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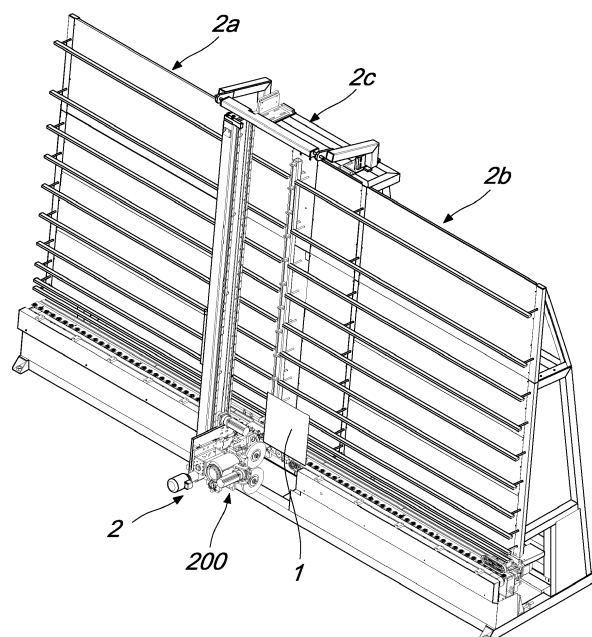
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(54) **Automatic machine and automatic method for localized removal of coatings deposited on glass plates**

(57) An automatic machine for removal of the nano-coating with a thickness of a few hundred angstroms from the perimetric margins of the face of glass plates (1) having a rectangular or other than rectangular shape that are substantially flat and arranged vertically or almost vertically, comprising a machine body (2) equipped with a resting surface with pseudovertical sliding (2c) and with a pseudohorizontal conveyor (500) and at least one working head (200, 100), movable in relation to the glass plate (1) along its perimeter, the working head comprising two

tool bodies (201a, 201p, 101a, 101p) that are adjustable and floating in a direction that is substantially transverse to the plane of the glass plate (1), each tool body (201a, 201p, 101a, 101p) comprising a cylindrical abrasive tool (202a, 202p, 102a, 102p) which rotates with a cutting motion to carry out the grinding operation, the two tool bodies (201a, 201p, 101a, 101p) of the working head (200, 100) being arranged in series, i.e., in succession with respect to the direction of the relative motion between the head (200, 100) and the glass plate (1).



*Fig. 2*

## Description

**[0001]** The present invention relates to an automatic machine and an automatic method for localized removal of coatings deposited on glass plates.

**[0002]** Currently, techniques are known for removing coatings (or, in the jargon, "edging") from the peripheral margin of glass plates. The function of the coatings is to give the glass certain properties described hereinafter.

**[0003]** Removal is performed in order to allow valid adhesion of the sealants to the glass, said sealants being used particularly to compose the insulating glazing (or double-glazing unit in the jargon), also described hereinafter.

**[0004]** The coating is constituted typically by multiple layers of metals and metallic oxides of atomic thickness deposited by means of nanotechnology processes, for example with the sputtering technique, and are anchored physically and chemically to the glass; however, since some layers can be easily oxidized, this anchoring to the glass is vulnerable with exposure to atmospheric agents, such as in particular humidity. Although the double-glazing unit, the composition of which will be explained hereinafter, inhibits atmospheric contact, since the coated surfaces are oriented inward, the part of the glass plate, and of the coating with it, that constitutes the perimetric edge, although it has a moderate extension in the transverse direction (hundreds of angstroms), reacts with the atmospheric agents and is exposed to oxidation. Over time, this oxidation detaches the coating from the glass and therefore the insulating glass in its entirety is brought into contact with atmospheric agents. Besides compromising the effectiveness of the insulation, already in itself a serious issue, this entails loss of retention of the external glass by the sealant and, in the rather frequent case of lack of mechanical fixing systems, such as the case of structural glazing, the possible falling of the external glass from the building, which is a particularly dangerous event.

**[0005]** The coating, therefore, has to be removed at the perimetric margin intended for the sealants. This removal must be complete in order to ensure the adhesion of the sealants and must have an esthetically pleasant finish because it is visible in all cases in which the glass plates are exposed in their entirety because they are not masked by the frames; this completeness does not occur with currently commercially available machines.

**[0006]** In order to better understand the configuration of the glass plate, not so much in its possible isolated use but especially in its use in combination with other components to constitute what is called a double-glazing unit, some concepts regarding the semifinished product, i.e., the glass plate, and the final product, i.e., the insulating glass commonly termed double-glazing unit, are summarized hereafter. The subsequent use of the double-glazing unit, i.e., as a component of door or window frames or of continuous glazing or structural glazing, is known to the person skilled in the art and is not discussed

in detail here.

**[0007]** With reference to the schematic view of the double-glazing unit shown in Figure 1a, the double-glazing unit is constituted typically by two or more glass plates 1001, 1002, etc., mutually separated by one or more spacer frames 1003, etc., which are internally hollow and are microperforated on the face directed toward the inside of the chamber.

**[0008]** The spacer frames 1003 contain, in their hollow part, hygroscopic material, not shown in the figure, the task of which is to absorb humidity. The chamber (or chambers) 1007 delimited by the glass plates 1001 and 1002 and by the frame 1003 can contain air or gas or mixtures of gases injected therein, which give the double-glazing unit particular properties, for example thermal insulation and sound-insulating properties. Recently, the use of a spacer profile 1003 has spread which has an essentially rectangular cross-section or a rectangular cross-section with two recesses and is made of expanded and flexible synthetic material (by way of non-limiting example:

silicone and EPDM) that embeds in its mass the hygroscopic material. The joint between the glass plates and the frame is obtained by means of two layers of seal: the first seal 1004 is used to provide a hermetic closure and

affects the lateral surfaces of the frame 1003 and the portions adjacent thereto of the glass plates (1001, 1002); the second seal 1005 affects the compartment constituted by the external surface of the frame and by the faces of the glass plates up to the edge thereof, and has the function of providing cohesion among the components, maintaining over time the mechanical strength of the joint among them. In the case of a spacer profile made of flexible material, a further bond between the spacer frame 1003 and

the glass plates 1001, 1002 is constituted by an acrylic adhesive 1006 that provides an immediate mechanical coupling among said elements, which is useful in the step of composing the double-glazing unit before the perimetric sealant 1005 is effective, since it requires a few hours for catalysis.

**[0009]** Figure 1 shows five of the many possible sectional views of double-glazing unit configurations 1a, 1b, 1c, 1d, 1e, only the first and last of which have been commented. However, it is straightforward to extend the above description to the configurations 1b, 1c, 1d, in which there are either multiple frames or offset or laminated glass plates. In the figure, the sun represents schematically the external environment of a building in which the double-glazing units are installed, while the inside of the building is represented schematically by a radiator.

**[0010]** The glass plates used in the composition of the double-glazing unit can have different shapes as a function of use; for example, the external glass 1001 (with

respect to the building) can be standard or selective or reflective glass (in order to limit the thermal intake during the summer months) and can also be laminated/armored glass (for intrusion/vandalism prevention functions) or can be laminated/toughened glass (for safety functions) and also combined, for example reflective and laminated glass, as well as offset with respect to the internal glass plate or the intermediate glass plate.

**[0011]** The internal glass plate 1002 (with respect to the building) can be of the standard or low-emissivity type (in order to limit the dissipation of heat during winter months) and can also be laminated/toughened glass (for safety functions) and also combined, for example low-emissivity and laminated.

**[0012]** The properties related to thermal insulation, both under winter conditions (low emissivity) and under summer conditions (selective), as well as the properties related to light transmission, are obtained by means of deposits of metals and metal oxides, generally multilayer ones, with a total thickness on the order of hundreds of angstroms, which however must be removed in the perimetric portions for interaction with the sealants.

**[0013]** From the simple summary given above, it is already evident that a production line for obtaining the double-glazing unit product requires many processes in sequence and each one requires a corresponding and particular machine to be arranged in series with respect to the other complementary ones. Some processes or operations, by way of non-limiting example and at the same time not all necessary, are the following, described in summary:

- *EDGING* on the peripheral margin of the face of the glass plate of any coatings, in order to allow and maintain over time the adhesion of the sealants as mentioned earlier, a method and a machine that the present invention deals with extensively in terms of important improvements with respect to the background art;
- *GRINDING* of the edges of the individual glass plates, in order to eliminate the sharp edge thereof, which is dangerous in terms of accidents and is the source of fractures of said glass plate because it contains microcracks, particularly in glass plates intended for toughening; or complete *GRINDING* of the edge;
- *WASHING AND DRYING* of the individual glass plates;
- *APPLICATION OF THE SPACER FRAME*: the frame, manufactured beforehand, filled with hygroscopic material and coated on the lateral faces with an adhesive sealant having sealing functions, is applied on one of the glass plates that constitute the double-glazing unit in an appropriately provided station of the production line of the double-glazing unit; as an alternative, the spacer frame can be manufactured directly against the glass plate by unwinding a flexible spacer and depositing it at the perimetric

edge of the glass plate with automatic or semiautomatic machines;

- *COUPLING AND PRESSING* of the assembly constituted by glass plates and frame (or frames);
- *FILLING WITH GAS* of the chamber (or chambers) thus obtained;
- *SECOND SEALING*.

**[0014]** The above listed processes can be carried out by the respective machine automatically or semiautomatically.

**[0015]** As regards edging, a step of the production of insulating glass to which the improvement provided by the present application refers, the background art, embodied essentially but also uniquely in the machines spread both by competitors and by the applicant of the present application as well as in the corresponding industrial property rights, performs only grinding processes, using a/one (both as indefinite article and as a numeral) dry (or wet) cylindrical grinding wheel with a mix that is elastic or at least deformable or subject to wear and contains abrasive granules dispersed uniformly in order to mutually adapt the tool and the glass plate in the contact region.

**[0016]** This edging, besides being performed as described earlier, i.e., in the production lines of the double-glazing unit, can also be performed before the cutting of the glass plate from the commercial format to the formats for use of the insulating glass. This occurs on cutting tables, where again a/one (both as indefinite article and as a numeral) dry grinding wheel with elastic mix follows the track constituted by the boundary between the various formats, straddling them so as to edge a band, which after scoring and cut running of the glass is divided between the adjacent formats. This solution is adopted if the bands to be edged have a limited width.

**[0017]** Methods and machines that perform edging are described, for example, in EP 0 769 348 B1 in the name of the same applicant as the present application, in EP 0 165 232 B2 in the name of Lisec Peter, in EP 1 314 513 B1 in the name of Lenhardt Maschinenbau GmbH, in DE 196 32 240 A1 in the name of Hegla Fahrzeug und Maschinenbau GmbH.

**[0018]** The greatest drawbacks common to all background art listed above are constituted by:

- difficulty, since the mix cannot be sufficiently elastic, of combining the shape of the abrasive tool with the part of the face of the glass plate to be edged, which are not perfectly co-planar, and therefore uneven removal of the coating;
- difficulty in removing the coating, which sometimes is particularly hard without affecting the surface of the glass and in an irregular manner;
- possibility that the coating appears to be removed but actually is not removed or is not removed completely;
- mediocre or poor definition of the boundary between

- the edged region and the non-edged region;
- the consequence of the above is that the tightness of the insulating glazing unit is compromised, if not in the short term certainly in the medium and long term;
- moreover, and worse, in the case of glazing, typically structural glazing, in which the peripheral margin is not encapsulated in a door or window frame but remains visible, every irregularity of the edged margin entails an unacceptable aesthetic flaw, in addition to a severe danger of detachment and falling of the external glass.

**[0019]** The most advanced prior art is DE 196 32 240 A1, which relates to a working head equipped with a tandem of two floating tools (cylindrical grinding wheels) of different widths, so as to select two widths of the edging bands as a function of the region of the plate being edged, before it is divided into the final formats, such as for example 20 mm in the internal regions of the plate and 10 mm along the external perimeter, the inner bands being subsequently scored and separated longitudinally along the central axes, thus obtaining the 10-mm margin. A single grinding wheel with a width of 20 mm could not perform the 10-mm edging along the external perimeter, since during this process it would wear out over half of its thickness and therefore it would not have a regular geometry for removing subsequently 20-mm bands in the inner regions. This is the prior art that approaches most closely the invention to which the present application relates, but only the latter solves the problems listed above and moreover increases the productivity of the process and of the machine and is innovative with respect to the Hegla patent and anyway performs a completely different process.

**[0020]** The aim of the present invention is therefore to solve the highlighted technical problems, eliminating all the drawbacks according to the background art and therefore devising an automatic machine and an automatic method that allow edging of the margins of glass plates in a reliable, repetitive, qualitatively perfect manner, which is lacking in the background art, and last but not least in an economical manner.

**[0021]** A further object of the present invention is to avoid altering the structure of the production line of the insulated glazing, taking advantage of the modularity that typically characterizes it.

**[0022]** Another object is to perform grinding in a manner consistent with the shape of the perimetric profile of the glass plate even when it is non-rectangular, due to the presence of inclined sides and of curvilinear portions.

**[0023]** This aim and these and other objects that will become more apparent from the description that follows are achieved by an automatic machine for edging the margins of substantially flat glass plates, characterized in that it comprises a machine body and at least one working head, adapted to carry at least two tools arranged in series with respect to each other, i.e., in suc-

cession with respect to the working direction, said tools being in floating contact with the margins of the glass plate and being movable, each one independently of the other or others, toward and away from the margin of the glass.

**[0024]** The relative movement between said at least one working head and said glass plate 1 (of which either the former or the latter can move or all of which can move simultaneously in the case of glass plates with a non-rectangular shape) constitutes, in the etymology of machine tools, the feed movement or forward movement.

**[0025]** The second movement, the one known as cutting movement in the etymology of machine tools, is the one imparted to the tool (grinding wheel) with an autonomous control.

**[0026]** A further movement, the one known as registering movement in the etymology of machine tools, is used to position the tool with respect to the external margin of the glass plate, both for edging in which the band corresponds to the thickness of the tool (grinding wheel), in which case the external margin of the tool corresponds to the edge of the glass or the edge of the chamfer of the glass, and for edging in which the band is greater than the thickness of the tool (grinding wheel), in which case there have to be multiple passes until the desired extension of the edging is covered; this registering movement is obtained by means of the initial arrangement of the axes that actuate the relative movement described earlier.

**[0027]** Advantageously, the processing of glass plates having a non-rectangular shape, for example a polygonal shape composed by all rectilinear sides, or a multiform shape, i.e., composed of rectilinear or curvilinear portions, preferably but not exclusively with a base portion constituted by a rectilinear side, is allowed; in the first case (polygonal, including the rectangle), by activating the tools referenced by the subscript a (front) for a rough grinding pass and the ones referenced by the subscript p (rear) for a finishing pass, simultaneously, in the second case (multiform), by activating the tools, the first one with the subscript a (front) for a rough grinding pass and the second one with the subscript p (rear) for a finishing pass, in successive steps because only one can be coupled tangentially to the perimeter, which is not rectilinear, of the glass plate, this occurring due to the combined action of the horizontal translation axis H, of the vertical translation axis V, and the rotation axis J.

**[0028]** Advantageously, the glass plate is arranged vertically, rests on a sliding surface and can move horizontally on a conveyor.

**[0029]** The arrangement described as vertical is actually slightly inclined with respect to the vertical plane (generally by 6°) in order to give static stability to the glass plate, i.e., prevent its tipping.

**[0030]** Further characteristics and advantages of the invention will become more apparent from the detailed description, given in the following chapter, of a particular embodiment of the invention, illustrated merely by way

of non-limiting example in the accompanying drawings, wherein:

Figures 1a-1e are partial sectional views of a series of typical configurations of a double-glazing unit; Figure 2 is a general perspective view of the machine that incorporates the invention, in the version with a single working head (assembly 200), without the numbering of the assemblies of components that are highlighted better in Figure 3;

Figure 3 is a general perspective view of the body of the machine that incorporates the invention and of its assemblies of components 100, 200, 300, 400, 500, in the version with two working heads (assemblies 100, 200), without the numbering of the components that are highlighted better in the subsequent figures;

Figure 4 is a perspective view of the working head 200 containing at least two tool bodies 201a, 201p, arranged in series, carrying in turn the tools 202a, 202p, which summarizes the inventive concept (arrangement in series of at least two tools that perform in succession the grinding processes, for example the first one being aggressive and affecting also the surface of the glass for assured removal of the coating (nanodeposit), the second one being a soft finishing process; for this purpose, both the mixes and the abrasives that constitute the tools can have the ideal compositions (a wide range of possibilities exists on the market) so that each tool performs the required process); in particular, the working head that can move vertically (assembly 200) is shown, a fixed lower head, not shown, optionally coexisting therewith; this figure shows schematically the processing mode of the tools having a registering motion R', R" and a cutting motion T with respect to the margin of the glass plate 1 and a forward motion (relative between the tools and the glass plate); the discontinuities in the illustration of the tools have the purpose of showing the actuators, each one performing the registering motion of the diving type of said tools;

Figure 5 is a more detailed perspective view, oriented differently than Figure 4, of the components of the working head (the one of the assembly 200), which shows clearly the tilting supporting mechanisms 203a, 203p, the actuation mechanisms 204a, 204p, and the feedback mechanisms 205a, 205p that allow the movement of the active face of the tools (grinding wheels) toward the glass plate and away from the glass plate, which originates the tilting registration R", and the mechanisms 206, 207, 208, 209, originating the registration R'; moreover, the discontinuity in the illustration of the tool 202a has the purpose of showing the fulcrum 203p about which the other tool 202p tilts;

Figure 6 is a perspective detail view of the components of the working head that belongs to the as-

sembly 200 in its connection to the hollow support that defines the rotation axis J that includes the components 301, 302, 303, 304, 305, 306, for the actuation of said rotation (background art);

Figure 7 is a perspective detail view of the components of the working head that belongs to the assembly 200 in its connection to the slider that runs along the vertical axis V that includes the components 401, 402, 403, 404, 405, 406, 407 for the actuation of said vertical movement (background art); Figures 8 and 8a are a perspective and a perspective detail view of the components that belong to the assembly 500, actuate the transport of the glass plate 1 along the horizontal axis H and are constituted by two systems, the first one 501 for the movable support of the glass plate 1, which interacts with the lower side 1d thereof, which consists of conveyor belts, or conveyor rollers, the second one for the synchronous movement of the glass plate 1 by means of the components 503, 504, 505, 506, 507, 508, by means of the sucker 502, both systems being shown in their essential components for the actuation of said horizontal movement (background art);

Figures 9a to 9n are views of the working principles for a machine and a method using only one working head 200, showing the tool with filling when it is in the active step of contact with the glass plate 1 and therefore of grinding and without filling when it is in the inactive step, while the margin of the side of the glass plate 1 that has been subjected already to the process of grinding either by means of the forward tool or by means of both tools is represented with a shaded area;

Figures 10a to 10f are views of the processing principles for a machine and a method using two working heads 100, 200; the tool is shown with filling when in the active step and without filling when in the inactive step, while the margin of the glass plate 1 that has already been subjected to the process of grinding either by means of the front tool or by means of both tools is represented with a shaded area; the steps are not detailed as for Figures 9a-9n but have been merged for the sake of simplicity;

Figures 11a to 11d are views of the shapes of the glass plates the processing of which is possible with the machine and the method according to the present invention;

Figure 12a is a view of an example of insertion of the machine 1000 according to the present invention in the production line of the insulating glass 1 (in a front elevation view);

Figure 12b is a view of an example of insertion of the machine 1000 according to the present invention in the production line of the insulating glass 1 (in plan view) and includes the identifications of the main body 2, of the input and output conveyors 2a and 2b, of the electric/electronic panel 11, of the control post 12, and of the safety devices 13;

Figures 12c-12f are views of glass plates having different shapes;

Figures 13 and 14 are views illustrating operation steps.

As anticipated earlier, Figures 1a-1e are schematic views of the peripheral portion of the double-glazing unit according to an exemplifying series of possible combinations: standard configuration (Fig. 1a), triple glazing with inner glass of the low-emissivity type (Fig. 1b), offset glazing with external glass of the selective type and inner glass of the low-emissivity type (Fig. 1c), laminated external glass and inner glass of the low-emissivity type (Fig. 1d), offset glazing with external glass of the toughened selective type and laminated inner glass of the low-emissivity type (Fig. 1e). Figures 1a to 1d show the spacer frame of the rigid type, Figure 1e shows the spacer frame of the flexible type. Attention is called again to the presence of two types of sealant used: the butyl sealant 1004, having the function to supply a gas- and water vapor-tight sealing that is stable over time (first seal), applied between the lateral surfaces of the frame and the glass plates, and the two-part or single-part polysulfide or polyurethane or silicone sealant applied at ambient temperature or single-part sealant 1005 applied hot, having the function of providing stable mechanical strength over time (second seal), which is applied between the external surface of the frame and the inner faces of the glass plates up to the edge thereof.

Figure 1e shows a further level of coupling between the parts, constituted by an acrylic adhesive 1006 having the function of bonding immediately the various components, without waiting for the catalysis of the second sealant, with the advantage of immediate handling of the insulated glazing, for example by lifting by means of suckers that operate on the external face of only one of the glass plates.

**[0031]** In the figures in which one or more glass plates are of the coated type (low-emissivity or selective) it is noted that said coating, shown by emphasizing its thickness, which in reality is only a few hundred angstroms, is interrupted or rather eliminated at the region affected by the sealants and the adhesives. This is to make the adhesion of the sealants and adhesives to the glass plates 1 efficient and stable over time. The coating layer, in fact, would be subjected over the years to an oxidation starting from the external edge of the glass plate that would entail a separation from it. Since the large source glass plates from which the formats of the target glass of the required dimensions are obtained in order to compose the insulating glazing unit are coated over their whole extension, this applies also to the target formats and therefore it is necessary to perform removal at the region intended to interact with the sealants.

**[0032]** With reference to the accompanying and already commented figures, single-digit numerals designate

the main components of the machine (two-digit figures designate the assemblies without subassemblies) so as to have a global overview thereof, the numeral 1 being reserved for the glass plate as material that is the subject of the processes and the numeral 2 being reserved for the machine body that performs its grinding process, while the details and the constructive mechanisms and the devices, such as the motors, the pneumatic cylinders, the sensors, etc., are designated by three-digit numerals in which the first digit is the digit of the main assembly to which it belongs (100 for the lower working head, 200 for the upper working head, 300 for the assembly for rotation about the axis J, 400 for the assembly for movement along the vertical axis V and 500 for the assembly for movement along the horizontal axis H) and four digit numerals designate the components of the double-glazing unit (1001 the external glass, 1002 the inner glass, 1003 the spacer frame and then the sealants (1004 the sealing butyl, 1005 the strength sealant, 1006 the acrylic adhesive), 1007 any gas other than air, although the glass plate is also generically designated by 1 when it is undergoing the grinding process, said process relating to the plates independently of the final composition of the double-glazing unit), and likewise four-digit numerals designate the machines that belong to the production line of the double-glazing unit.

**[0033]** The numeral 1 designates the single glass plate, the sides of which are respectively designated: the vertical front side 1a, the horizontal longitudinal sides, 1b the upper one and 1d the lower one (which can also be processed simultaneously in a machine option), and the vertical rear side 1c.

**[0034]** These conventions and numberings are provided in the various figures. The terms front and rear refer to the direction of the flow of the material being processed (glass plate 1) within the production line of the double-glazing unit. The terms front and rear are also used with reference to the face of the glass plate 1 as viewed by the operator.

**[0035]** With reference to Figures 2, 3, 4, 5, 6, 7, 8 and 8a relating to the machine and 9a-9n, 10a-10f and 11a-11d relating to the method according to a preferred embodiment, the essential components and the method of operation of the machine are described hereinafter.

**[0036]** The machine comprises a main body 2 connected in a cascade arrangement between two conveyors 2a and 2b, arranged respectively upstream and downstream of the machine body 2.

**[0037]** The input conveyor 2a is connectable to an upstream processing section, for example the section for cutting the glass from the dimensions of the source plates to the dimensions of the target plates, or the glass plate 1 to be edged can also be loaded manually or by controlling a handling unit on the input conveyor 2a.

**[0038]** The output conveyor 2b instead can be connected to a downstream processing section, for example the section for grinding the edges or the washing unit.

**[0039]** The conveyors, as well as the central machine

body, maintain the plate at an inclination of approximately 6 degrees with respect to the vertical, as can be seen in Figures 2 and 3.

**[0040]** The input conveyor 2a comprises a base for supporting the lower edge of the glass plate, on which a series of motorized support and conveyance rollers or belts of the known type is arranged. The conveyor comprises furthermore a resting surface with idle wheels or an air bearing, also of the known type, on which the glass plate is rested in a substantially vertical manner, in the sense mentioned above.

**[0041]** The conveyors are widely known and therefore they are not discussed in detail here. It is straightforward, therefore, to understand that the output conveyor 2b will be substantially similar to the input conveyor.

**[0042]** The input conveyor comprises preferably a thickness detector of the known type (not shown), which uses a potentiometer associated with a pad which, by means of the action of a pneumatic cylinder, is moved into contact with the front face of the glass plate, the rear face resting against the vertical reference plane 2a, in order to measure the thickness of the glass plate 1 to be processed before it enters the edging section, so as to provide a signal for the initial approach of the abrasive tools to the glass plate 1 as a function of its thickness, which typically is variable in the range of 3 to 40 mm. As an alternative or additionally, this information regarding the thickness of the glass plate 1 can come from an information system or can be set manually by the operator by means of the control post 12.

**[0043]** The machine body 2 comprises a section 2c of the known type constituted by a resting surface with a pseudovertical disposition with idle wheels for the support and sliding of the rear face of the glass plate 1, to contrast the thrust of the abrasive tools.

**[0044]** The working heads are designated by the sections 100 and 200 and will be described in detail hereinafter.

**[0045]** The machine body 2 contains a section 500 that comprises a conveyor 501 with rollers that are partly motorized and partly idle of the known type with horizontal axes or with belts (inclined by 6° with respect the horizontal plane), for the support and traction of the glass plate 1 along the horizontal (longitudinal) axis H.

**[0046]** The machine body 2 contains also a section 400 that actuates the vertical movement along the axis V of the working head of the section 200.

**[0047]** The machine body 2 contains also a section 300 for the swiveling and rotation of the section 200 about the axis J at right angles to the glass plate.

**[0048]** The glass plate 1 that arrives from the preceding processing machine (or loaded manually or by means of a handling unit on the input conveyor 2a of the machine) is caused to advance, conveyed by the support and conveyance system of the type 501 of the conveyor 2a of the body 2.

**[0049]** For the continuity of the vertical support, and to contrast the thrust of the grinding tools, the vertical plane

with idle wheels or air bearing for the sliding of the input conveyor 2a and output conveyor 2b are taken from the section 2c described earlier in the solution with idle wheels.

**[0050]** Based on the mechanism just described, the glass plate 1 is thus conveyed to the position in which a carriage actuated by the synchronous motor 503 and by a chain of known kinematic systems 504, 505, 506, 507, 508 engages with the sucker 502 said glass plate in its rear face and subsequently moves it with a synchronous axis along the direction H.

**[0051]** This control of the position of the glass plate 1 is important for the correct operation of the process performed by the working heads 101a, 101p and 201a, 201p, as will become apparent in the continuation of the description, so as to coordinate the synchronous movements: the horizontal movement H of the glass plate 1, the vertical movement V, and the rotational movement of the working heads 201a, 201p, necessary so that the edging tools 202a and 202p are always mated with the perimeter of the glass plate 1 having a rectangular shape (1 as shown in Figure 11a), in which case the rotational axis J performs discrete rotations by 90°, or having a non-rectangular shape (1', 1'', 1''' as shown in Figures 11b, 11c, 11d), in which case the rotational axis J performs discrete rotations at the cusps of the glass plates and continuous rotations at the curvilinear portions of the glass plates.

**[0052]** Going back to the description of the case of the rectangular glass plate 1, once the vertical edge 1a of the glass plate 1, synchronized by the actuations described above, arrives at a slowing-down sensor, not shown, the motion of the plate is slowed down until it stops completely once said vertical edge is at the stop sensor (not shown).

**[0053]** In order to describe the mechanisms that actuate both the cutting motion T of the tools and the registration movements R' and R'' and other functions, reference is made to Figures 4 and 5, which relate to the working head 200 containing the tool bodies 202a and 220p fixed to the spindle 310 by means of the brackets 309a, 309p, in a floating manner on the axes 203a, 203p. For the working head 100 the situation is the same, except that the axis J is not present and therefore the spindle 310 is replaced by a support fixed to the plate 307.

**[0054]** In these figures the following classes of movement can be identified simply by observing the mechanisms:

# cutting motion of the tools T;

# swiveling of the tool bodies 201a and 201p, which allows what was defined earlier as registration motion R'', about the axes 203a, 203p; movements which must be described individually in order to better describe their operation.

**[0055]** The cutting motion T is transferred to the tools 201a, 201p by means of the kinematic systems constituted by the motors 211a, 211p, with variable speed in

order to optimize the performance as a function of the type of coating to be removed (ground) and of the characteristics of said tools and the other processing parameters, on the axes of which said tools are keyed.

**[0056]** The swiveling of the tool bodies 201a, 201p has two components, in detail: the first of linear registration R', rather than actual swiveling, in order to arrange the work field of the tools as a function of the thickness of the glass (which has been measured in the input conveyor 2a, as mentioned earlier), which is done by the motor 206 that actuates the actuator 207 that moves the slider 307 with a feedback coming both from the potentiometer 308 and from the linear sensors 205a, 205p with which the pneumatic cylinders 204a, 204p are provided, which identify the start and the extent of the stroke thereof; the second component R'' of soft oscillation, in order to adapt to the irregularities of the face of the glass plate, which is done by the pneumatic cylinders 204a, 204p pivoted on the brackets 309a, 309p connected to the spindle 310 and operating on the swiveling arms 206a, 206p of the tool bodies 201a, 201p.

**[0057]** An essential characteristic of the floating movement is that it occurs in such a configuration as to keep the active face of the tools 202a, 202p in conditions of theoretical coplanarity with the face of the glass plate, so that the operation of the active parts of the tools, designated by the segments La and Lp in Figure 6, due to the floating behavior, compensates the undulations of the face of the glass plate 1 in the direction of the thickness of said plate, while the non-parallel arrangement of the tool segments La and Lp in contact with the face of the glass plate is compensated by the softness of said tools 202a, 202p, obtaining therefore one of the important characteristics of the present invention: i.e., that of removing the infinitesimal thicknesses of the coating on the margin of the glass plate, the planarity of which cannot be identical to that of the tool no matter how precise the execution of the kinematic systems might be (it is a matter of removing uniformly thicknesses on the order of hundreds of angstroms).

**[0058]** As a whole, the machine can use two working heads, a lower head 100 with a fixed arrangement (relative to the axis V and the axis J) and an upper head 200 that can move rotationally along the axis J and vertically along the axis V. The components of both of these working heads are identified in the description given earlier for the upper working head and any further description is unnecessary, except for completing what relates to the rotation of the vertical working head 200 about the axis J as visible in Figure 6 and the translation of said working head along the vertical axis V as shown in Figure 7.

**[0059]** The mechanisms for the rotation of the working head 200 are the ones that belong to the slider 307 and consist of the hollow support 306 that defines the axis J by means of the spindle 310 that rotates on the bearings 305 accommodated in said hollow support under the actuation of the synchronous motor 301, which operates on the tool bodies 201 a, 201p that are integral with the

spindle 310, as regards rotation, by means of a reduction unit 302, a pinion 303 and a ring gear 304. This rotation makes it possible to orient the working head 200, and with it the tools 202a, 202p, so as to mate with the perimeter of the glass plate 1, in a successive manner by performing rotations by 90° in the case of glass plates 1 having a rectangular shape, in a progressive manner by means of the interaction and interpolation of the axes H, V, and J in the case of glass plates having non-rectangular shapes 1', 1'', 1'''.

**[0060]** For translation along the vertical axis V, the slider 405 of Figure 7 carrying the working head 200 is moved along the guides 407, to which it is coupled by means of the sliding blocks 406, by means of the kinematic chain: synchronous motor 401, reduction unit 402, pinion 403 that meshes with the rack 404.

**[0061]** For the translation of the glass plate 1 along the horizontal axis H it is not necessary to elaborate on what has already been described in the description of Figure 8.

**[0062]** Having described all the essential components of a preferred embodiment of the machine, one now moves on to describe the working method (which corresponds to the diagrams of Figures 9a to 9n and 10a to 10f, which show only the first option, in the situations with one or two working heads) of the following options, all of which are possible by using the described mechanisms, the corresponding actuators, a control logic thereof, and software for managing said logic.

OPTION 1: processing of a rectangular glass plate 1 with a machine with one working head

OPTION 2: processing of a rectangular glass plate 1 with a machine with two working heads

OPTION 3: processing of a rectilinear contoured glass plate 1'

OPTION 4: processing of a partially curvilinear contoured glass plate 1''

OPTION 5: processing of a totally curvilinear contoured glass plate 1'''

OPTION ON THE OPTIONS: three rotation axes ( $\alpha$   $\beta$   $\gamma$ ), axes not shown in the figures but only mentioned in the description, instead of a single rotation axis J.

**[0063]** All the descriptions start from the position, already described, in which the glass plate (1, 1', 1'') is stopped at the stop sensor. The references of the components are also recalled so as to complete, in every description, the aspects related to the machine claims and not only the aspects of the method.

**[0064]** OPTION 1 (one working head 200): the diagrams of Figures 9a to 9n show, as anticipated in the description of the figures, both the front tool 202a and the rear tool 202p, with filling when in the active step and without filling in the resting step; the shaded area instead represents the side or that part of the side of the glass plate that has already been ground.

**[0065]** The process occurs, therefore, simply according to the following steps:

# processing of the vertical side by both of the tools operating in series and moving upward along the axis V (Figures 9a, 9b, 9c)  
 # rotation of the working head, about the axis J that passes through the centerline of the front tool and simultaneous offset motion of the glass plate along the axis H (Figure 9d)  
 # lowering of the working head in order to bring the tools into alignment with the margin of the glass plate (Figure 9e)  
 # advancement of the glass plate along the horizontal axis H (Figures 9f, 9g, 9h)  
 # lifting of the working head in order to allow the subsequent rotation thereof (figure 9i)  
 # rotation of the working head (Figure 9j)  
 # advancement of the glass plate along the horizontal axis H in order to bring the margin thereof into alignment with the tools (Figure 9k)  
 # processing of the vertical side by both of the tools operating in series and moving downward along the axis V (Figures 9l, 9m, 9n).

**[0066]** NOTE: in the figures showing the rotation step of the working head about the axis J, said rotation axis, which lies on the centerline of the front tool 202a, is indicated by a cross.

**[0067]** OPTION 2 (two working heads 100, 200): the diagrams of Figures 10a to 10f show, as anticipated in the description of the figures, the front tool 102a and the rear tool 102p of the first working head 100 and the front tool 202a and the rear tool 202p of the second working head 200, with filling when in the active step and without filling in the resting step; while a shaded area represents the side or part of the side of the glass plate that has already been ground.

**[0068]** The process occurs, therefore, simply according to the following steps (the description regarding the details of the rotations and the alignments is omitted, since it can be inferred from the description in OPTION 1):

# processing of the vertical side by both of the tools of the working head 200 that operate in series and move upward along the axis V (Figure 10b)  
 # rotation of the working head 200, lifting of the working head 100 and offsetting of the glass plate (Figure 10c)  
 # simultaneous processing of the horizontal sides 1b and 1d, by both of the tools of the working head 200 and both of the tools of the working head 100 (Figure 10d)  
 # rotation of the working head 200, lowering of the working head 100 and offsetting of the glass plate (Figure 10e)  
 # processing of the vertical side by both of the tools of the working head 200 that operate in series and move downward along the axis V (Figure 10f).

**[0069]** OPTION 3 (case to be embodied preferably with

only one working head): everything proceeds as in the description of option 1, except that in order to incline some sides, for example the non-vertical side 1a, the non-horizontal side 1b, etc., the axes H, V + J work interpolated by means of the linked actuation of the motors, which perform synchronous motions: 503 (which operates the sucker 502 along the axis H), 401 (which operates the working head along the axis V), 301 (which operates the working head in the rotation about the axis J). As regards the axis J, it is used to orient the pair of tools 202a, 202p so that it is tangent to the polygonal broken line to be followed and operates in a discontinuous manner at each cusp (preceded by movements of the plate and of the working head similar to those described in option 1). The tools can therefore operate simultaneously (always in the front-rear succession) because the rotation of the working head, although performed at the centerline of the front tool 202a, entails maintaining tangency, since the sides are rectilinear, for both of the tools; see Figure 13 for clarification. The linking of said motors occurs by means of electronic drives managed by software, said software having received as inputs all the information regarding the shape 1' of the glass plate, with known methods such as bar codes, databases, network, scanner, etc.. The lower side, which for these shapes must be horizontal for using the belt conveyor or the roller conveyor 501, is instead processed in a manner that is not interpolated but still synchronous by the pair of tools 202a, 202p while the glass plate 1' moves along the axis H, or by the pair of tools 102a, 102p in the case of a machine with two working heads.

**[0070]** OPTION 4: everything proceeds as in the description of option 2, except that in order to follow the inclination of some sides, for example non-horizontal or non-vertical sides 1a and now in particular the curvilinear shape of some other sides, the axis H, V,  $\theta$  operate interpolated by means of the linked actuation of the motors 503, 401, 301, which now operate in a synchronous manner, as in the case of the oblique sides in the methods according to option 3, but with a continuous variation of the axis J in order to orient the tools 202a in the first pass and 202p in the second pass, in a tangent manner with respect to the curvilinear shape to be followed, in the case of curvilinear parts. Two passes are described and necessary (operating in succession along all of the perimeter of the glass plate), since only one of the faces of the tools 202a and 202p at a time can be kept tangent to the curvilinear contour of the glass plate. The first tool 202a is moved in its tangent path in a simple manner, since the rotation axis  $\theta$  passes through the centerline of the tool/glass plate 1" contact segment; the second tool 202p is moved in its tangent path in a manner that is more complex but electronically possible (since 3 axis that can be interpolated are available), since the rotation axis of the head does not pass through the centerline of the tool/glass contact segment; for clarification see Figure 14. The linking of those motors occurs by means of electronic drives managed by software, said software

having received as inputs all the information regarding the shape 1" of the glass plate, with known methods such as bar codes, databases, network, scanner, etc..

**[0071]** The lower side, which must be horizontal for these shapes in order to use the belt conveyor or the roller conveyor 501, is instead processed in a manner that is not interpolated but still synchronous by the pair of tools 202a, 202p, while the glass plate 1" moves along the axis H, entrained by the sucker 502, or by the pair of tools 102a, 102p in the case of the machine with two working heads.

**[0072]** This partially curvilinear glass plate shape, therefore, is ground by complete paths of one tool at a time, i.e., it is subjected to multiple processing cycles (at least two, or more if the degree of processing requires a sequence of more than two tools, for example in the case of coatings that are particularly difficult to remove). It goes without saying that if the band to be ground is greater than the width of the tools, the cycle or cycles must be repeated on paths that are parallel to the one started first, until said band is covered progressively, possibly with a little overlap at the offset of the parallel paths. This clarification obviously concerns all five options.

**[0073]** OPTION 5: for this option only the working head 200 operates and the glass is supported and conveyed exclusively by the sucker 502 coupled to the synchronous axis H, while the interpolated axes H, V, J are actuated by the motors 503, 401 and 301, which all operate in a synchronous manner, so that the path of the tool follows the margin of the glass plate 1". Due to the shape of the glass plate, which does not have a rectilinear base, said plate cannot use the belt conveyor 501 but has to be transported solely by means of the sucker 502, to which it must be coupled manually or by means of an automatic loader.

**[0074]** Similarly to the preceding option, this shape of a glass plate, which is completely curvilinear, can be ground by means of complete paths of one tool at a time, i.e., it has to be subjected to multiple processing cycles (two or more if the degree of processing requires a sequence of more than two tools, for example in the case of coatings that are particularly difficult to remove).

**[0075]** OPTION ON THE OPTIONS: OPTIONS 4 and 5 that consider curvilinear shapes of the glass plates can be obtained with a machine and a method that use three rotation axes  $\alpha$   $\beta$   $\gamma$  instead of a single rotation axis J.

**[0076]** This solution will not even be claimed, since it is excessively expensive, but it is presented in the description so that third parties cannot file an application for improvement, claiming therefore a compulsory permit. This being the purpose, figures are not necessary to support the description.

**[0077]** It would be a matter of providing each tool 202a, 202p with its own rotation axis at right angles to the glass plate passing through the centerline of the tool/plate contact segment,  $\alpha$  for the tool 202a and  $\beta$  for the tool 202p, so as to simplify the linking among the axes H, V,  $\alpha$ , during the first processing pass performed with the front

tool and among the axes H, V,  $\beta$ , during the second processing pass performed with the rear tool, in the cases of curvilinear shapes according to OPTIONS 4 and 5, and of providing the entire cradle 307 with a third rotation axis, again at right angles to the glass plate,  $\gamma$ , which in practice is J, in order to rotate the working head for the cases of the rectilinear sides according to OPTIONS 1, 2, 3.

**[0078]** It goes without saying that the industrial application is certainly successful, since glass edging machines currently are very much in demand because the double-glazing unit market is expanding continuously, since it has been expanded in recent years by all those configurations that require the use of special glass, such as those described in the introduction (and in particular those coated with the nanotechnology methods for improving thermal insulation both under winter conditions and under summer conditions and, among these, those that are particularly difficult to be edged).

**[0079]** Moreover, this improvement of the thermal insulation, besides being imposed by recent technical statutory provisions enacted as transposition of the Kyoto protocol and aimed at energy saving, is also promoted by non-returnable public funding. Therefore, an increase in the use of coated glazing is expected, to the point of assuming that it will become compulsory. Only the subject matter of the present invention is capable of performing the removal of the coating in a valid and complete manner and without damaging the surface of the glass plate 1 (1', 1", 1'''), despite attacking it but in order to obtain a surface appearance with a finish that is pleasant because it is uniform, unlike the machines of the background art, in which incomplete removal entails risks for the seal and strength of the sealants.

**[0080]** It has thus been shown that the machine and the method according to the invention achieve the intended aim and objects, since they perform edging in a complete, functional and aesthetically impeccable manner, especially in situations in which one or both faces of the double-glazing unit remain visible, as in the case of structural glazing.

**[0081]** The invention is susceptible of numerous modifications and variations, all of which are within the scope of the appended claims. This includes, for example, the quantity of tools that can be extended to more than two, the mechanical solutions for the feeding motions of the tools, the support and conveyance of the glass and the actuation means, which can be electrical, electrical-electronic, pneumatic, hydraulic and/or combined, while the control means may be electronic or fluidic and/or combined.

**[0082]** An important constructive aspect is the logic combination of the actuations respectively for translation of the glass, for movement of the working head 200 so as to allow the processing of contoured glass plates, i.e., plates having non-rectangular shapes. In order to obtain this, as described earlier, the electric drives of the motors dedicated to the axes H, V, J are linked by means of an

electric axis, with numeric control.

**[0083]** Moreover, the tools 103a, 103p, 203a, 203p can have a shape and dimensions that are different from those indicated in the figures and can be constituted of mixes with different elasticities and deformabilities.

**[0084]** The constructive details can be replaced with other technically equivalent ones. The materials and the dimensions may be any according to the requirements, particularly arising from the dimensions (base, height and thickness) of the glass plates 1 or from the dimensions and shapes of the glass plates 1', 1'', 1'''.

**[0085]** The disclosures in Italian Patent Application No. TV2013A000168 from which this application claims priority are incorporated herein by reference.

**[0086]** Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the interpretation of each element identified by way of example by such reference signs.

## Claims

1. An automatic machine for removal of the nanocoating with a thickness of a few hundred angstroms from the perimetric margins of the face of glass plates (1) having a rectangular or other than rectangular shape that are substantially flat and arranged vertically or almost vertically, comprising a machine body (2) equipped with a resting surface with pseudovertical sliding (2c) and with a pseudohorizontal conveyor (500) and at least one working head (200, 100), movable in relation to said glass plate (1) along its perimeter, said working head comprising two tool bodies (201a, 201p, 101a, 101p) that are adjustable and floating in a direction that is substantially transverse to the plane of said glass plate (1), each tool body (201a, 201p, 101a, 101p) comprising a cylindrical abrasive tool (202a, 202p, 102a, 102p) which rotates with a cutting motion to carry out the grinding operation, **characterized in that** the two tool bodies (201a, 201p, 101a, 101p) of the working head (200, 100) are arranged in series, i.e., in succession with respect to the direction of the relative motion between said head (200, 100) and the glass plate (1).
2. The machine according to claim 1, **characterized in that** the tool bodies in the working heads (201a, 201p, 201q, 101a, 101p, 101q) are more than two.
3. The machine according to claims 1 and 2, **characterized in that** each tool body (201a, 201p, 101a, 101p) and its tool (202a, 202p, 102a, 102p) can be activated or deactivated in its condition of contact and grinding on the face of the glass plate (1), independently of the others.
4. The machine according to one or more of the preceding claims, **characterized in that** the abrasive tools (202a, 202p, 102a, 102p) each have a composition in terms of type of mix and type of abrasive that is suitable to perform a progression of grinding actions on the low-emissivity coating to achieve the complete removal thereof, the optimum finish and the clear definition of the boundary between the edged area and the non-edged area of the face of the glass plate (1).
5. The machine according to one or more of the preceding claims, **characterized in that** the tilting of the active tool body (201a, 201p, 101a, 101p) about the fulcrum (203a, 203p, 103a, 103p) is actuated by a pneumatic cylinder (204a, 204p, 104a, 104p) the displacements of the rod of which are detected through a transducer (205a, 205p, 105a, 105p) and fed back towards a slider (307) which moves transversely, with respect to the face of the glass plate (1), the entire tool body (201a, 201p, 101a, 101p) to compensate for the non-planar structure of the glass plate (1) and the wear of the tool and to adapt to the thickness of said glass plate (1).
6. The machine according to one or more of the preceding claims, **characterized in that** at least one working head (200) is orientable along the axis 7 that is normal to the face of the glass plate (1).
7. The machine according to claim 6, **characterized in that** by means of the combination of the synchronous motion H of the conveyor (500) of the sucker type and of the synchronous motions V + J of the working head (200), the grinding process can follow contours of the glass plate of the type 1' or 1'' or 1''' having a non-rectangular shape.
8. The machine according to one or more of the preceding claims, **characterized in that** the tool is constituted by an abrasive grinding wheel with an elastic mix.
9. The machine according to one or more of the preceding claims, **characterized in that** the width of the abrasive tool (202a, 202p, 102a, 102p) is smaller than the width of the margin to be edged and consequently the positioning of the abrasive tool (202a, 202p, 102a, 102p) with respect to the face of the glass plate (1) takes place progressively in different zones with respect to the edge of the glass plate (1), in order to cover progressively the margin to be ground by means of multiple grinding passes.
10. The machine according to one or more of the preceding claims, **characterized in that** the arrangement of the glass plate (1) is horizontal or pseudo-horizontal.

11. A method for removal of the nanocoating with a thickness of a few hundred angstroms at the perimetric margins of the face of substantially flat glass plates (1) having a rectangular or non-rectangular shape by grinding obtained with at least two abrasive tools that can dive towards the glass plate (1), **characterized in that** two or more machining passes are performed simultaneously along the perimetric path of the glass plate (1) along the same direction, since they are obtained by arranging in series the at least two tools, which operate simultaneously except for the offset due to the spacing between said two or more tools, during a complete cycle of relative movement between the tools and the glass plate (1), to follow rectilinear paths, along which the at least two tools are oriented correctly.
12. The method according to claim 11, **characterized in that** two or more machining passes are performed sequentially along the entire perimetric path of the glass plate (1), since they are obtained by means of successive complete paths of relative movement between the tool and the glass plate (1) for the entire perimeter with sequential activation of approach and rotation of the at least two tools, in order to follow curvilinear paths or mixed rectilinear-curvilinear paths, in curvilinear paths only one of the at least two tools being oriented correctly in each instance.

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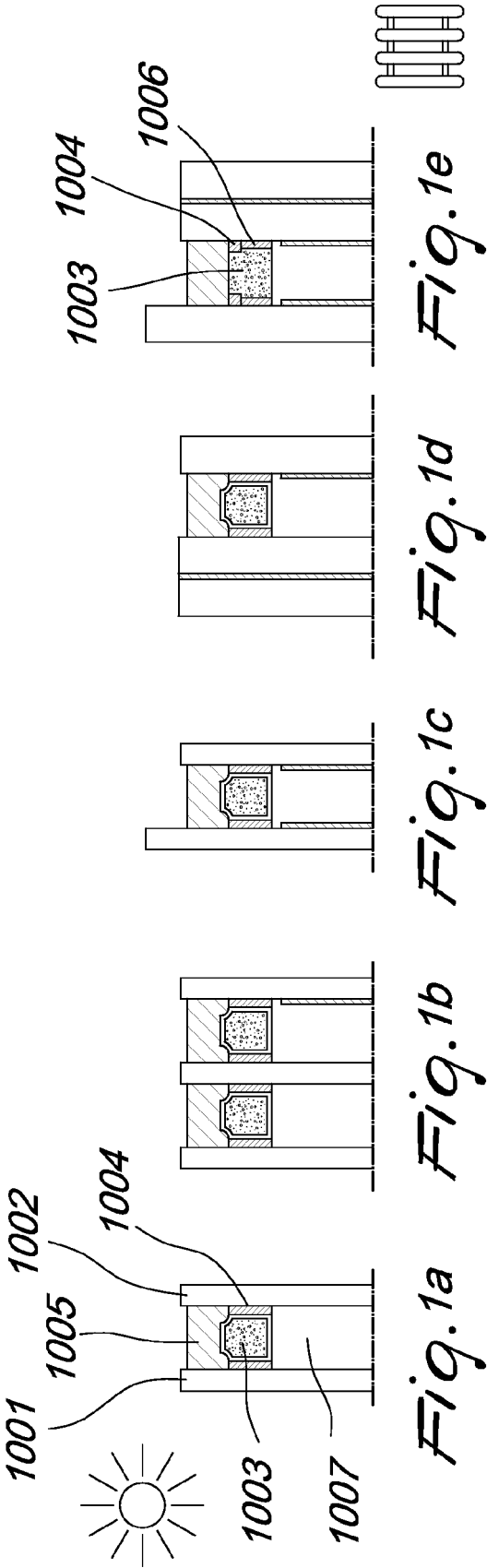
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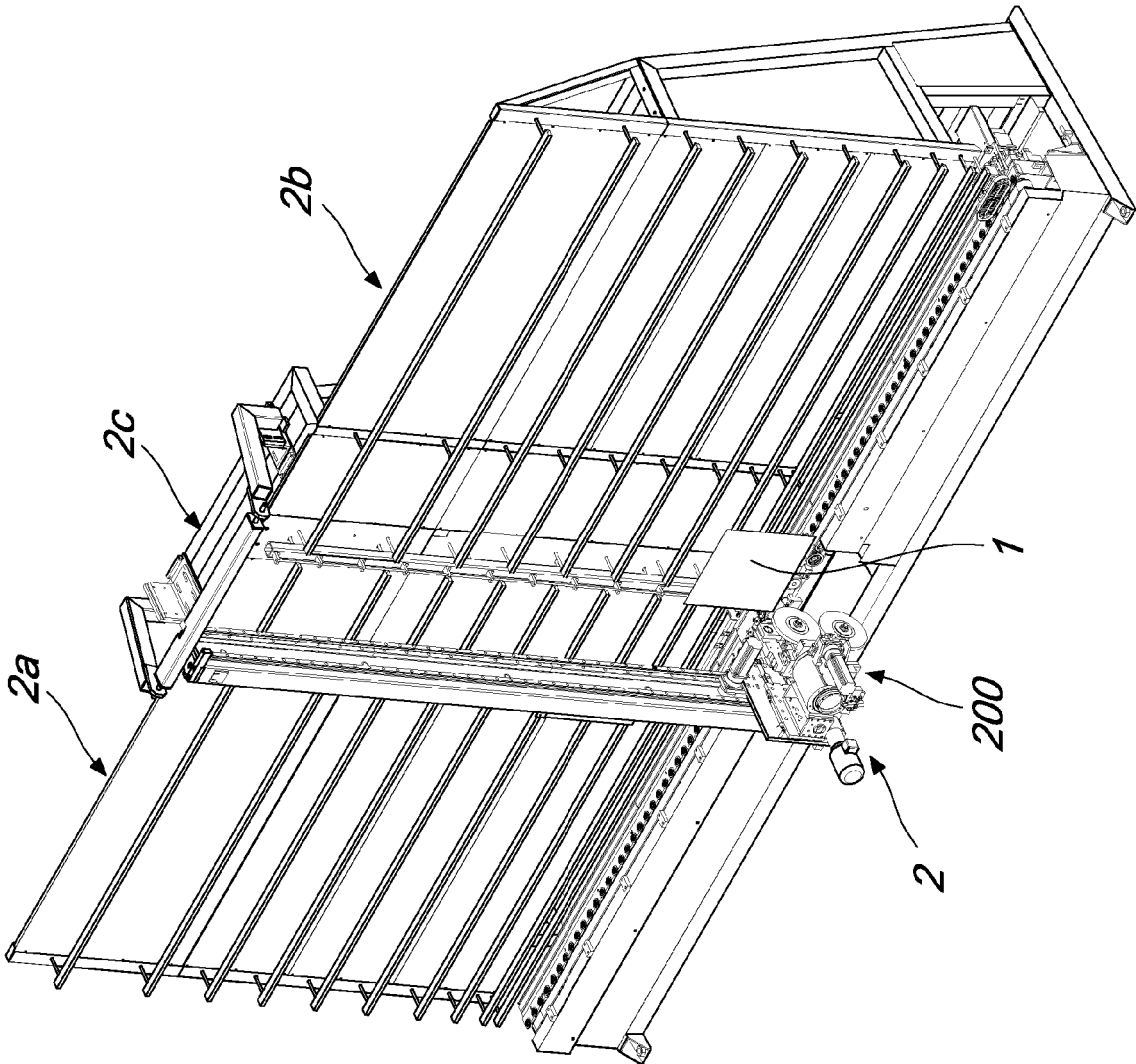
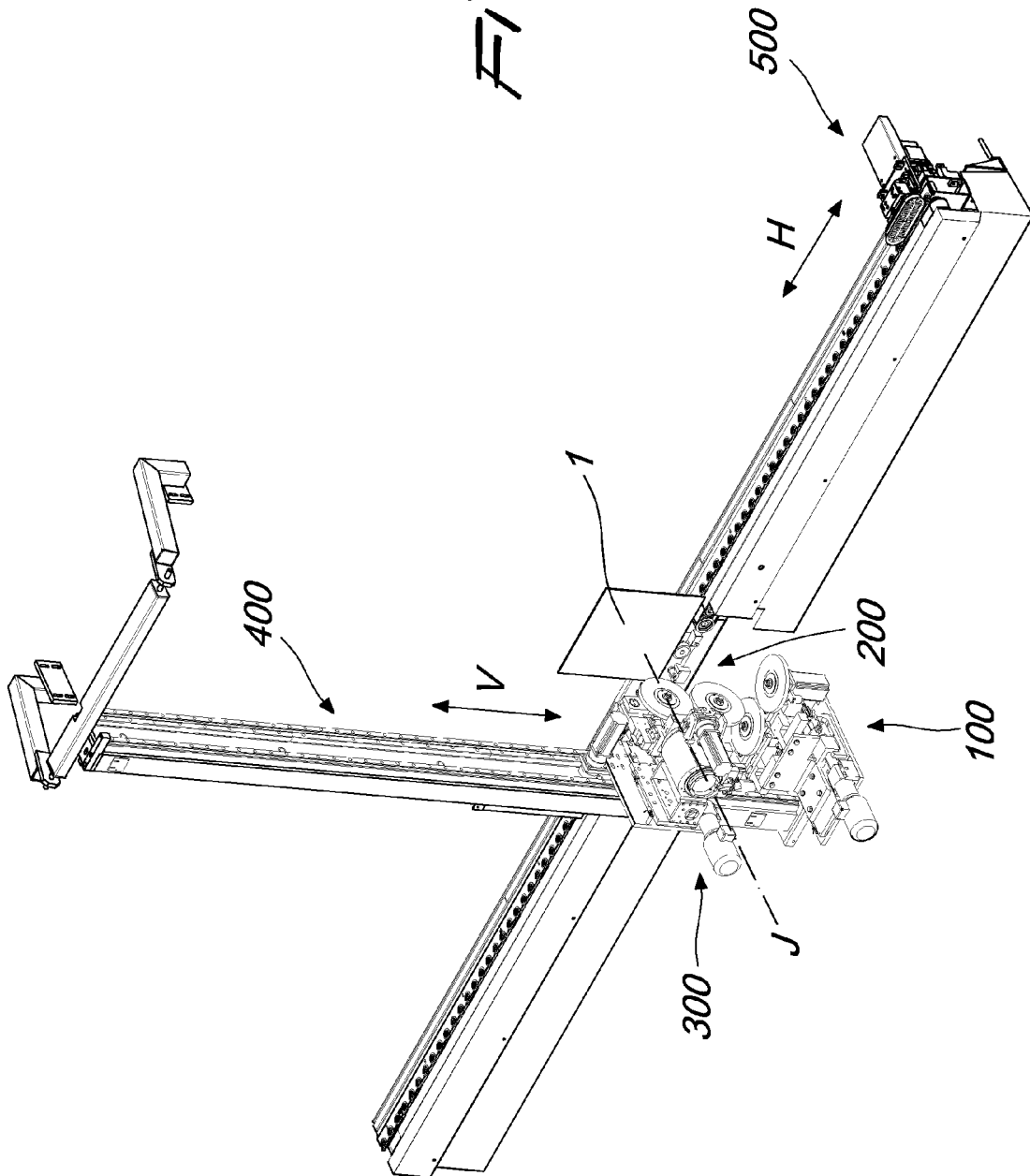
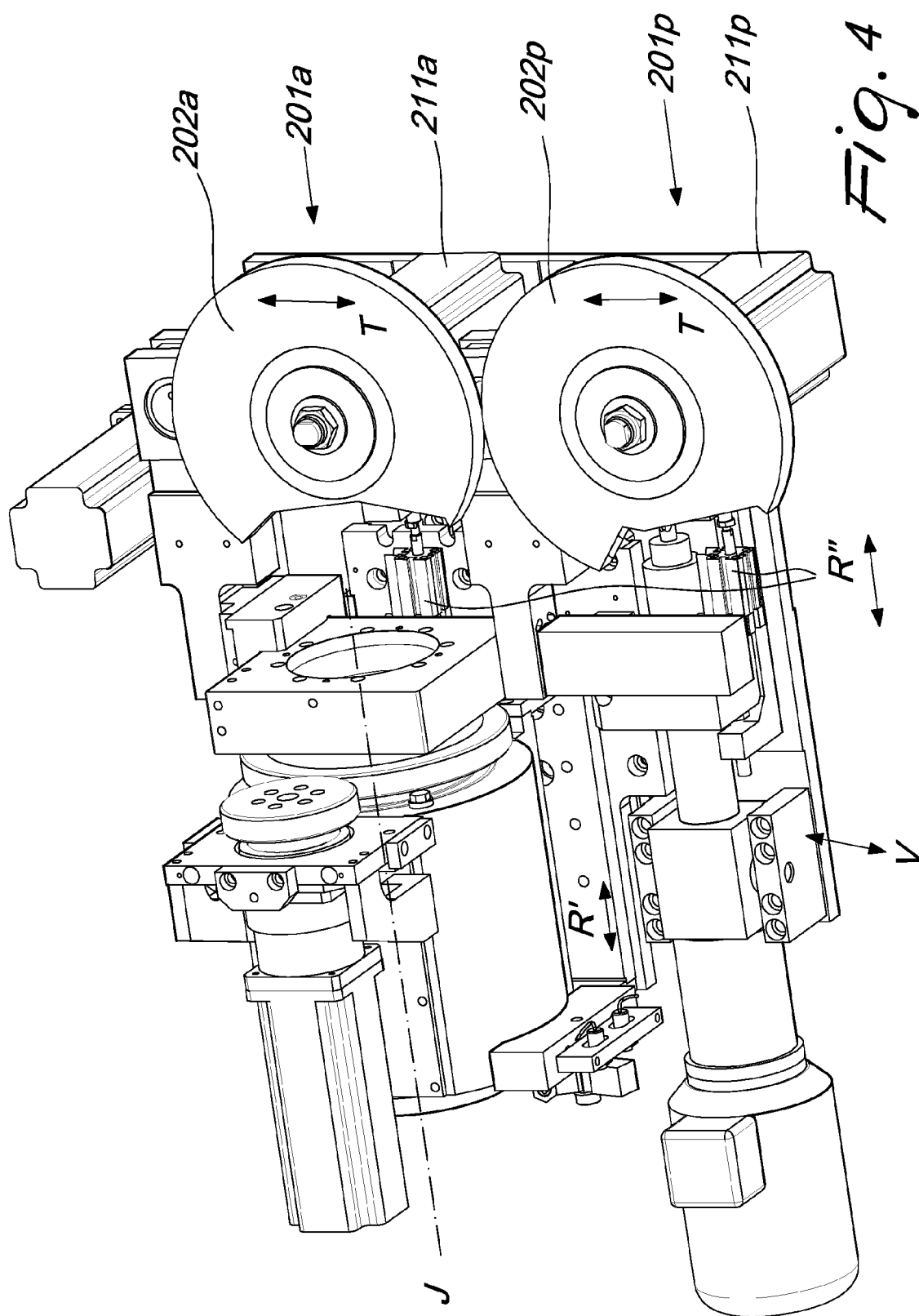
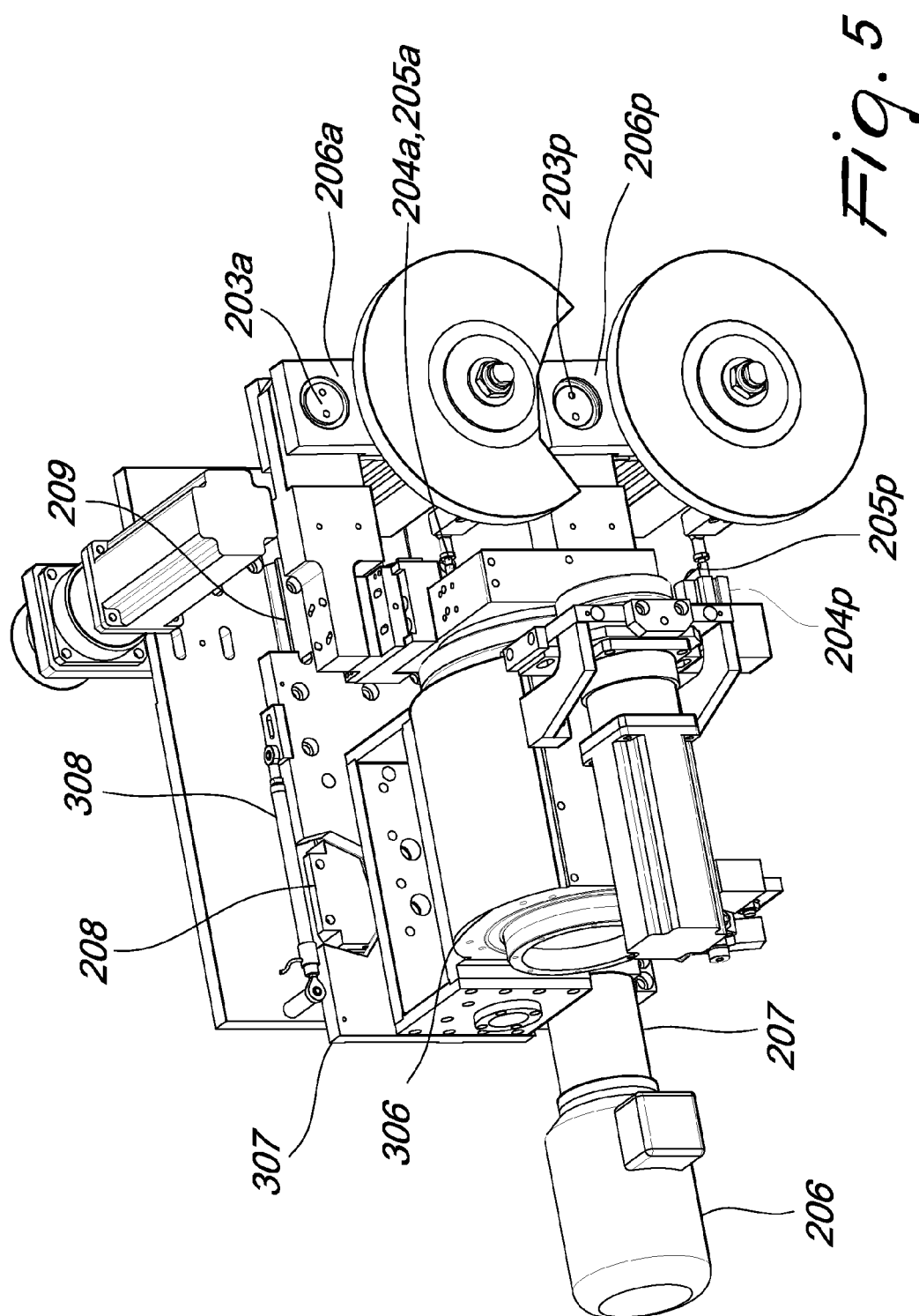


Fig. 2

Fig. 3







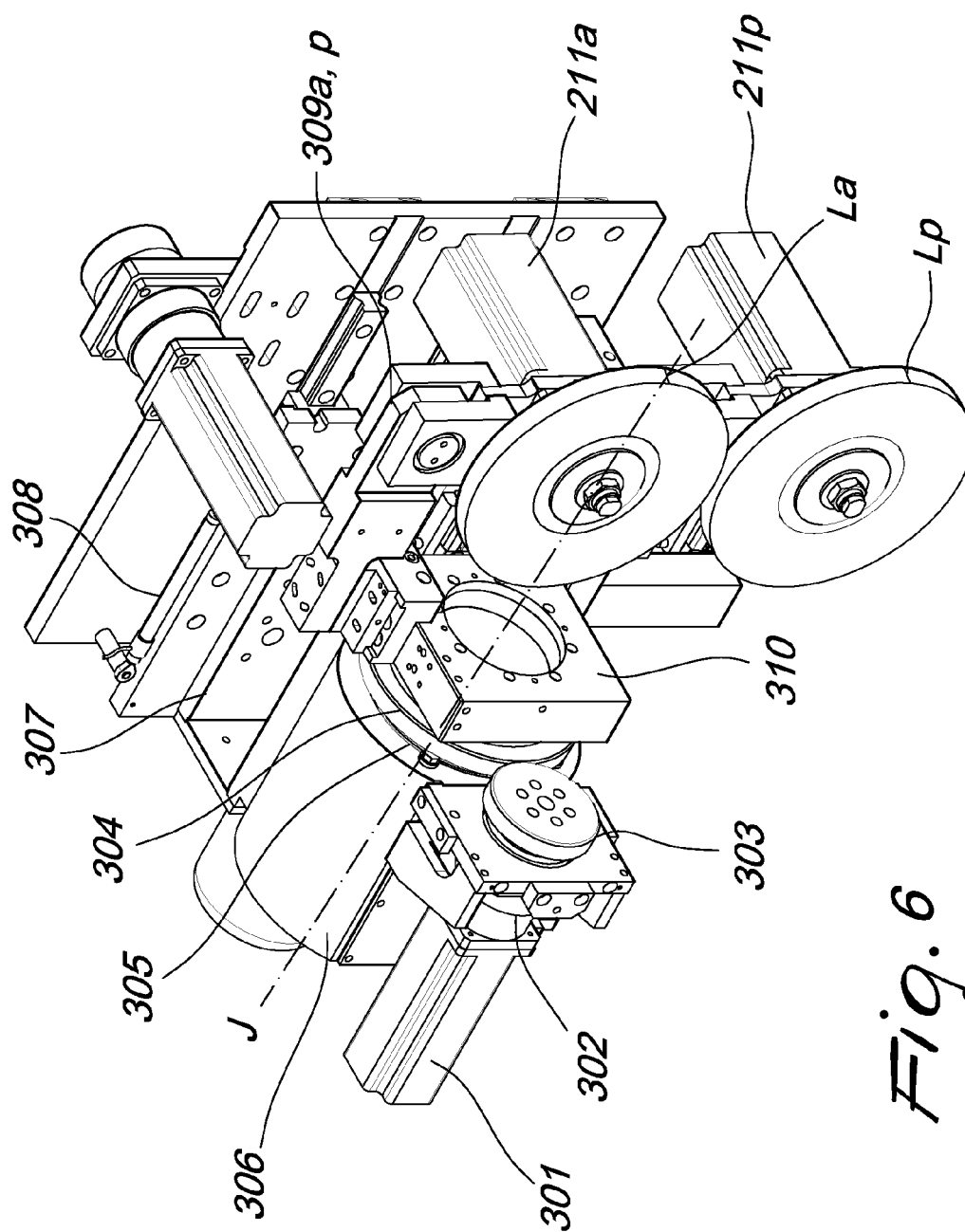
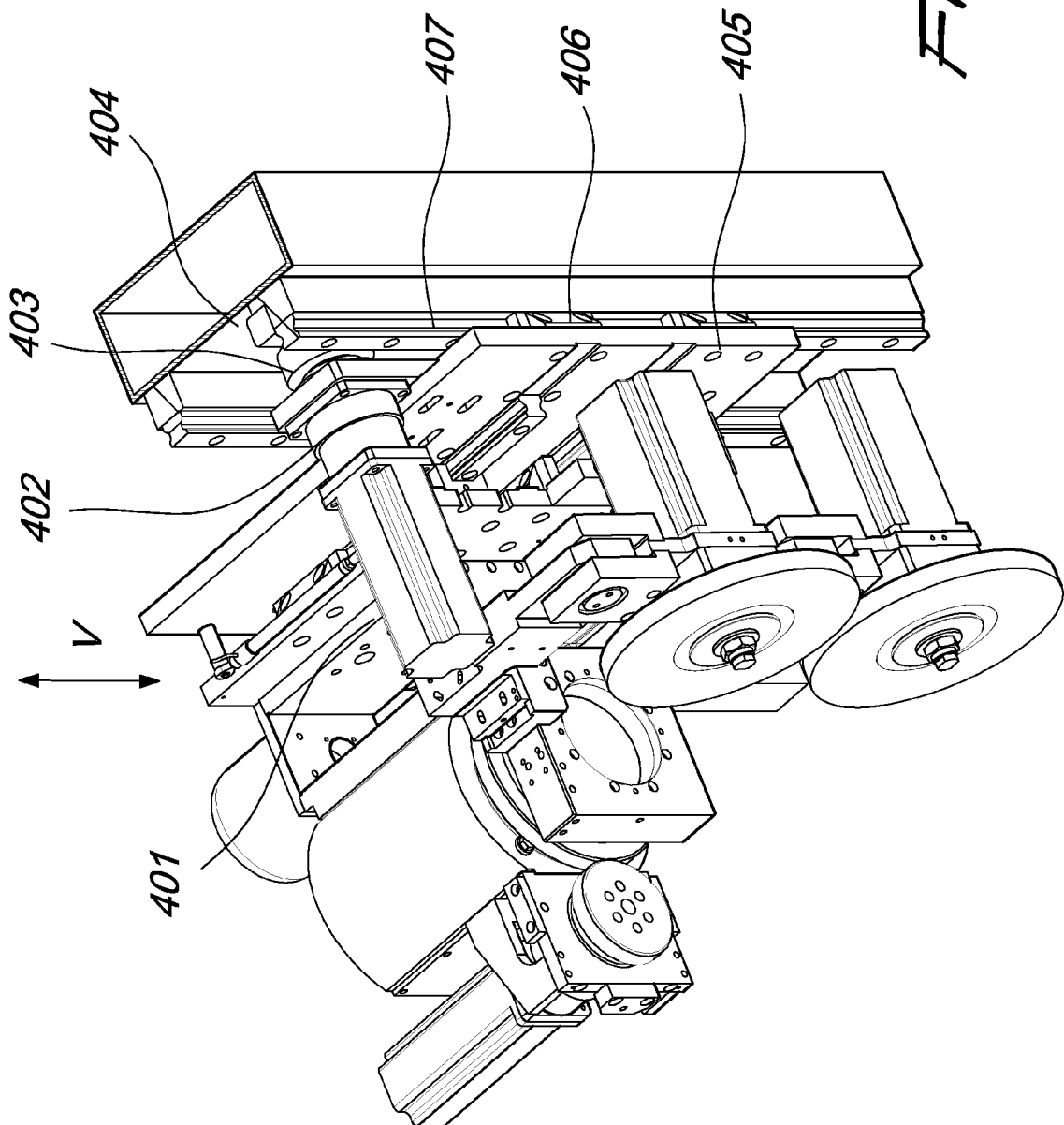


Fig. 6



*Fig. 7*

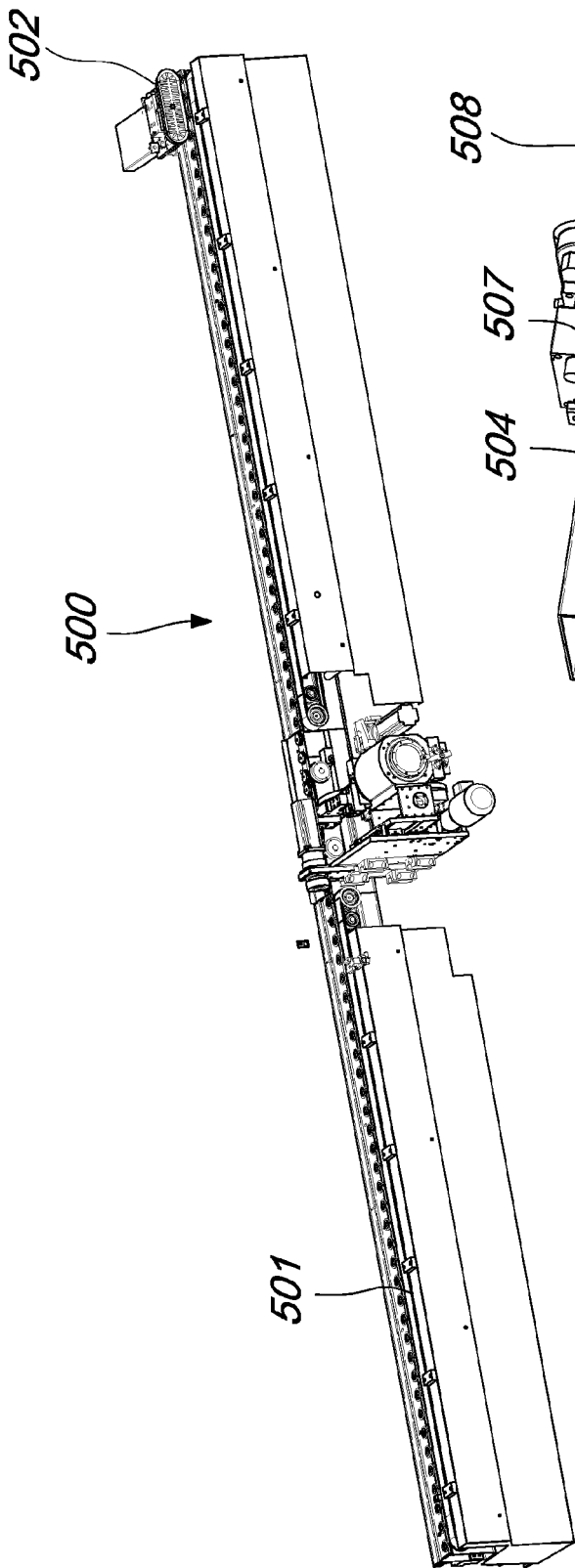


Fig. 8

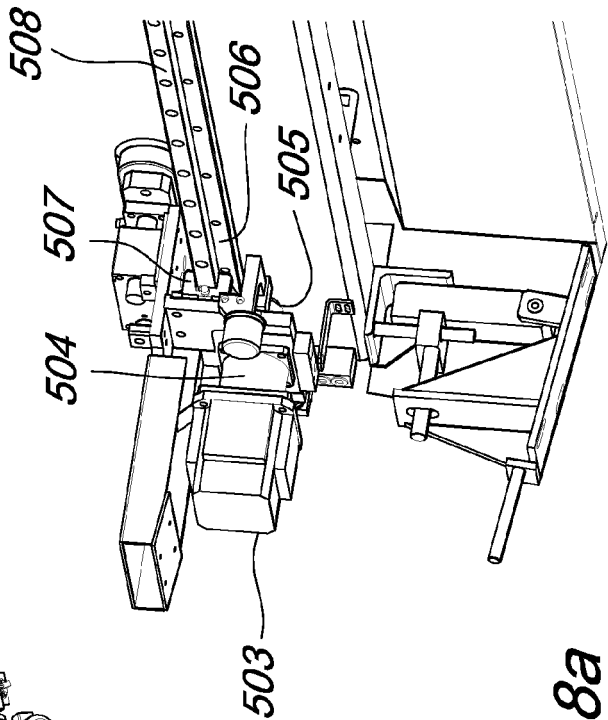
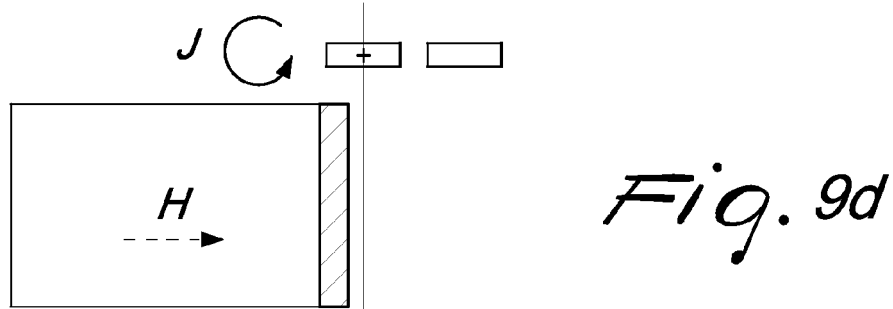
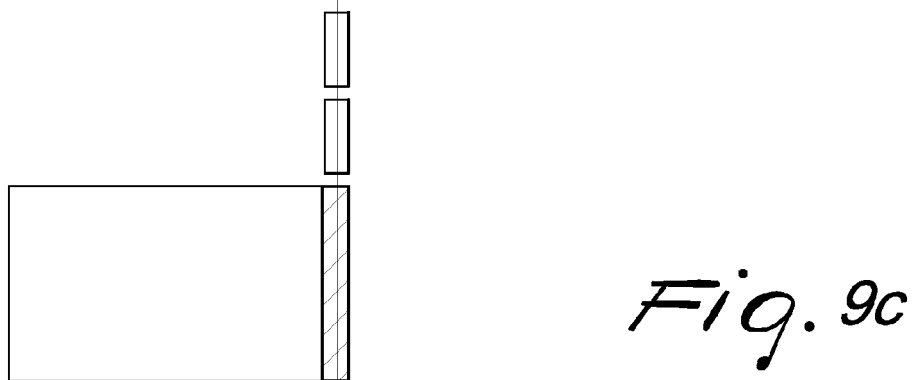
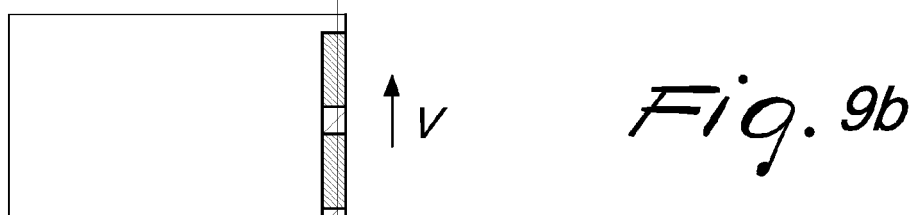
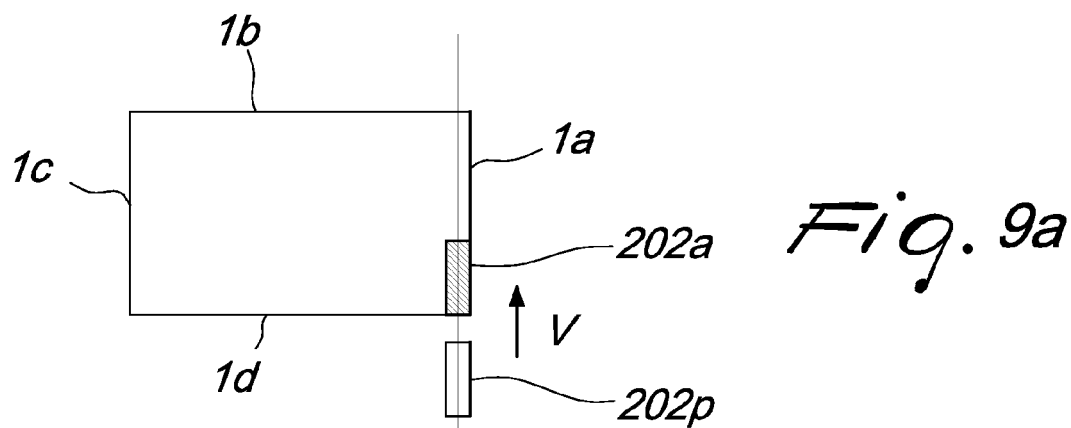
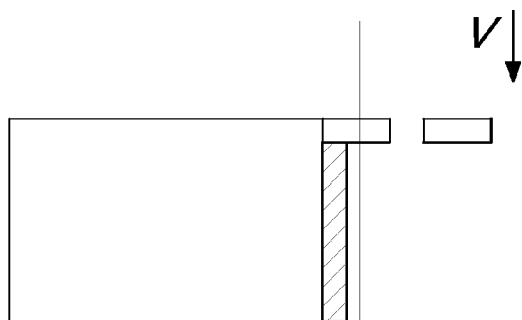


Fig. 8a

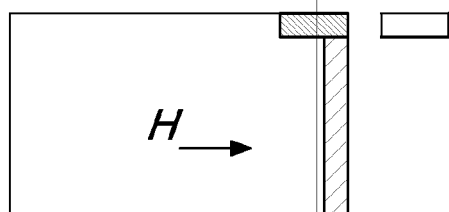


 TOOL ACTIVE

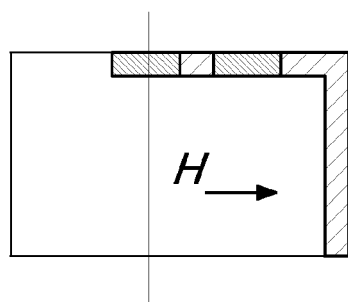
 TOOL INACTIVE



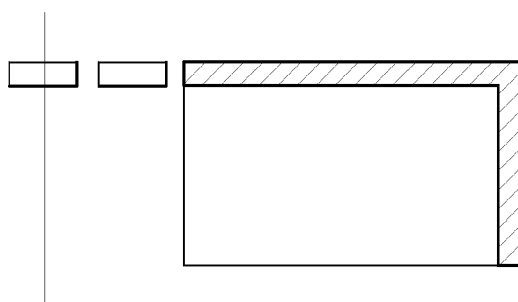
*Fig. 9e*



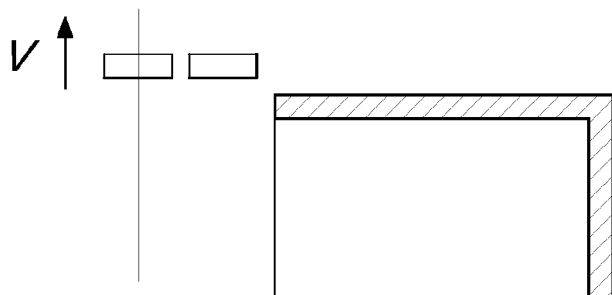
*Fig. 9f*



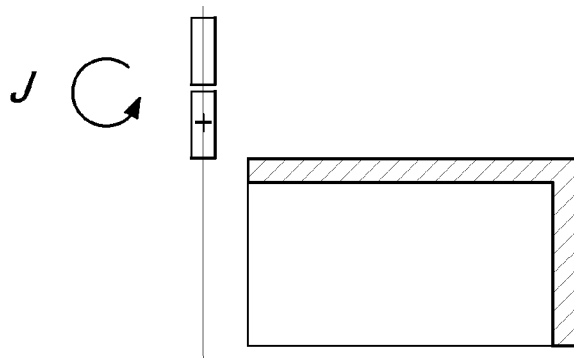
*Fig. 9g*



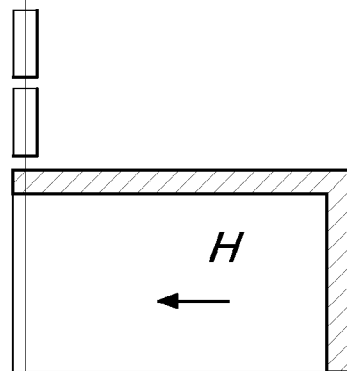
*Fig. 9h*



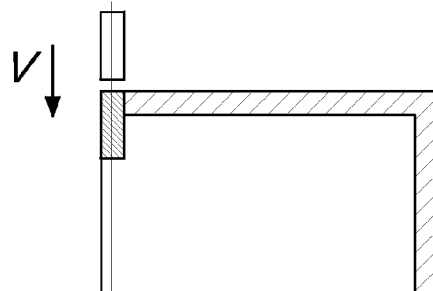
*Fig. 9i*



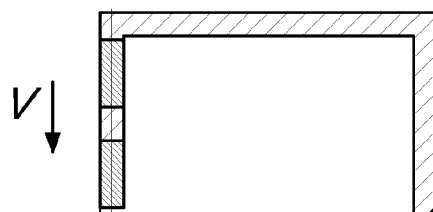
*Fig. 9j*



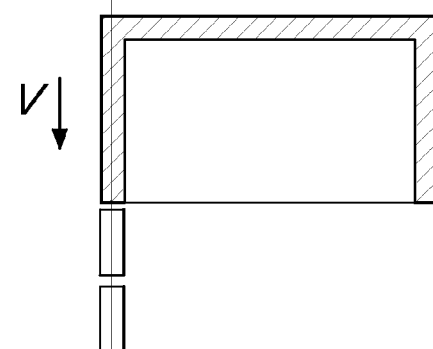
*Fig. 9k*



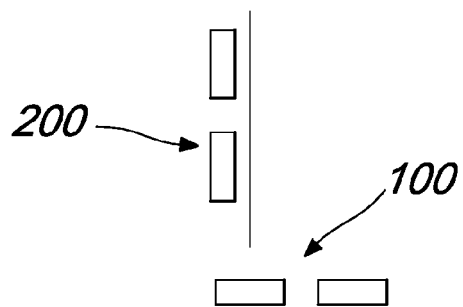
*Fig. 9l*



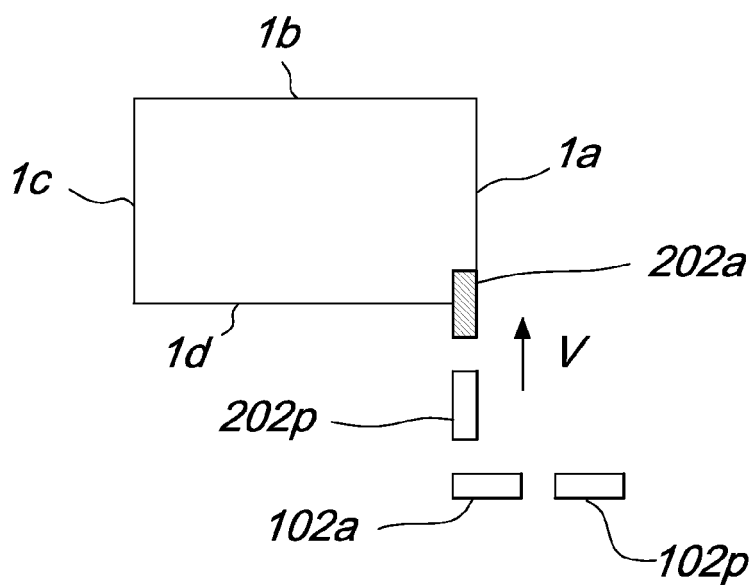
*Fig. 9m*



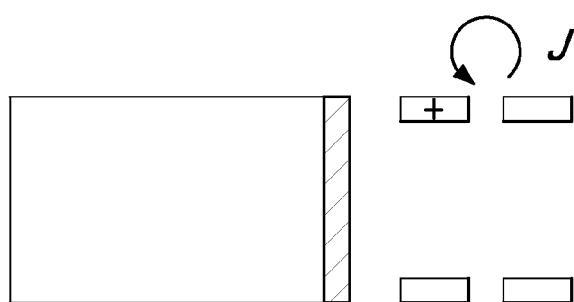
*Fig. 9n*



*Fig. 10a*



*Fig. 10b*



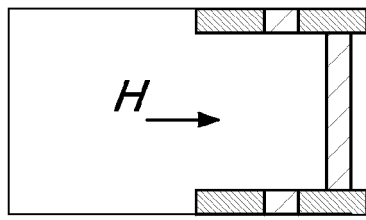
*Fig. 10c*



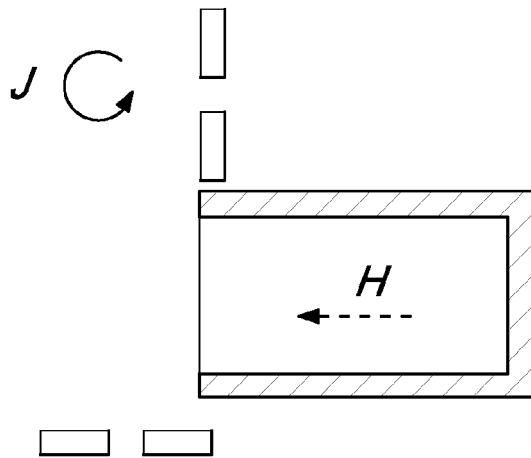
TOOL ACTIVE



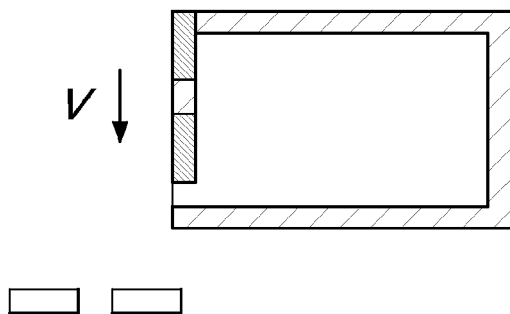
TOOL INACTIVE



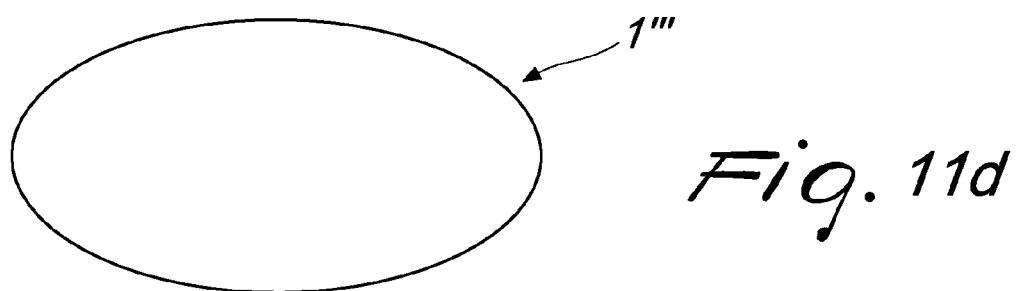
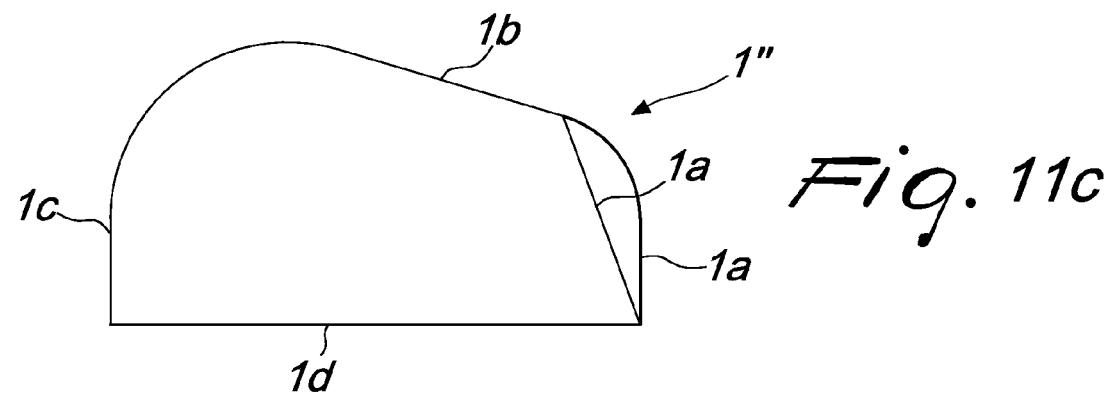
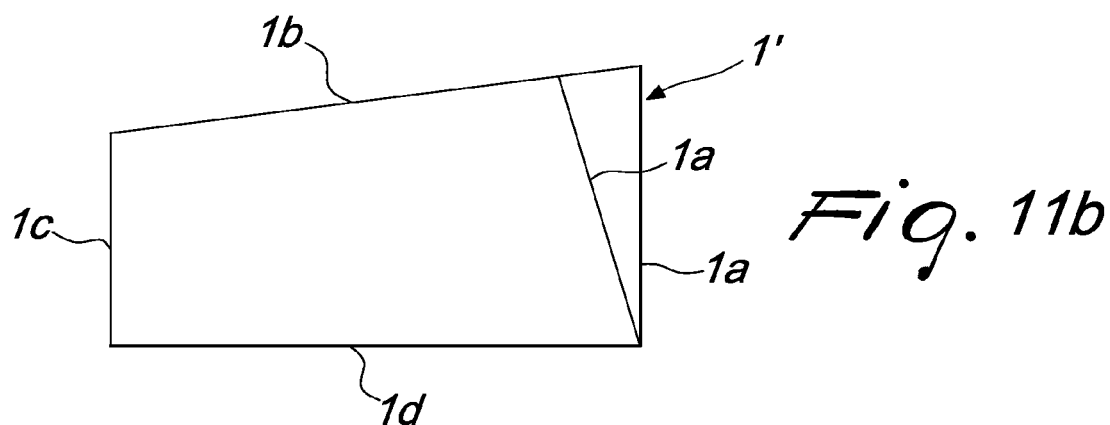
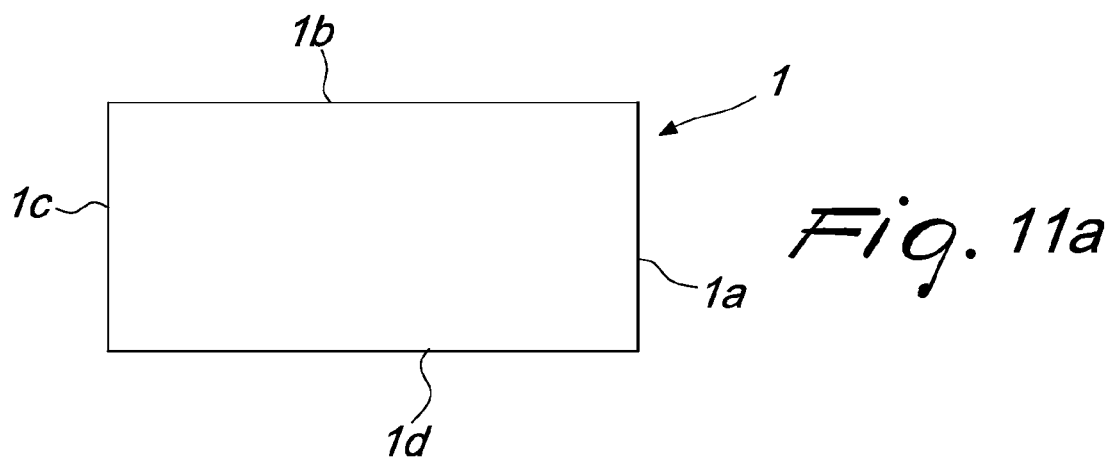
*Fig. 10d*



*Fig. 10e*



*Fig. 10f*



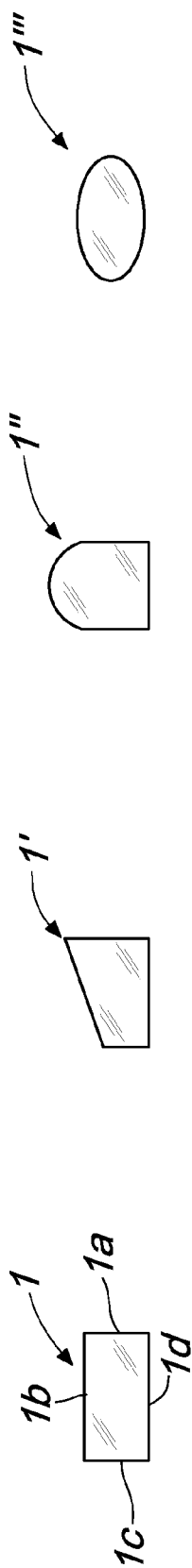


Fig. 12c Fig. 12d Fig. 12e Fig. 12f

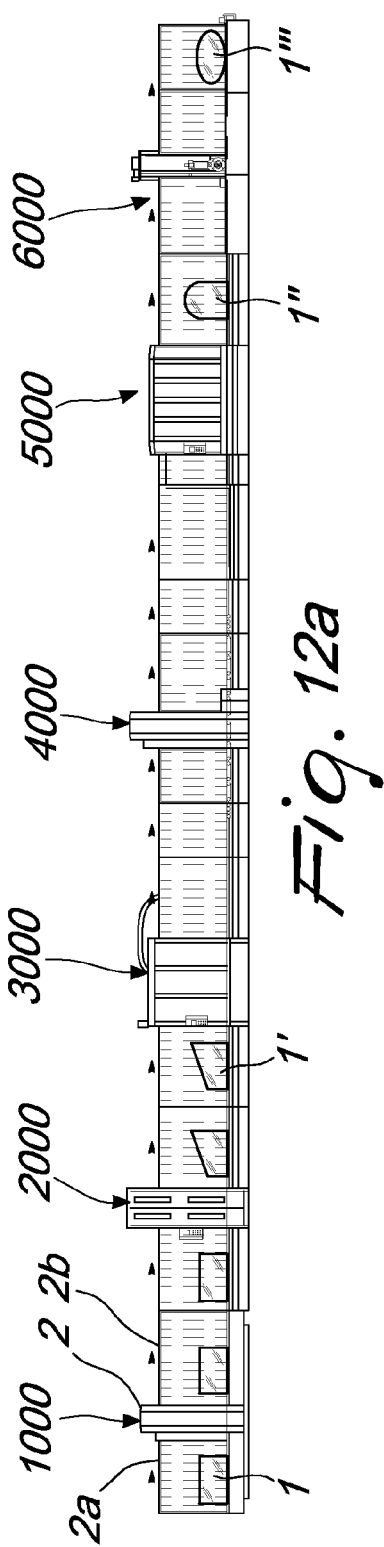


Fig. 12a

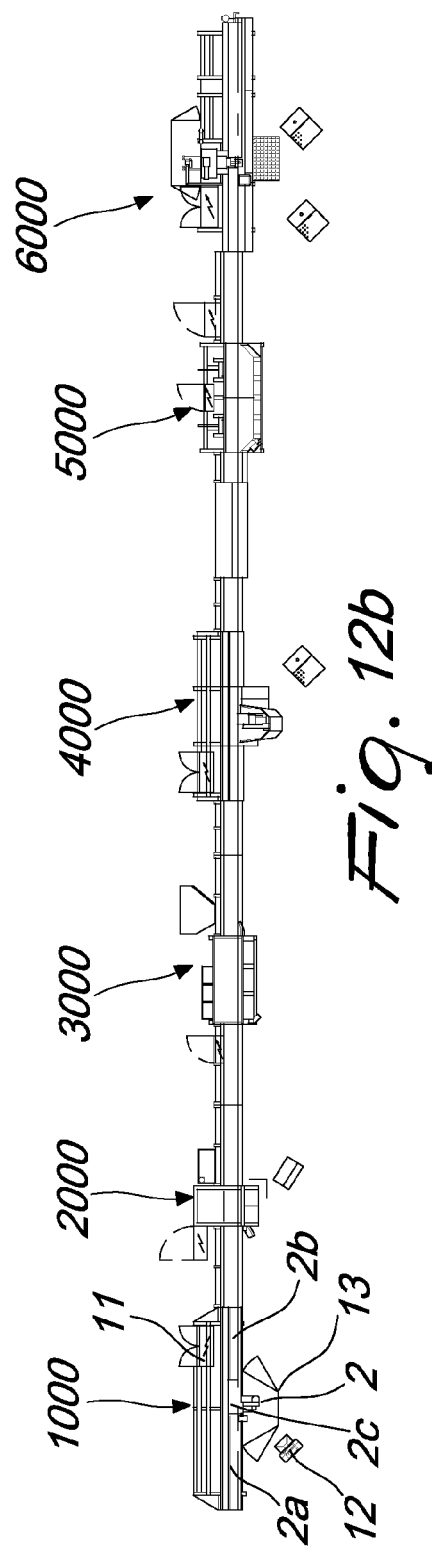


Fig. 12b

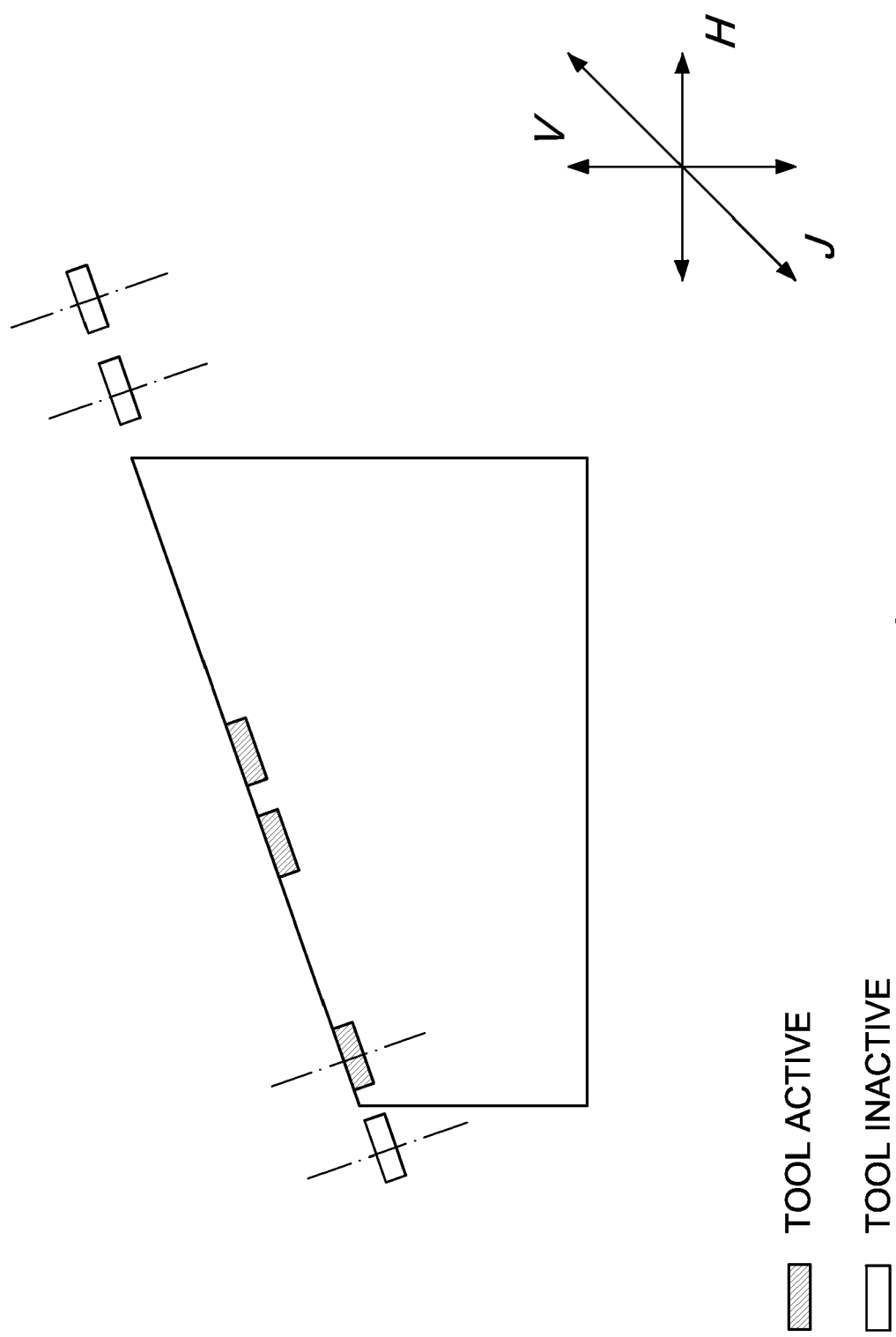
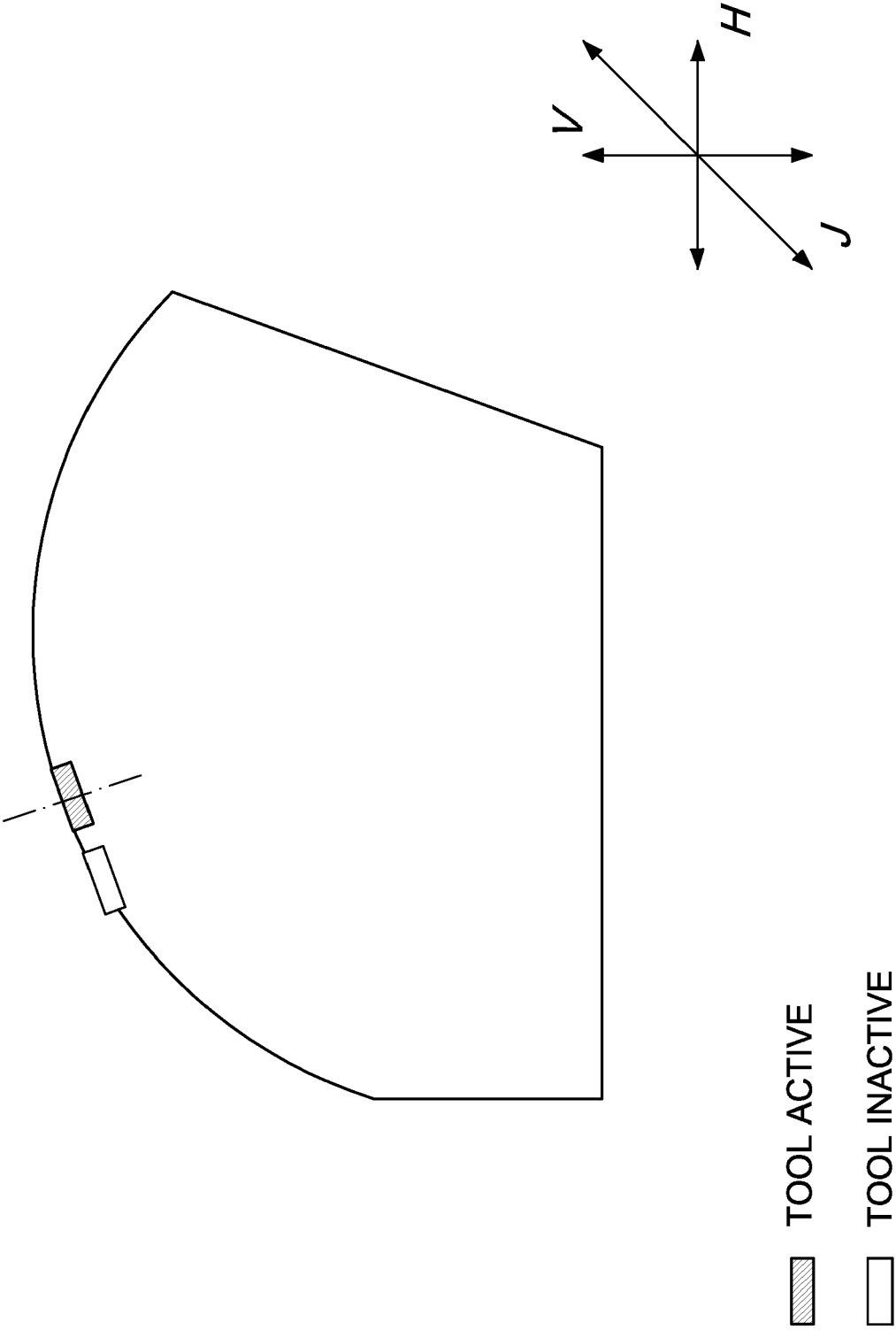


Fig. 13



*Fig. 14*



## EUROPEAN SEARCH REPORT

Application Number  
EP 14 18 9154

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| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                    |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                       |                                            |
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16-12-2014

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