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(71) Applicant: **Rollomatic S.A.**
2525 Le Landeron (CH)

(72) Inventors:
- **Marty, Jean-Charles**
  2520 La Neuveville (CH)
- **Picon, Fabien**
  2520 La Neuveville (CH)
- **Quirici, Even**
  2015 Areuse (CH)

(74) Representative: **P&TS SA (AG, Ltd.)**
Avenue J.-J. Rousseau 4
P.O. Box 2848
2001 Neuchâtel (CH)

(54) METHOD OF MACHINING SEVERAL WORKPIECE BLANKS WITH A MACHINE TOOL AND A SET OF CUSTOMIZED SUPPORTS FOR THE METHOD THEREOF

(57) The invention relates to a set of customized supports (10a, 10b, 10c) for supporting workpiece blanks (20a, 20b, 20c) of different diameters. Each customized support (10a, 10b, 10c) is adapted to be hold by a same mounting support (40) aligned with a spindle (112) of a machine tool (110) or to respective mounting support (40a, 40b, 40c) to be aligned with said spindle (112). Each customized support (10a, 10b, 10c) has a supporting surface (11) for supporting a portion of a workpiece blank (20a, 20b, 20c) during machining, wherein the shape and/or dimensions of said supporting surface (11) is different between each customized support (10a, 10b, 10c) of the set of customized supports so as to offset the difference in diameter between different workpiece blanks (20a, 20b, 20c) having different diameter such that a portion of a workpiece blank to be machined is always supported by a customized support (10a, 10b 10c) when mounted on the same mounting support (40) of the machine tool (110) or by a customized support (10a, 10b 10c) of respective mounting support (40a, 40b, 40c) without requiring any height adjustment of the mounting support (40; 40a, 40b, 40c). The invention also relates to a method of machining several workpiece blanks using the set of customized supports (10a, 10b, 10c) and to a machine tool (50) adapted to perform the method.

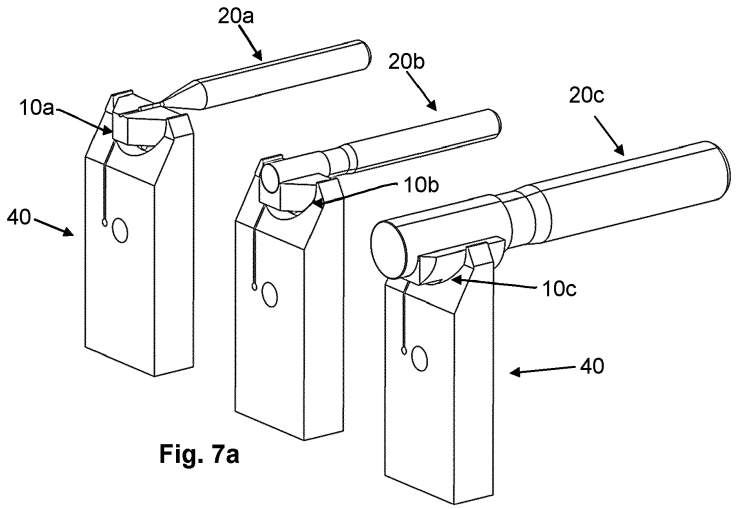

Fig. 7a

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Description

Field of the invention

[0001] The present invention relates to a method of machining several workpiece blanks, in particular cutting tools, of different diameters. The invention also relates to a set of customized supports for supporting workpiece blanks of different diameters as well as an automated system to carry out the aforesaid method.

Background of the invention

[0002] In the production by grinding of cutting tools, grinding wheels exert significant forces during material removal. These forces cause the tool blank to be deformed/displaced by bending/twisting, for example, resulting in dimensional errors or vibrations that can impair the quality of the cutting edges.

[0003] In order to limit dimensional errors or vibrations, it is possible to reduce the forces exerted on the tools during machining by reducing the machining speeds or by reducing the amount of material removed by the grinding wheels at one time. These methods lead to a considerable increase in tool machining times and thus in manufacturing costs. Another method that can limit dimensional errors or vibrations during tool machining is to support the blanks at specific positions and at specific times during the grinding cycle with one or more supports to prevent the tools from bending or vibrating under the effect of the grinding forces.

[0004] Today there are several ways to support tools during machining, including the use of fixed or retractable supports of various shapes. However, for each tool diameter, it is necessary to either replace or adapt the support by manual adjustment in order to optimize its efficiency and thus reduce the deformations or vibrations produced on the tool by the grinding forces. These exchanges or adaptations cause production stoppages and thus increase manufacturing costs.

[0005] When producing large quantities of tools of the same type and diameter, the support setting times can be spread over a large number of machined tools and therefore have little impact on the unit production cost.

[0006] On the other hand, when machining small quantities of tools, setup times and high changeover frequencies result in high costs for each tool produced. Machine operators have to intervene quickly for each new set-up in order to change, adapt or adjust the supports for the new tools and thus be able to restart production quickly. These set-up times reduce the productivity of the machine. It often happens that several machines finish tool production more or less at the same time and cannot be restarted in production because there are no operators available to adjust the supports of each machine.

[0007] In order to significantly reduce machine downtime between the change of different types of tools or diameters and without having to increase the number of machine operators, it is necessary to automate the tool changes necessary for the production of each type of diameter of tool, including the automatic change of the support.

[0008] An aim of the present invention is therefore to provide a set of customized supports for supporting a distal portion of different workpieces during machining of the workpiece and adapted for automated switching of customized support as a function of the workpiece to be machined.

[0009] Another aim of the present invention is to provide a method for changing the customized support as as a function of the workpiece to be machined.

Brief summary of the invention

[0010] These aims are achieved by a set of customized supports for supporting workpiece blanks of different diameters. Each customized support is adapted to be hold by a same mounting support aligned with a spindle of a machine tool or to respective mounting support to be aligned with the spindle. Each customized support has a supporting surface for supporting a portion of a workpiece blank during machining. The shape and/or the dimensions of the supporting surface is different between each customized support of the set of customized supports so as to offset the difference in diameter between different workpiece blanks having different diameter such that a portion of a workpiece blank to be machined is always supported by a customized support when mounted on the same mounting support of the machine tool or by a customized support of respective mounting support without requiring any height adjustment of the mounting support.

[0011] In an embodiment, each customized support comprises a concave surface for supporting a distal portion of a workpiece blank during machining. The radius of curvature of the concave surface of each customized support of the set of customized supports is different in order to offset said difference in diameter between different workpiece blanks having different diameter.

[0012] In an embodiment, each customized support comprises a gripping interface for automated interchangeability in the mounting support of a customized support with another customized support as a function of the diameter of the workpiece blank to be machined.

[0013] In an embodiment, each customized support comprises a mating part configured to be held in a complementary mating part of the mounting support.

[0014] In an embodiment, the mating part of each customized support is a convex bottom surface and the complementary mating part of the mounting support is a concave surface having a radius of curvature corresponding substantially to the radius of curvature of said convex bottom surface of each customized support.

[0015] Another aspect of the invention relates to a method of machining several workpiece blanks with a machine tool, notably a grinding machine. The method

comprises the seps of:

a. mounting a first workpiece blank of a first diameter in a spindle of the machine tool;
b. mounting a mating part of a first customized support into a complementary mating part of a mounting support of the machine tool, wherein the first customized support is selected among the set of customized supports according to any of paragraphs [0010] - [0013], as a function of the diameter of the workpiece blank to be machined;
c. machining the first workpiece blank and possibly one or more additional workpiece blanks of a same batch having the same or similar diameter as said first workpiece blank;
d. interchanging in the spindle the machined workpiece with a second workpiece blank having a second diameter different from the first diameter of the first workpiece blank;
e. interchanging said first customized support with a second customized support in the complementary mating part of the mounting support, wherein the second customized support is selected among the set of customized supports according to any of paragraphs [0010] - [0013], as a function of the diameter of said second workpiece blank to be machined, and
f. machining the second workpiece blank and possibly one or more additional workpiece blanks of a same batch having the same or similar diameter as said second workpiece blank.

[0016] In an embodiment, step b. may be performed before step a. and step e. may be performed before step d.

[0017] In an embodiment, a robotic arm with an end-effector is placed within arm reach of the mounting support and of a support storage storing different customized supports according to any of paragraphs [0010] - [0013], the step of interchanging said customized support with another customized support comprising:

- gripping with the end-effector of the robotic arm the customized support in the complementary mating part of the mounting support and placing said customized support in the support storage, and
- gripping another customized support in the support storage, and placing said another customized support in the complementary mating part of the mounting support.

[0018] In an embodiment, the mounting support comprises an elastic portion and actuating means arranged to cooperate with the elastic portion. The elastic portion comprises a distal end which forms a portion of the complementary mating part. The step of interchanging said customized support with another customized support further comprises:

- bending the elastic portion outwardly with the actuating means to widen the complementary mating part before the step of gripping the customized support in the complementary mating part, and
- releasing the actuating means to let the elastic portion to return to its unbent configuration after the step of placing said another customized support in the complementary matin part of the mounting support.

[0019] Another aspect of the invention relates to an automated system for automatic interchangeability of customized supports in the mounting support. The automated system comprises a machine tool, notably a grinding machine having a spindle, an automated clamping support, a support storage for storing different customized supports of the set of customized supports according to any one of paragraphs [0010] - [0013], and a robotic arm comprising an end effector configured to grip a customized support.

[0020] The robotic arm is configured to be actuated to bring a mating part of any customized support from the support storage into a complementary mating part of the mounting support and vice versa. The automated clamping support is configured to bring the complementary mating part from a clamping configuration to an unclamped configuration so that the robotic arm may remove the customized support from the mounting support and from an unclamped configuration to a clamping configuration once the robotic arm has placed another customized support in the mounting support.

[0021] In an embodiment, the support storage is a compartmentalized storage comprising at least six compartments, preferably at least ten compartments. Each compartment is adapted to store a customized support according to any one of paragraphs [0010] - [0013]. The shape and/or dimensions of the supporting surface of each customized support sored or to be stored in one compartment is different from the shape and/or dimensions of the supporting surface of the customized support stored or to be stored in any other compartment of the compartmentalized storage.

[0022] In an embodiment, the automated clamping support comprises an actuator. The actuator comprises a piston, a lever actuable by the piston, and actuating means arranged to cooperate with an elastic portion having a distal end which forms a portion of the complementary mating part in order to bend outwardly the elastic portion to bring the mounting support from a clamping configuration to an unclamped configuration.

[0023] In an embodiment, the mounting support comprises a longitudinal passage extending from a first lateral side of the mounting support through the mounting support up to a longitudinal slit extending upwardly up to the complementary mating part. A rod is arranged inside the longitudinal passage and comprises a first end in abutment against the elastic portion of the mounting support and a second end protruding from the first lateral side of the mounting support.

[0024] In an embodiment, the lever comprises an actuating part and is configured to pivot about an axis of rotation when actuated by the piston to bring and push the actuating part against the second end of the rod to impart a translation movement to the rod causing the first end of the rod, in abutment against the elastic portion of the mounting support, to push against the elastic portion thereby bending outwardly to widen the complementary mating part of the mounting support to bring it into an unclamped configuration.

[0025] In an embodiment, the lever is arranged to cooperate with an elastic member configured to urge the lever in a non-actuating configuration.

Brief description of the drawings

[0026] The invention will be better understood with the aid of the description of several embodiments given by way of examples and illustrated by the figures, in which:

- Figure 1a shows a perspective view of a customized support for supporting a workpiece blank of a first diameter to be machined;
- Figure 1b shows a front view of Figure 1a;
- Figure 2a shows a perspective view of a customized support for supporting a workpiece blank of a second diameter to be machined;
- Figure 2b shows a front view of Figure 2a;
- Figure 3a shows a perspective view of a customized support for supporting a workpiece blank of a third diameter to be machined;
- Figure 3b shows a front view of Figure 3a;
- Figure 4a shows a perspective view of a customized support according to another embodiment;
- Figure 4b shows a front view of Figure 4a;
- Figure 5a shows a perspective view of a customized support according to another embodiment;
- Figure 5b shows a front view of Figure 5a;
- Figure 6a shows a perspective view of a customized support according to another embodiment;
- Figure 6b shows a front view of Figure 6a;
- Figure 7a shows a perspective view of a mounting support holding respectively a first, a second and a third customized support supporting respective first, second and third workpiece blank of different diameters;
- Figure 7b shows a front view of Figure 7a;
- Figure 7c shows a partial front view of a mounting support holding a customized support according to another embodiment;
- Figure 8 shows a perspective view of an automated system comprising grinding machine with an automated clamping support for holding a customized support according to an embodiment and a robotic arm for automated change of customized support in the clamping support;
- Figure 9 shows a perspective view of the grinding machine of Figure 8 with a compartmentalized storage for storing a plurality of customized supports,
- Figure 10 shows a front view of the automated clamping support of Figures 7a and 8,
- Figure 11 shows a detailed view of the automated camping support of Figure 10,
- Figure 12 shows a front view of an automated clamping support for holding a customized support according to another embodiment in a rest configuration;
- Figure 13 shows a similar view of Figure 12 when the automated clamping support is activated, and
- Figure 14 shows a front view of an automated support for holding several customized supports according to another embodiment of the invention.

Detailed description of several embodiments of the invention

[0027] With reference to Figures 1a to 3b, each customized support of the set of customized supports 10a, 10b, 10c comprises a supporting surface in the form of a concave surface 12a, 12b, 12c arranged on an upper portion of the customized support and a mating part 16 arranged on a lower portion of the customized support. The mating part 16 of each customized support 10a, 10b, 10c of the set of customized supports, are identical and are shaped to be locked into a complementary mating part 42 of a mounting support 40 as shown for example in Figure 7b.

[0028] The mating part 16 may have for example circular convex surface while the complementary mating part 42 may a corresponding circular concave surface. The mating part may however have other shapes, such as a rectangular shape to be mounted on a mounting support 40 comprising a complementary rectangular shaped recess as shown in Figure 7c.

[0029] The respective concave surface 12a, 12b, 12c of respective customized supports 10a, 10b, 10c, which form together the set of customized supports, is however

unique in the sense that their respective radius of curvatures R_1, R_2, R_3 differs from one another. This unique concave surface 12a, 12b, 12c is designed to offset the difference in diameter between different workpiece blanks 20a, 20b, 20c to support a distal portion of a workpiece blank 20a, 20b, 20c with a specific diameter when the workpiece blank is mounted in the spindle 112 of a machine tool, notably a grinding machine 110 as shown for example in Figure 8.

[0030] A portion of a workpiece blank 20a, 20b, 20c to be machined is therefore always supported by a customized support 10a, 10b 10c designed specifically for the specific diameter of that portion when the corresponding customized support is mounted on the same mounting support 40 of the machine tool without requiring any height adjustment of the mounting support between the machining of two workpiece blanks of different diameters, which significantly reduce machine downtime.

[0031] The number of customized supports 10a, 10b, 10c, with a unique concave surface 12a, 12b, 12c, forming the set of customized supports may vary according to the application but the greater the number is, the more diverse the machined workpieces are without requiring human intervention for the height adjustment of the mounting support 40. The set of customized supports 10a, 10b, 10c may comprise at least ten customized supports with a unique concave surface, for example 15 unique customized supports or even more.

[0032] With reference to Figures 1a to 3b, each customized support 10a, 10b, 10c comprises a gripping interface 14 for automated interchangeability in the mounting support 40 of a customized support 10a with another customized support 10b, 10c as a function of the diameter of the workpiece blank 20a, 20b, 20c to be machined. The gripping interface 14 may take different forms for example a hole or a protruding part.

[0033] As illustrated in Figures 4a to 6b, the supporting surface 11 of each customized support adapted to support a distal end of the workpiece blank does not necessarily have a continuous concave surface as shown in Figures 1a to 3b.

[0034] For example, the supporting surface 11 may have a non-continuous concave surface having two rounded portions and a notch 13 therebetween as shown in Figures 4a and 4b. According to another variant, the supporting surface 11 is in the form of a V-shaped surface as shown in Figure 5a to 6b. The mating part may also have a shape different than a circular convex surface, for example a triangle prism to be fitted inside a corresponding V-shaped mating part as shown in Figures 6a and 6b.

[0035] In an embodiment, an automated system 100 for automated interchangeability of customized supports in the mounting support 40 is illustrated for example in Figure 8. The automated system 100 comprises the machine tool 110 for example a grinding machine, a support storage 130 having a plurality of compartment 132 (Figure 9) for sorting in each compartment a customized support 10a, 10b, 10c with a unique concave surface 12a, 12b, 12c, an automated clamping support 30 and a robotic arm 120 placed within arm reach of the automated clamping support 30 and of the support storage 130.

[0036] According to an embodiment shown in Figures 10 and 11, the automated clamping support 30 comprises the mounting support 40 and an actuator 60 configured to actuate the mounting support 40 to bring it from a clamping configuration to an unclamped configuration and vice versa as described in detail subsequently. A customized support 10a is firmly held by the mounting support 40 in the clamping configuration while the customized support can be removed from the mounting support 40 in the unclamped configuration.

[0037] The support storage 130 is preferably compartmentalized storage comprising different compartments 132. Each compartment 132 stores or is adapted to store a customized support with a unique concave surface. The robotic arm 120 comprises an end-effector 122 for gripping the gripping interface 14 of any customized support lodged in their respective compartment 132 to bring the mating part 16 of a particular customized support, chosen as a function of the diameter of the workpiece blank 20a, 20b, 20c to be machined, inside the complementary mating part 42 of the mounting support 40, whereupon the mounting support is actuated to bring it in a clamping configuration.

[0038] To that effect, the mounting support 40 is configured to cooperate with the actuator 60. The mounting support 40 comprises an elastic portion 46 having a distal end which forms a portion of the complementary mating part 42 of the mounting support. The elastic portion 46 is separated from the main part of the mounting support 40 by a longitudinal slit 44 extending upwardly to the complementary mating part 42.

[0039] The actuator 60 comprises a connecting part 68 fixed to the elastic portion 46 and an actuable assembly configured to actuate the connecting part 68 in a radial direction to bend the elastic portion 46 outwardly so as to widen the complementary mating part 42 of the mounting support 40 such that the end-effector 122 of the robotic arm 120 may position the mating part 16 of any customized support 10a, 10b, 10c in the complementary mating part 42 of the mounting support.

[0040] In an embodiment, the actuable assembly comprises a piston 62, a rigid linking part 64 and a lever 66. The lever 66 comprises a first end pivotally connected to the rigid linking part 64, a second end pivotally mounted around a pivot 70 fixed to the connecting part 68, and a cylindrical hole 67 mounted around a pivot 48 which is for example a pin which forms an integral part with the mounting support 40 or which is partly fitted inside a corresponding hole 48a of the mounted support 40 as illustrated in Figures 7a and 7b.

[0041] Upon actuation of the actuator 60, the piston 62 is actuated to produce a stroke, for example along an upward direction, which causes the rigid linking part 64 to move upwards, thereby pivoting the lever 66 in a coun-

terclockwise direction around the pivot 48 of the mounting support 40 in order to exert on the connecting part 68 a radial force to bend the elastic portion 46 outwardly to bring the mounting support 40 from a clamping configuration to an unclamped configuration.

[0042] The end-effector 122 of the robotic arm 120 can position the mating part 16 of any customized support 10a, 10b, 10c inside the complementary mating part 42 of the mounting support 40 as a function of the diameter of the workpiece blank 20a, 20b, 20c to be machined.

[0043] At this point, the piston 62 of the actuator 60 is actuated to produce a stroke along a downward direction, in order to stop the lever 66 from exerting a radial force on the connecting part 68. This causes the elastic portion 46 to move inwardly in a resting position in which the mating part 16 of the customized support 10a, 10b, 10c is held tight in the complementary mating part 42 of the mounting support 40.

[0044] Figures 12 and 13 show another embodiment of an automated clamping support 30 of the automated system 100 for automatic interchangeability of customized supports 10a, 10b, 10c in the mounting support 40. Figure 12 shows the automated clamping support 30, whereby a customized support 10 is firmly held in the complementary mating part 42 of the mounting support 40 while Figure 13 shows the automated clamping support 30, whereby the elastic portion 46 is about to be bent outwardly to widen the complementary part 42 of the mounting support 40 to bring the latter from a clamping to an unclamped configuration.

[0045] With reference to Figure 12, the automated clamping support 30 comprises a mounting support 40 comprises a longitudinal passage 50 extending from a first lateral side of the mounting support 40 through the mounting support 40 up to the longitudinal slit 44. A rod 52 is arranged inside the longitudinal passage 50. The rod 52 comprises a first end in abutment against the elastic portion 46 of the mounting support 40 and a second end protruding from the first lateral side of the mounting support 40. The second end of the rod 52 may comprise for example a ball bearing 53 configured to cooperate with a lever 74 as explained in detail subsequently.

[0046] The rod 52 comprises an inner threaded portion. A through-hole 55 extends from a second lateral side of the mounting support 40, opposite the first lateral side, through the elastic portion 46 to face the inner threaded portion of the rod 52. A screw 54 is screwed into the threaded portion of the rod 52 with its screw head 54a resting in the second lateral side of the mounting support 40.

[0047] The automated clamping support 30 further comprises an actuator 60 comprising a piston 72, a lever 74 mounted on a lever support 86 and arranged to be actuated by a distal end of the piston 72 to pivot about an axis of rotation 78. The upper portion of the lever support 86 may for example comprise a ball 88 fitted inside a corresponding semi-spherical cavity arranged on the lever 74 to ensure pivoting of the lever 74 about the axis of rotation 78.

[0048] The lever 74 comprises an actuating part 76 designed to cooperate with the second end of the rod 52 protruding from the first lateral side of the mounting support 40 for example with the ball bearing 53 fitted in the end portion of the rod. The lever 74 is arranged to cooperate with an elastic member 90, for example a tension spring configured to urge the lever in a non-actuating configuration.

[0049] In that respect, the lever 74 may comprise for example a first pin 82 and a second pin 96 is mounted on a pin support 94 arranged below the lever 74. Each extremity of a tension spring 90 is anchored to the first pin 82, respectively the second pin 96.

[0050] As illustrated in Figure 12, the actuation part 76 of the lever 74 is disengaged from the second end of the rod 52 protruding from the first lateral side of the mounting support 40. The tension spring 90 maintains the lever in the position illustrated in this Figure.

[0051] Referring now to Figure 13, the actuator 60 is actuated such that a stroke is imparted to piston 72 to move the piston preferably in an upward direction so that the distal end of the piston 72 pushes a portion of the lever 74 situated near one extremity and which may comprise a ball-bearing 84 to cooperate with the piston 72. The pushing action of the piston 72 rotates the lever 74 to bring its actuating part 76 with the second end of the rod 52 as shown in Figure 13.

[0052] At this point, the distal end of the piston continues to push the above portion of the lever 74 which causes the actuating part 76 of the lever 74 to impart a translation movement to the rod 52. This translation movement causes the first end of the rod 52 in abutment against the elastic portion 46 of the mounting support 40 to push against the elastic portion 46 thereby bending outwardly to widen the complementary part 42 of the mounting support to bring it into an un-clamped configuration where the customized support may be removed by the end effector 122 of the robotic arm 120 of the automated system 100.

[0053] The robotic arm 120 will then position in the customized support in a compartment 132 of the support storage and grip another customized support 10a, 10b, 10c from another compartment to bring it into the complementary part 42 of the mounting support 40 of the automated clamping support 30.

[0054] Upon positioning of said another customized support into the complementary part 42 of the mounting support 40, the actuator 60 is actuated such that a stroke is imparted to the piston 72 in a downward direction. At this point, the lever 74 is no longer in contact with the piston which causes the lever 74 to rotate about the axis of rotation 78 in a clockwise direction through the action of the tension spring 92, whereupon the actuating part 76 of the lever 74 is disengaged from the end potion of the rod 52. The elastic portion 46 of the mounting support 40 can return in its rest position thereby clamping the customized support in the complementary mating part

42 of the support 40.

[0055] In another embodiment illustrated in Figure 14, at least a first, a second and a third customized support 10a, 10b, 10c are fixed on respective first, second and third support 40a, 40b, 40c. Each customized support 10a, 10b, 10c comprises a concave surface with a unique radius of curvature. Each support 40a, 40b, 40c is connected to a rotary unit 210 mounting on bearings (not shown). The rotary unit 210 comprises a wheel 212 engaging a rack 214. The rack 214 is coupled to linear actuator 216 configured to drive in translation the rack 214, thereby rotating the rotary unit 210 to adjust any support 40a, 40b, 40c in correspondence with the spindle of a machine tool, for example a grinding machine. In an alternative non-illustrated embodiment, the rotary unit is mounted on a rotor of an electrical motor.

[0056] In a further non-illustrated embodiment, each customized support may form an integral part with a mounting support, wherein each mounted support comprises a unique customized support. Each mounted support may be brought by the end-effector of a robotic arm in alignment with a spindle of a machine tool and secured in that position such that a portion of a workpiece blank to be machined is always supported by a customized support of a corresponding mounting support without requiring any height adjustment of the mounting support.

Reference list

[0057]

Set of customized support 10a, 10b, 10c

Supporting surface 11

Concave surface 12a, 12b, 12c
Radius of curvature R1, R2, R3
V-shape surface
Non-continuous concave surface
Notch 13

Gripping interface 14
Mating part 16

First, second and third workpiece blanks 20a, 20b, 20c

Automated clamping support 30

Mounting support 40

Complementary mating part 42

Longitudinal slit 44
Elastic portion 46
First embodiment
Cylindrical hole 48a
Pivot 48
Second embodiment
Longitudinal passage 50
Rod 52
Rod ball bearing 53
Screw 54
Screw head 54a
Through-hole 55

Actuator 60
First embodiment
Piston 62
Rigid linking part 64
Lever 66
Cylindrical hole 67
Connecting part 68
Pivot 70
Second embodiment
Piston 72
Lever 74

Actuating part 76
Axis of rotation 78
Cylindrical cavity 80
First pin 82
Ball bearing 84

Lever support 86
Ball 88
Elastic member 90
Tension spring
Pin support 94
Second pin 96

Automated system 100

Machine tool 110 (e.g. grinding machine)
Spindle 112
Robotic arm 120
End effector 122
Support storage 130 (e.g. compartmentalized storage)
Compartments 132
Automated mounting support 30

Claims

1. A set of customized supports (10a, 10b, 10c) for supporting workpiece blanks (20a, 20b, 20c) of different diameters, each customized support (10a, 10b, 10c) being adapted to be hold by a same mounting support (40) aligned with a spindle (112) of a machine tool (110) or to respective mounting support (40a, 40b, 40c) to be aligned with said spindle (112), each customized support (10a, 10b, 10c) having a supporting surface (11) for supporting a portion of a workpiece blank (20a, 20b, 20c) during machining, wherein the shape and/or dimensions of said sup-

porting surface (11) is different between each customized support (10a, 10b, 10c) of the set of customized supports so as to offset the difference in diameter between different workpiece blanks (20a, 20b, 20c) having different diameter such that a portion of a workpiece blank to be machined is always supported by a customized support (10a, 10b 10c) when mounted on the same mounting support (40) of the machine tool (110) or by a customized support (10a, 10b 10c) of respective mounting support (40a, 40b, 40c) without requiring any height adjustment of the mounting support (40; 40a, 40b, 40c).

2. A set of customized support (10a, 10b, 10c) according to claim 1, wherein the supporting surface (11) of each customized support comprises a concave surface (12a, 12b, 12c) for supporting a portion of a workpiece blank (20a, 20b, 20c) during machining, the radius of curvature (R_1, R_2, R_3) of the concave surface (12a, 12b, 12c) being different between each customized support (10a, 10b, 10c) to offset said difference in diameter between different workpiece blanks (20a, 20b, 20c).

3. The set of customized supports (10a, 10b, 10c) according to claim 1 or 2, wherein each customized support comprises a gripping interface (14) for automated interchangeability in the mounting support (40) of a customized support (10a) with another customized support (10b, 10c) as a function of the diameter of the workpiece blank (20a, 20b, 20c) to be machined.

4. The set of customized supports (10a, 10b, 10c) according to any preceding claim, wherein each customized support (10a, 10b, 10c) comprises a mating part (16) configured to be held in a complementary mating part (42) of the mounting support (40).

5. The set of customized supports (10a, 10b, 10c) according to the preceding claim, wherein the mating part (16) of each customized support (10a, 10b, 10c) is a convex bottom surface and the complementary mating part (42) of the mounting support (40) is a concave surface having a radius of curvature corresponding substantially to the radius of curvature of said convex bottom surface of each customized support.

6. Method of machining several workpiece blanks with a machine tool, notably a grinding machine (110), the method comprising:

a. mounting a first workpiece blank (20a) of a first diameter in a spindle (112) of the machine tool (110);
b. mounting a mating part (16) of a first customized support (10a) into a complementary mating part (42) of a mounting support (40) of the machine tool (110), wherein the first customized support (10a) is selected among the set of customized supports (10a, 10b, 10c) according to any preceding claim, as a function of the diameter of the workpiece blank (20a) to be machined;
c. machining the first workpiece blank (20a) and possibly one or more additional workpiece blanks of a same batch having the same or a similar diameter as said first workpiece blank (20a);
d. interchanging in the spindle (112) the machined workpiece with a second workpiece blank (20b, 20c) having a second diameter different from the first diameter of the first workpiece blank (20a),
e. interchanging said first customized support (10a) with a second customized support (10b, 10c) in the complementary mating part (42) of the mounting support (40), wherein the second customized support (10b, 10c) is selected among the set of customized supports according to any preceding claim, as a function of the diameter of said second workpiece blank (10b) to be machined, and
f. machining the second workpiece blank (20a) and possibly one or more additional workpiece blanks of a same batch having the same or a similar diameter as said second workpiece blank.

7. The method according to the preceding claim, wherein step b may be performed before step a. and step. e may be performed before step d.

8. The method according to claim 6 or 7, wherein a robotic arm (120) with an end-effector (122) is placed within arm reach of the mounting support (40) and of a support storage (130) storing different customized supports (10a, 10b, 10c) according to any of claims 1 to 5, the step of interchanging said customized support (10a) with another customized support (10b) comprising:

- gripping with the end-effector (122) of the robotic arm (120) the customized support (10a) in the complementary mating part (42) of the mounting support (40) and placing said customized support (10a) in the support storage (130), and
- gripping another customized support (10b) in the support storage (130), and placing said another customized support (10b) in the complementary mating part (42) of the mounting support (40).

9. The method according to any of claims 6 to 8, where-

in the mounting support (40) comprises an elastic portion (46) and actuating means (52; 66, 68, 70) arranged to cooperate with the elastic portion (46), wherein said elastic portion comprises a distal end which forms a portion of the complementary mating part (42), the step of interchanging said customized support (10a) with another customized support (10b) further comprising:

- bending the elastic portion (46) outwardly with the actuating means to widen said complementary mating part (42) before the step of gripping the customized support (10a) in the complementary mating part (42), and
- releasing the actuating means to let the elastic portion (46) to return to its unbent configuration after the step of placing said another customized support (10b) in the complementary mating part (42) of the mounting support (40).

10. An automated system (100) for automatic interchangeability of customized supports (10a, 10b, 10c) in the mounting support (40), the automated system (100) comprising a machine tool, notably a grinding machine (110) having a spindle (112), an automated clamping support (30), a support storage (130) for storing different customized supports (10a, 10b, 10c) of the set of customized supports according to any one of claims 1 to 5 and a robotic arm (120) comprising an end effector (122) configured to grip a customized support (10a, 10b, 10c), wherein the robotic arm (120) is configured to be actuated to bring a mating part (16) of any customized support (10a, 10b, 10c) from the support storage (130) into a complementary mating part (42) of the mounting support (40) and vice versa, and wherein automated clamping support (30) is configured to bring said complementary mating part (42) from a clamping configuration to an unclamped configuration so that the robotic arm (120) may remove the customized support (10a, 10b, 10c) from the mounting support (40) and from an unclamped configuration to a clamping configuration once the robotic arm (120) has placed another customized support in the mounting support.

11. The automated system (100) according to the preceding claim, wherein the support storage is a compartmentalized storage (130) comprising at least six compartments (132), preferably at least ten compartments, each compartment (132) is adapted to store a customized support (10a, 10b, 10c) according to any one of claims 1 to 5, wherein the shape and/or dimensions of the supporting surface (11) of each customized support sored or to be stored in one compartment (132) is different from the shape and/or dimensions of the supporting surface (11) of the customized support stored or to be stored in any other compartment (132) of the compartmentalized storage (130).

12. The automated system (100) according to claim 10 or 11, the automated clamping support (110) comprising an actuator (60), wherein said actuator (60) comprises a piston (62; 72), a lever (66; 74) actuable by the piston, and actuating means (52; 66, 68, 70) arranged to cooperate with an elastic portion (46) having a distal end which forms a portion of the complementary mating part (42) in order to bend outwardly said elastic portion (46) to bring the mounting support (40) from a clamping configuration to an unclamped configuration.

13. The automated system according to the preceding claim, wherein the mounting support (40) comprises a longitudinal passage (50) extending from a first lateral side of the mounting support (40) through the mounting support up to a longitudinal slit (44) extending upwardly up to the complementary mating part (42), a rod (52) being arranged inside the longitudinal passage (50) and comprising a first end in abutment against the elastic portion (46) of the mounting support (40) and a second end protruding from the first lateral side of the mounting support 40.

14. The automated system (100) according to the preceding claim, wherein the lever (74) comprises an actuating part (76) and is configured to pivot about an axis of rotation (78) when actuated by the piston (72) to bring and push the actuating part (76) against said second end of the rod (52) to impart a translation movement to the rod (52) causing the first end of the rod (52) in abutment against the elastic portion (46) of the mounting support (40) to push against the elastic portion (46) thereby bending outwardly to widen the complementary matin part (42) of the mounting support to bring it into an un-clamped configuration.

15. The automated system (100) according to any of claims 12 to 14, wherein the lever (74) is arranged to cooperate with an elastic member (90), configured to urge the lever (74) in a non-actuating configuration.

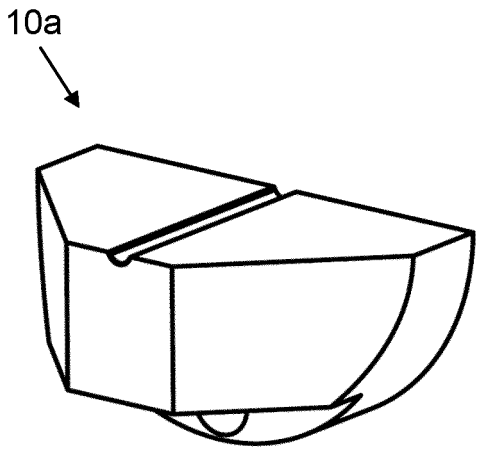


Fig. 1a

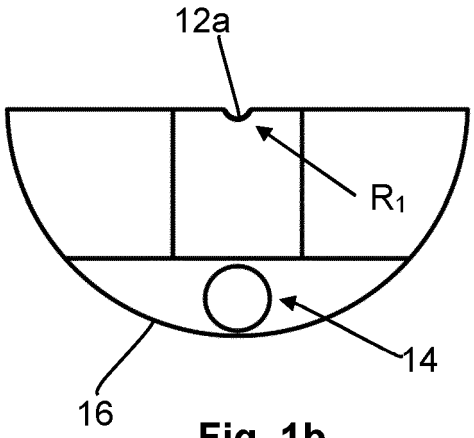


Fig. 1b

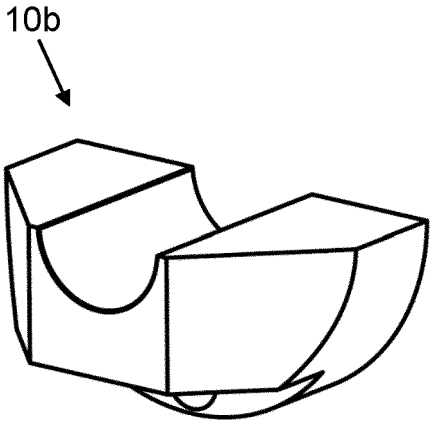


Fig. 2a

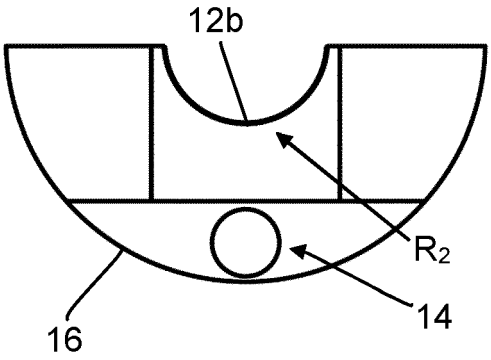


Fig. 2b

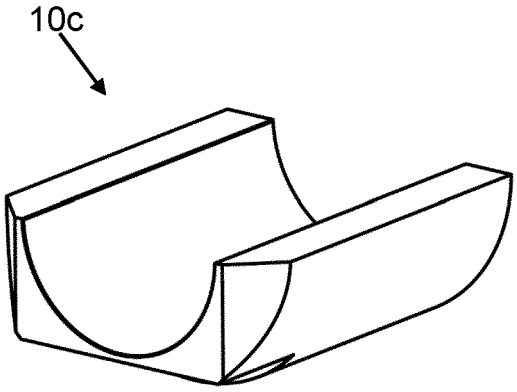


Fig. 3a

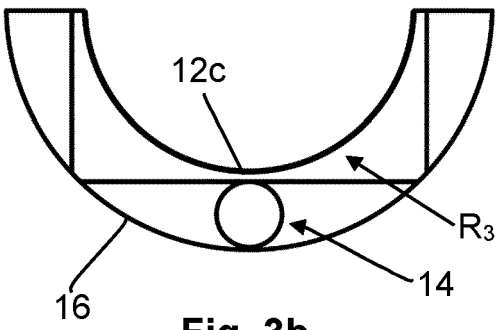


Fig. 3b

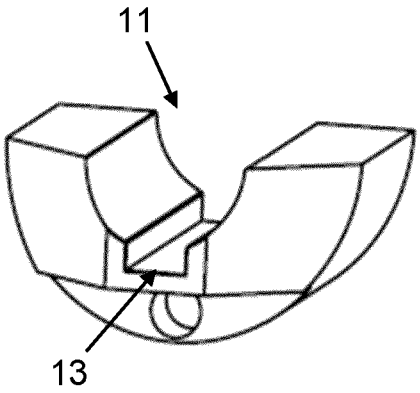


Fig. 4a

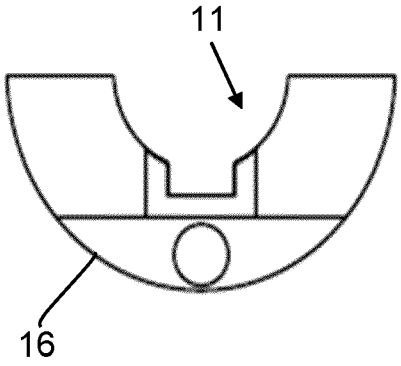


Fig. 4b

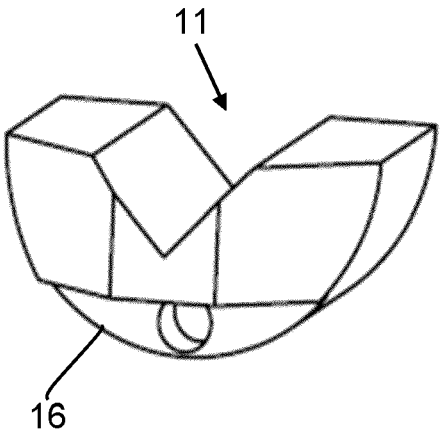


Fig. 5a

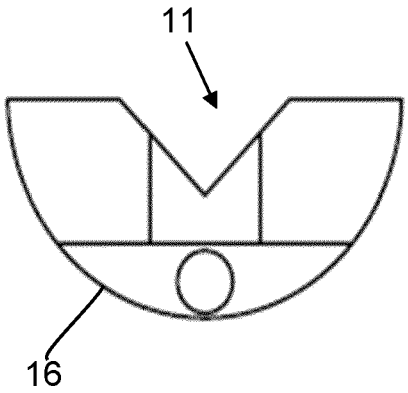


Fig. 5b

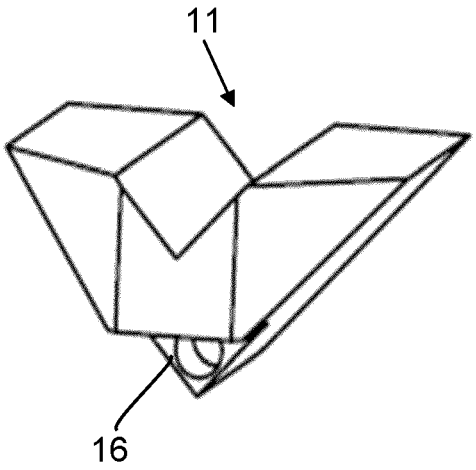


Fig. 6a

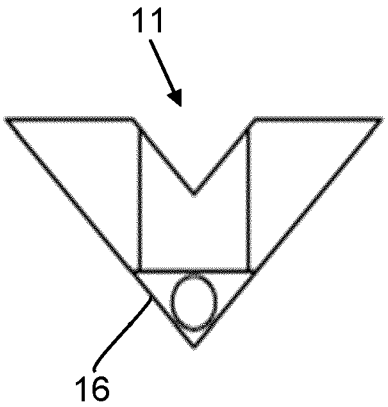


Fig. 6b

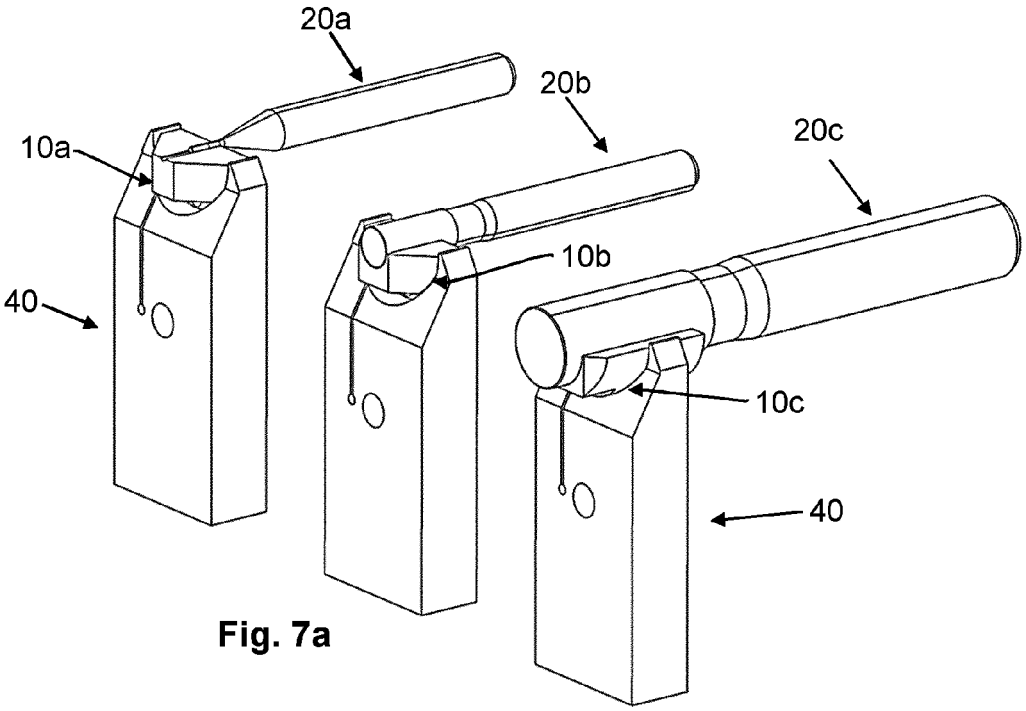


Fig. 7a

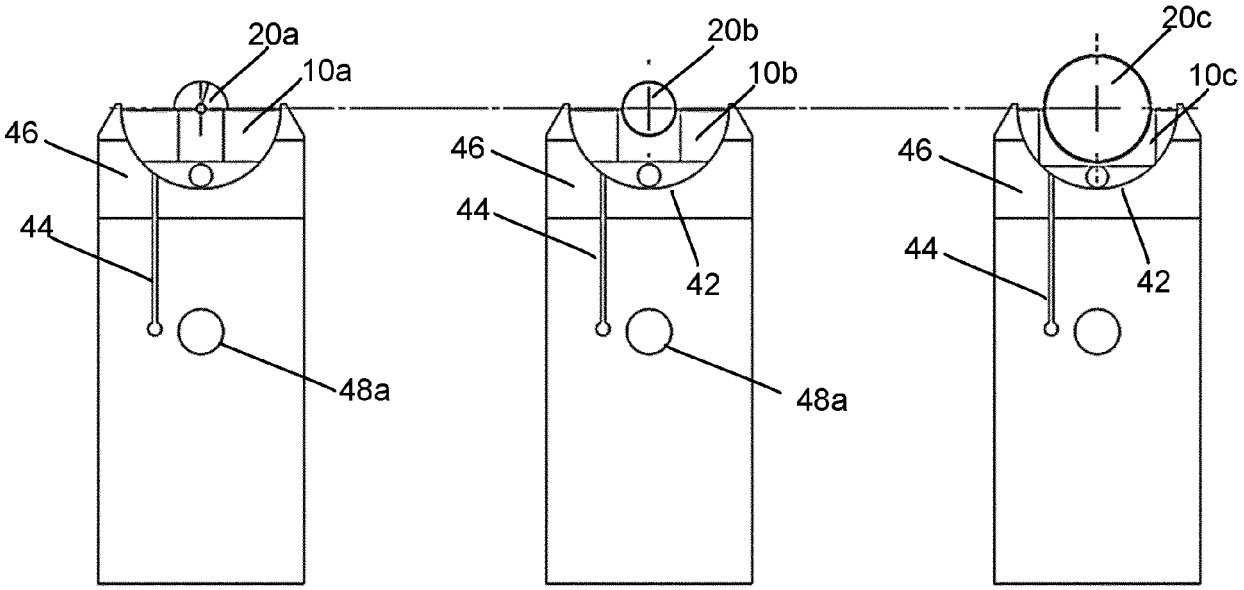
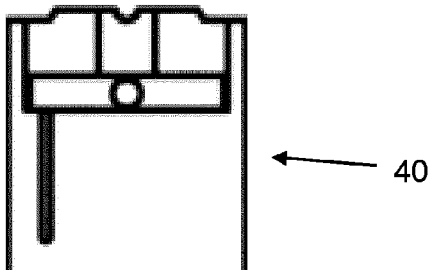


Fig. 7b

Fig. 7c



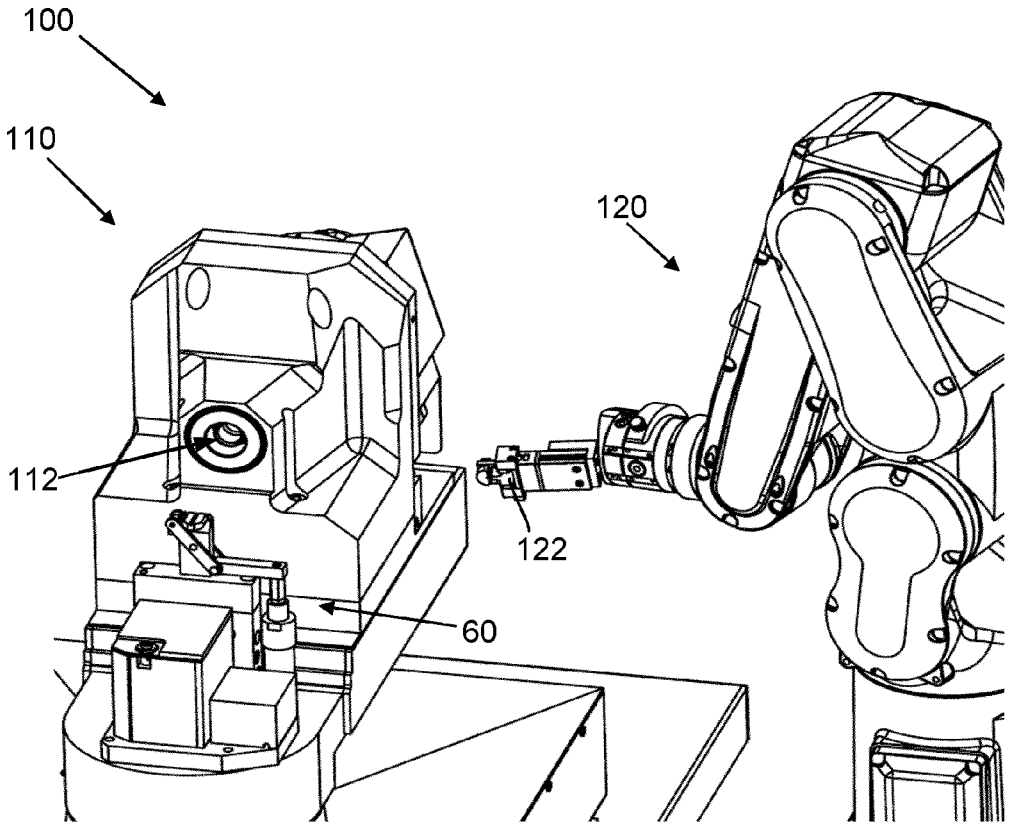


Fig. 8

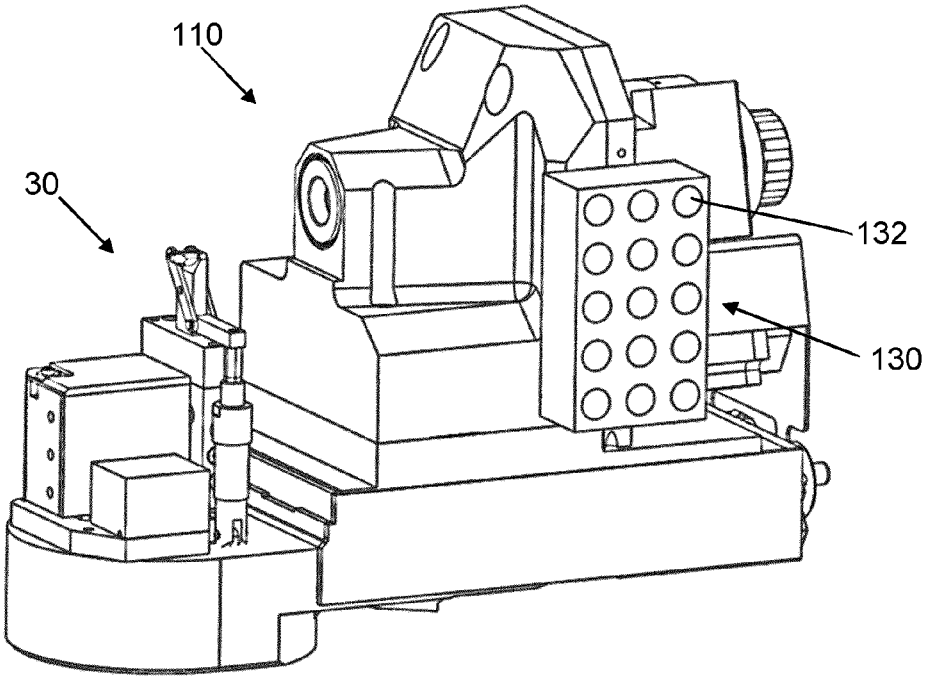


Fig. 9

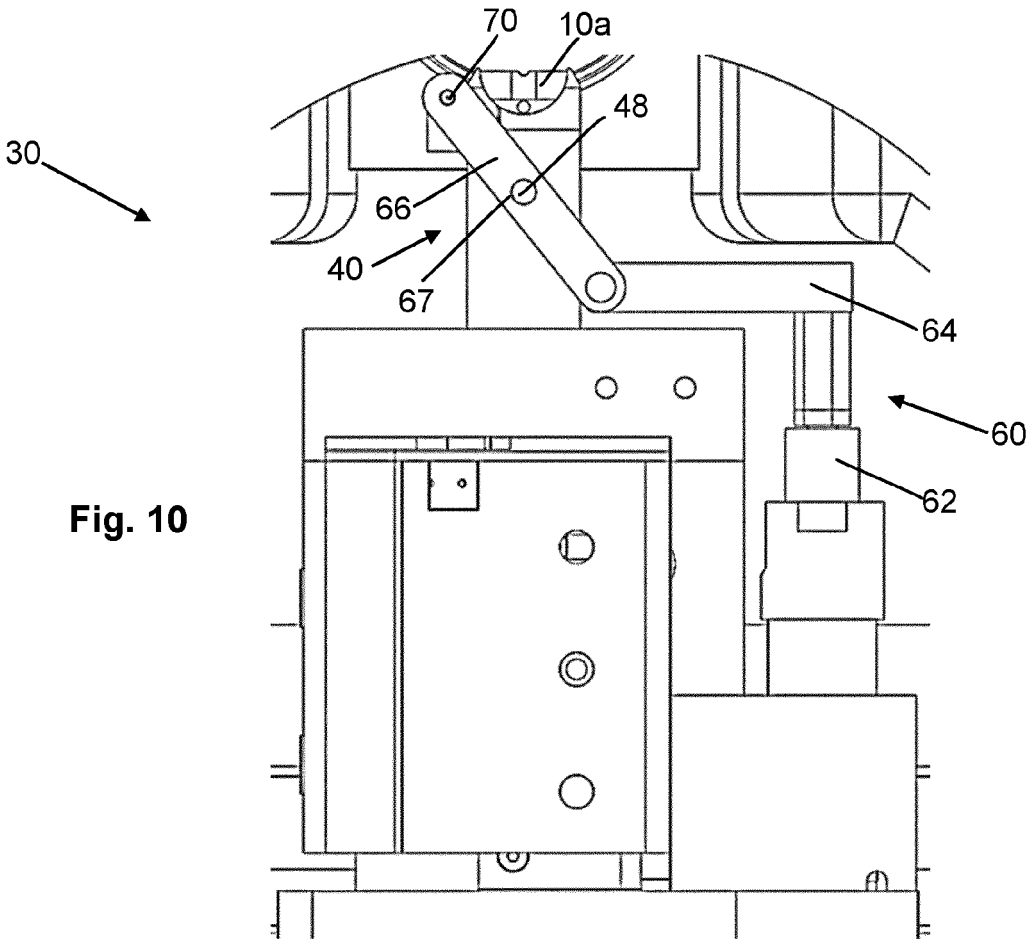


Fig. 10

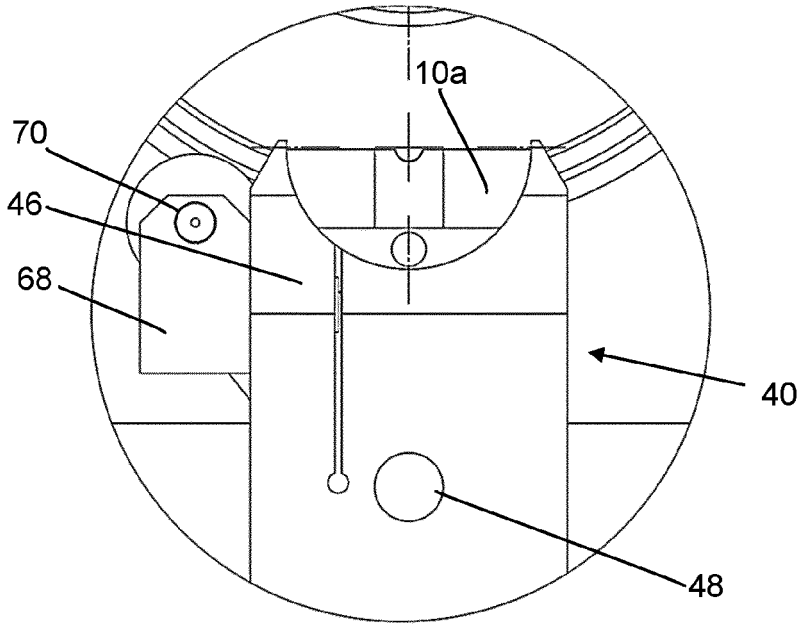


Fig. 11

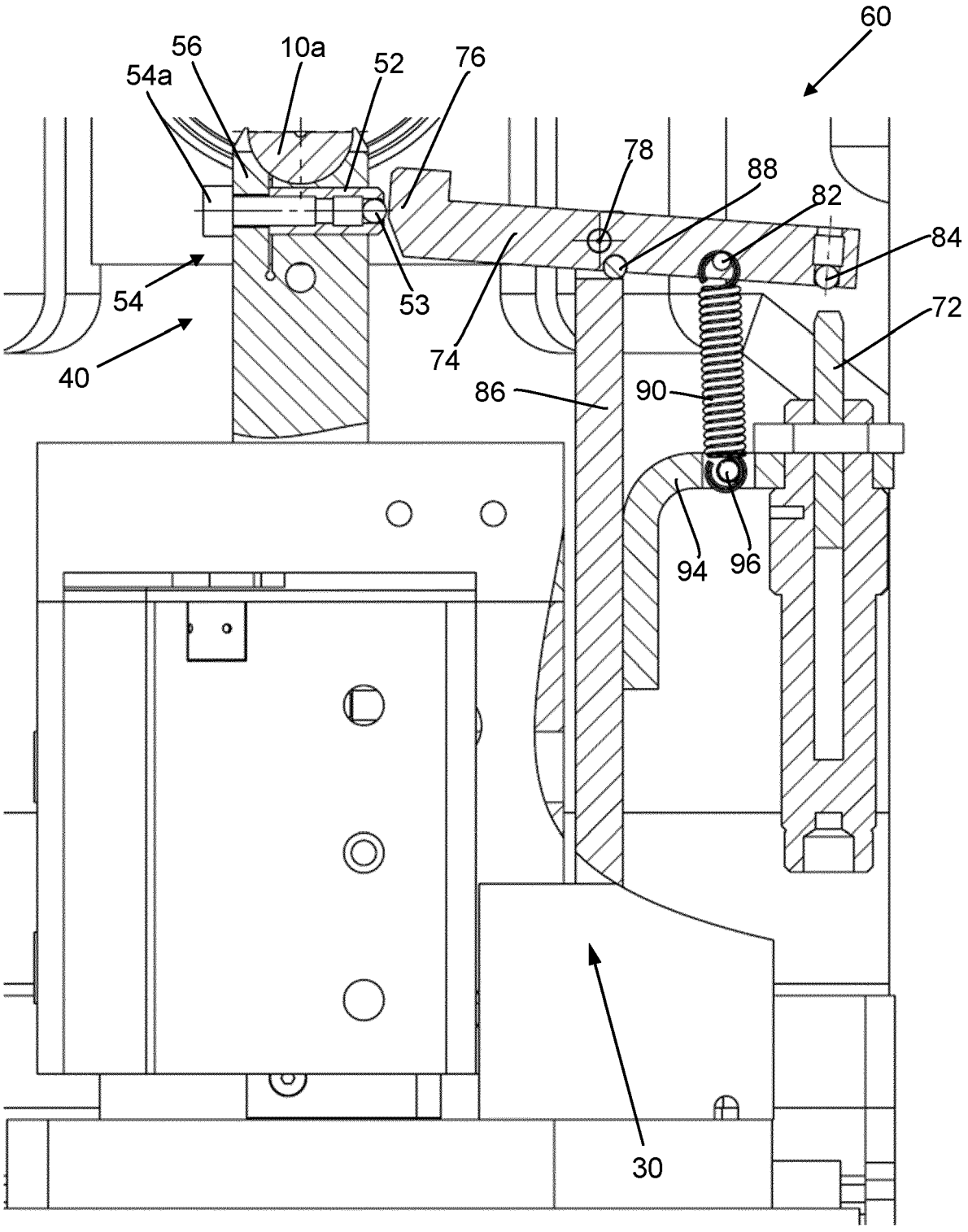


Fig. 12

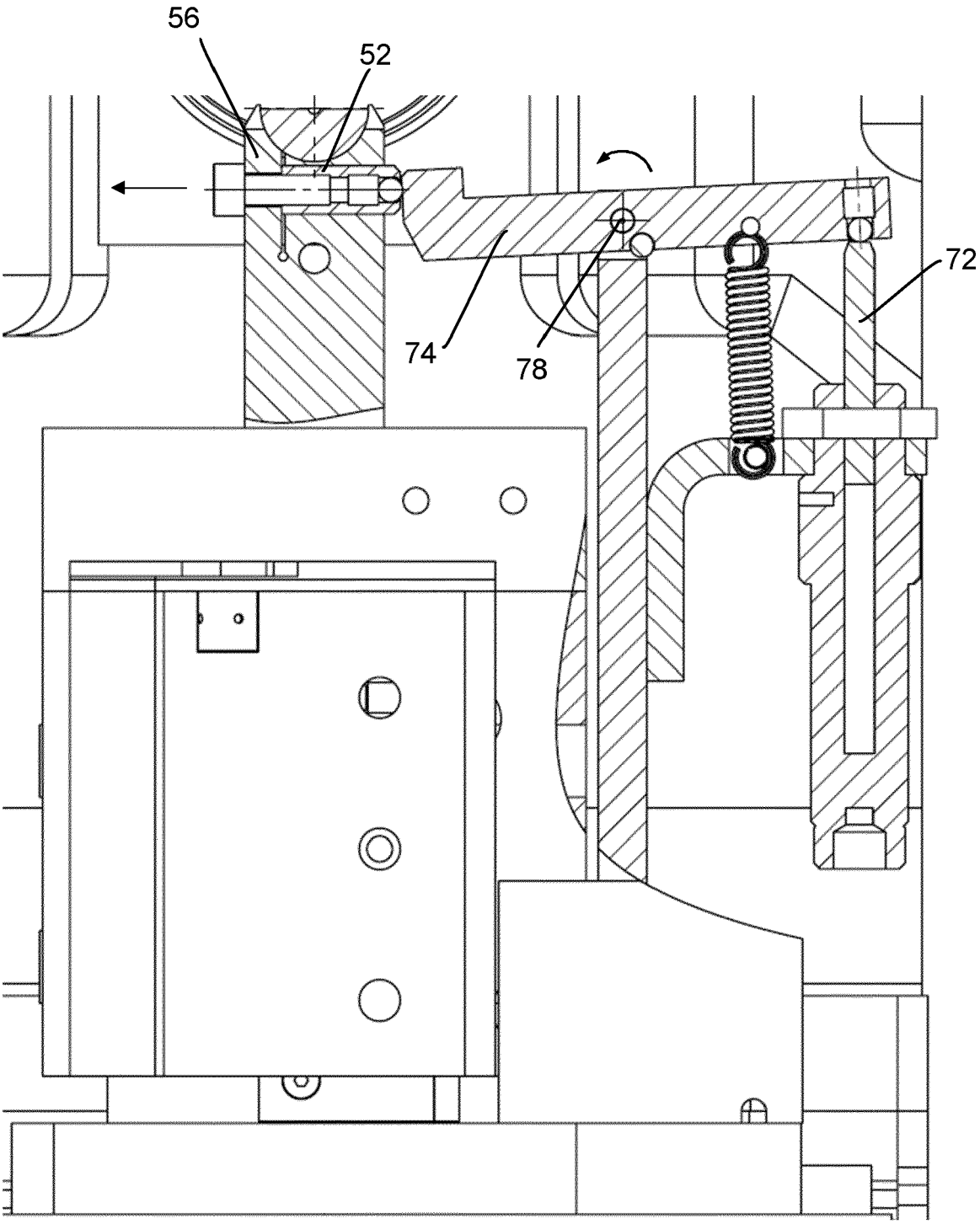


Fig. 13

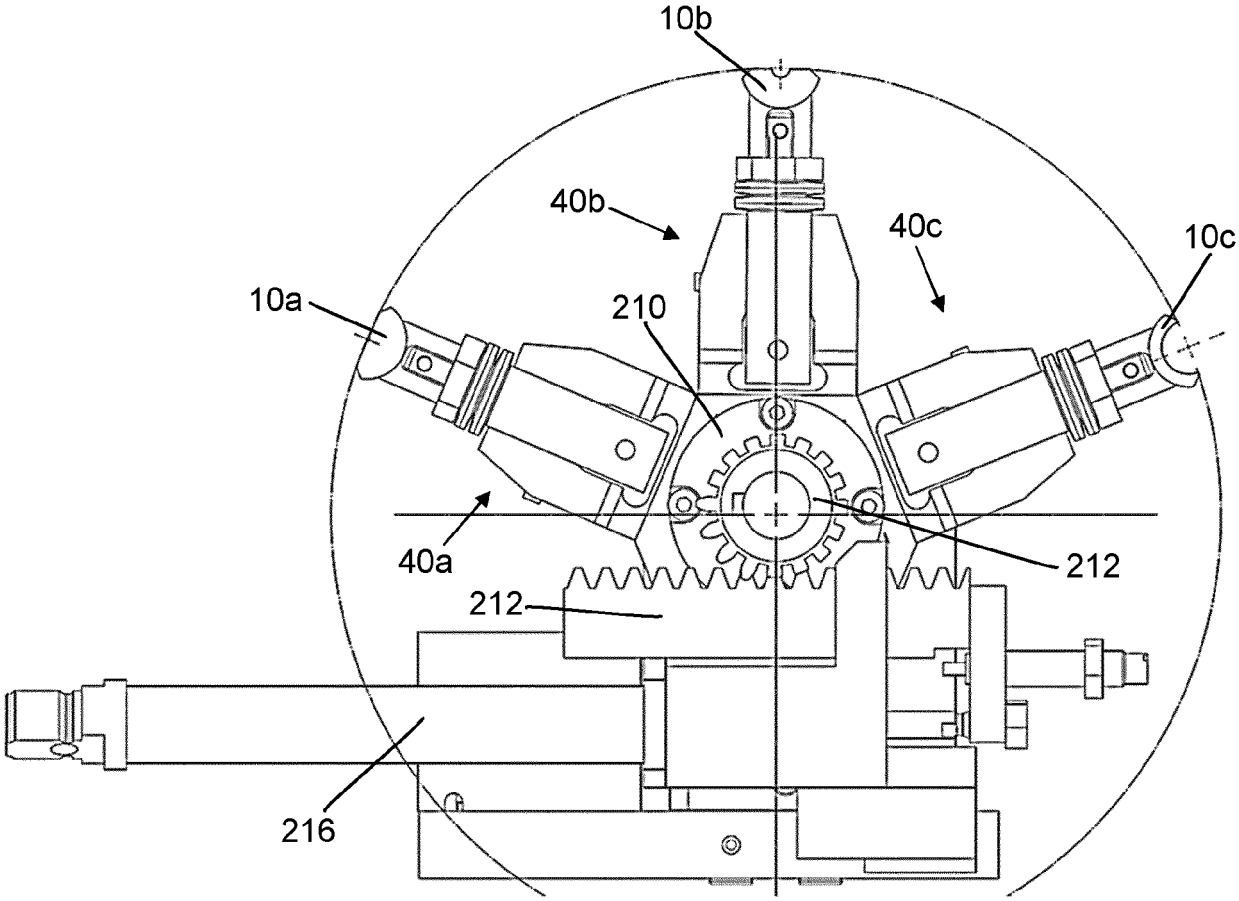


Fig. 14

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EUROPEAN SEARCH REPORT

Application Number
EP 21 17 6447

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 030 727 A1 (ROLLOMATIC SA [CH]) 4 March 2009 (2009-03-04) * paragraphs [0002] - [0003], [0008] - [0013]; claims 1-5; figures 1-4 *	1-7	INV. B24B5/22 B24B5/307 B24B41/06

TECHNICAL FIELDS SEARCHED (IPC)
B24B
B23Q

1 The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	18 October 2021	Lasa Goñi, Andoni

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)

Europäisches Patentamt
European Patent Office
Office européen des brevets

Application Number
EP 21 17 6447

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-7

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 21 17 6447

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-7

A set of customized supports as defined in claim 1, characterised by the special technical feature that each customized support comprises a mating part configured to be held in a complementary mating part of the mounting support (claim 4).
Problem solved: precisely holding the customised support in the mounting support.

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2. claims: 8, 10, 11

Method or automated system using a set of customized supports as defined in claim 1, characterised by the special technical feature of a robotic arm (claim 8).
Problem solved: automatic exchanging of the customized supports.

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3. claims: 9, 12-15

Method or automated system using a set of customized supports as defined in claim 1, characterised by the special technical feature that the mounting support comprises an elastic portion and actuating means arranged to cooperate with the elastic portion (claim 9).
Problem solved: grip the customized supports by the mounting support.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 21 17 6447

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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18-10-2021

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2030727 A1	04-03-2009	AT 529218 T	15-11-2011
		CN 101932407 A	29-12-2010
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		US 2010248589 A1	30-09-2010
		WO 2009027939 A2	05-03-2009

EPO FORM P0459

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