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(71) Applicant: **Automatismi Brazzale S.R.L**
36051 Creazzo (IT)

(72) Inventor: **Brazzale, Daniele**
36100 Vicenza (IT)

(74) Representative: **Vannini, Mario**
Maroscia & Associati S.r.l.
Contrà S. Caterina, 29
36100 Vicenza (IT)

(54) Machine, automatic line and method for surface machining of disk-shaped elements

(57) A machine tool for surface machining of disk-shaped elements, comprising a stationary table (2) which defines a median working plane (π), means (3) for removably locking one disk-shaped element (D) at a time, drive means (4) for moving the disk-shaped element (D) between a start position outside the working area and an operating position and vice versa, at least one pair of working tools (5', 5") rotatable about respective rotation axes (X_2, X_3) and having respective operating surfaces (6', 6") for acting upon the disk-shaped element (D). The rotation axes (X_2, X_3) are rotatably supported on second support axes (Y_2, Y_3) for changing the tilt (α) of the working tools (5', 5") relative to the median plane (π) and adjusting the angular position of the operating surfaces (6', 6") relative to the opposite faces (S', S") of the disk-shaped element (D).

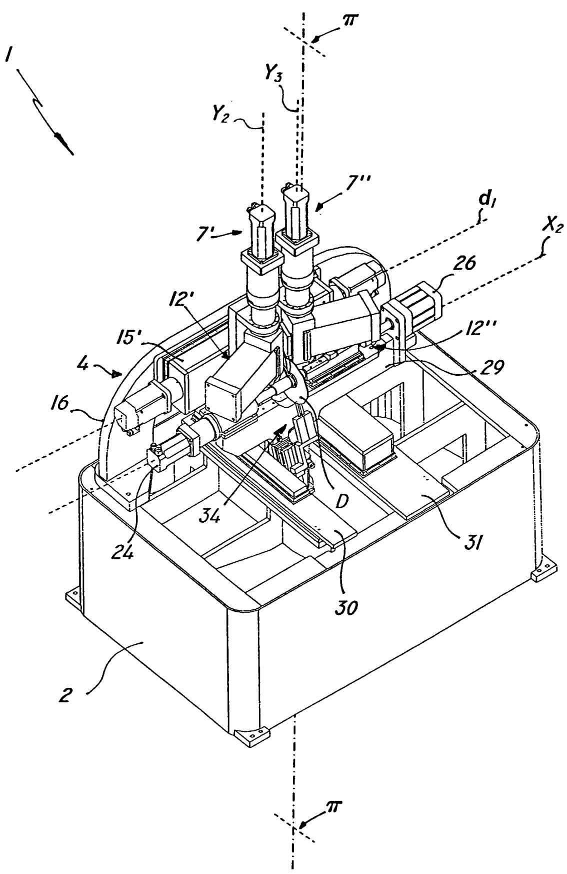

FIG. 1

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Description

Field of the invention

[0001] The present invention generally finds application in the field of machine tools for surface machining of items and particularly relates to a machine tool for surface machining of disk-shaped elements. The machine is particularly suitable for grinding, tapering and polishing disk-shaped cutting tools.

[0002] The invention further relates to a machining line comprising one or more of such machines and a method for surface machining of disk-shaped elements.

Background of the invention

[0003] Machine tools are known and commercially available which perform grinding, tapering, polishing or other surface machining on disk-shaped elements, particularly cutting tools such as blades, wheel cutters or circular saws.

[0004] These machines generally have a support structure for the workpiece to be mounted thereon and rotated at a predetermined speed. Then, the working tool is brought into contact with one of the faces of the disk-shaped element for material removal according to preset cutting parameters.

[0005] As the end of this step, the disk-shaped element is manually overturned to allow machining of the other face in the same manner as the former.

[0006] Apparently, these common solutions have the recognized limitation that machining has to be carried out separately on each face of the workpiece.

[0007] Therefore, the whole process will have very long layout times, especially due to the sometimes unacceptable dead times associated to the overturning of the disk-shaped element and to the consequent need to reset the operating parameters.

[0008] In an attempt to overcome the above drawbacks, several machine tool solution have been proposed in which surface machining of tools or other disk-shapped elements is carried out simultaneously on both faces.

[0009] US-B-6726525 discloses, for instance, a machine tool for simultaneous grinding of both faces of a disk-shaped element by means of a pair of abrasive wheels in mutually facing relationship between which the element to be ground is interposed. The wheels may translate along their rotation axes for machining depth adjustment. Moreover, both the disk-shaped element and the wheels may translate in their respective lying planes to allow whole-surface machining on both faces of the disk-shaped element, using relatively small tools.

[0010] While this solution allows simultaneous grinding of both faces of a disk-shaped element, it still does not allow to change the angle between the tools and the faces to be machined, to make surface profiles other than a planar profile.

[0011] US-B-7004816 discloses a method for grinding disk-shaped surfaces in which the material removal step is preceded by measurement of the size characteristics of the element to be ground, using a pair of probes, each probe being in contact with a face of the element.

[0012] This allows presetting of appropriate operating parameters for the tools, thereby improving accuracy.

[0013] Nevertheless, this solution does not allow machining to be monitored with the workpiece still mounted to the machine, for any re-machining to be carried out without removing the disk-shaped element.

[0014] Furthermore, the steps of positioning and removing the disk-shaped element, as well as the step of setting operating parameters are carried out manually. Therefore, the process still involves excessive dead times, which cause a considerably reduced throughput of the apparatus by which it is implemented.

Summary of the invention

[0015] The object of this invention is to overcome the above drawbacks, by providing a machine tool for surface machining of disk-shaped elements that is highly efficient and relatively cost-effective.

[0016] A particular object is to provide a machine tool for surface machining of disk-shaped elements that allows simultaneous machining of both faces of the element, with not necessarily planar cutting profiles.

[0017] A further object is to provide a machine tool that allows automatic measurement of the machining dimensions without removal of the machined element from the machine.

[0018] Another object of the invention is to provide a machine tool that affords high machining repeatability and speed.

[0019] Yet another object is to provide a machining line for surface machining of disk-shaped elements in which loading and unloading operations are fully automatized.

[0020] Finally, another important object is to provide a method for surface machining of disk-shaped elements that affords a considerable reduction of the times required for dimensional sensing and surface analysis of machined elements.

[0021] These and other objects, as better explained hereinafter, are fulfilled by a machine tool for surface machining of disk-shaped elements as defined in claim 1, which comprises a stationary table defining a first support axis and a median working plane substantially perpendicular to said first axis, means for removably locking one disk-shaped element at a time coaxial with said first axis, drive means associated to said first axis for moving the disk-shaped element between a start position outside the working area and an operating position and vice versa, at least one pair of working tools rotatable about respective rotation axes and having respective active surfaces designed to act upon the opposite faces of the disk-shaped element.

[0022] The machine is characterized in that the rotation axes are rotatably supported on second support axes for changing the tilt of the working tools relative to the median plane and adjusting the angular position of the active surfaces relative to the opposite faces of the disk-shaped element.

[0023] Thanks to this feature, the machine tool allows simultaneous machining of both faces of the disk-shaped element with planar or conical cutting profiles, by only changing tool tilt.

[0024] Advantageously, means may be provided for sensing the size of the disk-shaped element and checking whether surface machining has been properly carried out.

[0025] Suitably, the sensing means may include at least one pair of sensors operating on the opposite faces of each disk-shaped element being machined.

[0026] Preferably, the pair of sensors may in turn include a pair of sensing members moving along substantially parallel directions and designed to come into contact with opposite faces of the disk-shaped element.

[0027] By this additional feature of the invention the dimensional characteristics of the disk-shaped element may be sensed automatically and with the disk-shaped element mounted on the machine.

[0028] Dimensional and surface profile analysis for both faces of the disk-shaped element may be carried out without removing the disk-shaped element, which greatly reduces operating times.

[0029] According to another aspect, the present invention provides an automatic line for surface machining of disk-shaped elements which comprises a magazine for loading/unloading a plurality of disk-shaped elements to be machined and/or already machined and means for automatically transferring the disk-shaped elements between said magazine and at least one machine tool for surface machining of disk-shaped elements as defined in any one of claims 1 to 13.

[0030] This automatic line allows quick loading and unloading of the disk-shaped elements before or after machining, thereby further increasing the throughput of the machine.

[0031] In yet another aspect, the invention provides a method for surface machining of disk-shaped elements using a machine tool as defined in any one of claims 1 to 13.

Brief description of the drawings

[0032] Further features and advantages of the invention will be more apparent upon reading the detailed description of a preferred, non-exclusive embodiment of a machine, an automatic line and a method for surface machining of disk-shaped elements according to the invention, which is described as a non-limiting example with the help of the annexed drawings, in which:

FIG. 1 is a perspective view of a machine tool according to the present invention;

FIG. 2 is a perspective view of a detail of the machine of Fig. 1;

FIG. 3 is a top view of the detail of Fig. 2;

FIG. 4 is a front view of a first detail of Fig. 2;

FIG. 5 is an enlarged view of a detail of Fig. 4;

FIG. 6 is a perspective view of a second detail of Fig. 2;

FIGS. 7a and 7b are exemplary sectional side views of a disk-shaped element machined with different operating parameters using a machine tool according to the present invention;

FIG. 8 is a perspective view of an automatic line comprising a machine tool according to the present invention;

Fig. 9 shows a flowchart of a method for surface machining of disk-shaped elements according to the invention.

Detailed description of a preferred embodiment

[0033] Referring to the above figures, the machine tool of the invention, generally designated by numeral 1, may be used for surface machining of disk-shaped elements and particularly for grinding, tapering, polishing and similar machining operations on disk-shaped cutting tools such as blades, wheel cutters and circular saws.

[0034] In the exemplary configuration of FIG. 1, the disk-shaped element D, having substantially parallel opposite faces S', S", is mounted to the machine at the working area with its rotation axis A substantially horizontal.

[0035] In accordance with the invention, the machine tool 1 comprises a floor-mountable stationary table 2, which defines a first support axis X_1 for the disk-shaped element D and a median working plane π substantially perpendicular to the first axis X_1 and substantially vertical in the particular configuration of the figure.

[0036] There are further provided means (3) for removably locking the disk-shaped element D coaxial with the first axis X_1, drive means 4 associated to the first axis X_1 for moving the disk-shaped element D between a start position outside the working area and an operating position and vice versa, as well as a pair of working tools 5', 5" rotatable about respective rotation axes X_2, X_3 and having respective active surfaces 6', 6" for acting upon the disk-shaped element D.

[0037] According to a peculiar feature of the invention, the rotation axes X_2, X_3 are rotatably supported on second support axes Y_2, Y_3 for changing the tilt α of the working tools 5', 5" relative to the median plane π and adjusting the angular position of the active surface 6', 6" relative to the opposite faces S', S" of the disk-shaped element D.

[0038] Thus, the tilt angle α of each tool 5', 5" may be the changed even independently for each tool 5', 5" of each pair, to set the processing shape to be imparted to the faces S', S".

[0039] Therefore, the active surfaces 6', 6" of the tools

5', 5" will act upon the respective opposite faces S', S" of the disk-shaped element D at predetermined and variable angles α, to form a surface profile P for each face S', S" , which is not necessarily planar and constant throughout the radial extension of the disk-shaped element D.

[0040] Preferably, although not necessarily, the tools 5', 5" will have respective coincident tilts, such as in the example of FIG. 3, to form substantially similar surface profiles P for each face S', S".

[0041] In the preferred non-exclusive configuration as shown in the annexed figures, the two tools 5', 5" are a pair of abrasive wheels having respective substantially planar and vertical cutting surfaces 6', 6".

[0042] The rotation axes X_2, X_3 of the tools 5', 5" are substantially horizontal and their tilt α with respect to the median plane π may be changed by rotating them over a horizontal plane π' containing such axes X_2, X_3 and about the respective second support axes Y_2, Y_3.

[0043] Nevertheless, other configurations may be envisaged, in which, for example, the rotation axes X_2, X_3 are vertical and the disk-shaped element D lies over a substantially horizontal working plane, without departure from the scope of the present invention. I

[0044] Furthermore, the wheels 5', 5" may be replaced by other tools particularly suitable for other surface machining operations such as surface polishing and finishing, which only require an increase of the rotating speed of the tools 5', 5".

[0045] As particularly seen in FIG. 2, each tool 5', 5" will have a first drive unit 7', 7" associated thereto, with a first support shaft 8', 8" rotatable on its respective second support axis Y_2, Y_3, to cause rotation of the corresponding rotation axis X_2, X_3 thereabout.

[0046] Since the first drive units 7', 7" are substantially identical, they will be described hereafter with reference to only one of them, designated by unprimed numeral 7, it being understood that the same parts are found in all the first units. Likewise, reference will be made hereinafter to corresponding parts of similar elements using unprimed numerals, although such parts will be designated in the annexed figures by primed numerals.

[0047] Each of the first drive units 7 may include an electric motor 9 connected to the corresponding tool 5 via a reduction gear 10 and a transmission unit 11, as more clearly seen in FIG. 4.

[0048] However, the rotary motion of the tools 5 about their first axes $X_{2,}$ $X_{3,}$ as required by the step of material removal from surface of the disk-shaped element D, will be provided by second drive units 12 each associated to the axis of rotation X_2, X_3 of a tool 5.

[0049] Each of the second drive units 12 will also essentially include a motor 13 connected to its respective tool 5 via appropriate transmission members, generally designated by numeral 14.

[0050] Furthermore, the drive units 7 and 12 will be mounted to respective powered translation carriages 15 sliding along a first direction d_1 substantially orthogonal to the median plane π from opposite sides with respect to it.

[0051] The carriages 15 have the function to move the tools 5 between an inoperative position outside the working area and a predetermined operative position in which the tools 5 are in contact with respective opposite faces S', S" of the disk-shaped element D. The carriages 15 further allow adjustment of the machining depth of the active surfaces 6 on the faces S', S".

[0052] Also, both the drive units 7 and 12 and the translation carriages 15 will be mounted to a fixation plate 16 for fixed or removable attachment thereof to the table 2, on opposite sides with respect to the median working plane π.

[0053] FIG. 5 and FIG. 6 are clearer views of a particular configuration of the locking means 3. As shown, the disk-shaped element D is locked between two second support shafts 17, 18, which are rotatably mounted on the first axis X_1 on opposite sides with respect to the median plane π.

[0054] The second support shafts 17, 18 have their first axial ends, 19 and 20 respectively, equipped with flanges, 21 and 22 respectively, adapted to cooperate with each other to rotatably lock the disk-shaped element D on the first axis X_1.

[0055] Particularly, one of the second support shafts 17, i.e. the one to the left of the median plane π in the figure, will be associated, at its second axial end 23, to a first actuator 24 having a rotating spindle 25 for transmitting rotary motion, preferably with a constant angular velocity, to the disk-shaped element to be machined.

[0056] Thus, the flange 22 will be set into rotation by the friction generated with the face S" of the disk-shaped element D.

[0057] Also, the drive means 4 may include a second actuator 26 associated to the second actual end 27 of the other second support shaft 18, to drive it parallel to the first axis X_1 along a second direction d_2 substantially parallel to the first direction d_1 and thus cause the disk-shaped element to be locked between the flanges 21, 22.

[0058] In the illustrated configuration, the second actuator 26 is of the pneumatic type and the joint 49 connects it to the guide 28, which is substantially parallel to the first axis X_1 and integral with a bearing structure 29, on which the drive means 4 and the locking means 3 are also mounted.

[0059] Thus, the sliding motion of the guide 28 will transmit the force required for closing the cylinder 26 against the flange 22, while ensuring orthogonal and accurate positioning of the locking means 3.

[0060] The bearing structure 29 is in turn connected to a pair of first slides or carriages 30, 31 sliding on the stationary table 2 along a third direction d_3 substantially orthogonal to the second direction d_2 to carry the first support axis X_1 and thus the disk-shaped element D locked thereon, from an outside start or inoperative position to an operative position inside the working area. I

[0061] Advantageously, only one of these first slides, e.g. the slide 31, may be associated to a reduction gear

32 to be moved on the table 2, whereas the other slide 30 is driven thereby.

[0062] The first support axis X_1 is further mounted to a second slide 33, also powered, on which the bearing structure 29 may be mounted. The second slide 33 is slideably mounted to the first slides 30, 31 to move along a fourth direction d_4 substantially parallel to the median plane π.

[0063] By this arrangement, the disk-shaped element D may be carried to a proper profile P forming position, which is related to the diameter of the disk D and to the preset dimension of the position of maximum taper.

[0064] In the illustrated configuration, the translational motion along the fourth direction d_4 is substantially vertical and has the function to provide various dimensions for the position of maximum taper M of the surface profile P, depending on the diameter ϕ_e of the disk-shaped element D and the particular structural properties required at the end of the machining operation.

[0065] A first exemplary final configuration for the disk-shaped element D is shown in FIG. 7a. A tapering profile P is formed on each of the opposite faces S', S", with a position of maximum taper M at a radial distance δ that substantially corresponds to half the difference between the external diameter ϕ_e and the internal diameter ϕ_I of the annulus defined by the hub of the disk-shaped element D.

[0066] In the example of FIG. 7b, the position of maximum taper M is set at a distance δ substantially corresponding to two thirds of such difference.

[0067] Nevertheless, the machine also allows continuous variation of the distance δ by vertical translation of the slide 33, allowing for adjustment of the position of the spindle 25 and thus the disk-shaped element D to be machined.

[0068] FIG. 6 also shows the means 34 for sensing the size of the disk-shaped element D and checking whether surface machining has been properly carried out.

[0069] These sensing means 34 may include one or more pairs of sensors 35 operating on the opposite faces S', S" of the disk-shaped element D being machined and possibly connected to an electronic controller, which is not shown because it is known per se.

[0070] The controller may be equipped with software suitably configured for management of machining dimensions and working parameters, with the working parameters associated to the different dimensional and structural characteristics of the element to be machined stored therein.

[0071] In the preferred, non-exclusive, configuration of the figures, the sensors 35 include a pair of sensing members 36 moving along substantially parallel and radial fifth directions d_5, into contact with the opposite faces S', S" of the disk-shaped element D.

[0072] The sensing members 36 have the function to detect the thickness s of the disk-shaped element D as soon as it has been locked in position, and to analyze its surface profile P after or during each machining operation, at an annular area disposed at a predetermined radial distance from the axis A of the disk-shaped element D.

[0073] Thus, the sensing members 36 may transduce and transmit the dimensional data of the disk-shaped element D on the machine 1 to the electronic controller to allow automatic setting of working parameters.

[0074] Mechanical format-changing adjustments are thus minimized, wherefore automatic mechanical adaptation of the various parts of the machine 1 is obtained, as well as a minimized number of mechanical parts to be replaced for machining disk-shaped elements of different formats.

[0075] FIG. 6 also shows a particular configuration of the sensing means 34 in which the sensing members 36 are mounted to the end 37 of a support arm 38, whereas a pneumatic actuator 39 moves the sensing members 36 to a position proximate to the disk-shaped element D.

[0076] Advantageously, the sensing means 34 may be integral with the bearing structure 29. This configuration is particularly useful if a second pair of tools 5 is provided on the table 2, each tool being associated to respective drive units similar to the units 7 and 12 provided for the first pair of tools 5, and to respective locking means 3 and drive means 4, for carrying out a second machining operation on the disk-shaped element D after the first machining operation carried out by the first set of tools 5.

[0077] Here, the horizontal translational motion of the first slides 30, 31 moves the disk-shaped element D between such two pairs of tools 5. At the same time, the sensing means 34, driven with the bearing structure 29, are alternately carried to either pair of tools 5.

[0078] The machine 1 also features cooling and lubricating means, not shown, which convey fluid through a dedicated pump or a central system to the working area via one or more pipes.

[0079] FIG. 8 shows an automatic line 41 for surface machining of disk-shaped elements D according to the invention, which comprises a magazine 42 for loading/ unloading a plurality of disk-shaped elements D to be machined and/or already machined and means 43 for automatically transferring the disk-shaped elements D between the magazine 42 and a machine tool 1 as described above.

[0080] The automatic transfer means 43 essentially include an anthropomorphic arm 44 with an end 45 attachable to the table 2 and the opposite end 46 having means 47 for gripping one disk-shaped element D at a time.

[0081] Advantageously, the gripper means 47 may be of the pneumatic, vacuum type and include, for instance, a gripper wrist 48 with a suction plate designed for picking up a disk-shaped element D to be machined from the magazine 42 and positioning it on the locking flanges 21, 22.

[0082] Likewise, the arm 44 picks up a machined disk-shaped element D from the machine 1 to place it on the magazine 42, and performs automatic scraps management.

[0083] Thanks to this particular configuration the steps of loading and unloading the disk-shaped elements D before and after machining are fully automatic. The provision of a magazine 42 improves standalone operation of the whole line 41 by limiting human intervention requirements to simple loading of the workpieces to be machined in the magazine 42 and unloading machined pieces therefrom.

[0084] Also, the provision of an anticollision sensor, not shown, might further simplify management of the machining steps, reduce human error probability and allow automatic compensation for abrasive tool wear.

[0085] **FIG. 9** shows a flowchart depicting a method for surface machining of a disk-shaped element D using a machine 1 or an automatic line 41 as described above.

[0086] The method includes the steps of a) picking up the disk-shaped element D to be machined and/or corrected, b) providing a stationary support table 2 defining a median working plane π and a first support axis X_1 substantially perpendicular to the median plane π, c) locking the disk-shaped element D on the table 2 so that its rotation axis A coincides with the first axis X_1, d) providing at least one pair of working tools 5', 5" rotatable about respective rotation axes X_2, X_3 and having operating surfaces designed to act upon the opposite faces S', S" of one disk-shaped element D at a time, e) sensing the thickness s of the disk-shaped element D for setting cutting parameters and a final surface profile P for the opposite faces S', S", f) adjusting the tilt α of the rotation axes X_2, X_3 of the tools 5', 5" relative to the median plane π to change the surface profile P of the disk-shaped element D and optimize structural resistance, g) rotating the pair of working tools 5', 5" and moving them from opposite sides along a first direction d_1 substantially parallel to the first axis X_1 to perform a first machining operation, h) checking the thickness (s) of the disk-shaped element D by sensing and comparing it with the preset surface profile P.

[0087] The machining g) and checking h) steps may be repeated until the preset surface profile P is obtained on both opposite faces S', S" of the disk-shaped element D, i.e. until a predetermined number of machining operations are carried out, whereupon the disk-shaped element D will be discarded.

[0088] After the step f) of adjusting the tilt α, a step I) may be provided for adjusting the position of the disk-shaped element D along a substantially vertical direction and with respect to the rotation axes X_2, X_3 of the tools 5', 5" to determine the dimension corresponding to the proper surface profile P, as related to the diameter ϕ_e of the disk-shaped element D and the position of maximum taper M, and also depending on structural resistance requirements for the machined disk-shaped element D.

[0089] In operation, the anthropomorphic arm 44 will move onto the stack of disk-shaped elements D in the magazine 42, and pick up the first one to place it coaxially with the first support axis X_1 outside the working area.

[0090] The locking flanges 21, 22 will hold the element D in position while the anthropomorphic arm 44 releases the hold and moves out of the working area. Then, the first slides 30, 31 will carry the disk-shaped element D into the working area to the operating position.

[0091] The second slide 33 will carry the disk-shaped element D to the operating position while the tracers 36 are moved to a position proximate to the respective faces S', S" foe the sensing step e).

[0092] The first 7 and second drive units 12 will carry out the step b) of providing the tools 5', 5" and the step f) of adjusting the tilt a of their rotation axes X_2, X_3 as well as the step g) of rotating them and moving them forward along the first workpiece direction d_1 by the carriages 15 for machining depth adjustment.

[0093] Advantageously, the step h) of checking the surface state may be carried out by the sensing members 36 either at the end of or during a machining operation, and anyway without removing the machined element D from the machine 1. In the latter case, a rough machining step may be first carried out, followed by a sensing step, using the tracers 36, and a finishing step, with continuous check of the working parameters.

[0094] As the machining process is terminated, whether a conforming or non-conforming workpiece is produced, the disk-shaped element D is moved out of the working area and picked up by the anthropomorphous arm 44 which will place it in a special area of the magazine 42.

[0095] This will greatly reduce the overall machining times for each element D, while increasing the throughput of the whole machining line 41.

[0096] The above description clearly shows that the invention fulfils the intended objects and particularly meets the requirement of providing a machine tool for surface machining of disk-shaped elements, particularly cutting tolls, that allows simultaneous machining of both faces S', S" of the disk-shaped element D with not necessarily planar surface profiles P.

[0097] By the provision of automatic transfer means 42, the whole line 41 will ensure high reliability and safety, because any manual handling of the products to be machined by operators will be avoided, such means 43 and the machine 1 being used for almost all format-changing settings.

[0098] The machine, line and method of the invention are susceptible of a number of changes and variants, within the inventive concept disclosed in the annexed claims. All the details thereof may be replaced by other technically equivalent parts, and the materials may vary depending on different needs, without departure from the scope of the invention.

[0099] While the machine, line and method have been described with particular reference to the accompanying figures, the numerals referred to in the disclosure and claims are only used for the sake of a better intelligibility of the invention and shall not be intended to limit the claimed scope in any manner.

Claims

1. A machine tool for surface machining of disk-shaped elements, particularly cutting tools, wherein each disk-shaped element (D) has a rotation axis (A) and substantially parallel opposite faces (S', S"), comprising:

- a stationary table (2) defining a first support axis (X_1) and a median working plane (π) substantially perpendicular to said first axis (X_1);
- means (3) for removably locking one disk-shaped element (D) at a time coaxially with respect to said first axis (X_1);
- drive means (4) associated to said first axis (X_1) for moving the disk-shaped element (D) between a start position outside the working area and an operating position and vice versa,
- at least one pair of working tools (5', 5") rotatable about respective rotation axes (X_2, X_3) and having respective operating surfaces (6', 6") designed to act upon the opposite faces (S', S") of the disk-shaped element (D);

characterized in that said rotation axes (X_2, X_3) are rotatably supported on second support axes (Y_2, Y_3) for changing the tilt (α) of said working tools (5', 5") relative to said median plane (π) and adjusting the angular position of said operating surfaces (6', 6") relative to the opposite faces (S', S") of the disk-shaped element (D).

2. Machine tool as claimed in claim 1, **characterized in that** it comprises, for each tool (5', 5") of said pair, a first drive unit (7) having a first support shaft (8) rotatable about a corresponding second support axis (Y_2, Y_3) for rotating said rotation axis (X_2, X_3) about said second support axis (X_2, X_3).

3. Machine tool as claimed in claim 1, **characterized in that** it comprises, for each tool (5', 5") of said pair, a second drive unit (12) associated to the rotation axis (X_2, X_3) of said tool (5', 5") to set it into rotation thereabout.

4. Machine tool as claimed in claim 3, **characterized in that** said first (7) and second (12) drive units are mounted to respective translation carriages (15) slideable from opposite sides along a first direction (d_1) substantially orthogonal to said median plane (π) to move said tools (5', 5") from an outside inoperative position to an operating position proximate to the working area.

5. Machine tool as claimed in claim 1, **characterized in that** said locking means (2) include a pair of second support shafts (17, 18) rotatably mounted to said first axis (X_1) on opposite sides with respect to said median plane (π).

6. Machine tool as claimed in claim 5, **characterized in that** said second support shafts (17, 18) have respective first axial ends (19, 20), equipped with flanges (21, 22), adapted to cooperate with each other to rotatably lock the disk-shaped element (D) on said first axis (X_1).

7. Machine tool as claimed in claim 6, **characterized in that** said drive means (4) include a pair of actuators (24, 26) associated to respective second axial ends (23, 27) of said second support shafts (17, 18) for causing them to translate along a second direction (d_2) substantially parallel to said first direction (d_1) and to rotate about said first axis (X_1).

8. Machine tool as claimed in any one of the preceding claims, **characterized in that** said locking means (3) and said drive means (4) are mounted to a first slide (31) slideable on said stationary table (2) along a third direction (d_3) substantially orthogonal to said second direction (d_2) to move the disk-shaped element (D) from said outside inoperative position to an inside operative position.

9. A machine tool as claimed in any one of the preceding claims, **characterized in that** said locking means (3) and said drive means (4) are mounted to a second slide (33) slideable along a fourth direction (d_4) substantially parallel to said median plane (π) to place the disk-shaped element (D) in said operative position.

10. Machine tool as claimed in claim 1, **characterized in that** it has means (34) for sensing the thickness (s) of the disk-shaped element (D) and checking whether surface machining has been properly carried out.

11. Machine as claimed in claim 10, **characterized in that** said sensing means (34) include at least one pair of sensors (35) acting upon the opposite faces (S', S") of the disk-shaped element (D) being machined.

12. Machine as claimed in claim 11, **characterized in that** said at least one pair of sensors (35) includes a pair of sensing members (36) moving along fifth substantially parallel directions (d_5) and designed to come into contact with opposite faces (S', S") of the disk-shaped element (D).

13. Machine as claimed in claim 1, **characterized in that** it comprises at least two pairs of working tools (5', 5") mounted to said stationary table (2).

14. An automatic line for surface machining of disk-shaped elements, comprising at least one magazine (42) for loading/unloading a plurality of disk-shaped elements (D) to be machined and/or already machined and means (43) for automatically transferring the disk-shaped elements (D) between said at least one magazine (42) and at least one machine tool (1) for surface machining of disk-shaped elements (D) as defined in any one of claims 1 to 13.

15. Automatic line as claimed in claim 14, **characterized in that** said automatic transfer means (43) include an anthropomorphic arm (44) associated to said stationary table (2).

16. Automatic line as claimed in claim 15, **characterized in that** said anthropomorphic arm (44) has an end (45) attached to said table (2) and the opposite end (46) having means (47) for gripping one disk-shaped element (D) at a time.

17. Automatic line as claimed in claim 16, **characterized in that** said gripper means (47) are of the pneumatic, vacuum type.

18. A method for surface machining of disk-shaped elements, particularly for grinding of disk-shaped elements, using a machine tool as claimed in any one of claims 1 to 13, wherein the method includes the steps of

a) picking up a disk-shaped element (D) to be machined and/or corrected, having a rotation axis (A) and substantially parallel opposite faces (S', S");
b) providing a stationary support table (2) defining a median working plane (π) and a first support axis (X_1) substantially perpendicular to said median plane (π);
c) locking said disk-shaped element (D) on said stationary table (2) so that its rotation axis (A) coincides with said first axis (X_1);
d) providing at least one pair of working tools (5', 5") rotatable about respective rotation axes (X_2, X_3) and having operative surfaces (6', 6") designed to act upon the opposite faces (S', S") of one disk-shaped element (D) at a time;
e) sensing the thickness (s) of the disk-shaped element (D) for setting cutting parameters and a final surface profile (P) for the opposite faces S', S" of the disk-shaped element (D);
f) adjusting the tilt (α) of said rotation axes (X_2, X_3) of said tools (5', 5") relative to said median plane (π) to change the surface profile (P) of the disk-shaped element (D) and optimize structural resistance;
g) rotating said at least one pair of working tools (5', 5") and moving them from opposite sides along a first direction (d_1) substantially parallel to said first support axis (X_1) to perform a first machining operation;
h) checking the surface state of the opposite faces (S', S") of the disk-shaped element (D) by sensing and comparing it with a desired final thickness (s);
i) possibly repeating the machining (g) and checking (h) steps until the preset surface profile (P) is obtained on both opposite faces (S', S") of the disk-shaped element (D).

19. Method as claimed in claim 18, **characterized** it further comprises a step (l) of adjusting the position of the disk-shaped element (D) along a substantially vertical direction, after said step (f) of adjusting the tilt (α) of said tools (5), to determine the position of maximum taper (M) for said surface profile (P).

20. Machine tool, an automatic line and a method for surface machining of disk-shaped elements, **characterized** as specifically described and illustrated herein.

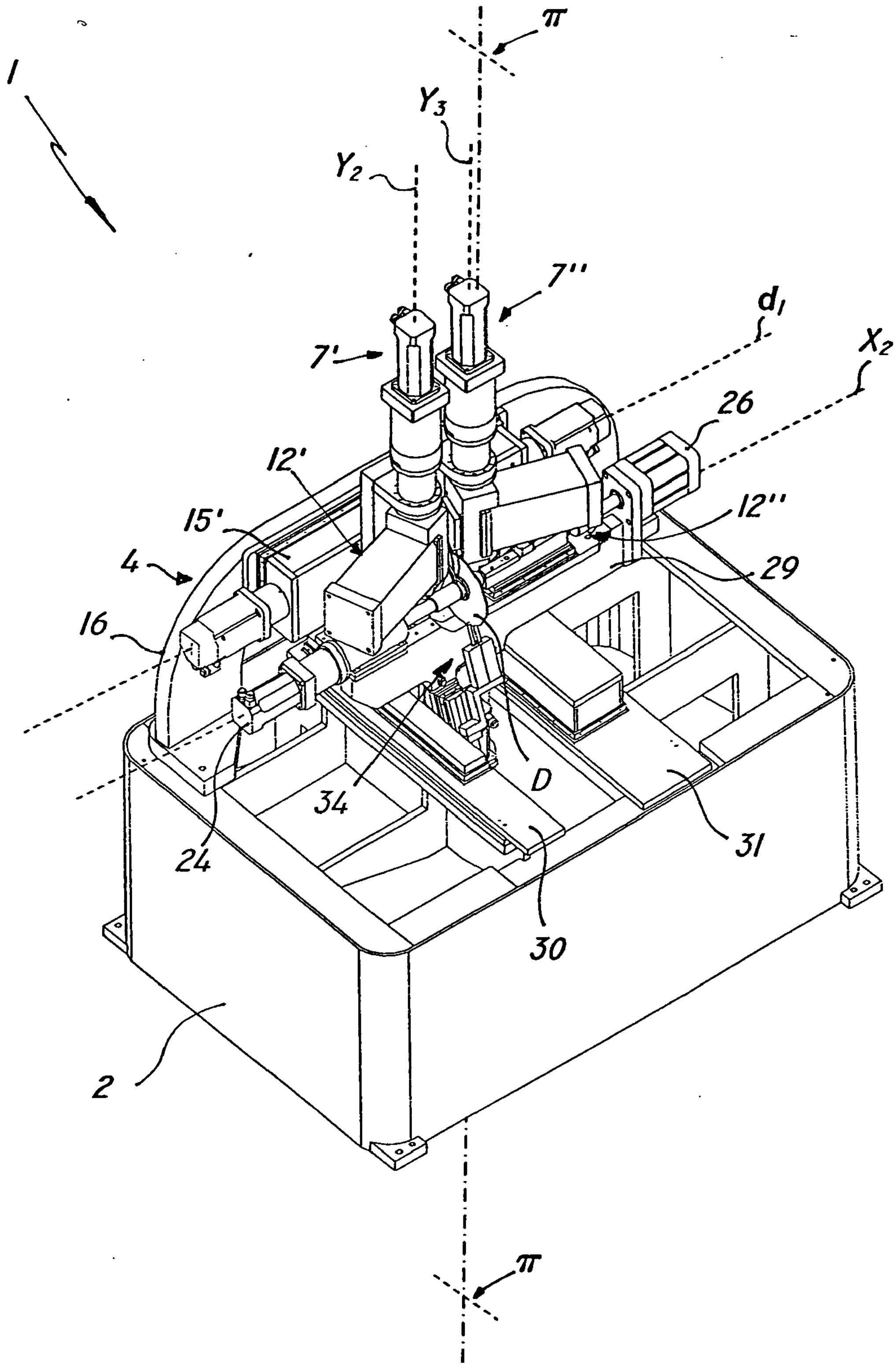

FIG. 1

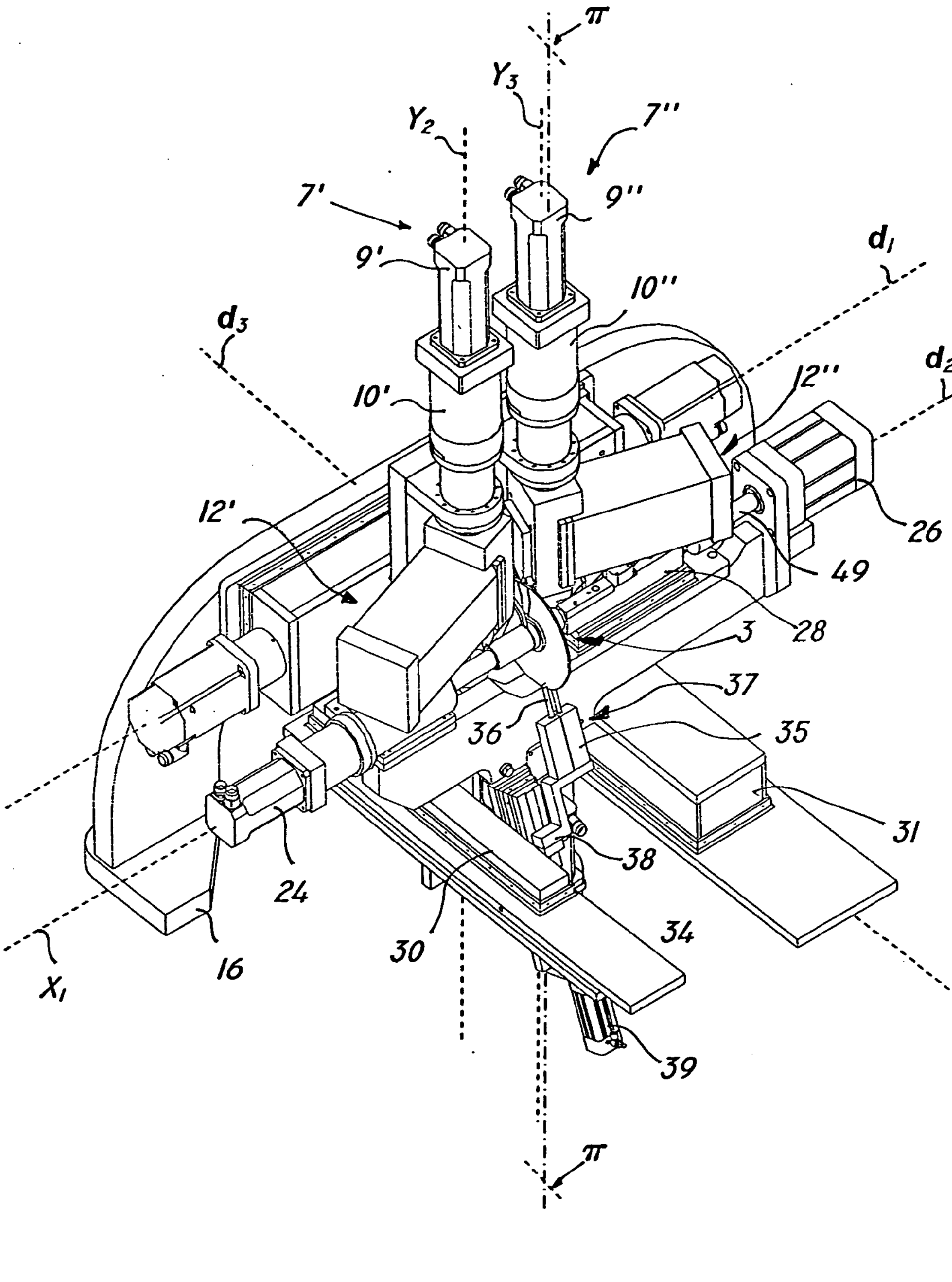
π
Y3
Y2
7''
7'
9''
9'
d1
10''
d3
d2
10'
12''
26
12'
49
28
3
37
36
35
31
38
24
30
34
16
X1
39
π

FIG. 2

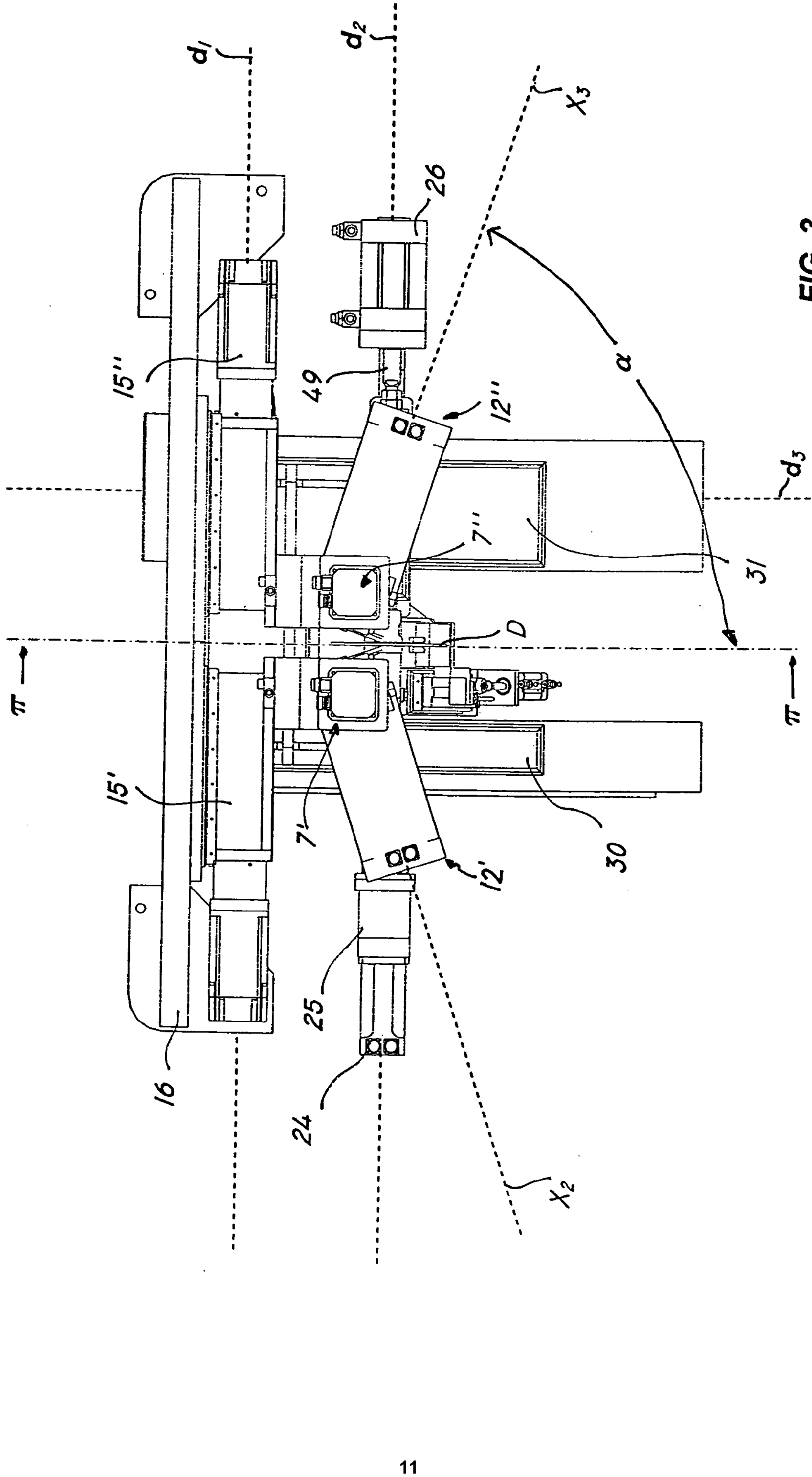

FIG. 3

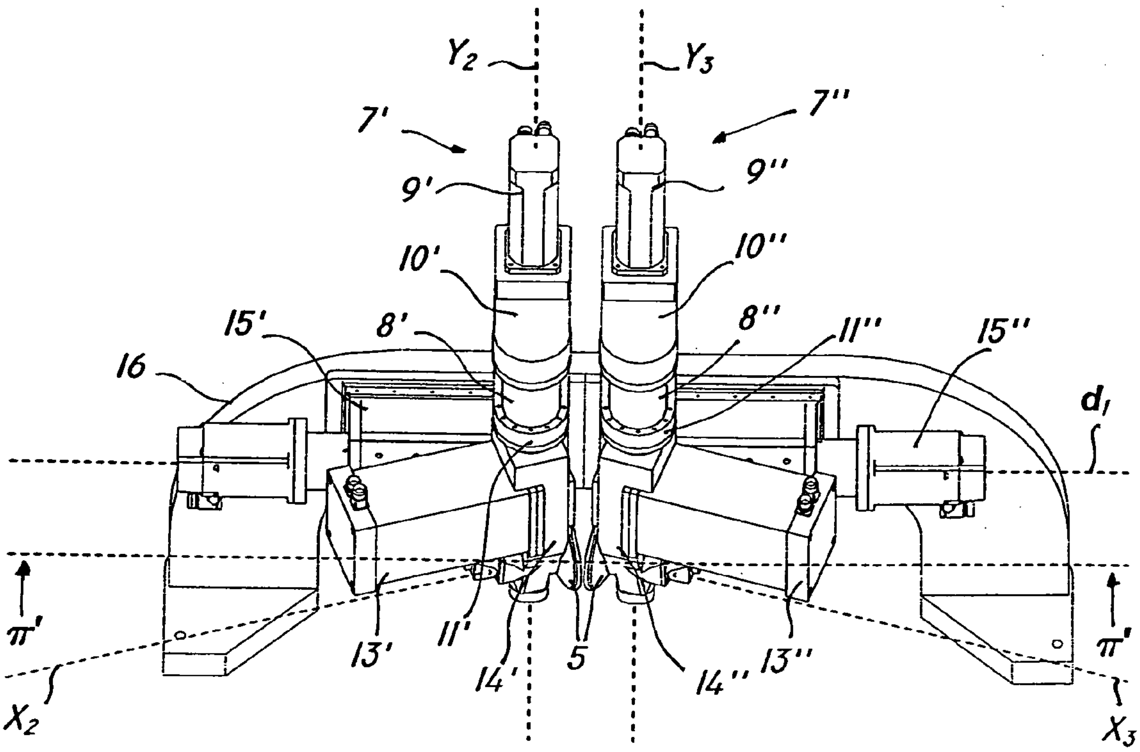
Y2
Y3
7'
7''
9'
9''
10'
10''
8'
8''
11''
15'
15''
16
d1
π'
π'
13'
11'
14'
5
14''
13''
X2
X3

FIG. 4

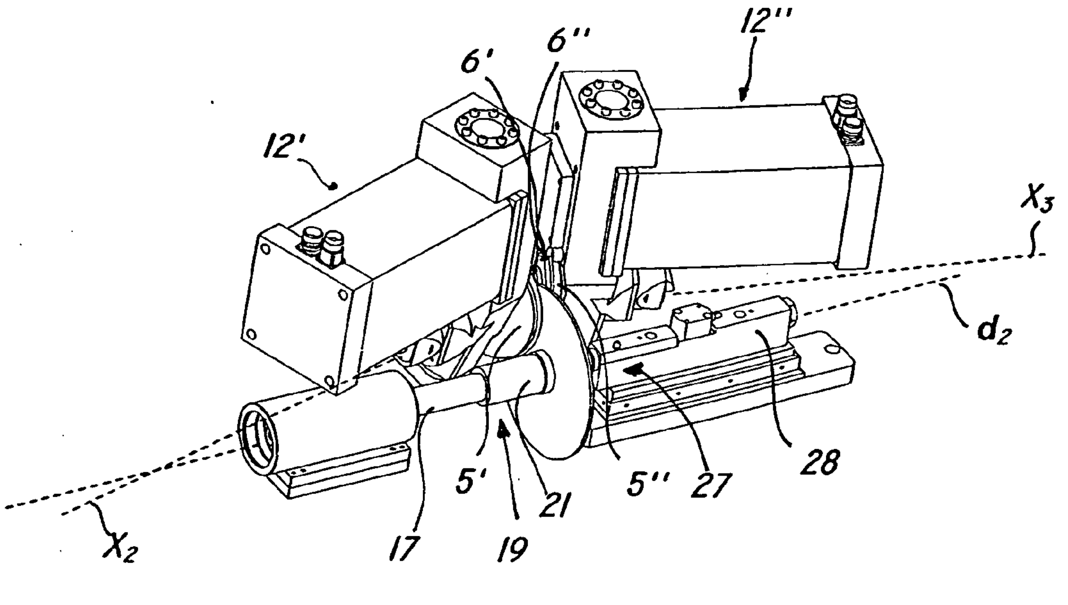
12''
6'
6''
12'
X3
d2
28
27
5''
21
5'
19
17
X2

FIG. 5

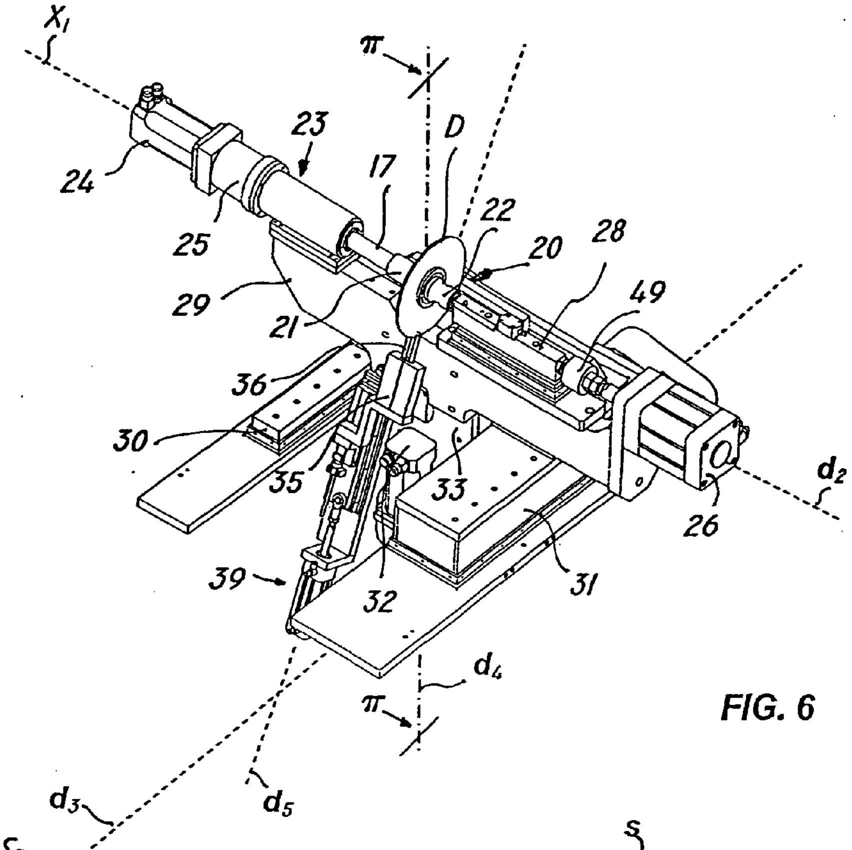

FIG. 6

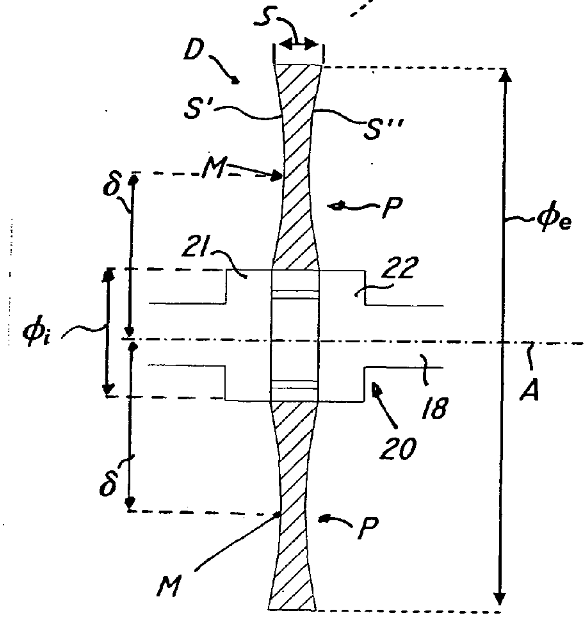

FIG. 7a

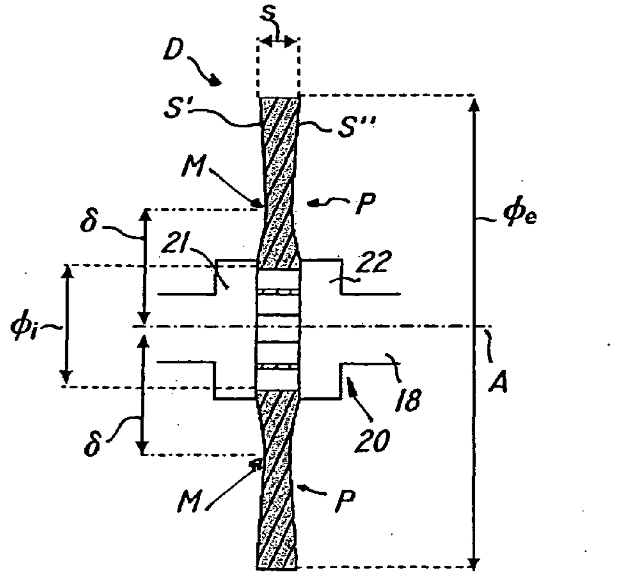

FIG. 7b

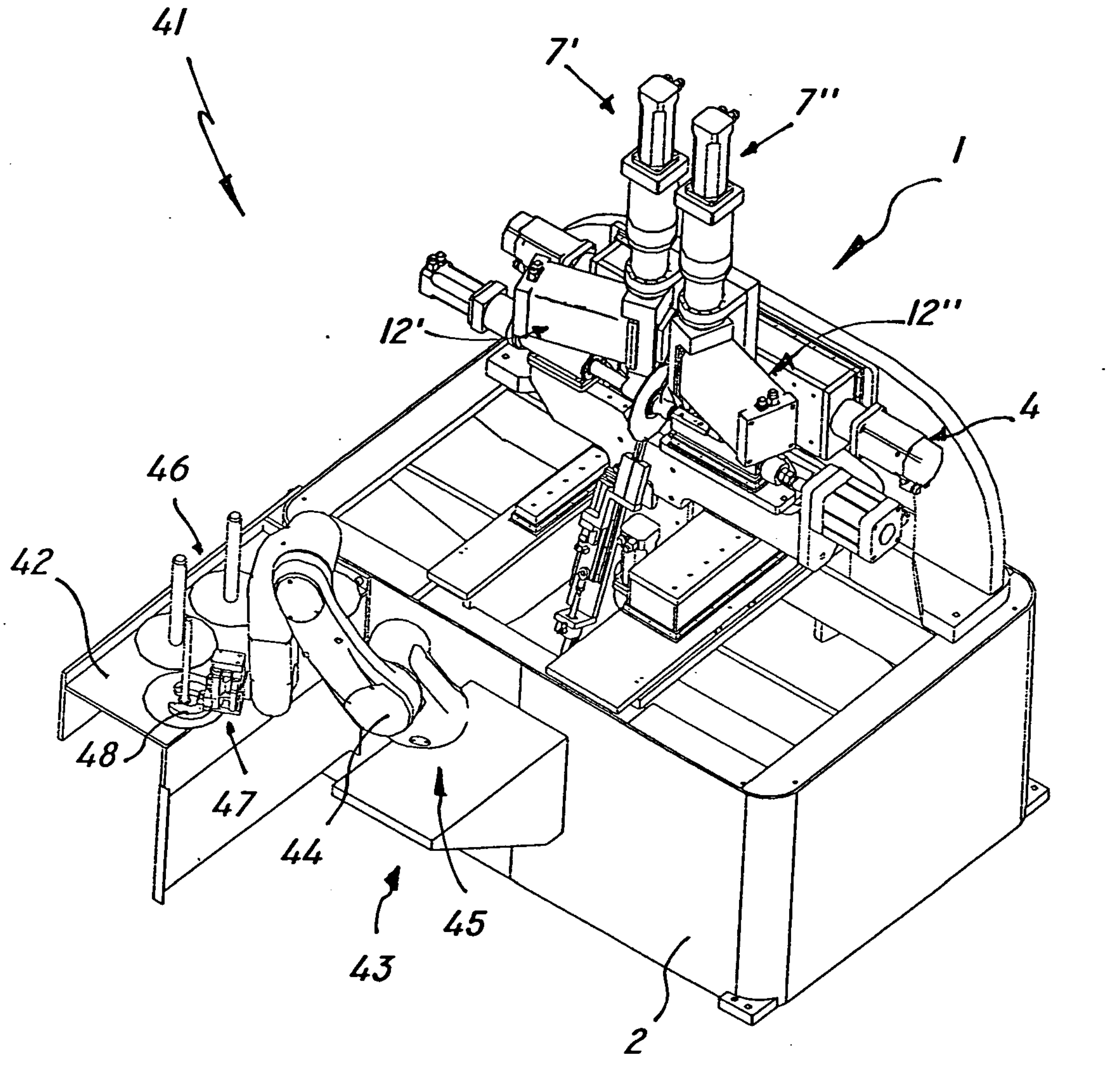

FIG. 8

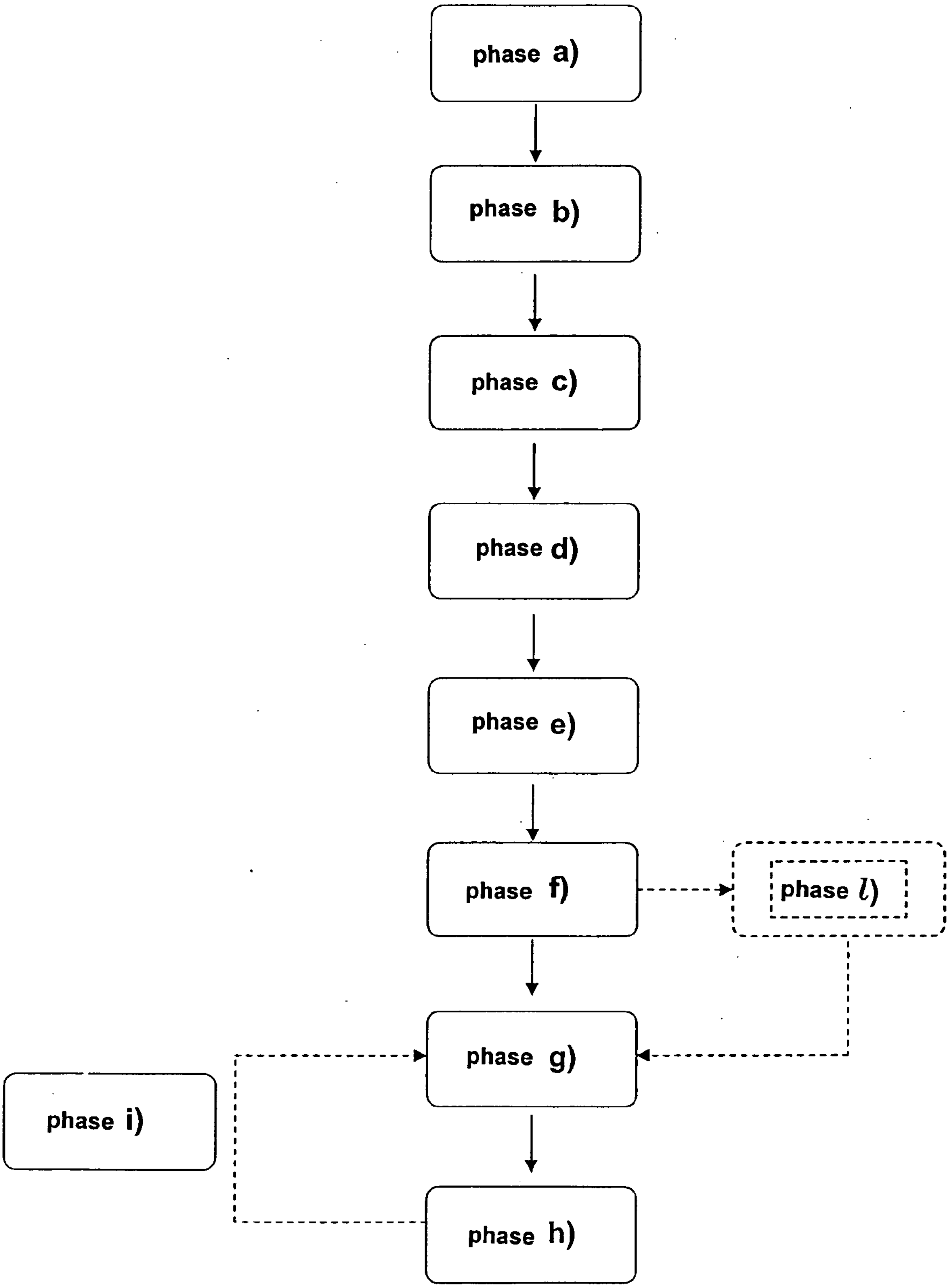
phase a)
phase b)
phase c)
phase d)
phase e)
phase f)
phase l)
phase g)
phase i)
phase h)

FIG. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 07 01 4840

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	US 2006/009125 A1 (OKURA KENJI [JP]) 12 January 2006 (2006-01-12) * paragraphs [0012], [0032] - [0035], [0039], [0061] - [0065], [0120]; figures 1,2 *	1-12,18, 19	INV. B24B7/17 B24B27/00
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B24B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	26 October 2007	Koller, Stefan

CATEGORY OF CITED DOCUMENTS

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26-10-2007

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