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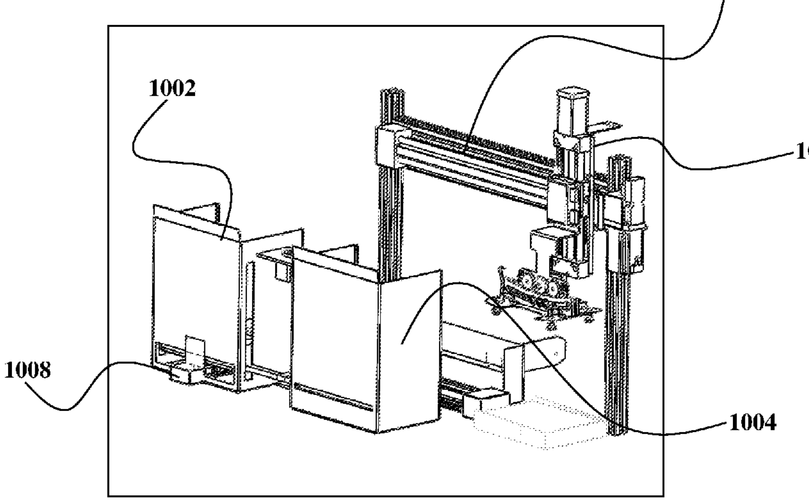
(54) **Title:** AUTOMATED COVERSLIPPER FOR LARGE FORMAT SLIDES WITH SWITCHABLE COMPATIBILITY TO HANDLE MULTI FORMAT SLIDES

FIG. 10A



(57) **Abstract:** A system for performing coverslipping includes multiple zones, where a coverslipper device is designated to move from one or more zones. An input zone comprises a slide tray, which comprises a stack of stained slides and a slide that is designated to be picked up by a slide pick-up platform. The picked-up slide reaches a dispensation zone and a mountant medium is dispensed via a nozzle and the slide pickup platform moves to a coverslipping zone. The coverslipper device picks the cover slips from a slip pick-up zone and moves to a coverslipping zone. The slide pick-up platform positions itself in the coverslipping zone while the picked coverslip is mounted over the slide. The processed cover slipped slide is transported by a slide conveyor and inserted into a slide tray, which is moved up and down and is positioned to accommodate the next processed slide.

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AUTOMATED COVERSLIPPER FOR LARGE FORMAT SLIDES WITH SWITCHABLE COMPATIBILITY TO HANDLE MULTI FORMAT SLIDES

FIELD OF INVENTION

Embodiments of the present application illustrates a device that performs coverslipping over large format slides, more particularly, an automated coverslipper for large format slides with switchable compatibility to handle multiple format slides, which effectively avoid air bubble formation between the coverslip and the slide.

BACKGROUND OF THE INVENTION

As known in the art, coverslipping is the process by which protective glass sheets are pasted over glass slides with tissue specimens. The primary goal of this process is to protect the specimen from external environment and impacts, and to improve the visibility by straightening the tissue. In the current art, coverslipping is performed on slides that are smaller in size. For example, a standard microscope slide measures about 75 mm × 25 mm (3 inch by 1 inch) and is about 0.2 mm thick. A range of other sizes are available for various special purposes, such as 75 x 50 mm for geological use, 46 x 27 mm for petrographic studies, 48 x 28 mm for thin sections, and 125 x 175mm for large tissue sections. Generally, the presently available automated coverslippers can only handle smaller slide sizes, typically, 25 x 75 mm (1” X 3”) slides and are incompatible to process large format slides and cannot switch between different sizes of slides.

However, there is a necessity to provide an efficient way to automate coverslipping of large format histology slides, for example, (150 X 200mm) while retaining compatibility to medium and small slides also. Current commercial products can only process only 1 X 3 slides. Being an electromechanical device and since the size of the slide is large, there is a need for a device that needs to be controlled by a custom defined protocol logic to perform error free coverslipping of such large format slides. The device should be capable of handling transport of stacks of such large format slides and continuously performs the process. The automation should also result in error-free, uniform coverslipping by preventing air-pockets between the coverslip and the slides. There is also the need to take into consideration that to apply the slip permanently over the slide, an adhesive liquid called mountant medium is dispensed over the glass slide. Therefore, there is this need for an improved coverslipping and dispensing technique that ensures uniform distribution of mountant medium thus ensuring zero or minimal in-significant air gaps.

SUMMARY OF THE INVENTION

The following presents a simplified summary of the subject matter to provide a basic understanding of some of the aspects of subject matter embodiments. This summary is not an extensive overview of the subject matter. It is not intended to identify key/critical elements of the embodiments or to delineate the scope of the subject matter. Its sole purpose to present some concepts of the subject matter in a simplified form as a prelude to the more detailed description that is presented later.

A system disclosed here addresses the need for an improved coverslipping and dispensing technique that ensures uniform distribution of mountant medium for ensuring zero or minimal in-significant air gaps. The system for performing coverslipping includes a coverslipper device, an input zone, a dispensation zone, a slip pick-up zone, a coverslipping zone, and an output zone. The coverslipper device is assembled onto a frame and designated to move from one or more zones. The input zone comprises a slide tray, where the slide tray comprises a stack of stained slides, and a slide is designated to be picked up by a slide pick-up platform. The slide picked up by the slide pick-up platform reaches the dispensation zone, and a mountant medium is dispensed via a wedge-shaped nozzle and slide pickup platform moves to coverslipping zone. The coverslipper device picks the cover slips stacked in a coverslip tray of the slip pick-up zone and moves to the coverslipping zone. The slide pick-up platform positions itself in the coverslipping zone while the picked coverslip is mounted over the slide. The processed cover slipped slide is transported by a slide conveyor and inserted into a slide tray, which is moved up and down and is positioned to accommodate the next processed slide.

In an embodiment, the coverslipper is capable of processing large format slides of sizes 6” X 8” and 5” X 7” and is adaptable with customized modifications to slides of smaller sizes including 1” X 3” and 2” X 3”. In an embodiment, the slide tray comprises the stack of stained slides that are inserted into evenly spaced grooves, wherein the slide tray is positioned to pick up the designated slide by the slide pick-up platform. In an embodiment, the wedge-shaped nozzle dispenses the mountant medium uniformly over the slide from a container. In an embodiment, the system further comprises a dispenser nozzle park zone. The wedge-shaped nozzle, after dispensing, is rested at a home position, where solvent containers are placed to prevent clogging of nozzle tips, and the wedge-shaped nozzles are partially immersed into solvent containers.

In an embodiment, the system further comprises an actuator that moves linearly at a predefined speed and dispenses the mountant medium on the slide using the wedge-shaped nozzle, and after the dispensing, the actuator retreats to a home position. Therefore, a tip of the wedge-shaped nozzle stays immersed into solvent medium that is contained in a tray to avoid drying of nozzle tip. In an embodiment, the system further comprises a combination algorithm that monitors real time suction pressure in a line that supplies suction force to the vacuum suction cups and facilitates vertical position sensing. The combination algorithm detects the picking-up of the coverslip based on build-up of the suction pressure and once the suction pressure crosses a threshold, a vertical downward motion of the coverslipper device is stopped. In an embodiment, the system further comprises a sensing system that works in communication with the combination algorithm to pick each slide to and to provide feedback to a processor to perform next operation. In an embodiment, a pick and place mechanism of the coverslipper device is controlled by a dedicated algorithm to facilitate accurate and uniform placement, and to prevent and eliminate formation of air bubbles.

In an embodiment, the coverslipper device comprises a vertical plate, a first curved plate, a and a second curved plate. The vertical plate comprises pinion gears that rotate on a shaft connected to one side of the vertical plate. The first curved plate comprises a rack gear on top, where the pinion gear rotates over the rack gear. The second curved plate is attached below the first curved plate, where a set of vacuum suction cups are attached on 4 corners to a lower side of the second curved plate. Rotation of the pinion gear over the rack gear translates the second curved plate along a predefined path, and the vacuum suction cups are detachably attached on the coverslip from a first end to a second end of the coverslip to lift the cover slip. In an embodiment, the predefined path of the second curved plate is achieved by a simultaneous multi-axis motion algorithm that enables a unique locus of motion to prevent occurrence of air pockets and bubbles below the cover slip.

In an embodiment, the rack facilitates an overall movement profile that mimics the human ankle motion between the Dorsiflexion and Plantarflexion positions. In an embodiment, the predefined path of the second curved plate is a rolling motion, which is a combination of movements of the mechanism in all axes, namely, X, Y and theta axis, wherein the combination algorithm facilitates movement along the respective X, Y and theta axis, to result in a user defined locus of motion. In an embodiment, the rack has a curved profile to ensure that the distance between the centre of the pinion gear and end of the vacuum suction cups is always the same regardless of the position of the rack and pinion gears, and wherein points of contact between the coverslip and the slide are at the same level regardless of the orientation of the second curved plate holding the vacuum suction cups.

In an embodiment, regardless of an angle of orientation of the coverslipper device, the points of contact between the coverslip and the slide are at same distance from the centre of the coverslipper device. In an embodiment, the process of coverslipping using the coverslipper comprises to dispense a mountant medium on a slide, position a coverslip using the coverslipper device directly above the slide exactly matching the slide's position, bring the first end of coverslip towards slide and placing on the slide, where starting contact area between coverslip and the slide is less than an empirically determined level to prevent air pockets, roll the coverslipper device towards end of slide to spread the mountant medium all over slide area uniformly, and release the coverslip from the coverslipper device by releasing suction force from the vacuum suction cups.

In an embodiment, the coverslip alignment mechanism is built with a custom designed coverslip tray with an alignment mechanism diagonally mounted for aligning the coverslips during each pickup of the coverslip. The coverslips are stacked in the coverslip tray, wherein the coverslips are made of glass with a smooth surface, which results in the coverslips on stack to tend to slip when a topmost coverslip is picked from the coverslip tray. This causes an edge reference of the coverslip to change and results in laying of the coverslip, and the edge reference of coverslip and the slide are not at same reference, which prevents coverslip breakage and tissue sample being un-used.

In an embodiment, the coverslip tray is in built with coverslip aligners which are connected to linear actuators and controlled by control software. In an embodiment, a process of picking coverslip involves initialising system, which extracts the aligners, enabling the user to load stack of coverslips, initialising system and aligning all the stacked coverslips to ensure that the coverslips are in same reference line, picking of the coverslip, wherein once the topmost coverslip is picked by suction cups, the aligners relax, enabling coverslip to be picked up gently, and after picking, the coverslipper device moves to coverslipping zone, while the aligners retract and aligns/hold the coverslip stack on same reference, wherein cover slips are picked up at the same reference point.

In an embodiment, the system further comprises an electromechanical control system comprises a data acquisition device (DAQ) that acquires data from different sensors and generate control signals for driving motors and controlling pneumatic systems. The motors, sensors, and pneumatic systems from each zone of the system are controlled by a single, central DAQ device which requires very high processing power and communication bandwidth. The motors, the sensors, and the pneumatic systems are physically connected to the DAQ device to reduce complexity in cable routing and to increase overall system footprint. In an embodiment, the system further comprises a distributed intelligence system that comprises the dedicated DAQ device for each zone, where the DAQ device is programmed specifically to perform functions intended for a specific zone that is selected from one of the input zone, the output zone, the coverslipping zone, the slider conveyer, the slip pick-up zone, and the dispensation zone.

The coverslipper disclosed herein addresses the need for an improved coverslipping and dispensing technique that ensures uniform distribution of mountant medium thus ensuring zero or minimal in-significant air gaps. The coverslipper is designed to handle large format slides, for example, 150 X 200 mm, since the current practice of analysing slides is limited to small sizes, typically 25 X 75 mm thus incompatible to analyse larger tissues such as human or large animal brains and other organ tissues. As the current slides processed are smaller in sizes, only small size coverslips matching those slides are internally transported and processed by currently available coverslippers in market. The coverslipper disclosed herein is capable of internally transporting and processing cover slips compatible to and dimensionally suiting the large format slides. Furthermore, the coverslipper has compatibility to process small, medium, and large format slides with an adaptive/retrofit coverslipper device. The formats process small format slides only and cannot be programmed/modified/customized to suit other sizes. This coverslipper provides possibilities to customize the relevant critical components of the system to suit small, medium, and large format slides.

This coverslipper uses a unique pickup technique. The large format coverslip is of maximum dimension of 150 X 200mm with thickness of 0.1 – 0.2mm, which is large and is made up of thin glass, which is brittle and difficult to handle manually for coverslipping. Several such slides are stacked in a coverslip tray amongst which the topmost coverslip shall be picked by a picker assembly. If not handled properly, the picking up of the coverslip could result in multiple slips picked up together or breakage of the coverslips. To facilitate a smooth and firm picking of single coverslip from the tray, a custom-made centre pivoted picker plate is designed with multiple double bellow vacuum suction cups positioned at strategic places. The double bellow vacuum suction cups are used specifically to have a cushion effect during picking up of the coverslip with minimal impact that ensures the coverslip is intact while picking.

The vacuum suction cups are provided with an optimal suction pressure to create a smooth picking action, hence preventing any breakage of coverslip. The picker plate is pivoted to a mechanism with axis motors which, in turn, provides a rolling motion for picking. With this rolling motion, the coverslip is picked from one end (with front end vacuum suction cups), followed by a rolling motion, the tail end of coverslip also is picked. Due to this technique of picking, it is empirically and experimentally verified that only an individual topmost coverslip is picked up safely.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

The following drawings are illustrative of examples for enabling systems and methods of the present disclosure, are descriptive of some of the methods and mechanism, and are not intended to limit the scope of the invention. The drawings are not to scale (unless so stated) and are intended for use in conjunction with the explanations in the following detailed description.

FIG. 1A shows a unique placement mechanism in association with the coverslipper as disclosed, as an example embodiment in the present disclosure.

FIG. 1B shows the coverslipper in action as shown in FIG. 1A, where initial contact area is minimal for avoiding air pockets, as an example embodiment in the present disclosure.

FIG. 1C shows the coverslipper in action as shown in FIG. 1A, where initial contact area is more than optimal level, which creates air pockets, as an example embodiment in the present disclosure.

FIGS. 2A-2D show how the coverslipper disclosed here implements a unique curved rack and pinion mechanism exhibiting unique motion characteristics, as an example embodiment in the present disclosure.

FIG. 2E shows the 2 X 3 coverslipper picker mechanism implements a unique curved rack and pinion mechanism exhibiting unique motion characteristics as an example embodiment in the present disclosure.

FIG. 3 shows how the coverslipper disclosed here uses a simultaneous multi-axis motion algorithm that enables a unique locus of motion, to ensure prevention of occurrence of air pockets and bubbles as an example embodiment in the present disclosure.

FIG. 4 shows a medium dispensing nozzle design that is used in the coverslipper mechanism, wherein the nozzle design is used for mounting to suit large format processing, as an example embodiment in the present disclosure.

FIGS. 5A-5F show how multiple patterns using the medium dispensing nozzle design of mountant medium for improved coverage, as an example embodiment in the present disclosure.

FIGS. 6A and 6B show the system architecture associated with the coverslipper that's included in the system that also defines a set of zones, as an example embodiment in the present disclosure.

FIGS. 6C-6F show the different zones comprised within the coverslipper system, as an example embodiment in the present disclosure.

FIG. 7 shows a vacuum suction-cup based slide pick-up mechanism associated with the coverslipper, as an example embodiment of the present disclosure.

FIGS. 8A and 8B show unique mountant dispensing mechanism, as disclosed herein as an example embodiment in the present disclosure.

FIG. 9 shows schematic of a sensing and control algorithm and related electronic sensing sub-systems associated with the coverslipper, as disclosed herein as an example embodiment.

FIGS. 10A-10C show a unique slide transport system that is associated with the coverslipper, as disclosed herein as an example embodiment.

FIG. 11 shows the sequence of operations using the slide transport system that is associated with the coverslipper, as disclosed herein as an example embodiment.

FIG. 12 shows working of the wedge-shaped nozzle of the coverslipper, as an example embodiment of the present disclosure.

FIGS. 13A-13C show an arrangement comprising a spray nozzle with manifold setup of the coverslipper and a schematic associated with the spray nozzle manifold setup, as an example embodiment of the present disclosure.

FIG. 14 shows a combination of multiple curved members strategically positioned around the mounting area of the slide rack to position and align all the slides in the slide rack in synchronization with one another, as an example embodiment of the present disclosure.

FIGS. 15A and 15B show a combination of one or more independent linear actuators holding the vacuum suction cups forming a programmable curved locus between the positions of the vacuum suction cups to pick the coverslip and place over the slide, as an example embodiment of the present disclosure.

FIGS. 16A and 16B show perspective views of the coverslip tray and aligners, as an example embodiment of the present disclosure.

FIG. 17 shows a schematic drawing that illustrates an electromechanical system control unit associated with the system architecture of the coverslipper device, as an example embodiment of the present disclosure.

FIG. 18 shows a schematic drawing that illustrates a distributed intelligence system associated with the system architecture of the coverslipper device, as an example embodiment of the present disclosure.

DETAILED DESCRIPTION

Exemplary embodiments now will be described. The disclosure may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey its scope to those skilled in the art. The terminology used in the detailed description of the exemplary embodiments illustrated in the accompanying drawings is not intended to be limiting. In the drawings, like numbers refer to like elements.

FIGS. 1A-1C show a unique placement mechanism in association with the coverslipper device **200** as disclosed as an example embodiment in the present disclosure. The coverslipping process using the coverslipper device **200** involves the steps described below, to achieve a bubble-free coverslipping. In a step 1: The mountant medium **104** is dispensed on slide **106**. Step 2 involves positioning of coverslip **102** directly above the slide **106** exactly matching the slide's **106** position. Step 3 involves bringing the start end of coverslip **102** towards slide **106** and place on slide **106**. Step 4 involves ensuring that the starting contact area between coverslip **102** and slide **106** is less than empirically determined level to prevent air pockets, as illustrated in FIGS. 1B and 1C. Step 5 involves rolling on the coverslipper mechanism towards end of slide **106** in such a way that this action spreads the mountant medium **104** all over the slide area till end of slide **106**, uniformly. Finally step 6 involves releasing the coverslip **102**.

Based on the FIG. 1A, and as shown in FIGS 2A and 2B, a novel rolling motion mechanism is implemented to facilitate and perform automation of the below mentioned procedure of coverslipping. In a step 1, the coverslip **102** is picked up gently from the coverslip tray **202**. In a step 2, the picked coverslip **102** is moved into the coverslipping zone **608**, as shown in FIGS. 6A and 6B. In a step 3, the coverslip **102** is positioned above the slide **106** and coverslipping is performed. The rolling motion mechanism deploys a three-axis motion mechanism with the functions, namely, X-axis Motion, Y- axis motion, and Rolling motion mechanism to facilitate coverslipping. Based on software analysis of the motion pattern required for the above coverslipping technique, the locus of motion is deduced, and an algorithm is used for the same. This algorithm controls and defines the movements of each individual axis and synchronized operation of all the axes.

FIGS. 2A-2E shows how the coverslipper device **200** disclosed here implements a unique curved rack **206** and pinion **208** mechanism (as described further in FIGS. 2D, 2E and 3), exhibiting unique motion characteristics. Here, FIGS. 2A and 2B shows axis of motion along the construction of the coverslipper device **200**. The core mechanism contains a rack **206** and pinion **208** arrangement. As shown in FIG. 2C, the rack **206** facilitates an overall movement profile that mimics the human ankle motion between the Dorsiflexion and Plantarflexion positions. The core mechanism also contains vacuum suction cups **210** that are attached below the arrangement of rack **206** and pinion **208** for picking up of the coverslip **102**. However, as shown in FIG. 2D, the rack **206** has a curved profile to ensure the distance between the centre of the pinion **208** wheel and the end of the vacuum suction cups **210** is always the same regardless of the position of the rack **206** and pinion **208** motion. This means that the points of contact between the coverslip **102** and the slide **106** will be at the same level regardless of the orientation of the plate **212** holding the vacuum suction cups **210**. Regardless of the angle of orientation of the coverslipper device **200** mechanism, the point of contact is at the same distance from the centre of the pinion **208**. This methodology ensures a smooth laying of coverslip **102** from one end of the slide **106** to another with optimal uniform pressure just enough to bond the coverslip **102** and the slide **106**.

In other words, as shown in FIGS. 2D-3 and with emphasis on FIG. 2E, the coverslipper device **200** comprises a vertical plate **216**, a first curved plate **218**, a and a second curved plate **220**. The vertical plate **216** comprises the pinion gear **208** that rotates on a shaft **208a** connected to one side of the vertical plate **216**. The first curved plate **218** comprises a rack gear **206** on top, where the pinion gear **208** rotates over the rack gear **208**. The second curved plate **220** is attached below the first curved plate **218**, where a set of vacuum suction cups **210** are attached to a lower side of the second curved plate **220**. Rotation of the pinion gear **208** over the rack gear **206** translates the second curved plate **220** along a predefined path, and the vacuum suction cups **210** are detachably attached on the coverslip **102** from a first end **102a** to a second end **102b**, as shown in FIG. 2D, of the coverslip **102** to lift the coverslip **102**.

FIG. 3 shows how the coverslipper device **200** disclosed here uses a simultaneous multi-axis motion algorithm that enables a unique locus of motion, to ensure prevention of occurrence of air pockets and bubbles. As also shown in FIG. 2C, the above rolling motion mechanism using the coverslipper **200** mimics a human ankle motion. This rolling motion (as in FIG. 3) is a combination of movements of the mechanism in all the axes, namely, X, Y and theta axis. A unique algorithm ensures accurate movement of respective axes, to result in a unique locus of motion as per the below figures and calculations. Here, FIG. 2D shows the distances of the central and extreme end vacuum suction cups **210** from the centre of the pinion **208**. The angle between the lines connecting the centre to the vacuum suction cups (A and B) is θ. Based on analysis, the horizontal and vertical distance of travel of the mechanism (X and Y respectively), are determined. Based on calculation, the speed and various synchronous timelines of motion are calculated, and the actions are performed. Accordingly, resulting motor speed for each axis is estimated to attain rolling motion.

FIG. 4 shows a mounting medium dispensing nozzle design **400** that is used in the coverslipper device **200** mechanism, wherein the nozzle design **400** is used for mounting to suit large format processing. While handling smaller slides **106**, a single nozzle based dispensing system ensures uniform dispensation. This coverslipper device **200** mechanism deploys a wedge-shaped dispensation system **400** to dispense suitable empirically evaluated mountant medium application patterns. These patterns ensure zero or minimal air bubbles and absence of air-pockets.

FIGS. 5A-5F show how multiple patterns **500a-500c** using the medium dispensing nozzle design **400** of mountant medium **104** for improved coverage. Optimal, customized dispensing pattern of mountant medium **104** plays a major role in achieving: 1. Bubble free coverslipping, 2. Uniform distribution of mountant medium **104** all over the slide area, 3. Covering up the tissue (on slide **106**) without any air pockets. Combinations of various dispensing patterns and different mountant medium **104** volumes were experimentally studied and characterized. Amount of mountant medium **104** to be used is derived by practical application study and optimal volume of mountant medium **104** per coverslipping operation is determined. Based on trials, three specific dispensation patterns are found to be successful as shown in FIGS. 5A-5F.

FIGS. 5A and 5B show a triple equidistant pattern **500a**, wherein three bands of mountant medium **104** are dispensed in parallel to the axis of coverslipping. FIG. 5A shows 3 stripes of mountant medium **104** and FIG. 5B shows output after coverslipping with no air bubbles. FIGS. 5C and 5D show a dual equidistant pattern **500b**, where two wider bands of mountant medium **104** were dispensed in parallel to the axis of coverslipping with a wedge-shaped nozzle **400**. FIG. 5C shows 2 stripes of mountant medium **104** and FIG. 5D shows output after coverslipping with no air bubbles. FIGS. 5E and 5F show a single dispense pattern **500c**, where a single wide band of mountant medium **104** is dispensed in the centre of slide **106** in parallel to the axis of coverslipping with a wedge-shaped nozzle **400**. FIG. 5E shows 1 stripe mountant medium **104** and FIG. 5F shows the output after coverslipping with no air bubbles. The bubble free coverslipping is achieved by coverslipping function, with all the above three types of dispense patterns.

FIGS. 6A and 6B show the system architecture associated with the coverslipper device **200** that's included in the system **600** that also defines a set of zones. This system **600** related to the coverslipper device **200** describes unique designated zones for each sub-process and ensures seamless processing. The system **600** design is divided into the following six zones based on the activity performed in each. FIGS. 6C- 6F show the different zones comprised within the coverslipper system **600**. About the input zone **602**, this zone has provisions for holding a slide tray **612** as shown in FIG. 6C. The slide tray **612** contains a stack of stained slides **106** inserted into evenly spaced grooves. The slide tray **612** is vertically moved up and down to position the slide **106** currently waiting to be picked up. The slide **106** is picked up by the arrangement of vacuum suction cups **210** on the slide pick-up platform and the slides **106** are picked up from bottom to top.

About the dispensation zone **604**, once the slide pick-up platform reaches this dispensation zone **604**, the mountant medium **104** is dispensed through wedge shaped nozzle **400** which performs a uniform mountant medium dispensing from container. About the dispenser nozzle park zone, after dispensing, the dispenser nozzle **400** is returned to home position, where solvent containers **1202** and **1204** are placed to prevent clogging of nozzle tips, the nozzles **400** are partially immersed into solvent containers **1202** and **1204**, as shown in FIG 12. About the slip pick-up zone **606**, the coverslip pick and place mechanism picks the coverslips **102** stacked in the coverslip tray **616**, as shown in FIG. 6B. About the slip placement zone or the coverslipping zone **608**, the slide pick-up platform positions itself in this coverslipping zone **608** while the dispenser nozzle manifold positions, applies and mounts the coverslip **102** over the slide **106**. The coverslip **102** pick and place mechanism is controlled by a dedicated algorithm to achieve accurate placement, uniform placement and, prevention and elimination of air bubbles. About the output zone **610**, the processed cover slipped slide **106** is transported by the slide conveyor **618** and inserted into a slide tray **612**. The slide tray **612** is moved up and is positioned to accommodate the next processed slide **106**.

FIG. 7 shows a vacuum suction cup **210** based slide pick-up mechanism associated with the coverslipper device **200**, as an example embodiment of the present disclosure. Owing to the large size of the slides **106**, picking up slides **106** from the input slide tray **612** needs to be done carefully to protect the slide **106** and the tissue on it. This invention uses a unique vacuum suction cup **210** mechanism that holds and picks the slide **106** from the input slide tray **612**. The key differentiation is that the slide **106** is held by the vacuum suction cup **210** in the bottom (opposite to where the tissue is present). Unlike other commercial products, where the slides **106** are picked up by gripping mechanism which may have impact on the edges of the slides **106**, this unique vacuum suction cup **210** arrangement ensures safe handling of the slide **106**, despite the size. The above module comprises of slide conveyor **1014** (linear motion system) with 4 vacuum suction cups **210** placed upside down for slide transporting to each zone.

FIGS. 8A and 8B show unique mountant dispensing mechanism, as an example embodiment of the present disclosure. Dispensing mountant medium **104** uniformly across the length and breadth of the coverslip **102** is important as irregular dispensing can cause 1). Air pockets, and 2). Over spillage of mountant medium **104** beyond slide extremities. To overcome above issues and to have a uniform distribution of mountant medium **104**, the following mechanism is designed, and the process is as follows: a) Slide **106** entering dispense zone. During this time dispense nozzle **400** will be in home position (mountant medium compatible solution tray **804**), b) Slide **106** enters dispense zone. Now actuator **802** moves linearly at a defined speed and dispenses mountant medium **104** on the slide **106**, and c) After dispensing, the actuator **802** retreats back to home position, where the wedge-shaped nozzle **400** tip stays immersed into a mountant medium **104** compatible solution present in a solution tray **804** (to avoid drying of nozzle **400** tip).

FIG. 9 shows schematic of sensing, and control algorithm and related electronic sensing sub-systems **900** associated with the coverslipper device **200**, as an example embodiment of the present disclosure. The sensing, and control algorithm and related electronic sensing sub-system **900** includes a pressure sensor **902**, a sensing and feedback circuitry **904**, and a CPU **906**. Repeated one-by-one pick up of coverslips **102** from the coverslip tray **202** requires an accurate vertical motion and needs a precise sensing of the position. As the coverslip **102** is very thin (around 0.17mm), the sensing must be in real-time. In the longer run, it may not be practical, if the mechanism needs repeated periodic calibration. To overcome this issue, a combination algorithm monitors real time suction pressure in the line that supplies the vacuum suction cups **210** along with the vertical position sensing. This algorithm detects the pick-up of coverslip **102** based on the suction pressure build up and once the suction pressure crosses the thresholds, stops further vertical downward motion. This sensing system **900** is used in slide conveying system to pick each slide to ensure that the slides **106** are picked up and information is shared as a feedback via the sensing and feedback circuitry **904** to the control system to perform next operation.

FIGS. 10A shows a unique slide transport system **1000** that is associated with the coverslipper device **200** as disclosed herein as an example embodiment. The coverslipper device **200** is mounted on a frame defined by a X axis drive **1010** and a Y axis drive **1012**. The slide transport components include an input / output tray module **1002** and **1004**, slide racks **1006** as shown in FIG. 10B, containing stained slides **106** as the input **1002**, both the input and output racks **1002** and **1004** move together (up/down) simultaneously and contains actuators **802** for movement of required slide **106**. About the slide conveyor **1014** and dispensing module **400**, as shown in FIG. 10C, the slide conveyor has slide bed on top of slide conveyor **1014** that comprises the slots for large format slides that are provided to ensure the slide **104** sits on this platform while ejected from the input tray **1002** and ejected back to output tray **1002** after coverslipping. As far as the dispensing is concerned, as the slide **104** start moving towards coverslipping zone **608**, mountant dispensation happens on the slide **104**. Here, the mountant dispense module is stationed and dispensation happens while the slide conveyor **1014** moves. The slide ejector module **1008** comprises of a linear motion is introduced to push the slide from input tray **1002** to the slide conveyor **1014** bed and push into the output tray **1004** from slide conveyor **1014** bed after coverslipping process is done.

Referring to FIGS. 11 and 12, FIG. 11 shows the sequence of operations using the slide transport system that is associated with the coverslipper device **200** as disclosed herein as an example embodiment. The loading of glass slide **106** on slide conveyor **1014** is initiated as a first step. In a second step, the mountant medium **104** is dispensed over the slide **106**. In a third step, the coverslip **102** is picked up. In a fourth step, the positioning and coverslipping action is performed. In the fifth step, the slide **106** is unloaded into output tray **1004**. FIG. 12 shows the working of the wedge-shaped nozzle **400** of the coverslipper device **200**, as an example embodiment of the present disclosure. FIG. 12 shows an arrangement comprising of a linear mechanism and a container/tray **1202** and **1204** filled with Xylene moving in vertical direction, in combination with the wedge-shaped nozzle **400** moving linear mechanism, which ensures that the nozzle **400** tip is immersed into Xylene in between and after dispensation.

In other words, the coverslipper device **200** is assembled onto a frame and designated to move from one or more zones. The input zone **602** comprises a slide tray **1002**, where the slide tray **1002** comprises a stack of stained slides **106**, and a slide **106** is designated to be picked up by a coverslipper device **200** from a slide pick-up platform. The slide **106** picked up from the slide pick-up platform reaches the dispensation zone **604**, and a mountant medium **104** is dispensed via a wedge-shaped nozzle **400**. The slip pick-up zone **606**, wherein the coverslipper device **200** picks the cover slips **102** stacked in a coverslip tray **616** of the slip pick-up zone **606** and moves to the coverslipping zone **608**. The slide pick-up platform positions itself in the coverslipping zone **608** while the picked coverslip **102** is mounted over the slide **106**. The processed cover slipped slide **106** is transported by a slide conveyor **1014** and inserted into a slide tray **1002**, which is moved up and down and is positioned to accommodate the next processed slide **106**.

FIGS. 13A-13C show an arrangement comprising a spray nozzle **1300** with manifold **1302** setup of the coverslipper **200** and a schematic associated with the spray nozzle **1300** manifold setup, as an example embodiment of the present disclosure. The spray nozzle **1300** with manifold **1302** setup sprays Xylene on the slides housed by the input slide tray **1002** to ensure that the slides **106** and the tissues on the slides **106** are moistened with the Xylene liquid and hence facilitate seamless placement of the coverslip **102** over the slide **106** while preventing air bubble/pocket formation. As shown in FIG. 13B, when the input slide tray **1002** with slides **106** are loaded on the input tray **1002**, the tray is moved downwards, and xylene pump **1306** gets initiated and xylene gets sprayed onto the slides **106** one by one on all slides **106** on the input tray **1002**.

FIG. 14 shows a combination of multiple curved members **1402** strategically positioned around the mounting area of the slide rack **1006** to position and align all the slides **106** in the slide rack **1006** in synchronization with one another. In combination with vacuum suction cups **210** on the slide transporting platform, this alignment ensures that the orientation, alignment, and centre of the slides **106** are in line with that of the coverslip **102** when the coverslip **102** is placed over the slide **106**. FIGS. 15A and 15B show a combination of one or more independent linear actuators **1502**, **1504**, and **1506** holding the vacuum suction cups **210** forming a programmable curved locus between the positions of the suction cups **210** to pick the coverslip **102** and place over the slide **106**. The three linear actuators **1502**, **1504**, and **1506** are mounted in a custom pattern to pick the coverslip **102**. The actuators **1502**, **1504**, and **1506** are actuated in a serial manner in such away actuator-1 **1502** retracts and pick one end of the coverslipper **200** followed by actuator-2 **1504** and actuator-3 **1506** that picks up middle and opposite end of coverslip **200**. The algorithm controls the rotary axis motion **1510** and the actuators **1502**, **1504**, and **1506** gently pick the coverslip **102** in a predefined manner. Furthermore, an X axis and Y axis are deputed to perform transport of coverslip **102** to next zone for coverslipping.

FIGS. 16A and 16B show perspective views of the coverslip tray **1602** and coverslip aligners **1604**, as an example embodiment of the present disclosure. The coverslips **102** are stacked in the coverslip tray **1602** and since the coverslips **102** are made of glass, the surface is smooth, which causes the coverslips **102** on stack to tend to slip when a topmost coverslip **102** is picked from the coverslip trays **1602**, which causes the edge reference of the coverslip **102** to change and facilitate laying of the coverslip **102**. Considering this, the edge of coverslip **102** and slide **106** won't be at same reference, and therefore prevents breakage of the coverslip **102** and the tissue sample being un-used. The coverslip **102** alignment mechanism is built with custom designed coverslip tray **1602** with alignment mechanism diagonally mounted for aligning coverslips **102** on each process/ pickup. The coverslip tray **1602** is in built with coverslip aligners **1604** which are connected to linear actuators **1608**, along with a linear slide guide **1606**, and controlled by control software. The process of picking coverslip **102** involves:

1. System initialises, which extracts the coverslip aligners **1604**, enabling the used to load stack of coverslips **102**.
2. Once, the coverslips **102** are stacked and system initialises and aligns all stacked coverslips **102** ensuring the coverslips **102** are in same reference line.
3. During picking function, once the topmost coverslip **102** is picked by vacuum suction cups **210**, the coverslip aligners **1604** relax, enabling coverslip **102** to be picked up gently.
4. After picking, the coverslipper device **200** moves to coverslipping zone **608**, while the coverslip aligners **1604** retract and aligns/hold the coverslip **102** stack on same reference.
5. The above function enables the system to pick the coverslips **102** at same reference point.

FIG. 17 shows a schematic drawing that illustrates an electromechanical control system **1702** associated with the system **600** architecture of the coverslipper device **200**, as an example embodiment of the present disclosure. As known in the art, an electromechanical control system **1702** comprises of a data acquisition (DAQ) device **1704** controlled by a personal computer (PC) **1706** that acquires data from different sensors and generate control signals for driving motors, controlling pneumatic systems, etc. The motors, sensors, and pneumatic systems from each zone of the coverslipper system **600** must be controlled by a single, central DAQ device **1704** which requires very high processing power and communication bandwidth. Therefore, the DAQ device **1704** with the help of the PC **1706** controls the slide conveyor **1014**, slide input zone **602**, dispensation zone **604**, slip pick-up zone **606**, coverslipping zone **608**, and output zone **610**. Also, the motors, sensors, and pneumatic systems from each zone of the coverslipper system **600** are physically connected to the DAQ device **1704** to reduce complexity in cable routing and to increase overall system footprint.

FIG. 18 shows a schematic drawing that illustrates a distributed intelligence system **1800** associated with the system **600** architecture of the coverslipper device **200**, as an example embodiment of the present disclosure. The distributed intelligence system **1800** has a dedicated DAQ device **1704** for each zone**.** These DAQ devices **1704** are programmed specifically to perform functions intended only for that zone that is selected from one of slide input and output zone **602** and **610**, coverslipping zone **608**, slide conveyor **1014**, slip pick-up zone **606**, and dispensation zone **604**. For example, the slip pick-up zone **606** shall have a DAQ device **1704** that would be programmed to perform the coverslip picking operation. This system **600** design minimizes the need for high bandwidth, simplifies the cable routing and reduces system footprint.

As disclosed in the present disclosure, the cover slips **102** are small squares of glass that cover the specimen placed on the microscope slide. They flatten the specimen for a better visibility and decrease the rate of evaporation from the sample, both in wet and dry mounted slides. If a stain or other liquid has been added, the coverslip **102** keeps it on the specimen. Coverslips **102** also protect the specimens from contamination by airborne particles or other substances. The coverslips **102** are of different shapes and sizes as per the requirement during microscopic examination of a biological material. These may be rectangular, may be circular/round with different diameters. The most used coverslips **102** are rectangular shape of about 1 inch by 3-inch size. The coverslip **102** or cover glass serves in improving the quality of diagnosis during examination by providing following benefits:

- Prevents contact between the microscope's objective lens and the specimen.

- Provides an even thickness (in wet mounts) for viewing depth.
- Viewing enhancement as the specimen is flattened.
- Deceleration of evaporation from the sample, both in wet and dry mounted slides.
- Permanent affixation for long term and repeated use of permanent specimens.

Furthermore, the coverslipper device **200** enables specimens in large format sizes to be protected and stored for years together. The coverslipper device **200** economizes the coverslipping process by way of implementing indigenously conceived ideas and developed algorithms. The coverslipper device **200** is versatile enough to support multiple sizes of slides, which is not developed anywhere in the world. The coverslipper device **200** has capability to process large format coverslips **102** and, again, is not developed anywhere in the world.

As will be appreciated by one of skill in the art, the present disclosure may be embodied as a method and system. Accordingly, the present disclosure may take the form of an entirely hardware embodiment, a software embodiment or an embodiment combining software and hardware aspects. It will be understood that the functions of any of the units as described above can be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general-purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts performed by any of the units as described above.

Instructions may also be stored in a computer- readable memory that can direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable memory produce an article of manufacture including instruction means which implement the function/act performed by any of the units as described above.

In the specification, there has been disclosed exemplary embodiments of the invention. Although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation of the scope of the invention.

We claim:

1. A system for performing coverslipping:

a coverslipper device assembled onto a frame and designated to move from one or more zones;

an input zone that comprises a slide tray, wherein the slide tray comprises a stack of stained slides, wherein a slide is designated to be picked up by a coverslipper device from a slide pick-up platform;

a dispensation zone, wherein the slide picked up from the slide pick-up platform reaches the dispensation zone, and a mountant medium is dispensed via a wedge-shaped nozzle;

a slip pick-up zone, wherein the coverslipper device picks the cover slips stacked in a coverslip tray present in the slip pick-up zone, and moves to a coverslipping zone;

the coverslipping zone, wherein the slide pick-up platform positions itself in the coverslipping zone while the picked coverslip is mounted over the slide and

an output zone, wherein the processed cover slipped slide is transported by a slide conveyor and inserted into a slide tray of the output zone, wherein the slide tray is moved up and down and is positioned to accommodate the next processed slide.

2. A system as claimed in claim 1, wherein the coverslipper device is capable of processing large format slides of sizes 6” X 8” and 5” X 7” and is adaptable with customized modifications to slides of smaller sizes including 1” X 3” and 2” X 3”.

3. A system as claimed in claim 1, wherein the slide tray comprises the stack of stained slides that are inserted into evenly spaced grooves, wherein the slide tray is positioned to pick up the designated slide by the slide pick-up platform.

4. A system as claimed in claim 1, wherein the wedge-shaped nozzle dispenses the mountant medium uniformly over the slide from a container.

5. A system as claimed in claim 1, further comprising a dispenser nozzle park zone, wherein the wedge-shaped nozzle, after dispensing, is rested at a home position, wherein solvent containers are placed to prevent clogging of nozzle tips, and wherein the wedge-shaped nozzles are partially immersed into solvent containers.

6. A system as claimed in claim 1, wherein pick and place mechanism of the coverslipper device is controlled by a dedicated algorithm to facilitate accurate and uniform placement, and to prevent and eliminate formation of air bubbles.

7. A system as claimed in claim 1, further comprising an actuator that moves linearly at a predefined speed and dispenses the mountant medium on the slide using the wedge-shaped nozzle, and after the dispensing, the actuator retreats to a home position, wherein tip of the wedge-shaped nozzle stays immersed into the mountant medium that is contained in a tray to avoid drying of nozzle tip.

8. A system as claimed in claim 1, further comprising a combination algorithm that monitors real time suction pressure in a line that supplies suction force to the vacuum suction cups and facilitates vertical position sensing, wherein the combination algorithm detects the picking-up of the coverslip based on build-up of the suction pressure and once the suction pressure crosses a threshold, a vertical downward motion of the coverslipper device is stopped.

9. A system as claimed in claim 8, further comprising a sensing system that works in communication with the combination algorithm to pick each slide and to provide feedback to a processor to perform next operation.

10. A system as claimed in claim 1, wherein the coverslipper device comprises:

a vertical plate that comprises a pinion gear that rotates on a shaft connected to one side of the vertical plate;

a first curved plate comprising a rack gear on top, wherein the pinion gear rotates over the rack gear; and

a second curved plate attached below the first curved plate, wherein a set of vacuum suction cups are attached to a lower side of the second curved plate, wherein rotation of the pinion gear over the rack gear translates the second curved plate along a predefined path, and wherein the vacuum suction cups detachably attach on a coverslip from a first end to a second end of the coverslip to lift the cover slip.

11. The system as claimed in claim 10, wherein the predefined path of the second curved plate is achieved by a simultaneous multi-axis motion algorithm that enables a unique locus of motion, to prevent occurrence of air pockets and bubbles below the cover slip.

12. The system as claimed in claim 1, wherein the rack facilitates an overall movement profile that mimics the human ankle motion between Dorsiflexion and Plantarflexion positions.

13. The system as claimed in claim 12, wherein the predefined path of the second curved plate is a rolling motion, which is a combination of movements of the mechanism in all axes, namely, X, Y and theta axis, wherein the combination algorithm facilitates movement along the respective X, Y and theta axis, to result in a user defined locus of motion.

14. The system as claimed in claim 13, wherein the rack has a curved profile to ensure the distance between the centre of the pinion gear and end of the vacuum suction cups is always the same regardless of the position of the rack and pinion gears, and wherein points of contact between the coverslip and the slide are at the same level regardless of the orientation of the second curved plate holding the vacuum suction cups.

15. The system as claimed in claim 14, wherein regardless of an angle of orientation of the coverslipper device, the points of contact between the coverslip and the slide are at same distance from the centre of the coverslipper device.

16. The system as claimed in claim 10, wherein the process of coverslipping using the coverslipper device comprises to:

dispense a mountant medium on a slide;

position a coverslip using the coverslipper device directly above the slide exactly matching the slide's position;

bring the first end of coverslip towards slide and place on the slide, wherein starting contact area between coverslip and the slide is less than an empirically determined level to prevent air pockets;

roll the coverslipper device towards end of slide to spread the mountant medium all over slide area uniformly; and release the coverslip from the coverslipper device by releasing suction force from the vacuum suction cups.

17. The system as claimed in claim 10, wherein the coverslip alignment mechanism is built with a custom designed coverslip tray with an alignment mechanism diagonally mounted for aligning the coverslips during each pickup of the coverslip, wherein the coverslips are stacked in the coverslip tray, wherein the coverslips are made of glass with a smooth surface, which results in the coverslips on stack to tend to slip when a topmost coverslip is picked from the coverslip tray, which causes an edge reference of the coverslip to change and results in laying of the coverslip, and wherein the edge reference of coverslip and the slide are not at same reference, which prevents coverslip breakage and tissue sample being un-used.

18. The system as claimed in claim 17, wherein the coverslip tray is in built with coverslip aligners which are connected to linear actuators and controlled by control software.

19. The system as claimed in claim 18, wherein process of picking coverslip involves:

initialising system, which extracts the aligners, enabling the user to load stack of coverslips;

initialising system and aligning all the stacked coverslips to ensure that the coverslips are in same reference line;

picking of the coverslip, wherein once the topmost coverslip is picked by suction cups, the aligners relax, enabling coverslip to be picked up gently; and

after picking, the coverslipper device moves to coverslipping zone, while the aligners retract and aligns/hold the coverslip stack on same reference, wherein cover slips are picked up at the same reference point.

20. The system as claimed in claim 19, further comprising an electromechanical control system comprises a data acquisition device (DAQ) that acquires data from different sensors and generate control signals for driving motors and controlling pneumatic systems, wherein the motors, sensors, and pneumatic systems from each zone of the system are controlled by a single, central DAQ device which requires very high processing power and communication bandwidth, wherein the motors, the sensors, and the pneumatic systems are

physically connected to the DAQ device to reduce complexity in cable routing and to increase overall system footprint.

21. The system as claimed in claim 20, further comprising a distributed intelligence system that comprises the dedicated DAQ device for each zone, wherein the DAQ device is programmed specifically to perform functions intended for a specific zone that is selected from one of the input zone, the output zone, the coverslipping zone, the slider conveyer, the slip pick-up zone, and the dispensation zone.

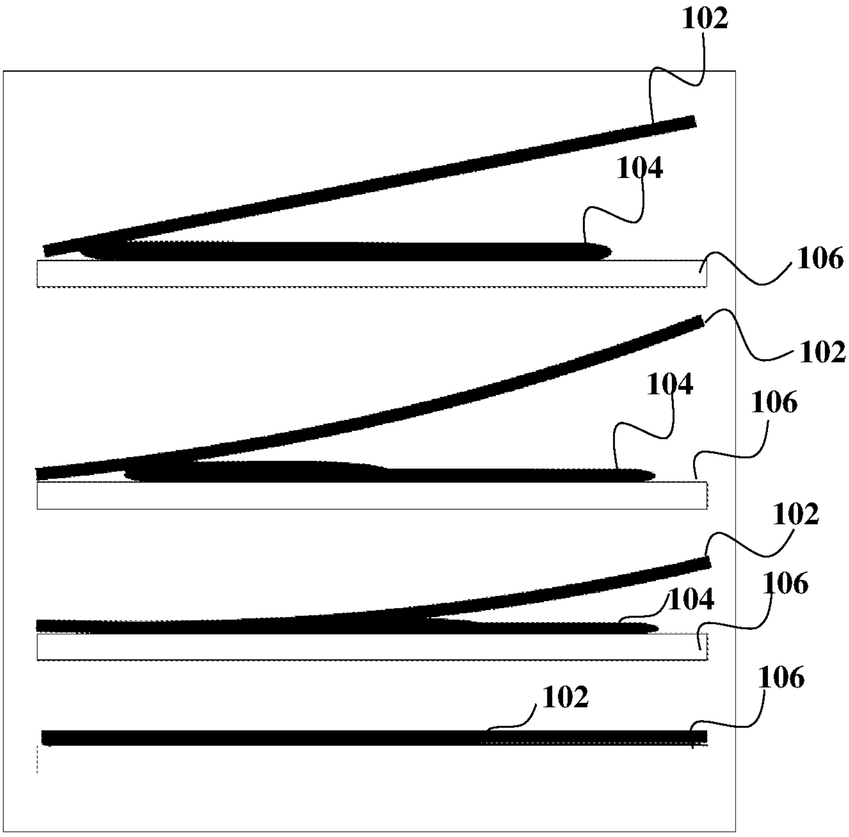


FIG. 1A

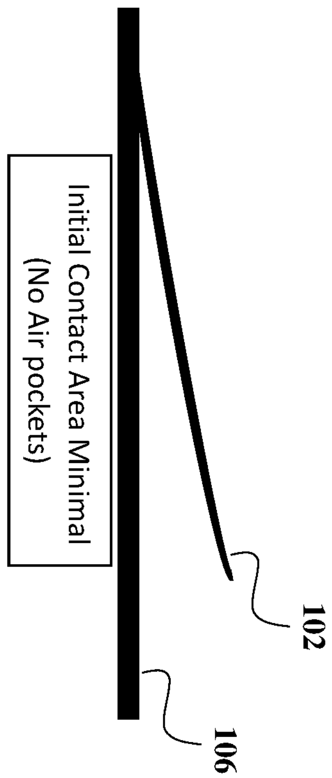

Initial Contact Area Minimal
(No Air pockets)
102
106

FIG. 1B

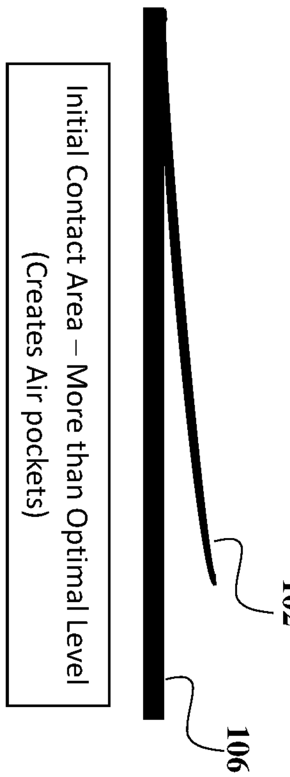

Initial Contact Area – More than Optimal Level
(Creates Air pockets)
102
106

FIG. 1C

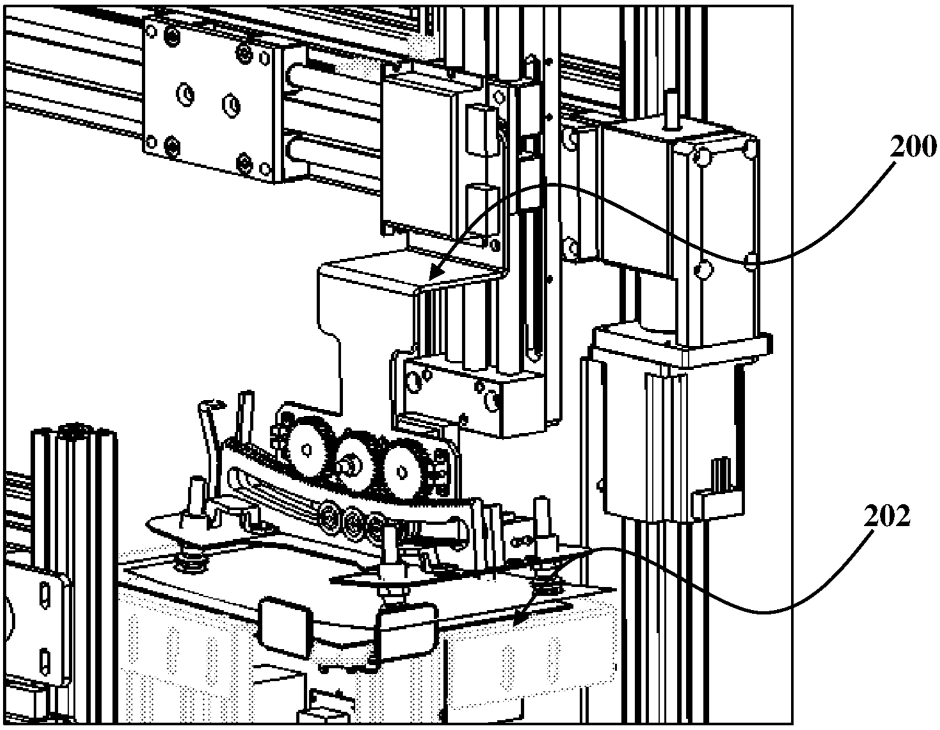


FIG. 2A

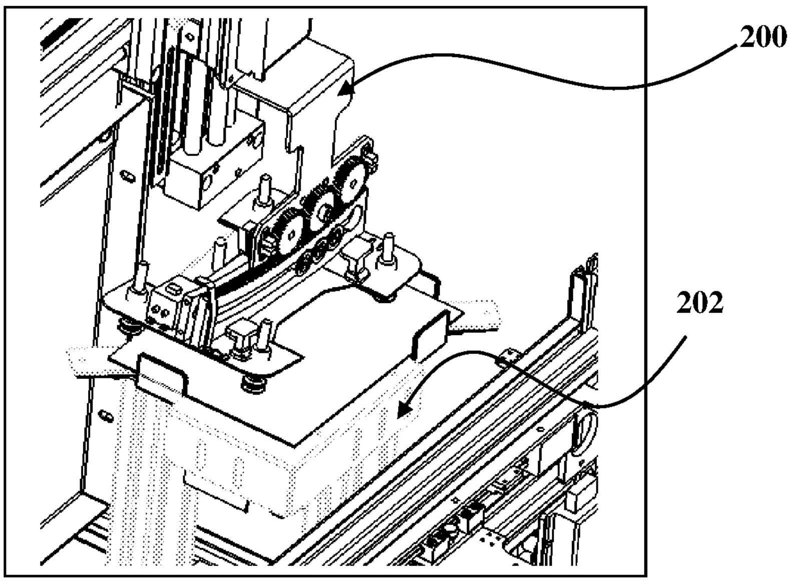


FIG. 2B

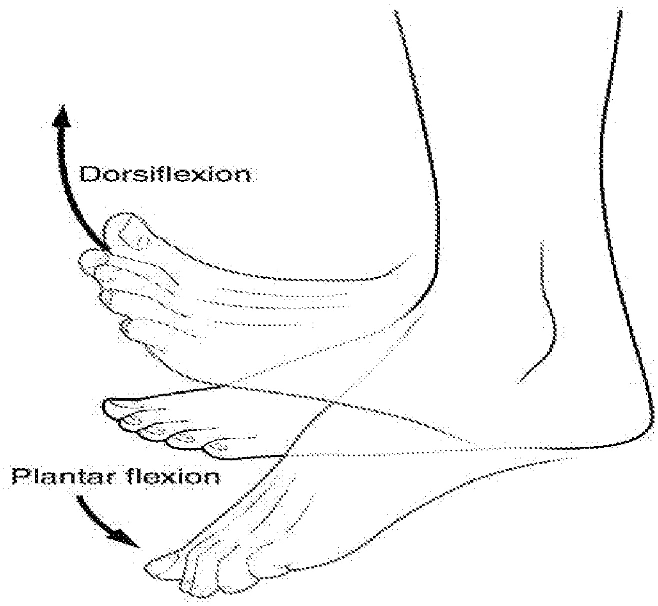


FIG. 2C

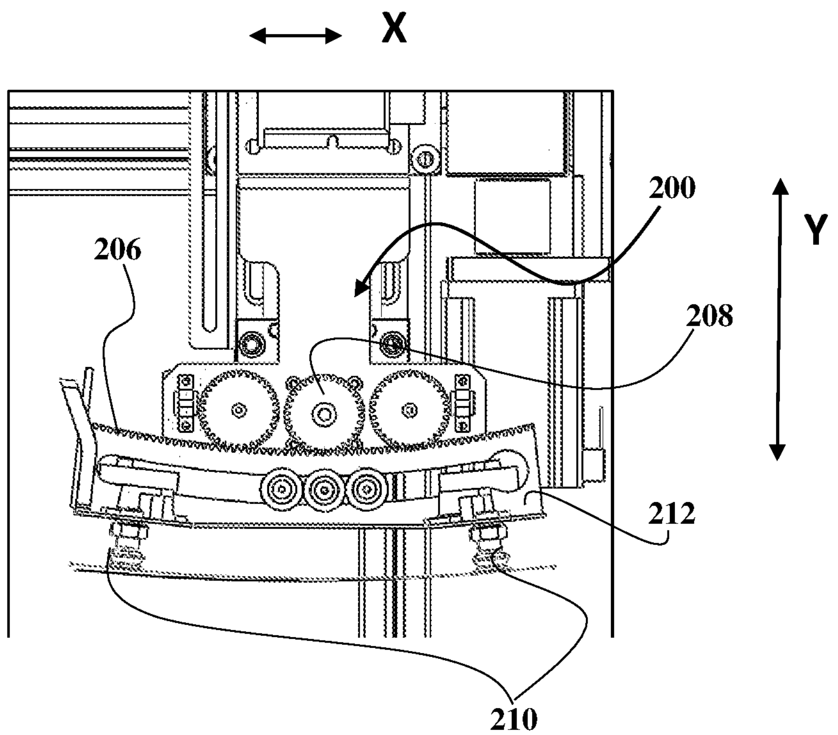


FIG. 2D

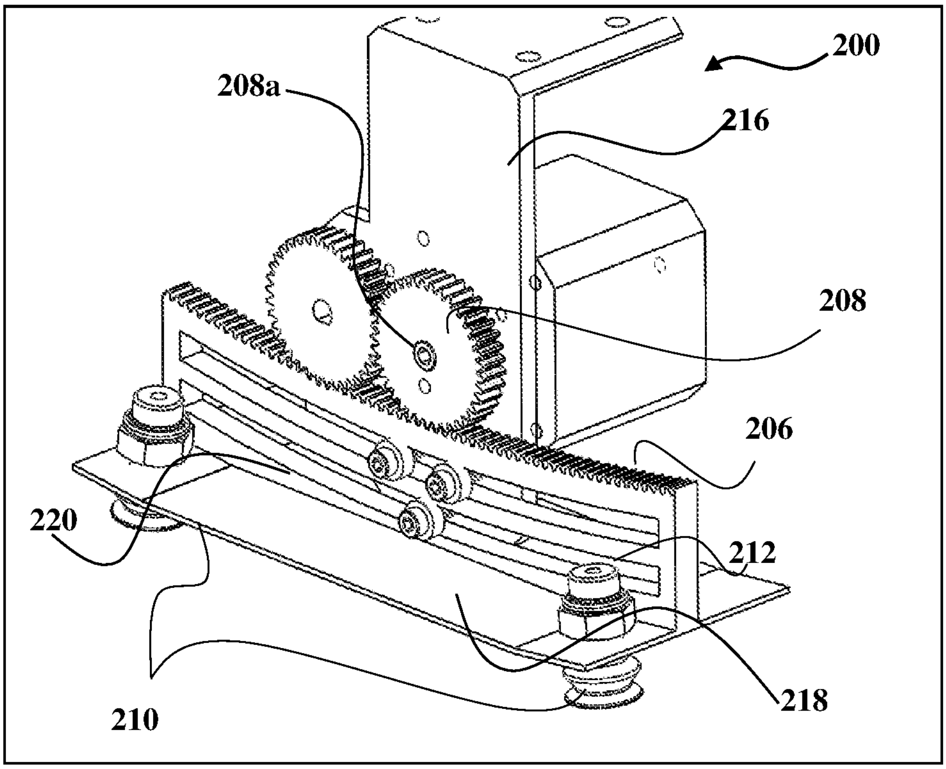


FIG. 2E

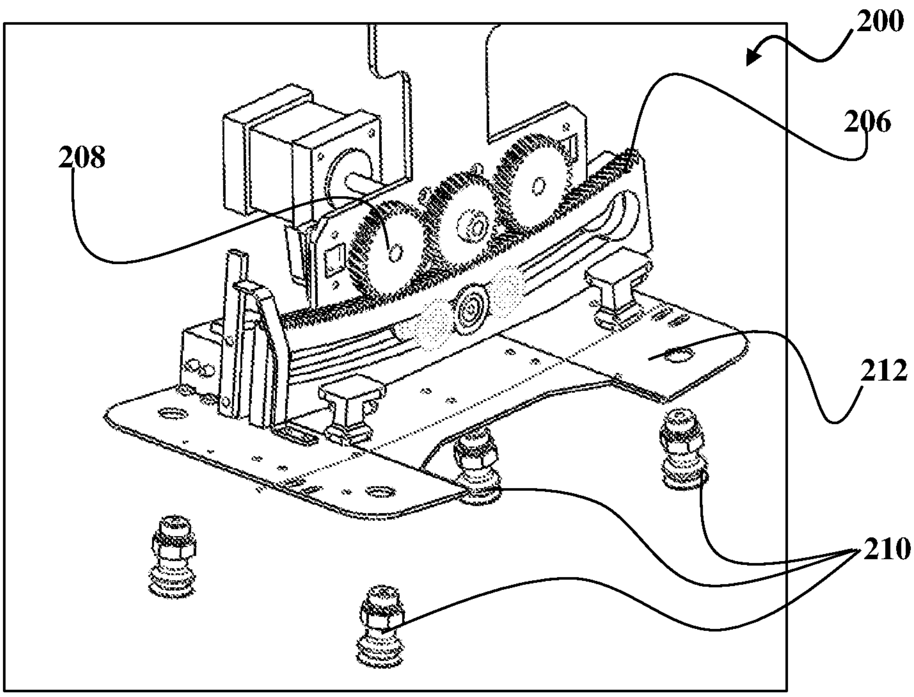


FIG. 3

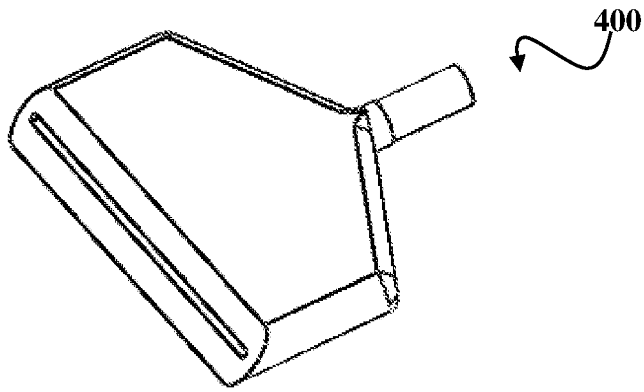


FIG. 4

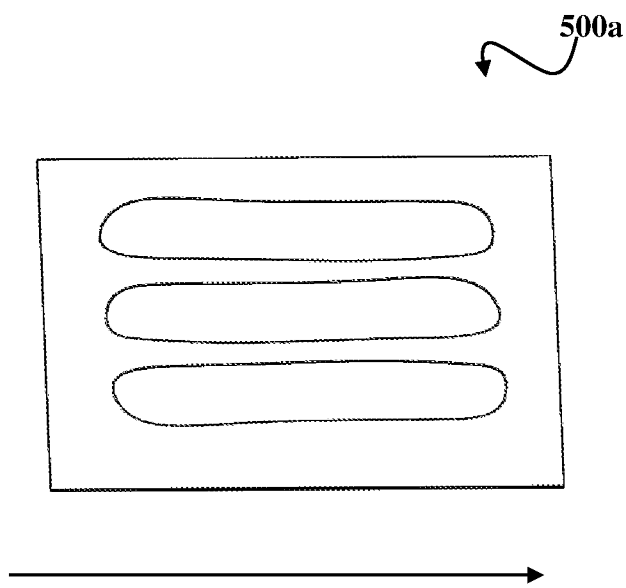


FIG. 5A

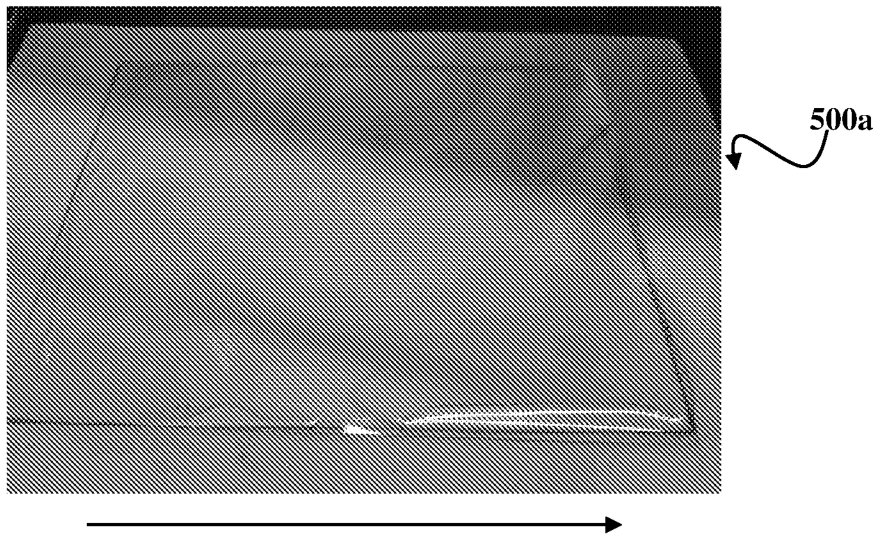


FIG. 5B

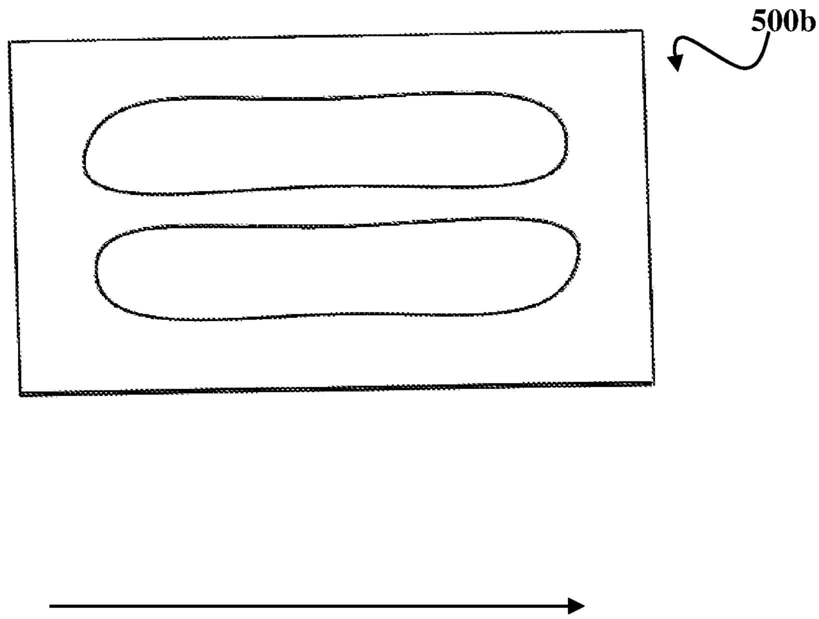


FIG. 5C

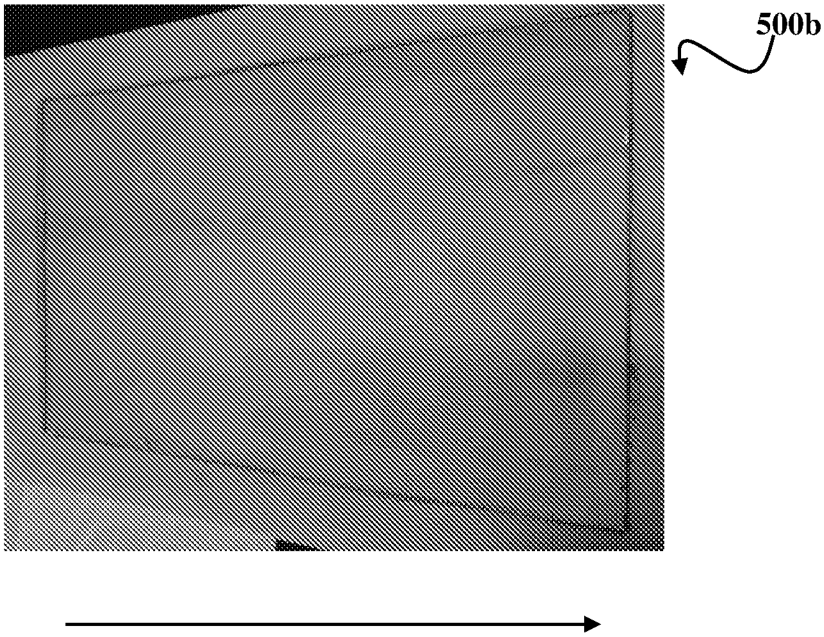


FIG. 5D

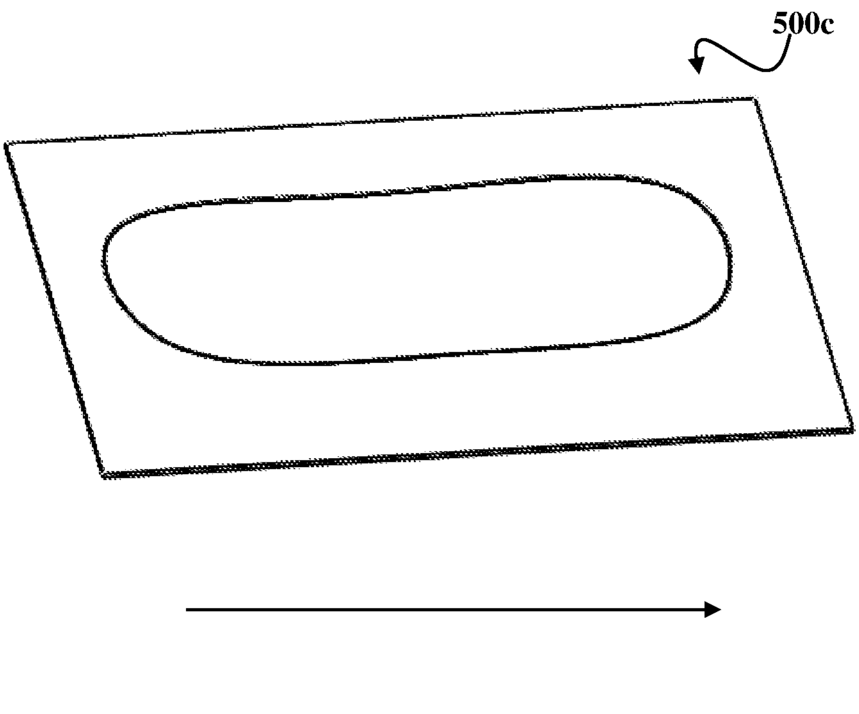


FIG. 5E

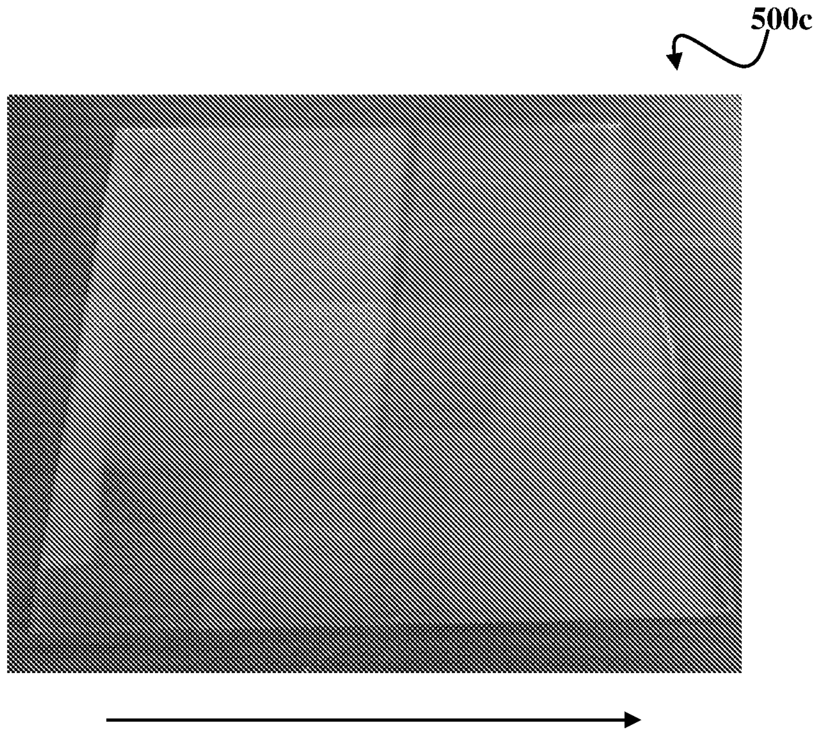


FIG. 5F

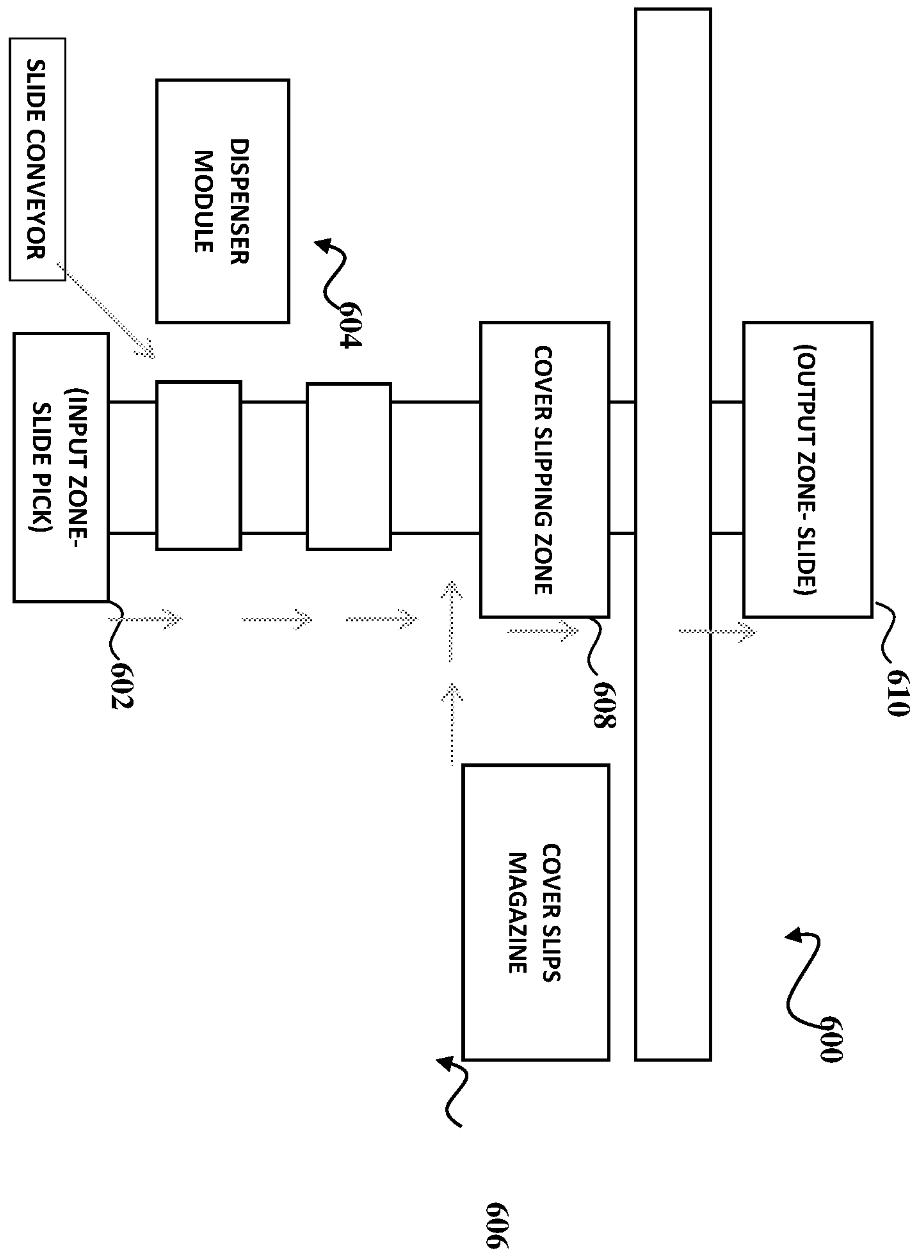

SLIDE CONVEYOR
DISPENSER MODULE
604
(INPUT ZONE- SLIDE PICK)
602
COVER SLIPPING ZONE
608
(OUTPUT ZONE- SLIDE)
610
COVER SLIPS MAGAZINE
606
600

FIG. 6A

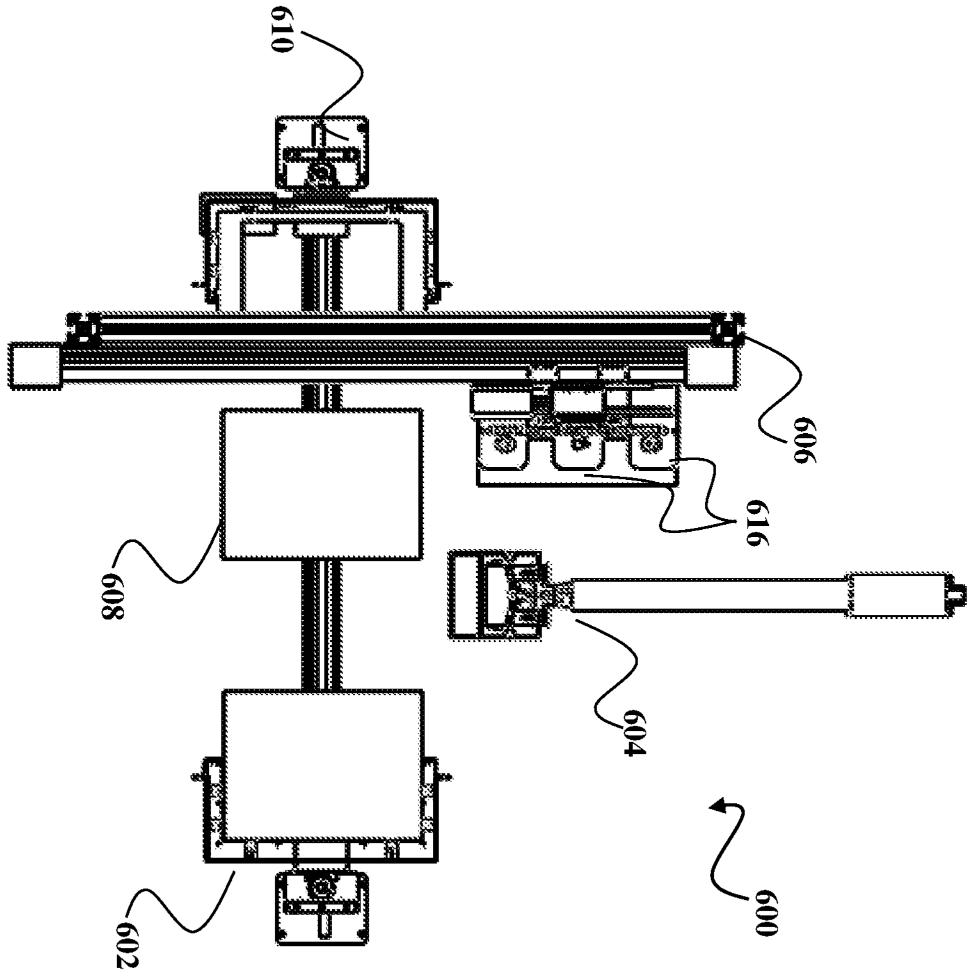


FIG. 6B

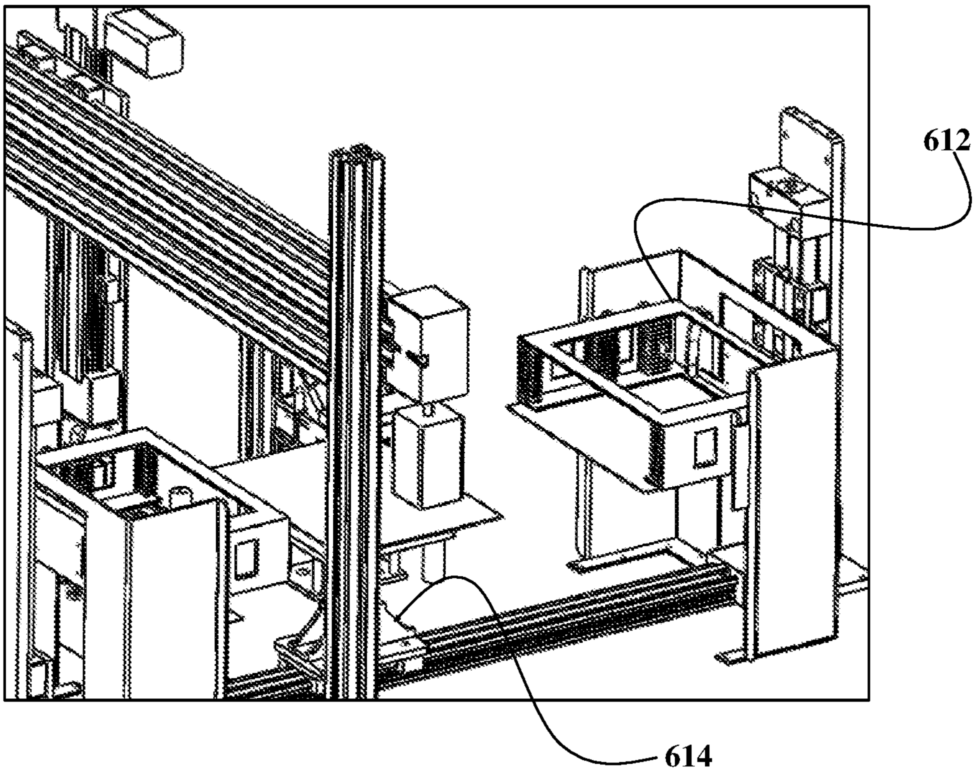


FIG. 6C

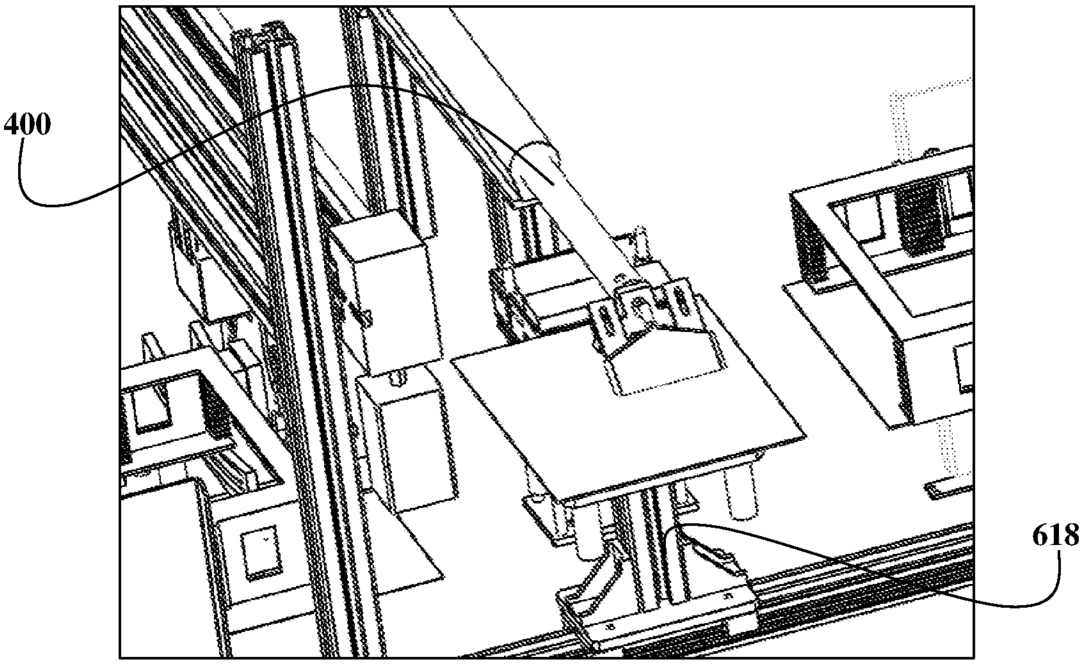


FIG. 6D

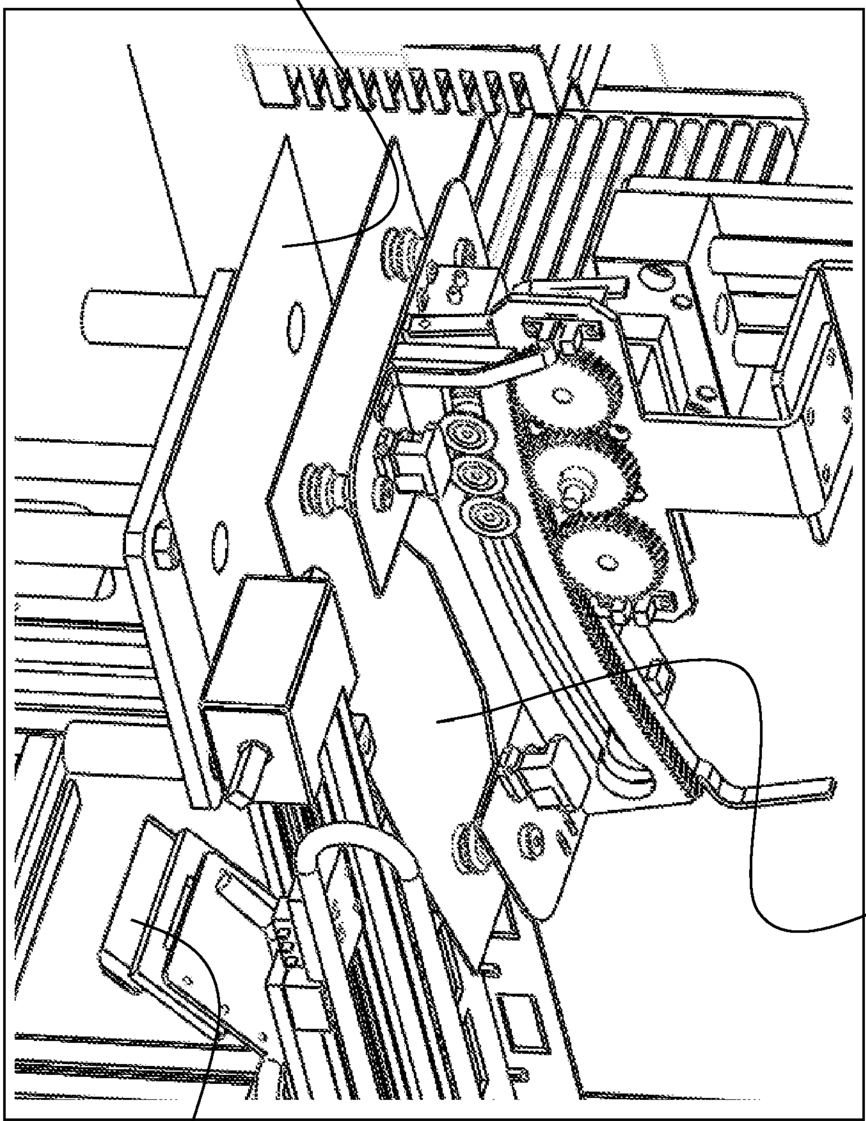


FIG. 6E

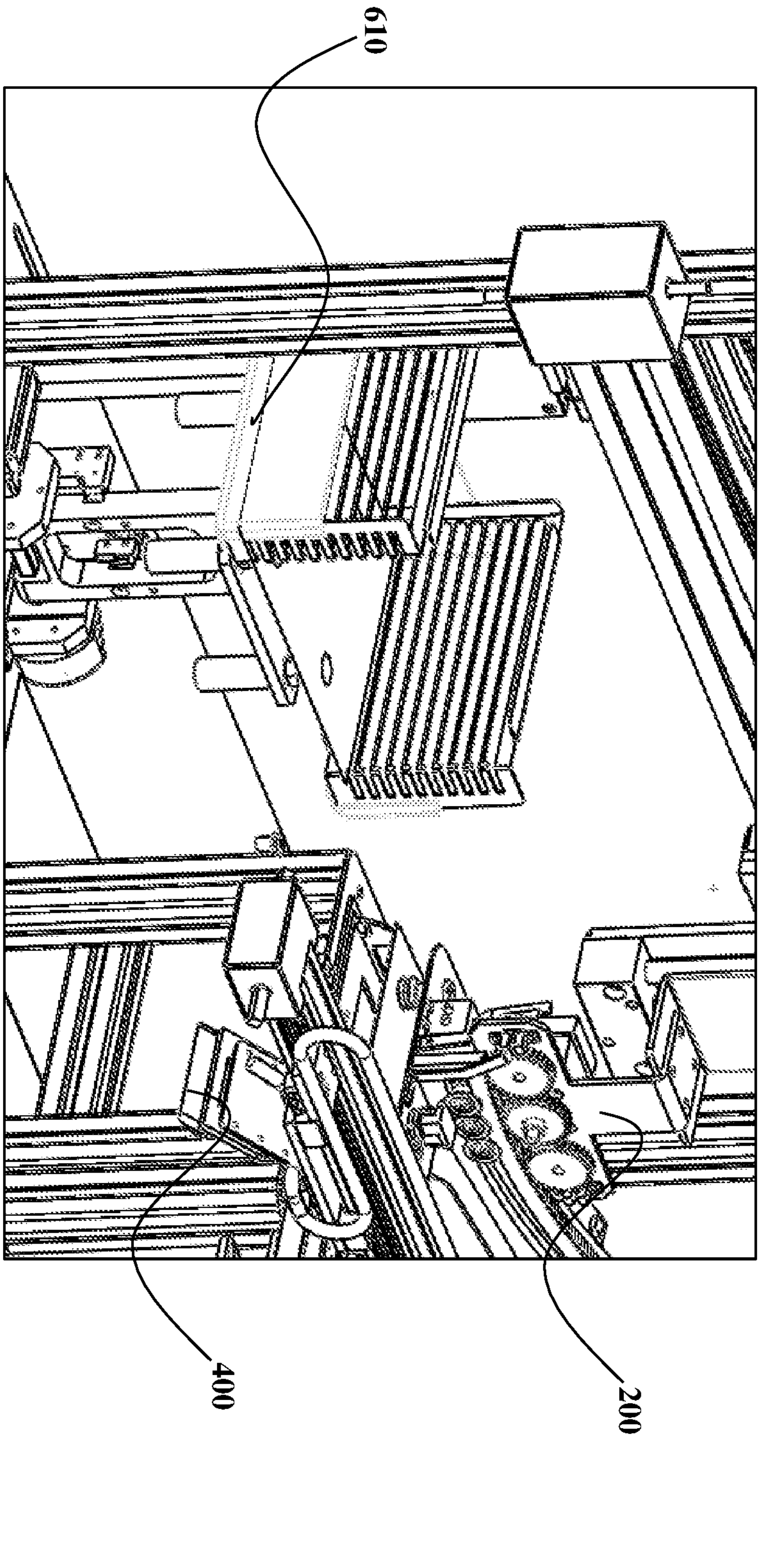


FIG. 6F

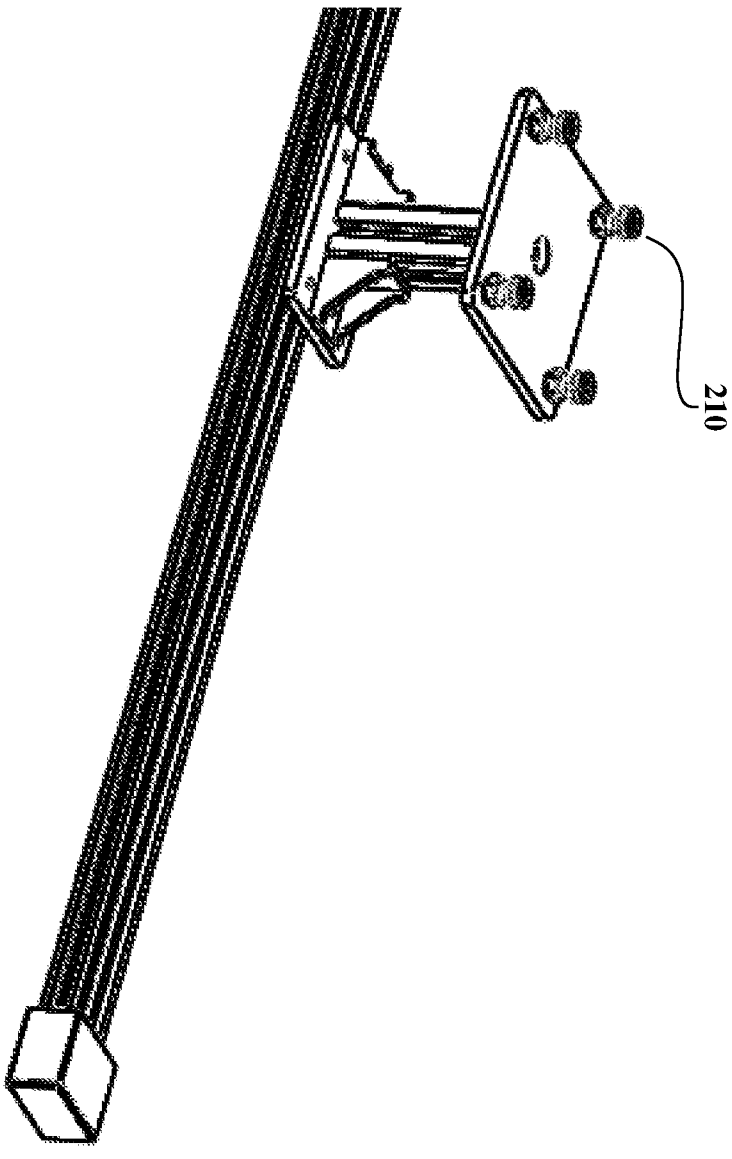


FIG. 7

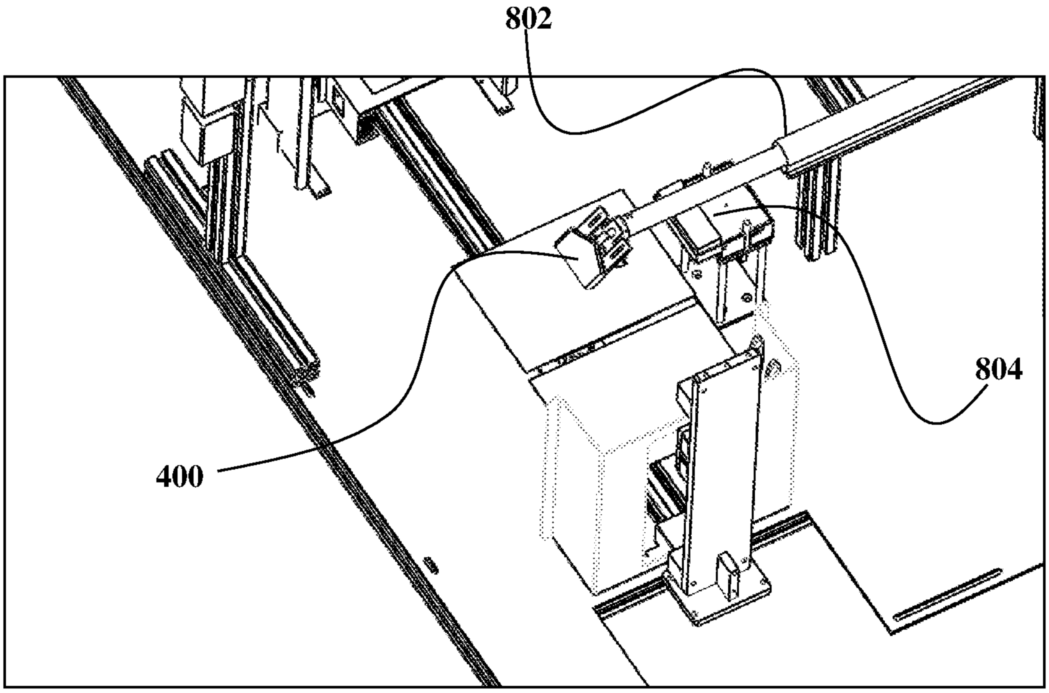


FIG. 8A

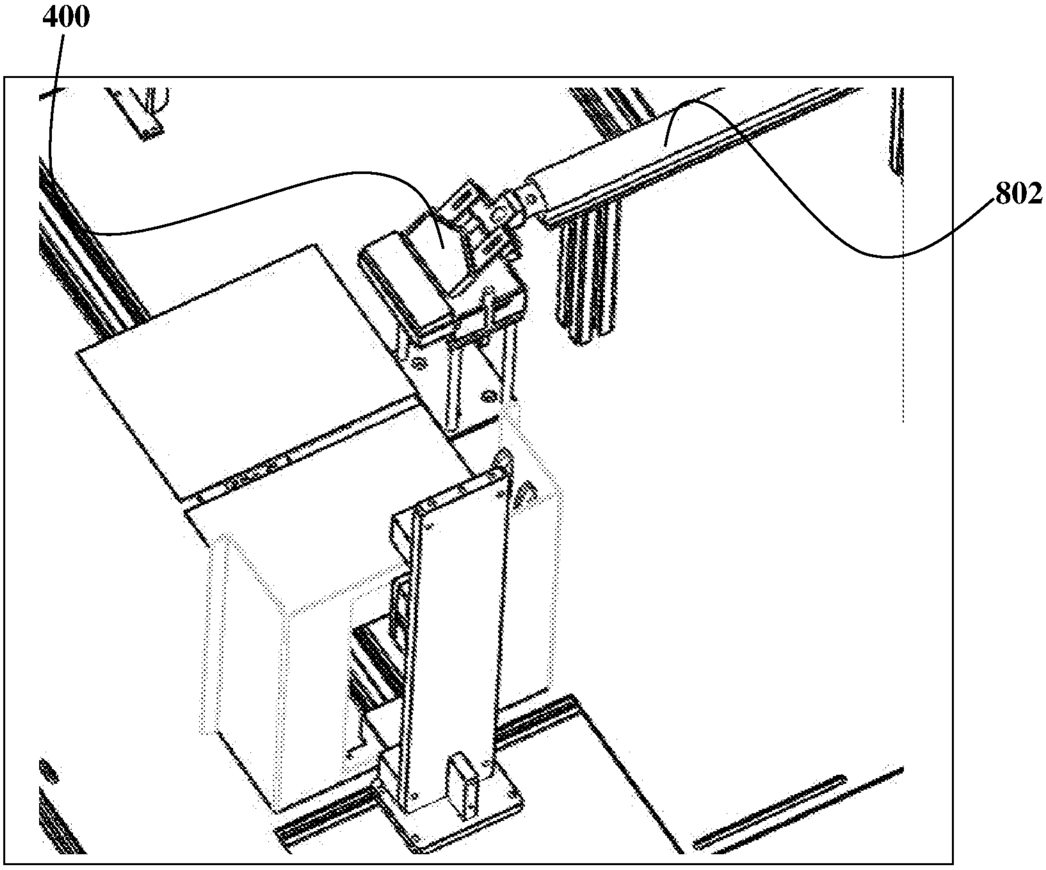


FIG. 8B

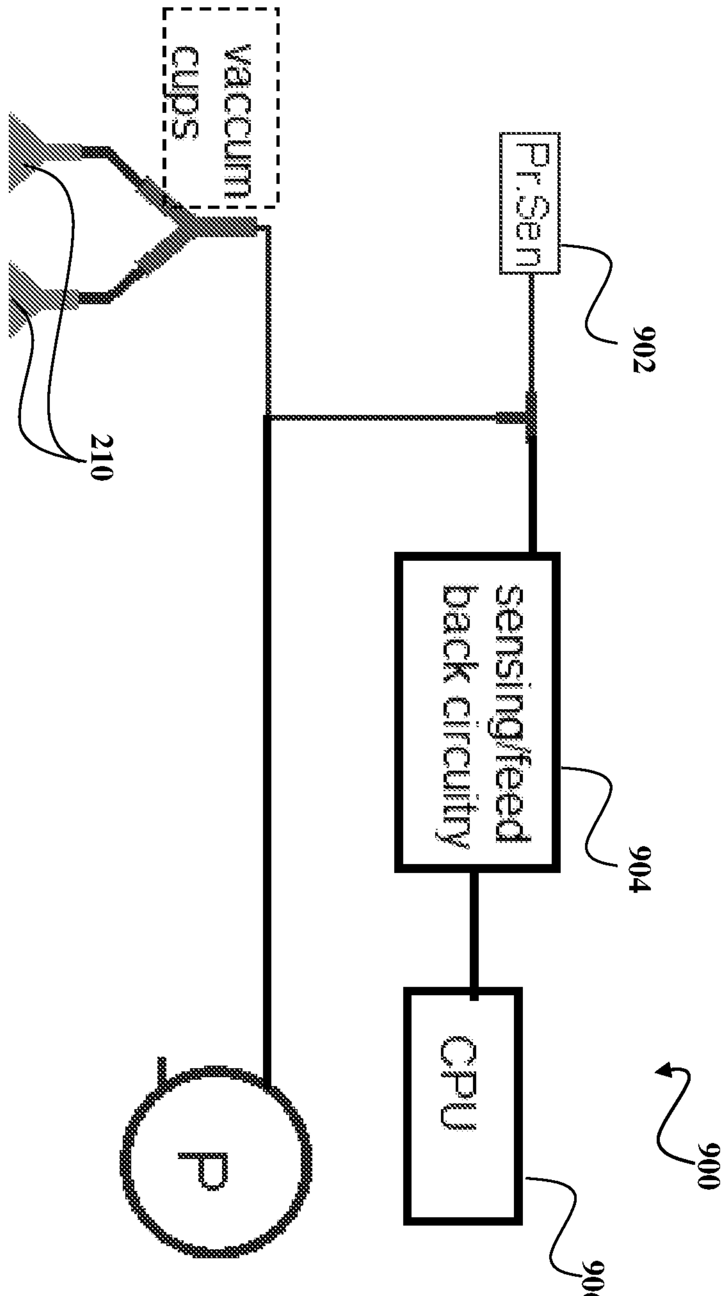

vaccum cups
210
Pr.Sen
902
sensing/feed back circuitry
904
CPU
906
P
900

FIG. 9

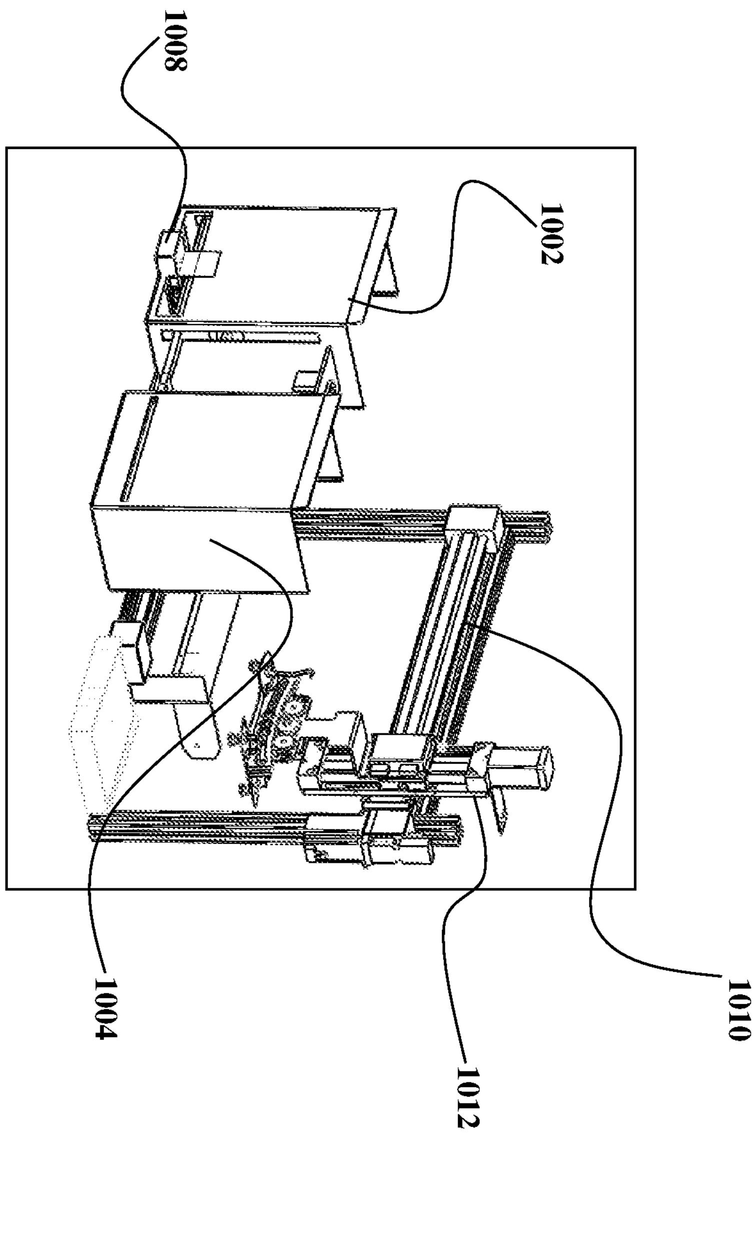


FIG. 10A

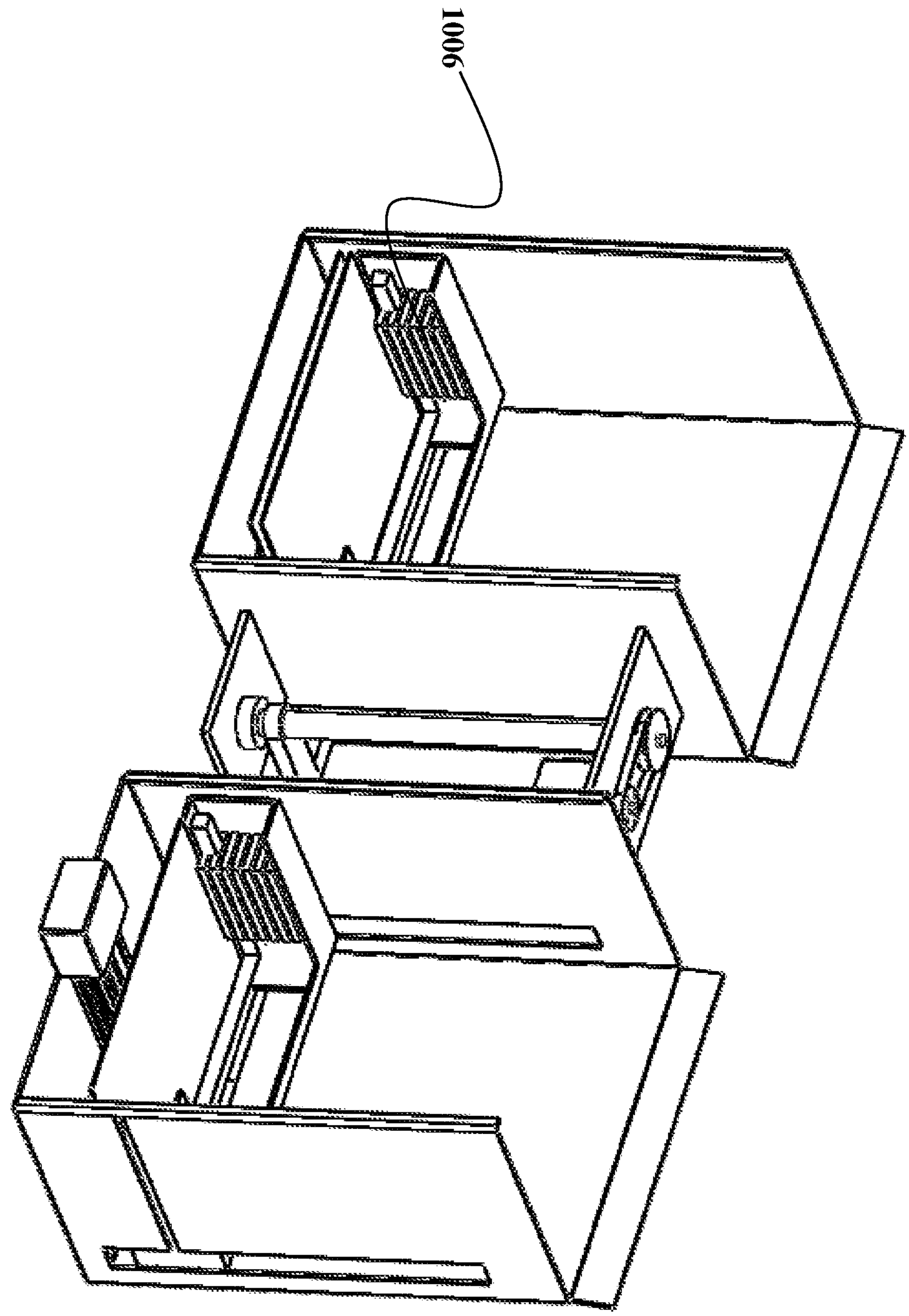


FIG. 10B

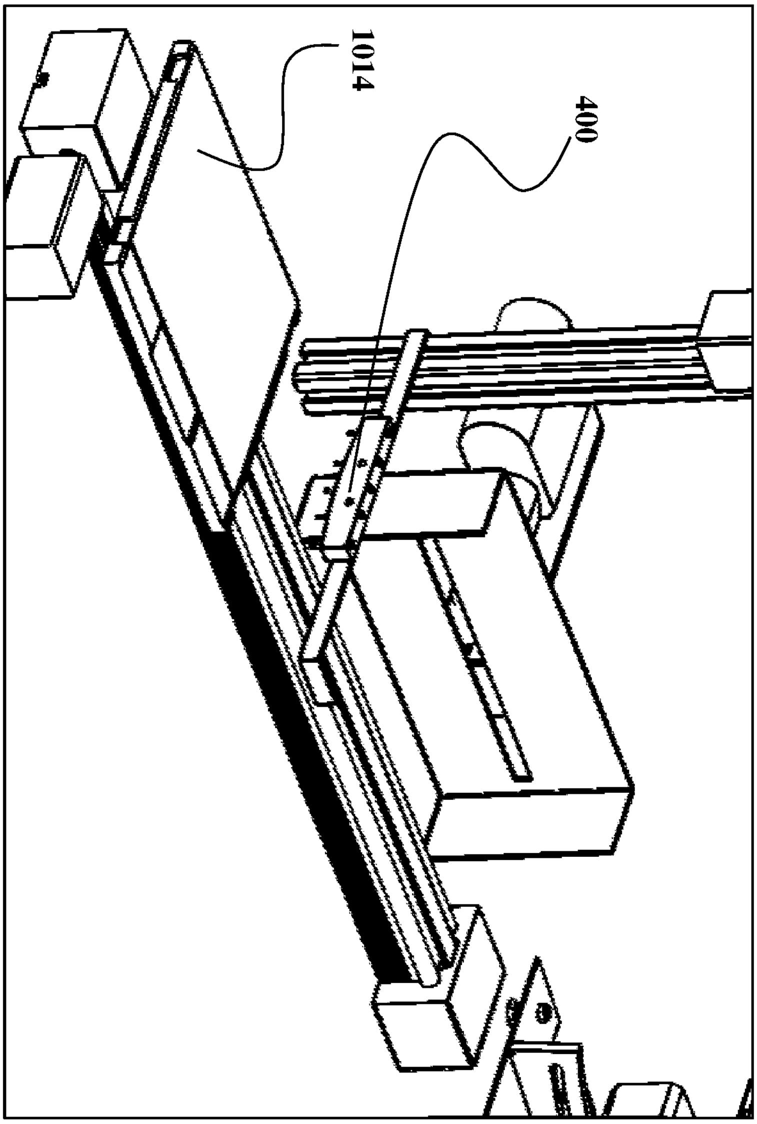
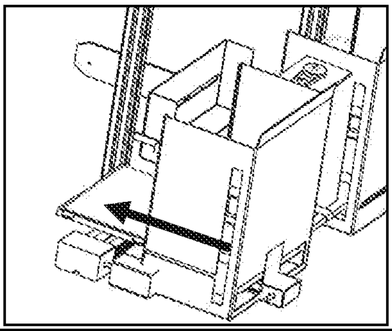
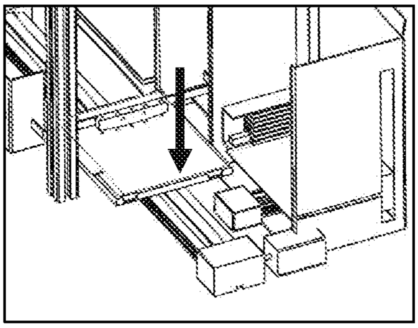


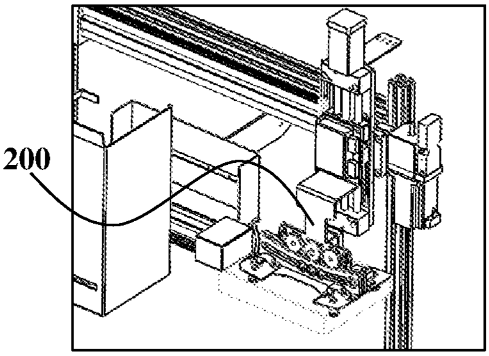
FIG. 10C



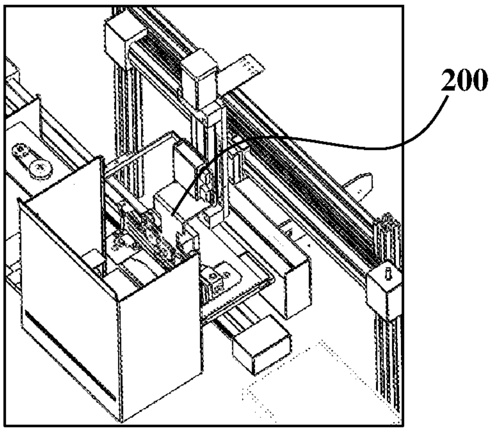
(A) LOADING OF GLASS SLIDE ON CONVEYER



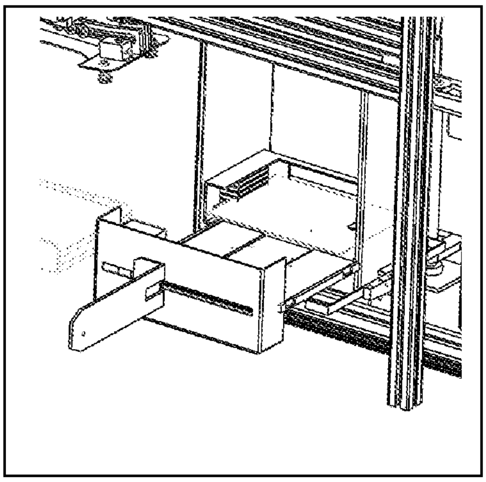
(B) DISPENSING MOUNTANT ON SLIDE



(C) PICKING UP COVER SLIP



(D) POSITIONING AND COVER SLIPPING



(E) UNLOADING THE SLIDE INTO OUTPUT TRAY

FIG. 11

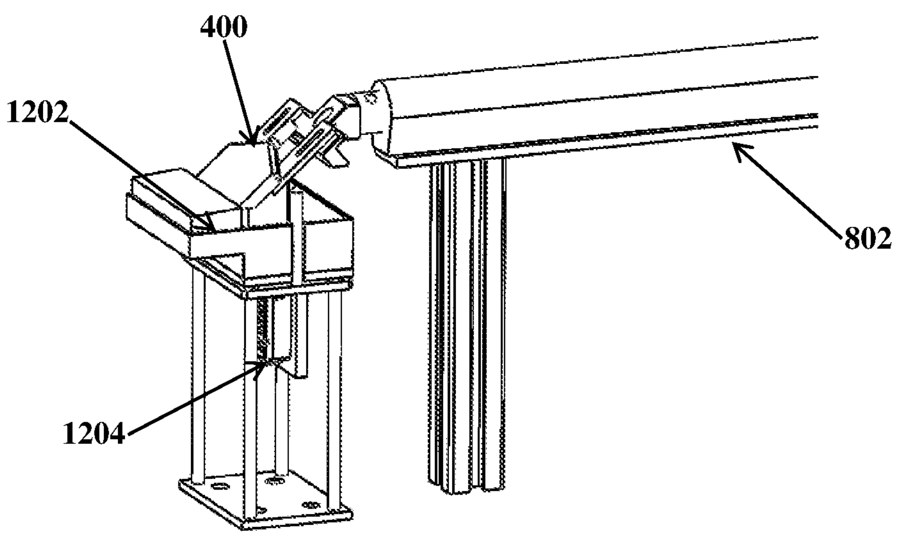


FIG. 12

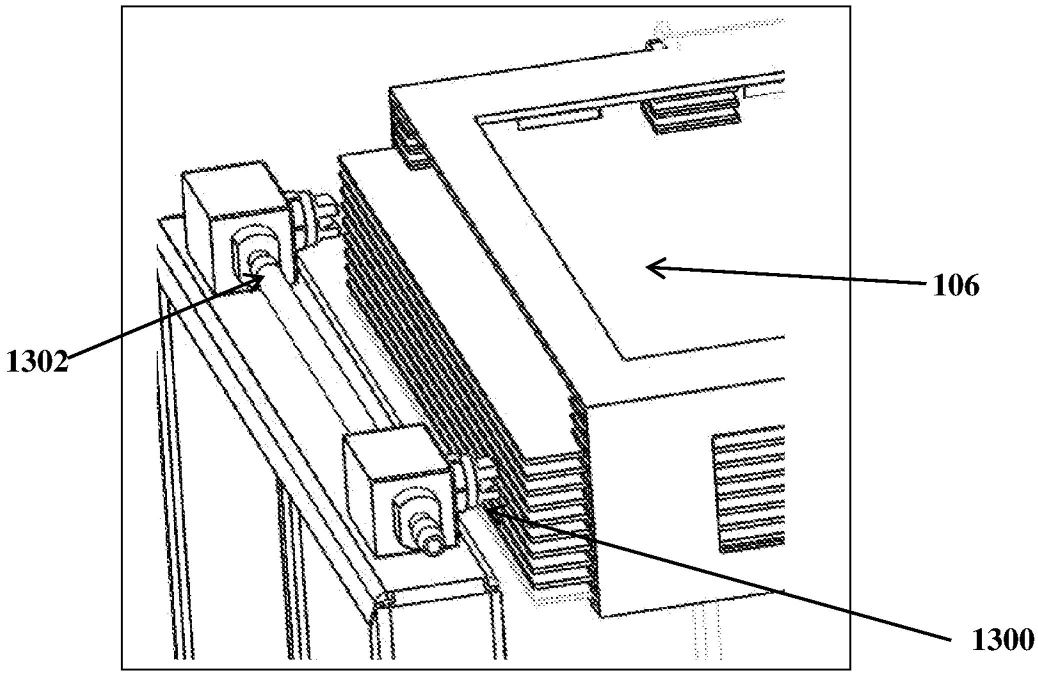


FIG. 13A

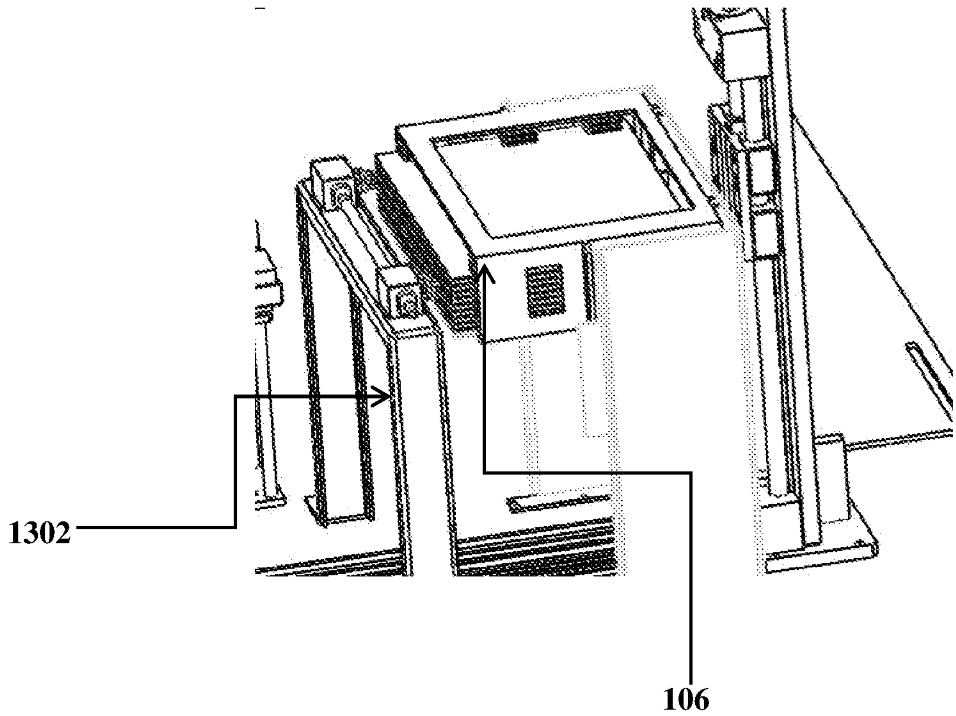


FIG. 13B

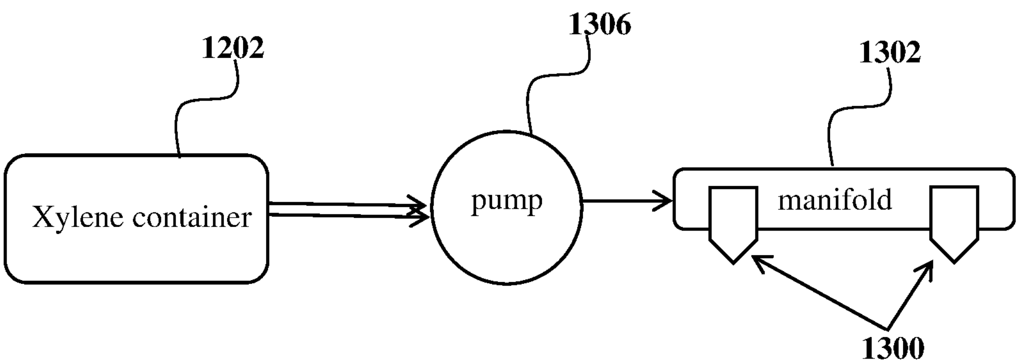


FIG. 13C

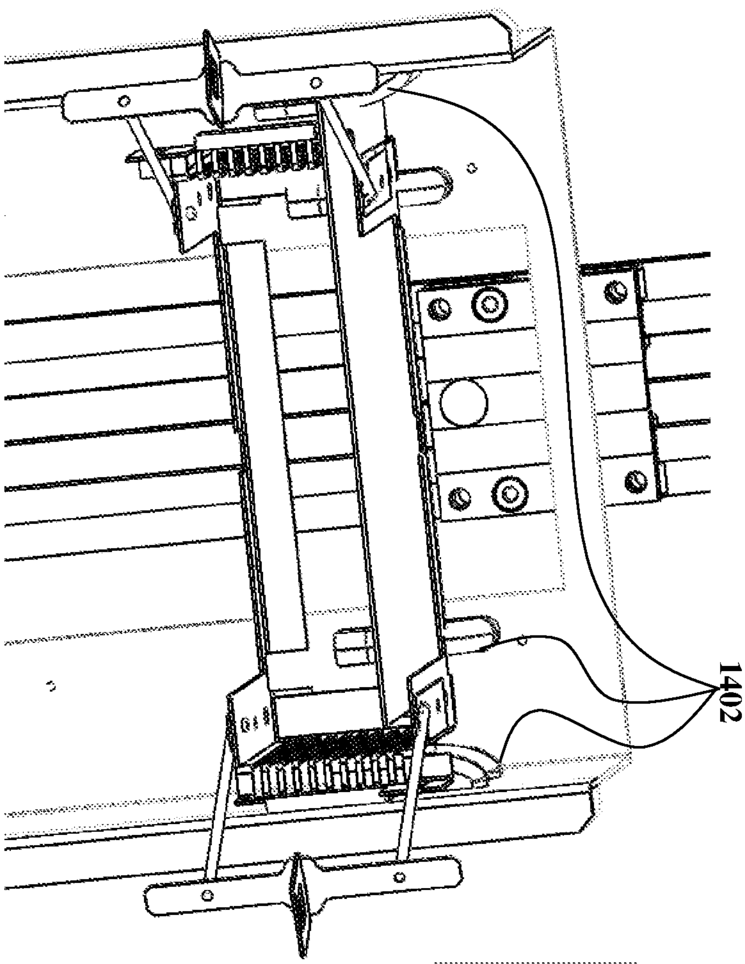


FIG. 14

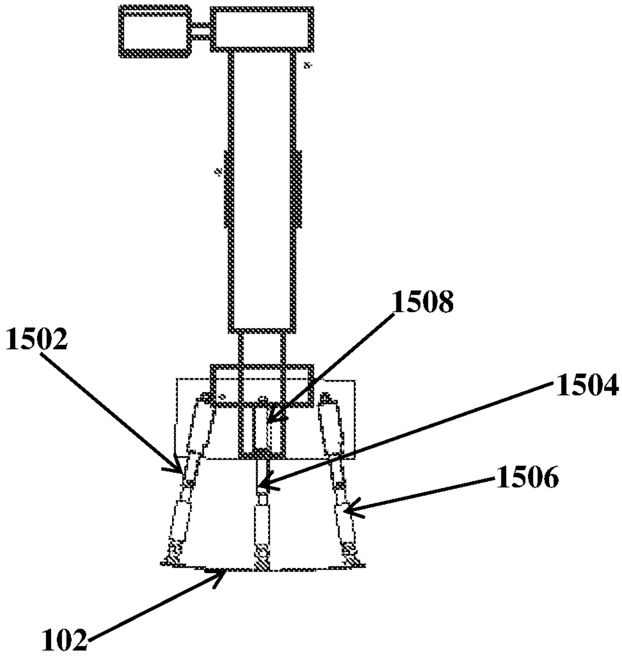


FIG. 15A

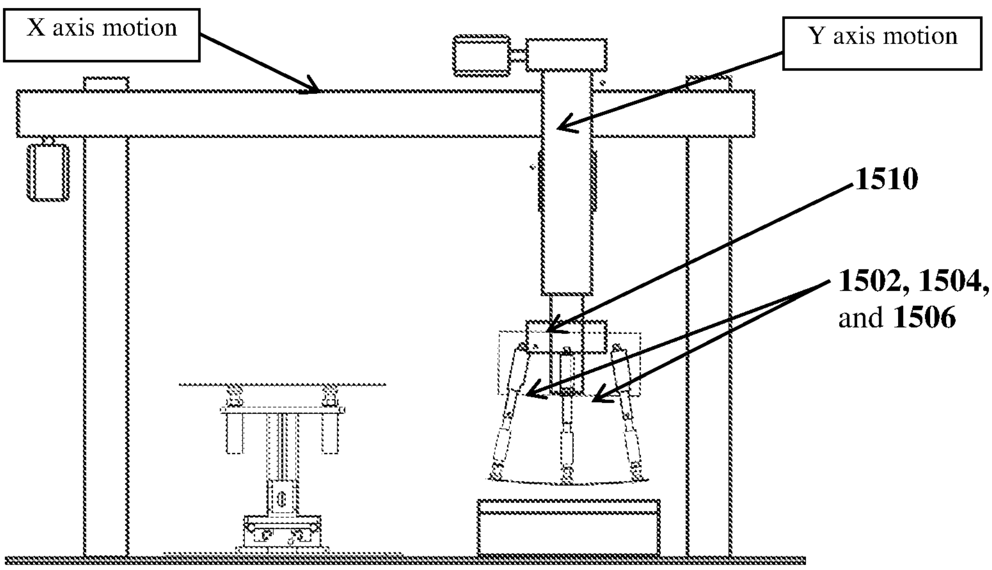


FIG. 15B

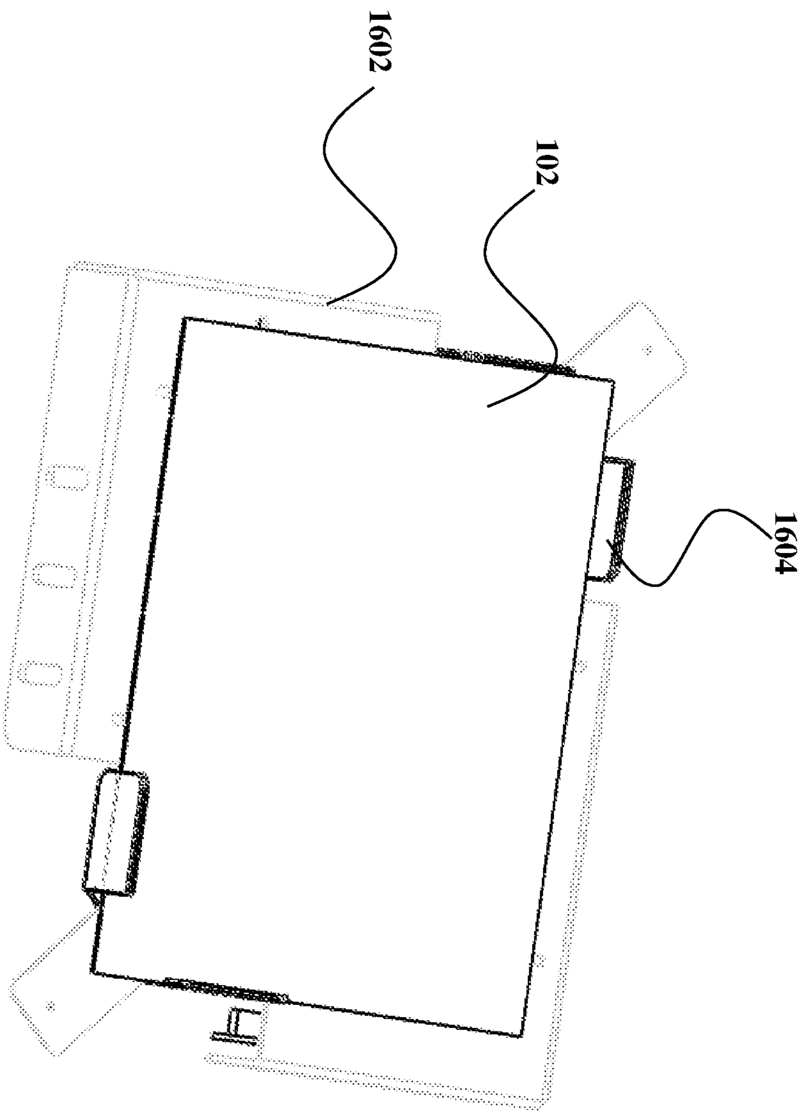


FIG. 16A

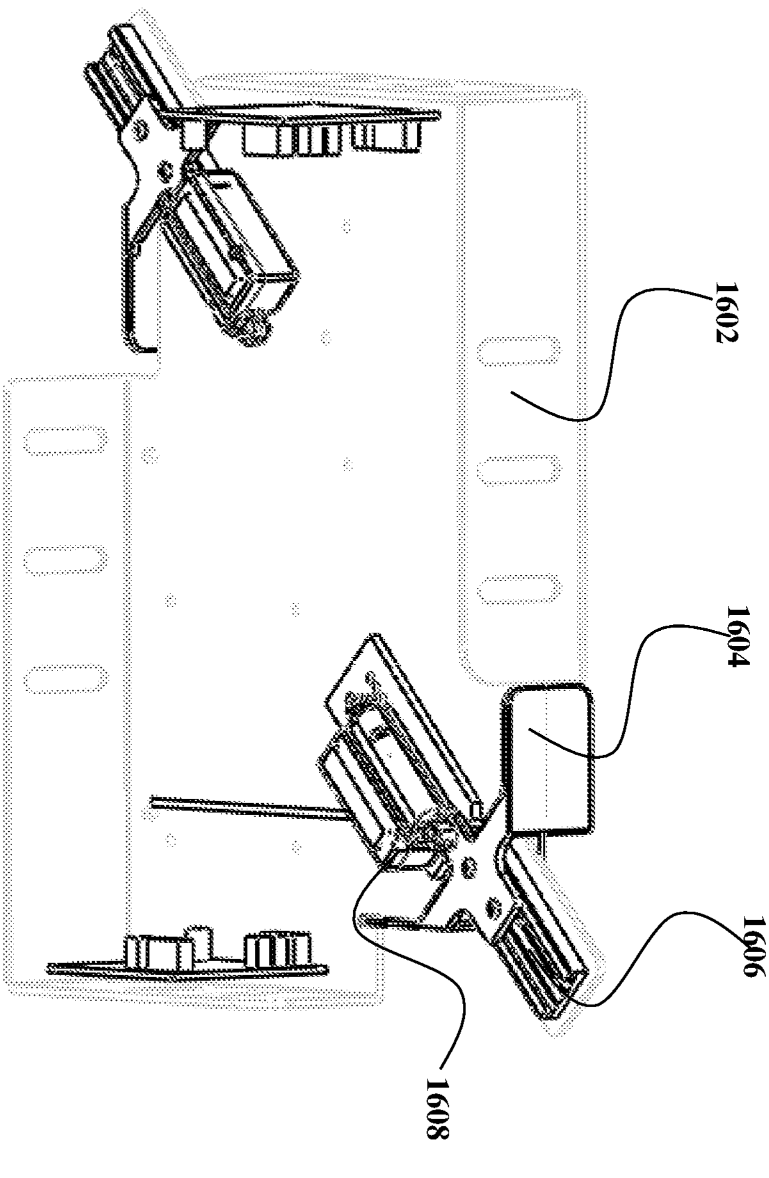


FIG. 16B

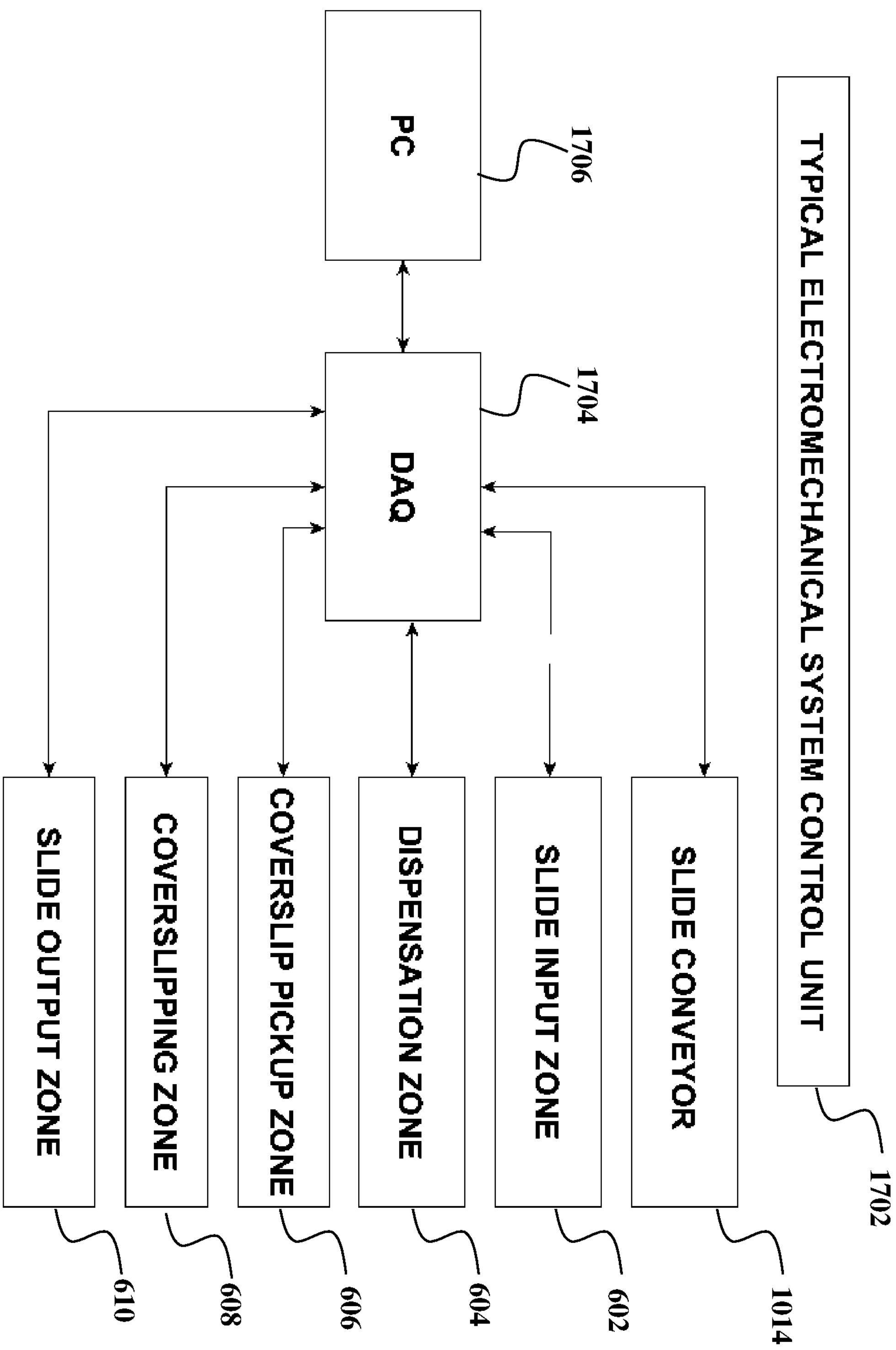

TYPICAL ELECTROMECHANICAL SYSTEM CONTROL UNIT
1702
PC
1706
DAQ
1704
SLIDE CONVEYOR
1014
SLIDE INPUT ZONE
602
DISPENSATION ZONE
604
COVERSLIP PICKUP ZONE
606
COVERSLIPPING ZONE
608
SLIDE OUTPUT ZONE
610

FIG. 17A

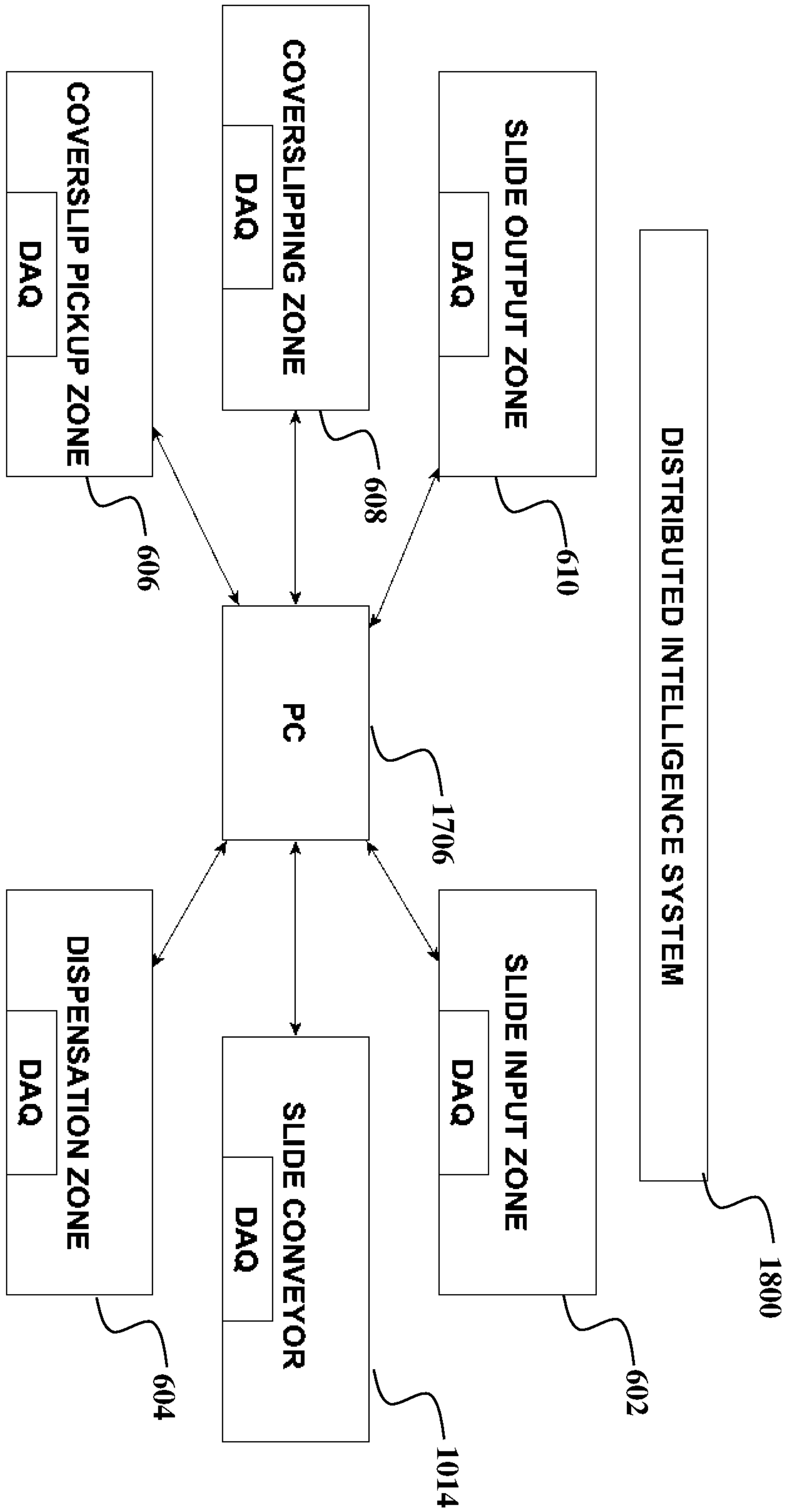

DISTRIBUTED INTELLIGENCE SYSTEM
1800
SLIDE OUTPUT ZONE
DAQ
610
COVERSLIPPING ZONE
DAQ
608
COVERSLIP PICKUP ZONE
DAQ
606
PC
1706
SLIDE INPUT ZONE
DAQ
602
SLIDE CONVEYOR
DAQ
1014
DISPENSATION ZONE
DAQ
604

FIG. 17B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IN2022/050598

A. CLASSIFICATION OF SUBJECT MATTER
G01N1/28,G02B21/34 Version=2022.01

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)

G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

PatSeer, IPO Internal Database

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US2008029218A1 (VENTANA MED SYST INC) 07 Feb 2008 (07/02/2008) Paragraph [0041],[0052],[0055],[0057,[0071]	1,3-21
A	Paragraph [0041],[0052],[0055],[0057,[0071]	2
Y	WO9520176A1 (AUSTRALIAN BIOMEDICAL Et al.) 27 Jul 1995 (27/07/1995) Line 9-21 in Page-8, Line 18 in Page 9 to line 15 in page 10, Line 28 in Page 10 to line 6 in page 11, Figure 4a	1,3,4,6,8-21
A	Line 9-21 in Page-8, Line 18 in Page 9 to line 15 in page 10, Line 28 in Page 10 to line 6 in page 11, Figure 4a	2
Y	WO2019101658A1 (VENTANA MED SYST INC Et al.) 31 May 2019 (31/05/2019) Paragraph [0099] .	1,7,18
A	Paragraph [0099] .	2

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"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)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"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
"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
"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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30-09-2022	30-09-2022

Name and mailing address of the ISA/	Authorized officer
Indian Patent Office Plot No.32, Sector 14,Dwarka,New Delhi-110075 Facsimile No.	Nathu Singh Shankla Telephone No. +91-1125300200

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP6232138B2 (VENTANA MED SYST INC) 15 Nov 2017 (15/11/2017) Paragraph [0117]	1,4,5,7
A	Paragraph [0117]	2

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IN2022/050598

Citation	Pub.Date	Family	Pub.Date
US 2008029218 A1	07-02-2008	AT 400523 T	15-07-2008
		AU 2003243167 A1	10-11-2003
		CA 2481181 A1	06-11-2003
		DK 1499548 T3	01-09-2008
		EP 1499548 A2	26-01-2005
		ES 2307962 T3	01-12-2008
		JP 2005523857 A	11-08-2005
		JP 2008077107 A	03-04-2008
		JP 2012068669 A	05-04-2012
		US 2004092024 A1	13-05-2004
		WO 03091137 A2	06-11-2003
WO 2019101658 A1	31-05-2019	CN 111356912 A	30-06-2020
		EP 3714251 A1	30-09-2020
		JP 2021504686 A	15-02-2021
		US 11391654 B2	19-07-2022
JP 6232138 B2	15-11-2017	AU 2014363678 A1	16-06-2016
		CA 2932492 A1	18-06-2015
		CN 105980828 A	28-09-2016
		EP 3080580 A1	19-10-2016
		ES 2877855 T3	17-11-2021
		US 10416176 B2	17-09-2019
		US 10551395 B2	04-02-2020
		WO 2015086534 A1	18-06-2015