

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
18 May 2006 (18.05.2006)

PCT

(10) International Publication Number
WO 2006/052919 A1

(51) International Patent Classification:
B65G 49/06 (2006.01) **B65G 51/03** (2006.01)

(21) International Application Number:
PCT/US2005/040351

(22) International Filing Date:
8 November 2005 (08.11.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/625,583 8 November 2004 (08.11.2004) US
60/644,981 21 January 2005 (21.01.2005) US

(71) Applicant (for all designated States except US): **NEW WAY MACHINE COMPONENTS, INC.** [US/US];
4009-1 Market Street, Aston, PA 19014 (US).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **DEVITT, Andrew, J.** [US/US]; 12 N. Bryn Mawr Place, Media, PA 19063 (US).

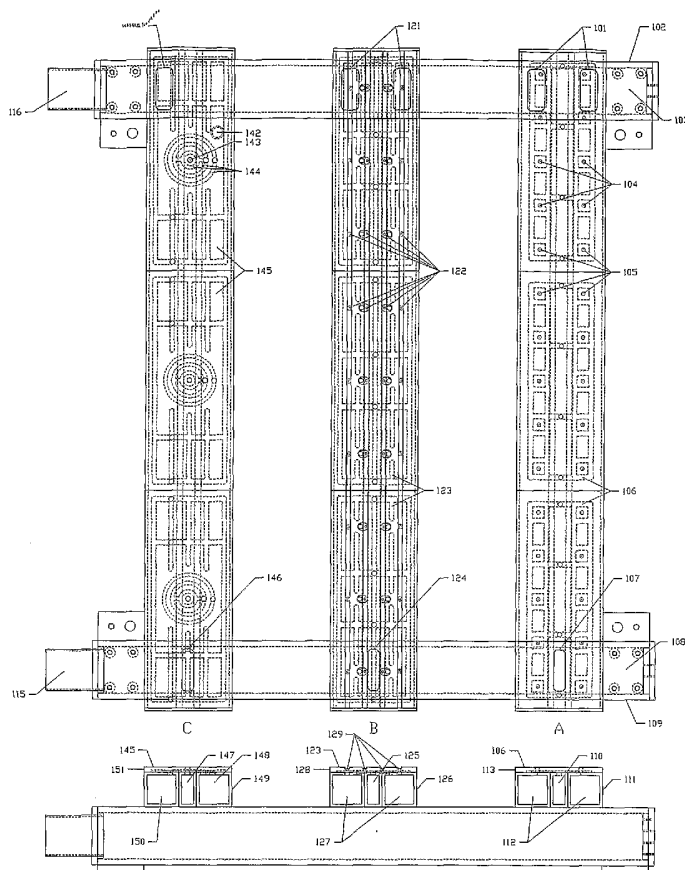
(74) Agents: **GREENBAUM, Michael, C.** et al.; Blank Rome LLP, 600 New Hampshire Avenue NW, Suite 1100, Washington, DC 20037 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),

[Continued on next page]

(54) Title: NON-CONTACT POROUS AIR BEARING AND GLASS FLATTENING DEVICE



(57) Abstract: Thin substrates, such as flat glass panels, are levitated on a porous media air bearing creating a pressurized film of air and preloaded against the air film by negative pressure areas. The pressure can be distributed most uniformly across the pressure areas by defusing the pressure through a porous medium. Such a bearing can be used for glass flattening by holding the glass such that the unevenness is migrated to the side opposite the side to be worked on.



European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

NON-CONTACT POROUS AIR BEARING AND GLASS FLATTENING DEVICE**Reference to Related Applications**

[0001] The present application claims the benefit of U.S. Provisional Patent Application No. 60/625,583 (Conf. No. 8294), filed November 8, 2004, and U.S. Provisional Patent Application No. 60/644,981 (Conf. No. 7250), filed January 21, 2005, both of whose disclosures are hereby incorporated by reference in their entireties into to present disclosure.

Field of the Invention

[0002] The invention is directed to a system and method for supporting thin work pieces, particularly glass, for precision inspection, coating, patterning, and other processes without contacting the work piece.

Description of Related Art

[0003] Flat-panel display (FPD) screens especially for computer and large screen televisions have pushed manufacturers to processing very large and thin glass substrates. As the substrates get larger they become more difficult to handle with robotic arms due to deflections of the glass from its own weight. A method for transporting glass on a cushion of air could eliminate many problems buy supporting the glass more uniformly without touching the glass. Most of the current efforts in this regard include air floatation tables employing orifices and compressed air from outside of the clean room. The cost involved in cleaning, drying and temperature controlling the compressed air is a very expensive cost of ownership issue. Also as these large glass sheets are predominantly processed in the horizontal plane, the supporting air nozzles or orifices create airflow geysers in competition with the natural down flow of the clean room air. Further, these jets of air create low-pressure around them attracting particulates which have settled on the support surface and sending them up on the geysers of air. It is then likely that these particulates will settle on to the workpiece surfaces, which is exactly what is to be avoided. These types of conveyors also suffer from the fact the

glass is not naturally flat. Corners or edges may want to turn up or turn down, causing contact with the air table or vertical lift at higher speeds. More advanced systems use vacuum to hold glass flat against an array of pressurize orifices that are supplied with air by compressors from outside the room at pressures in excess of one atmosphere (14 psi).

[0004] A fundamental physical problem to be overcome stems from the low stiffness of the glass. It is simpler to generate vacuum and pressure forces by using continuous uninterrupted surface areas. Unfortunately this is likely to result in the distortion of the glass. To avoid this distortion it is best to put the alternating pressure and vacuum regions at a high frequency (pitch). The unfortunate thing on this side is that the air bearing pressure areas become inefficient on exponential curves as the lands get narrower thus requiring higher pressures to achieve the same lift height. This couples to the second derogatory effect which is that the flow through a gap is a cubic function of the gap. So pressures and flows go up as the period between vacuum and pressure is reduced.

[0005] One potential application for this technology is the handling and transporting of flat panel glass sheet during the manufacturing of flat-panel display screens. During this process it is desirable to move glass rapidly from point-to-point. The speed is limited by leading edges of the glass that may want to curl up away from the guidance. Up turning edges can send the glass airborne at high velocities, especially between vacuum ports as employed in prior art. This tendency to curl up or down may be from a natural stress in the glass or from additional coatings applied during the manufacturing process.

[0006] FPD glass has a natural 5 to 7 micron thickness variation as it is made, when it is sucked down to a flat vacuum chuck for processing, all 5 to 7 microns of thickness variation will appear as surface flatness error opposite the chuck side. By sucking the glass up by vacuum pressure to a non-contact air bearing chuck that is arrayed around an optical aperture, the flat side of the glass can be presented to the optics. This satisfies the requirement for

shorter depth of field and enables higher resolution lithography while greatly minimizing the structural loop between the optics and the glass. The thickness variation error in the glass does not cause problems for conventional LCD manufacturing but it is becoming a limiting factor for higher resolution types of lithography that will be required for higher definition displays.

[0007] The prior art includes the following:

[0008] Patent number: US6781684 Inventor: Ekhoﬀ, Donald L This reference uses the structure to conduct pressure and vacuum to the various pressure and vacuum openings on the surface of the structure, which supports the air film, which supports the workpiece. The patent teaches a continuous uninterrupted surface. This uninterrupted surface interferes with the natural down flow of clean room environments this is further aggravated by having by having pressure orifices which amount to vertical air stream jets, which send particulates up against the natural down flow. This reference also employees raised regions with coplanar surfaces surrounding the exhaust ports. These raised regions acted as Pinch valves for self-regulating fly height purposes. Although this is a clever design there are significant problems with its application. As the edges and corners of the glass tend to blow up or down these raised regions present a vertical wall for the glass to hit against. A further disadvantage of this invention is that any particulate that may be present on the surface will be attracted to the gap between the raised planar surface around the exhaust port and the workpiece of interest being floated by the fact that the exhaust gas is being sucked through that gap. This is likely to cause backside damages and scratches to the workpiece. A further disadvantage is that the air pressure gap must be relatively thick (at least as thick as the raised areas) which results in the low stiffness of air film that will provide little resistance or damping to vertical vibrations. This means the glass will be more prone to chatter than a system operating on a thinner air

film. The damping coefficient of an air film decreases as a cubic function of increases in the gap.

[0009] Published patent application no: US20030177790A1 Inventor: Langsdorf, Andreas; This reference has some similarities to the current invention with the important following differences. Namely this reference is concerned only with hot glass in the handling during the ceramic process. Although it does employ modular support beams, which conduct pressure through the interior of their structure, they are only claimed to conduct pressure. Most importantly Langsdorf does not claim for vacuum

[0010] WIPO PCT WO2004/079496 Inventors: Shigeru, Yamamoto; Adin, Raanan

[0011] Patent application number US 2003/0169524 A1 Filed: December 27, 2002 Issued; September 11, 2003 Inventors: Adin, Raanan; Yuval Yassour Porous media air bearings are not in any definition orifice type bearings. There are well known and recognized classifications of air bearing types including; step, orifice and porous. The Ekhoﬀ patent is analogous to step type compensation. Levin and Yuval patent is consistent with the orifice type but with the clever use of turbulent flow restriction in the orifice.

[0012] The Ekhoﬀ patent filed November 7, 2000 and issued August 24, 2004 clearly claims for manufacturing and inspecting electronic circuits by using an air flotation system to translate the workpiece. It is interesting to note that the Adin, Yassour provisional patent application filed on December 27, 2001 and issued on September 11, 2003 also clearly claims for manufacturing and inspecting electronic circuits by using an air flotation system to translate the workpiece.

Summary of the Invention

[0013] It is therefore a goal of the present invention to overcome the above-noted deficiencies of the prior art.

[0014] To achieve the above and other goals, the present invention is directed to a method for supporting and transporting thin substrates by levitating them on a porous media air bearing creating a pressurized film of air and preloading them against the air film by negative pressure areas. The pressure can be distributed most uniformly across the pressure areas by defusing the pressure through a porous media. Low-pressure regions can be holes or grooves connected via orifices to low-pressure chambers. These low-pressure chambers can be internal areas of structural tubing used to support the surface or plenums created by separation plates.

[0015] Using porous air bearing technology is novel in this area of art and has many advantages. First everywhere there is porous media bearing face, which in these embodiments is everywhere there is not a vacuum hole or groove, there is force pushing up. This becomes more intuitively obvious when a person actually presses with their finger on glass supported by a porous air bearing. Several pounds of force is required to ground the glass even with only 10psi in put pressure, orifice bearings allow the glass to be grounded with only fractions of an ounce when pressed on between pressure nozzles as air will not naturally flow to an area of increased resistance and only ounces when pressed directly over a hole as the air expands immediately as it exits the nozzle, losing pressure. Additionally once the gap over the nozzle is reduced the pressure directly over the nozzle may increase but the effective area for the pressure to act becomes little more than the area of the hole in the nozzle. Additionally as the leading edge of the glass transits over the pressure nozzles there is a perturbation and the edge of the glass may curl down between the pressure nozzles. A porous media bearing face provides the leading edge of the glass with uniform pressure as in transits including right

to the bitter edges of the bearing. A porous air bearing is silent and the low air flow can not be detected emanating from the surface by feel so it will not create vertical air streams, these are the reasons adaptive nozzles are used in some prior art.

[0016] The present invention is also directed to a technique for flattening glass. The common technique for holding large thin glass work pieces is to suck them down to a vacuum chuck the same size as the glass. In that method there are two main sources of flatness errors; the flatness of the chucks supporting the glass including any contamination which may be between the glass and the chucks and the thickness of the glass itself. By conveying the glass on a of film of air and employing precision zones adjacent to precision processes the cost and many of the problems associated with substrate sized vacuum chucks can be eliminated. A further advantage, and the subject of this patent application, is to design the precision zone so as to present the flattest possible surface for high-resolution lithography and or other precision processes. By positioning the vacuum preloaded air bearing array on the same side as the processing, natural thickness errors in the glass or substrate can be removed or minimized for processing.

Brief Description of the Drawings

[0017] Preferred embodiments of the invention will be set forth in detail with reference to the drawings, in which:

[0018] Figure 1 discloses the labyrinth porting used to distribute the multiplicity of pressures and vacuum to the appropriate places under the porous media. The end view also discloses which chambers in the extrusions are used for conducting which of the pressure or vacuum sources. Bearing B refers to embodiment B, bearing C refers to embodiment C and bearing A refers to embodiment A.

[0019] Figure 2 is a top-level drawing of the same bearings disclosing the patterns that would be found on the face of the bearings.

[0020] Figure 3 shows a photograph of the actual apparatus of embodiment B employing linear grooves and bearing strips parallel to the translation of the glass.

[0021] Figure 4 shows a photograph of the embodiment C for the high lift low flow apparatus. Embodiment A may also be seen between two arrays of embodiment C employed with ambient grooves. In this case embodiment C is being used as a rough high speed conveyor and embodiment A is being tested for a high precision work area.

[0022] Figure 5 shows a photograph of embodiment A without ambient pressure grooves.

[0023] Figure 6 is a drawing detailing the embodiment A which discloses the porting under the porous media conducting pressure and vacuum sources and a preferred embodiment of the bearing face design employing ambient pressure grooves and solid stock with full length bottom mounting.

[0024] Figures 7A-7C show a glass flattening technique according to a preferred embodiment.

[0025] Figure 8 shows another glass flattening embodiment.

[0026] Figure 9 shows another glass flattening embodiment.

[0027] Figure 10 shows a glass flattening technique according to the prior art.

Detailed Description of the Preferred Embodiments

[0028] Various preferred embodiments of the invention will be set forth in detail with reference to the drawings, in which like reference numerals refer to like elements throughout.

[0029] A device is disclosed for supporting and transporting thin substrates by levitating them on a porous media air bearing creating a pressurized film of air and preloading them against the air film by negative pressure areas. The pressure can be distributed most uniformly across the pressure areas by defusing the pressure through a porous media. Since the entire top surface the conveyer or precision chuck has air pressure bleeding out the surface it is not dependant on flow though the gap to support an area of increased load. Another advantage of the porous media air bearing is that because the air escapes from the whole surface the velocity of the air is very low, eliminating vertical air streams. Vacuum regions can be holes or grooves connected via orifices to vacuum plenums within the conveyer or precision chuck. These vacuum plenums can be internal areas of structural tubing used to support the surface or tubing created by separation plates or plenums milled from solid stock. The fact that the conveyers and chucks can be from extrusion 244, 223, 206 with internal plenums for various pressures reduces cost. Their modularity allows for separation between them so that the vertical down stream flow of clean room air may flow between them. They may be made from metal, ceramic (for high temp.), fiberglass, carbon fiber or plastics. It is convenient that the structures that support the conveyers may also be used as manifolds to conduct vacuum or high pressure air to the the plenums of the conveyers. The porous media may be of graphite, carbon, ceramic, metal or plastic

[0030] A high speed embodiment will be disclosed.

[0031] Our research has found that grooves 129, 225 running parallel to the motion of the glass (embodiment B) (see Figures 1, 2 and 3) provide the best vacuum hold down force at the leading edge of high velocity glass. We found the preferred embodiment includes

pressure areas thru porous media 128,224 and vacuum grooves 129, 225 running parallel to the motion of the glass. The pressure area is supplied with air pressure from underneath via a groove network 123 which is supplied thru hole 130 to plenum 125, in turn ported to manifold 115 thru duct 124. The width of the pressure areas 222 and vacuum grooves 129, 225 are determined by the stiffness of the material being suspended and the force of various vacuum and pressure sources exposed to the glass. The vacuum grooves 129, 225 are evacuated via orifice 122, 221 to a vacuum plenum 127. This embodiment provides the most consistent hold down force at the leading edge of glass. Orifices 122, 221 placed periodically in the bottom of the groove 129, 225 evacuate the grooves 129, 225. The manifold 102, 201 and ducting 121, which are used to conduct vacuum to the plenums 127 and so the lower side of the orifices 122, 221 are such that the pressure in them does not change regardless of whether the glass is over the orifices 122, 221 or not. This can be affected by having a conductance through the manifolds 102, 201 and ducts 116, 121, 210 and plenums 127 an order of magnitude more than the conductance through the orifices 122, 221. The grooves 129, 225 are significantly different than the grooves in claim 45 of US patent 6644703 B1 as they are conducted to vacuum source, where in that reference they are not.

[0032] A low flow embodiment will be disclosed.

[0033] In some cases it is desirable to maintain a large gap between the support surface and the glass (embodiment C) (see figures 1, 2 and 4). In this case the vacuum grooves 129, 225 described above create so much down force that it can be difficult to maintain an air gap in excess of 25 um without requiring pressure and hence flow at undesirably high levels. The problem is such that air gaps of 25 um or more have relatively low stiffness and so even low vacuum pressures will drive the gap to the 25 um region or below. It should be noted that flow through the gap is closely related to a cubed function of the gap. An object of this embodiment is to provide for vacuum hold down at high gaps without high input flow.

[0034] In order to affect this condition vacuum holes 143, 241 are employed which are conducted with or without orifices to vacuum plenum 147. The vacuum holes 143, 241 are placed in the surface relatively far apart from each other, this distance being on the order of 100 to 300 mm to create high stiffness areas as needed by the application. Around each of the vacuum holes 143, 241 is a separately plumbed grove net work 144, which conducts relatively high pressure air to the porous media surrounding the vacuum hole 242. This high pressure may be on the order of 10 to 50psi, which is sufficient to create an air gap on the order of 25 to 300 um even directly around the vacuum port. This high pressure grove net work 144 is connected to plenum 148 via holes 152. Plenum 148 may be supplied thru port 142 which may have a smaller aperture as the air being conducted thru it has a higher pressure. The rest of the pressure area 243 can be supplied with relatively low-pressure air 1 to 10psi thru grove net work 145. Without having to counteract the vacuum force the low pressure area 243 can easily support 25 to 300 um fly heights with relatively low air flow. The high vacuum area 143, 241 surrounded by high-pressure areas 144, 242 creates a high stiffness region even at relatively high fly height of 75 to 300 um. Because the total area of the high pressure area is limited so is the total flow. The high pressure, low pressure and vacuum are separated at the bond line between the porous media and the extrusion or machined from solid housing buy the glue beads used to hold the porous media to the extrusion or machined from solid housing.

[0035] Precision conveyers and chucks will now be disclosed.

[0036] In another embodiment (A) of the invention, vacuum holes 104, 202, 609 are put on a smaller pitch of approximately 25 to 50 mm (see figures 1, 2, 4, 5 and 6). A porous media air bearing land 610 is positioned about the vacuum hole 104, 202 as shown in figures 4 and 6. The air bearing area 106, 204, 610 is supplied air via a grove net work 105, 606 which is supplied thru port 107 to plenum 110 to manifold 109 or in the from solid case from port 611

to supply hole 612. The air bearing land is defined by ambient pressure grooves 601 or the edges of the bearing itself. Vacuum is supplied to the vacuum holes via plenum 112 or 602. When this embodiment is employed on an extrusion the vacuum may be ducted thru ports 101 and when employed on a chuck from solid stock the chuck may be bolted down thru bolt holes (4) 608 over a hole 603 on the surface 605 of base structure 607. The vacuum hole 104, 202 609 is provided with a precision drilled or removable orifice that is matched to one half of the flow thru each of the air bearing land areas. In this way the flow thru the orifice is the same whether the glass is over the hole or not.

[0037] This embodiment results in the most consistent fly heights over the length of the bearing and the least distortion of the glass. Further it provides the most high stiffness areas and the highest average stiffness and damping. When this embodiment is from solid stock and bolted to a stable structure vertical stability of .7mm glass can be less than ± 1 nanometer while flying in an operational mode. It is also possible to employ this embodiment without ambient grooves (see figure 5).

[0038] Note that the embodiment described in fig. 6 is designed to have a bottom surface that is very flat, parallel to the top bearing surface and individual precision chucks are provided in matched thicknesses so that they may be mounted to a planar surface and create a plane from their top surfaces.

[0039] Embodiments for glass flattening will now be described.

[0040] Fig 7A is a representation of flattening the glass for a precision optical process by use of an array of vacuum preloaded air bearings; these bearings could be consistent with the previously disclosed air bearing conveyers or precision chucks. Because the vacuum force is significantly stronger than the bending force of the glass the vacuum force pulls the glass 707 against the air film 705, which has a relatively high stiffness and is supported in a flat plane by the face 703 of the air bearing array 704. Gap is inversely proportional to stiffness; so

small gaps have higher stiffness. We have found 15 to 35 microns fly height to be good compromise between manufacturing tolerances/ safety against touchdowns and stiffness. Notice that the surface of the glass being processed has been flattened against the air film 705. A further advantage is not only does this invention flatten thickness variation within a single sheet, there may also be large thickness variation between different sheets but the distance between the optics and the surface of interest will always be the same. In previous art the distance between the optics and the surface of the glass being processed would have had to be physically adjusted because of the thickness change of the glass. Also, because much processing is done with some sort of a radiation 701 (light, laser, etc...), heat from this process can warm the glass 707 causing it to grow. Axial growth (in X and Y, not in thickness) is the main cause of position error. By holding the glass 707 over a precision chuck 742 as in figure 7C, all of this radiation will be captured by the glass 707 or the chuck 742 in the case of a precision air bearing chuck as previously described the heat can come back to the glass though radiation from the chuck or conductance though the air gap. In the case of conventional vacuum chucks there is physical contact between the glass and the chuck, as shown in fig. 10, so radiation that makes it though the glass will be absorbed into the chuck as heat which will effect the chuck's dimensional stability and the heat will be conducted into the glass though contact effecting it's dimensional stability even more. By guiding the glass 707, on the same side that is being processed, by vacuum preloaded conveyor or precision air bearings as described in figure 7A the optical path under the glass 711 can be clear for a meter or more allowing excess radation to take its heat away from the glass and areas of interest here, much of the radiation may flow through the glass 707 to some surface a meter or more away, preventing thermal problems.

[0041] Fig 7B. depicts thickness variation in typical FPD sheets. Periods 723 between the glass 707 maximum 721 and minimum 720 thicknesses (the amplitude of this difference is about 5 to 7 microns) is on the order of 100 to 200 mm.

[0042] Fig 7C depicts glass flowing on a precision air bearing chuck or conveyer illustrating that the flat side of the glass would be the side adjacent to the chuck and not the side available for processing from above.

[0043] Fig. 10 is an illustration of prior art, comprising a substrate sized vacuum chuck 762, which can be on the order 2 meters by 2 meters, to which the glass 707 is urged into physical contact by the higher ambient atmospheric pressure. Providing there is no contamination between the glass 707 and the chuck 762, the glass 707 will become flat on the chuck side 708. If there is contamination this will often damage the glass. The opposed side 706 that will be available for precision processes will have the total thickness error 741 as a flatness error. In the practice of conventional art the glass 707 is in contact with the chuck 762.

[0044] Fig 8 is an embodiment where the glass is also suspended from an air bearing vacuum preloaded precision chuck 810. It flows off the chuck 810 into a long narrow precision area 801 orthogonal to the motion of the glass and appropriate for applying a coating from coating nozzle 811, or line inspection or exposure as examples. In the coating application the glass 807 after passing the precision area, would likely flow onto another precision chuck or conveyor air bearings 804 that support the glass 807 from underneath, as it would not be advantageous to run air bearings on a freshly coated surface, although the glass 807 could flow onto a conveyor 802 that continues to suspend the glass 807 from above as in inspection or exposure. The conveyers 804 may have an aperture as described in figure 7A.

[0045] Fig 9 is a representation of an embodiment for lithography or optical inspection. In this case apertures of different sizes 903 like; 100mm by 100mm, 150mm by 150mm or 200mm by 250mm as examples are surrounded by precision air bearing vacuum preloaded

chucks 901. These bearings will have the effect of flattening the glass. More effective flattening and transfer can be achieved by alternating the exposure zones 903. This embodiment is a partial plain view of the profile view shown in Fig 7A.

[0046] While various preferred embodiments of the present invention have been set forth in detail, those skilled in the art who have reviewed the present disclosure will readily appreciate that other embodiments can be realized within the scope of the invention. For example, numerical values are illustrative rather than limiting, as are disclosures of specific materials. Also, any features from one embodiment can be incorporated into any other embodiment wherever appropriate. Therefore, the present invention should be construed as limited only by the appended claims.

I claim:

1. A vacuum preloaded porous air bearing assembly for conducting flows at pressures above and below ambient, the bearing assembly comprising:

a main body having a face and having a plurality of vacuum holes or grooves formed in the face; and

a porous medium disposed at said face;

wherein the main body has formed therein:

a first network of conduits for conveying a first fluid flow at a pressure above ambient from a source of said first fluid flow through said main body and out of said main body through said porous medium; and

a second network of conduits for conveying a second fluid flow at a pressure below ambient from a source of said second fluid flow through said main body and out of said main body through said vacuum holes or grooves.

2. A bearing assembly as claimed in claim 1, wherein the bearing assembly is horizontal.

3. A bearing assembly as claimed in claim 1, wherein the bearing assembly is inclined on an angle.

4. A bearing assembly as claimed in claim 1, wherein the bearing assembly is vertical.

5. A bearing assembly as claimed in claim 1, wherein:

a first pressure above ambient is conducted to a first portion of the first network under a majority of the surface area of the bearing, which defines a first porous media bearing area; and

a second pressure above ambient, which is higher than said first pressure above ambient, is conducted to a second portion of the first network to a second porous media bearing area that is directly around the vacuum holes.

6. A bearing assembly as claimed in claim 1, wherein:

the vacuum holes or grooves are provided as grooves in a direction parallel to a direction of movement of a work piece over the face; and

the porous medium is formed as porous media air bearing land areas which are also in a direction parallel to the direction of movement.

7. A bearing assembly as claimed in claim 1, wherein:

the vacuum holes or grooves are provided as vacuum holes;

the porous medium is provided as a porous media air bearing land which surrounds the vacuum holes; and

the bearing assembly further has ambient pressure grooves which surround the porous media air bearing land.

8. A method for moving a sheet of glass, the method comprising:

(a) providing a vacuum preloaded porous air bearing assembly for conducting flows at pressures above and below ambient, the bearing assembly comprising:

a main body having a face and having a plurality of vacuum holes or grooves formed in the face; and

a porous medium disposed at said face;

wherein the main body has formed therein:

a first network of conduits for conveying a first fluid flow at a pressure above ambient from a source of said first fluid flow through said main body and out of said main body through said porous medium; and

a second network of conduits for conveying a second fluid flow at a pressure below ambient from a source of said second fluid flow through said main body and out of said main body through said vacuum holes or grooves;

(b) applying the first and second fluid flows to first and second networks of conduits;
and

(c) using the first and second fluid flows to support the sheet of glass relative to the face.

9. A method as claimed in claim 19, wherein the bearing assembly is used to flatten the gross shape of the work piece over all or locally.

10. A method as claimed in claim 19, wherein the bearing assembly is used to flatten the thickness variation of the glass so as to present one side flat with all or most of the thickness error manifesting itself as an out of flatness on the opposite side.

11. A method as claimed in claim 10, wherein the workpiece is patterned with light, laser, ink, physical imprinting, or wherein the workpiece is scanned or inspected, or wherein the workpiece is coated, dried, cleaned, repaired, or stripped.

12. A method for locally flattening natural thickness errors of glass, the method comprising:

(a) providing vacuum preloaded air bearings, arrayed around or near to an area of the glass to be flattened;

(b) positioning the glass with the side of the glass to be flattened facing the air bearings; and

(c) supporting the glass with the vacuum preloaded air bearings to flatten the side of the glass to be flattened.

13. A method as claimed in claim 25, further comprising (d) processing a portion of the flattened side of the glass by; patterning with light, laser, ink, physical imprinting; inspecting, scanning, repairing or coating.

14. A method as claimed in claim 13, wherein porous media air bearing technology is used.

15. A method as claimed in claim 13, wherein orifice air bearing technology is used.
16. A method as claimed in claim 13, wherein vacuum holes are used.
17. A method as claimed in claim 13, wherein vacuum grooves are used.
18. A method as claimed in claim 13, wherein the glass is horizontal and the bearings and process are either above or below the glass.
19. A method as claimed in claim 13, wherein the glass is vertical and the bearings and process are on either side of glass.
20. A method as claimed in claim 13, wherein the glass is on an angle with the bearings and processing on either side of the glass.
21. A method as claimed in claim 13, wherein the glass moves relative to the bearings and processing, parallel to the face of the bearings in the X and or Y direction.
22. A method as claimed in claim 13, wherein the bearings and the processing move relative to the glass in the X and or Y direction.
23. A method as claimed in claim 13, wherein the glass moves relative to the bearings in one direction and the processing moves relative to the glass in the other direction.

1/10

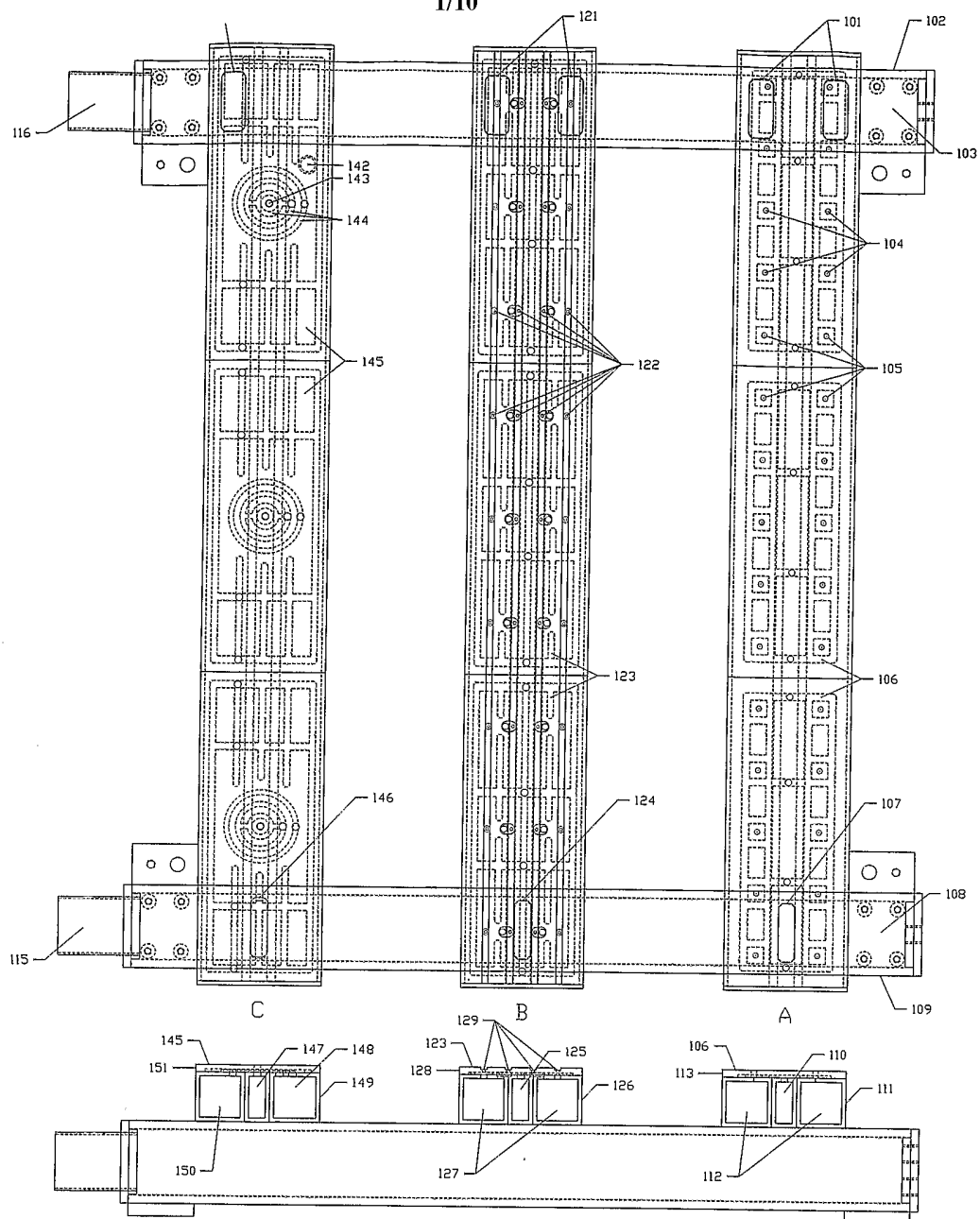


Figure 1

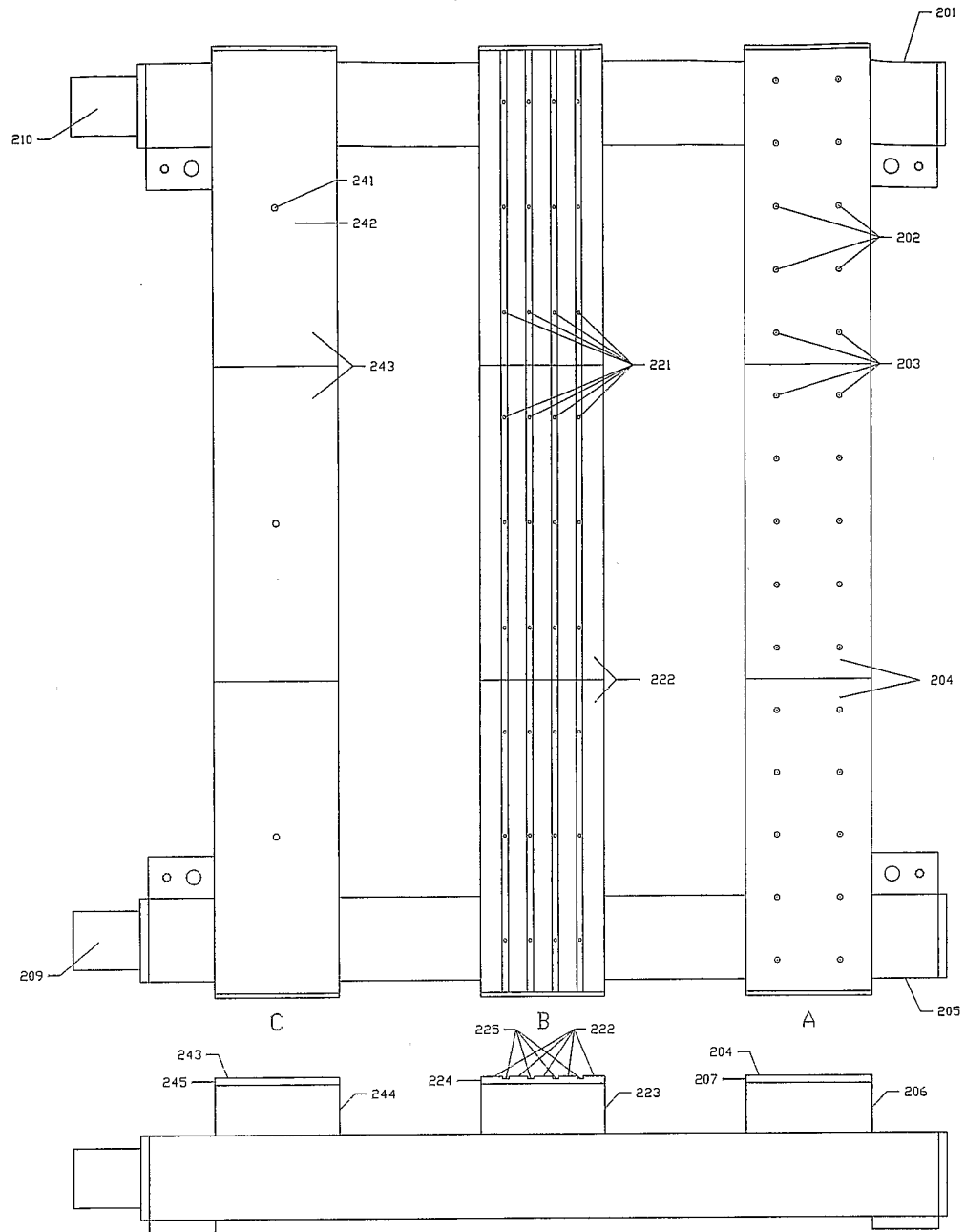


Figure 2

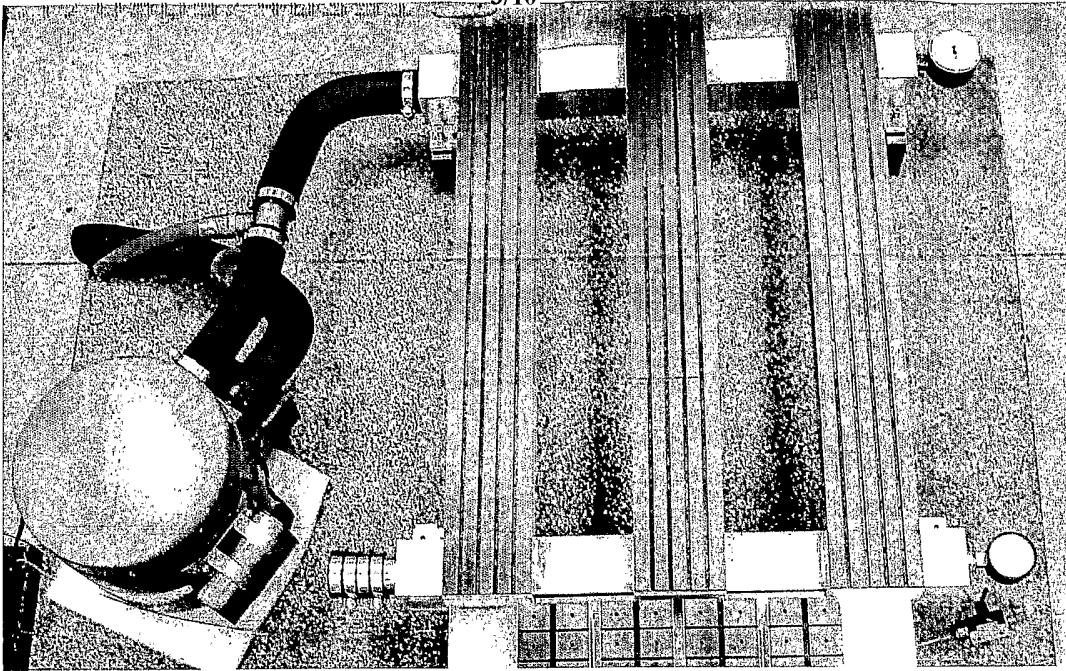


Figure 3

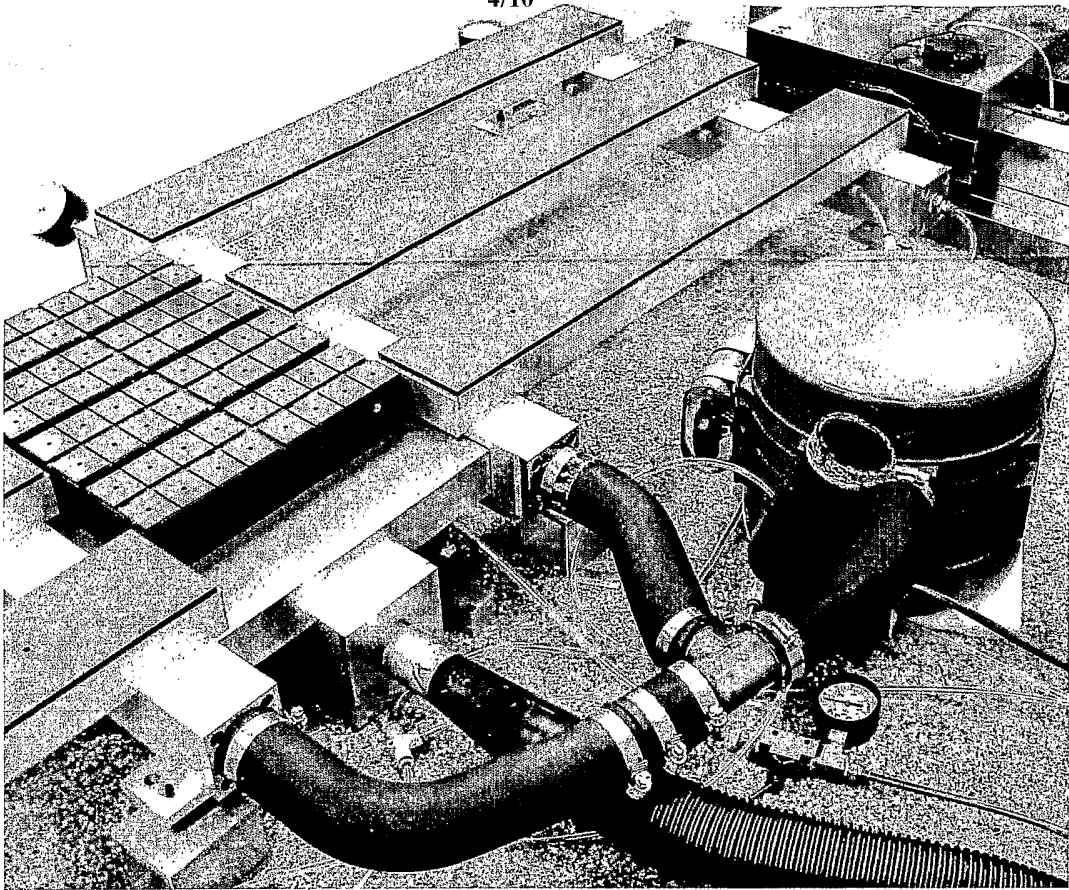


Figure 4

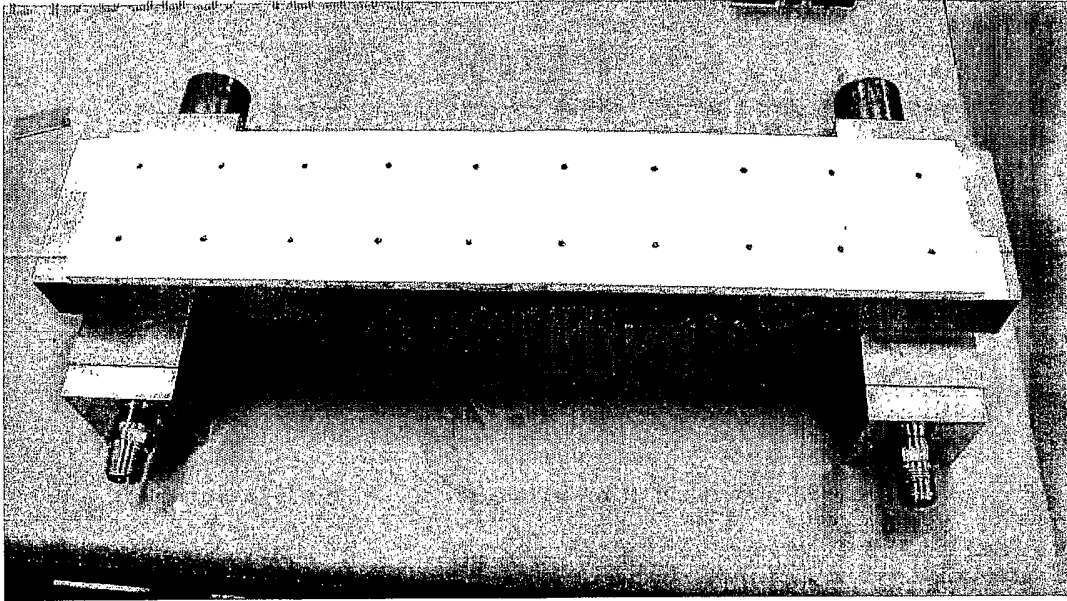


Figure 5

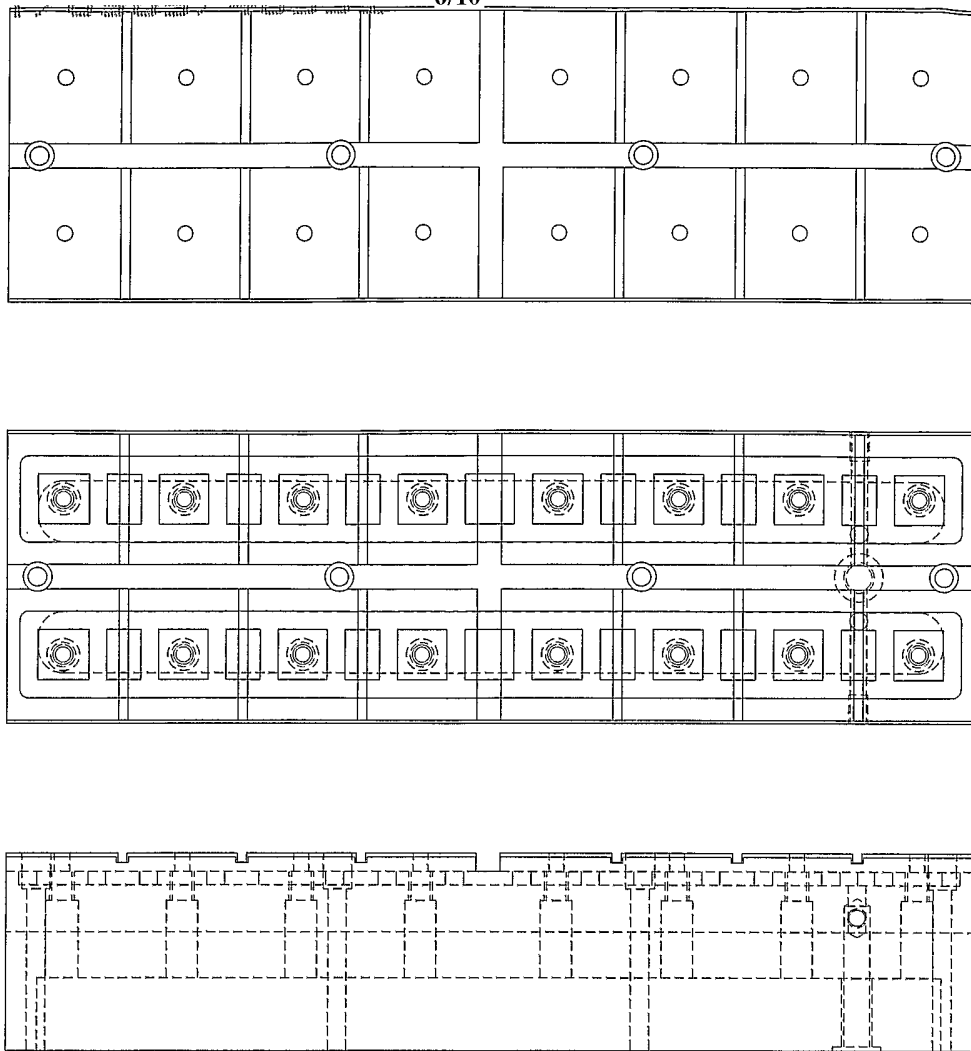


Figure 6

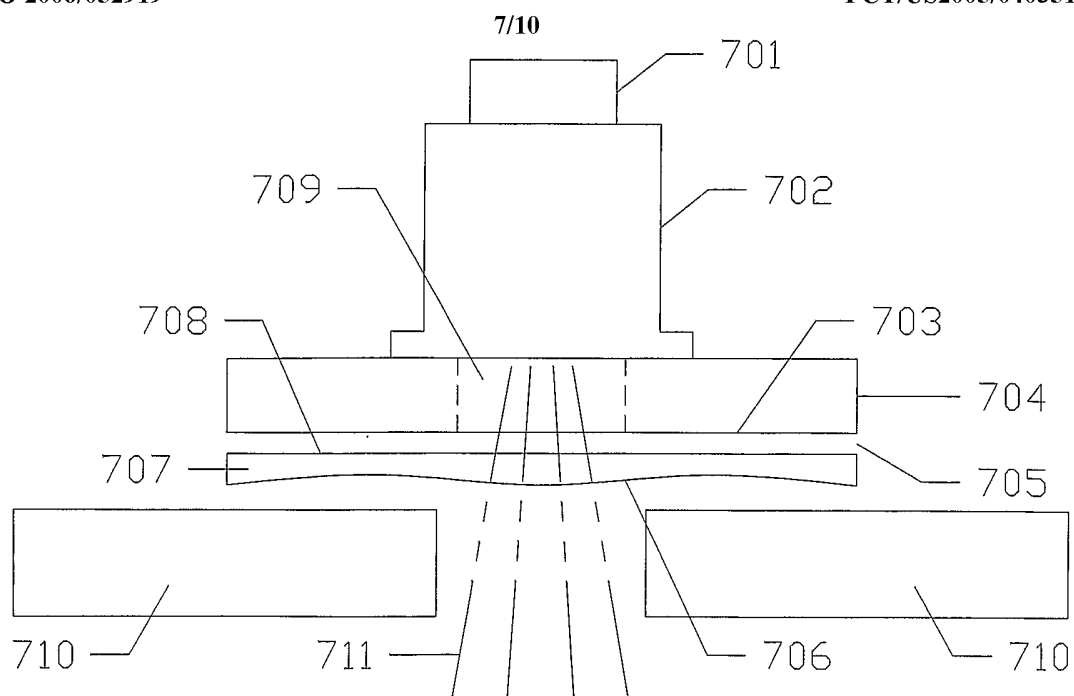


FIG. 7A

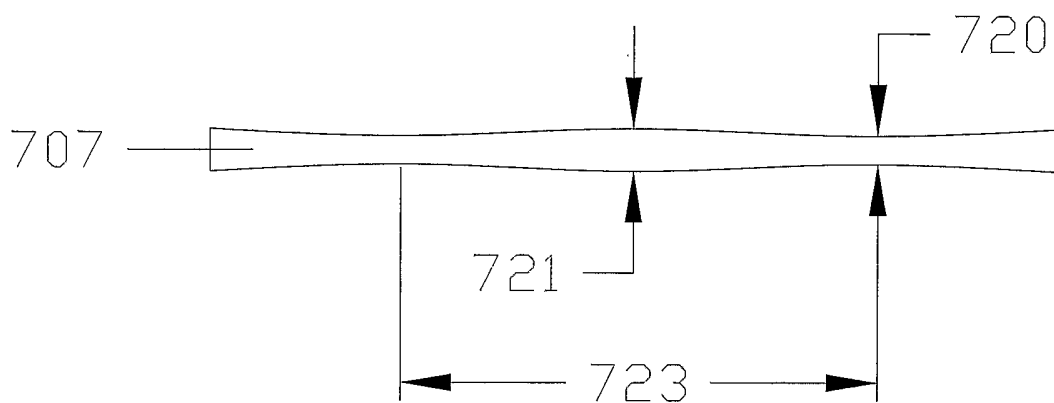


FIG. 7B

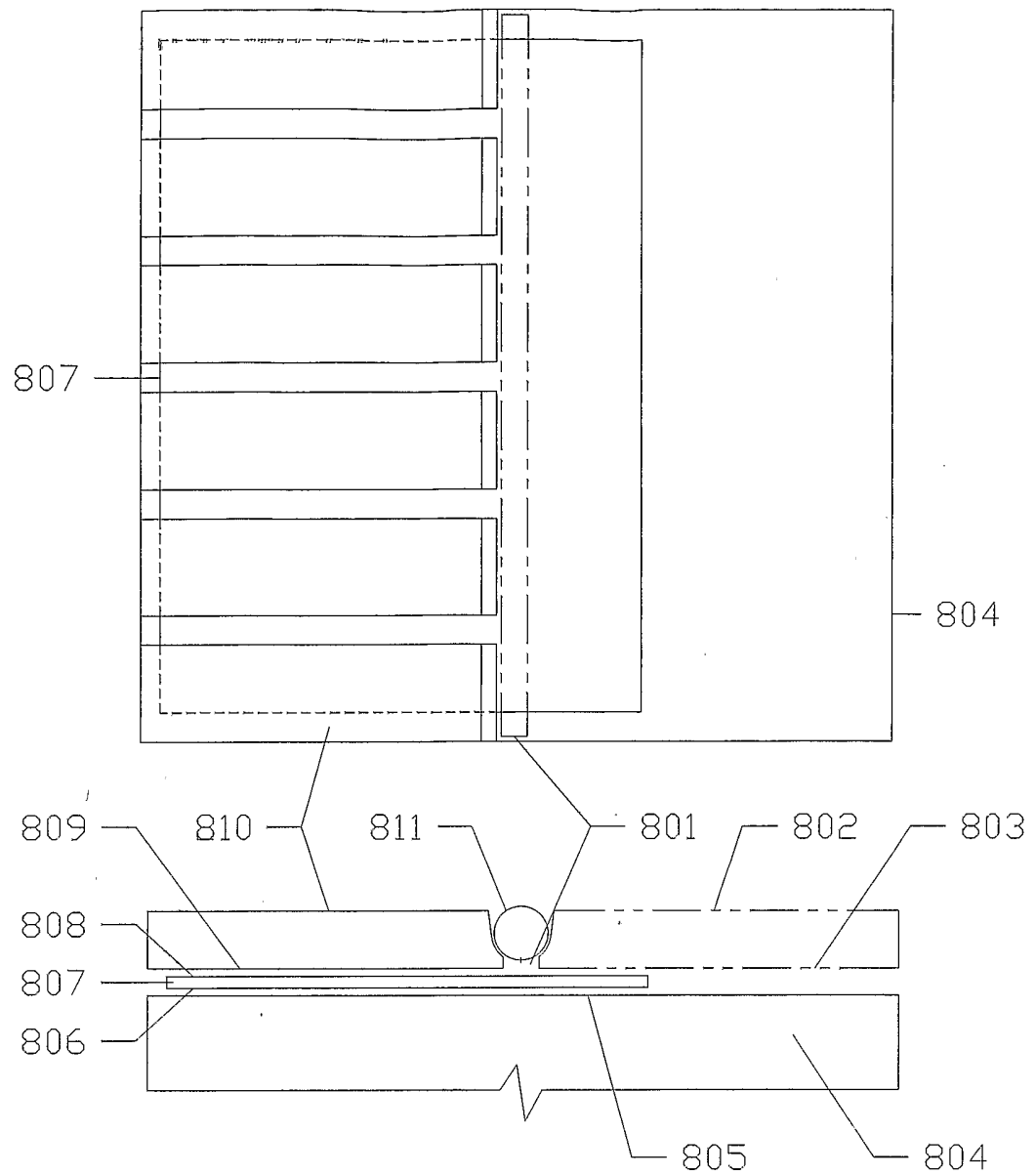


FIG. 8

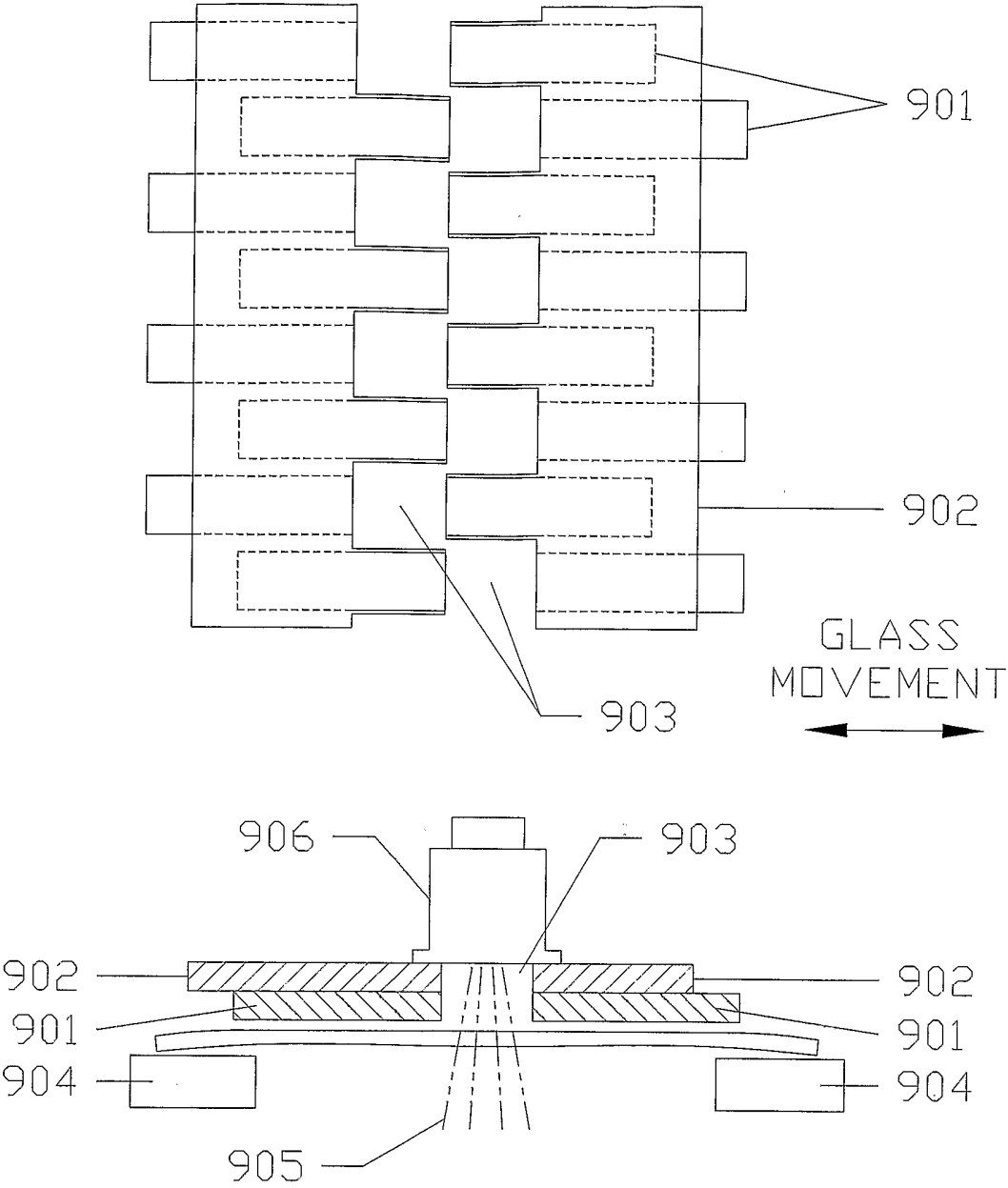


FIG. 9

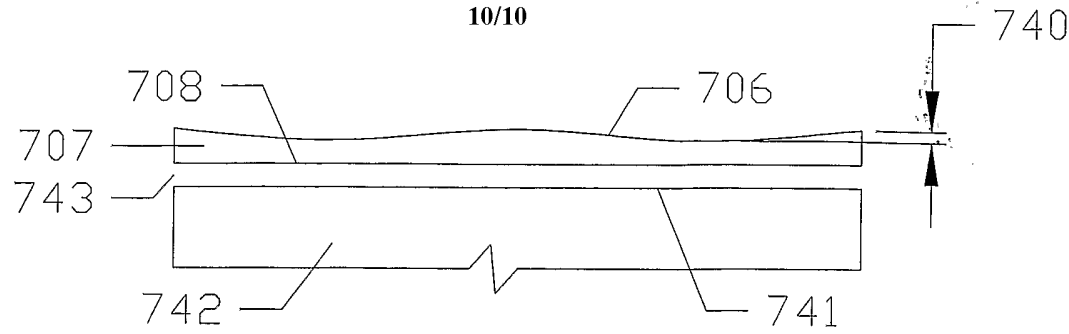


FIG. 7C

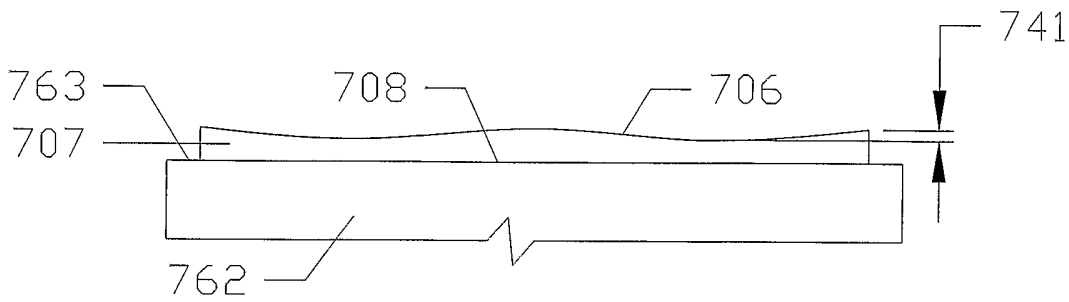


FIG.10

INTERNATIONAL SEARCH REPORT

national application No
T/US2005/040351

A. CLASSIFICATION OF SUBJECT MATTER <div style="display: flex; justify-content: space-around;"> B65G49/06 B65G51/03 </div>		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) <div style="text-align: center;">B65G C03B F27B</div>		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the International search (name of data base and, where practical, search terms used) EPO-Internal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 03/060961 A (COREFLOW SCIENTIFIC SOLUTIONS LTD; YASSOUR, YUVAL; REICHMAN, HILLEL; L) 24 July 2003 (2003-07-24) paragraph [0214] - paragraph [0215]; figures 9a, 10f, 16-18 paragraph [0248] - paragraph [0249]	1-23
A	US 2003/177790 A1 (LANGSDORF ANDREAS ET AL) 25 September 2003 (2003-09-25) cited in the application paragraph [0046] - paragraph [0047]; figures	1-23
A	US 4 618 292 A (JUDGE ET AL) 21 October 1986 (1986-10-21) the whole document	1-23
-/--		
<div style="display: flex; justify-content: space-between;"> <input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex. </div>		
<div style="display: flex;"> <div style="flex: 1;"> <p>* Special categories of cited documents :</p> <p>*A* document defining the general state of the art which is not considered to be of particular relevance</p> <p>*E* earlier document but published on or after the international filing date</p> <p>*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>*O* document referring to an oral disclosure, use, exhibition or other means</p> <p>*P* document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="flex: 1;"> <p>*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>* & * document member of the same patent family</p> </div> </div>		
Date of the actual completion of the International search <div style="text-align: center;">17 March 2006</div>		Date of mailing of the international search report <div style="text-align: center;">30/03/2006</div>
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016		Authorized officer <div style="text-align: center;">Lawder, M</div>

INTERNATIONAL SEARCH REPORT

International application No
T/US2005/040351

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 078 775 A (MALTBY, JR. ET AL) 7 January 1992 (1992-01-07) the whole document -----	1-23
A	US 6 540 001 B1 (MCNESTRY MARTIN) 1 April 2003 (2003-04-01) the whole document -----	1-23

INTERNATIONAL SEARCH REPORT

Information on patent family members

national application No

T/US2005/040351

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 03060961	A	24-07-2003	AU 2002361485 A1	30-07-2003
			AU 2002367070 A1	30-07-2003
			CA 2473766 A1	24-07-2003
			CN 1631064 A	22-06-2005
			CN 1623219 A	01-06-2005
			EP 1461826 A1	29-09-2004
			WO 03061354 A2	24-07-2003
			JP 2005528586 T	22-09-2005
			TW 222423 B	21-10-2004
US 2003177790	A1	25-09-2003	AU 1389602 A	26-03-2002
			CN 1458908 A	26-11-2003
			DE 10045479 A1	04-04-2002
			WO 0222514 A1	21-03-2002
			EP 1322562 A1	02-07-2003
			JP 2004509046 T	25-03-2004
US 4618292	A	21-10-1986	NONE	
US 5078775	A	07-01-1992	AT 167173 T	15-06-1998
			AU 1747192 A	21-10-1992
			DE 69225887 D1	16-07-1998
			DE 69225887 T2	22-10-1998
			EP 0576601 A1	05-01-1994
			ES 2116335 T3	16-07-1998
			FI 934061 A	16-09-1993
			JP 3190673 B2	23-07-2001
			JP 6506182 T	14-07-1994
			KR 170429 B1	15-01-1999
			WO 9216467 A1	01-10-1992
US 6540001	B1	01-04-2003	AT 229451 T	15-12-2002
			DE 60000952 D1	23-01-2003
			DE 60000952 T2	17-07-2003
			EP 1078858 A1	28-02-2001
			GB 2353269 A	21-02-2001