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(54) Automatic machine and automatic method for bending and calendering spacer profiles to obtain spacer frames for an insulating glazing unit

(57) An automatic machine for bending and/or calendering spacer profiles (1) intended to form spacer frames (4, 4', 4") for an insulating glazing unit (5) composed of: a carriage or a belt feeder (300) for the synchronous movement of the spacer profile (1) upstream of a bending head (400); a bending head (400) composed of a matrix that consists of jaws (401a, 401p) that are adjustable as a function of the width of the spacer profile (1) and of a punch (402) that can be moved toward the inside curve of the profile; a bending lever (403) directly downstream of the punch (402) that is provided with a synchronous rotary motion (co); the coordinated operation of all these mechanisms actuating the bending and/or calendering according to the background art, downstream of the bending head (400) there being a mechanism (100) that mates with the initial portion (2) of the spacer frame (3, 3', 3"), supporting it and guiding it during all the operating steps of bending and/or calendering along a path that is synchronous with the geometric position described by the initial portion (2) of the spacer frame during the forming of the spacer frame (3, 3', 3") performed by the feeder (300) and by the bending head (400).

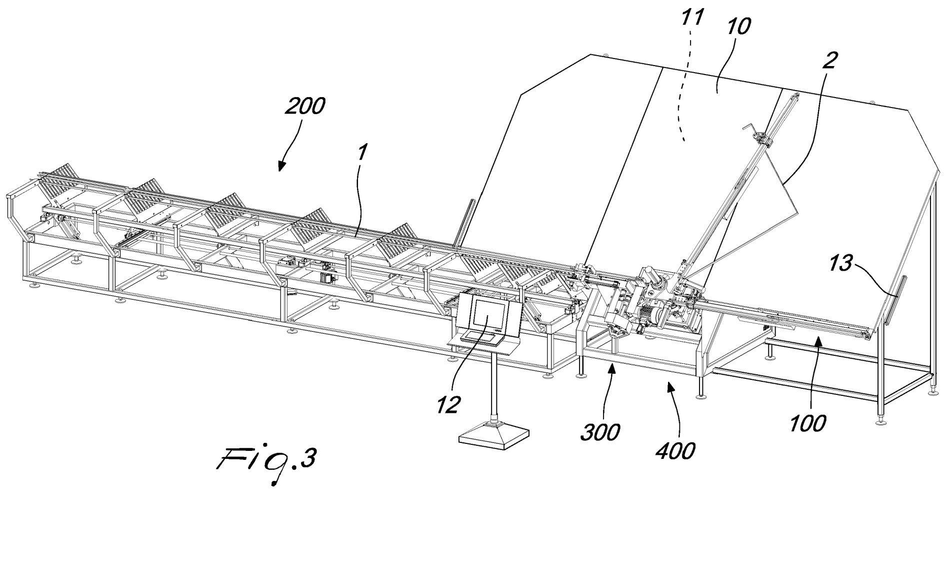

Fig.3

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Description

[0001] The present invention relates to an automatic machine and an automatic method for bending and calendering spacer profiles to obtain spacer frames used in the composition of an insulating glazing unit. In particular, the invention relates to the means for retaining and guiding the frame portion downstream of the bending/calendering head, which is subject to gravity, inertia and friction actions, which are not secondary in relation to the negligible resistance capacity of the profile. Retention and guiding occur synchronously with the operations for the production of the frame. This makes it possible to increase the bending and calendering rate so as to increase the productivity of the machine and of the method, and also allows improving the quality of the finished frame in terms of geometric and aesthetic regularity.

[0002] Currently it is known to perform the bending of spacer profiles to obtain spacer frames for insulating glazing units, known in the jargon also as double-glazing units (this term will be used hereinafter), on profile bending machines both with semiautomatic methods (one corner at a time is bent by means of a bending head and between one bend and the next the profile is moved manually by the operator) and with automatic methods (intervention by the operator during the entire process is excluded, except optionally during the steps for loading the profiles into the buffer magazine and optionally for unloading the bent spacer profile, on which the operator optionally performs the further final operation of coupling an insert for head-to-tail closure, in order to pass from a shape which is open, but has the geometry of a frame that is complete but not joined in the initial and final portion, to the closed and stable shape). It is in this field that the machine and the method according to the present invention are applied, introducing an important improvement, with respect to the widespread background art summarized above, that improves the speed of bending and calendering operations and leads to a more refined geometric and aesthetic execution.

[0003] For a better understanding of the configuration and function of the spacer frame and of its semifinished component that originates it, the spacer profile, some concepts relating to the spacer profile and to the final product, i.e., the double-glazing unit, are summarized hereafter, assuming that the subsequent use of the double-glazing unit, i.e., as a component of the door or window or as an element of curtain walling and of structural glazing facades, is known.

[0004] The double-glazing unit is constituted by the composition of two or more glass sheets separated by one or more hollow spacer frames that are micro-perforated on the face that is directed inward; the spacer frames are arranged in proximity to the perimeter of the glass sheets and contain in their hollow part hygroscopic material, and the chamber (or chambers) delimited by the glass sheets and by the frame (frames) can contain air or a gas other than air or mixtures of gases other than air that give the double-glazing unit particular properties, for example thermally insulating and/or soundproofing properties. The joining between the glass sheets and the frame (or frames) is obtained typically by means of two levels of sealing, the first one having the function of providing a hermetic seal against the leakage of the gas and against the entry of environmental humidity and affecting the lateral surfaces of the frame and the part of the adjacent glass sheets, the second one having the function of providing cohesion among the components (glass sheets and spacer frame/frames) and mechanical strength of the junction between them and affecting the compartment constituted by the outer surface of the frame (frames), including the variously shaped part for blending with the side walls, and from the faces of the glass sheets to the edge thereof, against stresses of a mechanical nature (wind load, snow load, etc.) or of a thermal kind (exposure to temperature variation cycles between the external part and the internal part of the building). Figures 1A, 1B, 1C, 1D and 1E show some solutions relating to this perimetric junction of the double-glazing unit.

[0005] In order to complete the summary introduction relating to double-glazing units, it is convenient to delve more specifically into the configuration of the glass sheets, not so much in their possible isolated use but most of all as a function of their use in combination with the spacer frame to constitute the double-glazing unit, summarizing hereafter some concepts related to the semifinished components themselves, i.e., the glass sheets and the spacer frame, and the final product, i.e., the double-glazing unit. The subsequent use of the double-glazing unit, i.e., as a component of doors or windows or of curtain walling or of structural glazing facades, as has been mentioned already, is known to the person skilled in the art and is not discussed here in detail.

[0006] With reference to the schematic representation of Figure 1A of the double-glazing unit, in greater detail the double-glazing unit is constituted typically by two or more glass sheets 1001, 1002, etc., mutually separated by one or more spacer frames 1003, etc., which are internally hollow and are micro-perforated on the face that is directed toward the inside of the chamber.

[0007] The spacer frames 1003 contain, in their hollow part, hygroscopic material 1008, the purpose of which is to absorb humidity. The chamber (or chambers) 1007 (or onward) delimited by the glass sheets 1001 and 1002 (or onward) and by the frame 1003 (or onward) can contain air or gas or mixtures of gas injected therein, which give the double-glazing unit particular properties, for example thermally insulating and soundproofing properties. Recently, the use has become widespread of a spacer profile 1003, which has an essentially rectangular cross-section or a rectangular cross-section with two recesses and is made of organic material (by way of non-exhaustive example: silicone and EPDM) which is expanded and flexible and embeds in its mass the hygroscopic material; however, this solution, despite being practical from the point of view of automation in the manufacture of the insulating glazing unit since the operation of manual laying of the spacer frame is eliminated and despite being valid from the point of view of thermal insulation, since it is made of low-conductivity material, has some drawbacks. The main drawback relates to the preponderance of organic material in its composition and therefore to the mediocre barrier function both for retention of the gas that is present in the chamber and for the lack of penetration of humidity from the external environment toward the chamber, which would entail condensation inside the chamber. Additional drawbacks are: the complexity in the change of width and colors, the lack of adhesion with some types of sealant and, last but not least, the limitation of the maximum dimensions of the double-glazing unit, which excludes its use in structural glazing. Accordingly, the more traditional solution of the rigid frame instead is regaining popularity. The junction between the glass sheets and the frame is obtained by means of two levels of sealing: 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 sheets 1001, 1002 and has a thermoplastic behavior; the second seal 1005 affects the compartment constituted by the external surface of the frame and the faces of the glass sheets 1001, 1002 up to the edge thereof and has the function of providing cohesion among the components, once the sealant has been catalyzed, i.e., after a few hours, at the same time maintaining the mechanical strength of the junction between them. In the case of the flexible spacer, said spacer is pre-coated on a portion of its sides with an acrylic adhesive 1006, which has, as its sole but not significant advantage, an immediate coupling with the walls of the glass sheets, so as to allow the handling of the double-glazing unit without waiting for catalysis of the two-component sealants.

[0008] Figures 1A, 1B, 1C, 1D and 1E show five of the many possible sectional views of double-glazing unit configurations, of which only the first one has been commented. However, it is straightforward to extend the description given above to the configurations of Figures 1B, 1C, 1D, 1E, where either multiple frames or offset glass sheets or laminated glass sheets are provided. In the figure, the sun represents schematically the external environment of the building in which the double-glazing units are installed, while the interior of the building is represented schematically by a radiator.

[0009] The glass sheets used in the composition of the double-glazing unit can have different shapes as a function of their use; for example, the external glass sheet 1001 (with respect to the building) can be normal or selective or reflective (in order to limit thermal intake during summer months) and it can also be laminated/armored (for intrusion prevention/vandalism prevention functions) or it can be laminated/tempered (for safety functions) and can also be combined, for example reflective and laminated, as well as offset with respect to the internal glass sheet or the intermediate glass sheet.

[0010] The internal glass sheet 1002 (with respect to the building) can be normal or of the low-emissivity type (in order to limit the dispersion of heat during winter months) and it can also be laminated/tempered (for safety functions) and can also be combined, for example low-emissivity and laminated.

[0011] The properties related to thermal insulation both under winter conditions (for which low-emissivity glass is indicated) and under summer conditions (for which selective glass is indicated), as well as the properties related to light transmission, are obtained by depositions of metals and metallic oxides, generally of the multilayer type, with a total thickness in the order of hundreds of angstroms, which must however be removed in the perimetric portions of interaction with the sealants.

[0012] All the above is to demonstrate that the function of the spacer frame in the composition of the double-glazing unit, in particular the rigid one, is primary and has to be brought out for the following essential reasons:

- the cost of the glass sheets used today is increasingly significant, due to the choice of high-performance solutions, such as the coated and/or tempered and/or laminated and/or offset glass sheets described above, and therefore the execution of the spacer frame contrary to best manufacturing practice would compromise an overall value orders of magnitude higher, i.e., the value of the finished double-glazing unit composed of high-value sheets;
- in a finished double-glazing unit, if the spacer frame had functional or aesthetic defects, breakup of the assembly to recover the glass sheets would not be easy;
- the choice of the aesthetic appearance of the spacer frame, which is visible inside the double-glazing unit, since it is an architectural complement not only of the double-glazing unit but of the door or window itself or even of the curtain walling or structural glazing facade, must be broad, and this is achieved in an optimum and aesthetically valuable manner only with spacer profiles of the rigid type;
- manufacturers of micro-perforated hollow rigid spacer profiles have enhanced and differentiated their plants in order to provide products that have increasingly high performance in terms of: thermal insulation (achieving low conductivity values as with flexible spacers by using inorganic materials with a low conductivity coefficient or inorganic/organic composite materials), broad range, workability (cutting and bending), costs that are more than reasonable and in particular are competitive with respect to other solutions;
- importance of the barrier function, both with respect to the leakage of the gas and with respect the inflow of water vapor, which is achieved only with at least one wall made of inorganic material.

[0013] In conclusion, although the contribution of the spacer frame in terms of cost is marginal, its function is instead primary, and bending (or calendering for curvilinear parts) must be performed according to best manufacturing practice.

[0014] Moreover, it is evident that a manufacturing line, in order to obtain the double-glazing unit product, requires many processes in a cascade.

[0015] Each one of these cascade processes requires a related and particular machine, to be arranged in series with respect to the other complementary machines. Some processes or operations, by way of non-exhaustive example and at the same time not all necessary, are the following, which are described in summary:

- EDGING, by grinding, of the peripheral margin of the face of the glass sheet from any coatings, in order to allow and maintain over time the adhesion of the sealant, as already explained;
- GRINDING of the edges of the individual glass sheets, in order to eliminate their sharp edge, which is dangerous from the point of view of accident prevention and is the source of fractures of the glass sheet itself, since it contains micro-cracks, particularly in glass sheets intended for tempering; or complete GRINDING of the edge, in order to give dimensions, shape and finish thereto and therefore even greater value to the double-glazing unit;
- WASHING AND DRYING of the individual glass sheets;
- APPLICATION OF THE SPACER FRAME: the spacer frame, manufactured beforehand, filled with hygroscopic material and coated on its lateral faces with an adhesive sealant that has sealing functions, is applied on one of the glass sheets that constitute the double-glazing unit in an adapted station of the double-glazing unit production line; the conversion from spacer profile 1 to spacer frame 4 (1003) by means of the bending, calendering and closing operations, particularly its execution according to best manufacturing practice, is the subject of the present patent application and occurs in a machine that is external to the line of machines according to the present listing, and likewise the filling of the hollow part of the spacer profile with hygroscopic material 1008 occurs in another machine, which also is external to the line;
- MATING AND PRESSING of the assembly constituted by the glass sheets and the frame (frames);
- FILLING WITH GAS of the chamber (chambers) thus obtained;
- SECOND SEALING.

[0016] The processes listed above can be performed by the respective machine automatically or semiautomatically.

[0017] EP1285708B1, as well as the machines manufactured by Peter Lisec and by all competitors, teach or anticipate nothing regarding the inventive concept that is the subject of the present application, and indeed the teaching is even misleading, i.e., it is to increase the sophistication of the bending tool in order to obtain an aesthetically acceptable bend instead of introducing a stable movement of the profile as it becomes a frame and lies downstream of the bending tool, said movement rather having a basic role both from the physical point of view and from the point of view of productivity with respect to the execution of the bend entrusted only to the bending head.

[0018] The main problems inherent in the known methods summarized above are:

- incidence of the inertial effect of the profile, which increases as the profile generates the frame, since the extension downstream of the bending tool becomes longer, both during execution of the bending (or calendering) in progress and on the deformation of the frame part that has already been created;
- consequent need to reduce the bending speed and therefore the productivity in order to contrast the inertial effects linked to the rotation of the profile and of the already-formed frame part, which increase progressively;
- consequent need to reduce also the translation speed and consequently the productivity during the step in which it is necessary to align the position of the next bend (calendering) with the bending (calendering) head, in order to contrast the inertial effects linked to the translation of the profile and of the frame part that has already been formed, which increase progressively;

- incidence of the friction between the frame being formed and the sliding surface thereof;
- as regards the four preceding items, as well as gravitational action, frequent resorting to the intervention of the operator for manual guiding of the part of the frame 2 being formed, in the case of large frames on which gravitational, inertial and friction effects would not be bearable in view of the limited flexural strength of the spacer profile 1 even if the speed of the process were reduced.

[0019] There's more: in view of the considerable development of double-glazing units, considering the various shapes and applications described in the introduction, likewise there are now dozens of types of spacer profiles, which used to be limited to a few units. It is sufficient to consider that in addition to the increase in the range of widths, which were once typically 6, 9, 12, 15 mm and are now 6, 8, 9, 12, 14, 15, 16, 18, 20, 24, 25, 32 mm, a differentiation of the materials has taken place; once it was exclusively pickled aluminum, whereas now the following have been added: anodized aluminum in various colors, coated aluminum in various colors, screenprinted aluminum, plastic-coated aluminum, electroplated carbon steel, stainless steel, stainless steel/plastic in various colors and in various shapes. It goes without saying that the masses involved and the corresponding gravitational actions and inertial and friction reactions have increased not only due to the effect of the increase in width but also due to the materials, which are denser than aluminum, and due the increase in the size of double-glazing units (today values even equal to those of what are called jumbo sheets, i.e., 7.5 x 3.21m, are reached).

[0020] The aim of the present invention is therefore to solve the described technical problems, eliminating all the drawbacks of the cited background art and thus providing a method and a machine that allow bending and calendering of spacer profiles for double-glazing units, obtaining a valuable quality of the bent or calendered part and increasing productivity (to set a term of comparison, from the currently common 120 frames/hour with rectangular dimensions of 1000 x 750 mm to approximately 200 frames/hour).

[0021] The above aim and other objects of the invention that will become better apparent hereinafter are achieved by a machine as claimed in claim 1.

[0022] The summary description of the drawings and the detailed description of an embodiment of the invention will clarify how it is possible, substantially by means of an oscillating arm provided with a sliding carriage provided with clamps that are free with respect to their pivot for coupling to the carriage, and simply with just two synchronous axes, to provide a polar system that is adapted for retaining the first part of the frame throughout the production cycle (for bending and optionally calendering) thereof, said system operating synchronously with all the other known movements of the profile bending machine.

[0023] Further characteristics and advantages of the invention will become more apparent from the detailed description, given in the chapter that follows, of a preferred embodiment of the invention, illustrated merely by way of non-limiting example in the accompanying drawings, wherein:

Figures 1A, 1B, 1C, 1D and 1E are partial sectional views of a series of prior art configurations of a double-glazing unit, already described in the background art section of the present invention;

Figure 2 is a perspective view of various shapes of spacer frames as required to compose the double-glazing unit; in particular, Figure 2a shows a rectangular shape 4, Figure 2b shows a polygonal shape 4', Figure 2c shows a partly rectilinear and partly curvilinear shape 4", Figure 2d shows a detail of a bent corner; the frame start and end junctions (which convert the shapes from open ones (3, 3', 3"), as manufactured by the profile bending machine, to closed ones) are visible;

Figure 3 is a general perspective view of the complete machine that incorporates the traditional part, which therefore belongs to the background art, and the inventive part, which is constituted by the device adapted to manage the support and movement of the part of the spacer profile that has already been formed into a portion of frame initially, until the complete frame is obtained at the end of the cycle, synchronously with the operations performed by the traditional conveyance systems and the bending/calendering head;

Figure 4 highlights the main constructive details related to the traditional part and related to the inventive part;

Figure 5 groups all the components of the inventive part;

Figure 6 is an enlarged-scale view of the essential parts of the details of Figure 5;

Figure 7 is a view of the portion of the inventive part which, coupled to a rectilinear portion of the frame being manufactured, follows in polar coordinates co, r, the path that said frame portion traces on the resting surface of the machine during the process and the operations for bending/calendering; due to representation requirements, co and r are indicated as variable vectors, not in their actual extents;

Figure 7A is an enlarged-scale view of a detail of Figure 7;

Figures 8 and 9 are schematic views of the operating principle of the inventive concept as regards the method, the first figure for the case of a rectangular spacer frame and the second figure for the case of a partially rectilinear and partially curvilinear spacer frame;

Figure 10 is a view of the arrangement of the machine according to the present invention, i.e., of the profile bending machine, within the production line of the double-glazing unit and of the corresponding possible interfacing.

[0024] In order to describe better the way of carrying out the invention, which includes all the equivalents, reference is made initially to the part relating to the background art, i.e., to the part of the machine that performs bending or calendering, to then move on to the added value represented by the present industrial invention patent application, describing the steps of the operating cycle and the mechanisms used in the preferred embodiment of the invention, and mentioning possible alternative configurations that will then be referenced in the claims.

[0025] With reference to the assembly of the figures, the reference numerals are anticipated as follows:

the series 100 has been assigned to the new part of the machine, i.e., to the content of the invention that consists of the guiding system (support and movement) of the spacer frame during the forming thereof, which is adapted to compensate the loads produced by the force of gravity and by inertial and friction reactions; where subscripts have been used, a stands for forward and p stands for rear, the reference being the position of the operator on the front part of the machine.

[0026] The subsequent numberings identify respectively:

- series 200, the (known) magazine that contains a plurality of different types (in terms of dimensions or shapes) of spacer profiles 1;
- series 300, the (known) advancement system of the spacer profile 1;
- series 400, the (known) bending/calendering head, comprising therein the (known) bending arm.

[0027] The reference numeral 1 designates the single spacer profile; the numeral 2 designates the spacer frame in its step of progressive forming; the numerals 3, 3', 3" designate the frame as manufactured by the machine that performs the process; the numerals 4, 4', 4" designate the frame as completed with the head-tail joint, intended for the subsequent operation for filling with hygroscopic material, which is performed by a machine that does not belong to the present invention and is in any case known, before being intended to compose the double-glazing unit 5.

[0028] The numeral 10 designates the surface of the machine for the sliding of the spacer frame 2 during its forming step, which is also the arrangement surface of the finished frame 3, 3', 3", where it stays while waiting to be unloaded (predominantly manually but possibly also automatically). This surface is typically inclined with respect to the vertical plane, generally by 45°, as a condition to compensate for the actions of gravity and friction that act on the frame 2 during the forming of said frame 2 and that would be respectively: maximum and nil if the surface had a vertical arrangement, nil and maximum if the surface had a horizontal arrangement.

[0029] The reference numeral 11 designates the electrical panel (located below the sliding surface 10) which contains, in addition to the electrical components, also the hardware of the logic part, i.e., the PLC (Programmable Logic Controller) and the PC (Personal Computer).

[0030] The reference numeral 12 designates the operator interface, which is constituted by a touchscreen monitor and a keyboard.

[0031] Generically, the reference numeral 13 designates the protective structures, be they of the type of mechanical screens or optical barriers or laser barriers that can be configured according to the region to be protected or electrically sensitive mats etc., particular attention being devoted not only to the functional, economic and ergonomic aspects that are typical of the present invention but also to accident-prevention aspects.

[0032] The numbers starting with 1001 designate the main components of the double-glazing unit, as seen in the peripheral junction according to Figure 1A, where the main component is the spacer frame 4, although it is renamed 1003 in the configuration of the junction for the sake of uniformity with the other components.

[0033] The description that follows refers to an arrangement of the machine in which the magazine 200 of the spacer profiles 1 is arranged on the left and the working surface 10 of the spacer frame 2 and of arrangement of the finished spacer frame 3, 3', 3" is arranged on the right, as shown in the figures. It goes without saying that the condition might be mirror-symmetrical as a function of factory layout requirements and would be supported by it, but the description would be adapted to the different orientation.

[0034] Starting therefore with the steps of the cycle and the components of the machine that belong to the background art, the following is the path and the following are the processes to which the spacer profile 1 (hereinafter profile 1) is subjected in order to become a portion of a spacer frame 2 and a spacer frame 3, 3', 3" (hereinafter frame 3, 3', 3").

[0035] The profile 1, which lies together with other identical profiles in one of the compartments of the magazine 200, while the other compartments might contain other profiles of the same type or of a different type, is guided through mechanisms of the conveyor/feeder (in particular, the synchronous conveyor belts 301a, 301p with continuous action, but a carriage provided with clamps having an intermittent and bidirectional action might likewise be used) to the bending/calendering head 400. For the progressive forming of the frame 2 until its completion is reached in the configurations 3, 3', 3", the method and the mechanisms operate as follows depending on the final type, i. e. one of the alternatives 3, 3', 3".

[0036] <u>Type 3 case</u> (rectangular frame, i.e., shaped with four right angles, including therein therefore the particular case of a square frame): the profile 1, if inserted for the first time, is guided, through the belt feeder 301a, 301p, to a reference position identified by a sensor, slightly upstream of which a cutter end-faces it in order to establish the zero position (this operation will not be repeated in the continuation of the production of frames having the same profile type, since the profile can be considered as having an unlimited length since the magazine 200 performs, as is known, the automatic joining of subsequent profiles by inserting a mechanical connector in the trailing and leading cavities of the spacer profiles 1, generally with a length of 6 m). From this position, defined as zero position, the profile 1 is advanced between the jaws 401a, 401p by means of the synchronous action of the feeder belts 301a, 301p, until it passes beyond the position of the bending punch 402 (understood as the position where the punch is successively lowered until it interferes with the inside curve of the profile 1) by a first preset length that can be set as a data item.

[0037] Subsequently, the jaws 401a, 401p close against the side walls of the profile, maintaining in any case a slight play, the bending punch 402 descends and the bending lever 403 performs a rotation, the axis of which coincides, except for adjustments for the proper execution of the bending action, with the contact line between the punch 402 and the inside curve of the profile 1, this rotation measuring 90° plus or minus a second preset degree that is constituted by an input data item adapted to obtain a precise bending angle of 90° by taking into account the elastic return of said profile 1 (typically the rotation requires a phase adjustment of a few degrees with respect to 90° as a function of the type of profile). Once bending has been performed, the punch 402 returns to the inactive position, the bending lever 403 returns to the inactive position and the jaws 401a, 401p at first tighten further in order to calibrate the width of the profile 1 and then reopen. Then, by synchronous action of the feeder belts 301a, 301p, the profile 1 is advanced by a distance that is equal to the length of the first complete side of the rectangle (preferably but not necessarily the shorter one), and then the succession of the actions of the mechanisms (listed in a complete sequence which corresponds to the above description) 401a, 401p, 402, 403, 403, 402, 401a, 401p, 401a, 401p is repeated to conclude the second bending. One proceeds in this way to the execution of the third and fourth bands, after which the feeder belts 301a, 301p cause the advancement of the profile 1 by a distance that is equal to the length of the last side minus the first preset determined previously and then the cutter cuts the profile 1 so that the perimetric extension of the frame 3 is the one that corresponds to the required rectangle. It goes without saying that the action of the cutter is coordinated with the action of a clamp, which corresponds to the cutter assembly that retains the profile during the cutting operation. At this point the frame 3 is available for its manual or automatic extraction.

[0038] Type 3' case (frame shaped with at least two angles that are different from a right angle, i.e., different from 90°): the progression of the steps and of the mechanisms reproduces what has been described in the above case, but the oscillation angle (i.e., the angle of the active stroke and of the return stroke to the inactive position) of the bending lever 403 and the quantity of operations vary, since they are parameters as a function of the geometry of the frame 3' having a polygonal shape (from the regular or irregular triangle condition, with three sides and three angles, to the regular or irregular polygon condition, with n sides and n corners).

[0039] Type 3" case (frame containing at least one curvilinear part): for the non-curvilinear parts, what has been described for the above two cases applies; for the curvilinear parts, in summary (the detail would be more complex, since it would be equipped also with the logic, in any case known, on pre-bending, since it is variable depending on the shape of the frame) the principle related to the cycle and the mechanisms is as follows. First of all the bending lever 403 performs a pre-bending of finite extent, while the punch 402 contrasts the inside curve of the profile 1, then said lever remains in a stationary position that is proximate or corresponds to the pre-bending end position, the punch 402 detaches slightly from the inside curve of the profile 1 to avoid damaging it in the subsequent step, and the feeder belts 301a, 301p intervene so that the profile 1, by sliding with its inside curve below the punch 402 and with its outside curve above the bending lever 403, undergoes a calendering operation. Clearly, the parameters of angular placement of the bending lever 403 and of extent of the stroke of the profile 1 pushed by the feeder belts 301a, 301p determine the radius and breadth of the curvilinear part of the frame 3"; these parameters, which are stored in a database of the machine, are acquired automatically by the software of the machine as a function of the inputs that describe the shapes and dimensions of the finished frames 3".

[0040] One might also consider the cases of completely curvilinear frames (the case of portholes used in shipbuilding and in the naval field), since the method and the mechanisms can provide them (from a circle to an ellipse to shapes with various radii or with a continuously variable radius), but with the sole superfluous consequence of encumbering the description. In any case, for this type the processing mode would relate only to calendering, as can be deduced easily.

[0041] All this long introduction on the part related to the background art was indispensable for understanding the important function of the invention by means of diagrams that can be interpreted and referred to easily.

[0042] Moving on therefore to the steps of the cycle and to the components of the machine introduced with the invention, the following is the mode of operation and the following are the components of the machine that intervene so that the part of the frame 2 that is formed progressively is supported and guided, by means of a device that hereinafter will be referred to as a support, downstream of the bending/calendering head in order to contrast the gravitational, inertial and friction actions to which the frame 2 is subjected during the forming thereof, so as to improve its execution both in terms of quality and in terms of production.

[0043] Types 3 and 3' case. The description is merged for the two types, since a differentiated specific description has already been provided for the known part of the method and of the mechanisms and substantially the distinction relates only to the succession of the bends and of the sides of the polygon, which can be other than four, and the degrees of the bending angles, which can be partly 90° and partly different from 90° or all different from 90°.

[0044] As regards the method, it is useful to comment the diagram of Figure 8, which does not indicate the progressive portions of the frame 2 but indicates the finished frame 3, since the sequences would lead to overlaps. The letters A to H represent the positions in which the coupling between the support 110 introduced with the present invention and the frame 2 operates during the progressive forming thereof until the final forming thereof occurs in the situations 3 (and 3' to be imagined). The support 110 progresses in its coupling position with the frame 2 following, with a movement of the polar type (r, ω), the path followed by the point that is shared with the side of the frame 2, which in Figure 8 is to be understood as being on the first short side (i.e., on the side directly behind the first preset bend), whereas for orientability in tune with the orientation of the side of the frame 2 it is the frame 2 itself that actuates the angular adjustment p of the support 110, since the support is free (with spring-loaded return when it is in the cycle start position). From the inactive position A (a condition which arises from a machine reset or from the end of the cycle after manufacturing of a frame of any shape (3, 3', 3")), the support 110 moves to the position B, at a distance r from the center of rotation of the bending lever, said distance r being established by the process software as a function of the dimensions of the side of the frame 2 that is affected by the bending and waits, in order to couple thereto, for the arrival and placement of the profile 1 that has already been transformed into a frame portion 2, being provided with the first bend of limited extent according to the first preset data item defined in the description of the background art. Then, together with the execution of the second bend, i.e., with the rotation of the bending lever 403, the support 110 moves, generating an angle ω of 90° (plus or minus the value of the second preset) in order to reach the position C, while with respect to itself it performs an angular rotation equal to p, which is actuated by the portion of the frame 2, since the support 110 is free with respect to the arm 101 and has low friction and inertia and high elasticity. At this point, since the frame 2 performs a longitudinal movement due to the conveyor 300, the support 110 passes from position C to position D due to the actuation steps that operate in a concatenated manner and relate to the rotational axis co and to the radial axis r in a further concatenation with the synchronous longitudinal axis performed by the conveyor 300. It is superfluous to repeat the description related to the subsequent paths that bring the support 110 to positions E F, G, H. Broken lines show the position of the frame 2 during the rotation step, where the progression of the rotation p of the support 110 is indicated.

[0045] As regards the mechanisms, reference is made to Figures 5, 6, 7 to complete the modes of actuation of the axes described in the part related to the process. The rotational axis co is actuated by the synchronous motor 102, which by means of the reduction unit 103 and the bracket 104 acts on the arm 101. This is evident from Figure 6, which shows an axonometric view from the plane 10 toward the operator, where the unnumbered part comprised between the reduction unit 103 and the bracket 104 constitutes the bracketing to the known profile bending machine, said bracketing being adjusted so as to make the rotation axis co of the arm 101 coincide with the rotation axis co of the bending lever 403. The radial axis r is actuated by the synchronous motor 108, which acts by means of the reduction unit 109 and the sprocket 107 on the toothed belt transmission 105 guided by the free sprocket 106, said belt being coupled to the carriage that bears the support 110. All this always occurs in concatenation with the longitudinal synchronous axis provided by the feeder 300 and with the rotational synchronous axis, also referred to as co, actuated by the bending lever 403, which are obtained with synchronous motors and transmission components that are all known. The rotational axis p, which is not actuated since it is generated by the ability of the portion of the frame 2 to rotate components which are rotationally free, is made possible by means of the following components, which are shown complete with every detail in Figure 7, wherein: the numeral 110 designates the support as a whole; the numeral 111 designates the rotation axis about which the part of the support 110 that is free performs the angular stroke p as actuated by the portion of the frame 2 that is coupled to said support 110; the numeral 112 designates the spring of the spiral type that is wound on the drums 113 and 114 and, upon uncoupling from the frame 2, returns the clamps for coupling the support 110/frame 2 to the inactive position; the numeral 115 designates the group of free wheels that allow the support 110 to glide along the arm 101 of the device according to the invention; the numeral 116 designates the clamp that couples the support 110 to the transmission belt 105 for the stroke thereof along the synchronous radial axis r; the numeral 117f designates the fixed jaw and the numeral 117g designates the rotatable jaw, actuated by the pneumatic actuator 118, said jaws, during closure, mating with a locally rectilinear portion of the frame 2; the numeral 119 designates the slider body that joins the system of free wheels 115 to the bearing 120 that provides the free rotation axis 111. It is sufficient, therefore, to add to what has been described earlier that the support 110 is coupled to the arm of the frame 2, in the condition in which the first bend (i.e., the one with a short side extension) has been performed and the frame is supported by the conveyor/feeder 300 to the extension of the first side, at a distance r of the polar system r/ω where ω = 0, by closure of the rotatable jaw 117g, and therefore follows all the paths described in the process, either with only the activation of the axis ω (bending step) or with concatenated activation of the axes r and ω (step in which the frame 2 is advanced by the conveyor/feeder 300), whereas step p of free rotation self-adjusts since it is actuated by the arm of the frame 2.

[0046] Type 3' case (frame containing at least one curvilinear part). As regards the method, it is useful to comment the diagram of Figure 9, while what has already been said for the previous types applies to the mechanisms. Figure 9 speaks for itself if one reads it with the comments already developed for Figure 8; it is sufficient to add that the process software optimizes the initial and final positions of the processing of the frame 3' so the coupling between the support 110 and the frame 2 occurs in a position in which the frame 2 is rectilinear.

[0047] In general it should be noted that all the mechanisms of the inventive assembly 100 operate above the working surface 10, i.e., on the side of the operator, since the support, by acting on all of the plane 10, could not be actuated with mechanisms located in the opposite part of the plane.

[0048] Naturally and furthermore, all the movements connected to the steps of the cycle are mutually interlocked, by means of a parallel logic system that is always active and is provided with sensors, in order to prevent, during movements of the mechanisms, conditions of interference of the spacer profiles 1 and of the spacer frames 2, 3, 3', 3" with parts of the machine or parts of the machine with each other.

[0049] The present invention is susceptible of numerous constructive variations (with respect to what can be deduced from the drawings, the details of which are evident and self-explanatory, and from the description), all of which are within the scope of equivalence with the inventive concept; thus, for example, the mechanical solutions for the translation of the spacer profile 1, which can be of the slider type instead of the belt type, the actuation means, which can be electrical, electrical-electronic, pneumatic, hydraulic and/or combined, etc., the control means, which can be electronic or fluidic and/or combined, etc.

[0050] The constructive details may be replaced with other technically equivalent ones. The materials and the dimensions may be any according to the requirements in particular arising from the dimensions, shapes and types of the spacer profiles 1 and of the finished spacer frames 3, 3', 3". In particular, the devices as described that actuate the movement of the support 110 may also perform alternative methods, for example the method of activating themselves by coupling in each instance with the part of the frame 2 that is arranged horizontally downstream of the bending head 400 after the feeder 300 has advanced the profile 1 and before the bending head performs the bending. Although this method is not as effective as the one described, it may be necessary, for example if the extensions of some sides of the frame 2 do not allow retention during the subsequent feeding due to a limitation of the stroke r of the support 110 on the arm 101.

[0051] Likewise, the axis 111 with rotation p of the support 110 described as free and actuated by the portion of the frame 2 being coupled may instead be performed by a synchronous actuator. Likewise, the r/ω polar system might be replaced by a Cartesian x/y system.

[0052] It goes without saying that the industrial application is assuredly successful, since the machines that bend the spacer profiles 1 to form the spacer frames 4 intended for the double-glazing units 5 have been established on the market for over twenty years and now the number of types of profiles 1 continues to be increased by innovations, for example stainless steel or composite materials, which are currently growing considerably due to the low value of their heat conductivity coefficient. Moreover, the market of double-glazing units is growing continuously and in recent years has been increased by all the applications that require a shape other than rectangular, and it is evident that new investments will be aimed at the most recent and innovative technology that resorts to profile bending machines since they are able to produce even spacer frames 4 that have a curvilinear shape. The subject matter of the present invention leads to important added values with respect to the background art in terms of considerable increase in productivity and improvement of the quality of the finished frame.

[0053] The insertion of the present invention in the production line of the double-glazing unit 5 is shown in Figure 10 (shown in plan view), which includes the machine downstream of the profile bending machine, i.e., the desiccant filler for the insertion of the hygroscopic material 1008 in the cavity of the spacer frame 4, 4', 4", and the additional machine for spreading the butyl sealant 1004 on the sides of said spacer frame, as an evident confirmation of widespread industrial application.

[0054] The disclosures in Italian Patent Application No. TV2013A000167 from which this application claims priority are incorporated herein by reference.

[0055] 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 bending and/or calendering spacer profiles (1) intended to form spacer frames (4, 4', 4") for an insulating glazing unit (5) composed of: a carriage or a belt feeder (300) for the synchronous movement of the spacer profile (1) upstream of a bending head (400); a bending head (400) composed of a matrix that consists of jaws (401a, 401p) that are adjustable as a function of the width of the spacer profile (1) and of a punch (402) that can be moved toward the inside curve of said profile; a bending lever (403) directly downstream of the punch (402) that is provided with a synchronous rotary motion (co); the coordinated operation of all these mechanisms actuating the bending and/or calendering according to the background art, **characterized in that** downstream of the bending head (400) there is a mechanism (100) that mates with the initial portion (2) of the spacer frame (3, 3', 3"), supporting it and guiding it during all the operating steps of bending and/or calendering along a path that is synchronous with the geometric position described by said initial portion (2) of the spacer frame during the forming of the spacer frame (3, 3', 3") performed by the feeder (300) and by the bending head (400).

2. The machine according to claim 1, **characterized in that** the mechanism (100) is composed of an arm

(101) that has a synchronous rotary motion, the rotation axis (co) of which is identified in the same rotation axis (co) of the bending lever (403) and the actuation of which is achieved by means of a synchronous motor (102), a reduction unit (103) on the output shaft of which a bracket (104) is keyed which has the function of a hub that retains the arm (101), said arm (101) being provided with a carriage/support (110), which can slide by means of the wheels (115), is moved by means of a toothed belt (105) guided on a free sprocket (106) and is actuated by a driving sprocket (107) actuated by a synchronous motor (108) by means of a reduction unit (109), a clamp being arranged on said carriage/support (110) and being composed of a fixed jaw (117f) and a rotatable jaw (117g), the opening and closing command of which is activated by a rotary pneumatic actuator (118), said clamp being free on a rotation axis (111 = ρ) obtained with a bearing (120) and being returned to its zero position by means of a mechanism composed of a spiral spring (112) wound on the drums (113 and 114).

3. The machine according to claims 1 and 2, **characterized in that** the mechanism (100) does not maintain the coupling with the initial portion (2) of the spacer frame throughout the process for forming the frame (3, 3', 3") but is uncoupled before the bending lever (403) performs the subsequent bend and realigns and is recoupled with the portion of the new side after the arm (101) has been moved into a horizontal angular position (co = 0).

4. The machine according to one or more of the preceding claims, **characterized in that** the mechanisms that allow the free rotation of the jaws (117f, 117g) about the axis (111) with a stroke p have low friction and inertia and high elasticity, so that the frame (2), composed of a low-strength profile (1), can control the rotation of said jaws (117f, 117g) about p.

5. The machine according to one or more of the preceding claims, **characterized in that** the axis (111) is not free but is actuated by a synchronous actuator that controls the step p on the basis of the orientation that the portion of the frame (2) with which the support (110) is coupled traces during the bending and/or calendering operations.

6. A method for bending and/or calendering spacer profiles (1) intended to form spacer frames (4, 4', 4") for the insulating glazing unit (5), said bending and/or calendering being performed by progressive steps on the spacer profile (1) when it is in its rectilinear condition, **characterized in that** during said progressive steps the part that has already been processed in the form of a partial frame (2) is supported and guided in order to contrast the actions caused by gravity, inertia and friction.

7. The method according to claim 6, **characterized in that** support and guiding are achieved by means of synchronous actuators with polar positioning (ω, r) and free rotation ρ.

8. The method according to claim 6, **characterized in that** support and guiding are obtained by means of synchronous actuators with polar positioning (ω, r, ρ).

9. The method according to claim 6, **characterized in that** support and guiding are obtained by means of synchronous actuators with Cartesian positioning (x, y, instead of co, r) for equal solutions according to claims 7 or 8 for the rotation p (respectively free or actuated).

10. The method according to claims 6 to 9, **characterized in that** support and guiding do not operate without discontinuities during the forming of the frame (2) but with progressive positioning steps on different portions of the frame (3, 3', 3").

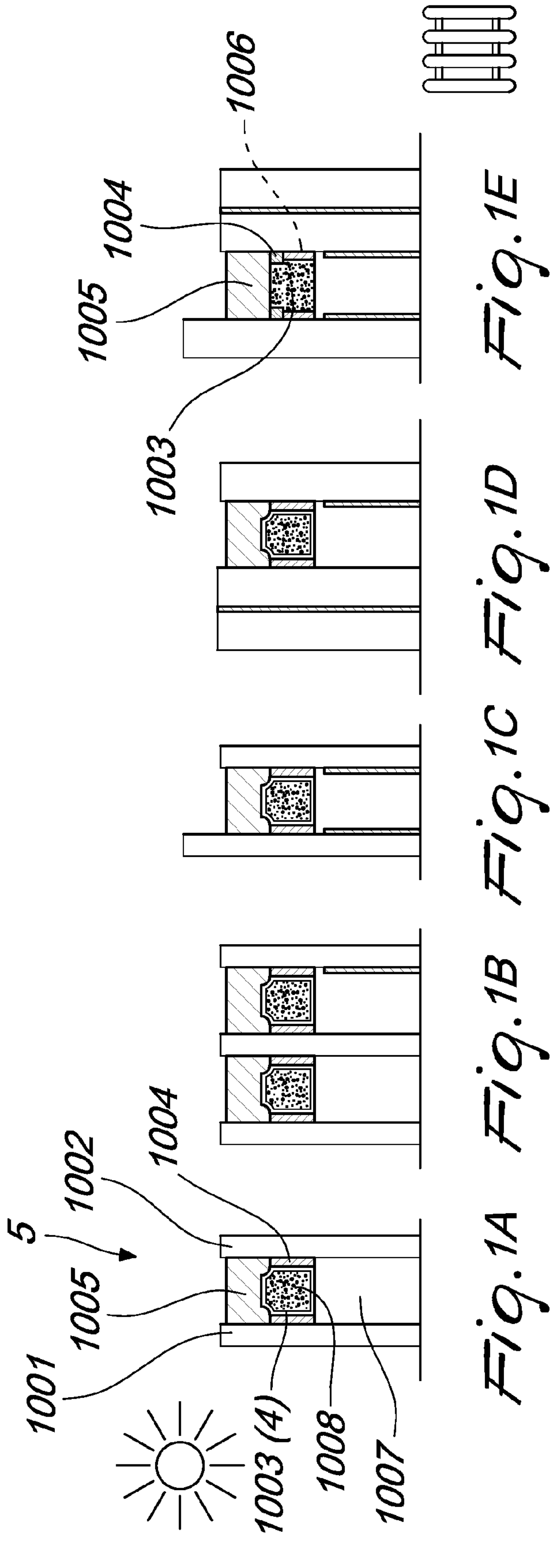

Fig.1A Fig.1B Fig.1C Fig.1D Fig.1E

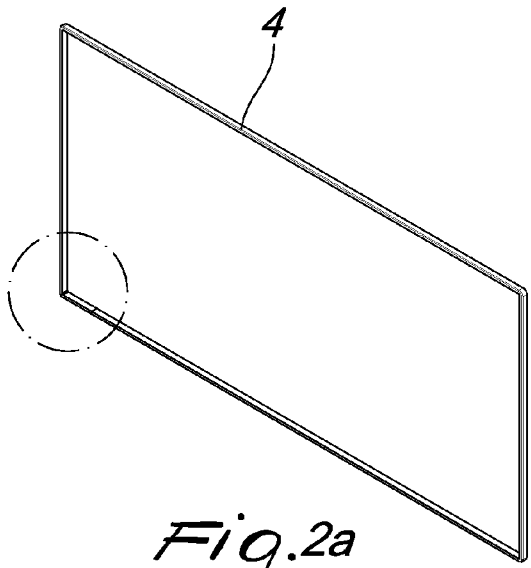

Fig.2a

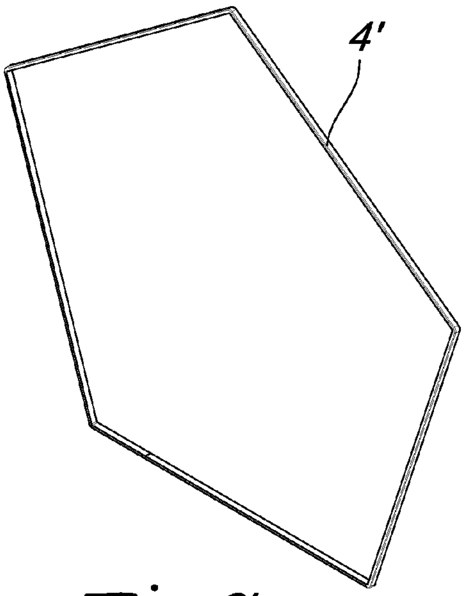

Fig.2b

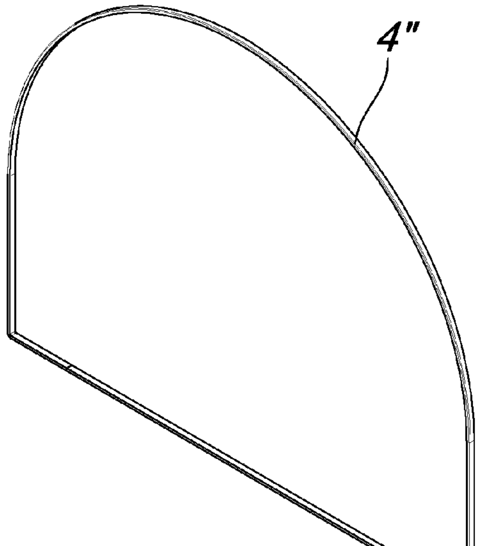

Fig.2c

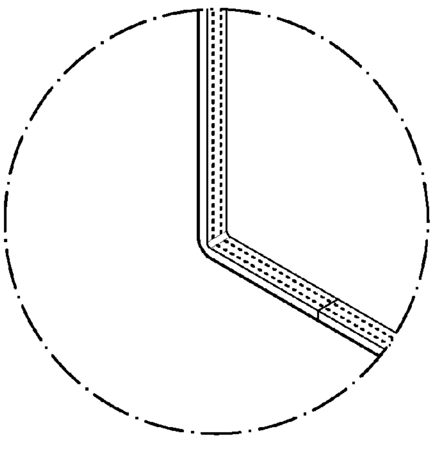

Fig.2d

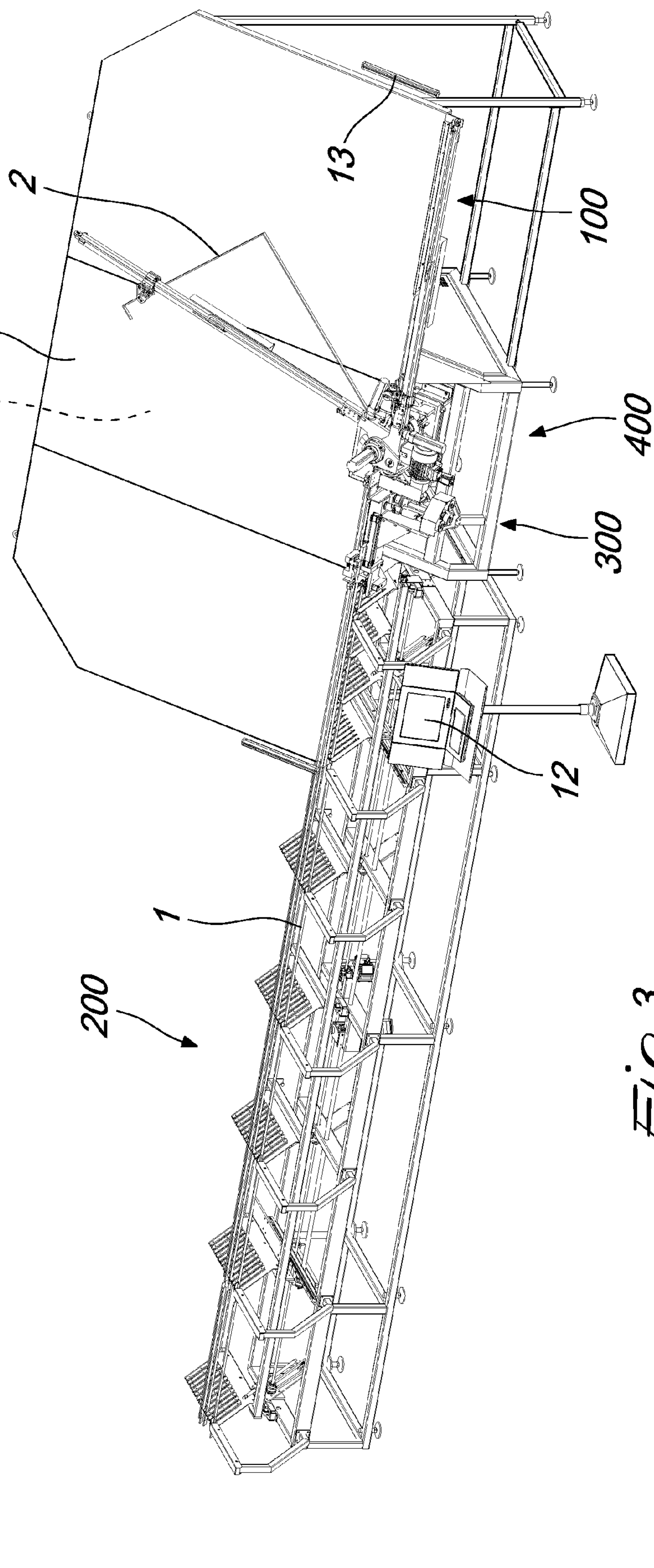

Fig.3

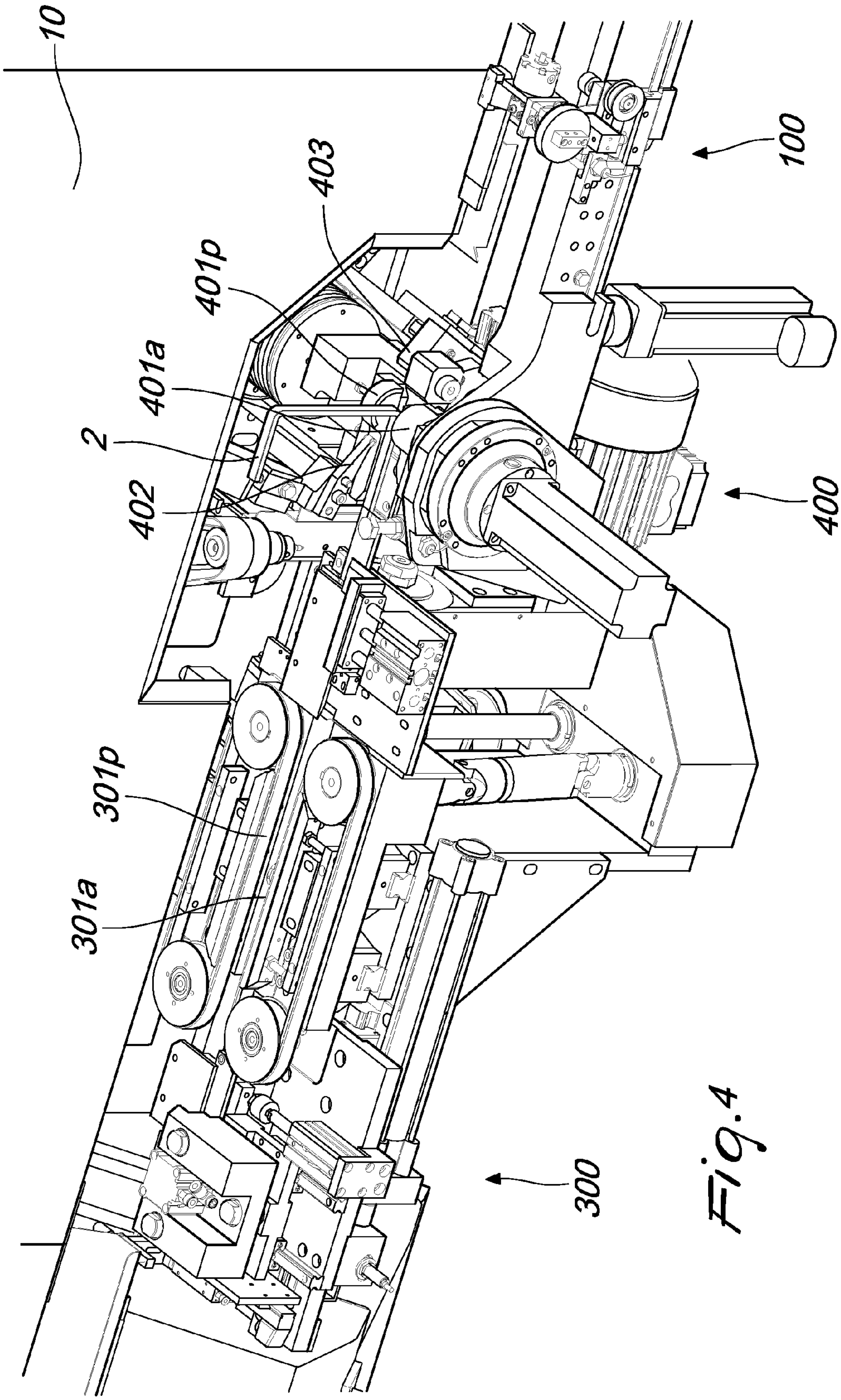

Fig.4

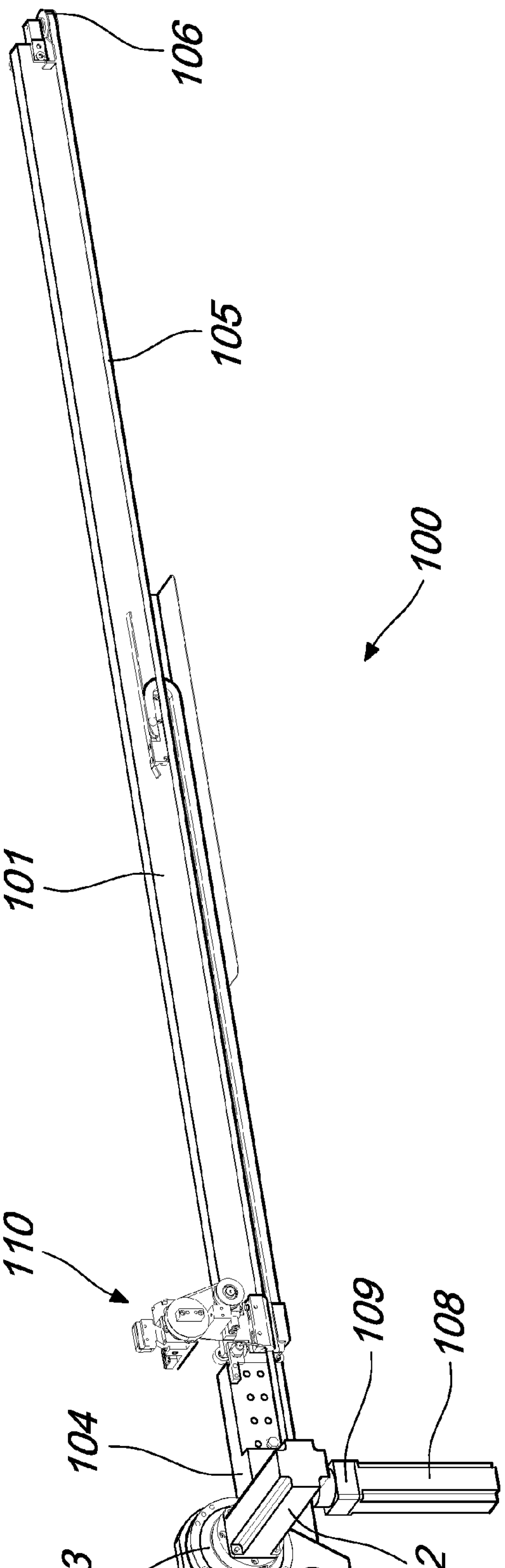

Fig.5

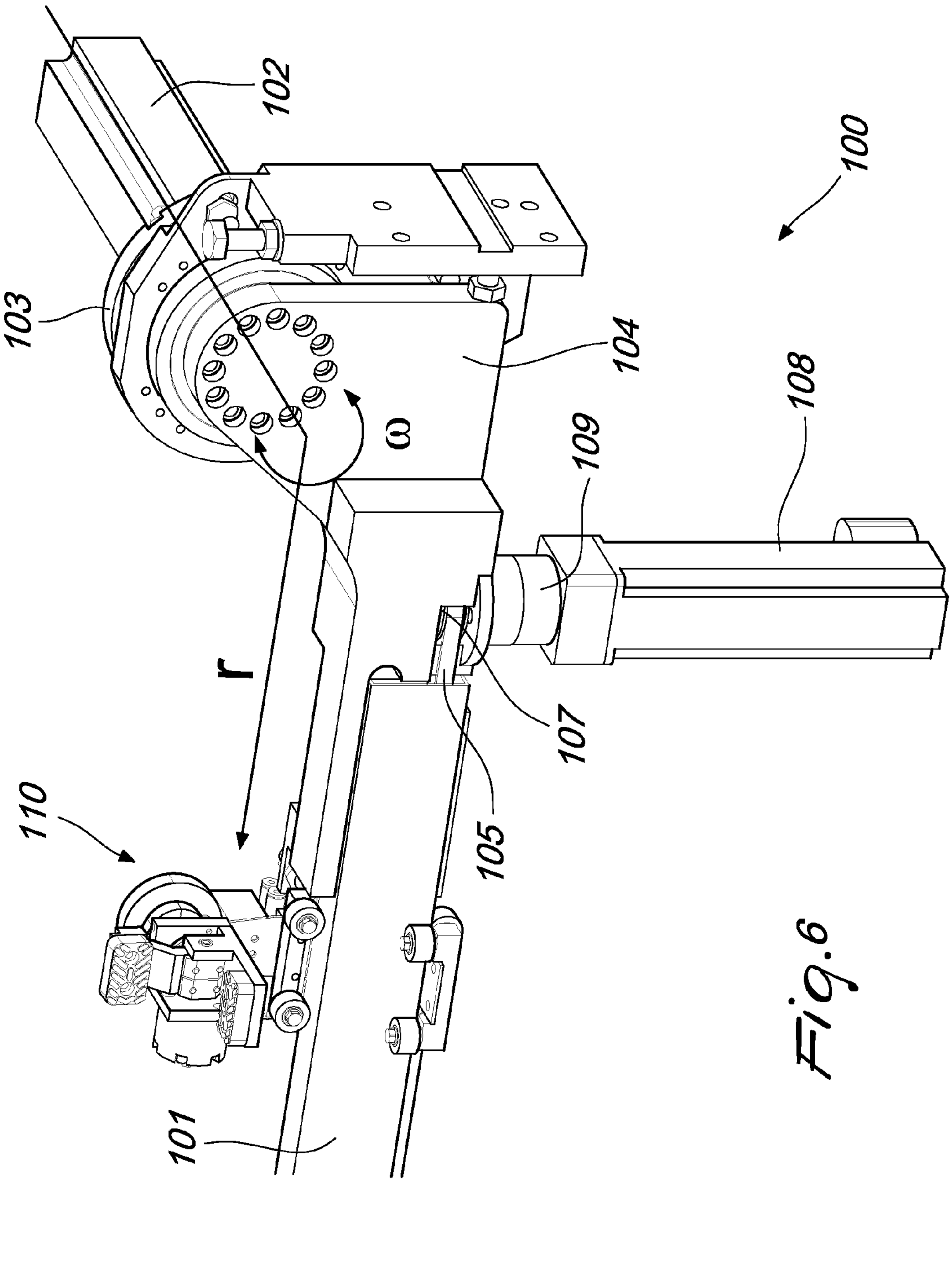

Fig.6

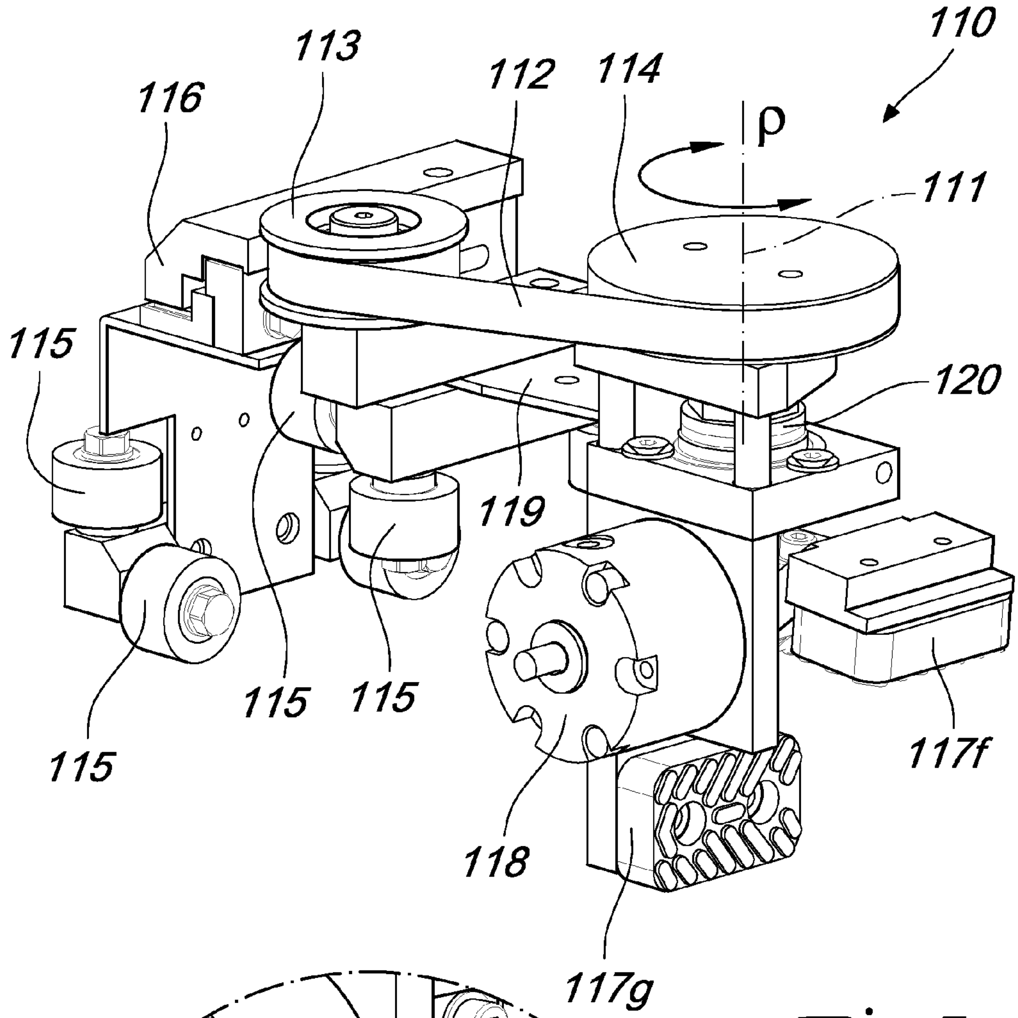

Fig.7

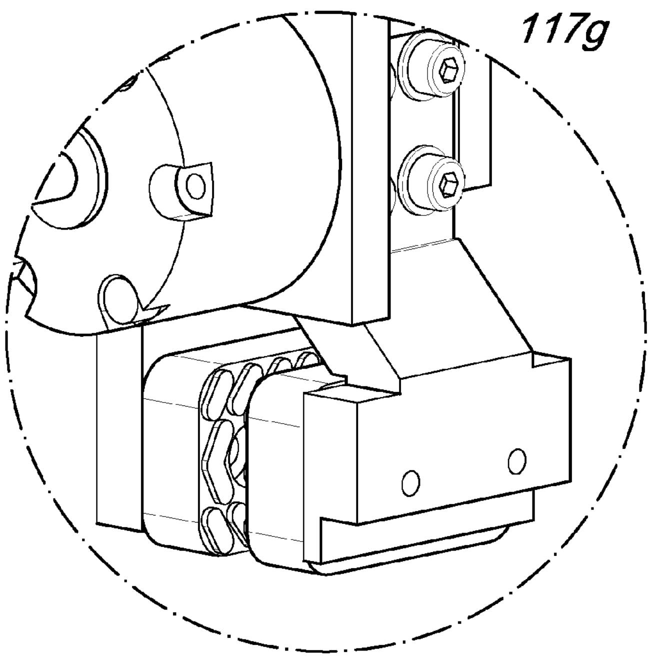

Fig.7A

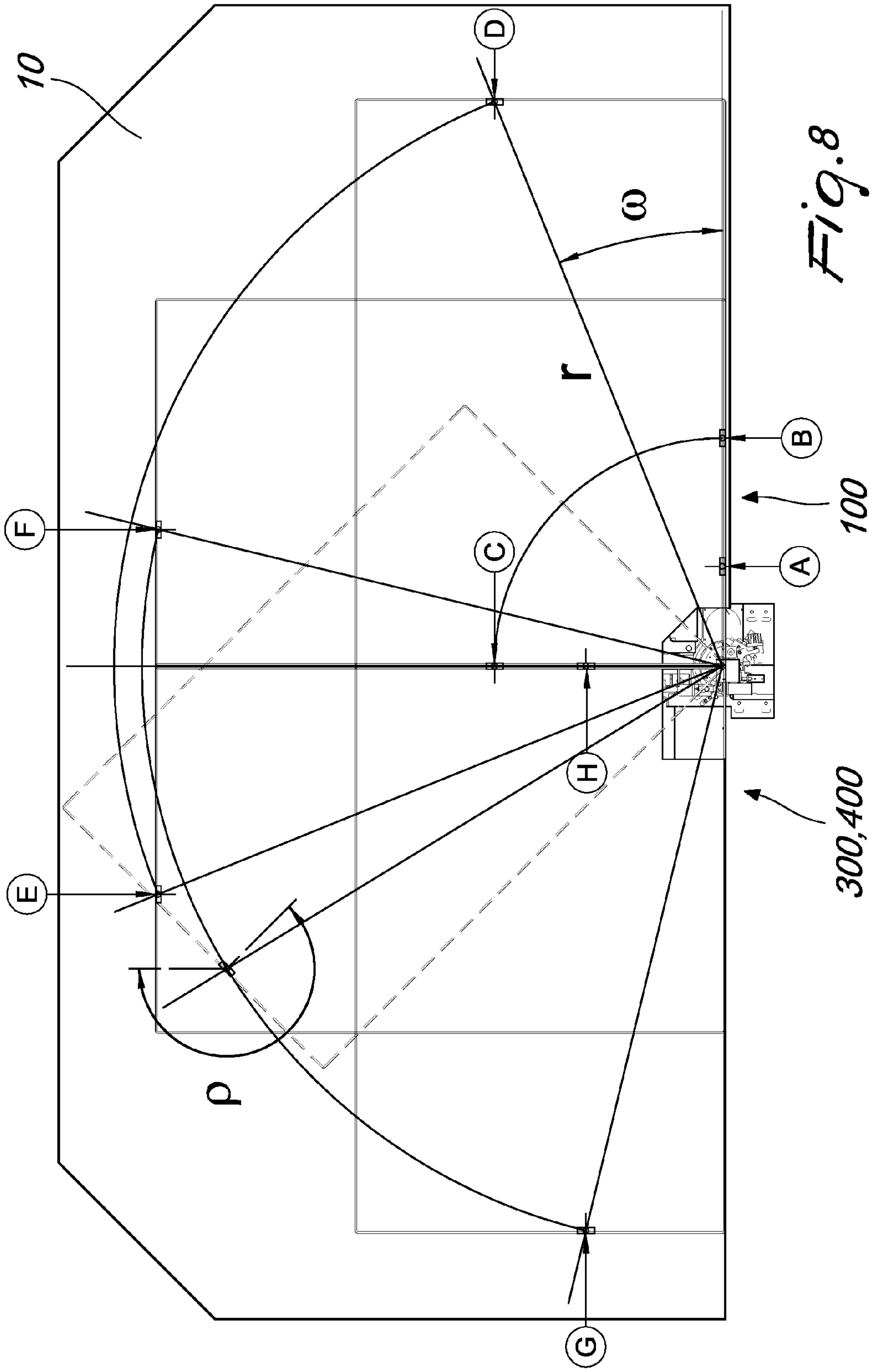

Fig.8

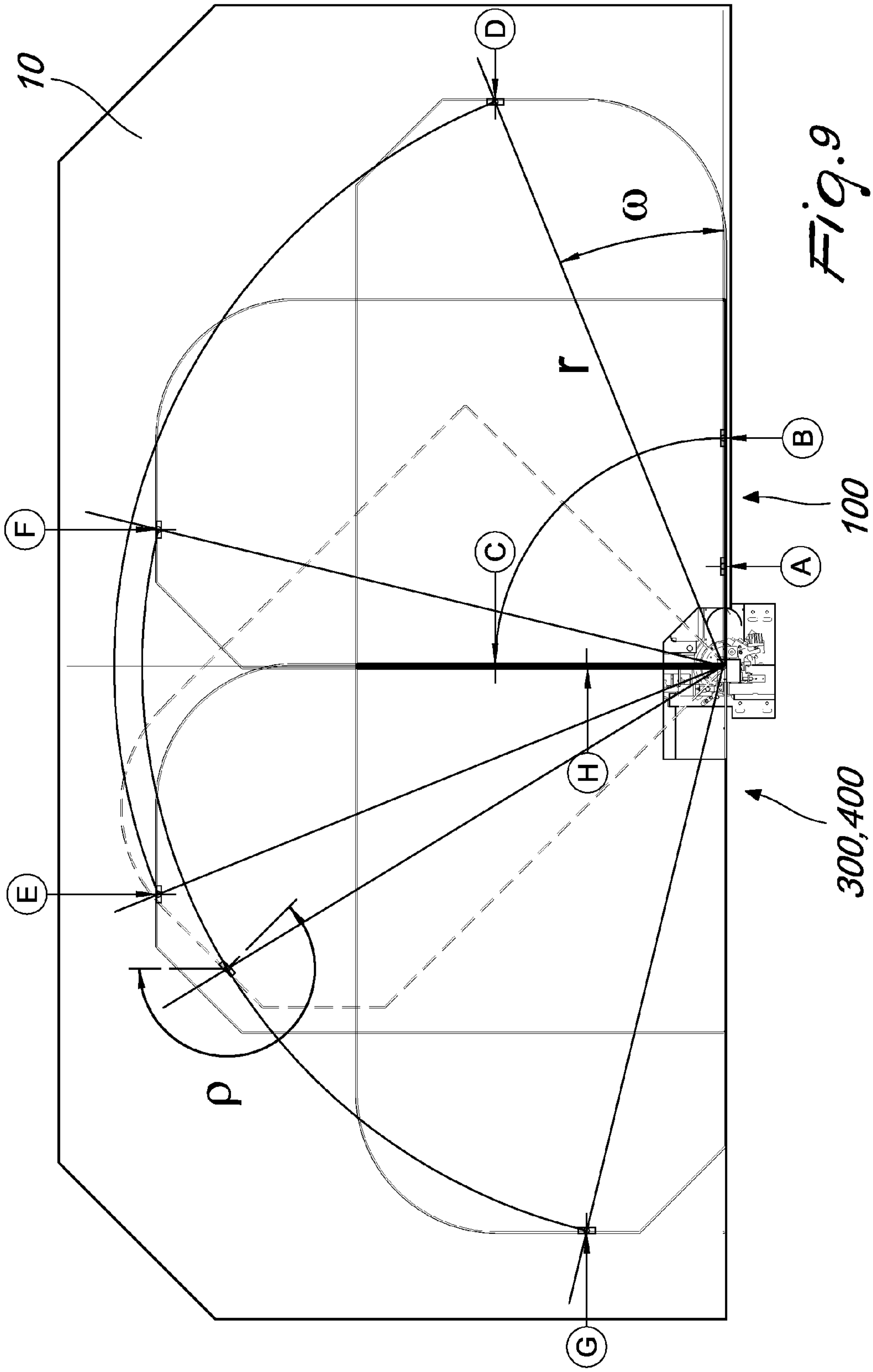

Fig.9

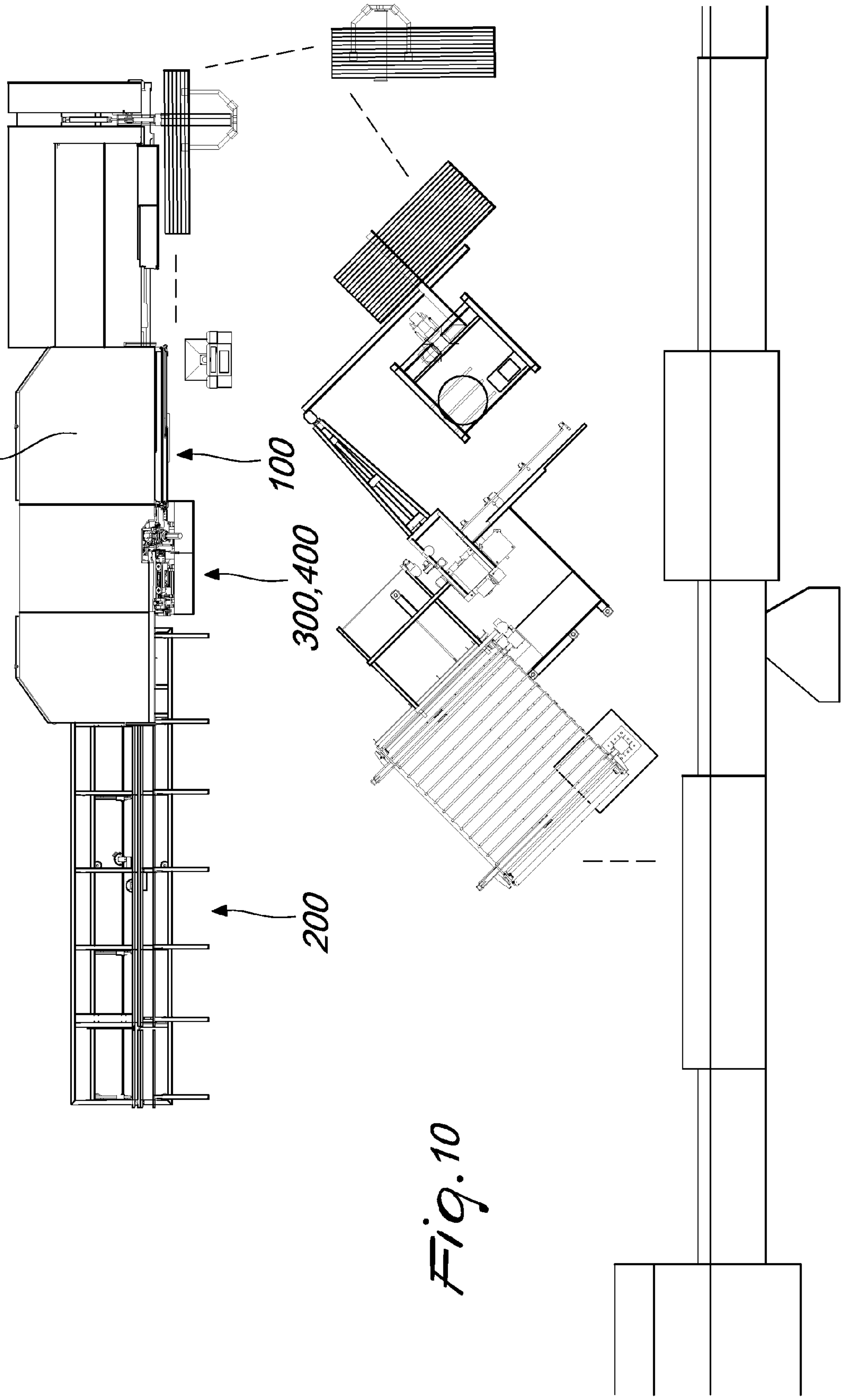

Fig.10

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EUROPEAN SEARCH REPORT

Application Number
EP 14 18 9153

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 5 136 871 A (LISEC PETER [AT]) 11 August 1992 (1992-08-11) * column 4, line 49 - line 59 * * line 11 - column 9, line 19 * * abstract; figures *	6 1	INV. B21D43/10 B21D53/74 E06B3/673
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B21D
E06B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	2 March 2015	Pieracci, Andrea

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