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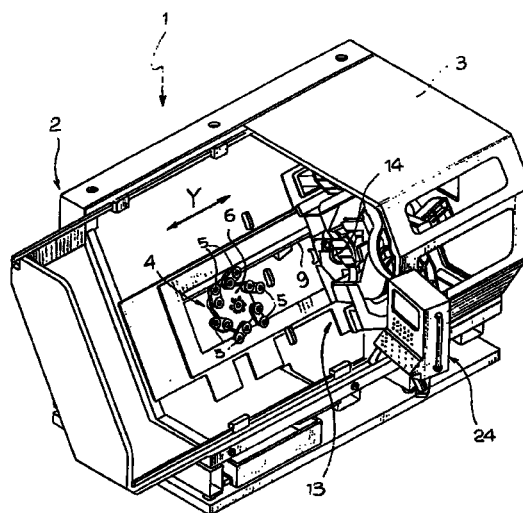
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(54) **Apparatus for machining the edge of glass plates**

(57) Described herein is an apparatus for machining the edges of glass plates (L), where the plate (L) is supported in a plane that is substantially vertical or anyway strongly inclined with respect to the horizontal, and is made to rotate in this plane. The plate is carried by a supporting assembly (4), which is in turn mounted on a slide (8) that is mobile on the fixed supporting structure of the apparatus in a horizontal direction of motion towards and away from a machining head (13) equipped with a grinding wheel (14) orientable in space. The movements of the mobile parts of the apparatus are governed by a numerical control system (24) in which the profile of the plate of glass to be machined is preliminarily acquired.

Fig. 1



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Description

[0001] The present invention relates to the field of apparatus for machining the edges of glass plates, in particular for bevelling the said edges.

[0002] For certain applications, such as mirrors, plates of glass for elements of furnishing, and so forth, the formation of a bevel is required on the edge of the glass plate. For this purpose, apparatus of various types are at present used. A first category of known apparatus is that of the so-called manual bevelling apparatus. Such apparatus comprise means for supporting the plate in a horizontal plane and for making it rotate about a vertical axis, as well as a rotary grinding wheel carried at the end of an arm which can be oriented about a vertical axis and which is pushed manually so as to cause the grinding wheel to come into contact with the edge of the plate during rotation of the latter.

[0003] The known apparatus of this first type consequently require the intervention of skilled staff for a non-negligible length of time. The horizontal position of the plate means that the cooling water used during machining and the swarf remain on the plate while the latter is being machined.

[0004] A second type of known apparatus is represented by the so-called automatic bevelling apparatus. These apparatus are equipped with a copying device consisting of a pair of tracer points, which come into contact with the edge of the plate. The grinding wheel is consequently controlled in such a way as to follow the profile of the plate thus detected, whilst the latter is made to turn in a horizontal plane about a vertical axis. This second type of apparatus presents the same drawback mentioned above deriving from the horizontal position of the plate as regards the problem of cooling water and swarf remaining on the plate during machining. In addition, since the said second type of apparatus works by copying the plate edge, it is necessary for the edge to be finished before bevelling is carried out. Consequently, the working cycle with said apparatus first of all comprises grinding of the edge of the glass plate, next machining of the bevel, and finally a second machining of the edge that is formed on the glass plate by the bevelling operation. Execution of the cycle described above entails a relatively long time, with a consequent low productivity of the apparatus, due to the fact that all the plates coming out of the bevelling apparatus must undergo re-machining.

[0005] There moreover exists a third type of known apparatus which is sold by the applicant Intermac under the BEVEL trade-mark. This apparatus is a numerical control bevelling apparatus in which the plate is set in a horizontal plane. This first of all involves the usual drawback due to the persistence of water and swarf on the plate. In addition, this latter type of apparatus presents a few problems in the machining of very thin plates. During the bevelling operation, the grinding wheel is pressed vertically with its front face inclined against the

peripheral edge of the glass plate, which is thus subjected to a bending stress. The plate must therefore be adequately supported and guided in the vicinity of its edge in order to prevent it from breaking. In more traditional apparatus this is obtained by providing supporting and guiding wheels underneath the plate in the vicinity of the grinding wheel. However, this solution cannot be adopted in the BEVEL numerical control apparatus described above on account of the specific conformation of the apparatus. In the said apparatus it is therefore necessary to use a jig which supports the plate in the vicinity of the edge of the latter. This means that it is necessary to have available a plurality of jigs according to the various types of plate, with consequent expenses for, and waste of time in, tooling of the apparatus, which result in higher costs and in reduced apparatus output.

[0006] Also in apparatus provided with a mechanical copying device it is not possible to carry out grinding of thin plates, in that the tracer point may cause said plates to break.

[0007] In conclusion, none of the known apparatus described above is able to carry out either grinding or bevelling of thin glass plates without any drawbacks.

[0008] The main purpose of the present invention is to overcome such drawbacks.

[0009] It is moreover to be borne in mind that from the European patent application EP-A-0 798 075 of the present applicant Intermac, an apparatus is already known for machining the edges of glass plates, comprising means for supporting the plate in a substantially vertical plane and for causing it to rotate in this plane, and a machining head comprising a grinding wheel which is orientable in space and is designed to come into contact with the edge of the plate during rotation of the latter. The solution proposed in said document is able to overcome the drawback regarding the presence of cooling water and swarf on the plate, in that the plate is kept in a substantially vertical plane. However, the apparatus proposed in said patent application has been unable to find a practical implementation on account of a series of drawbacks deriving from the specific geometry of said apparatus, which envisaged rotation of the plate about a substantially fixed axis and the arrangement of the grinding wheel on a carriage that moves vertically away from/up to the plate. Similar drawbacks may be found in the apparatus described and illustrated in the French patent No. 2 545 025, in which the glass plate is made to rotate in a plane substantially inclined at an angle of 45° with respect to the horizontal, and the grinding wheel is carried by a carriage which moves away from/up to the plate.

[0010] A further purpose of the present invention is to achieve the targets specified above, without at the same time introducing the drawbacks that are characteristic of the apparatus known from the documents EP-A-0 798 075 and FR-A-2 545 025.

[0011] With a view to achieving these and further purposes, the subject of the invention is therefore an

apparatus for machining the edge of glass plates, in particular for bevelling the edges of glass plates, comprising means for supporting the plate in a vertical plane, or anyway in a plane substantially inclined with respect to the horizontal, and for causing the plate to rotate in this plane, and a machining head comprising a grinding wheel designed to come into contact with the edge of the plate during rotation of the latter, characterized in that the aforesaid means for supporting the plate are carried by a slide or carriage mounted on a fixed supporting structure in such a way that it is free to move along a horizontal direction away from/up to said grinding wheel, said apparatus comprising a numerical control system for controlling movement of said grinding wheel and of said plate-supporting means.

[0012] In a preferred embodiment, the aforesaid machining head is provided with means for orienting the grinding wheel about three mutually orthogonal axes which cross in an area corresponding to the grinding wheel. More precisely, the machining head comprises:

a first supporting structure mounted so that it is free to turn on the fixed structure of the apparatus about a first axis which is set perpendicular to the plane in which the plate lies;

a second supporting structure mounted on said first supporting structure in such a way that it is orientable about a second axis set parallel to the plane in which the plate lies; and

a third supporting structure, which supports the grinding-wheel spindle in rotation and which is installed on said second supporting structure in an oscillating way about a third axis set parallel to the plane in which the plate lies and orthogonal to the said first and second axes.

[0013] Thanks to the above-mentioned structure and arrangement, the grinding wheel can be oriented during machining in order to guarantee perfect execution both of the process of grinding the edge of the plate and of the bevelling operation.

[0014] According to a further important characteristic of the invention, the apparatus comprises a pair of wheels for supporting and guiding the glass plate in the proximity of the grinding wheel, these wheels being interchangeable in the operating position for grinding and bevelling of the plate. Thanks to the structure and arrangement described above, the apparatus according to the invention enables a series of advantages to be obtained. In the first place, since the plate is kept in a substantially vertical plane, the water and swarf do not remain on the plate during machining. In the second place, the apparatus is equipped with a numerical control system for controlling the movements of the plate and of the grinding wheel during machining. The profile of the plate to be machined may be entered in the control system, without any need for setting up the mechanical tracer-point devices for feeling the profile. At the

same time, owing to the particular geometry of the apparatus, the plate can be supported, both during grinding of the edge and during bevelling, by means of supporting wheels adjacent to the grinding wheel, which avoid the need to use jigs (with consequent advantages in terms of tooling time and apparatus output) and guarantee execution of the operation without any breakages of the glass plates even when the latter are very thin. In addition, since it is not necessary to feel the profile of the plate using mechanical tracer-point devices, a preliminary operation of grinding the plate edge is not required prior to carrying out the bevelling process.

[0015] The arrangement of the means for supporting the plate on a mobile slide in a horizontal direction when bringing the grinding wheel up to or moving it away from the edge also enables solution of the problems that led to the failure of the apparatus illustrated in EP-A-0 798 075 being implemented. Furthermore, the particular geometry of the machining head described above enables the position of the grinding wheel with respect to the plate to be adapted in an optimal way during execution of the bevelling operation. The possibility of oscillation of the third supporting structure about the aforesaid third axis enables adjustment of the bevel angle. The possibility of rotation of the first supporting structure about the aforesaid first axis makes it possible to maintain the basic plane of the grinding wheel, once the latter has been inclined for carrying out bevelling, constantly tangential to the profile of the plate during machining. Finally, the possibility of oscillation of the second supporting structure about the aforesaid second horizontal axis makes it possible to perform the so-called "anti-sticking" function in order to reduce considerably the area of contact between the basic surface of the grinding wheel and the edge of the plate.

[0016] In brief, therefore, the apparatus according to the invention is able to overcome all the drawbacks referred to above present in the various types of known apparatus, and in particular is able to carry out without problems both the grinding process and the process of bevelling even thin plates, with a high production efficiency.

[0017] Further characteristics and advantages of the present invention will emerge from the ensuing description, with reference to the attached drawings which are provided purely as non-limiting examples, and in which:

Figure 1 is a perspective view of a preferred embodiment of the apparatus according to the invention, with certain parts removed for reasons of clarity of representation;

Figure 2 is a view at an enlarged scale of a detail of the apparatus of Figure 1;

Figure 3 is an elevation of a detail of Figure 2;

Figure 4 is a plan view of the detail of Figure 3;

Figure 5 is a perspective view of the detail of Figure 4;

Figures 6 and 7 are, respectively, a perspective view and a side view illustrating the operation of the grinding wheel forming part of the apparatus according to the invention, during execution of a plate-edge grinding operation; and

Figures 8 and 9 are, respectively, a perspective view and a side view illustrating the mode of operation of the grinding wheel forming part of the apparatus according to the invention, during execution of a bevelling operation.

[0018] In Figure 1, the reference number 1 designates, as a whole, an apparatus for machining the edges of glass plates, comprising a fixed structure 2 provided with a protective casing 3 (illustrated only partially in Figure 1).

[0019] The apparatus 1 comprises an assembly 4 for supporting the glass plate to be machined. The said assembly is provided, in a way in itself known, with a plurality of sucker-type devices 5 which have the purpose of holding the glass plate stably on the assembly 4. As may be seen in Figures 1 and 2, the said assembly basically includes a turntable 6 lying in a plane substantially inclined with respect to the horizontal plane. The invention does not rule out the possibility of the inclination reaching 90°, so as to set the glass plate in a perfectly vertical plane, but, as has already been pointed out, it applies in any case also to solutions which envisage the plate being set in a plane closely approaching the vertical plane or anyway strongly inclined (over 10°) with respect to the horizontal plane, as in the case of the example illustrated. The turntable 6 is mounted, in such a way that it can turn about an axis 7 normal to the plane in which it lies, on a slide 8 (see Figure 5) which is mounted in a sliding way along a horizontal direction Y between two guides 9 carried by the fixed structure 2 of the apparatus. This structure comprises reference means 10 (see Figure 2) for positioning the glass plate, the said means 10 being adjustable on respective guides 11 and moreover having an inoperative or retracted position (underneath the plate-resting surface), where they are taken after the plate has been picked up by the sucker-type devices 5 so as to render the edge of the plate to be machined completely accessible. The movement of the slide 8 is controlled by an electric motor 12 by means of an external thread 13 which engages an internal thread (not illustrated) rigidly connected to the slide 8 (see Figure 3).

[0020] By means of the displacement of the above-mentioned slide 8 along the Y axis, the assembly 4 for supporting the glass plate can be moved up to or away from a machining head 13 carrying a grinding wheel 14 for machining the edge of the glass plate L (see Figure 3) mounted on the assembly 4. The machining head 13 is supported by a fixed supporting structure or mount 15 (see Figures 2 and 3) which is rigidly connected to the fixed structure 2 of the apparatus. The mount 15 supports in rotation a first supporting structure 16 about an

axis C set perpendicular to the plane in which the plate L lies, i.e., parallel to the axis 7 of rotation of the assembly 4 for supporting the plate. The angular position of the first supporting structure 16 about the axis C is controlled by an electric motor 18 (Figure 2) mounted on the mount 15.

[0021] In turn, the first supporting structure 16 supports a second supporting structure 19 (see Figure 3) about an axis T that is parallel to the plane in which the plate L lies. The angular position of the second supporting structure 19 about the axis T is controlled by a hydraulic cylinder (not illustrated in the drawings).

[0022] In turn, the second supporting structure 19 defines an arched guide 20 on which a third supporting structure 21 is mounted in a sliding way. Mounted so that it can turn on said third supporting structure 21 is the spindle of the grinding wheel 14, the axis of which is designated by 22 in Figure 3. In this way, the third supporting structure 21 can be made to oscillate about an axis B that is parallel to the plane in which the plate L lies and orthogonal to the axis T. The three axes C, T, B meet in a point corresponding to the grinding wheel 14.

[0023] The position of the third supporting structure 21 on the arched guide 20 is controlled by a motor unit 23 which operates a pinion (not illustrated) which meshes with a toothing (not illustrated either) associated to the guide 20.

[0024] Also envisaged is the possibility of a further axial displacement of the grinding wheel up to/away from the plate L in a direction perpendicular to the plane in which the plate L lies (for adjustment according to the thickness of the plate).

[0025] The constructional details of the motor means which control displacement about the three axes C, T, B are not illustrated, in so far as they may be built in any known way and in so far as the elimination of these items from the drawings renders the latter easier and faster to understand.

[0026] The motor means which control movement about the axes C, T, B, as well as the motor 12 which controls displacement of the slide 8 carrying the assembly 4 for supporting the glass plate are all controlled by a numerical control system, the cabinet of which is designated by 24 in Figure 1.

[0027] The numerical control system can send commands to the apparatus to carry out both grinding of the edge of the glass plate L (see Figures 6 and 7) and bevelling (see Figures 8 and 9). According to which of the two types of the two operations, grinding or bevelling, is to be performed, a respective wheel 25 or 26 is activated for supporting the edge of the plate L in the vicinity of the grinding wheel 14, so as to guarantee perfect execution of machining without any risk of the plate breaking, even in the case of a very thin plate. The two wheels 25, 26 are interchangeable in the operating position, according to the type of machining to be carried out. For this purpose, each of said wheels is mounted so that it is free to turn at the end of a tele-

scopic supporting element 27, controlled, for instance, by a hydraulic cylinder, in order to enable displacement of each of said wheels 25, 26 between a raised, operating, position and a lowered, inoperative, position.

[0028] Operation of the apparatus according to the invention is described in what follows.

[0029] With reference to Figures 3, 8 and 9, in the case where it is necessary to carry out a bevelling operation, the grinding wheel 14 is inclined as illustrated in Figure 8, by rotation about the axis B. This rotation is obtained by translating the supporting structure 21 on the arched guide 20. The maximum angular oscillation that may be set about the axis B is, in the case of the example illustrated, approximately 45°. Once the grinding wheel 14 has been inclined as illustrated in Figure 8, by means of rotation about the axis B, it is also inclined laterally, by rotation of the structure 19 about the axis T, to reduce the surface of contact between the grinding wheel 14 and the plate L, thus achieving the so-called "anti-sticking" effect. To carry out machining, the slide 8 is brought up to the machining head 13 so as to bring the edge of the plate L up against the grinding wheel 14. The assembly 4 is set in rotation about the axis 7 so as to bring the various portions of the edge of the plate L, in succession, into contact with the active surface of the grinding wheel 14 (see Figures 8 and 9). During machining, the first supporting structure 16 is oriented about the axis C in such a way as to maintain the basic plane of the grinding wheel 14 constantly tangential to the edge of the plate, whatever the profile of the latter may be. Of course, the various motor means with which the apparatus is equipped are governed by the numerical control system 24 according to a pre-set program so as to follow the profile of the plate L, which is preliminarily acquired by the control system. During bevelling, the grinding wheel 14 (Figure 8) exerts a thrust downwards on the edge of the plate, which is, however, adequately supported by the wheel 26. In this way, the risk of breakage of the plate is prevented, even in the case of a very thin plate, without thereby any need for using jigs as, instead, is necessary in the case of some known apparatus that were mentioned at the beginning of the present description.

[0030] The machining head also includes means for varying the position of the grinding wheel 14 along the axis 22, so as to adapt said position to the thickness of the plate. In addition, a grinding-wheel magazine is envisaged (only partially visible in the right-hand top part of Figure 2) for automatic replacement of the grinding wheel.

[0031] In the case where the edge of the plate L is to be trimmed, the grinding wheel 14 is positioned with its axis 22 perpendicular to the plane in which the plate L lies, as illustrated in Figures 6 and 7. Also in this case the plate is adequately supported by the wheel 25, which is set further away from the grinding wheel 14 than the wheel 26, in order to prevent any interference with the grinding wheel 14 when the latter is in the posi-

tion corresponding to the grinding operation.

[0032] From the foregoing description it is evident that the apparatus according to the invention is able to combine the advantages of known apparatus without, however, presenting any of the drawbacks that have been mentioned at the beginning of the present description. In particular, the apparatus according to the invention is able to carry out both the grinding operation and the bevelling operation on plates that are even very thin, without any risk of the plates breaking and without any of the drawbacks discussed previously.

[0033] Of course, without prejudice to the principle of the invention, the details of construction and the embodiments may vary widely with respect to what is described and illustrated herein purely for the purpose of providing an example, without thereby departing from the scope of the present invention.

Claims

1. An apparatus for machining the edges of glass plates (L), comprising means (4) for supporting the plate (L) in a plane that is substantially vertical or anyway strongly inclined with respect to the horizontal, and for causing the plate (L) to rotate in its plane, and a machining head (13) comprising a grinding wheel (14) which is orientable in space and is designed to come into contact with the edge of the plate (L) during rotation of the latter, characterized in that said means for supporting the plate (L) in a substantially vertical plane are carried on a slide (8) which is mounted so that it is able to move on a fixed supporting structure (2) along a horizontal direction (Y), up to and away from said grinding wheel, said apparatus comprising a numerical control system for controlling the movements of said grinding wheel and of said means for supporting the plate (L).
2. An apparatus according to Claim 1, characterized in that said machining head (13) is provided with means for orienting the grinding wheel about three mutually orthogonal axes (C, T, B) which substantially cross at the grinding wheel (14).
3. An apparatus according to Claim 2, characterized in that said machining head (13) comprises:
 - a first supporting structure (16) mounted so that it is free to turn on the fixed structure (2) of the apparatus about a first axis (C) which is set perpendicular to the plane in which the plate (L) lies, and substantially passes through the centre of the grinding wheel (14);
 - a second supporting structure (19) mounted on said first supporting structure (16) in such a way that it is orientable about a second axis (T) that is parallel to the plane in which the plate (L)

lies, and substantially passes through the centre of the basic surface of the grinding wheel (14); and

a third supporting structure (21), which supports the spindle (22) of the grinding wheel (14) in rotation and which is installed on said second supporting structure (19) in an oscillating way about a third axis (B) that is parallel to the plane in which the plate (L) lies, and is orthogonal to said first axis (C) and said second axis (T).

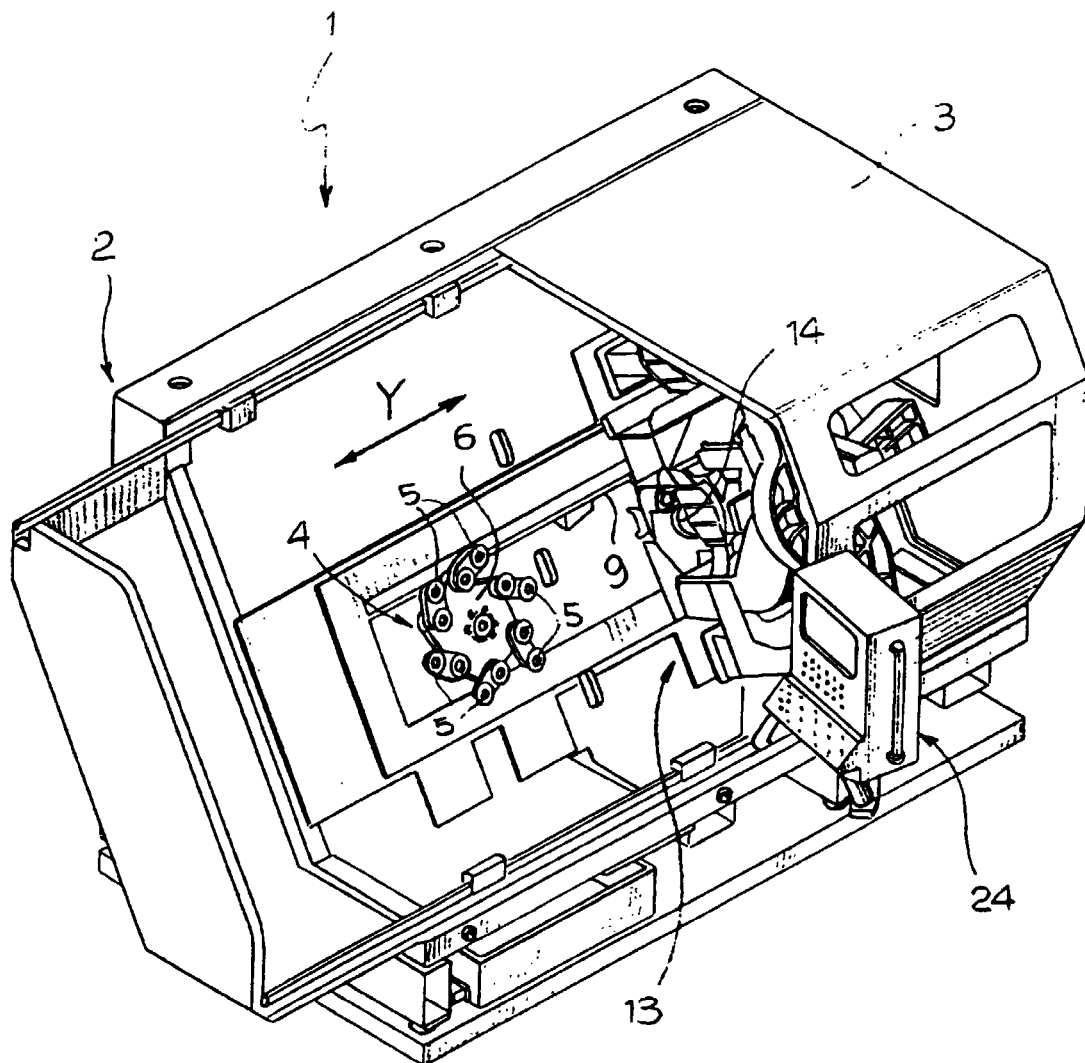
4. An apparatus according to Claim 3, characterized in that said supporting structure (21) is mounted in a sliding way on an arched guide (20) forming part of said second supporting structure (19).
5. An apparatus according to Claim 1, characterized in that it comprises a pair of wheels (25, 26) for supporting and guiding the glass plate (L) in the vicinity of the grinding wheel (14), said wheels (25, 26) being interchangeable in the operating position, respectively for the grinding and for the bevelling of the plate.
6. An apparatus according to Claim 1, characterized in that the fixed supporting structure (2) carries a plurality of reference and supporting means (10) which support the plate (L) in a precise position until the latter is picked up by said supporting means (4), said reference and supporting means (10) being mounted in a sliding way on respective guides (11) for their proper positioning, and presenting an operating position and a non-operating position.
7. An apparatus according to Claim 1, characterized in that the aforesaid plate-supporting means (4) comprise a turntable (6) which is mounted, so that it can turn about an axis (7) perpendicular to the plane in which the plate (L) lies, on said slide (8), which is in turn mounted in a sliding way between a pair of parallel guides (9) carried by the fixed structure for supporting the apparatus.
8. An apparatus according to Claim 4, characterized in that said first supporting structure is mounted so that it is free to turn on a mount (15) belonging to the fixed structure (2) of the apparatus and is controlled by an electric motor (18) supported by said mount (15).
9. An apparatus according to Claim 4, characterized in that said second supporting structure is mounted in such a way that it is free to oscillate about said second axis (T) at one end of the aforesaid first supporting structure (16) and is controlled by means of a hydraulic cylinder.

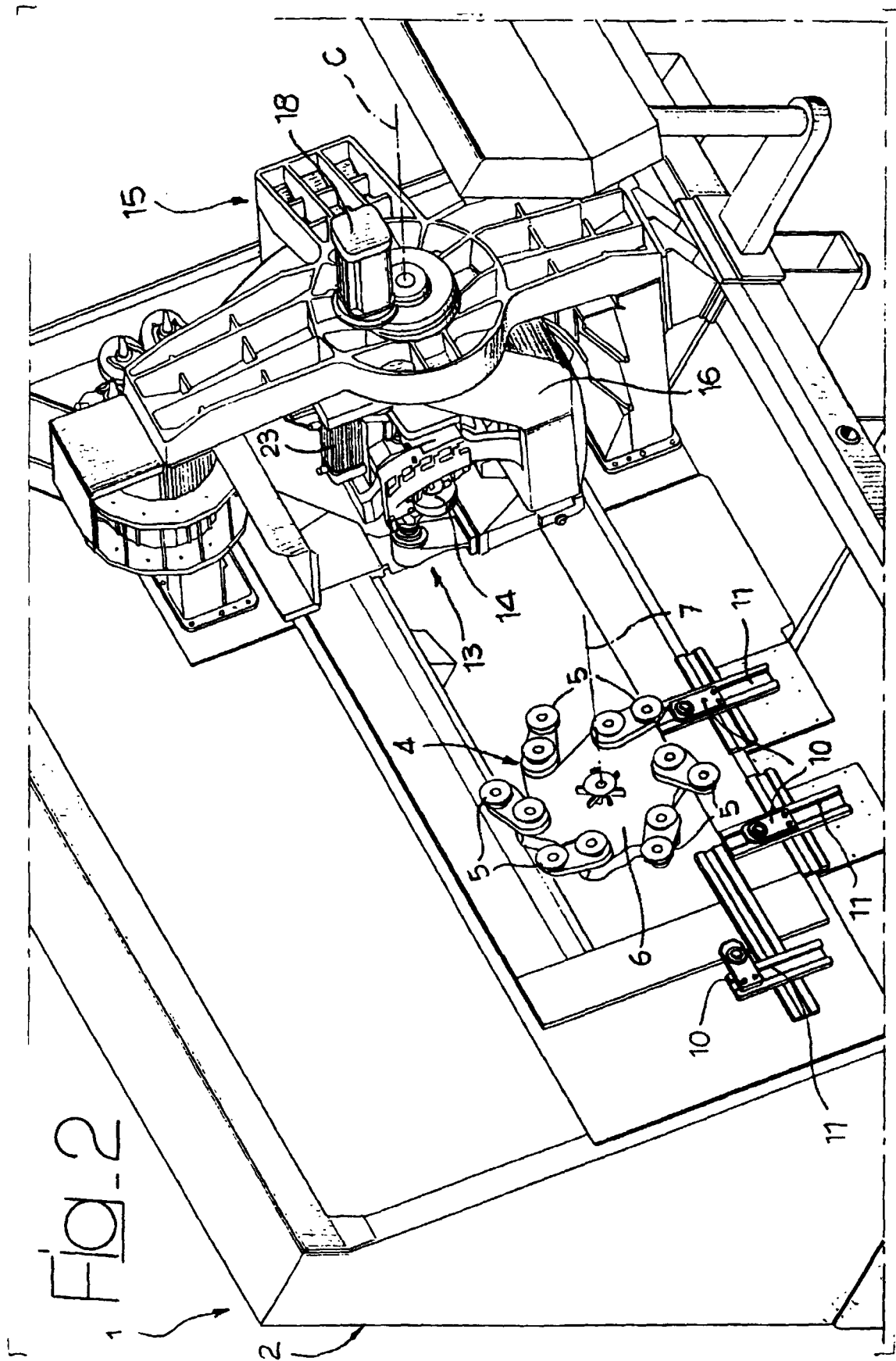
10. An apparatus according to Claim 4, characterized in that the aforesaid third supporting structure (21) carries a driving motor (23) for operating a pinion that meshes with a toothing associated to the aforesaid arched guide 20 to cause a displacement of said third supporting structure (21) along said arched guide (20).

11. An apparatus according to Claim 1, characterized in that said slide (8) is controlled by an electric motor (12) carried by the fixed structure (2) of the apparatus by means of a external thread-internal thread system (13).

12. An apparatus according to Claim 1, characterized in that said grinding wheel is supported with the possibility of a displacement in a direction perpendicular to the plane in which the plate lies, for adjustment according to the thickness of the plate to be machined.

Fig. 1





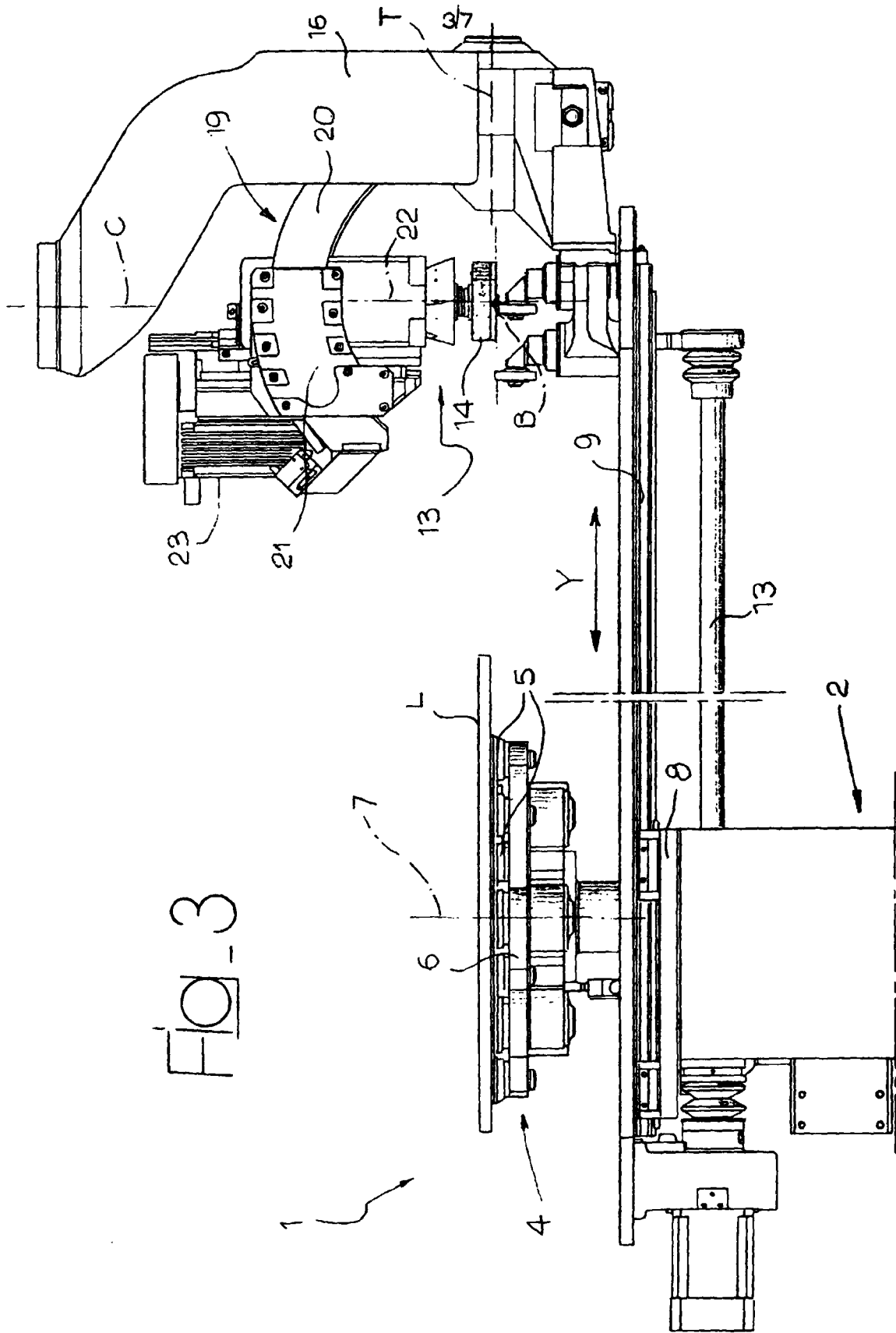
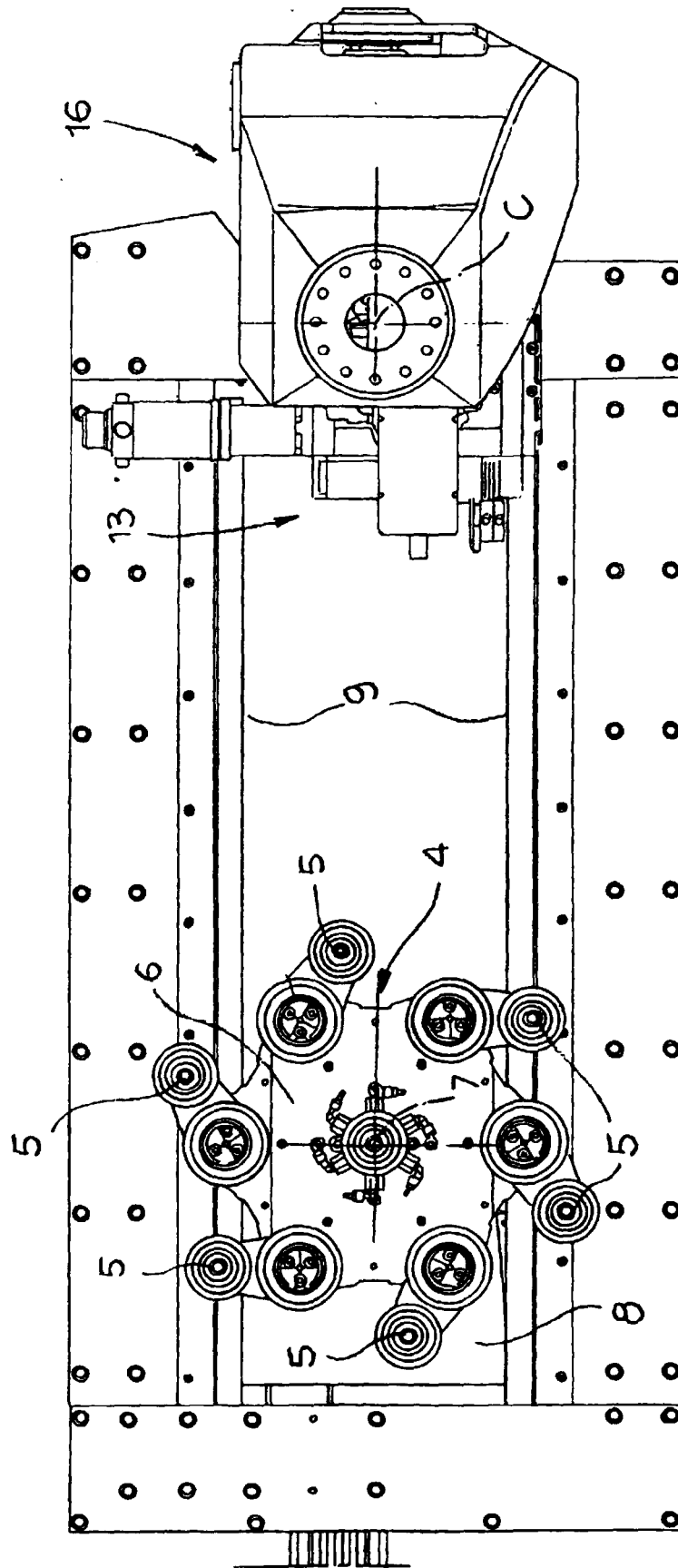


FIG. 4



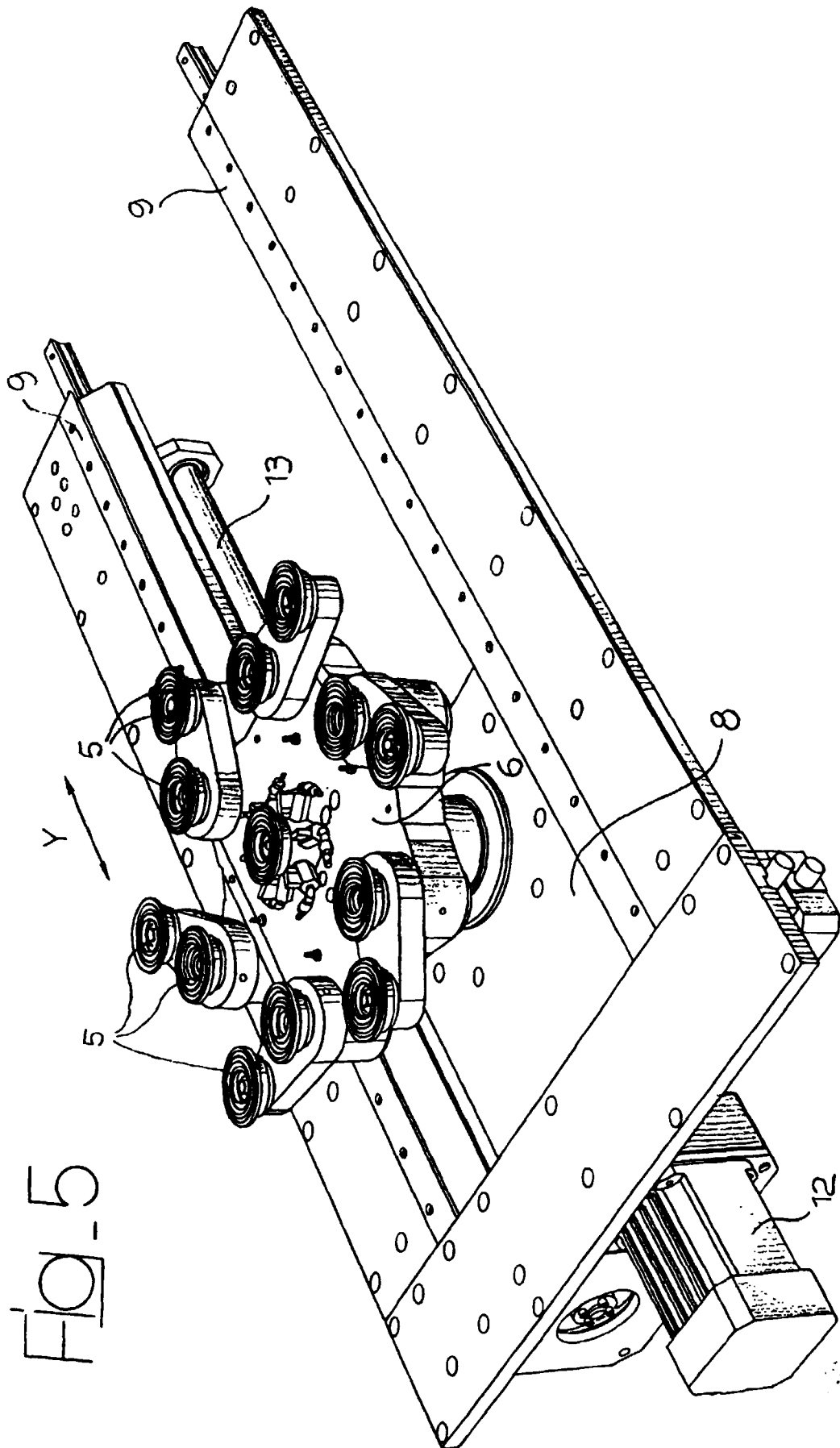


Fig. 6

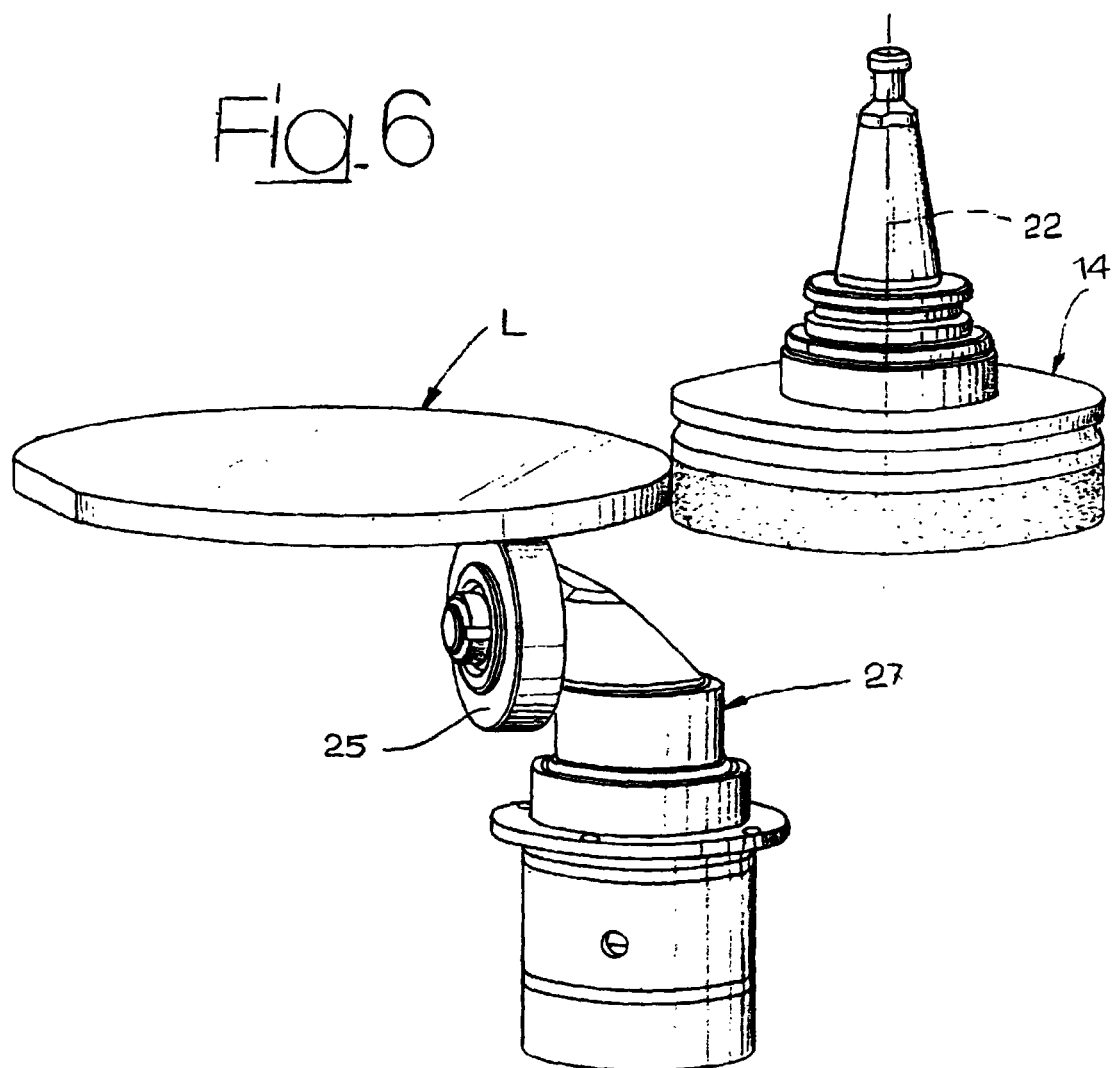


Fig. 7

