Preferably according to the invention, in at least one of said tool holders, the relative tool may be mounted so that said active edge is incident to said operative axis.

[0037] Always according to the invention, in at least one of said tool holders, the relative operating axis may belong to the geometric plane of said flat plate.

[0038] Still according to the invention, in at least one of said tool holders the relative tool may be a rolling type tool, wherein said rigid plate may have the shape of a circle, whose active edge is located on the external circumference, and said tool may be supported in rotation by a pin of said tool holder, arranged in a normal way with respect to said operative axis.

[0039] Further according to the invention, said operating unit may comprise first actuating means for rotating said rotating plate with respect to said supporting base, and second actuating means for controlling the movements of said support column with respect to said rotating plate, on said first guide means.

[0040] Advantageously according to the invention, said second actuating means may be actuators for rectilinear motions, and act on said first slide to control said first stroke, and on said second slide to control said second stroke.

[0041] Always according to the invention, said second actuator means may be actuators for rotary motions), and act on said second member of said rotational torque, to command said second rotation.

[0042] Still according to the invention, said supporting base may be suitable for positioning on a movable translating carriage, in a machine tool equipped with a processing unit, and said actuator means of said operating unit may be fed by said machine tool, and/or controlled in their movements by said processing unit.

[0043] Further according to the invention, said active edge may be a cutting edge, to perform cuts, and said at least one said tool holder may comprise a pneumatic or electric actuator, which gives an oscillating axial motion to said tool plate.

Brief description of the figures

[0044] The present invention will be now described, for illustrative but not limitative purposes, according to its preferred embodiments, with particular reference to the figures of the enclosed drawings, wherein:

- figure 1 shows an isometric view of a machine on which the operating unit object of the invention is installed;
- figure 2 shows an enlarged isometric view of the mobile structure of the machine of figure 1;
- figure 3 shows an orthogonal side view of a first embodiment of the operating unit, in which translational guide means are provided;
- figure 4 shows an orthogonal side view of a second embodiment of the operating unit, in which rotary guide means are provided, of the revolving pair type;
- figure 5 shows an isometric view of the operating unit of figure 4, and in which one of the tool holders is lowered to a position suitable for working on a piece;
- figure 6 shows an orthogonal side view of the operating unit of figure 5, in which the piece being worked is shown;
- figure 7 shows an isometric view of the working group in the first embodiment of figure 3;
- figure 8 shows an orthogonal side view of the operating unit of figure 7;
- figure 9 shows an embodiment according to the prior art;
- figure 10 shows a tool holder according to the prior art;
- figure 11 shows schematically a cutting curve performed on the piece with a tool holder, whose axis has been brought into coincidence with a first axis of the overall rotation of the operating unit.

Detailed description

[0045] In the various figures, similar parts will be indicated with the same reference numbers.

[0046] With reference to the cited figures, the description of a typical operating unit G object of the present invention is given below, which is described when it is associated with a generic machine tool of the type shown in figures 1 and 2, comprising a horizontal table for supporting of the flat sheets L to be worked, a data processing unit, and a kinematic chain of translating carriages, suitable for conferring to the operating unit G controlled translations along three orthogonal directions.

[0047] The operating unit G that forms the object of the present invention is described hereinafter in two preferred embodiments or arrangements, structurally similar

to each other, however substantially different for an intermediate part hereinafter referred to as the first guide means 20. The latter, in a first setup are made as first guide means of the translational type, in particular as a cross carriage 21, while in a second embodiment, they are made as a rotary type first guide means, in particular as a rotoidal pair 22.

[0048] The operating unit G is longitudinally developed around its own axis C, which, in the use of the operating unit installed on said machine tool, is arranged vertically. In this arrangement, in the operating unit G the following can be distinguished:

- an upper part thereof, made identically in both said arrangements, and placed above said first guide means 20;
- an intermediate part, materialized by said first guide means 20, made as a cross carriage 21 in the first set-up, or as a rotoidal pair 22 in the second setup;
- a lower part, also made in a substantially similar way in both said setups, and located below said first guide means 20.

[0049] The upper part of said operating unit G is the part which, in use, is most distant from the piece being worked.

[0050] In more detail, said upper part comprises a supporting base 1, through which the unit G is associated with the machine tool. Said supporting base 1 is rigidly connected to the last slide of a kinematic chain made up of series translating carriages belonging to the machine tool, which slide in a controlled manner, each with respect to the previous one, and the first with respect to the work table of the machine, according to three respective mutually orthogonal directions, of which a first X and a second Y directions are horizontal and arranged along the sides of the work table, while a third direction Z runs vertically, i.e., normally to said work table.

[0051] The supporting base 1 supports a rotating plate 2 so that it can rotate around a first axis C, integral with the supporting base 1 itself, said first axis C being arranged, in the use of the operating unit G, orthogonally with respect to the horizontal work table of the machine.

[0052] The rotating plate 2 can perform rotations 1T of various amplitudes and in the direction around said first axis C, therefore, with respect to said supporting base 1. Said rotations 1T are actuated by first actuator means 41, which comprise an electric motor and a relative cylindrical gear transmission, of the type with toothed pinion and crown, arranged with axes parallel to said first axis C. The processing unit of the machine tool, to which the operating unit G is associated and slaved, provides for controlling in a controlled way the aforementioned rotations 1T of the rotating plate 2.

[0053] Below said rotating plate 2, said first guide means 20 are connected, which are made according to two different methods, each relating to one of the two said set-ups or embodiments of the operating unit G, and which separate said upper part from said lower part of the operating unit itself.

[0054] In said first arrangement of the operating unit G, the first guide means 20 are made as a cross carriage 21. In this solution, below the rotating plate 2, first prismatic pairs 23 are obtained, which are oriented - when in use the group is mounted on the machine tool - according to the first X direction.

[0055] On the first prismatic pairs 23, by means of relative pads, the first slide 7 of the cross carriage 21 can perform a first stroke 71. Below the first slide 7, second prismatic pairs 24 are obtained, oriented orthogonally with respect to said first prismatic pairs 23, which consequently in use are oriented parallel to the second Y direction.

[0056] On second prismatic pairs 24, a second slide 8 of the cross carriage 21, equipped with relative pads, can perform second strokes 81.

[0057] In said cross carriage 21, according to known arrangements, there are second actuator means 42' for rectilinear motions, controlled in use by the processing unit of the associated machine tool. The second actuator means act between said first slide 7 and said rotating plate 2, in order to command the strokes 71 of the first slide 7. The second actuator means 42' for rectilinear motions also acts between said second slide 8 and said first slide 7, in order to also control the strokes 81 of the second slide 8 with respect to the first slide 7.

[0058] In this way, the second slide 8 is translatable with respect to the rotating plate 2, according to both said X and Y directions, and according to both directions thereof.

[0059] In the second arrangement or embodiment of the operating unit G, the first guide means 20 are instead made as a rotoidal pair 22. In this solution, below the rotating plate 2, the first member 22A of said rotoidal pair 22 is rigidly connected, which, in the preferred solution described here, is materialized by a first disk 22A provided with a relative first pin, placed in correspondence with a second axis R of said rotating plate 2, arranged parallel to said first axis C.

[0060] The internal hole of an assembly of two coaxial rolling bearings (not shown in the figures) is keyed onto said first pin, the outer rings of which are engaged in the hole of a second disk 22B, facing said first disk 22A, which materializes the second member 22B of the rotoidal pair 22. In this way, the second disk 22B can be rotated with respect to said rotating plate 2.

[0061] In both said setups of the operating unit G, below the second slide 8 in the case of the first setup, or below the second disc 22B in the case of the second setup, there are the further members of the operating unit G, constituting the lower part of the group itself.

[0062] Said lower part of the operating unit G is connected to the first guide means 20, made in the two said different shapes, as respectively illustrated in the following.

[0063] The lower part comprises a support column 3

substantially having the shape of a right prism with a square section, the geometrical axis 3A of which is parallel to said first axis C; it is provided for the retention of four tool holders W1,2,3,4, equipped with respective tools U1 ,2,3,4, which substantially refer to the tool holders already described previously in the prior art, which in some versions are also provided as commercial parties. Said tool holders are respectively associated with the respective four lateral faces 251,2,3,4 of the lateral surface 25 of the support column 3, with the respective geometric axes A1,2,3,4 all oriented parallel to the first axis C of the operating unit, and with the respective tools U1,2,3,4 all facing downwards, i.e. towards the piece L.

[0064] In more detail, four respective linear tracks 261,2,3,4 are made on the four side faces 251,2,3,4, which in the present case are guides of the THK type, on each of which one respective of the tool holders W1 ,2,3,4, carried by a relative pad.

[0065] The peculiar square section shape of the support column 3, described in the present preferred embodiment of the operating unit, can be slightly varied in other embodiments, where it can take the shape of a right prism with any section, for example in the shape of an equilateral triangle, or of a regular pentagon, or still with a generic section even with add-ons, depending on the number, always very limited, of tool holders that will be used in the operating unit.

[0066] The regularity of the polygon which represents the straight section of said support column 3, while being in any case a preferable solution, in the second set-up also becomes a necessary condition for the operation, as will be seen below when the functional aspects of the second set-up are illustrated.

[0067] On any linear track 26k (k=1,2,3,4) of said linear tracks 261,2,3,4, each respective tool holder Wk can be locked in a respective initial position 51k, located at the upper end of the respective track linear, therefore distant from the piece L being worked. The same tool holder Wk can likewise be locked in a respective final position 53k on the same linear track 26k, located at its lower end, and therefore close with respect to the piece L being worked.

[0068] Between the initial 51k and final 53k positions of any linear track 26k, the generic tool holder Wk slides in the two directions of the Z direction, under the action of a respective third actuator means 43k, forming part of a set of third means actuators 431,2,3,4, respectively placed on each of said linear tracks 261,2,3,4 and each acting according to its own line of action, placed on the respective linear track, and oriented according to the direction of the C axis, the parallel to the Z direction on the machine.

[0069] As regards the actuation of each of the tool holders Wk (k=1,2,3,4) on the respective linear track 26k, for said second arrangement a first variant is also allowed, not shown, in which the third actuator means 431,2 ,3,4 instead of being placed one for each of the linear tracks 261,2,3,4, can be reduced to a single third actuator means 43, mounted integral with the rotating plate 2 and with its own line of action coinciding with the first axis C, said single third actuator means 43 controls the sliding of the tool holder Wk, which, from time to time, executes the stroke between its respective upper 51k and lower 53k positions, or vice versa, and which for this purpose has been carried from time to time with its own axis Ak at the line of action of said single third actuator means 43, and coinciding with said first axis C.

[0070] In the first and second set-up, described above, the connection of the lower part of the working unit G to the first guide means 20 is made in a different way, however in a rigid way.

[0071] In the first set-up of the operating unit G, in which the first guide means 20 are made in the form of a cross carriage 21, the union of the lower part of the operating unit G to the guide means 20 is achieved by rigidly joining - with a series of screws bits - the upper base of the support column 3 to the face of the second slide 8, opposite to that where the second prismatic pairs 24 are made, and which therefore faces the piece L.

[0072] In the second setup of the operating unit G, in which the first guide means 20 are made in the form of a rotoidal pair 22, the combination of the lower part of the operating unit G to the guide means 20 is achieved by rigidly joining, with suitable screws, the base top of said support column 3, to the lower face - which faces piece L - of the second disk 22B of said rotary pair 22.

[0073] In the union, the geometric axis 3A of the support column 3 is made coincident with the second axis R of the rotating plate 2.

[0074] With regard to the tool holders Wk, for cutting, the preferred solution provides for the assembly of a tool Uk configured with a metal flat plate 9k, equipped with an active edge 10k, made sharp by sharpening or other technology, where the plane of the plate 9k includes the operative axis Ak of the tool holder, and where the same active edge 10k is incident to the aforementioned operative axis Ak.

[0075] A variant of tool holder sometimes used for cutting, provides for the generation of an alternating oscillatory motion of the cutting plate with respect to the tool holder itself, along the direction of the operational axis Ak. In more detail, the tool holder Wk here comprises a pneumatic or electric actuator, which imparts an oscillating axial motion to said tool bit 9k, so that the speed on the piece L of the active cutting edge 10k of the bit adds to the translation speed due to dragging of the tool holder Wk itself on the piece, and the cutting operation is more effective, on certain materials.

[0076] For creasing, on the other hand, the tool holder Wk preferably envisages a rolling type tool Uk, where, therefore, the aforementioned flat plate 9k has the shape of a circle, the active edge 10k of which is its own outer circumference, and where furthermore the tool (Uk) is supported in rotation by a pin, which is both perpendicular to the operating axis Ak of the tool holder Wk and integral with the latter.

[0077] The operating unit G operates as follows, depending on whether the first or the second setup is considered.

[0078] In the first arrangement or embodiment, after a tool holder Wk of them has been designated in the set of tool holders W1,2,3,4, associated with a relative tool Uk suitable for a given operation to be carried out, the processing unit of the machine tool controls said second actuator means 42' of the cross carriage 21, for the execution of a first stroke 71 and a second stroke 81, respectively for said first slide 7 and second slide 8 of the cross carriage 21. Said strokes represent two Cartesian movements along said first X direction and second Y direction, capable of translating the axis Ak of the designated toolholder Wk until it coincides with the first axis C of the operating unit G.

[0079] Subsequently, the processing unit commands the translating carriages of the machine tool, which support the operating unit G by means of its supporting base 1, to perform a combined translation along the X and Y directions, following which the foot of said first axis C - and therefore of said axis Ak - coincides with an initial point O' of the work curve A, along which to carry out the subsequent work on the piece L, for example, cutting.

[0080] Still subsequently, the rotating plate 2 is actuated by the first actuator means 41, to carry out - again under command of the processing unit - a rotation 1T around said first axis C, so that the tool Uk - when lowered and penetrated on the piece L of the necessary depth - shows on the piece its oriented trace 15, like a segment, already oriented according to the tangent to the curve A in its initial point O'.

[0081] A further operating step provides that said tool holder Wk, still stationary on its own linear track 26k in an initial position 51k, proximal to the cross carriage 21, is operated in vertical lowering along said linear track, up to a distal position 53k from the cross carriage 21; said vertical lowering being actuated by a respective 43k of the third actuator means 431 ,2,3,4 present on the linear tracks, where the relative command, also in this case, comes from the processing unit of the associated machine. In this step, the working tool Uk has penetrated the plate making up the piece L, according to a segment, which is considered oriented in the direction of the sharpened part of the tool, therefore according to the proceeding of the cut, and which is also called oriented trace 15, on the center Ck of which the foot Co of said first axis C also falls.

[0082] The movement along said third Z direction of the relative translating carriage of the machine, being controlled, serves to deepen the tool by the desired amount into the piece.

[0083] From the described configuration, the machine begins to move its translating carriages along the X and Y directions, so that the foot Co of said first axis C travels on the working sheet all the points P of the cutting curve A, starting from the initial point O' of it, and thus generating the curve itself with the cut.

[0084] The sequence of points P of the piece L on which the tool must act is stored in the processing unit of the associated machine tool and is supplied, for example, with an equation of curve A.

[0085] During these operations, and always under the command of the logic unit, the machine orients the rotating plate 2 so that, as the cut progresses, the oriented trace 15 of the tool on the workpiece is always oriented as the tangent to the curve itself.

[0086] In the second arrangement or embodiment, after one Wk of them has been designated in the set of tool holders W1,2,3,4, associated with a relative tool Uk suitable for a given operation to be carried out, the processing unit commands said second actuator means 42" of the rotoidal pair 22 the execution of a second rotation 2T of said second disk 22B of the rotoidal pair 22 itself. Said rotation 2T represents a rotary movement around the second axis R, therefore around the geometric axis 3A of the support column 3, capable of moving the axis Ak of the designated tool holder Wk, until it coincides with the first axis C of the operating unit G. This is achieved since, by construction, the axes A1,2,3,4 of all the tool holders W1,2,3,4, are arranged on the column 3 on the generatrixes of a right circular cylinder having the second axis R as its axis, and as radius the metric dimension CR, distance between said first axis C and second axis R.

[0087] Subsequently, the processing unit commands the translating carriages of the machine tool which support the operating unit G via its supporting base 1, to perform a combined translation along the X and Y directions, following which the foot of said first axis C - and therefore of said axis Ak - coincides with an initial point O' of the work curve A, along which to carry out a subsequent work, for example cutting, on piece L.

[0088] Still subsequently, the rotating plate 2 is actuated by the first actuator means 41, to carry out a controlled rotation 1T around the first axis C, following which the tool Uk - when it has been lowered and penetrated into the piece L by the necessary depth - highlights on the piece its oriented trace 15, as a segment, already oriented according to the tangent to the curve A at its initial point O'.

[0089] A further operating step provides that the tool holder Wk, still stationary on its own linear track 26k in the relative initial position 51k proximal to the rotoidal pair 22, is operated in vertical lowering along said linear track, up to a position 53k, distal to the revolving pair 22. The vertical lowering is performed by a respective 43k of the third actuator means 431,2,3,4 present on the linear tracks, where the relative command also in this case comes from the processing unit of the associated machine.

[0090] As already mentioned, in the present second arrangement, it is possible to reduce the number of third actuator means 431,2,3,4 from four, arranged one on each linear track, to only one 43, integral with said rotating plate 2 and acting axially according to said first axis C.

[0091] Once the tool holder Wk has been lowered by

translating it towards the piece along said first axis C, its tool Uk penetrates the sheet, which materializes the piece L, according to a segment, oriented trace 15 of the tool on the piece, where on the center Ck of this trace oriented 15 the foot Co of the first axis C falls, orthogonal to the plane xy of the reference system Oxyz.

[0092] The movement along said third direction Z of the relative translating carriage of the machine, being controlled, serves to make the tool Uk penetrate the piece L by the desired quantity.

[0093] From the configuration described, as in said first set-up, the machine begins to move its translating carriages along the X and Y directions, so that the foot Co of the first axis C travels all the points P of the cutting curve A on the sheet being worked, starting from the initial point O' of it, thus physically generating the curve A itself with the cut.

[0094] The sequence of points P of the piece L on which the tool must act is stored in the processing unit of the associated machine tool and is supplied, for example, with an equation of the curve A itself.

[0095] During these operations, and always under command from the processing unit, the machine orients the rotating plate 2 so that, as the cut progresses, the oriented trace 15 of the tool on the workpiece is always oriented as the tangent to curve A itself.

[0096] In both setups described, the purpose of the movements that are made to perform by the various members of the operating unit G - and to the operating unit itself as a whole, through the movements of the translating carriages of the associated machine tool - is to bring the axis Ak of the tool holder Wk (k=1 ,2,3,4) to be selected for the work, at coinciding with the first axis C of the machining unit, and this takes place in the two different ways examined above, depending on the set-up. Subsequently, the foot of said first axis C must be brought to each point P of the work curve A assigned on the piece, and this takes place by means of the translations commanded by the translating carriages of the machine tool to which the operating unit is associated. Finally, it is necessary to rotate the rotating plate 2 of the operating unit G, with which the tool holder is made integral during this operation, around said first axis C, so that the oriented trace 15 of the tool can be oriented according to the tangent in P to the given working curve.

[0097] In other words, after having brought the axis Ak of a tool holder to coincide with said first axis C of the operating unit, it is then necessary to bring, by means of the translations of the translating machine carriages, the center Ck of the oriented track 15 of the tool - also the foot Co of the first axis C on the surface of the piece L - in correspondence with each point P of the working curve to be generated. Finally, it is necessary to rotate the rotating plate 2 of the operating unit G around said first axis C, until the oriented trace 15 of the tool is directed as the tangent to the working curve, and oriented in the advancement direction.

[0098] According to this operating mode, the actuation of the rotations 1T around said axis Ak of the tool holder Wk in operation, necessary to follow the inclination α of the tangent to the cutting curve in the various points P thereof, does not require an actuator dedicated to the rotation of the single tool holder, as instead happened in the prior art. In fact, these are rotations about the first axis C, and they are carried out in any case by the first actuating means 41 of the operating unit itself.

[0099] The suitability of the operating unit G to perform the movements just described derives directly from the reciprocal arrangement of its members, as previously described in said first and second setups. Instead, the amplitude of the aforementioned movements, which, according to the architectures described, the various members must and can perform in order to correctly perform the cutting function, can be deduced from geometric and kinematic considerations that the particular design of the operating unit makes relevant to it.

[0100] The following considerations quantify the extent of the rotations to be performed around said first axis C, and the coordinates of the positions to be reached with the foot Co of said first axis C, and substantially apply to both said setups.

[0101] Therefore, having assigned a Cartesian reference system, with the three orthogonal axes Oxyz parallel to said directions X, Y, and Z, and with the origin O placed on the work table of the machine, in reference to a cutting operation to be performed on the sheet-shaped piece L, a cutting curve A is assigned on the flat surface of the piece itself, for example by means of a Cartesian equation of it, or by means of its parametrization.

[0102] For creasing, the following considerations apply.

[0103] Said cutting curve A is, by definition, a plane curve, which usually results from the connection of several arcs, connected to each other at the ends, such that the connection in succession of these arcs represents the entire curve A. Some of these arcs can be portions of notable and particularly simple curves, such as straight line segments and/or arcs of circles or parabolas, while other arcs - to be cut, for example, to create artistic shapes - can also be non-trivial curves.

[0104] On said cutting curve A, a curvilinear abscissa s is considered, which is the length of the section of the curve, supposedly rectified, and measured from a point O' of the curve A itself. This curvilinear abscissa is called the natural parameter of curve A. The cut begins from said point O', which, as it proceeds along the curve A, passes through its generic point P, following point O' in the direction of the cut.

[0105] With the positions made, the parameter s increases in the advancement direction of the cut along the curve A, and said generic point P, seen as a function of s, is also indicated as *P(s)*.

[0106] Formally, said length s is assumed as a continuous variable, even if in carrying out operations on the computer - such as, for example, numerical derivations - it is discretized by the processing unit, and the theoret-

ical differential quantities are calculated as finite differences.

[0107] In this sense, the cutting curve A can be considered as a continuum of points *P(s),* and on it the mathematical techniques relating to the curves parametrized by a continuous variable can be formally used.

[0108] Therefore, a generic point P=(x, y) on the given cutting curve A becomes a known function *P*(*s*) = (*x*(*s*),*y*(*s*)) of the parameter s. Likewise, the vector (*P*(*s*) - *0*) identifies the point on the Oxy plane *P(s)* of the curve A, where the center Ck of the oriented trace 15 of the tool Uk which has been selected for the work must be brought - by means of the translations of said translating carriages of the machine; where, as it has been described, the operating unit G, on the said center Ck of the oriented tool track 15, the foot Co of the said first axis C must also fall, orthogonally to the said work table.

[0109] With these positions, in the same spot *P(s)* of the curve A, be the tangent versor T is the normal unit vector N to the cutoff curve A, they also result in respective functions T(s) ed *N*(*s*) of the same parameter s, and can be quantified with the following geometric formulas:

$$\underline{T}(s)=dP/ds\ ,$$

$$\underline{N} = Ro\cdot(d\underline{T}/ds) = Ro\cdot(d^2P/ds^2) = \pm\underline{k}\wedge\underline{T},$$

$$1/Ro\cdot(s)= \left\| d^2P/ds^2 \right\|,$$

$$Q(s) = P(s)+Ro\cdot\underline{N}$$

$$\alpha = arctg(Ty/Tx),$$

where: k is the versor of the Z axis of the right reference Oxyz; Ro=Ro(s) is the radius of curvature of cutting curve A at its point P(s); α(s) is the inclination of the tangent line on the X axis; Q(s) is the center of curvature of shear curve A at P.

[0110] In the double sign of the term $\pm\underline{k}\wedge\underline{T}$, the positive sign is assumed when the versor $\underline{T}$ runs along the curve leaving the concave part of the curve, i.e., the versor N, to the left; otherwise, it assumes a negative sign. Other symbols have their usual mathematical meaning.

[0111] The numerical values corresponding to the given formulas are easily computable, for each point P(s) of A, by means of usual calculation programs normally implemented in the processing units of machine tools, simply by supplying an equation of the curve A, in any form, as for example in the Cartesian form; or in the parametric form P(s) mentioned above; or in a re-parameterized form with another parameter, which advantageously maintains the same travel direction of the physical cut.

[0112] With the given formulas, the suitability of the operating unit G remains proven also from the quantitative point of view of the movements foreseen in it, when a calculation code is implemented - resident in the associated machine tool - based on the seen formulas, or on other equivalent, known from geometry.

Advantages

[0113] A first advantage of the present invention is that, although all the tool holders which are used for the cutting and/or creasing operations remain available on board the operating unit itself, it is not necessary for each tool holder to be associated with its own controlled rotation actuator. In fact, in the operating unit described here, the orientation of the tool holder, which is selected from time to time to operate on the piece, is carried out by means of the controlled rotation of the rotating plate 2 around the first axis C, after bringing the axis of the working tool holder to coincide with the first axis C itself. In this way, with a single controlled rotary actuator, the correct orientation of the plate, which materializes the tool is guaranteed, i.e. of the oriented trace 15 of the working tool, in accordance with the tangent to the cutting curve A, on all points thereof. This minimizes the number of rotary actuators.

[0114] A further advantage of the present invention is represented by the fact that, unlike what happens in the prior art, in the operating unit described here it is not necessary that each tool holder is associated with its own actuator for the controlled lowering of the tool holder towards the workpiece. Instead, here a simple actuator of the on-off type, dedicated to each tool holder, of the type of the described third actuator means 431,2,3,4 is sufficient.

[0115] In fact, once the selection of the tool holder Wk to be lowered onto the piece has been made, with the respective 43k of said third actuator means, the subsequent fine vertical adjustment of the tool holder on the piece is here performed, by means of the translation along said third direction Z of one of the translating carriages of the machine tool.

[0116] Therefore, also for the vertical actuation of the tool holder from time to time in work, with the operating unit conforming to the present invention, the multiplication of the costs necessary to equip each tool holder with a controlled vertical linear axis is avoided, an equal effect being obtained here with a single controlled actuator, moreover external to the operating unit, but borrowed by very advantageously exploiting a characteristic normally present in the wide class of machine tools suitable for being associated with the invention described herein.

[0117] The present invention has been described for illustrative but not limitative purposes, according to its preferred embodiments, but it is to be understood that modifications and/or changes can be introduced by those skilled in the art without departing from the relevant scope as defined in the enclosed claims.

Claims

1. Operating unit (G) for cutting or creasing flat sheets (L) made of soft materials such as cardboard, poliwave plastics, composite materials, comprising

   a supporting base (1),
   a rotating plate (2), rotatably coupled to said supporting base (1) about a first axis (C) to perform a first rotation (1T);
   a support column (3), having one end constrained to said rotating plate (2), by means of first guide means (20), wherein said support column (3) is adapted to constrain a plurality of tool holders (Wk), arranged on it with the respective operating axes (Ak) parallel to said first axis (C), and equipped with respective tools (Uk);
   wherein said operating unit (G) is **characterized in that** said first guide means (20) are configured to allow a translation (61), or rotation (62) first movement of said support column (3) with respect to said rotating plate (2), such that the operating axis (Ak) of one of said tool holders (W1,2,..., k,... n) coincides with said first axis (C).

2. Operating unit (G) according to the preceding claim,

   wherein said support column (3) has on its side surface (25) a plurality of linear tracks (261,2,..., k,... n) parallel arranged to said first axis (C), on each of which a respective tool holder (Wk) is slidingly constrained, and lockable in a respective initial (51k), or final (53k) position, and
   wherein said group (G) comprises at least one linear actuator (43k), acting along at least one (26k) of said linear tracks (261,2,..., k,... n), to command a translation of the relative tool holder (Wk) from said initial position (51k), to said final position (53k) of said linear track (26k), wherein the respective tool (Uk) is engaged, in use, on a flat plate (L).

3. Operating unit (G) according to any one of the preceding claims,

   wherein said first guide means (20) comprise translating guide means, configuring a cross carriage (21),
   wherein the first slide (7) of the cross carriage (21) is slidable with respect to said rotating plate (2), along a first direction (X) thereof, to perform a first stroke (71) on first prismatic pairs (23), interposed between said first slide (7) and said rotating plate (2), and
   wherein the second slide (8) of the cross carriage (21) is sliding, with respect to said first slide (7), along a second direction (Y), transversal to said first direction (X), to perform a second stroke (81) on second prismatic pairs (24), interposed between the second slide (8) and the first slide (7).

4. Operating unit (G) according to the preceding claim,

   wherein said support column (3) is integral, by means of its own base, to said second slide (8), and
   wherein said first translation movement (61) of said column support (3) with respect to said revolving plate (2), on the first guide means (20, 21), is made by means of one and/or both of said first stroke (71), second stroke (81).

5. Operating unit (G) according to any one of the preceding claims,

   wherein said first guide means (20) comprise rotary guide means, configuring a rotoidal pair (22) made around a second axis (R) of said rotating plate (2), parallel to said first axis (C), and spaced by a metric dimension (CR) from it, and wherein in said rotoidal pair (22)

      the first member comprises a first disk (22A) integral with said rotating plate (2), and
      the second member comprises a second disk (22B), coaxial with said first disk (22A), and further rotatable with respect to said rotating plate (2), to perform a second rotation (2T) around said second axis (R).

6. Operating unit (G) according to the preceding claim,

   wherein said support column (3) substantially emulates the shape of a right prism with a regular polygonal section, and is made integral with said second disk (22B) of said rotoidal pair (22) by means of its own base, wherein the geometric axis (3A) of said prism is arranged coincident with said second axis (R); said linear tracks (261,2,..., k,... n) being arranged on the lateral faces of said prism, so that each said axis (A1,2,..., k,... n) respective of each said tool holder (W1,2,..., k,... n) is placed at a distance from said geometric axis (3A) equal to said metric height (CR), and
   wherein said first movement (62), of rotation of said support column (3) with respect to said revolving plate (2), on said first guide means (20,22), is made by means of said second rotation (2T).

7. Operating unit (G) according to any one of the preceding claims,

   wherein one of said tool holders (W1,2,..., k,...

n) comprises a respective tool (Uk) having the shape of a flat plate (9k), preferably made of metal, equipped with a respective active edge (10k) acting, in use, on said flat plate (L), and wherein said active edge (10k) is sharp, to perform cuts or bevel-type, to perform creasing.

8. Operating unit (G) according to any one of the preceding claims, wherein in at least one (Wk) of said tool holders (W1,2,..., k,... n), the relative tool (Uk) is mounted so that said active edge (10k) is incident to said operative axis (Ak).

9. Operating unit (G) according to any one of claims 1-7, wherein in at least one of said tool holders (W1,2,..., k,... n), the relative operating axis (Ak) belongs to the geometric plane of said flat plate (9k).

10. Operating unit (G) according to any one of claims 1-7,

wherein in at least one of said tool holders the relative tool (Uk) is a rolling type tool, wherein said rigid plate (9k) has the shape of a circle, whose active edge (10k) is located on the external circumference,
and wherein said tool (Uk) is supported in rotation by a pin of said tool holder (Wk), arranged in a normal way with respect to said operative axis (Ak).

11. Operating unit (G) according to any one of the preceding claims, comprising

first actuating means (41) for rotating said rotating plate (2) with respect to said supporting base (1), and
second actuating means (42) for controlling the movements of said support column (3) with respect to said rotating plate (2), on said first guide means (20).

12. Operating unit (G) according to claims 3 and 11, wherein said second actuating means (42) are actuators for rectilinear motions (42'), and act on said first slide (7) to control said first stroke (71), and on said second slide (8) to control said second stroke (81).

13. Operating unit (G) according to claims 5 and 11, wherein said second actuator means (42) are actuators for rotary motions (42"), and act on said second member (22B) of said rotational torque (22), to command said second rotation (2T).

14. Operating unit (G) according to any one of the preceding claims,

wherein said supporting base (1) is suitable for positioning on a movable translating carriage, in a machine tool equipped with a processing unit, and
wherein said actuator means (41, 42, 42', 42 ", 431,2,..., k,..., n) of said operating unit (G) are fed by said machine tool, and/or controlled in their movements by said processing unit.

15. Operating unit (G) according to claim 7, wherein said active edge (10k) is cutting edge, to perform cuts, and
wherein said at least one said tool holder (Wk) comprises a pneumatic or electric actuator, which gives a oscillating axial motion to said tool plate (9k).

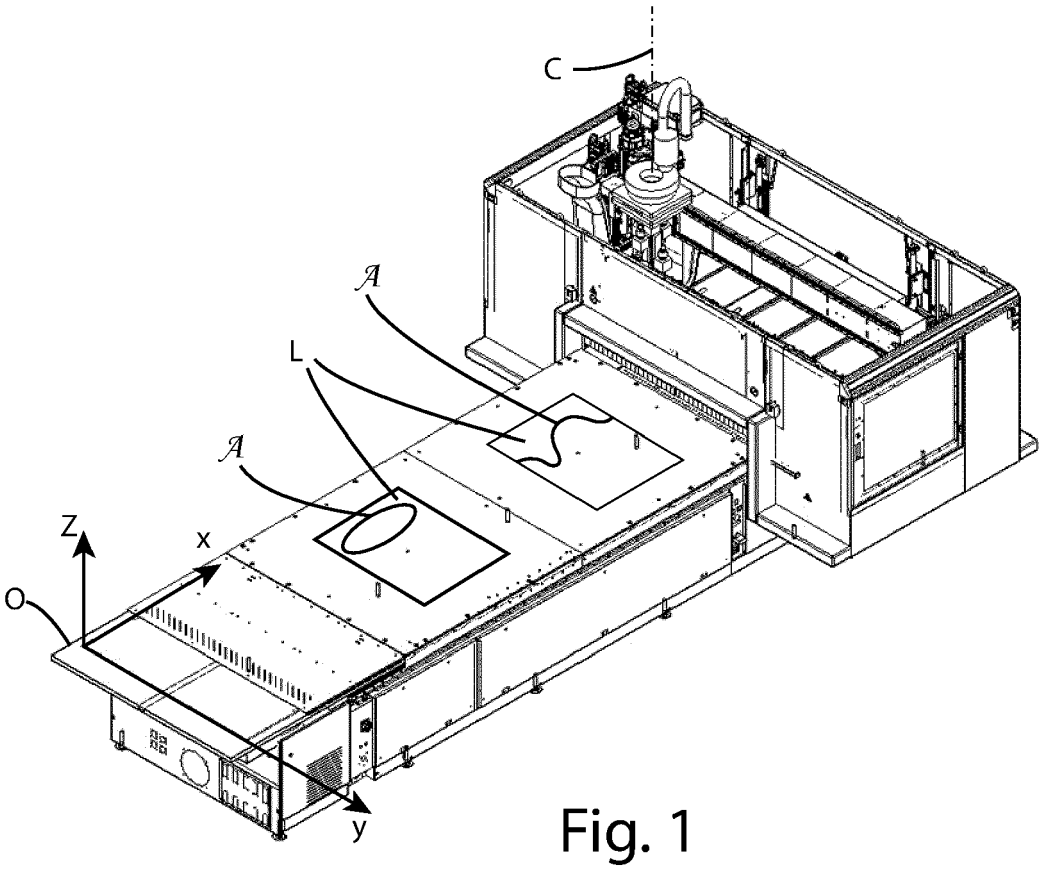

Fig. 1

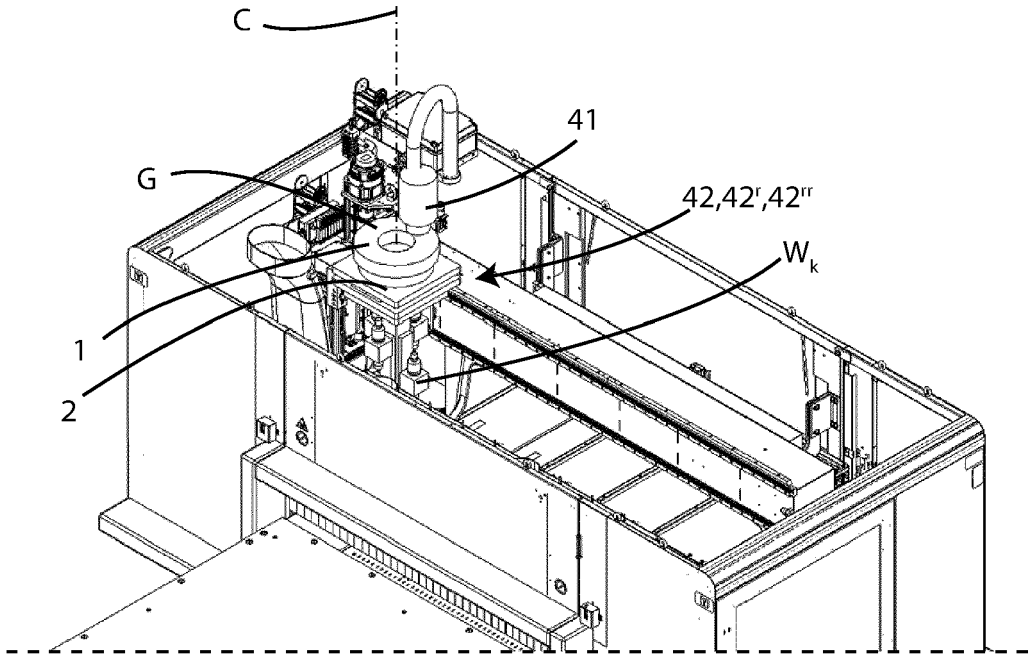

Fig. 2

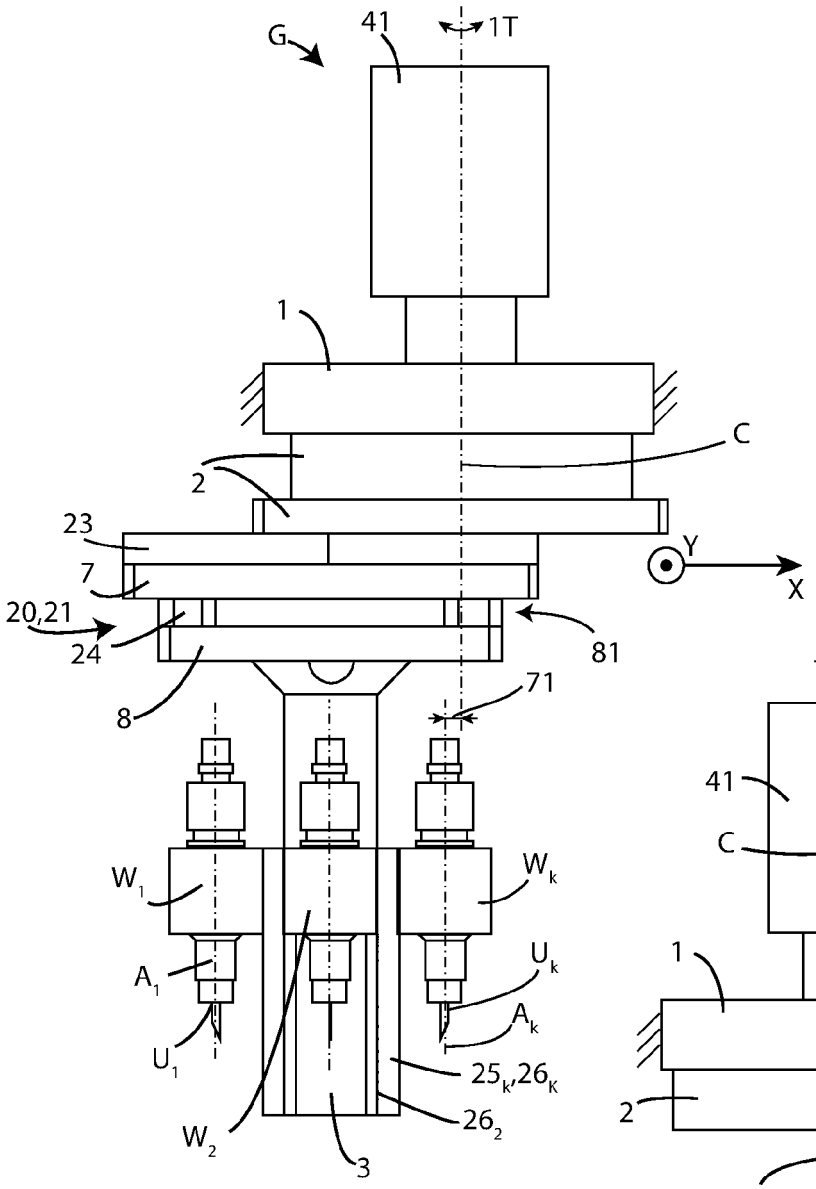
G
41
1T
1
C
2
23
7
20,21
24
81
71
8
Y
X
W1
Wk
Uk
A1
Ak
U1
25k,26K
W2
262
3

Fig. 3

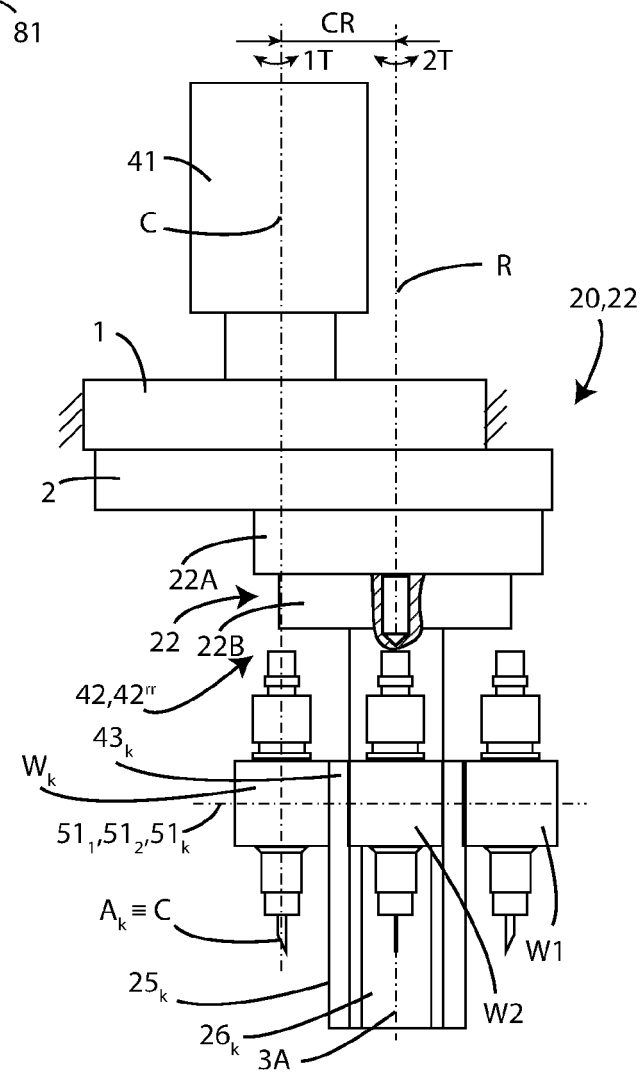
CR
1T
2T
41
C
R
20,22
1
2
22A
22
22B
42,42rr
43k
Wk
51₁,51₂,51k
Ak ≡ C
25k
26k
3A
W1
W2

Fig. 4

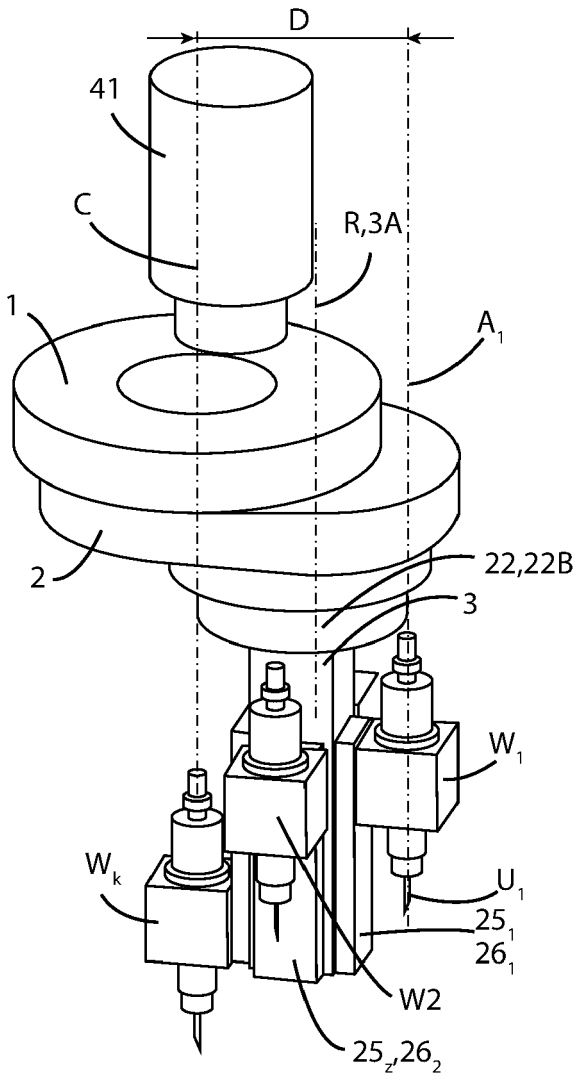
D
41
C
R,3A
1
A1
2
22,22B
3
W1
Wk
U1
251
261
W2
252,262

Fig. 5

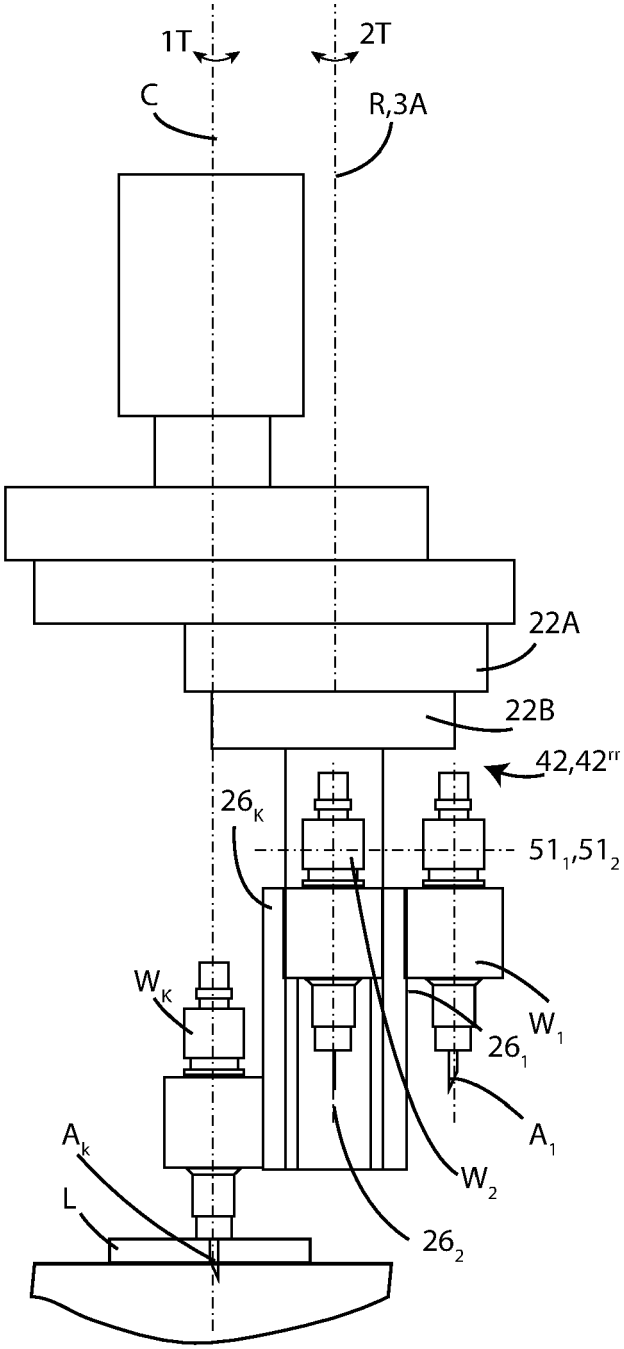
1T
2T
C
R,3A
22A
22B
42,42rr
26K
511,512
WK
W1
261
A1
Ak
W2
L
262

Fig. 6

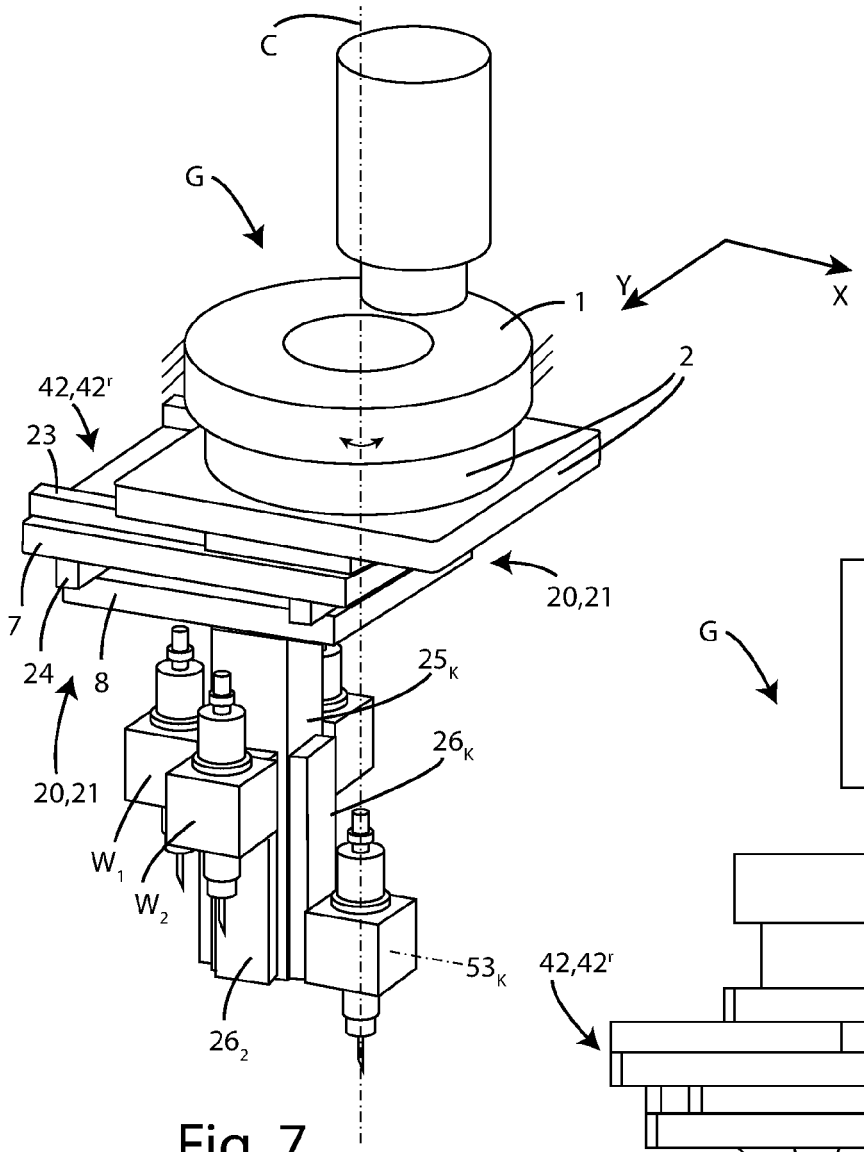
C
G
Y
X
1
2
42,42r
23
20,21
7
24
8
20,21
25K
26K
W1
W2
53K
26₂

Fig. 7

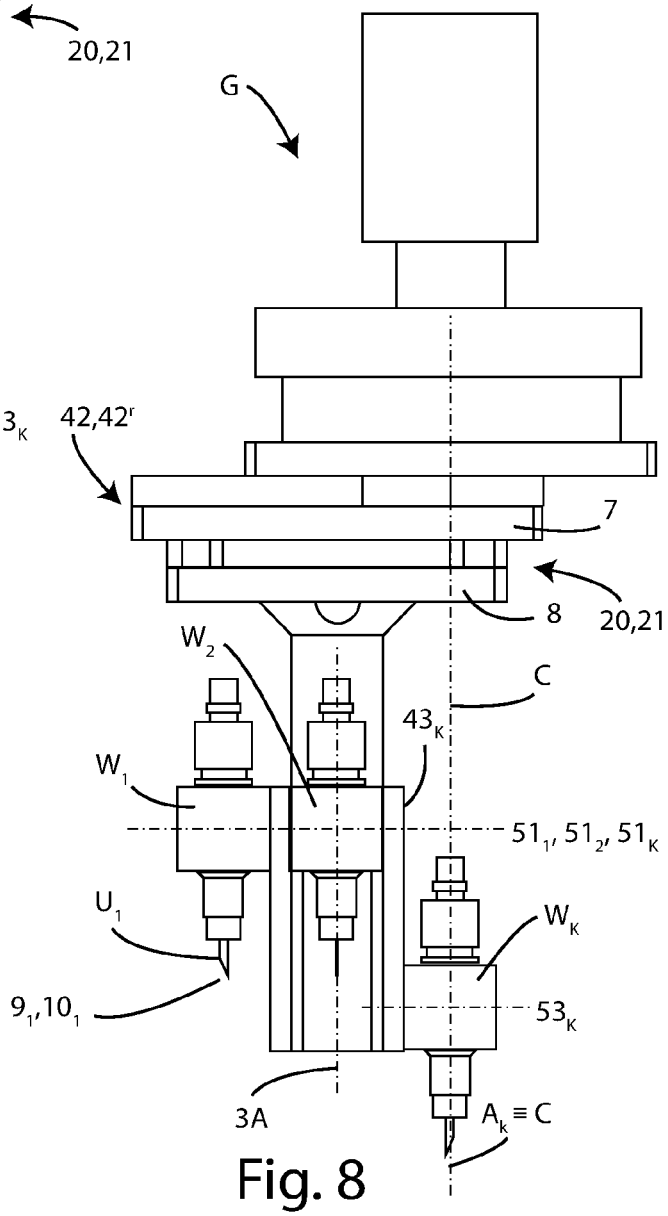
G
42,42r
7
8
20,21
W2
C
43K
W1
51₁, 51₂, 51K
U1
WK
9₁,10₁
53K
3A
Ak ≡ C

Fig. 8

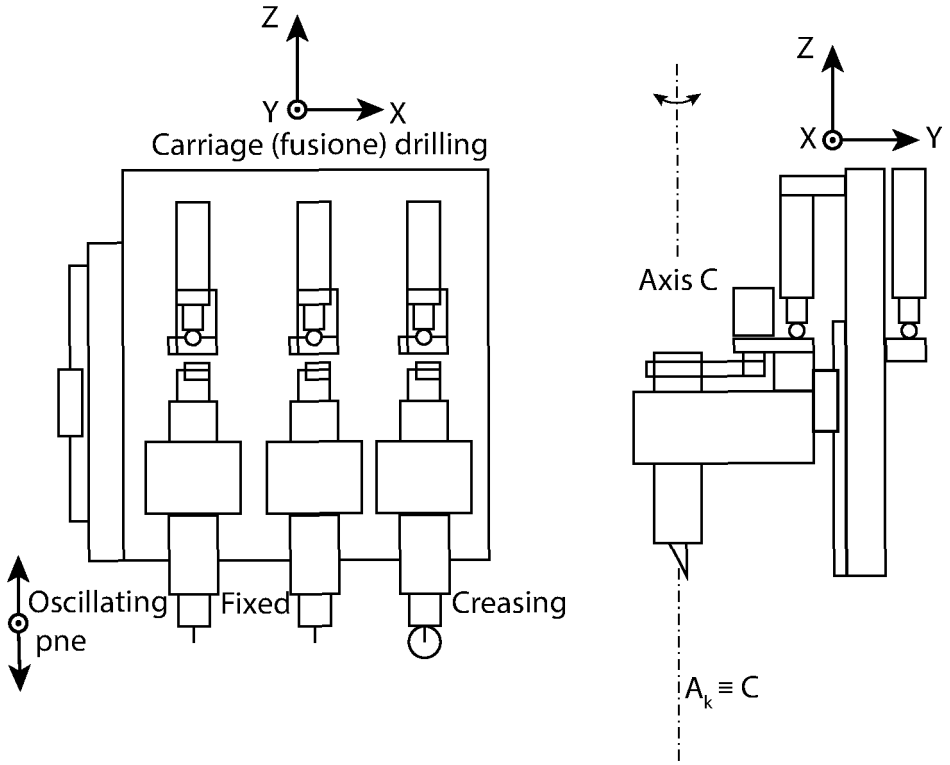
Z
Y
X
Carriage (fusione) drilling
Oscillating
pne
Fixed
Creasing
Z
X
Y
Axis C
$A_k \equiv C$

Fig. 9

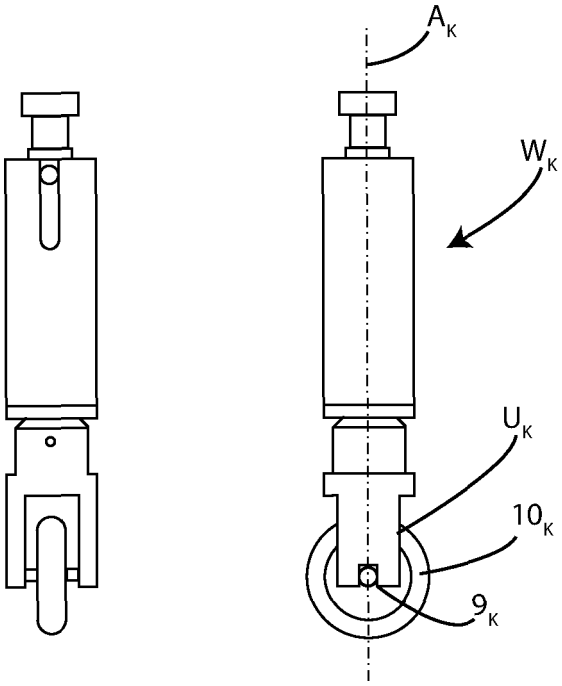
A_K
W_K
U_K
10_K
9_K

Fig. 10

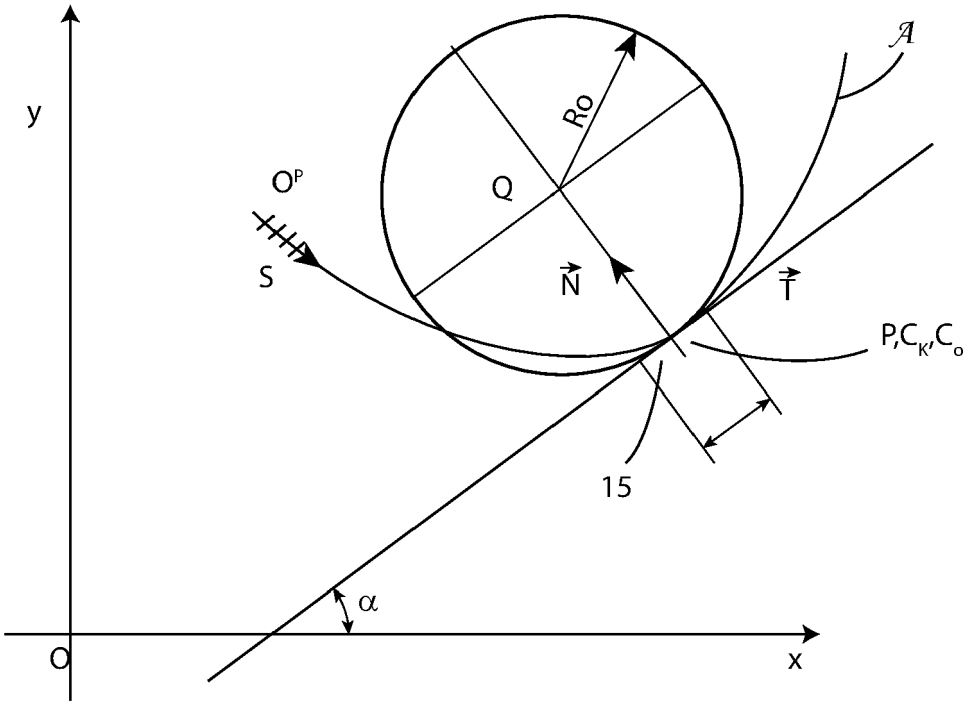

Fig. 11

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 23 17 5342

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2007/256530 A1 (STEIN DARRYL C [US]) 8 November 2007 (2007-11-08) * paragraph [0025] - paragraph [0029]; figures 1-5 *	1-15	INV. B26F1/38 B26D5/00 B26D5/02 B26D5/08 B26D7/26 B31F1/08 B26D3/08 ADD. B26D7/00 B26F1/44
A	DE 10 2007 022200 A1 (SCM GROUP SPA [IT]) 22 November 2007 (2007-11-22) * paragraph [0026] - paragraph [0031]; figures 1,2 *	1	
A	GB 2 004 210 A (STARK G) 28 March 1979 (1979-03-28) * page 3, line 9 - line 95; figures 1-3 *	1	
A	US 5 451 196 A (CHIRON WERKE GMBH [DE]) 19 September 1995 (1995-09-19) * column 4, line 56 - column 6, line 32; figures 1,2,5 *	1	

TECHNICAL FIELDS SEARCHED (IPC)
B26F B26D B31F B23Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	26 October 2023	Maier, Michael

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 17 5342

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
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

26-10-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007256530 A1	08-11-2007	CN 101437656 A	20-05-2009
		EP 2015905 A1	21-01-2009
		JP 5283617 B2	04-09-2013
		JP 2009536584 A	15-10-2009
		US 2007256530 A1	08-11-2007
		WO 2007133196 A1	22-11-2007
DE 102007022200 A1	22-11-2007	NONE	
GB 2004210 A	28-03-1979	AT 357842 B	11-08-1980
		BE 870514 A	02-01-1979
		BR 7806056 A	15-05-1979
		CH 631097 A5	30-07-1982
		DD 140114 A5	13-02-1980
		DE 2741802 A1	12-04-1979
		ES 473392 A1	16-04-1979
		FR 2403142 A1	13-04-1979
		GB 2004210 A	28-03-1979
		IT 1098572 B	07-09-1985
		JP S5453373 A	26-04-1979
		JP S6357179 B2	10-11-1988
		NL 7809179 A	20-03-1979
		US 4223579 A	23-09-1980
		YU 217778 A	30-06-1982
US 5451196 A	19-09-1995	DE 4329252 A1	02-03-1995
		EP 0640432 A1	01-03-1995
		ES 2094603 T3	16-01-1997
		JP 2608530 B2	07-05-1997
		JP H07156037 A	20-06-1995
		US 5451196 A	19-09-1995

EPO FORM P0459

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