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

(11) **EP 3 045 281 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
20.07.2016 Bulletin 2016/29

(21) Application number: **16151205.8**

(22) Date of filing: **14.01.2016**

(51) Int Cl.:
B28D 1/00 *(2006.01)* ***B28D 1/14*** *(2006.01)*
B28D 1/18 *(2006.01)* ***B28D 7/04*** *(2006.01)*
B24B 9/10 *(2006.01)* ***B23Q 7/04*** *(2006.01)*

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

(30) Priority: **16.01.2015 IT TV20150007**

(71) Applicant: **Forel Spa**
31056 Roncade (Treviso) Frazione Vallio (IT)

(72) Inventors:
- **VIANELLO, Fortunato**
  31056 RONCADE, FRAZIONE VALLIO TV (IT)
- **VIANELLO, Riccardo**
  31056 RONCADE, FRAZIONE VALLIO TV (IT)

(74) Representative: **Modiano, Micaela Nadia et al**
Modiano & Partners
Via Meravigli, 16
20123 Milano (IT)

(54) AUTOMATIC MACHINE FOR DRILLING AND MILLING FLAT GLASS SHEETS ARRANGED VERTICALLY AND ITS USE

(57) An automatic machine (1000) for drilling and milling and optionally perimetric grinding of substantially flat glass sheets (1) arranged vertically or almost vertically, having a rectangular or other than rectangular shape, the glass sheet being able to remain stationary or being provided with an adjustment and feeding motion along the horizontal axis X, comprising: an input conveyor (100); an output conveyor (200); a machine body, which comprises at least two mutually opposite electric spindles, each provided with movements, with respect to the glass pane (1), for feeding, adjustment and cutting that bear tool holders (302, 402) and associated abrasive tools (303, 403) adapted to performing one or more of following processes: grinding, drilling, milling and polishing, by combined action of at least two of the movements listed above; the machine (1000) being provided with at least one tool magazine (500) of the linear fixed or movable or translating chain or rotating revolver type, said magazine, which accommodates the various types of abrasive tool (303, 403) with corresponding tool holders (302, 402) for grinding, drilling, milling, polishing, being interfaced with the spindles (301, 401) of the electric spindles for returning the tool (303, 403) with the corresponding tool holder (302, 402) that has finished its own processing cycle and for picking up the tool (303, 403) with corresponding tool holder, required for the subsequent processing cycle, at least one of receptacles of the tool magazine (500), instead of containing an abrasive tool or being empty, containing an accessory (505, 506) that is other than the abrasive tool (303, 403).

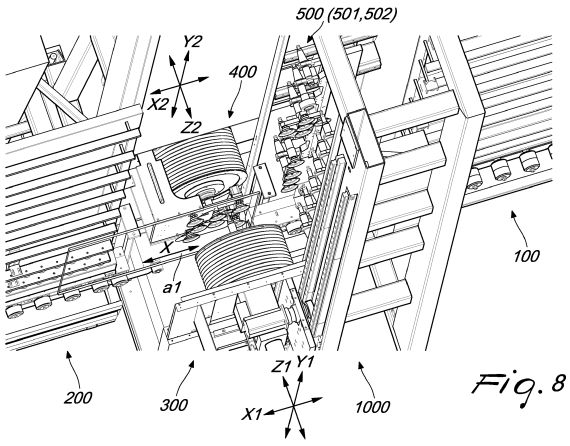

Fig. 8

EP 3 045 281 A1

Description

[0001] The present invention relates to a device and method adapted to fill some shortcomings that are currently present in machines for drilling and milling glass sheets, having a rectangular or other than rectangular shape, with an arrangement that is vertical or slightly inclined with respect to the vertical. One predominant shortcoming being the support and removal of scrap.

[0002] Methods for drilling and milling glass sheets, having a rectangular or other than rectangular shape, as obtained following cutting from the original production format to the destination formats and, in most cases but not exclusively, following the grinding of the perimetric edge, are currently known. In principle, the grinding, drilling and milling operations are applicable to any step of the processing of the glass sheet after cutting, for example before its use as is for the composition of the insulating glazing unit or as a necessary operation prior to tempering or as preparation of the glass sheet to obtain a definite and regular geometry and surface finish.

[0003] Grinding of the perimetric edge is performed for many reasons, which are listed here not in order of importance: the first one relates to safety in handling said glass sheets, in which the edges would be dangerously sharp if they were not ground; the second one relates to the elimination of edge defects of the sheets, typically so-called micro-cracks produced by scoring and cutting processes, which might trigger breakages of the sheet in the subsequent processing steps (in particular the tempering step) as well as in the subsequent states of transport or use; the third one can be simply to define the format of the glass sheet with better dimensions, geometry and surface finish than can have been obtained with the first processing step, i.e., cutting, which leaves the edges rough, and this occurs for architectural uses, for uses in interior decoration and in particular for use in the composition of a structural glazing unit (a typical enclosure of buildings), the geometry of which is required to be precise in its dimensions and shape and the edge finish of which is required to be uniform in view of the visual effects linked to this configuration; additional reasons for resorting to grinding of the perimetric edge may be the most disparate.

[0004] In particular in the case of architectural uses or uses in interior decoration, the need is frequent to have glass sheets that have holes with a cylindrical geometry, generally a chamfered one, or openings that have a rectangular or contoured shape and affect or not the peripheral margin. A classic example is constituted by glass doors, where interfacing with the hinges requires the presence of holes or openings and interfacing with the handle or lock also requires the presence of holes or openings. Respectively, holes with a cylindrical geometry, usually a chamfered one, are obtained, if small, by drilling; openings and larger holes are obtained by milling. These operations are already usually performed by means of machines known as drills for the first case, milling machines for the second case, or drilling/milling machines for combined cases, in manual or semiautomatic conditions (since the placement of the sheet and of the fixing restraints requires manual interventions) or automatic ones.

[0005] In all these cases the problem of the vibration of the portion of the glass sheet proximate to the region of action of the tool is unsolved or partially solved in perimetric grinding and drilling and milling.

[0006] A further and important problem is linked to the retention and subsequent movement of the part of the glass sheet that will become scrap (a term which is a synonym of waste or debris) of finite dimensions, i.e., all those byproducts of drilling and milling that do not consist of glass dust but consist of parts which, once processing has ended, would fall downward, in view of the substantially vertical arrangement of the glass sheet, or would be propelled in several directions, damaging not only such scrap and the parts of the machine struck by the waste but also the surface of the glass sheet that will constitute the finished part intended for use. Moreover, in the background art of so-called vertical machining centers, drilling and milling must be divided up so as to obtain small scraps that can be managed by falling due to the action of gravity, albeit with the drawbacks cited above, and therefore any scrap of prohibitive size entails that the processing is converted into a plurality of and progressive processing steps to break up such scrap. This occurs, therefore, with a greater expenditure of energy, since it is necessary to convert into glass powder even portions of the scrap, and also with an increase in processing time.

[0007] All these problems are dealt with by the subject matter of the present invention by retaining the parts of the glass sheet that otherwise would be subjected to vibrations during drilling and milling and by guiding, at the end of each processing step, the parts that have become scrap to the waste collection region, or to the output conveyor if the scrap constitutes raw material of such dimensions that it can be used subsequently.

[0008] With reference to the drilling and milling of glass sheets, protection at the Industrial Property level is particularly crowded, in view of the development of the use of glass sheets in architectural fields related to enclosures, stairways and handrails in civil building work, related to curtain walls, balustrades and protections in naval constructions, and related to interior decoration, and in recent years also due to the diffusion of oriental manufacturers of machines dedicated to these operations.

[0009] A selection of the patent applications related to the most pertinent background art, in the sense that it already provides some solution for the management of scrap, with respect to the invention that will be described subsequently, leads only to PCT/IB2015/057703 filed on October 9, 2014 by the same Applicant.

[0010] The remaining background art never approaches the concept that at least one of the processing heads can be used as a means for restraining a portion of the

glass sheet during processing, both if such portion belongs to the finished part and if such portion belongs to the scrap created by processing.

[0011] It is therefore convenient to reference this title for an easy understanding of the present innovative and inventive solution, which leads not so much to a sort of dependent claim or to an improvement patent that can be used only as a development of this prior art, but rather to an actual invention, which can be applied also to all other machines according to the background art, performing one or more of the operations of perimetric grinding, drilling and milling of glass sheets with a vertical or substantially vertical arrangement.

[0012] PCT/IB2015/057703 partially solves the problem of the retention and conveyance of scrap, as can be deduced from the corresponding description (pages 26 and 27), from the corresponding figures (in particular Figures 3 and 21), and from the corresponding claims (6, 7), but these solutions have the prerogative of constituting dependent claims, which are rather specific for the same invention and instead are not applicable more broadly in the same invention or more universally in machines that perform perimetric grinding, drilling and milling.

[0013] Other background art deals only, optionally and not satisfactorily, with the retention of the portion of the glass sheet proximate to the region affected by processing, and this is done by means of carriages or tracked systems provided with suckers coupled to the glass sheet, which therefore follow and restrain it when it is moving along the horizontal longitudinal axis, in the situation in which, during relative motion between the glass sheet and the tool, horizontal milling or vertical milling or inclined milling or curvilinear milling is performed, but it does not deal with the retention and the conveyance of the scrap to the collection region. In all these background arts, including PCT/IB2015/057703, the tool magazines, typically of the linear type (fixed or translating for example by means of a chain) or of the revolver type (rotating), accommodate abrasive tools in the combinations of various composition related to the agglomerates and abrasives, as a function of the type of glass and of the processing parameters and of various shapes as a function of the type of processing (grinding or drilling or milling), of the profile to be obtained in the sense of the thickness of the glass sheet and of the desired finish (coarse rough edge, medium rough edge, fine rough edge, polished edge).

[0014] None of this background art, including PCT/IB2015/057703, leads to the inventive concept of the present application, which in summary consists in providing the tool magazine or magazines also with accessories that are different from the tools but with the shape that uses the same means for coupling with the spindle of processing heads; these accessories being constituted by at least one sucker or at least one pad. In the case of a sucker (suckers), each accessory can be shaped so as to be suitable to couple by interlocking either to the portion of sheet that belongs to the finished part or to the portion of sheet that becomes scrap, and the innovation consists in having an accessory magazine together or complementarily with the tool magazine, each of said accessories being interfaceable for example with the spindle of the rear processing head (or more generally with a head or with each of the heads), with progressive replacements according to the shape of the processes to be performed or of the scrap to be removed. The same applies for the pads, which instead have the sole function of contrasting the thrust of the opposite tool during processing, coupling to the glass sheet like a support.

[0015] The aim of the present application is therefore to solve the highlighted technical problems of the background art and therefore to devise innovative solutions that allow the functional management of the scrap produced by drilling and milling of glass sheets.

[0016] Within this aim, an object of the present invention is to restrain the part of the glass sheet that will be converted into scrap, or the part of the glass sheet that is adjacent to the part that will be converted into scrap, or both, during drilling and milling, and to guide the scrap to the position for discharge or conveyance to subsequent processes.

[0017] This aim and these and other objects that will become better apparent from the description that follows are achieved by an automatic machine and method for drilling and milling glass sheets that are substantially flat and are arranged vertically or slightly inclined with respect to the vertical, comprising a known machine body, having various shapes, provided with at least two mutually opposite processing heads which are also known and have various shapes and are adapted to make contact with the faces of the glass sheet having any shape, in any position, said processing heads being each provided with their own synchronous motions (independently of each other) for feeding (or advancement) and adjustment according to various axes, each processing head being provided with a spindle in order to impart to the respective tool the rotary motion in order to allow the cutting motion; the tools being extractable from tool magazines and returnable to the tool magazines.

[0018] Such machine and method use an additional function that relates to either processing head or both and consists in using the spindle or spindles by interfacing therewith, according to the requirements of the step of the processing cycle, not a tool but an accessory, constituted by at least one sucker or at least one pad, that can be picked up from the tool magazine or magazines.

[0019] Where previously the terms that define the feeding (or advancement), adjustment, cutting motions have been used, these terms are derived from the known sector of machine tools and therefore do not require supplemental definitions.

[0020] Further characteristics and advantages of the invention will become better apparent from the detailed description that follows of a particular embodiment of the invention, illustrated by way of nonlimiting example in the

accompanying drawings, which are commented here. The situation shown is the one of the machine as disclosed in application PCT/IB2015/057703, which is implemented here with what has been derived from the innovation of the present invention. Such implementation can be applied to any other machine that performs drilling and milling processes and is provided with a tool magazine.

Figure 1 relates to the background art and shows the restraint mode of the glass sheet, performed by means of a set of suckers that belong to the carriage of the rear processing head, during the milling operation being performed in the lower part of said sheet by means of a tool of the front processing head. Only in this situation can the scrap be left to fall into the collection region without damaging the finished product. If the milling is not located downward and is not open toward the perimeter, the processing head guides the scrap, supported by the suckers that belong to the carriage, to the release region. However, this can occur only within the field of action of the suckers, which despite being adjustable can only meet some combinations. The view is toward the rear face of the glass sheet.

Figure 2 is a view of an example of the finished product: original glass sheet converted into finished format, ground at its perimetric edge and provided with some openings, two of which have such dimensions and shapes that the corresponding scrap would vibrate during processing (like the surrounding regions), would be too large to be provided in a single piece, and could not be left to fall at the end of machining. The view is toward the front face of the glass sheet.

Figures 3a, 3b, 3c show respectively the condition of starting drilling performed simultaneously by the spindles and corresponding tools of the opposite processing heads, completion of the drilling subsequently performed by the spindle and the corresponding tool of the front processing head, said tool provided with a water jet or an air jet that flows through its hollow part, expelling the scrap toward the rear of the machine, said scrap being able to fall since it is small.

Figure 4 contains the inventive core of the invention, i.e., the complementary function of the spindle of the processing head (for example the rear head) used to position the means for restraining the part of the glass sheet that will become scrap. The same figure shows the milling process, in solid lines for the part that has already been performed and in dashes for the part to be completed, which is performed by the spindle of the processing head (for example the front head) and the corresponding tool. The means for restraining the scrap is constituted by a set of suckers, which are arranged with a configuration that is complementary to the shape of the scrap, accessory taken from the tool-accessory magazine and coupled to the spindle of said processing head, the means for coupling to the spindle being the same one used for the tools and the spindle being also able to couple said accessory, preventing its rotation. The view is toward the rear face of the glass sheet.

Figure 5 is a view of the part of the tool-accessory magazine, which shows a combination of tools-accessories that is constituted, starting from below, by: a group of three suckers arranged in a line; a sucker; a group of three suckers arranged so as to form a corner; a group of five suckers arranged so as to form a cross; a contrast pad; a bit for drilling and chamfering, with production of small cylindrical scrap; a tool magazine toward which the processing head (for example the rear head), by using its synchronous vertical feeding and adjustment axis and its synchronous transverse feeding and adjustment axis, interfaces in order to deposit the tool or the accessory used in the preceding function or to pick up the tool or the accessory intended for the subsequent processing.

Figure 6 is a sectional view of the electric spindle (i.e., of the actual spindle that constitutes the rotor part and of the casing that constitutes the stator part that contains the electrical windings), of the known mechanisms that provide the coupling between the spindle and the tool holder accessory holder (effective also with respect to rotation, as obtained by means of the two lugs that are visible in the enlarged-scale inset), so as to allow it to assume, in addition to the function of coupling to the tool holders, also the function, which is an inventive content of the present invention, of accommodating and managing the accessories (shown) used to for the interlocking restraint (and therefore also rotation locking restraint) of the part of the glass sheet that will become scrap, in order to convey the scrap to the outlet, for restraining the regions of the glass sheet affected by the action of the abrasive tools. This restraint, limited to the resting contact type of support, is also used for the accessory if it is constituted by a pad or by a roller.

Figure 6a is an enlarged perspective view of a detail of Figure 6.

Figure 7 is a view of the circuits which as an alternative, by passing through the hollow parts of the spindle and of the tool holder and of the tool, lead to the active part of the spindle either the water for cooling and lubrication of the tool and for expulsion of small cylindrical scrap (a situation which is not shown but is classic in the background art) or the compressed air (again for expelling small cylindrical scrap), or, as shown in the open condition of two of the three valves, by passing through the hollow parts of the spindle and of the accessory holder and of the accessory, conveys vacuum for the activation of the sucker or group of suckers (the shaded valve is un-

derstood to be closed in this step).

Figure 8 is a perspective view of the rear processing head and the front processing head, the overall structure of the machine including therein the input conveyor and output conveyor, the front tool-accessory magazine and the rear tool-accessory magazine in the conditions of use of the inventive concept of the invention.

Figures 9a-9i are useful for the description of the processing cycle.

[0021] The machine dedicated to the drilling and milling processes, or more generally comprising also the process of grinding the perimetric edge, is constituted substantially by an input conveyor 100, a main body that is described in detail hereinafter, and an output conveyor 200.

[0022] Both conveyors, as well as the central machine body, keep a glass sheet 1 at an inclination of approximately 6° with respect to the vertical, to provide the conditions of stability thereof during transport, stops and processes, arrangement conditions that indeed entail seeking a solution for managing scrap in a manner other than by falling by gravity.

[0023] In a preferred embodiment of the invention, the main body of the machine, already according to the background art, substantially comprises: the front processing head 300; the rear processing head (and head for fixing the plate in the case of application PCT/IB2015/057703) 400; each processing head (or corresponding spindle of the electric spindle) being provided with: a cutting motion; a feeding (or advancement) and adjustment motion along vertical axes, respectively Y1 and Y2; a feeding (or advancement) and adjustment motion along transverse axes, respectively Z1 and Z2; one or both of said heads being also optionally provided with a feeding (or advancement) and adjustment motion along horizontal axes, respectively X1 and X2, or the sheet being movable with its own feeding (or advancement) and adjustment motion along the horizontal axis X; the tool magazine 500.

[0024] The processing head or heads that are intended also for the function of restraining the part of the glass sheet that will become scrap or of fixing the part of the glass sheet proximate to the machining tool, is or are provided with an electric spindle, the spindle of which, designated by the reference numerals 301, 401, can be locked in angular phase by means of known devices (Figure 6 shows the restraints between spindles 301, 401 and accessory holder tool holders 302, 402) and the end part of which, i.e., the one directed toward the glass sheet, has a universal shape, i.e., suitable both to couple to the tool holders 302, 402 and to couple to the accessory holders 302, 402 for restraining the portion of glass sheet 1, a universal shape of the female "Morse" cone type. Viewed from the tool-accessory side, such tools-accessories are accommodated in a toolholder 302, 402 or in an accessory holder 302, 402 that has a universal shape, typically a male "Morse" cone, i.e., suitable to mate with the spindle of the electric spindle at one end by means of known coupling and uncoupling restraints, and with the tool or accessory at the opposite end.

[0025] Software which receives as input the format of the glass sheet 1 and the type of processing (for example the ones of Figure 2 or of Figure 1) provides the information to the PLC (Programmable Logic Controller), which processes the outputs for placing the spindle which has the function of constraining a portion of the glass sheet 1, initially in the conditions for interfacing with the tool-accessory magazine 500 to pick up the correct accessory and then in the position for interfacing with the glass sheet 1 for constraining either the region that will become scrap 2 as a consequence of the processing operations or the region of the finished product 3 that will be stressed during the action of the tools.

[0026] The tool magazine 500 is also part of the central body and is split into a front row 500 and a rear row 502, for example of the rack type, the operation of which belongs to the background art and simply consists in arranging each rack in the operating region of the spindles of the processing heads for example by means of pneumatic actuators 503, 504, not shown, in order to interface with the axis of the spindle or in the step of retraction of the tool holder-accessory holder that has ended the function or in the step of delivery of the tool holder-accessory holder required for the subsequent function (see Figures 5 and 8).

[0027] A section 600, shown only schematically in Figure 7 since it is known, relates to the control unit for creating the vacuum required for the activation of the grip of the portion of the glass sheet 1 by means of the at least one sucker. Such control units can be optionally constituted by a pneumatic ejector (solution shown in Figure 7) or by a vacuum pump and by known accessories such as manual valves, electric valves, connectors, etc.

[0028] Passing now to the description of the processing cycle as performed on the glass sheet 1 by interaction of the various mechatronic components described earlier, in order to achieve milling with a rounded triangular closed shape that is not open toward the perimeter of the glass sheet 1, which entails the formation of scrap 2 that has a complementary shape with respect to the finished shape 3, minus the portion of glass sheet that is converted into dust, i.e., the one that corresponds in practice to the diameter of the milling tool 303, 403. This combining both the disclosure of the method and the disclosure of the device. The most universal case is described of restraining only the part of the glass sheet 1 that will become scrap 2, since with an adequate distribution of the suckers 505 toward the margins of the scrap 2 the restraint of the regions affected by the action of the tools 303, 403, which belong both to the scrap 2 and to the finished part 3, is also provided.

[0029] This description can therefore be extrapolated to the situations of other forms of processing or integrated by any perimetric grinding process, since it is established background art and is in any case complementary with

respect to the aim of the present invention.

[0030] Likewise, it is possible to extrapolate to the situation in which both regions of the part of the glass sheet 1 that will become scrap 2 and regions thereof that will be converted into the finished part 3 are restrained by accessories 505, 506 that act simultaneously or alternately on said regions 2, 3; in the case of the suckers 505, the ones that act on the region 3 of the glass sheet 1 having to be provided with a flow control system in order to drain and with a movement system to disengage when the axes X2, Y2, Z2 (or X1, Y1, Z1) must be actuated to remove the scrap 2. This more complex case, by entailing for example time-controlled valve one-way valves for releasing the suckers of the regions 3, is not claimed but is merely described in order to avoid the filing of improvement patent applications by third parties.

[0031] The glass sheet 1, which has a thickness s, arrives from the preceding grinding machine if the machine in which the present invention is applied does not perform perimetric grinding, or is loaded manually or by means of a loader onto the input conveyor 100, is made to advance until it stops at a stop reference that is located in sequence as a function of the progression of processes to be performed on the glass sheet 1 as a consequence of the information transferred from the production management system to the process PLC of the machine (by means of a KEYBOARD, USB, NET, SCANNER, etc.), for example beginning with the processing shown in dashed lines in Figure 9a.

[0032] At this point the rear processing head 400, by means of the adjustment motion along the axis 2, is arranged at the height in elevation (an operation that could also be performed earlier) and the spindle 401 now with the function of a drill by means of a transverse stroke along the axis Z2 provides a guide hole with a depth of approximately 1/3 s by using the tool 403 and the plate being retained by suckers 416 that belong to the rear processing head 400.

[0033] In sequence, the front processing head 300, which in turn is arranged along the axis Y1 at the height of the guide hole, completes the opposite drilling for the complementary depth, equal to approximately 2/3 s by means of a transverse stroke along the axis Z1, the corresponding spindle 301 being in drilling mode by using the tool 303.

[0034] This occurs because the drilling of the glass sheets, if performed by a tool 403, 303 that acts from a single face p1, a1, in exiting through the opposite face a1, p1, would evidently entail cracks.

[0035] As an alternative, the two spindles 401, 301 can act simultaneously, according to the respective axes Z2 and Z1 until the rear one has performed the transverse stroke equal to 1/3 s and therefore retracts, while the front one, which also has reached completion of the transverse stroke equal to 1/3 s, continues its completion stroke so that a through hole is provided, the scrap 2 of which is shaped like a cylindrical core and is expelled by means of the action of the water jet or compressed air jet that arrives from the hollow part of the front tool 303. This is shown in Figures 3a, 3b, 3c (sectional views of the glass sheet 1) and in Figures 9b, 9c (seen toward the rear face p1 of the glass sheet 1).

[0036] Once its drilling action has ended, the rear processing head 400 and with it the spindle 401 returns the drilling bit tool 403 to the tool-accessory magazine 502 and picks up from it the accessory 505 that is suitable for the subsequent restraint of the portion of glass sheet 1 that is intended to be converted into scrap 2, in this case a set of three suckers arranged in a right-angled triangle (alternative shapes of the accessory 505, which can be selected as a function of the shape of the scrap 2, are in any case available in the magazine 502), then it repositions itself by moving along the axis Y2 at the elevation suitable for interfacing with the portion of the glass sheet 1 that will become scrap 2. By means of the adjustment stroke along the axis Z2 and optionally along the axis X2, the rear processing head 400 places the active faces of the suckers 505 against the face p1 of the glass sheet 1, then vacuum is activated through the hollow part of the spindle 401, so as to restrain in interlocking mode ($\Delta X = 0$; $\Delta Y = 0$; $\Delta Z = 0$; $\Delta\varphi = 0$, where φ is the axis of rotation that is perpendicular to the plane XY) the portion of the glass sheet 1 that will become scrap 2 in positions that are not only useful for supporting and removing it at the end of the cycle but also for stabilizing the regions being processed during the milling step. This is shown in the sequence of Figures 9d, 9e, 9f, the view of which is toward the face p1 of the glass sheet 1. This subsequent step, as shown in Figures 9e, 9f, is performed by the milling tool 303 actuated by the spindle 301 of the front processing head 300, which are connected by the tool holder 302, both as regards the cutting motion and as regards the feeding (advancement) motions along the vertical axis Y1 (step shown in Figure 9f), along the horizontal axis X1 and along the combination thereof, so as to trace the path suitable to obtain the desired shape of the opening (Figure 9g). This milling starts from the position in which the hole described in the preceding paragraphs has been provided beforehand after placing the milling tool 303, actuated through the axes X1 and Y1 according to the coordinates of the processing start point and then the adjustment penetration of the milling tool 303 in said hole through the axis ZI (Figures 9e, 9f).

[0037] If the shape to be milled is open toward the perimeter of the glass sheet 1 the guide hole is not necessary, since processing can begin from the outside of the glass sheet 1.

[0038] What is essential is that in any situation the restraint provided by the accessory 505 install on the rear spindle 401 by means of the accessory holder 402, optimized accessory selected within the range that is resident in the tool-accessory magazine 502, is effective for avoiding the vibrations produced by milling, for supporting the scrap 2, and for guiding it to the expulsion station or toward the output conveyor or toward the scrap collection tray. This is made possible by the inventive con-

cept of the present invention, i.e., the interfaceability of the spindle 401 (and optionally 301) not only with the tool magazine but also with the accessory magazine. This guiding is performed initially by activating the axis Z2, which performs a stroke that is slightly greater than the thickness s of the glass sheet 1 in order to extract the scrap 2 transversely to the glass sheet 1 (Figure 9h) and then by activating the axis Y2 for the downward motion (Figure 9i) and optionally the axis X2. The final step is therefore the release of the vacuum (venting, by connection to the ambient air or to a source of compressed air, see Figure 7) for uncoupling between the sucker (suckers) 505 and the scrap 2 and for the transfer thereof either to the scrap collection tray or to the output conveyor 200.

[0039] The sequence of the processing cycle described here is shown schematically in Figures 9a ÷ 9i, which show the process.

[0040] The spindle of the rear processing head (or front processing head or both), as mentioned earlier, can also accommodate another type of accessory, i.e., a pad 506, which instead of providing the glass sheet portion 1 with a restraint of the interlocking type ($\Delta X = 0$; $\Delta Y = 0$; $\Delta Z = 0$; $\Delta\varphi = 0$ typical of the sucker) provides a restraint of the resting type ($\Delta Z = 0$), simply with the function of contrasting the transverse action of the opposite tool 303, 403, for example during drilling or milling, in which case it is also possible to accept relative movements between the glass sheet 1 and the pad 506, such pad sliding against the face p1 of the glass sheet 1; the pad, as an alternative, can be shaped like a free roller (which enables relative movements along the axis X or the axis Y or a combination of said axes, therefore without damaging the surfaces a1, p1 of the glass sheet 1 (some sheets being optionally provided with coatings that are particularly susceptible to damage), contact occurring by rolling and not by sliding, the spindle being able to perform synchronous rotations about its own axis Z in order to keep the axis of the free roller perpendicular to the tangent to the path that is produced by the shape of the processing, including a curvilinear shape, obviously in a position which is external or internal with respect to the space occupation of the opposite tool, or the pad being able, as an alternative, to be shaped like a ball on a cradle of balls (which enables relative movements in all directions of the plane and therefore also with a curvilinear path, without the need to rotate the spindle 301, 401).

[0041] The descriptive detail related to the cycle for picking up and returning the tools-accessories, which involves the function of the axes Y2, Z2 and optionally X2 (or Y1, Z1, X1) with the appearance/disappearance of the racks 501 and 502 of the tool-accessory magazine 500 on the part of the actuators 503 and 504, not shown in the figures, is omitted since it is intuitive from the viewing of Figures 5 and 8 and is established in the background art. It is stressed once again, anyway, that the inherent novelty resides in the duality of the functions of this magazine, as described in greater detail previously.

[0042] The glass sheets 1 can have a rectangular or other than rectangular shape (for example contoured with portions that are all straight or shaped with some of the portions which are curvilinear, the base of the glass sheet 1 being usually rectilinear). A software interfaced with the library of the shapes required by the production job supplies the input to the PLC (Programmable Logic Controller) that is suitable both to stop the sheet 1 in a precise phase with respect to the processing heads 300, 404 and to adjust and actuate the axes X1, Y1, X2, Y2.

[0043] All the movements related to the steps of the cycle are obviously mutually interlocked, with the aid of a parallel logic which is always active, in order to avoid, during the process, conditions of interference among actuator elements, tools, accessories and material being processed (glass sheet 1) other than those required for grinding, drilling and milling which entail operating interference of the process between the tool 303, 403 and the glass sheet 1. This is done for the functionality of the process, to preserve the integrity of the machine and for the safety of operators, of maintenance technicians and of visitors.

[0044] It has thus been shown that the machine according to the invention achieves the intended aim and objects, which, it is stated once again, consists in restraining the portions 2 and 3 of the glass sheet 1 during processing, in restraining and moving the parts of the glass sheet 1 that will become scrap 2, and in the corresponding movements and the corresponding management. This by using the primary inventive concept, which is to interface the spindles 301, 401 not only with processing tools (grinding, drilling, milling performed with abrasive tools 303, 403) but also with accessories such as suckers 505 (in various shape combinations) and pads 506.

[0045] The invention is susceptible of numerous modifications and variations, all of which are within the scope of the appended claims. Thus, for example, the mechanical solutions for the feeding, adjustment and cutting motions of the tools and for picking up, adjusting and returning the tools 303, 403 and the accessories 505, 506 (systems of suckers and pads), the support and transport of the glass sheet 1 and the actuation means, which can be electrical, electric-electronic, pneumatic, hydraulic and/or combined, while the control means can be electronic or fluidic and/or combined.

[0046] Obviously, the machine, by operating in a wet environment due to the cooling and lubricating flow directed onto the tools, is provided with protections (some of which are visible in Figure 8) such as bulkheads, sheaths, accordion-like elements, etc. to avoid the escape of fluids and the contamination of the parts that are not suitable to bear contact with liquids.

[0047] As already described, the machining scrap produced by drilling, of the so-called core type, which is small or in any case has dimensions that are smaller than those required for interfacing with the sucker accessory, can be removed by way of the action of the flow of water for cooling/lubrication that is directed through the hollow part

of the spindle 301, 401, of the tool holder 302, 402 and of the tool 303, 403 or as an alternative by way of the action of a stream of compressed air that is also directed through said hollow parts.

[0048] Obviously the industrial application is of assured success, since in many applications it is necessary to process not only the perimetric edge of the glass sheet 1, this occurring already according to a number of known methods that are by now widespread, but portions of the surface of the glass sheet 1 also require additional processes, such as drilling and milling according to the description, these processes being by now widespread but by resorting to methods which, except for PCT/IB2015/057703, which in any case solved the problem only partially, do not consider the constraint and the automatic removal of the scrap 2.

[0049] Examples of requirements of these drilling and/or milling processes are many and precisely for at least the following products: balustrades, handrails, steps, shelters, partitions and walkable walls (for all of which the evolutions of the standards have led to particular attention: regarding the fixing methods, which occur with machining operations, which affect the thickness s of the glass sheet 1, for both drilling and milling; on the type of these machining operations).

[0050] Moreover, a field that is developing every day and also requires, in addition to the milling of the perimetric edge, the drilling and milling of the glass sheets 1, with adequate degrees of finish, is constituted by all those applications that resort to the use of tempered glass sheets, such as those in furnishings or electrical household appliances.

[0051] Furthermore, a considerable and expanding field of use is the nautical and naval one, glass sheets assuming an important proportion in enclosure structures (windows and portholes), in protective structures (balconies, parapets and handrails) and in interior decoration structures.

[0052] The drilling and milling of the glass sheet 1 thus constitutes an added value that is very important and qualifies the product, especially if this processing is performed with machines and methods that are not only superior in terms of quality and productivity but are also more functional in the management of the scrap 2 than what is currently commercially available.

[0053] The disclosures in Italian Patent Application No. TV2015A000007 (102015902322090) from which this application claims priority are incorporated herein by reference.

[0054] 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 (1000) for drilling and milling and optionally perimetric grinding of substantially flat glass sheets (1) arranged vertically or almost vertically, having a rectangular or other than rectangular shape, the glass sheet being able to remain stationary or being provided with an adjustment and feeding motion along the horizontal axis X, comprising: an input conveyor (100); an output conveyor (200); a machine body, which comprises at least two mutually opposite electric spindles, each provided with movements, with respect to the glass pane (1), for feeding, adjustment and cutting that bear tool holders (302, 402) and associated abrasive tools (303, 403) adapted to performing one or more of following processes: grinding, drilling, milling and polishing, by combined action of at least two of the movements listed above; the machine (1000) being provided with at least one tool magazine (500) of the linear fixed or movable or translating chain or rotating revolver type, said magazine, which accommodates the various types of abrasive tool (303, 403) with corresponding tool holders (302, 402) for grinding, drilling, milling, polishing, being interfaced with the spindles (301, 401) of the electric spindles for returning the tool (303, 403) with the corresponding tool holder (302, 402) that has finished its own processing cycle and for picking up the tool (303, 403) with corresponding tool holder, required for the subsequent processing cycle, **characterized in that** at least one of receptacles of the tool magazine (500), instead of containing an abrasive tool or being empty, contains an accessory (505, 506) that is other than the abrasive tool (303, 403).

2. The automatic machine (1000) according to claim 1, **characterized in that** the accessory (505, 506), other than the abrasive tool (303, 403), is provided with an accessory holder (302, 402) for fixing to the spindles (301, 401) that is identical to the one with which the abrasive tools (303, 403) are equipped.

3. The automatic machine (1000) according to claim 1 or 2, **characterized in that** the terminal (302, 402) for fixing to the spindles (301, 401) is a so-called Morse cone.

4. The automatic machine (1000) according to claim 2, **characterized in that** the terminal of the accessory holder (302, 402) for fixing to the spindles (301, 401) is provided with restraints for preventing rotational sliding.

5. The automatic machine (1000) according to one or more of the preceding claims, **characterized in that** the spindles (301, 401) are provided with a rotation preventing brake.

6. The automatic machine (1000) according to one or more of the preceding claims, **characterized in that** the accessory (505, 506) other than the abrasive tool (303, 403) consists of at least one sucker (505).

7. The automatic machine (1000) according to one or more of the preceding claims, **characterized in that** the accessory (505, 506) other from the abrasive tool (303, 403) consists of a support, provided with a terminal (302, 402), that is provided with a plurality of suckers (505) distributed as a function of the shape and dimensions of the parts of the glass sheet (1), be they scrap (2) or belonging to the finished part (3).

8. The automatic machine (1000) according to claim 7, **characterized in that** the support is provided with a matrix of couplings for fixing the suckers (505) in order to allow variability of the configuration of their distribution.

9. The automatic machine (1000) according to one or more of the preceding claims, **characterized in that** the accessory (505, 506) other than the abrasive tool is a pad (506), or a free roller (506), or a ball on a cradle of balls (506).

10. The automatic machine (1000) according to one or more of the preceding claims, **characterized in that** the hollow parts of the spindle (301, 401) and of the tool holder (302, 402) or the accessory holder (302, 402) are connected alternatively, by means of circuits provided with flow control systems, to the feeds respectively of: refrigerant/lubricating fluid, compressed air, vacuum.

11. A method for drilling and milling and optionally perimetric grinding of glass sheets (1) which are substantially flat and arranged vertically or almost vertically, having a rectangular or other than rectangular shape, processes performed by way of relative motions between the abrasive tools (303, 403), picked up from and returned to at least one tool magazine (500) of the linear fixed or movable or translating chain or rotating revolver type, and the glass sheet (1), the motions being optionally for adjustment, feeding (or advancement) and cutting, also in combination among them, the tools (303, 304) being interfaceable with at least two mutually opposite spindles (301, 401), each provided with motions, with respect to the glass sheet (1), that are not only rotational but also along one or more of the three main axes X, Y, Z, **characterized in that** at least one of the spindles (301, 401), in addition to processing the glass sheet (1) by way of the abrasive tools (303, 403), performs the alternative function of fixing and conveying the parts of the glass sheet (1) that will become scrap (2) and/or of fixing the parts of the glass sheet (1) that will become a finished part (3), using, as replacement of the tools (303, 403), accessories (505, 506) that consist of suckers, pads, rollers, balls on a cradle of balls, which can be picked up and returned to the tool-accessory magazine (500).

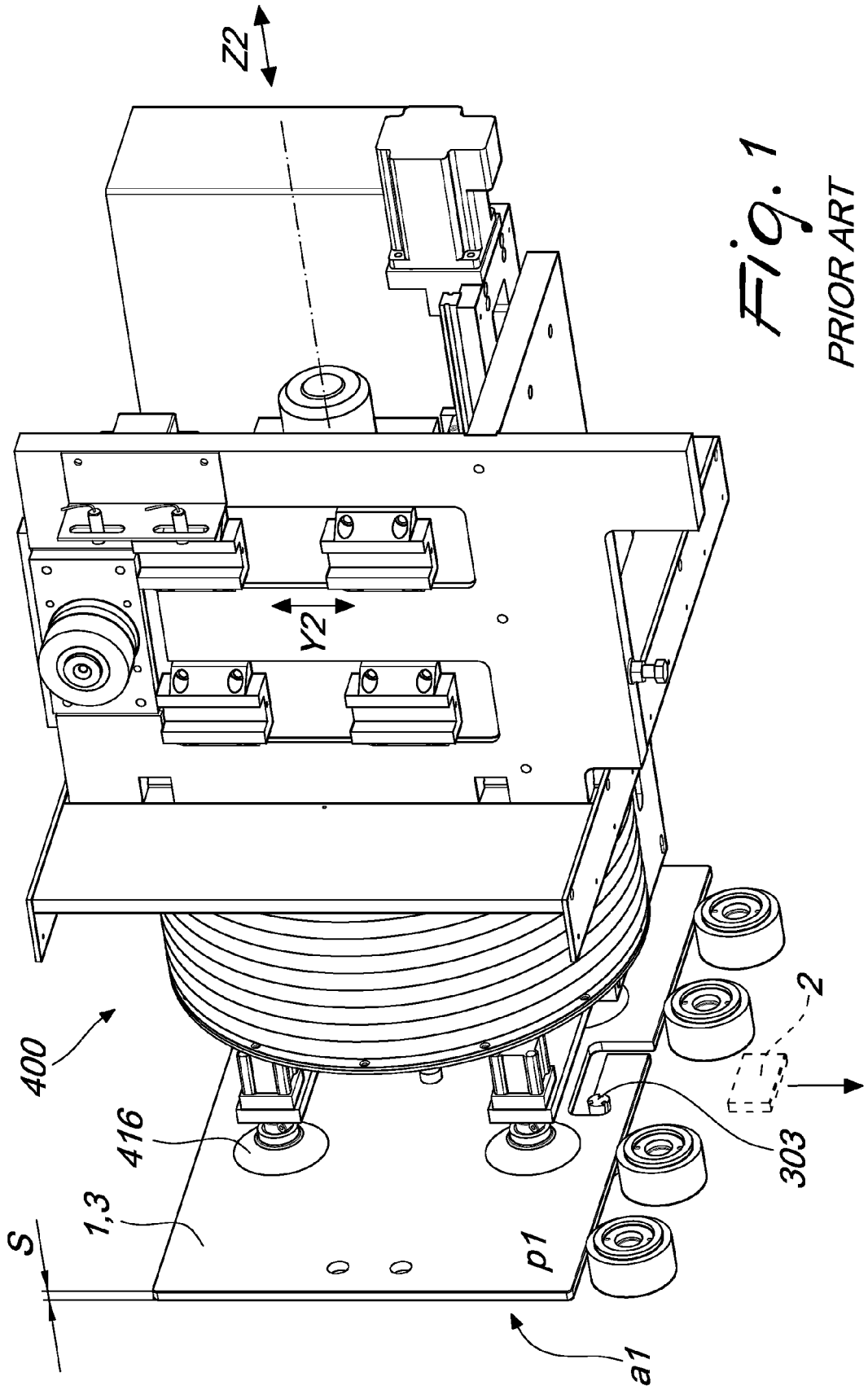

Fig. 1
PRIOR ART

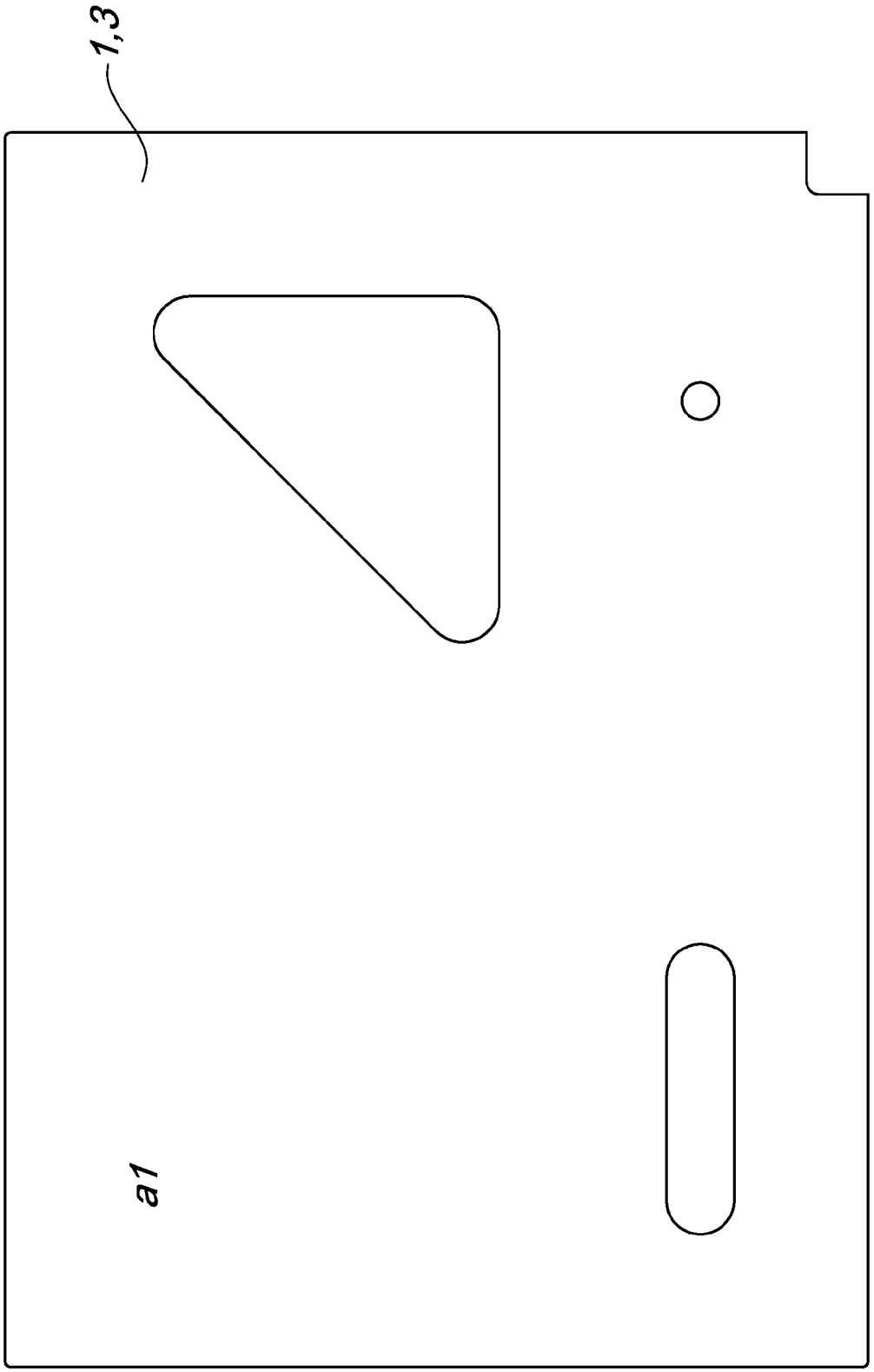

Fig. 2

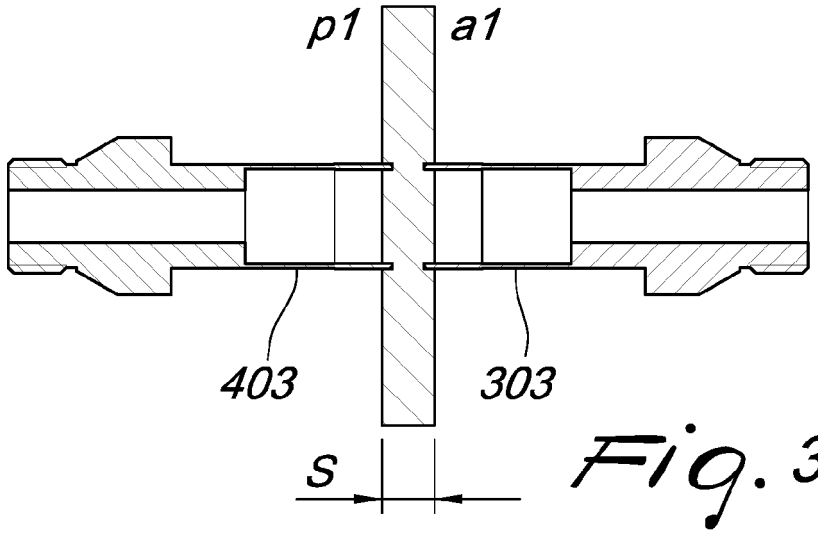

Fig. 3a

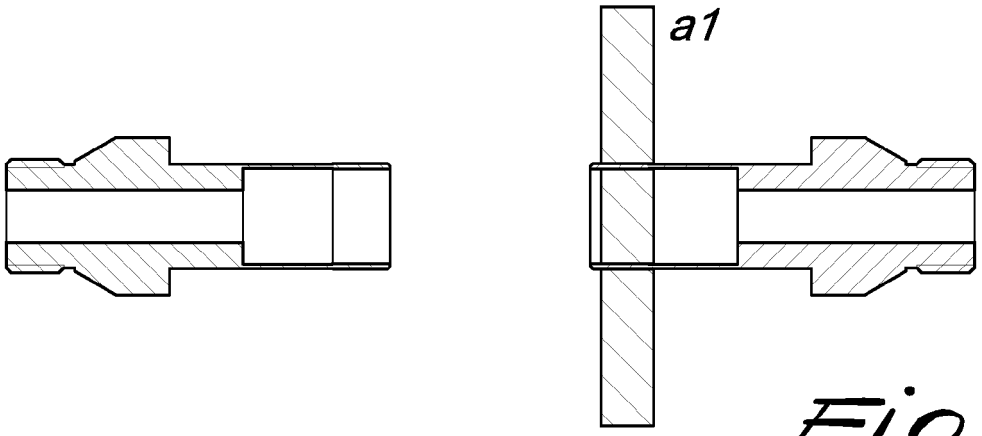

Fig. 3b

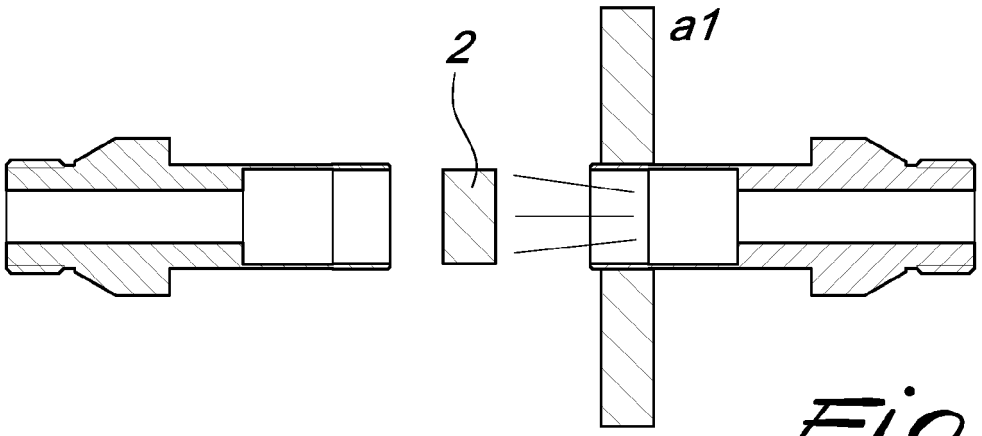

Fig. 3c

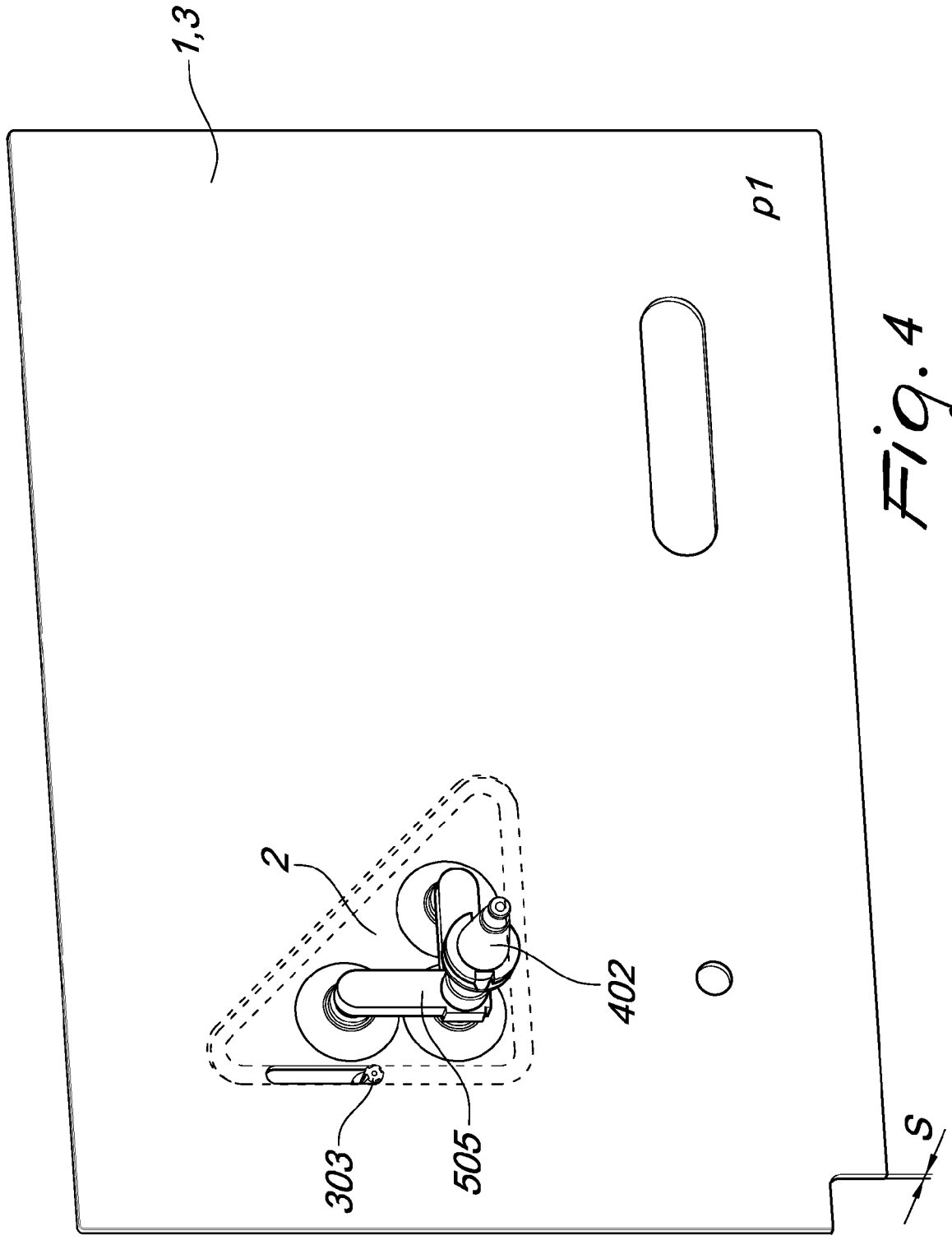

Fig. 4

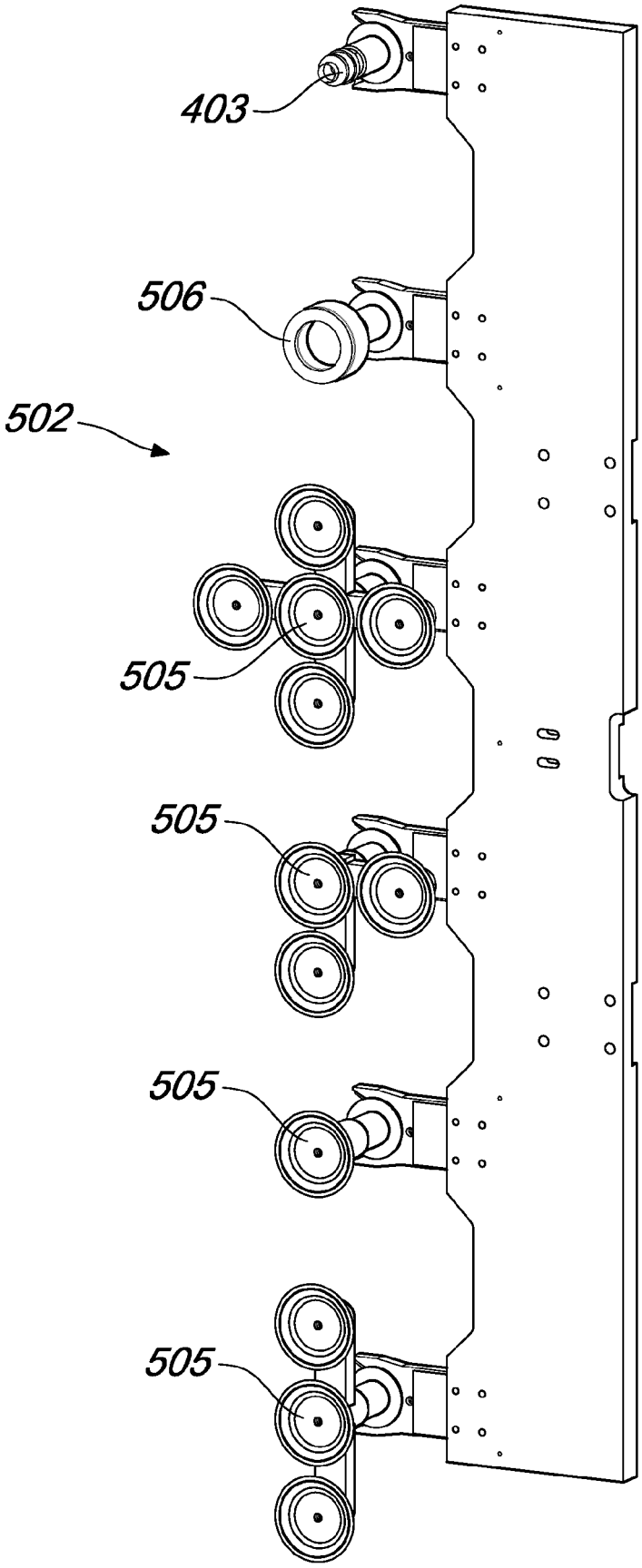

Fig. 5

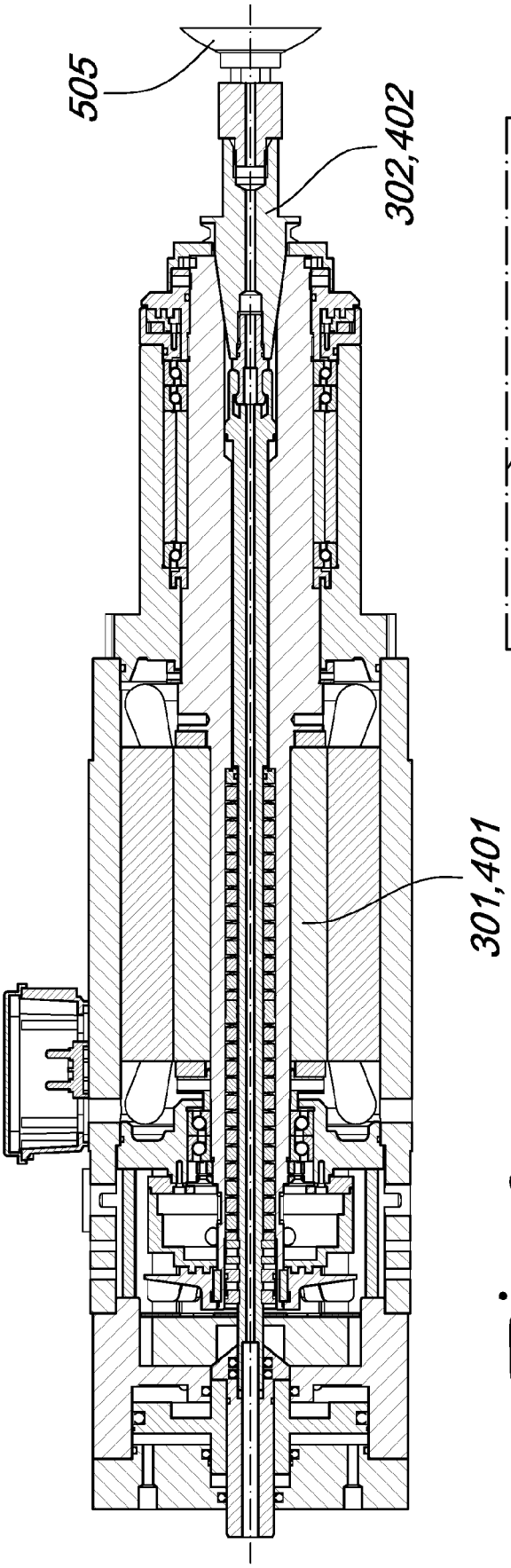

Fig. 6

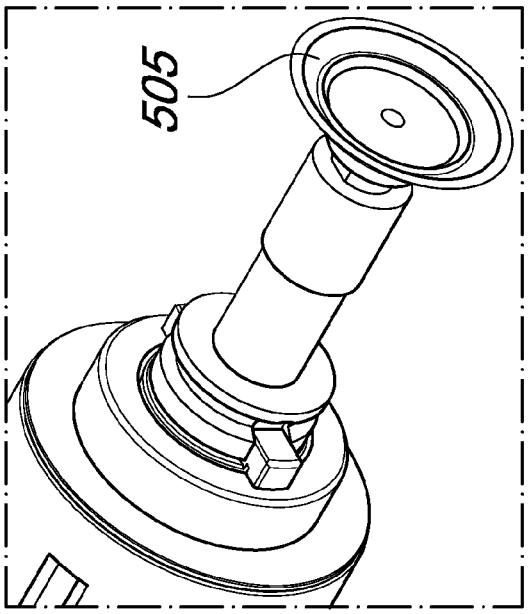

Fig. 6a

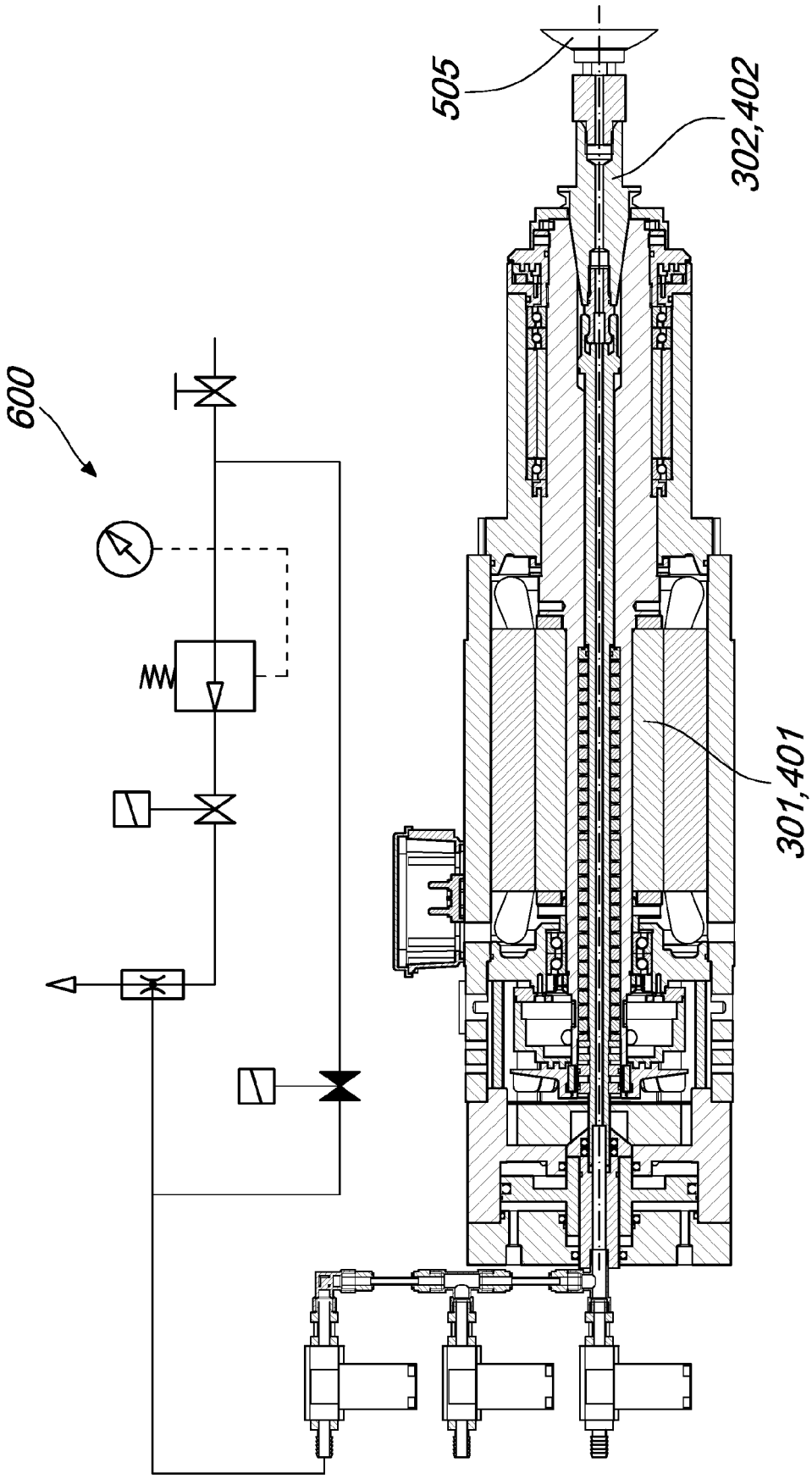

Fig. 7

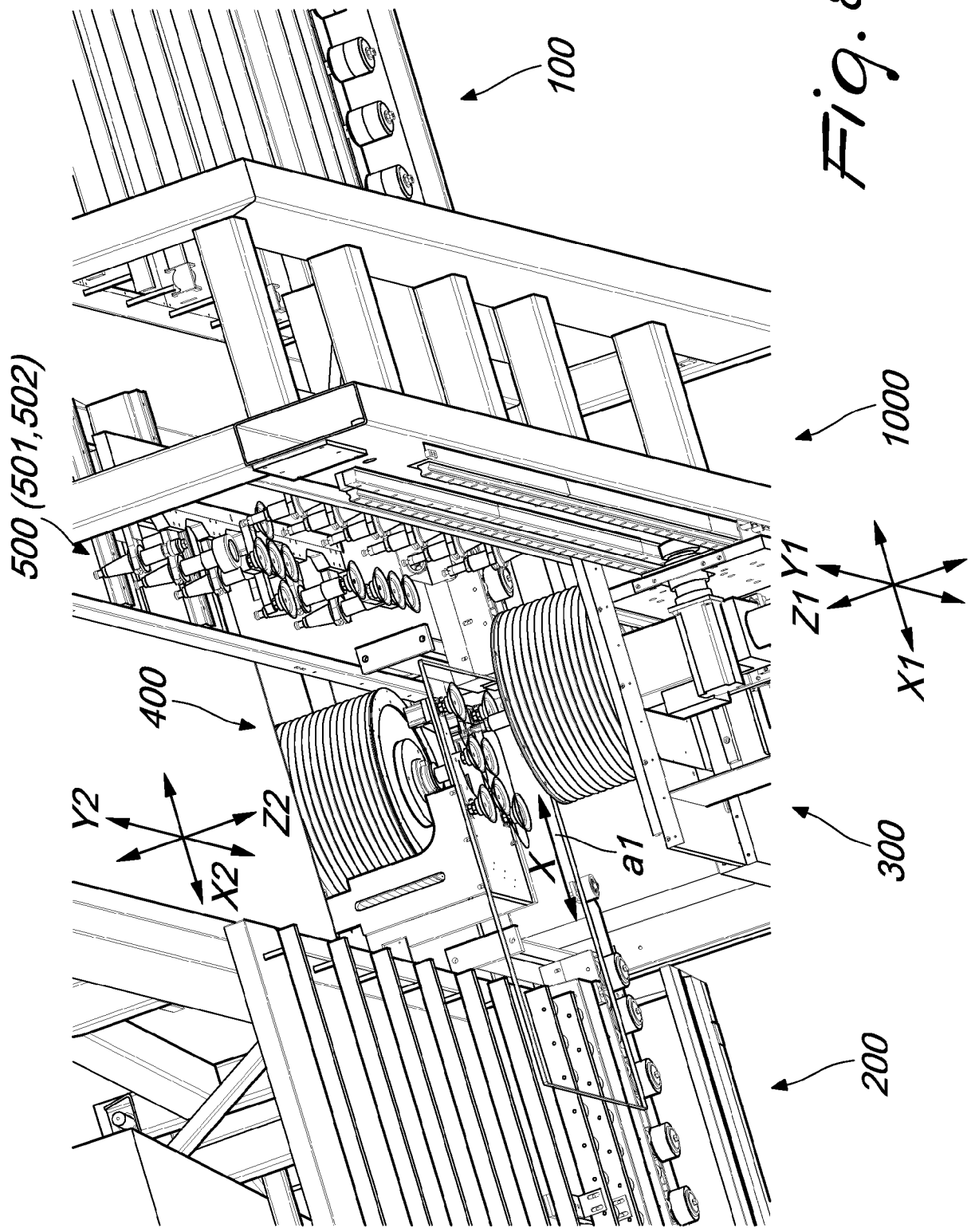

Fig. 8

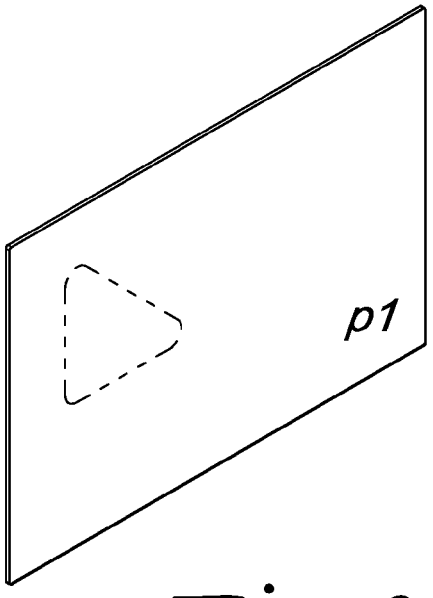

Fig. 9a

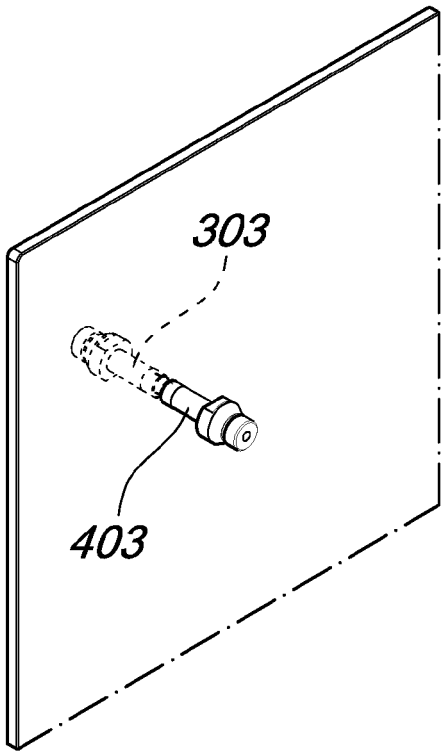

Fig. 9b

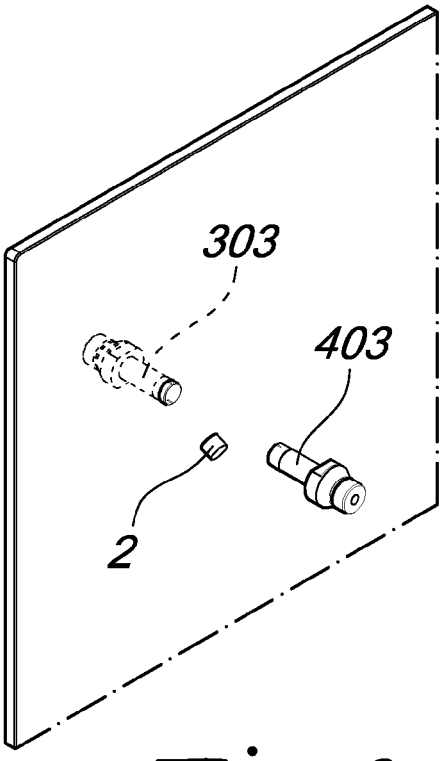

Fig. 9c

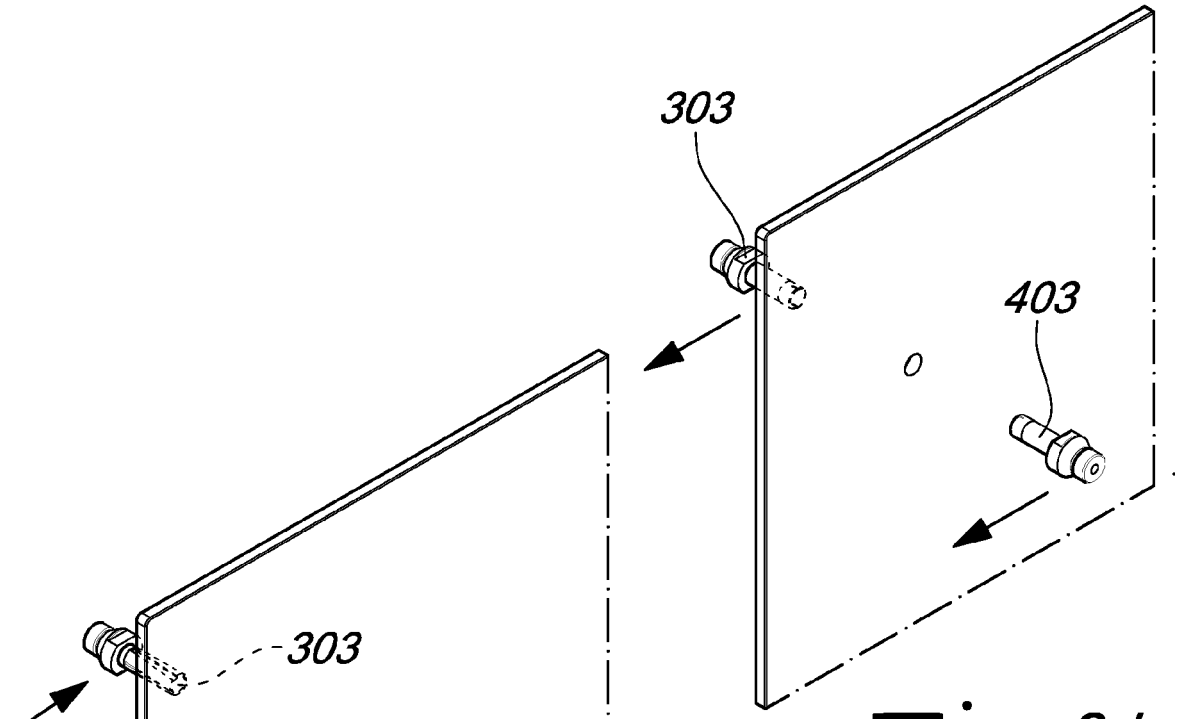

Fig. 9d

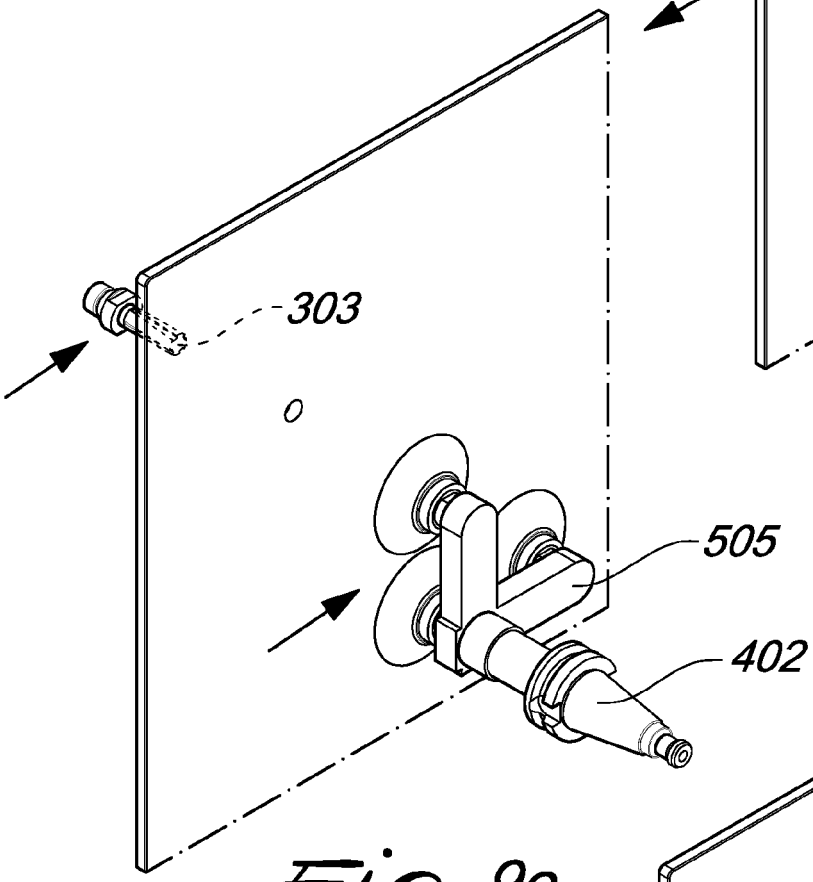

Fig. 9e

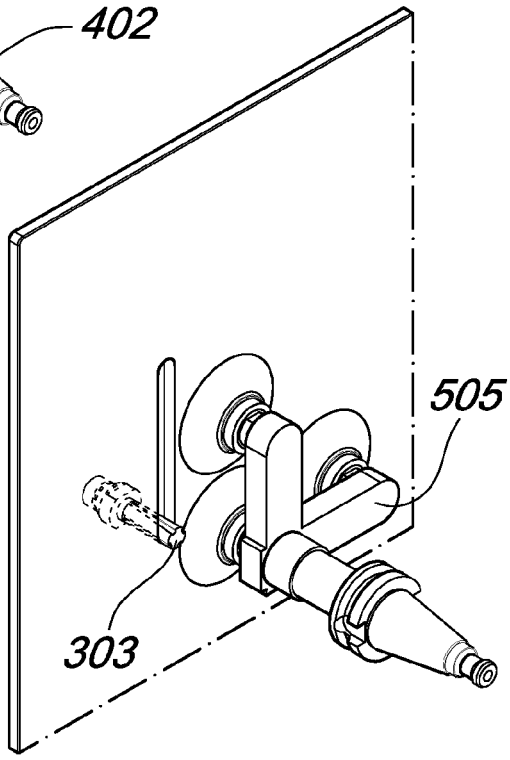

Fig. 9f

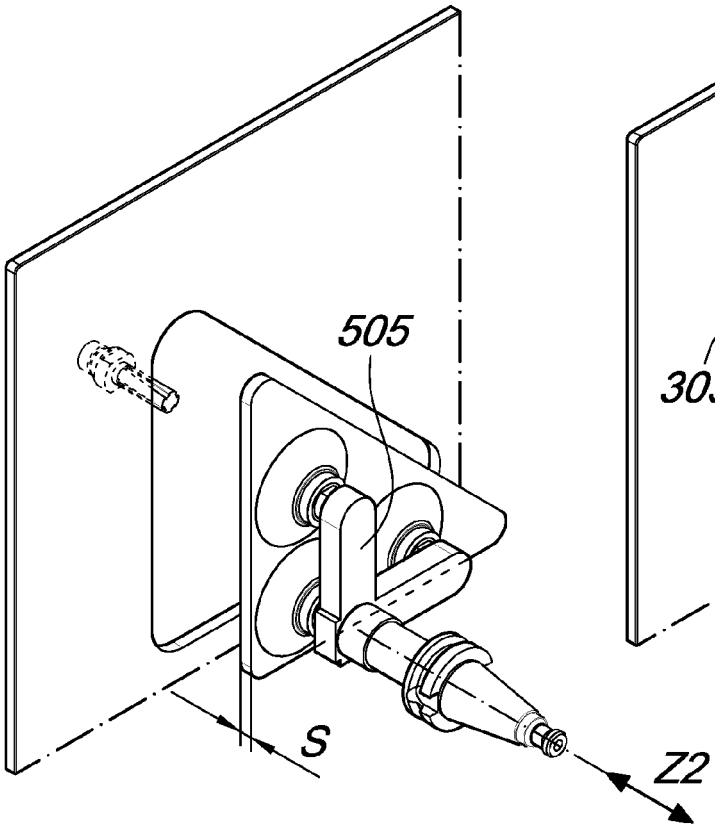

Fig. 9h

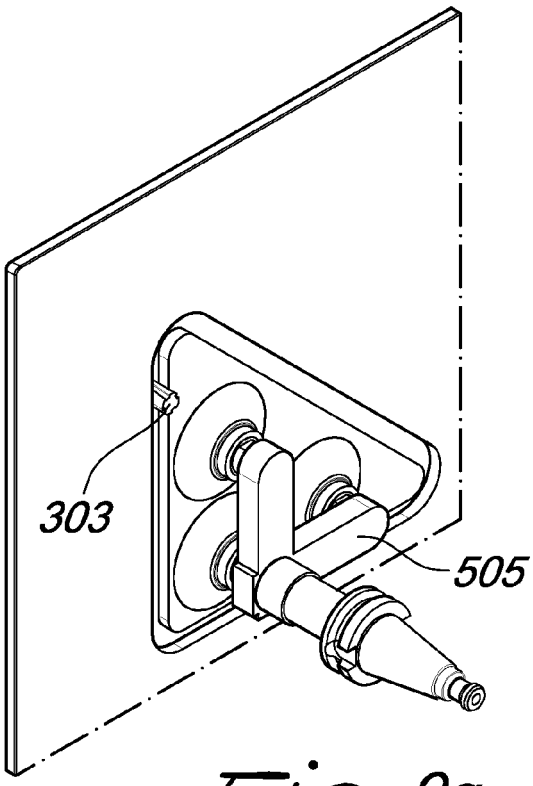

Fig. 9g

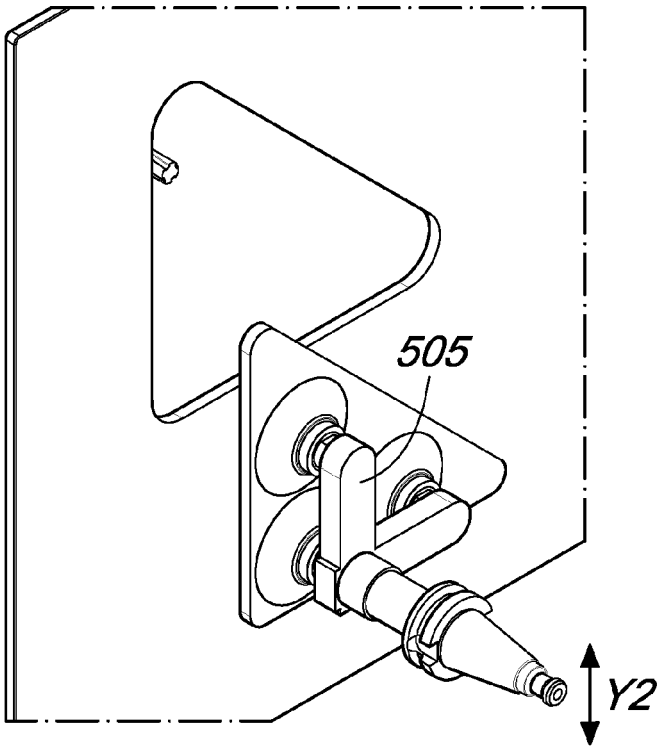

Fig. 9i

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 16 15 1205

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	DE 296 21 422 U1 (KRAUS HERMANN [DE]) 9 April 1998 (1998-04-09) * page 1, paragraph 1 * * page 13, paragraph 2 * * page 22, paragraphs 1,3 * * page 23, paragraph 1 * * page 24, paragraph 2 * * figures 1,2 *	1,11	INV. B28D1/00 B28D1/14 B28D1/18 B28D7/04 B24B9/10 B23Q7/04
A	DE 20 2008 012632 U1 (WEEKE BOHRSYSTEME GMBH [DE]) 25 February 2010 (2010-02-25) * paragraphs [0001], [0009], [0014], [0017], [0049], [0005], [0055], [0060] * * figures 3,4,6 *	1,11	
A	EP 2 631 048 A1 (FORVET S R L [IT]) 28 August 2013 (2013-08-28) * paragraphs [0022], [0038] - [0040] * * figures 7,8 *	1,6,11	
A	DE 298 25 149 U1 (P&L GMBH & CO KG [DE]) 23 June 2005 (2005-06-23) * paragraphs [0012], [0015], [0021] * * claims 1,3,4 * * figures *	1,2,11	TECHNICAL FIELDS SEARCHED (IPC) B28D B24B B23Q
A	EP 2 687 327 A1 (BIESSE SPA [IT]) 22 January 2014 (2014-01-22) * paragraphs [0013], [0017], [0052], [0060] * * claim 3 * * figures 10-14 *	1,11	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	4 May 2016	Chariot, David

CATEGORY OF CITED DOCUMENTS

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

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

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 16 15 1205

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

04-05-2016

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 29621422 U1	09-04-1998	AT 1822 U1	29-12-1997
		DE 19701000 A1	18-06-1998
		DE 29621422 U1	09-04-1998
DE 202008012632 U1	25-02-2010	DE 202008012632 U1	25-02-2010
		EP 2340147 A1	06-07-2011
		WO 2010034530 A1	01-04-2010
EP 2631048 A1	28-08-2013	NONE	
DE 29825149 U1	23-06-2005	NONE	
EP 2687327 A1	22-01-2014	CN 103538154 A	29-01-2014
		EP 2687327 A1	22-01-2014

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO IB2015057703 W **[0009] [0013] [0014] [0023]**
- IT TV20150007 A **[0053]**
- IT 102015902322090 **[0053]**