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(54) **APPARATUS AND METHOD FOR THE DRYING/CURING OF CHEMICAL PRODUCTS**

(57) Apparatus (100, 200) for photopolymerizing/drying a coating applied to pieces (10) wherein said pieces (10) to be dried are conveyed inside an inert tunnel (30) inside which there is provided a controlled atmosphere having a composition different from the earth atmosphere, said apparatus comprising:
- a conveyor of said pieces,
- at least a supplying bar (1, 2, 3, 4, 5, 6) for the controlled supply of an inert gas,
- said inert tunnel being provided with at least one photopolymerizing/drying lamp (12) for photopolymerizing/drying said coating applied to said pieces (10),
characterized in that

at the inlet and/or outlet of said pieces (10) to be dried, said tunnel (30) is provided with at least one device, preferably in the form of a hood (31, 32), suitable for generating an air blade.

In a further feature said tunnel (30) is in a fluidic connection with a fixture (40) inside which there is provided said lamp (42), said fixture (40) being isolated from the natural earth atmosphere; said fixture (40) being supplied with the same inert gas provided through said bars (1, 2, 3, 4, 5, 6), which gas reaches the inert tunnel (30) through said fluidic connection in addition and/or alternatively to the inert gas provided by said supplying bars (1, 2, 3, 4, 5, 6).

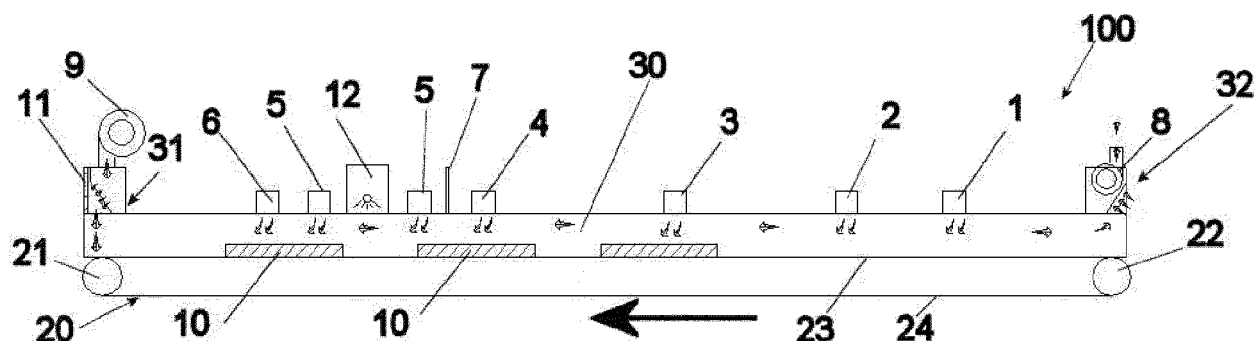


FIG. 1

Description

[0001] The present invention relates to an apparatus and a method for providing a drying oven under controlled atmosphere for photopolymerizing/drying photopolymerizable/dryable chemical products (paints or glue, generally indicated as coating) through the emission of radiations having a pre-defined wavelength. In particular, the invention relates to an inert tunnel for the photopolymerization/drying of sundry materials (wood, fibrocement, glass, plastics, etc.) preferably capable of conferring a matt (opaque) finishing to pieces (panels or rolls) having a mainly flat surface, or to three-dimensional pieces. More particularly, the invention relates to a device suitable to prevent the ingress of atmospheric air into the drying tunnel.

[0002] In a preferred embodiment, the invention relates also to a device that improves the working of a photopolymerizing lamp, preferably an excimer lamp, with which the drying tunnel is provided.

[0003] Indicatively, the mainly flat panels to be dried after painting are provided with dimensions ranging 200x400x4 mm to 1300x3000x50 mm.

[0004] Materials provided in rolls can be dried too, said rolls being provided with dimensions ranging 300 mm in width and 0.5 mm of thickness, up to 1300 mm in width e 6 mm of thickness.

[0005] Three-dimensional pieces are pieces wherein the three dimensions of the piece are comparable. Indicatively, said three-dimensional pieces are provided with dimensions ranging 200x400x100 mm a 1300x3000x200 mm.

[0006] It is known that the surface finish of furniture belongs to two main families:

- Glossy finish, wherein the surface reflects light; in the most extreme cases the glossy finish is reflecting and a mirroring effect occurs;
- Matt finish, wherein the surface does not reflect light; usually such finish is due to the presence of a plurality of microdepressions on the surface of the painted panel, which capture light preventing its reflection like in a mirror.

[0007] The degree of opacity of finish is usually evaluated with a numeric index ranging 1-100, wherein the panels with glossy finish score around 100, while the panels with matt finish score around 2-5. In the art, a matt finish can have a score up to 30-40, while the finishes having an index of 50-60 are indicated as semi-glossy.

[0008] In the art, industrial methods for obtaining such matt finish are known. One of the documents disclosing such a method is e.g. EP2198981B1 of IOT Innovative Oberflächentechnologien GMBH. Such document discloses a method wherein a panel coated with monomers and/or oligomers of acrylate and methacrylate undergoes a treatment with a xenon and/or argon excimer emitter and a medium pressure mercury emitter, under an

inert gas.

[0009] It is known that the excimer treatment for being successful must occur in an inert atmosphere, i.e. an oxygen-free atmosphere. The content of oxygen in the natural earth atmosphere is around 21%. Typically, when working in an oxygen-free atmosphere is necessary, oxygen can be replaced with nitrogen (N₂), carbon dioxide (CO₂) or argon (Ar). In the following, reference will be made to nitrogen, which is a harmless gas, widely used in industry, without for this losing generality.

[0010] It is known that, in order to obtain perfect final results, inside the inert tunnel the concentration of oxygen must be at a minimum, and perfectly uniform in the point wherein the polymerization reaction occurs, that is, in correspondence of the polymerizing/excimer lamp. In fact, the oxygen molecules in the site of reaction (i.e. in correspondence to the polymerizing lamp) cause defects in the final surface of the panel. It is also known that the concentration of oxygen tends to be higher in correspondence of the ingress and egress points of the pieces to be dried into/from the inert tunnel.

[0011] Moreover, it is known that such polymerizing lamps, and in particular excimer lamps, develop heat and must be cooled in order to maintain the efficiency of the lamps themselves and of the process.

[0012] In the art, painted panels to be dried/finished are conveyed through closed belt conveyors inside a tunnel containing said inert atmosphere. Typically, two rollers actuate the closed belt; usually one of them is motorized, while the other is an idle roller. In lateral view, the closed belt assumes an oval shape, with its two long sides parallel to each other. Panels are carried by the upper outward section, while the lower section is the return section.

[0013] When the materials to be dried are in the form of rolls of materials and/or continuous films, the closed band conveying system can be spared. In fact, it is known feeding the drying oven by unwinding the roll through a suitable device, while the progressively unwound tract of material is slid on rollers provided in the inert tunnel, which can be motorized or idle rollers.

[0014] According to the kind of production, increasing the conveying speed of the pieces to be dried in said inert tunnel may be necessary, wherein said pieces undergo treatment through an excimer lamp, or anyway through a lamp suitable for polymerizing the coating applied to the pieces to be dried. Generally, the higher the speed of the system conveying the material to be dried, the higher the quantity of gas needed to keep the tunnel saturated with nitrogen. Indicatively, the conveying speed of the material inside said tunnel ranges 5 m/min to 30 m/min; in some cases, a speed 50 m/min can be reached.

[0015] In the art, using mechanical blades is known in order to prevent the flow of nitrogen from the inside of the inert tunnel to the surrounding earth atmosphere, and especially the flow of earth atmosphere toward the inside of the inert tunnel. Nonetheless, when the conveying speed is very high, and/or the pieces to be dried show a

wide variability, said mechanical blades show their limits.

[0016] Aim of the present invention is providing an inert tunnel (in absence of oxygen), inside which a device emits radiations of a pre-set wavelength for polymerizing/drying a coating applied to said pieces, allowing to minimize the quantity of inert gas needed to saturate the drying tunnel.

[0017] A further aim of the present invention is providing an inert tunnel (without oxygen), inside which a special fixture provided for the polymerizing lamp emitting radiations of a pre-set wavelength for photopolymerizing/drying painted materials, allowing to minimize the quantity of inert gas needed to saturate the inert tunnel and obtain final results free of defects.

[0018] This object is achieved by an apparatus and a method having the features of the independent claims. Advantageous embodiments and refinements are specified in claims dependent thereon.

[0019] Both devices, the one for preventing the ingress of atmospheric air into the drying tunnel, and the special fixture provided for the polymerizing lamp, concur to the aim of lowering the concentration of oxygen inside the drying tunnel, and therefore cooperate to obtain polymerized pieces with excellent quality, minimizing the number of pieces that have to be discarded.

[0020] The apparatus according to the present invention is provided with a barrier device allowing to minimize the flow of gases between the inside and the outside of the tunnel. In particular, the device provides an air blade at the ingress and egress ends of the pieces to be dried of said inert tunnel.

[0021] The atmospheric air provided by the air blade injected at the inlet and outlet of pieces can be provided with a vertical direction, parallel to the transversal section of the inert tunnel.

[0022] Alternatively, the air blade can be slanting with respect to the direction of conveying of pieces. At the inlet of the pieces, the air blade is directed in a direction contrary to the conveying direction of pieces, while at the outlet the air blade is directed in the same direction as the conveying of pieces. Indicatively, the angle of the air blade does not exceed about 45° with respect to the vertical direction, i.e. to the transversal section of the inert tunnel.

[0023] Should the air blade be directed toward the inside of the tunnel, it should be provided with a pressure equal to or inferior to that of the nitrogen tending to escape from said tunnel, without which the inside of the tunnel would tend to be polluted in the working area of the polymerizing lamp.

[0024] Moreover, said air blade must be provided with an intensity and a distribution of air that are perfectly uniform on the whole section of the inlet/outlet of pieces.

[0025] Being slightly lighter than air, the gaseous nitrogen contained in said tunnel tends to expand upwards, both inside the tunnel (higher concentration upwards), and immediately after escaping out from the tunnel. In fact, it is known that atmospheric air comprises about

80% of nitrogen but also other gases, and especially that its specific weight varies according to the humidity degree of the atmospheric air. The airflow coming from said air blade presses down nitrogen, slowing down its outflow. For these reason, directing the air blade from top to bottom is convenient.

[0026] In use, the flow of the air blade must be adjusted according to the conveying speed of pieces in the inert tunnel and to the quantity of nitrogen injected into the tunnel itself; due the difference in the molecular weight between nitrogen and air, at the same pressure level, nitrogen is much faster than air.

[0027] The present invention is provided with different embodiments.

[0028] Concerning the inlet of pieces, there are provided three alternative possibilities:

- The supplying air blade is vertical, parallel to the transversal section of the inert tunnel;
- The supplying air blade is slanting, with a tilting angle variable between the vertical direction and about 45° with respect to the vertical direction, i.e. to the transversal section of the inert tunnel; the air blade is tilted in a direction opposed to the conveying direction of the pieces to be dried;
- The air blade is vertical, but works suctioning, i.e. the atmospheric air at the ingress of the pieces to be dried is suctioned and directed upwards.

[0029] Concerning the outlet of pieces, there are provided three alternative possibilities:

- The supplying air blade is vertical, parallel to the transversal section of the inert tunnel;
- The supplying air blade is slanting, with a tilting angle variable between the vertical direction and about 45° with respect to the vertical direction, i.e. to the transversal section of the inert tunnel; the air blade is tilted in the same conveying direction of the pieces to be dried;
- The air blade is vertical, but works suctioning, i.e. the atmospheric air at the egress of the pieces to be dried is suctioned and directed upwards.

[0030] In each of the above-indicated cases, said air blade is generated by a hood, whose details will be explained further on with the help of Figures. The hood generating the air blade must be produced so as to generate a laminar flow provided of an adjustable direction.

[0031] Indicatively, the speed of the inert gas, measured at the egress point of the pieces, is 0.1-0.5 m/s, while the speed of the vertical supply air blade is roughly double, i.e. 0.2-1 m/s. For the suctioning air blade, a speed of the air blade of 0.1-1 m/sec is sufficient, the specific speed being a consequence of the parameters of the machine placed upstream the inert oven.

[0032] In one of its preferred embodiments, the apparatus according to the present invention further compris-

es a fixture inside which said polymerizing or excimer lamp is mounted; said fixture is supplied with an inert gas for two reasons:

- Cooling the polymerizing/excimer lamp;
- Providing an area pressurized with inert gas in the very point where the treatment of the painted surface occurs, so improving the distribution of the inert gas and therefore the quality of final pieces.

[0033] Such fixture, in fluid communication with the inert tunnel, but sealed with respect to the external environment, pours the inert gas used for its cooling directly inside the inert tunnel, and in particular on the piece to be dried at the moment and in the point where the photopolymerization occurs, triggered by the irradiation by the polymerizing/excimer lamp.

[0034] The pressurization is obtained by injecting the inert gas inside a wide chamber: the expansion of the gas allows it to diffuse over the whole surface to be treated in a perfectly uniform way, by the injection through a plurality of calibrated holes.

[0035] In a most preferred embodiment, immediately upstream and downstream the fixture, but independent from it, there are provided other two bars supplying inert gas, which contribute to the supply of inert gas in the area irradiated by the polymerizing/excimer lamp where the polymerizing reaction occurs.

[0036] A first advantage of the present invention is the possibility of obtaining an inert atmosphere in the inert tunnel while optimizing the quantity of inert gas, with a noteworthy saving in the quantity of inert gas that has to be provided in order to obtain a suitably inert atmosphere. Experimental tests showed that for an inert tunnel having a transversal section of about 30x1450 mm according to the known art, 140 m³/h of inert gas must be provided. Conveying speed being equal, with the inert tunnel according to the present invention, 90 m³/h of inert gas must be provided. In other words, the consumption of inert gas decreases by 30%.

[0037] A second advantage of the present invention is that mechanical barriers at the inlet and outlet are not necessary, therefore the pieces can be treated while passing, allowing speeds of the production line otherwise impossible. In particular, it is known that systems using mechanical barriers that must be opened and closed allow a conveying speed of about 5 m/min, while with the present invention there are no limits to the conveying speed of pieces. It was experimentally verified that conveying speeds of 50 m/min, and even up to 100 m/min can be provided.

[0038] A third advantage is linked to the flexibility of the inert oven according to the present invention, which can be used to dry pieces of any shape and dimension: from materials in rolls to pieces loaded side by side on the band conveyor in a casual way, so maximizing the hourly manufacturing capability. This would not be possible with mechanical closing systems.

[0039] In its preferred embodiment, a fourth advantage of the present invention is that the inert gas is injected in the points of the inert tunnel and at the moment where it is especially necessary, i.e. at the moment when the polymerization reaction is triggered by the radiations emitted by the polymerizing/excimer lamp.

[0040] In its preferred embodiment, a further advantage is that in the apparatuses according to the known art, the cooling of the polymerizing or excimer lamp is performed with a circuit supplied with cool water. This entails relevant dimensions of the fixture comprising the lamps, which does not allow to inject the inert gas directly in the irradiation area.

[0041] Further advantages and properties of the present invention are disclosed in the following description, in which exemplary embodiments of the present invention are explained in detail on the basis of the drawings:

Figure 1	Longitudinal section of the apparatus according to a first embodiment of the present invention;
Figure 2	Longitudinal section of the apparatus according to a second embodiment of the present invention;
Figure 3	Front view of the hood generating the air blade;
Figures 4A, 4B	Lateral sections of the hood;
Figure 5	Axonometric view of the hood in an exploded view.
Figure 6	Longitudinal section of the overall apparatus;
Figure 7A, 7B	Front and axonometric view of the fixture;
Figure 8	Transversal section of the fixture;
Figure 9A, 9B	Axonometric views of the fixture observed from bottom, in an assembled and in an exploded view;
Figure 10	Magnified detail of the exploded axonometric view of the fixture observed from bottom.

[0042] Figure 1 shows a first embodiment of the present invention, in a longitudinal section: an apparatus 100, comprising an inert tunnel 30. In this first embodiment, the inert oven 100 comprises a first hood 32, in its turn comprising a fan 8 for suctioning air at the inlet of pieces, and a second hood 31, in its turn comprising a fan 9 for supplying air at the outlet of pieces. The Figure is a schematized view, wherein the walls of the oven were removed for better clarity. The bold arrow shows the conveying direction of pieces.

[0043] Said apparatus 100 comprises a belt conveyor 20, actuated by at least two rollers; a motorized roller 21, placed at the exit of the apparatus 100, while an idle roller 22 is placed at the entry of the apparatus 100. Said closed band belt conveyor 20 is provided with an upper outward section 23 and a lower return section 24. The pieces 10

to be dried are conveyed on the upper outward section 23; in the case represented in this Figure, panels are shown. The bottom main side of pieces 10 is supported on the surface of the outward section 23.

[0044] Said inert oven 100 comprises a plurality of bars 1, 2, 3, 4, 5, 6 providing an inert gas, in the preferred embodiment nitrogen. The number of bars is determined by the designer according to the dimensions of the tunnel and to the allowed residual percentage of oxygen. The direction of supply and circulation of nitrogen is shown by the small curved arrows. Said inert oven further comprises a polymerizing lamp 12, in the preferred embodiment an excimer lamp, for polymerizing the coating applied at least to the top surface of pieces 20. In an embodiment, the inert oven 100 further comprises an oximeter 7 intended to detect the gaseous oxygen percentage inside said inert tunnel 30.

[0045] At the inlet of the pieces 10, the apparatus 100 comprises said hood 32, in its turn comprising a fan 8 for suctioning atmospheric air, and at the outlet of pieces said hood 31 in its turn comprising a fan 9 for supplying air. Said hoods 31 and 32 generate each an air blade for containing nitrogen inside said inert tunnel according to the present invention.

[0046] In this embodiment, the air blade provided by the hoods 31 and 32 is perpendicular to the conveying direction of pieces or parallel to the transversal section of the inert tunnel 30, thanks to the presence of a wall 11 that is as well perpendicular to the conveying direction of pieces or parallel to the transversal section of the inert tunnel 30.

[0047] Figure 2 shows a second embodiment of the present invention, in a longitudinal section: an apparatus 200, comprising an inert tunnel 30. In this second embodiment, the inert oven 200 comprises a first hood 31, and a second hood 31; both hoods are provided with a fan 9 for supplying air. The Figure is a schematized view, wherein the walls of the oven were removed for better clarity. The bold arrow shows the conveying direction of pieces.

[0048] In this embodiment, the air blade provided by said hoods 31 is perpendicular to the conveying direction of pieces or parallel to the transversal section of the inert tunnel 30, thanks to the presence of a wall 11 that is as well perpendicular to the conveying direction of pieces or parallel to the transversal section of the inert tunnel 30.

[0049] Said apparatus 200 comprises a belt conveyor 20, actuated by at least two rollers; a motorized roller 21, placed at the exit of the apparatus 200, while an idle roller 22 is placed at the entry of the apparatus 200. Said belt conveyor is provided with an upper outward section 23 and a lower return section 24. The pieces 10 to be dried are conveyed on the upper outward section 23; in the case represented in this Figure, panels are shown. The bottom prevailing side of pieces 10 is supported on the surface of the outward section 23.

[0050] In the case said apparatus 100, 200 is used only to dry materials provided in rolls or continuous films, the

closed band conveying system 20 is not provided, but is replaced by a (not shown) conveying system which progressively unwinds the roll, while the unwound tract of material is slid inside said inert tunnel 30, by sliding it over motorized or idle rollers.

[0051] Said inert oven 200 comprises a plurality of bars 1, 2, 3, 4, 5, 6 providing an inert gas, in the preferred embodiment nitrogen. The number of bars is determined by the designer according to the dimensions of the tunnel and to the allowed residual percentage of oxygen. The direction of supply and circulation of nitrogen is shown by the small curved arrows. Said inert oven further comprises a polymerizing lamp 12, in the preferred embodiment an excimer lamp, for polymerizing the coating applied at least to the top surface of pieces 20. In an embodiment, the inert oven 200 comprises further an oximeter 7 intended to detect the gaseous oxygen percentage inside inert tunnel 30.

[0052] The apparatus 200 comprises two hoods 31, each provided with a fan 9 for supplying atmospheric air, said first hood 31 being placed at the inlet of the pieces 10, and second hood 31 being placed at the outlet of pieces 10. Said two hoods 31 generate an air blade for containing nitrogen inside said inert tunnel according to the present invention. Said two hoods 31 are substantially identical, and are placed symmetrically with respect to the central point of the inert tunnel 30.

[0053] In this embodiment, the air blade provided by the hoods 31 is perpendicular to the conveying direction of pieces or parallel to the transversal section of the inert tunnel 30, thanks to the presence of a wall 11 that is as well perpendicular to the conveying direction of pieces or parallel to the transversal section of the inert tunnel 30.

[0054] Figure 3 shows a detail of said hood 31 in a front view. Said hood 31 comprises substantially an external housing 33 in the form of a box, and a fan 9 for supplying air allowing to generate said air blade. Moreover, said housing is provided with a tilting wall 11, whose tilting can be adjusted from perpendicular to the ground up to a tilting of about 45° toward the exterior of said housing.

[0055] Said housing 33 is provided with the shape of a parallelepiped, whose longitudinal axis is placed perpendicularly to the conveying direction of pieces. Said hood 31 or 32 is placed so that the tilting wall 11 is always oriented toward the exterior of the apparatus 100 or 200. In other words, the tilting wall 11 tilts in a direction contrary to the conveying direction of pieces when the hood 31 or 32 is placed at the inlet of the pieces to be dried. The tilting wall 11 tilts in the same conveying direction of pieces when the hood 31 or 32 is placed at the outlet of the pieces to be dried.

[0056] Figures 4A and 4B are two transversal sections of said hood 31, showing the working of the tilting wall 11. Figure 4A shows the tilting wall 11 in its position perpendicular to the ground, while Figure 4B shows the tilting wall 11 in a couple of positions tilted with respect to the ground

[0057] The tilting wall is manually adjusted at the start

of the apparatus 100, 200 according to the environmental conditions, or according to the adjustment of the other machines comprised in the production line and to the ventilation conditions of the environment. The aim of the tilting wall 11 is to add a further possibility of adjustment to the supply or suction of air, which otherwise would be adjustable acting only on the number of rounds of the fan.

[0058] Figure 5 shows an exploded view of an axonometric view of said hood 32. Said hood 32 comprises said housing 33 made preferably of metal sheet, a wall 11 of which is tiltable. Said hood 32 further comprises a fan 8 that suctions air from the environment to force it inside said housing 33. As can be easily understood, in the case of the hood 31, in lieu of the fan 8, it comprises a fan 9 for supplying air toward the environment.

[0059] Said hoods 32, 31 further comprise a tubing 35 of a length suitable for tunnelling the air suctioned or supplied by the fan 8, 9 in a symmetrical central point of said housing 33.

[0060] Said air is then forced through an internal pierced wall 34 that gives to said air blade a laminar flow, regular and homogeneous for the whole length of the hood. Said pierced wall comprises a plurality of small holes and is placed, slightly tilted, in front of said tubing 35 and wall 11. Indicatively, said pierced wall 34 is provided with holes having a diameter of about 2 mm; in an area of 10 cm² there are provided about 100 holes.

[0061] The composition and the working of the hood 32, which suctions air from the inert tunnel and forces it into the environment, are substantially the same as those of the hood 31, with the difference that the fan 9 supplies air instead of suctioning it. In both cases, the tilting of the tilting wall 11 can be adjusted as desired within an angle of maximum 45° with respect to a vertical direction.

[0062] The opening of the tilting wall 11 has the effect of decreasing the speed and the pressure of the suctioned or supplied air of the air blade. Opening the tilting wall 11 leads to a more sensitive adjustment of the fan 8 or 9 with low volumes of injected inert gas.

[0063] The choice of a hood supplying air 31 or suctioning air 32 is linked to the overall production line. In fact, when in use, the photopolymerizing oven 100, 200 is a portion of a production line comprising a wide variety of machines. At the inlet of the tunnel 30, the supplying hood 31 can be placed when the preceding machine is provided with a suctioning system that would tend to suction the nitrogen from said tunnel 30. Alternatively, at the inlet of the tunnel 30 a suctioning hood 32 can be placed when the preceding machine is pressurized with an autonomous supply of air: in this case, the excess of supplied air provided by the preceding machine might pollute the inert tunnel 30 with air coming from the environment. At the outlet of the inert tunnel 30, in order to prevent the natural outlet of nitrogen from the tunnel itself, preferably a supplying hood 31 is placed. In this case, too, the choice of a supplying air hood 31 or suctioning air hood is connected to the machine immediately downstream the apparatus 100 or 200.

[0064] Of course, said apparatuses 100, 200 are provided with a PLC allowing to adjust different devices in known ways, like e.g. the conveying speed of pieces 10 by acting on the motorized roller 21; the quantity of inert gas provided by bars 1, 2, 3, 4, 5, 6; the quantity of energy emitted by the polymerizing lamp 12; the flow of air provided by fans 8 or 9, etc. The tilting of the tilting wall 11 can be performed manually or can be automated.

[0065] In a preferred embodiment, said oximeter 7 is connected to a feedback mechanism. In this way, the supply of an inert gas by said bars 1, 2, 3, 4, 5, 6 is automatically adjusted according to the value of oxygen detected by the oximeter, increasing the supply of inert gas when the value of the detected oxygen increases in said inert tunnel 30.

[0066] Figure 6 shows a preferred embodiment of the present invention, in a longitudinal section: an apparatus 100, comprising an inert tunnel 30. In this embodiment, the inert oven 100 comprises a first hood 32, and a second hood 31, which both hinder the gaseous exchanges between inert tunnel 30 and external environment, wherein the natural earth atmosphere comprises about 20% of oxygen. The Figure is a schematized view, wherein the walls of the oven were removed for better clarity.

The bold arrow shows the conveying direction of pieces.

[0067] Said apparatus 100 comprises a closed belt conveyor 20, actuated by at least two rollers; a motorized roller 21, placed at the exit of the apparatus 100, while an idle roller 22 is placed at the entry of the apparatus 100. Said closed belt conveyor 20 is provided with an upper outward section 23 and a lower return section 24. The pieces 10 to be dried are conveyed on the upper outward section 23; in the case represented in this Figure, panels 10 are shown. The bottom main side of pieces 10 is supported on the surface of the outward section 23.

[0068] When said apparatus 100 is used only to dry materials provided in rolls or continuous films, the closed band conveying system 20 is not provided. It is replaced by a known (not shown) conveying system which progressively unwinds the roll, while the unwound tract of material is slid inside said inert tunnel 30, by sliding it over motorized or idle rollers.

[0069] Said inert oven 100 comprises a plurality of bars 1, 2, 3, 4, 5, 6 providing an inert gas, in the preferred embodiment nitrogen. The number of bars is determined by the designer according to the dimensions of the tunnel and to the allowed residual percentage of oxygen.

[0070] Obviously, although not illustrated, also an apparatus 200 can be provided a fixture 40 like the one described in the following.

[0071] Said inert oven 100, 200 further comprises a fixture 40 in its turn comprising a polymerizing lamp 42 (better observable in the Figures 7-10), in the preferred embodiment an excimer lamp, for polymerizing a coating applied at least to the top surface of pieces 10. In an embodiment, the inert oven 100, 200 further comprises an oximeter 7 intended to detect the gaseous oxygen percentage inside side inert tunnel 30.

[0072] At the inlet of the pieces 10, the apparatus 100 comprises said hood 32, in its turn comprising a fan for suctioning atmospheric air, and at the outlet of pieces said hood 31 in its turn comprising a fan for supplying air. Said hoods 31 and 32 generate each an air blade for containing nitrogen inside said inert tunnel according to the present invention.

[0073] The fixture 40 is placed adjacent to the inert tunnel 30, and is provided with a housing 44 insulating it from the external environment. The connection between the fixture 40 and the inert tunnel 30 is sealed, so as to prevent a gas exchange between the earth atmosphere outside the apparatus 100, 200 and the inert atmosphere contained in the inert tunnel 30. On the other hand, the underside of the fixture 40 is in fluidic communication with the interior of the inert tunnel 30.

[0074] Figures 7A, 7B show the fixture 40 according to the present invention, in a front and in an axonometric view from the bottom, respectively. The fixture 40 is provided with an overall parallelepiped shape, with its longitudinal axis perpendicular to the conveying direction of pieces. Over the fixture 40 there is optionally provided an electrical transformer 41 for supplying the polymerizing/excimer lamp 42. Said component 41 is a commercial component and is not part of the present invention. On the top face of said fixture 40 there is provided at least one, preferably two inlet points 43 for the inert gas.

[0075] Figure 8 shows a transversal section of the fixture 40 according to the lines A-A shown in Figure 7A. As already mentioned, on the top face of the fixture there is provided at least one, preferably two inlet points 43 for the inert gas. The inert gas is optionally supplied by the same (not shown) source supplying the inert gas bars 1-6 which directly supply the inert tunnel 30, or the fixture 40 can be provided with an autonomous supply, different from that of the bars 1-6.

[0076] Figures 9A and 9B show two axonometric views of the fixture 40, Figure 9A in an assembled view and Figure 9B in exploded view, respectively.

[0077] Figure 10 shows a magnification of the detail B highlighted in Figure 9B.

[0078] The set of Figures 8, 9A, 9B and 10 allows to explain the working of the fixture 40.

[0079] Said fixture 40 comprises an expansion chamber 46, which in its portion oriented toward the external environment is delimited by a housing 44, while its bottom portion comprises a reflector 45, inside which there is placed said polymerizing/excimer lamp 42. The reflector 45 surrounding said polymerizing/excimer lamp 42 is provided with a substantially semi-cylindrical shape, with its longitudinal axis parallel to that of the lamp 42 itself, and is preferably made of a reflecting material, so as to maximize the emission of energy toward the inert tunnel 30.

[0080] Said inert gas, after entering from its inlet point/s 43, expands inside said expansion chamber 46 following the path shown by the small arrows, and outlets from the fixture 40 entering into the inert tunnel 30 from three main areas:

- A first row 49 of small calibrated holes placed immediately above the lamp 42;
- A double row of small calibrated holes 47 placed immediately to the left of the lamp 42;
- A double row of small calibrated holes 48 placed immediately to the right of the lamp 42.

[0081] In an embodiment, the whole surface of the reflector 45 is pierced uniformly.

[0082] In most preferred embodiment, immediately upstream and downstream said fixture 40 there are provided two further bars 5 supplying inert gas, which are independent from the fixture.

[0083] Indicatively, the flow rate of inert gas injected into the inert tunnel 30 through the fixture 40 is about 10-40 m³/h. The average speed of the inert gas emitted by the fixture 40 can range 1-7 m/sec, preferably 2-4 m/sec. Experimentally, the best results were obtained with the same flow rate of inert gas injected through said fixture 40 and the bars 1-6 supplying inert gas to the inert tunnel; e.g. both the fixture 40 and the bars 1-6 adjusted to emit inert gas with a flow rate of 20 m³/h. As the outlet section for gas emission of the fixture 40 is smaller than the outlet section of the bars 1-6 supplying inert gas, the speed of the inert gas tends to be higher in correspondence of the fixture 40 than in correspondence of the bars 1-6. Consequently, the speed of the inert gas tends to be higher in correspondence of the polymerizing lamp 42.

[0084] Of course, said apparatus 100 is provided with a PLC allowing to adjust different devices in known ways, like e.g.: the conveying speed of pieces 10 by acting on the motorized roller 21; the flow rate of inert gas provided by bars 1, 2, 3, 4, 5, 6; the flow rate of inert gas emitted by said fixture to said holes 47, 48, 49; the quantity of energy emitted by the polymerizing lamp 12; the flow of air provided by hood 31, 32, etc.

[0085] The PLC of the apparatus allows to independently adjust the supply of inert gas through bars 1-6 and holes 47, 48, 49 provided in the fixture.

[0086] In a preferred embodiment, said oximeter 7 is connected to a feedback mechanism. In this way, the supply of an inert gas by said bars 1, 2, 3, 4, 5, 6 is automatically adjusted according to the value of oxygen detected by the oximeter, increasing the supply of inert gas when the value of the detected oxygen increases in said inert tunnel 30.

- | | |
|----|----------------------------|
| 1 | bar supplying an inert gas |
| 2 | bar supplying an inert gas |
| 3 | bar supplying an inert gas |
| 4 | bar supplying an inert gas |
| 5 | bar supplying an inert gas |
| 6 | bar supplying an inert gas |
| 7 | oximeter |
| 8 | fan for supplying air |
| 9 | fan for suctioning air |
| 10 | piece |
| 11 | tilting wall |

12	polymerizing lamp		
20	closed band		
21	motorized roller		
22	idle roller		
23	outward section	5	
24	return section		
30	inert tunnel		
31	supplying hood		
32	suctioning hood		
33	hood housing	10	
34	pierced wall		
35	tubing		
40	fixture		
41	transformer		
42	polymerizing lamp	15	
43	inlet point of inert gas		
44	housing		
45	reflector		
46	expansion chamber		
47	holes	20	
48	holes		
49	holes		
100	inert oven		
200	inert oven	25	

Claims

1. Apparatus (100, 200) for photopolymerizing/drying a coating applied to pieces (10) wherein said pieces (10) to be dried are conveyed inside an inert tunnel (30) inside which there is provided a controlled atmosphere having a composition different from the earth atmosphere, said apparatus comprising:
 - a conveyor of said pieces,
 - at least a supplying bar (1, 2, 3, 4, 5, 6) for the controlled supply of an inert gas,
 - said inert tunnel being provided with at least one photopolymerizing/drying lamp (12) for photopolymerizing/drying said coating applied to said pieces (10),
 - at the inlet and/or outlet of said pieces (10) to be dried, said tunnel (30) being provided with at least one device, preferably in the form of a hood (31, 32), suitable for generating an air blade,

characterized in that

said air blade is generated by said hood (31, 32) comprising:

 - A boxed housing (33), preferably made of metal sheet, provided with the shape of a parallelepiped, whose longitudinal axis is placed perpendicularly to the conveying direction of the pieces to be dried;
 - Said boxed housing (33) being provided with a tilting wall (11), always oriented toward the out-
2. Apparatus (100, 200) for photopolymerizing/drying a coating applied to pieces (10) according to claim 1, wherein said air blade is oriented with at least a directional component perpendicular to the conveying direction of pieces, or at least a directional component parallel to the conveying direction of pieces.
3. Apparatus (100, 200) for photopolymerizing/drying a coating applied to pieces (10) according to claim 1, wherein the direction of said air blade is alternatively:
 - vertical, i.e. it is perpendicular to the conveying direction of the pieces; or
 - slanting, i.e. is tilted with respect to the ground with an angle ranging 0° - 45°.
4. Apparatus (100, 200) for photopolymerizing/drying a coating applied to pieces (10) according to one or more of claims 1-3, wherein, when placed at the inlet and/or outlet of pieces said air blade works according to one of the following three alternatives:
 - Said air blade supplies air and is vertical, parallel to the transversal section of the inert tunnel;
 - Said air blade supplies air and is slanting, provided with a tilting angle ranging between a vertical direction and about 45° with respect to a vertical direction or to the transversal section of the inert tunnel, said air blade being tilted in the same direction when placed at the outlet or in a direction opposite when placed at the inlet, with respect to the conveying direction of the pieces to be dried;
 - Said air blade is vertical and suctions air, i.e. atmospheric air is suctioned and directed upwards.
5. Apparatus (100, 200) for photopolymerizing/drying a coating applied to pieces (10) according to one or more of the preceding claims, wherein the flow of said air blade is directed from top to bottom.
6. Apparatus (100, 200) for photopolymerizing/drying a coating applied to pieces (10) according to one or more of the preceding claims, wherein said pieces (10) to be dried are:

- mainly flat panels provided with dimensions ranging 200x400x4 mm to 1300x3000x50 mm and/or
 - materials in rolls provided with a width ranging 300 mm - 1300 mm and a thickness ranging 0.5 - 6 mm and/or
 - three-dimensional pieces provided with dimensions ranging 200x400x100 mm up to a 1300x3000x200 mm.
7. Apparatus (100, 200) for photopolymerizing/drying a coating applied to pieces (10) according to one or more of the preceding claims, further comprising an oximeter (7); preferably said apparatus being configured to work with a feedback device allowing to adjust the quantity of inert gas according to the value of oxygen detected by said oximeter.
8. Method for the treatment of coatings applied to pieces (10) making use of the apparatus (100, 200) according to one or more of claims 1 - 7, wherein the keeping of an inert atmosphere inside said inert tunnel (30) for drying pieces is obtained through the generation of an air blade at the inlet and/or outlet of said tunnel (30), said air blade being oriented in a direction with at least a directional component perpendicular to the conveying direction of pieces and/or to the longitudinal extension of said channel (30), or at least with a directional component parallel to the conveying direction of pieces and/or to the longitudinal extension of said tunnel (30), the quantity of air provided through said air blade being varied through tiltable organs (11) deflecting the air flow of said air blade with respect to the conveying direction of pieces and/or to the longitudinal extension of said tunnel (30), said tiltable organs (11) consisting in a tilting wall always oriented toward the outside of said channel of a boxed body of a hood housing (33) having its longitudinal axis perpendicular to the pieces to be dried, said air blade being generated by a fan (9) for supplying air or a fan (8) for suctioning air and through a pierced wall (34), said pierced wall being also placed about perpendicularly to the conveying direction of the pieces to be dried.
9. Method for the treatment of coatings applied to pieces (10) making use of the apparatus (100, 200) according claim 8, wherein the quantity of inert gas supplied by said bar/s (1, 2, 3, 4, 5, 6) is feedback-adjustable according to the quantity of oxygen inside said inert tunnel (30) detected by said oximeter (7).
10. Apparatus (100) for photopolymerizing/drying a coating applied to pieces (10) according to one or more of the preceding claims 1 to 7 in which said tunnel (30) being in a fluidic connection with a fixture (40) inside which there is provided said lamp (42),
- said fixture (40) being isolated from the natural earth atmosphere;
- said fixture (40) being supplied with the same inert gas provided through said bars (1, 2, 3, 4, 5, 6), which gas reaches the inert tunnel (30) through said fluidic connection in addition and/or alternatively to the inert gas provided by said supplying bars (1, 2, 3, 4, 5, 6) and in which said fixture (40) comprises:
- A sealed external housing (44);
 - A gas expansion chamber (46);
 - A reflector (45), preferably made of a reflecting material.
 - in particular said lamp (42) being a photopolymerizing lamp emitting a suitable wavelength, optionally an excimer lamp.
11. Apparatus (100) for photopolymerizing/drying a coating applied to pieces (10) according to claim 10, wherein said fluidic connection between said fixture (40) and said inert tunnel (30) occurs through the flowing out of said inert gas from said fixture (40) through one or a combination of features taken from the following list:
- At least one row of small calibrated holes (49) placed in a reflector (45) surrounding said lamp (42), said row being placed vertically over the lamp (42);
 - At least one row of small calibrated holes (47) placed immediately on the left of the lamp (42);
 - At least one row of small calibrated holes (48) placed immediately on the right of the lamp (42).
12. Apparatus (100) for photopolymerizing/drying a coating applied to pieces (10) according to one of claims 10 or 11, wherein said fixture (40) is provided with one, preferably two points (43) of inlet of the inert gas; the supply of the inert gas being the same, or alternatively being independent from the supply of the bars (1, 2, 3, 4, 5, 6) supplying the inert gas to said inert tunnel (30) and optionally supplying the said gas at the same pressure.
13. Apparatus (100) for photopolymerizing/drying a coating applied to pieces (10) according to one or more of the preceding claims, wherein said lamp (42) is a photopolymerizing lamp emitting a suitable wavelength, preferably an excimer lamp.
14. Method for the treatment of coatings applied to pieces (10) making use of the apparatus (100, 200) according to one or more of claims 1 to 13, **characterized in that** it provides the generation of an area pressurized with inert gas at the point where and at the moment when the polymerizing reaction is triggered through said lamp (42), through a localized supply of said inert

gas inside said tunnel and on the piece (10) through the fixture (40) supporting said lamp (42), said inert gas at the same time cooling said lamp (42) and in which optionally flow rate of inert gas is supplied by a couple of bars (5) placed immediately upstream and downstream said fixture (40), while preferably both the fixture (40) and the supplying bars (1, 2, 3, 4, 5, 6) supply inert gas at the same pressure.

15. Apparatus (100) for photopolymerizing/drying a coating applied to pieces (10) wherein said pieces (10) to be dried are transported inside an inert tunnel (30) inside which there is provided a controlled atmosphere having a composition different from the earth atmosphere through the supply of an inert gas by at least a supplying bar (1, 2, 3, 4, 5, 6), said inert tunnel being provided with at least one photopolymerizing/drying lamp (42) for photopolymerizing/drying said coating applied to said pieces (10),

said tunnel (30) being in a fluidic connection with a fixture (40) inside which there is provided said lamp (42), said fixture (40) being isolated from the natural earth atmosphere; said fixture (40) being supplied with the same inert gas provided through said bars (1, 2, 3, 4, 5, 6), which gas reaches the inert tunnel (30) through said fluidic connection in addition and/or alternatively to the inert gas provided by said supplying bars (1, 2, 3, 4, 5, 6),

characterized in that

said fixture (40) comprises:

- A sealed external housing (44);
- A gas expansion chamber (46);
- A reflector (45), preferably made of a reflecting material.

16. Apparatus (100) for photopolymerizing/drying a coating applied to pieces (10) according to claim 15 **characterized in that** it is provided with one or more of the features of claims 1 to 7 and 10 to 13.

17. Method for the treatment of coatings applied to pieces (10) making use of the apparatus (100, 200) according to claim 14,

characterized in that

it provides the generation of an area pressurized with inert gas at the point where and at the moment when the polymerizing reaction is triggered through said lamp (42), through a localized supply of said inert gas inside said tunnel and on the piece (10) through the fixture (40) supporting said lamp (42), said inert gas at the same time cooling said lamp (42) and wherein optionally a further flow rate of inert gas is supplied by a couple of bars (5) placed

immediately upstream and downstream said fixture (40), while preferably both the fixture (40) and the supplying bars (1, 2, 3, 4, 5, 6) supply inert gas at the same pressure.

18. Method according to claim 17 which method further comprises one or more of the steps of the method according to one or more of claims 8, 9, or 14.

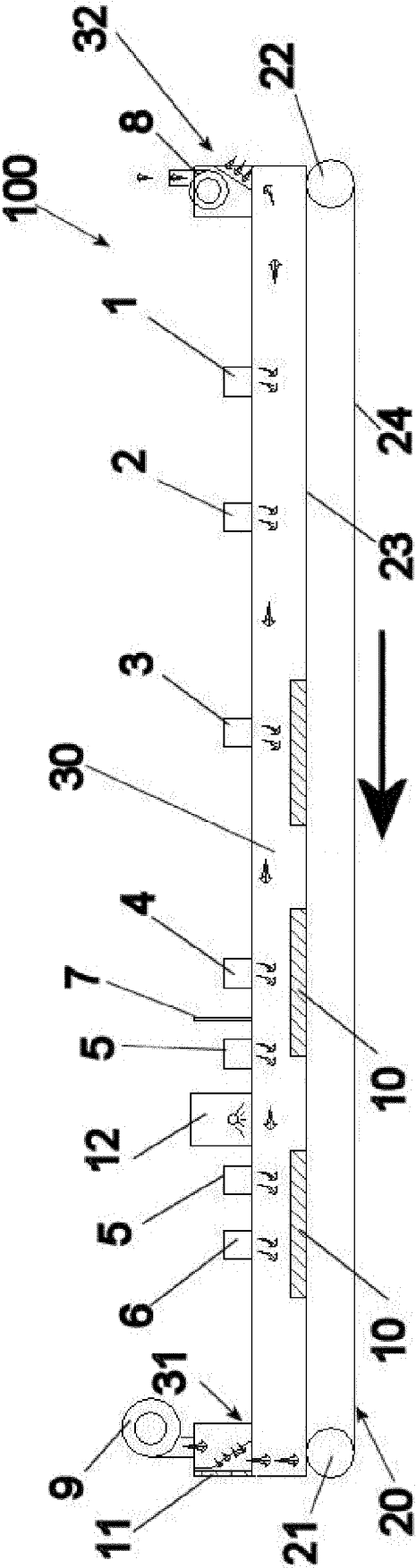


FIG. 1

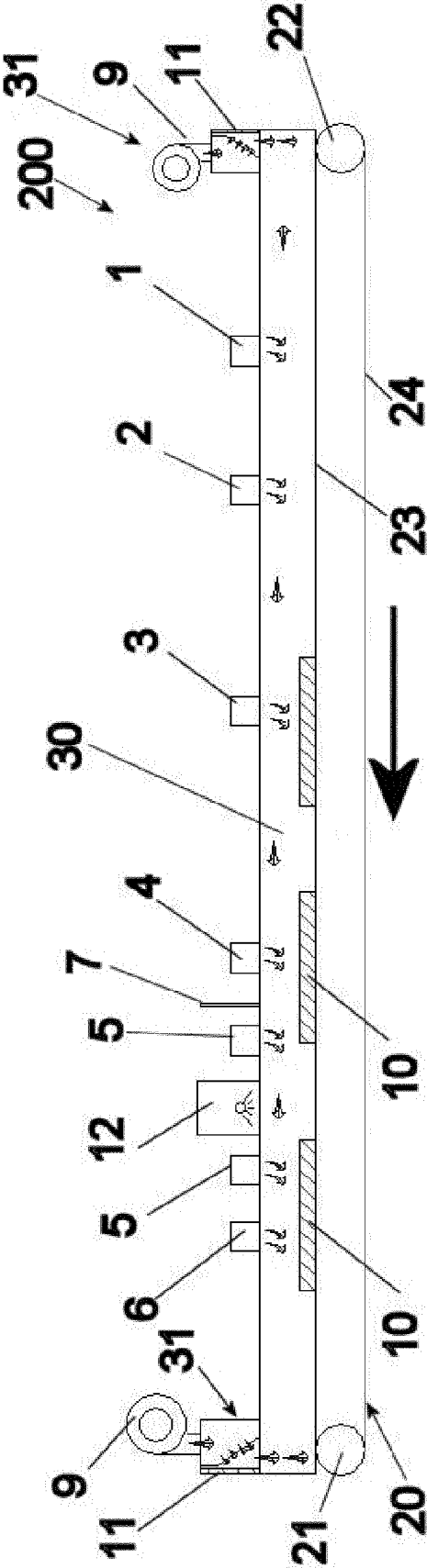
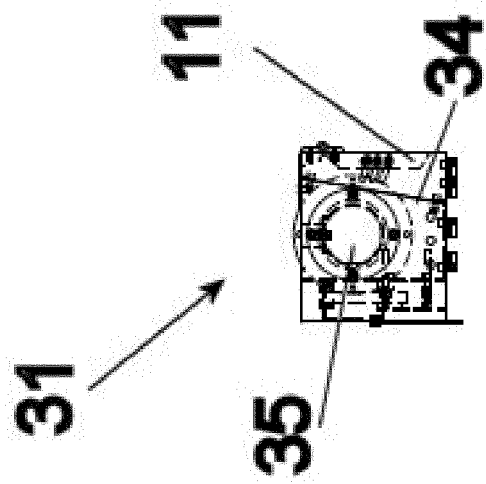
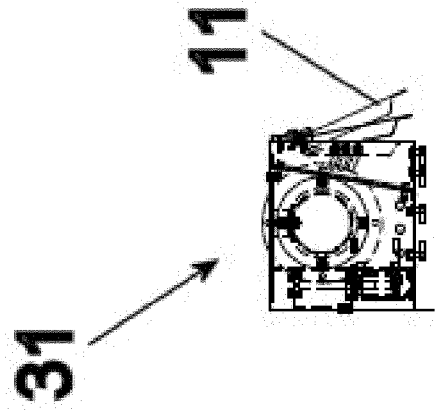
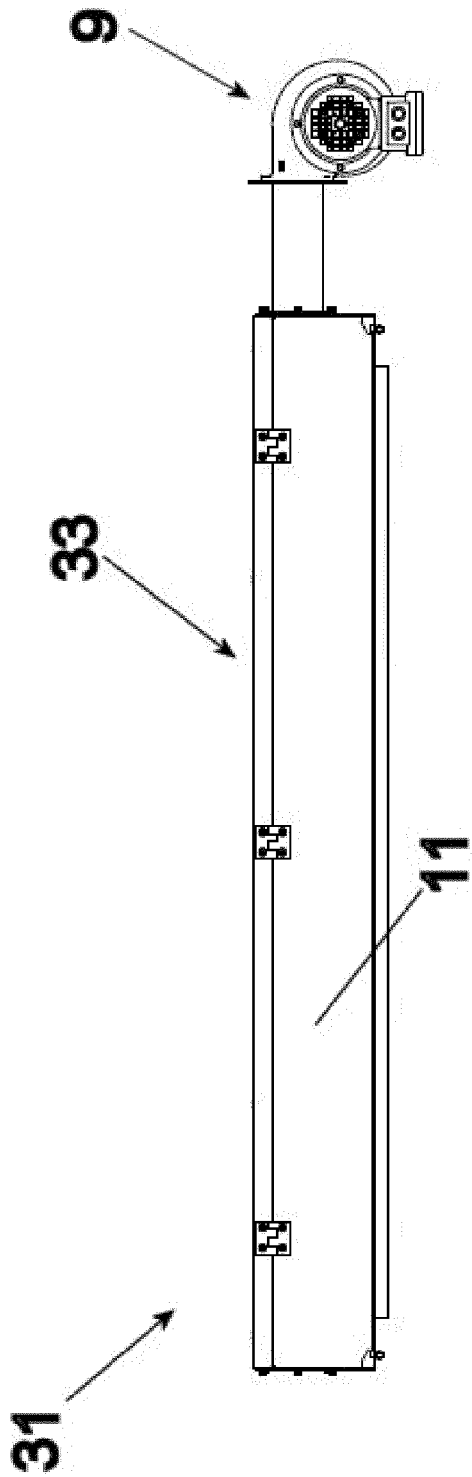


FIG. 2



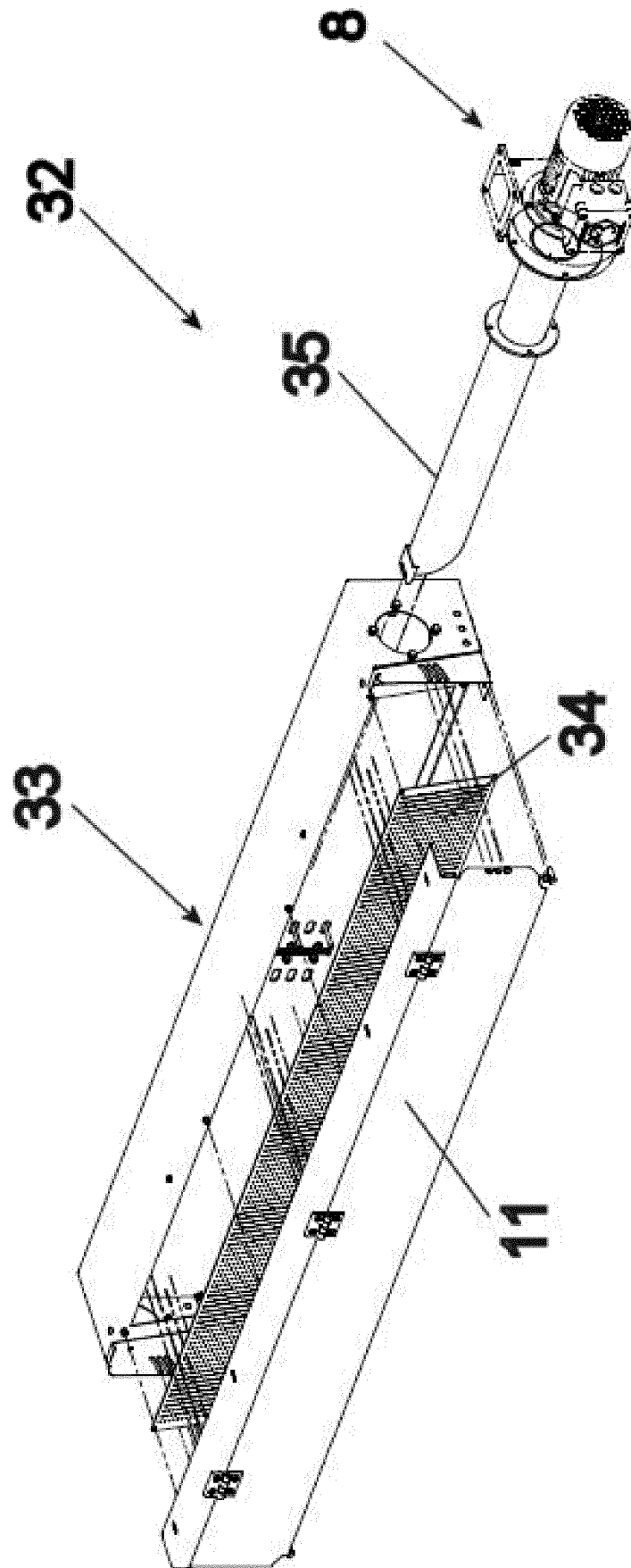


FIG. 5

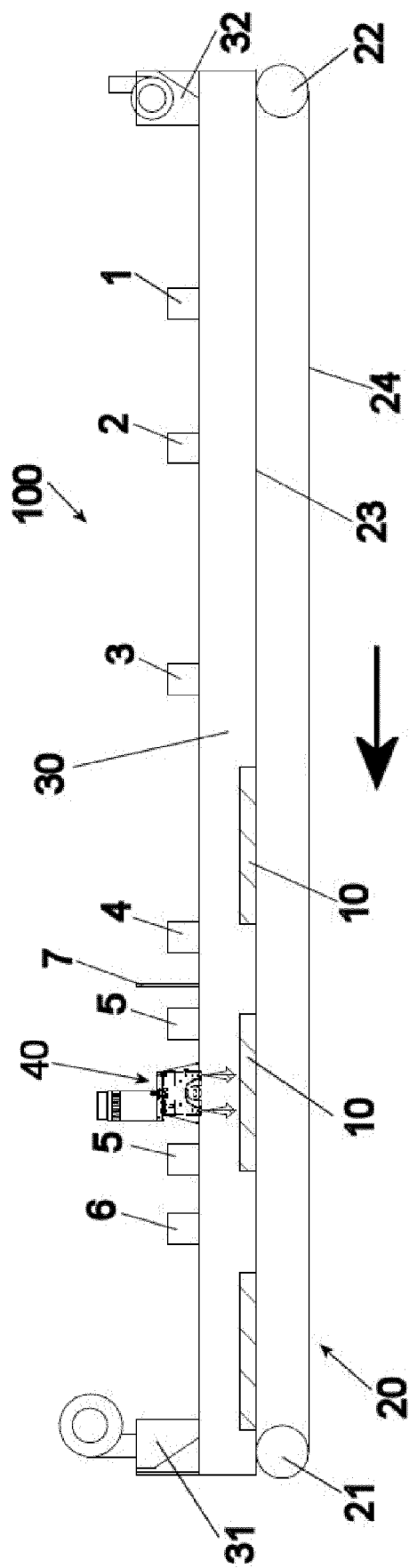


FIG. 6

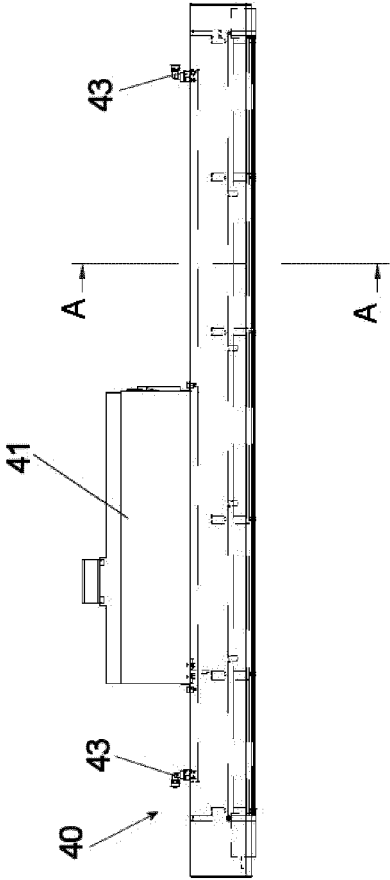


FIG. 7A

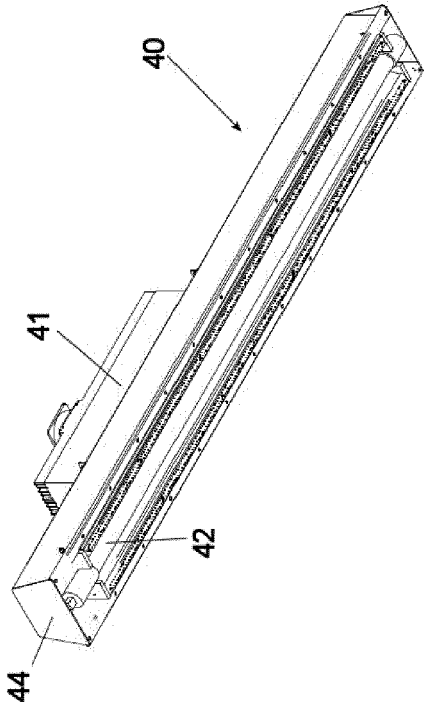


FIG. 7B

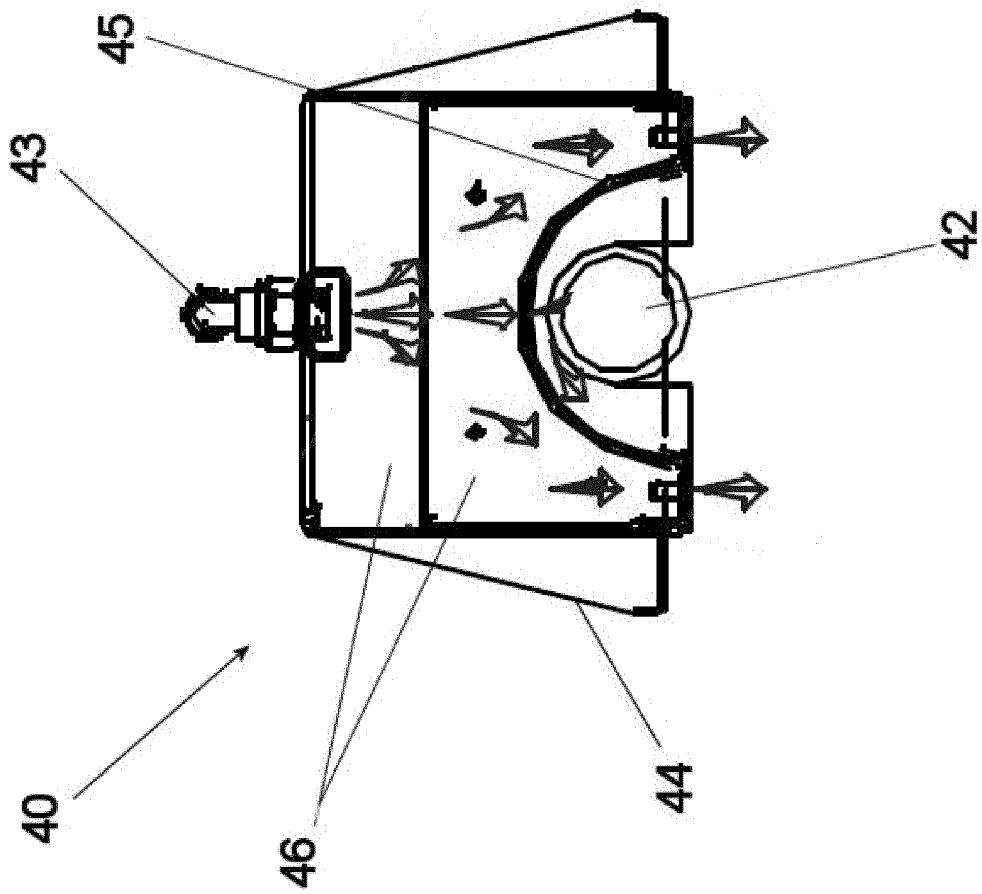


FIG. 8

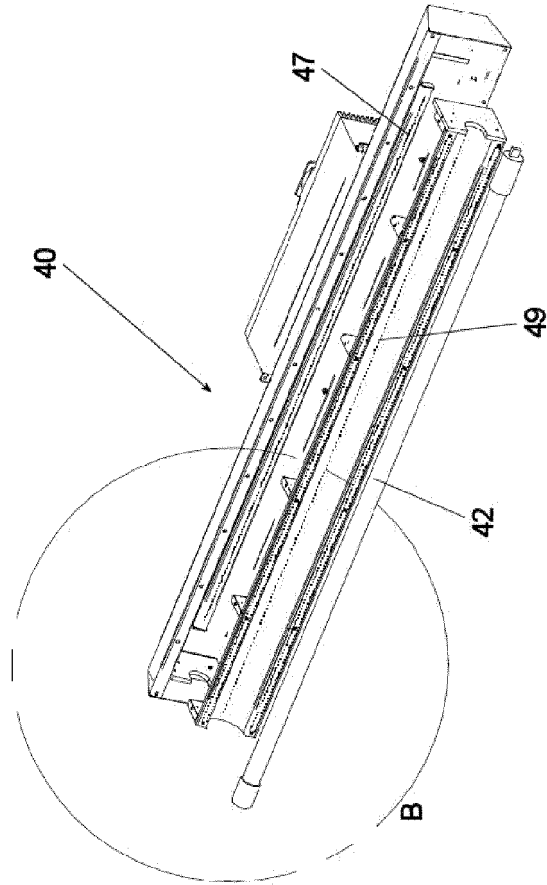


FIG. 9B

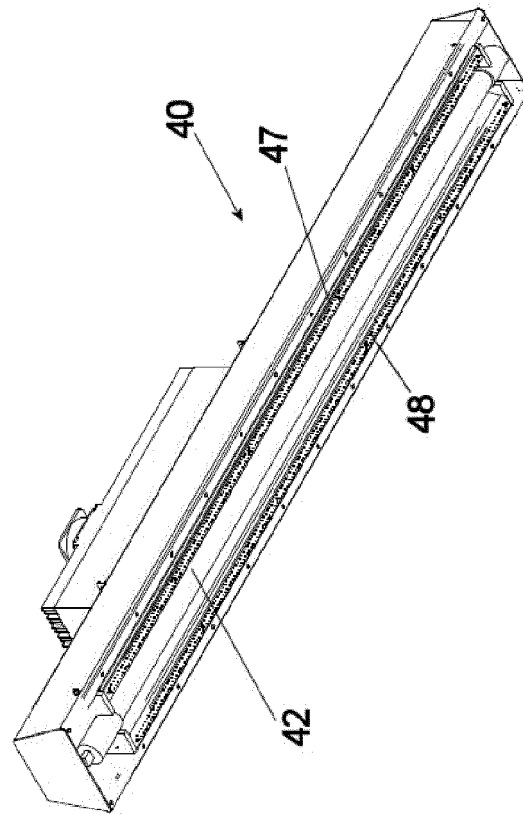
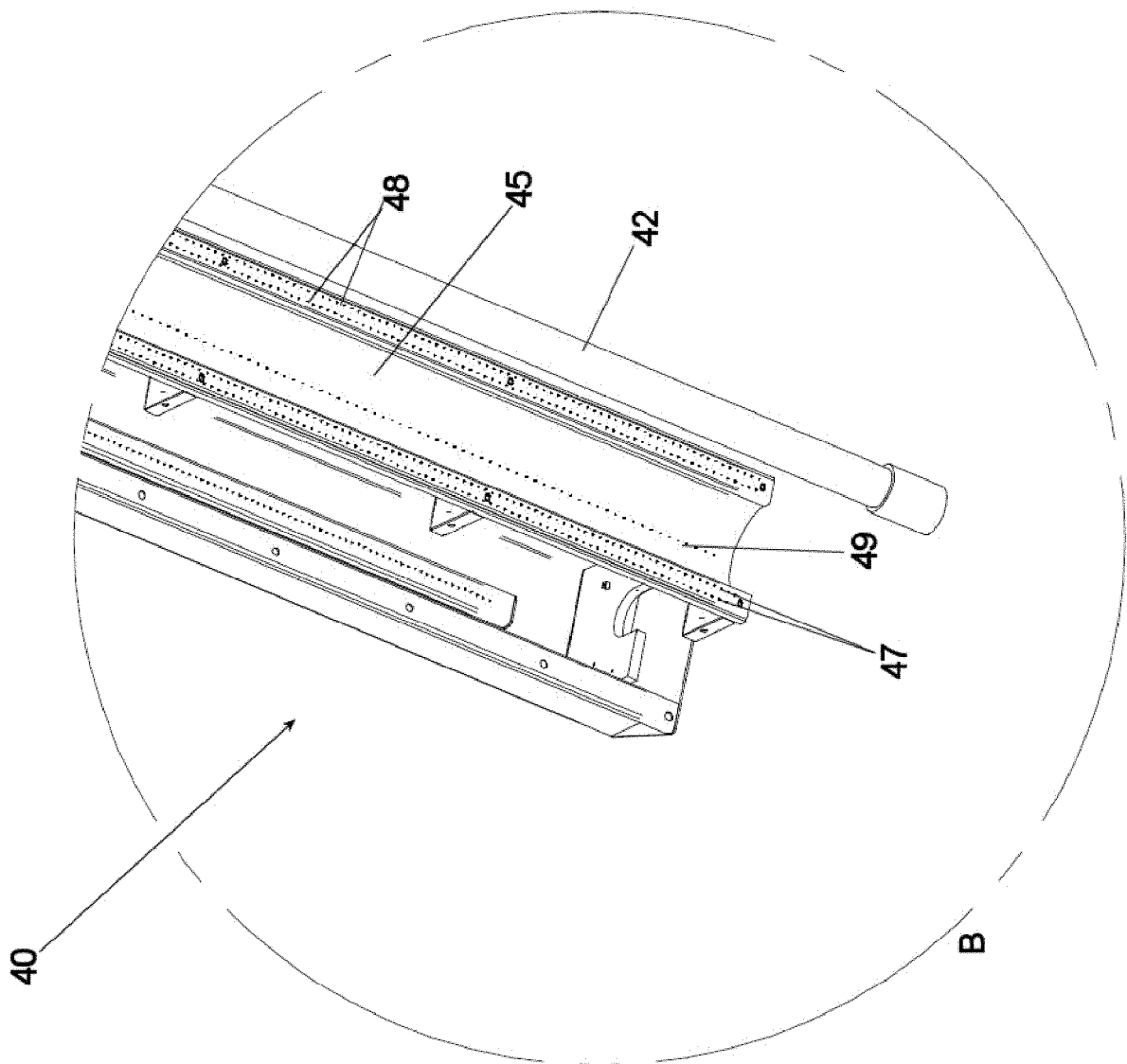


FIG. 9A

FIG. 10





PARTIAL EUROPEAN SEARCH REPORT

Application Number

under Rule 62a and/or 63 of the European Patent Convention.
This report shall be considered, for the purposes of
subsequent proceedings, as the European search report

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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 34 16 502 A1 (GOLDSCHMIDT AG TH [DE]) 7 November 1985 (1985-11-07)	1-7, 10-13	INV. F26B15/18
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-/--			

INCOMPLETE SEARCH

The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC so that only a partial search (R.62a, 63) has been carried out.

Claims searched completely :

Claims searched incompletely :

Claims not searched :

Reason for the limitation of the search:

see sheet C

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EPO FORM 1503 03.82 (P04E07)

Place of search	Date of completion of the search	Examiner
The Hague	30 August 2022	De Meester, Reni
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		



PARTIAL EUROPEAN SEARCH REPORT

Application Number

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EPO FORM 1503 03.82 (P04C10)

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (IPC)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
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A	EP 1 967 284 A2 (IST METZ GMBH [DE]) 10 September 2008 (2008-09-10) * figures 2-3 *	1-8, 10-13	
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INCOMPLETE SEARCH SHEET C

Application Number

EP 22 15 3139

Claim(s) completely searchable:

1-8, 10-13

Claim(s) not searched:

9, 14-18

Reason for the limitation of the search:

1 The present application contains 18 claims, of which 6 are independent. There is no clear distinction between the independent claims because of overlapping scope. There are so many claims and they are drafted in such a way that the claims as a whole do not comply with the provisions of clarity and conciseness in Article 84 EPC, as it is particularly burdensome for a skilled person to establish the subject-matter for which protection is sought. Non-compliance with the substantive provisions is such that a meaningful search of the whole claimed subject-matter could/can not be carried out (Rule 63 EPC and Guidelines B-VIII, 3).

2 Moreover, the application contains 2 independent apparatus claims (1 and 15) and 4 independent method claims (8,9,14,17). This goes against Rule 43(2) EPC, as the current set of claims does not fall under any of the exceptions mentioned in Rule 43(2) EPC.

3 Only one independent apparatus claim and one independent method claim should thus be indicated as the subject-matter to be searched.

The expression "making use of the apparatus according to claim 8" used in claim 9 is vague and unclear, as the subject-matter of claim 8 is a method. Therefore it leaves the reader in doubt as to the meaning of the technical feature to which it refers, thereby rendering the definition of the subject-matter of said claim unclear (Article 84 EPC) and hence making a meaningful search impossible for the subject-matter of claim 9 (Rule 63 EPC).

5 The expression "making use of the apparatus according to one or more of claims 1 to 13" used in claim 14 is vague and unclear, as the subject-matter of claims 8-9 is a method. Therefore it leaves the reader in doubt as to the meaning of the technical feature to which it refers, thereby rendering the definition of the subject-matter of said claim unclear (Article 84 EPC) and hence making a meaningful search impossible for the subject-matter of claim 14 (Rule 63 EPC).

6 The expression "making use of the apparatus according to claim 14" used in claim 17 is vague and unclear, as the subject-matter of claim 14 is a method. Therefore it leaves the reader in doubt as to the meaning of the technical feature to which it refers, thereby rendering the definition of the subject-matter of said claim unclear (Article 84 EPC) and hence making a meaningful search impossible for the subject-matter of claim 17 (Rule 63 EPC).

7 The expression "with one or more of the features of claims 1 to 7 and 10 to 13" used in claim 16 is vague and unclear, as there are thousands of possible combinations of the features of claims 1 to 7 and 10 to 13. Therefore it leaves the reader in doubt as to the meaning of the technical feature to which it refers, thereby rendering the definition of the subject-matter of said claim unclear (Article 84 EPC) and hence making a meaningful search impossible for the subject-matter of claim 16 (Rule 63 EPC).

INCOMPLETE SEARCH
SHEET C

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8 The expression " which method further comprises one or more
of the steps of the method according to one or more of claims 8, 9, or
14." used in claim 18 is vague and unclear, as there are thousands of
possible combinations of one or more of the steps of the method according
to one or more of claims 8, 9, or 14. Therefore it leaves the reader in
doubt as to the meaning of the technical feature to which it refers,
thereby rendering the definition of the subject-matter of said claim
unclear (Article 84 EPC) and hence making a meaningful search impossible
for the subject-matter of claim 18 (Rule 63 EPC).

9 The applicant is therefore invited to file a statement
indicating the subject-matter to be searched within the time limit
indicated in the present communication (Rule 63(1) EPC).

ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 22 15 3139

30-08-2022

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ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 22 15 3139

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REFERENCES CITED IN THE DESCRIPTION

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