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Miller et al.

(54) SUBSTRATE NEST WITH DRIP REMOVER

(76) Inventors: **Kenneth C. Miller**, Fremont, CA (US); **Rito Ligutom**, Fremont, CA (US); **Helmuth Treichel**, Fremont, CA (US); **Flint Thorne**, Fremont, CA (US)

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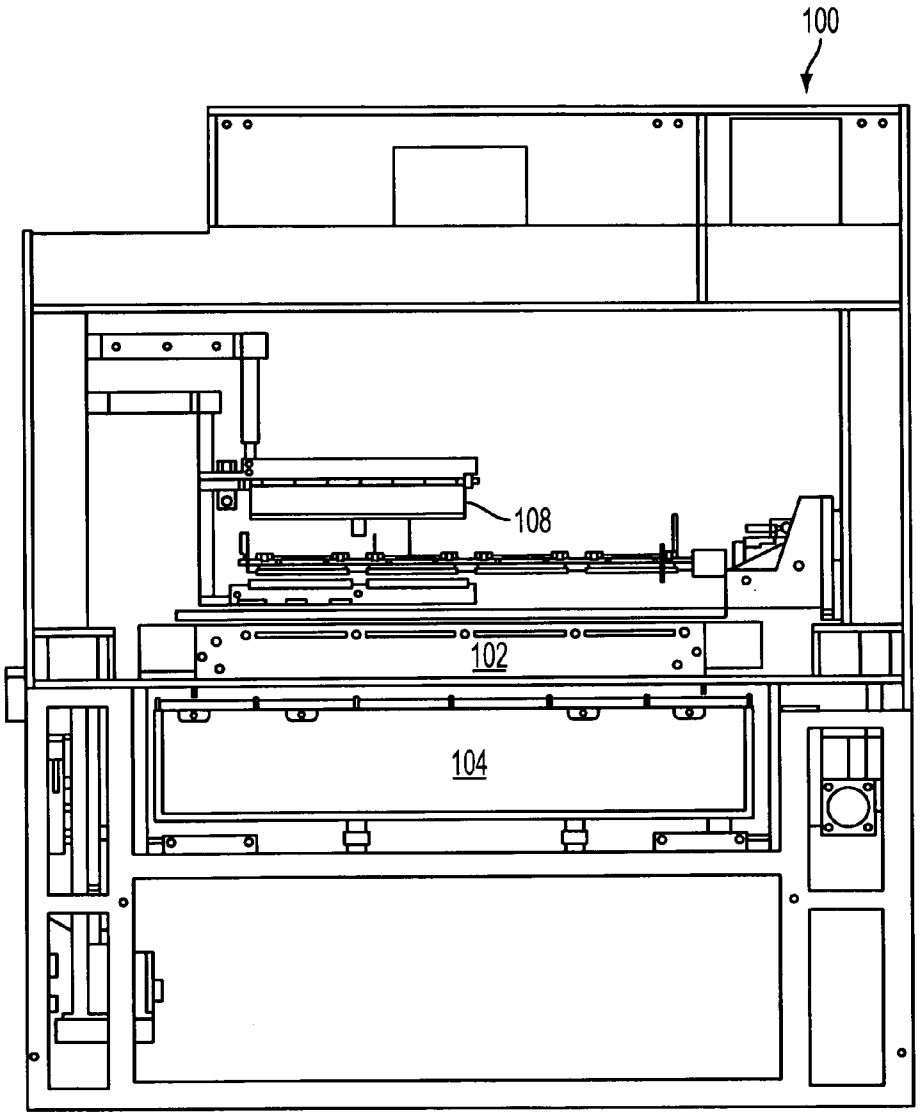
(57) **ABSTRACT**

An apparatus for supporting a work piece is provided. The apparatus includes outer support rails having support slots for supporting the work piece, the outer support rails disposed on opposing sides of the apparatus between opposing end members of the apparatus. Inner support rails extend between the opposing end members of the apparatus. An inner surface of each of the inner support rails has vertically disposed extensions extending therefrom. The vertically disposed extensions are aligned in pairs along a length of the inner support rails. A moveable device is disposed between the pairs of vertically disposed extensions. The moveable device is buoyantly moveable so that as the work piece is lifted, the moveable device follows. A method for cleaning a work piece is also included.



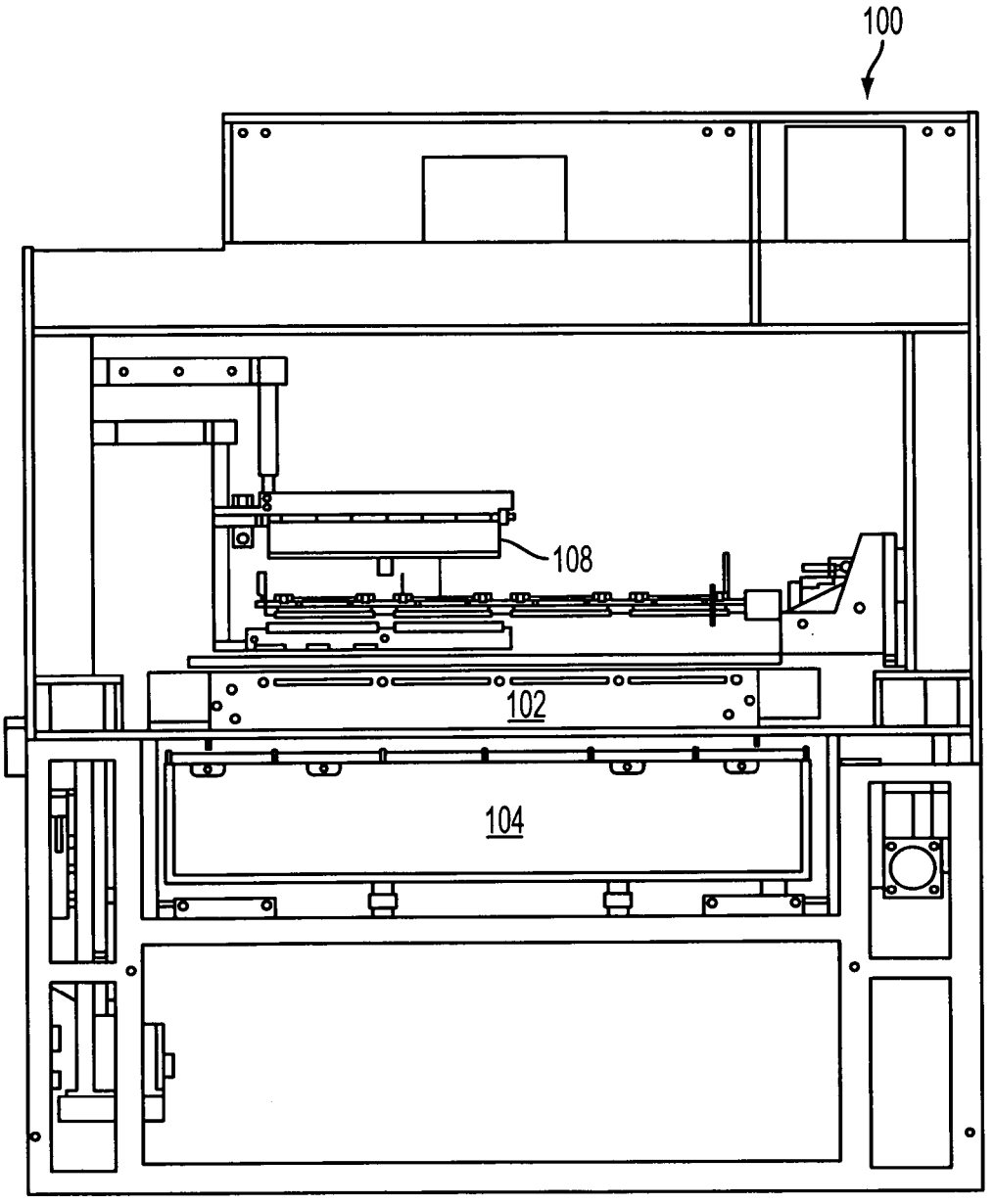


FIG. 1

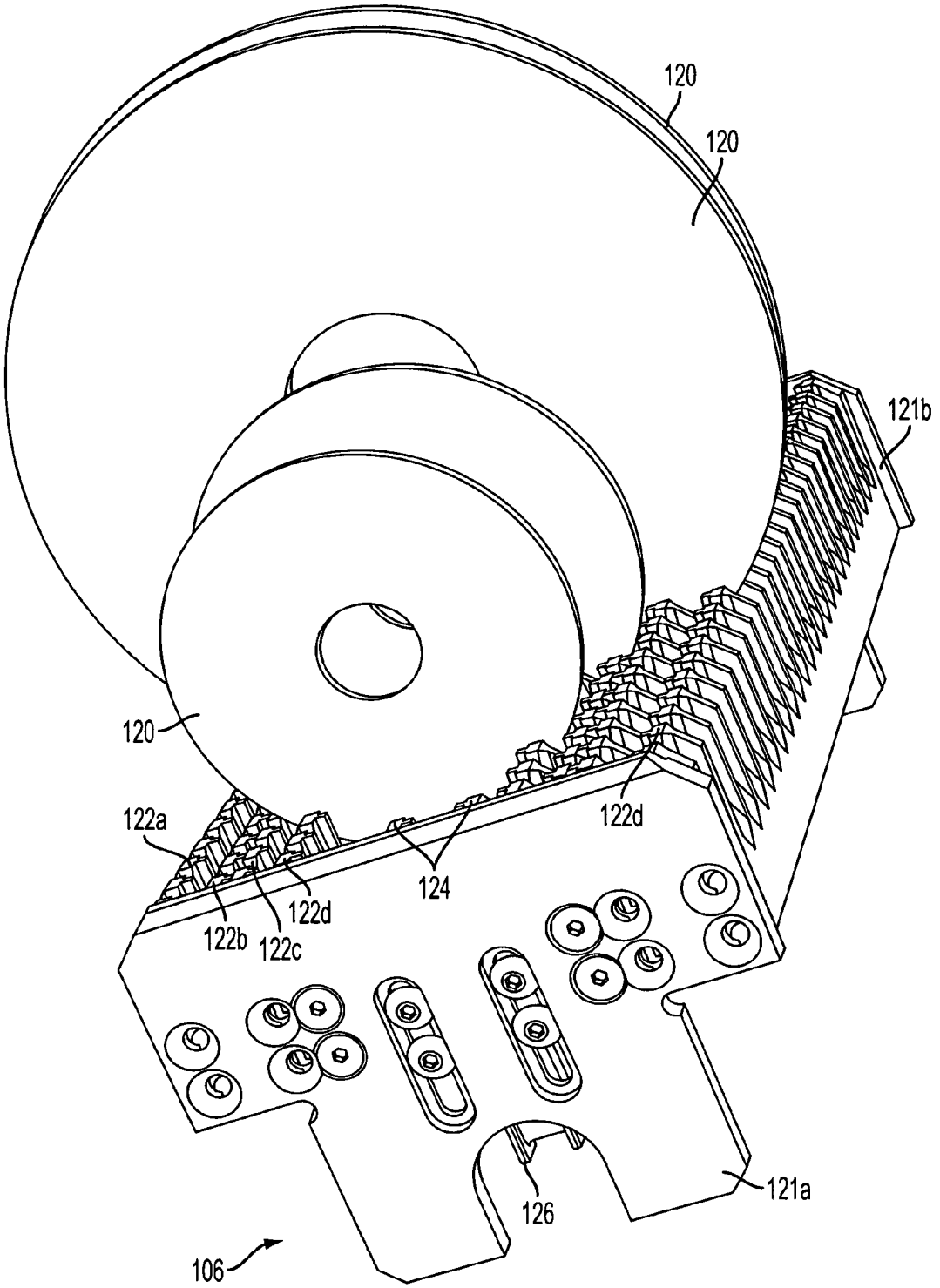


FIG. 2

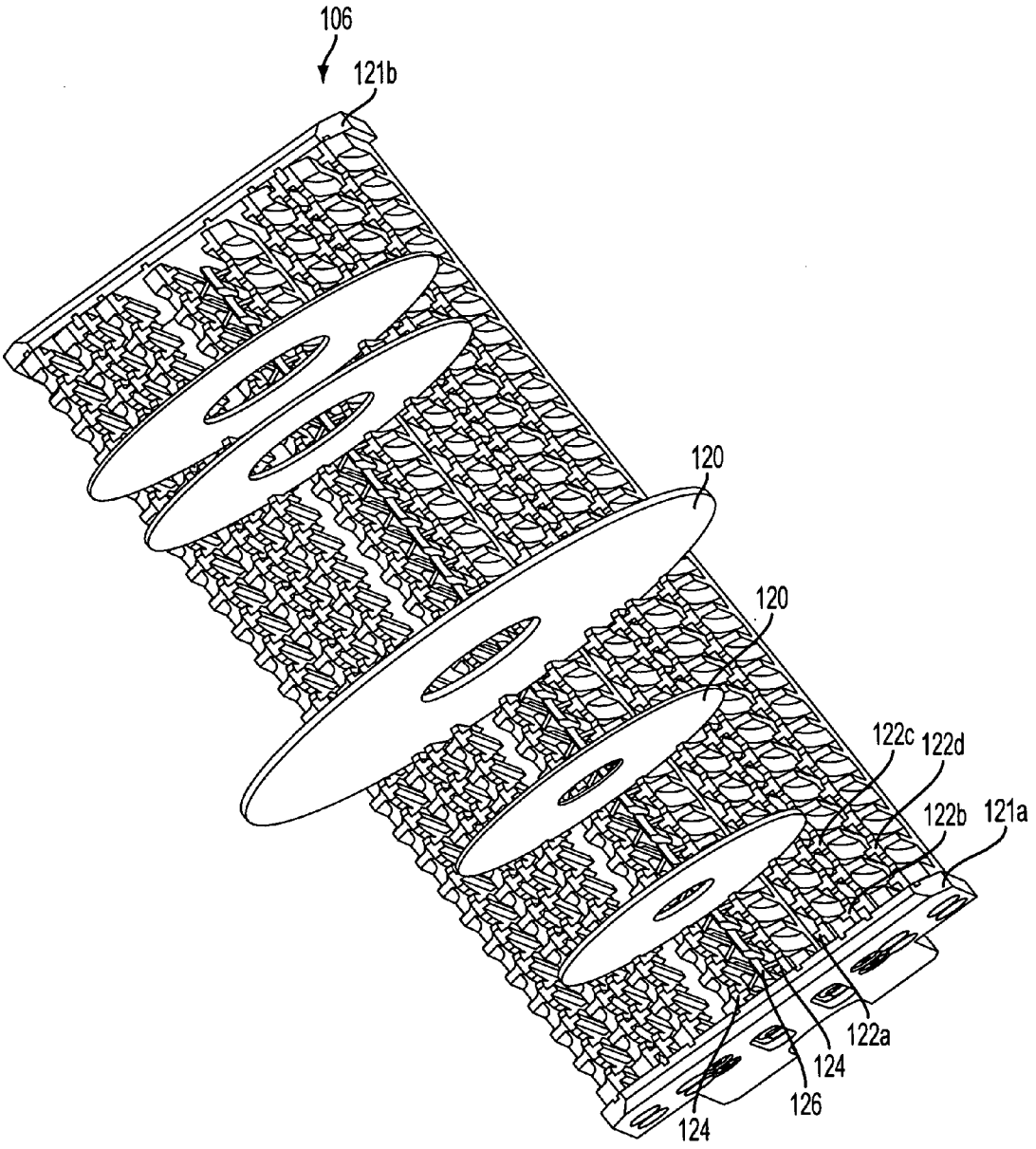


FIG. 3

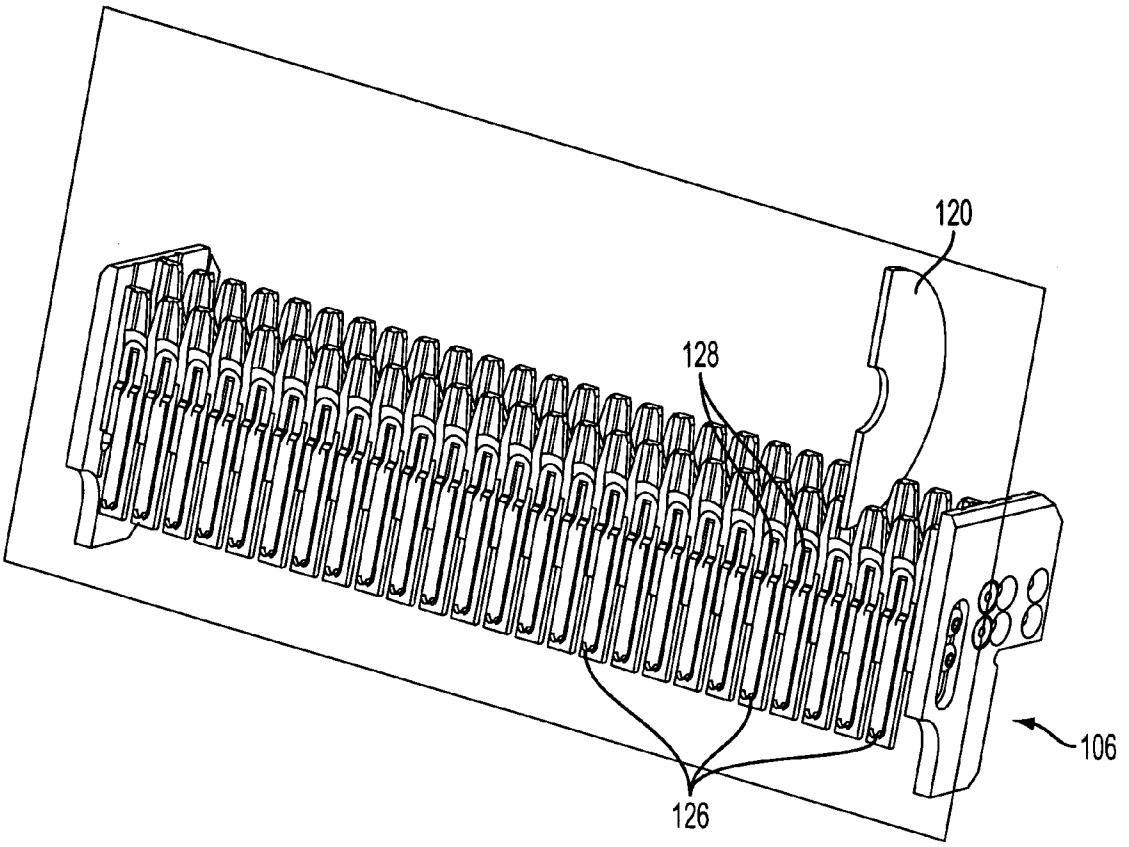


FIG. 4

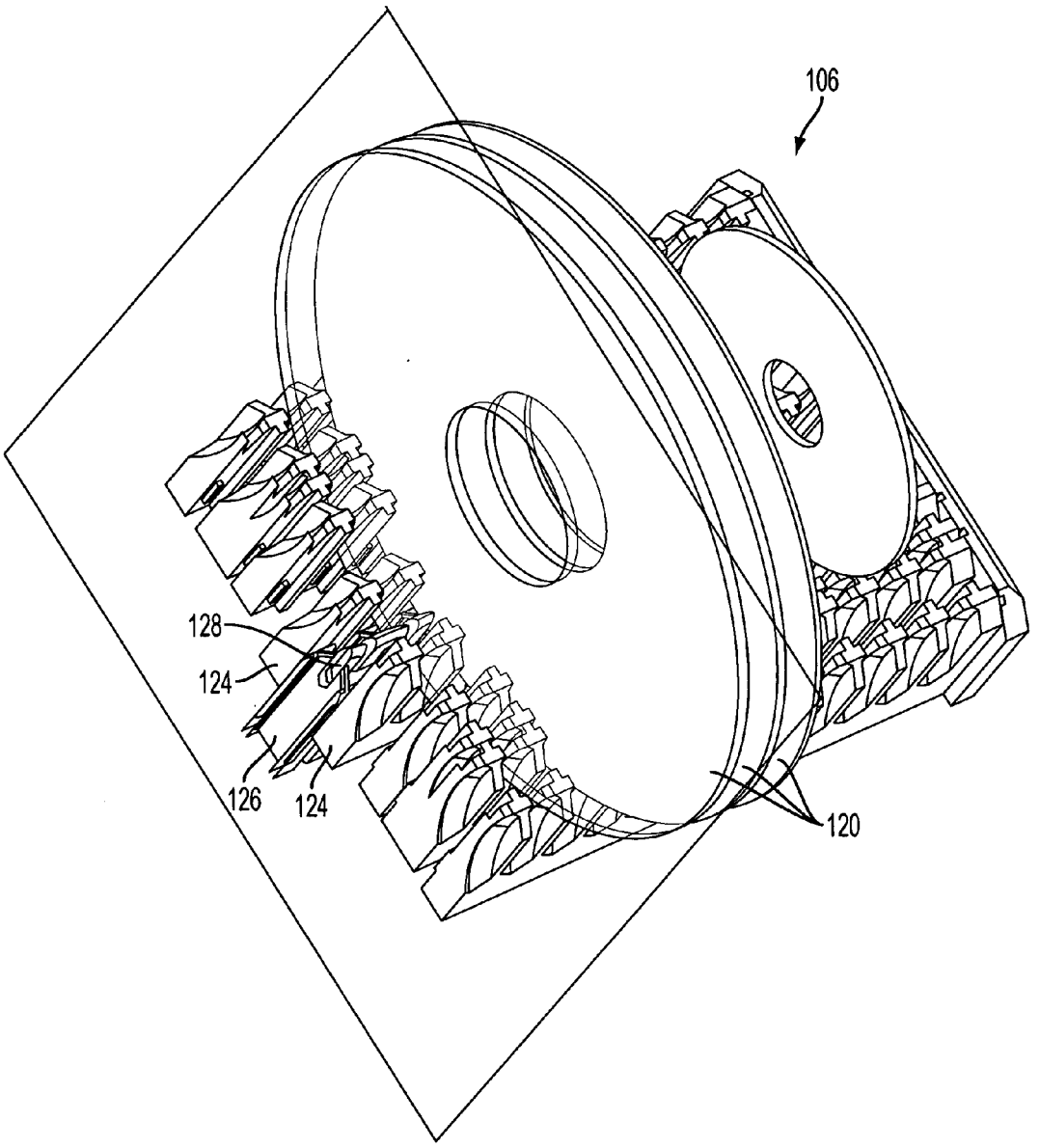


FIG. 5

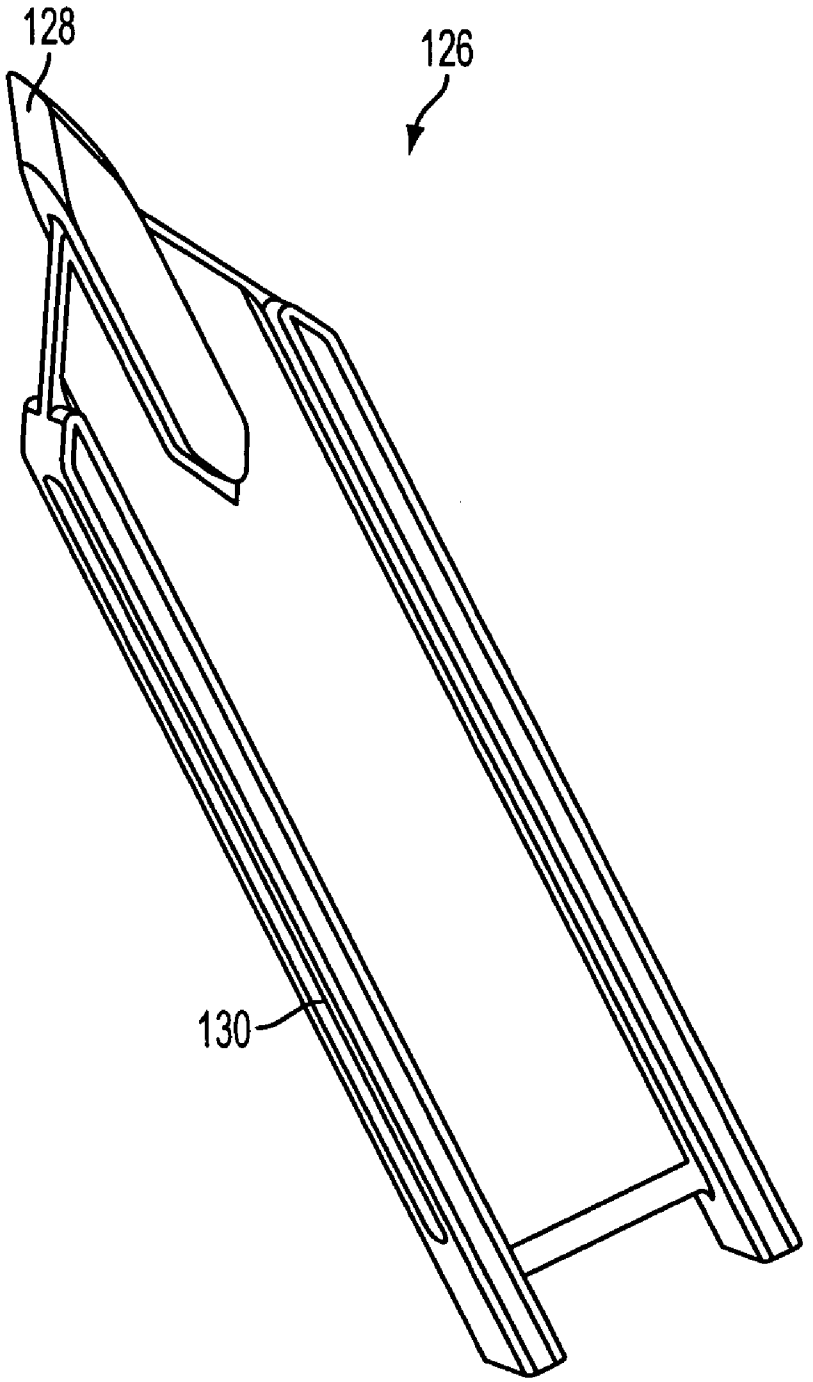


FIG. 6

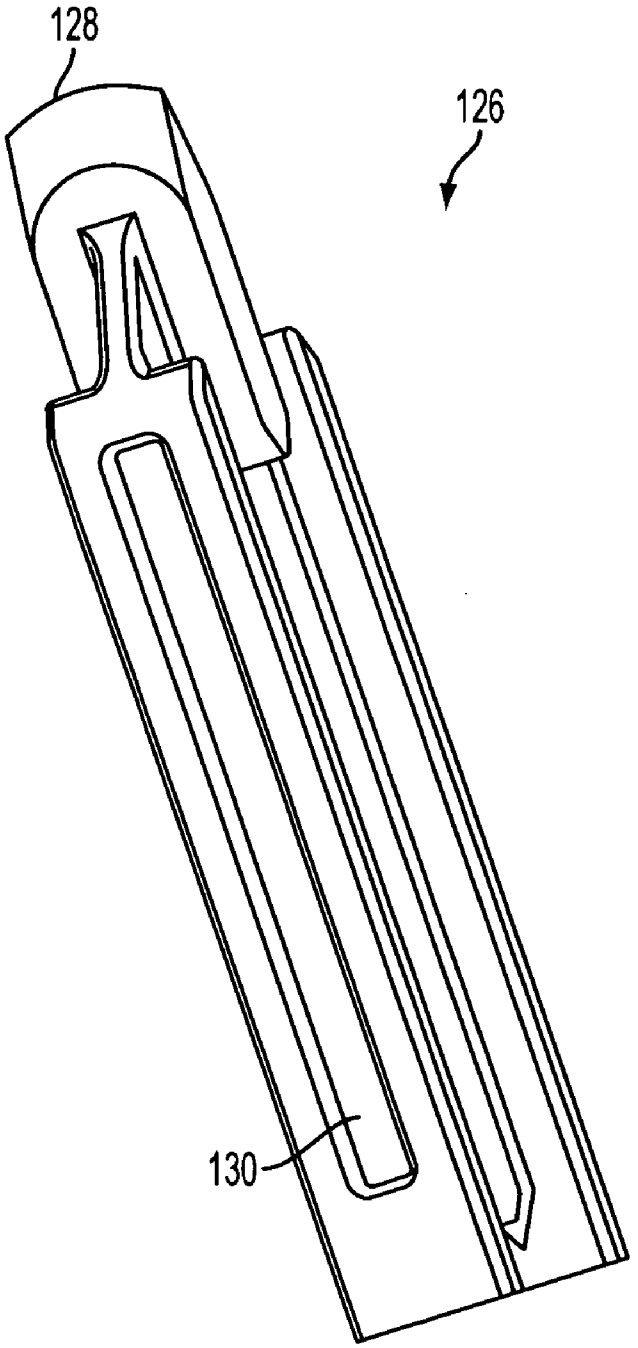


FIG. 7

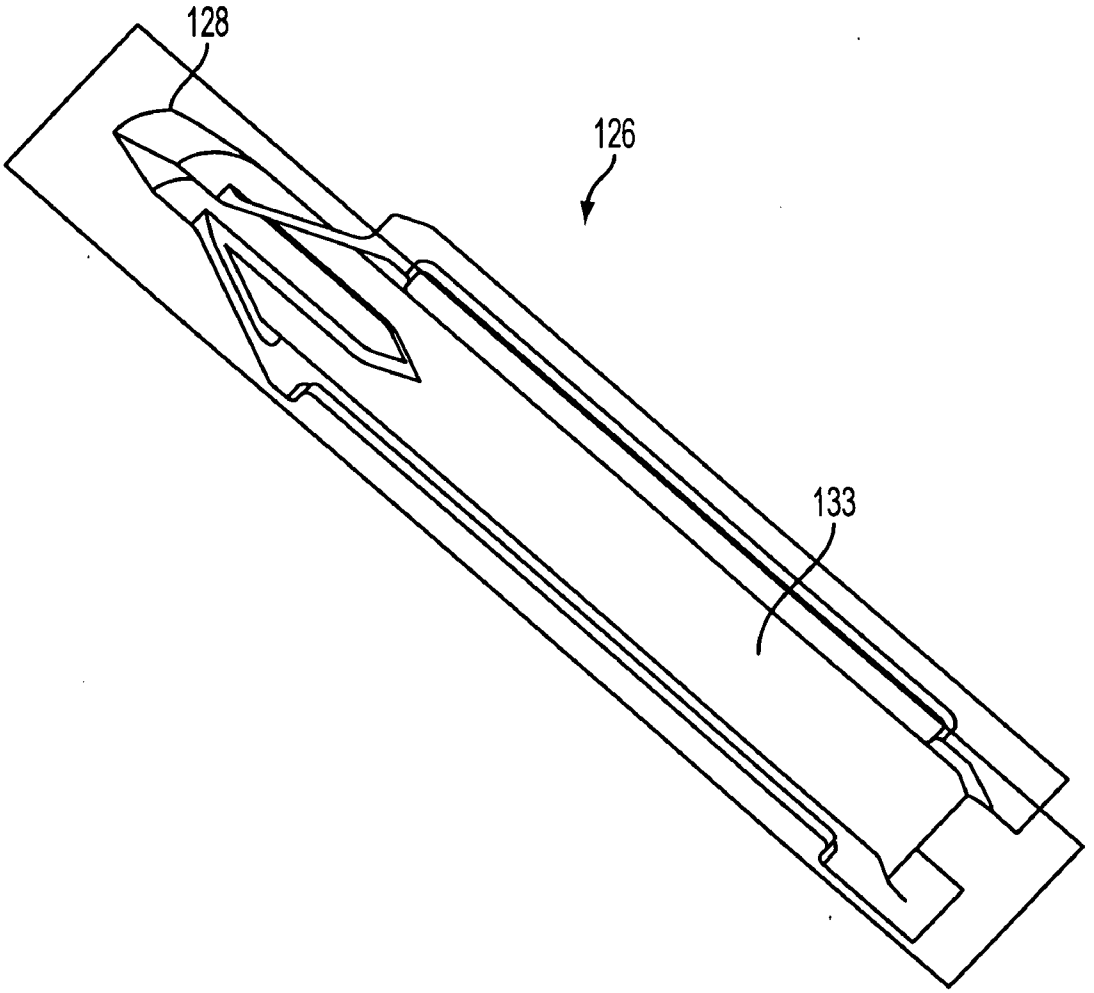


FIG. 8

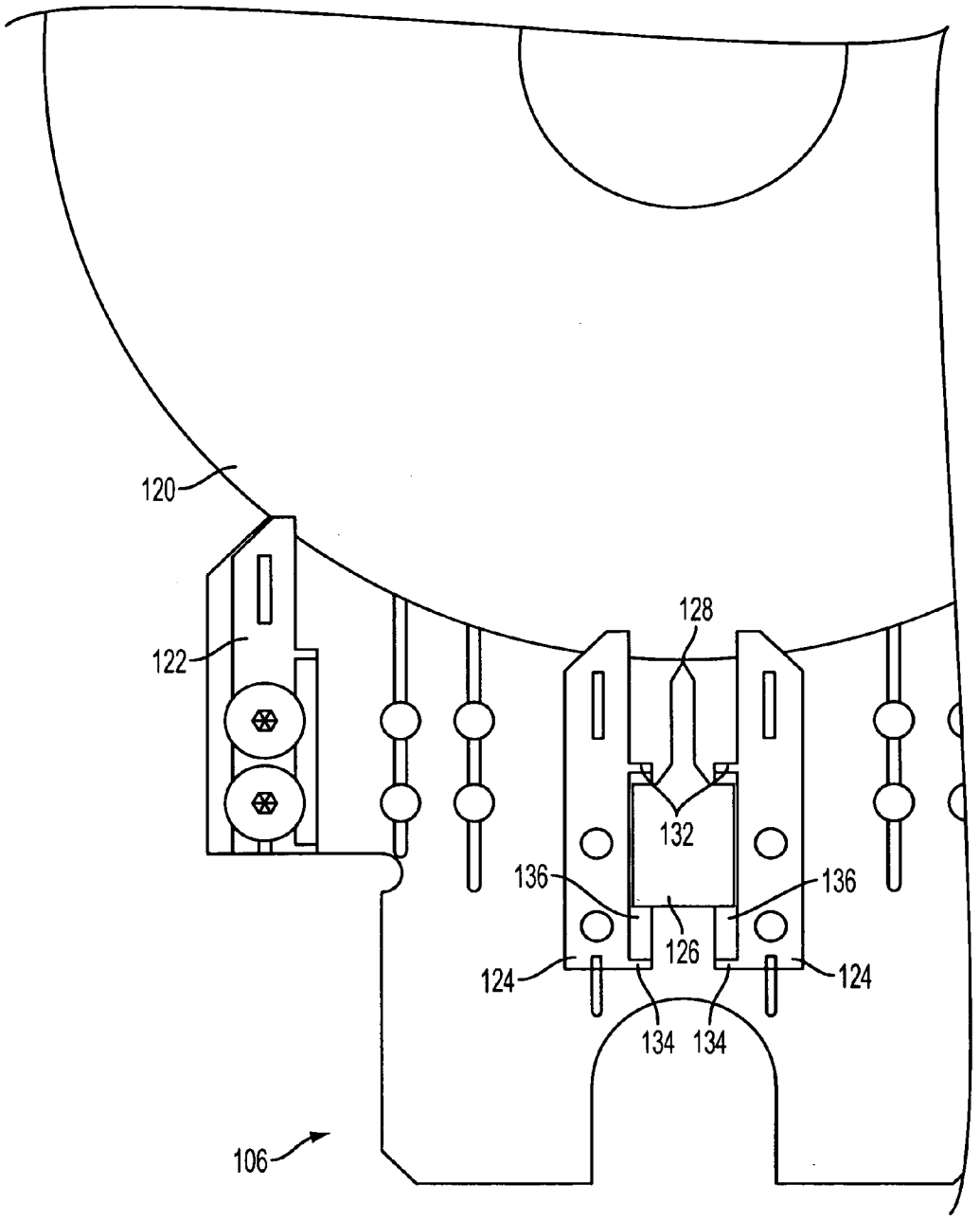


FIG. 9

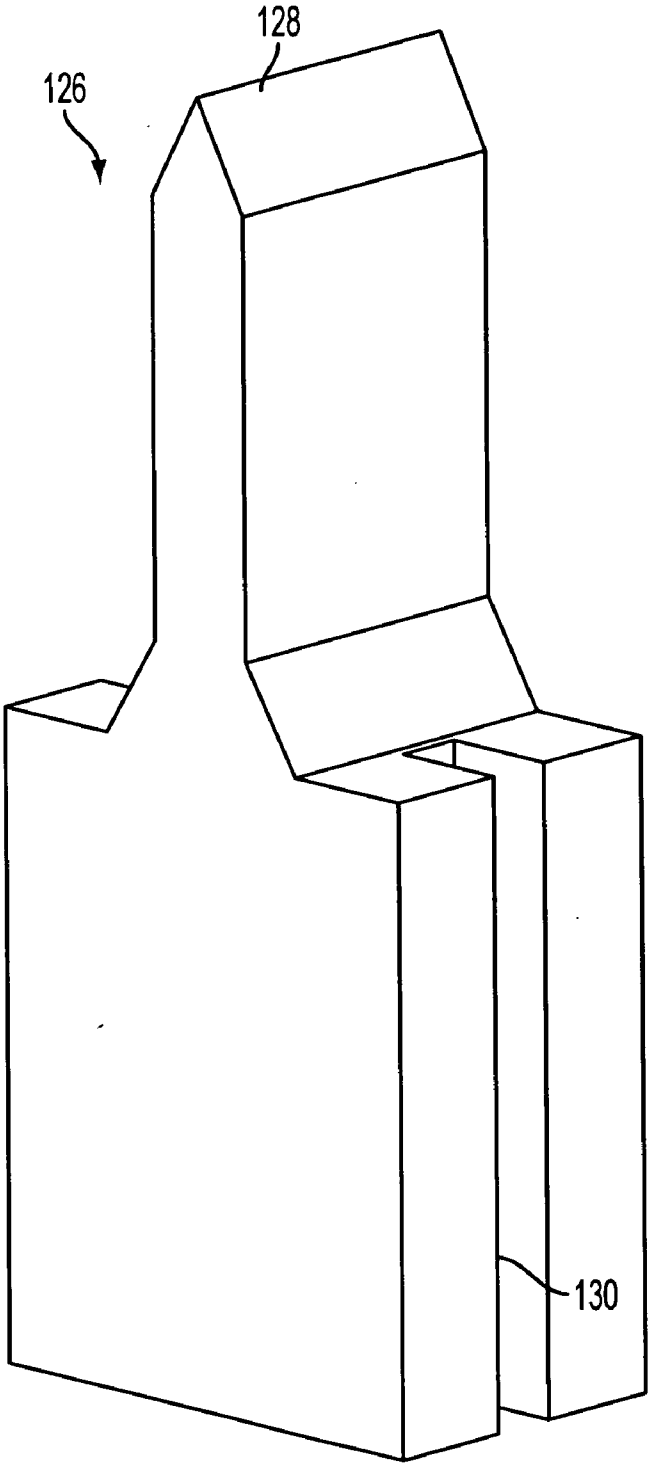


FIG. 10

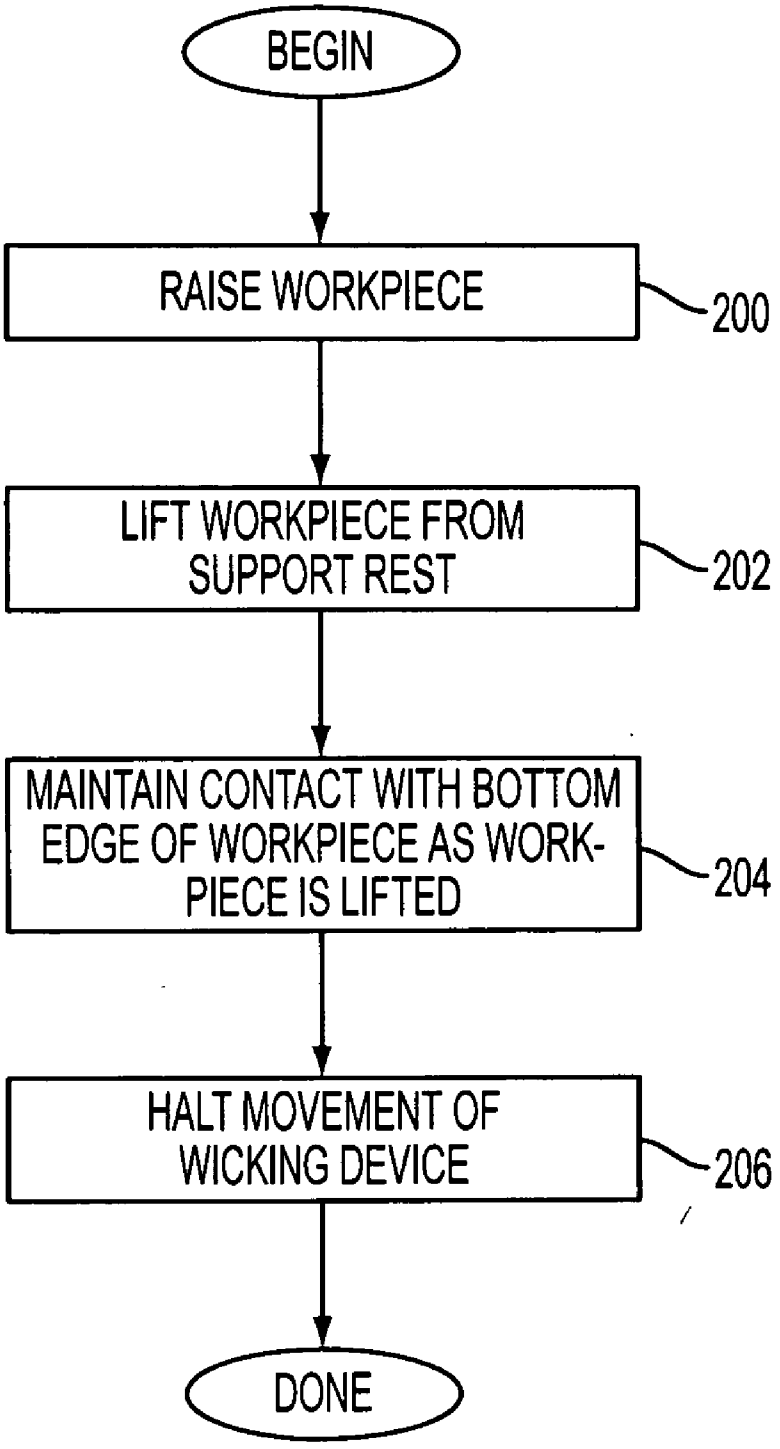

BEGIN
RAISE WORKPIECE
200
LIFT WORKPIECE FROM SUPPORT REST
202
MAINTAIN CONTACT WITH BOTTOM EDGE OF WORKPIECE AS WORK-PIECE IS LIFTED
204
HALT MOVEMENT OF WICKING DEVICE
206
DONE

FIG. 11

SUBSTRATE NEST WITH DRIP REMOVER

BACKGROUND

[0001] In many manufacturing processes for semiconductor and/or magnetic disk manufacturing, it is necessary to treat a work piece in a liquid environment and then dry the work piece. As is well known, particulates or contaminates that attach during the drying process may eventually cause defects in the work piece. In addition, inefficient drying may not only add to the processing time, but may also leave defects on a surface of the work piece, as well as promote oxidation. Thus, it is extremely important that when a substrate is dried, there are no impurities left on its surface. In addition, during the drying process, a work piece holding mechanism is in contact with the work piece. One of the defects sometimes left during the drying process is a drying mark at a point of contact where a work piece is held during drying. In order to eliminate this defect, the embodiments described below provide a mechanism for efficiently drying a semiconductor and/or magnetic disk work piece.

[0002] It is within this context that embodiments of the invention arise.

SUMMARY OF THE INVENTION

[0003] Broadly speaking, embodiments of the present invention fill these needs by providing methods of and apparatus configured to efficiently clean work pieces, especially substrates for the semiconductor and/or magnetic disk manufacturing process.

[0004] In one embodiment, an apparatus for supporting a work piece is provided. The apparatus includes outer support rails having support slots for supporting the work piece, the outer support rails disposed on opposing sides of the apparatus between opposing end members of the apparatus. Inner support rails extend between the opposing end members of the apparatus. An inner surface of each of the inner support rails has vertically disposed extensions extending therefrom. The vertically disposed extensions are aligned in pairs along a length of the inner support rails. A moveable device is disposed between the pairs of vertically disposed extensions. The moveable device is buoyantly moveable so that as the work piece is lifted out of a liquid during drying, the moveable device follows.

[0005] In another embodiment, a support nest for cleaning a work piece is provided. The support nest includes a plurality of spaced apart wicking devices moveably disposed between pairs of vertically disposed extensions extending from inner surfaces of support rails. The support rails are disposed along a length of the support nest. The wicking devices are moveable along vertical guides defined along the inner surfaces of the support rails so that as the work piece is lifted from a cleaning liquid, the wicking devices travel with corresponding work pieces to maintain contact with an edge of the work piece. In addition, when the support nest is submerged in the cleaning liquid, a top portion of the wicking devices extends above the surface of the cleaning liquid when the wicking device is fully extended.

[0006] In yet another embodiment, a method for cleaning a work piece is provided. The method includes raising a work piece submerged in a cleaning bath toward a bath fluid/air interface and lifting the work piece from a submerged support with a transition arm located above the fluid/air interface. The method further includes following a bottom edge of the work piece with a wicking device moveably attached to the submerged support, wherein the wicking device contacts the bottom edge of the work piece. Movement of the wicking device is halted after a top portion breaks the bath fluid/air interface while the submerged support remains submerged. The bottom edge of the work piece remains in contact with the wicking device as it passes through the fluid/air interface.

[0007] Other aspects and advantages of the invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The invention, together with further advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings.

[0009] FIG. **1** is a simplified schematic diagram illustrating an overview of a substrate cleaning system utilizing the support nest having individual wicking devices in accordance with one embodiment of the invention.

[0010] FIG. **2** is a simplified schematic diagram illustrating a support nest that includes individualized wicking devices for each work piece in accordance with one embodiment of the invention.

[0011] FIG. **3** is a simplified schematic diagram illustrating a top view of a support nest having a movable wicking device in accordance with one embodiment of the invention.

[0012] FIG. **4** is a simplified schematic diagram illustrating a cross-sectional view along a length of the support nest and individual wicking devices in accordance with one embodiment of the invention.

[0013] FIG. **5** is a simplified schematic diagram illustrating a cross-sectional view along a width of the support nest in accordance with one embodiment of the invention.

[0014] FIG. **6** is a simplified schematic diagram of the wicking device in accordance with one embodiment of the invention.

[0015] FIG. **7** is a simplified schematic diagram illustrating a side view of the wicking device in accordance with one embodiment of the invention.

[0016] FIG. **8** is a simplified schematic diagram illustrating a cross-sectional view of the wicking device in accordance with one embodiment of the invention.

[0017] FIG. **9** is a simplified schematic diagram illustrating a cross-sectional view of the support nest and wicking device in accordance with one embodiment of the invention.

[0018] FIG. **10** is a simplified schematic diagram illustrating an alternative embodiment for the wicking device in accordance with one embodiment of the invention.

[0019] FIG. **11** is a flowchart illustrating the method operations for cleaning a work piece in accordance with one embodiment of the invention.

DETAILED DESCRIPTION

[0020] The embodiments described below relate to apparatus for supporting a work piece during cleaning and drying operations. In one embodiment, the apparatus may be used to support magnetic disks that store data. It should be appreciated that the embodiments are not limited to supporting magnetic disks, in that any semiconductor circuit device, flat panel display, or other substrate may be supported for cleaning by the embodiments described herein. The term work

piece as used herein may refer to any substrate being processed. In addition, the terms disk and disc are used interchangeably, and may also reference any such substrate or work piece. . For example, the support can be utilized for a cleaning operation with a dual hand off mechanism as described in U.S. patent application Ser. No. 11/531,905, and a drying chamber as described in U.S. patent application Ser. No. 12/122,571, both of which are incorporated herein by reference for all purposes.

[0021] The embodiments described herein provide for a support nest that supports a plurality of work pieces during a cleaning and drying operation. The support nest includes individual wicking devices for each work piece in order to prevent any fluids stains or marks on the surface of the disk. The individual wicking devices for each work piece mitigate or reduce the occurrence of watermarks and stains by following or traveling with the work piece as the work piece is raised from the support nest to a location above a fluid air interface. As will be described in more detail below, the embodiments utilizes a movable device that can be buoyant to stay in contact with each work piece at a lowermost location, e.g., a six o'clock location on the work piece as the work piece is lifted, until the work pieces are completely out of the fluid bath. The buoyancy of the movable device is such that the work piece will not be lifted out of the support nest by the movable device.

[0022] FIG. **1** is a simplified schematic diagram illustrating an overview of a substrate cleaning system **100** utilizing the support nest having individual wicking devices in accordance with one embodiment of the invention. Substrate cleaning system **100** can include a drying chamber **102**, a cleaning tank **104**, and a transport assembly **108**. After controlled exposure within the cleaning tank **104**, e.g., a fluid bath, substrates or work pieces are moved via transport assembly **108** to drying chamber **102**. Drying chamber **102** may be a chamber or just an open area above the fluid bath. Support nests that include individual wicking devices that are described in more detail below, may be integrated into transport assembly **108** in one embodiment. For further information regarding the transport assembly **108**, refer to U.S. patent application Ser. No. 11/531,905. It should be appreciated that the system of FIG. **1** is one exemplary system that may be used for the support nest and wicking device described herein and is not meant to be limiting as the wicking device may be used in other suitable systems. In addition, the system components of FIG. **1** are illustrative and not drawn to scale.

[0023] FIG. **2** is a simplified schematic diagram illustrating a support nest that includes individualized wicking devices for each work piece in accordance with one embodiment of the invention. Support nest **106** includes two end members **121***a* and **121***b* between which are disposed a plurality of outer support rails **122***a* through **122***d*. Outer support rails **122***a* through **122***d* are configured to support a variety of different diameters of work pieces **120** in one embodiment. In the embodiments shown herein work pieces **120** are illustrated as magnetic disks, however, any suitable work piece, such as semiconductor substrates, glass substrates, etc., may be held within support nest **106**. Each of outer support rails **122***a* through **122***d* are configured with saw tooth openings that provide support for corresponding work piece **120**. As illustrated in FIG. **2**, outer support rails **122***a* through **122***d* are disposed in corresponding pairs. That is, each outer support rail has a corresponding outer support rail disposed along and opposing side of support nest **106** where the corresponding pairs are equidistant from a centerline of the support nest in one embodiment. Multiple outer support rail pairs are shown supporting multiple disc sizes. However, in practice, only two outer support rails are used at a time for one size disc. Support nest **106** further includes inner support rails **124** which extend between opposing end members **121***a* and **121***b* of the support nest. Wicking device **126** is moveably disposed between vertical extensions extending from the inner surfaces of opposing inner support rails **124**. Wicking device **126** is described in more detail below.

[0024] FIG. **3** is a simplified schematic diagram illustrating a top view of a support nest having a movable wicking device in accordance with one embodiment of the invention. Support nest **106** supports a plurality of work pieces **120**. Depending on a diameter of work piece **120**, saw-tooth slots defined within outer support rails **122***a* through **122***c* provide the required support for holding each of the work pieces in a substantially vertical orientation. Inner support rails **124** extend between end members **121***a* and **121***b* of support nest **106** and are defined between outer carriers **122***a* through **122***c*. In one embodiment, extensions defined on opposing surfaces of corresponding inner support rails guide wicking device **126** in a vertical manner so that a surface of a top portion of wicking device **126** remains in contact with a bottom edge of work piece **120** as the work piece is moved from support nest **106**. One skilled in the art will appreciate that the support nest may be submerged in a fluid bath for a cleaning operation in one embodiment. The fluid bath may be any suitable cleaning chemistry for cleaning semiconductor substrates and magnetic disks including deionized water. Upon completion of the cleaning operation the support nest is raised towards an air fluid interface above the fluid bath. The work pieces are moved above the air fluid interface while support nest **106** remains submerged in the fluid bath. A transport mechanism removes work pieces **120** from support nest **106** and as the work pieces are lifted, wicking device **126** remains in contact with the bottom edge of the work piece. In one embodiment, wicking device **126** is buoyant, i.e., floats in the fluid of the fluid bath.

[0025] FIG. **4** is a simplified schematic diagram illustrating a cross-sectional view along a length of the support nest and individual wicking devices in accordance with one embodiment of the invention. Wicking devices **126** are disposed along a length of support nest **106**. In this exemplary embodiment wicking devices **126** are hollow, in order to be buoyant. In one embodiment a top edge **128** of wicking device **126** remains in contact with the bottom surface of work piece **120**. It should be appreciated that in the embodiments described herein wicking device **126** is buoyant, but is not capable of lifting work piece **120**. That is, wicking device **126** follows movement of the work piece and does not initiate movement of the work piece, as the movement of the work piece is provided by an external mechanism. It should be appreciated that the support nests illustrated herein are exemplary in dimensions and the number of work pieces capable of being supported. Accordingly, these exemplary illustrations are not meant to be limiting.

[0026] FIG. **5** is a simplified schematic diagram illustrating a cross-sectional view along a width of the support nest in accordance with one embodiment of the invention. Support nest **106** is illustrating supporting a plurality of work pieces **120**. Each work piece has a corresponding individual wicking device **126** that is in contact with a bottom edge of the vertically oriented work pieces. In one embodiment the point of

contact with the bottom edge is approximately at the six o'clock position. Wicking device **126** is movably disposed between inner support rails **124**. As work piece **120** is moved a top surface **128** of wicking device **126** remains in contact with the bottom of the work piece. A distance of travel of wicking device **126** is controlled between the vertically oriented extensions on the inner surface of the inner support rails **124** by providing stops. The stops may be defined on the vertically oriented extensions on the sides of wicking device **126**, or a combination of the two, as will be explained further below.

[0027] FIG. **6** is a simplified schematic diagram of the wicking device in accordance with one embodiment of the invention. The wicking device **126** has a top edge **128** that contacts the bottom edge of a corresponding work piece. Side surfaces of wicking device **126** have indentation **130** defined along the length of each side surface. Indentation **130** will mate with the corresponding vertical extensions between opposing inner support rail surfaces in order to orient and guide the vertical movement of wicking device **126**. In this embodiment the travel is limited by the length of indentation **130**. It should be appreciated that the shape of wicking device **126** is not limited to the illustration of FIG. **6**. That is, alternative shapes and designs may be used to achieve the functionality of wicking device **126**. In addition, alternate configurations can be made for top surface **128** for contacting the bottom edge of a work piece. For example, top surface **128** may have a knife edge, a flat edge that has a width, a curved edge with or without indentations, or any other suitable configuration that will allow contact between the surface and the bottom edge of the work piece.

[0028] FIG. **7** is a simplified schematic diagram illustrating a side view of the wicking device in accordance with one embodiment of the invention. Wicking device **126** is illustrated having indentation **130** defined along each side surface. As mentioned above, indentation **130** mates with a vertical extension protruding from an inner surface of the inner support rails of the support nest. As the work piece is moved, wicking device **126** travels vertically as guided through the mating of the side extensions and indentation **130**, so that top surface **128** remains in contact with a bottom edge of the work piece. As discussed above, wicking device **126** is not capable of lifting the workpiece but can travel along with the workpiece.

[0029] FIG. **8** is a simplified schematic diagram illustrating a cross-sectional view of the wicking device in accordance with one embodiment of the invention. Wicking device **126** is illustrated having a hollow interior **133**. The hollow interior **133** enables wicking device **126** to be buoyant. In one embodiment wicking device **126** may be a solid piece and the movement of the wicking device can be controlled through a spring-loaded mechanism. In this embodiment, the force applied by the spring loaded mechanism is not sufficient to lift the work piece, however, the mechanism ensures movement of wicking device **126** with the workpiece. The spring or springs may be located at a base of the wicking device in one embodiment. The material of construction for the springs may be any material compatible with the cleaning fluid and that provides the required spring action over an extended period of use. The wicking device may be composed of any material compatible with the cleaning fluid also. In the buoyant embodiment, wicking device **126** may be composed of a material such, as any suitable metal or plastic material compatible with the process. As mentioned above, top surface **128** remains in contact with a bottom edge of the work piece to enable removal of any remaining fluid on the planar surfaces of the work piece.

[0030] FIG. **9** is a simplified schematic diagram illustrating a cross-sectional view of the support nest and wicking device in accordance with one embodiment of the invention. Work piece **120** is supported by corresponding outer rails of support nest **106**. As mentioned above, work piece **120** may be supported through a saw tooth slot defined within the outer rails **122**. Inner rails **124** provide vertical extensions **136** which guide wicking device **126** as work piece **120** is moved. The vertical movement of work piece **120** and the buoyancy or spring-loaded mechanism for wicking device **126** provides for contact being maintained between the bottom edge of work piece **120** and the top surface **128** of the wicking device. Travel of wicking device **126** is limited by shoulders **132** and **134** defined on vertical extensions **136**. It should be appreciated that the illustrative embodiment in FIG. **9** is not drawn to scale. Thus, through the embodiments described herein wicking device **126** is able to rise above a fluid air interface as work piece **120** is removed from support nest **106**. As a result, wicking device **126** causes any fluid remaining proximate to the six o'clock position on work piece **120** to be attracted to the wicking device. Thus, once the vertical movement of wicking device **126** is stopped and the work piece moves away from top surface **128**, any fluid remains with the top surface **128** of wicking device **126** through forces of attraction so that the vertically oriented planar surfaces of work piece **120** may be fully dried without any drying marks remaining. Thus, in one embodiment, the wicking device provides a continuous path for the fluid to be pulled off of the work piece by the surface tension of the fluid. The support nest described herein may be composed of any material compatible with the cleaning fluid. Some exemplary material for the support nest includes Polyether ether ketones, and other suitable plastic or metal components that are suitable with the process.

[0031] FIG. **10** is a simplified schematic diagram illustrating an alternative embodiment for the wicking device in accordance with one embodiment of the invention. Wicking device **126** includes slots **130** defined along an entire side surface of the wicking device. In this embodiment stops are provided on the inner rails upon which wicking device **126** is guided. Wicking device **126** includes top edge **128**, which makes contact with a bottom surface or edge of the work piece. As mentioned above, wicking device **126** may be hollow in order to provide the necessary buoyancy. Alternatively, wicking device **126** may be spring-loaded so that as a work piece moves, edge **128** remains in contact with a bottom surface of the work piece. As mentioned above, the buoyant or spring-loaded embodiments exert a force that is not sufficient to move or lift the corresponding work piece.

[0032] FIG. **11** is a flowchart illustrating the method operations for cleaning a work piece in accordance with one embodiment of the invention. The flowchart initiates with operation **200** by raising a work piece that is submerged in a cleaning bath upon completion of a processing operation. The work piece is raised towards a fluid air interface by a support nest holding the workpiece in one embodiment. The method advances to operation **202** where the work piece is lifted from a submerged support by a transition arm that is disposed above the fluid air interface. The work piece may be lifted as the submerged support is rising or stationary. In operation **204** a bottom edge of the work piece is followed by a wicking

device that maintains contact with the bottom edge of the work piece as the work piece is removed from the support. Here, the workpiece is supported by the transition arm, yet the wicking device maintains contact with the bottom edge of the work piece. In operation **206**, movement of the wicking device is halted after a top surface of the wicking device breaks the fluid air interface. It should be appreciated that the support remains submerged even while the top surface of the wicking device is above the fluid air interface. The transition arm will remove the work piece to another support nest for further processing in one embodiment.

[0033] The above embodiments provide for a wicking device that contacts each work piece to prevent any cleaning/rinsing fluid stains or marks left on the workpiece after a processing or cleaning operations. The wicking device or drip remover essentially provides for a continuum of the water or other cleaning fluid (and associated surface tension and molecular attraction) from the work piece, across the drip remover, to the fluid bath. The continuous contact between the drip remover and the work piece provides a path for the water or cleaning fluid to be pulled off of the work piece by the fluid bath. In one embodiment, a droplet of the cleaning fluid is never allowed to form on the bottom of the work piece as the cleaning fluid is pulled away due to the surface tension and molecular attraction as the work piece and drip remover leave the fluid bath. It should be appreciated that the wicking device may be a disposable part, which may be replaced after any number of processing or cleaning operations are performed. Thus, the wicking device may be considered a consumable in one embodiment.

[0034] Although the foregoing invention has been described in some detail for purposes of clarity of understanding, it will be apparent that certain changes and modifications may be practiced within the scope of the appended claims. Accordingly, the present embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalents of the appended claims.

What is claimed is:

1. An apparatus for supporting a work piece, comprising:
a buoyantly moveable device disposed so that as the work piece is lifted from the apparatus supporting the work piece, the buoyantly moveable device follows the work piece.

2. The apparatus of claim **1**, wherein buoyancy of the movable device is insufficient to lift the work piece.

3. The apparatus of claim **1**, comprising:
outer support rails having support slots for supporting the work piece; and
inner support rails having support slots for supporting the work piece.

4. The apparatus of claim **3**, wherein the support slots of the outer and inner support rails are in a saw tooth configuration.

5. The apparatus of claim **1**, wherein the moveable device has a hollow center.

6. The apparatus of claim **3**, wherein the inner surface of each inner support rail includes a stop to limit vertical movement of the moveable device.

7. The apparatus of claim **1**, wherein a top portion of the moveable device extends past a top surface of the apparatus when the moveable device is at a highest vertical height.

8. The apparatus of claim **4**, wherein the vertically disposed extensions function as the stop.

9. The apparatus of claim **1**, wherein the work piece is circular.

10. A support nest for cleaning a work piece, comprising:
a plurality of spaced apart wicking devices moveably disposed between pairs of vertically disposed extensions extending from inner surfaces of inner support rails, the inner support rails disposed along a length of the support nest, the wicking devices moveable along vertical guides defined along the inner surfaces so that as the work piece is lifted from a cleaning bath, the wicking devices travel with corresponding work pieces, such that when the support nest is submerged in the cleaning bath, a top portion of the wicking devices extends above a surface of the cleaning bath when the wicking device is fully extended.

11. The support nest of claim **10**, wherein the wicking device is buoyantly moveable along the vertical guides and a force provided by the wicking device is insufficient to move the work piece.

12. The support nest of claim **10**, wherein the wicking device is spring mounted and a force of the spring is insufficient to lift the work piece.

13. The support nest of claim **10**, wherein the wicking device has a hollow center region.

14. The support nest of claim **10**, wherein the support nest is configurable to hold work pieces having varying diameters.

15. The apparatus of claim **10**, wherein the top portion of the wicking device is angled.

16. The apparatus of claim **10**, further comprising:
a plurality of pairs of outer support rails placed outside of the inner support rails, the pairs of outer support rails providing support for the work piece.

17. The apparatus of claim **16**, wherein the pairs of outer support rails support the work piece in a vertical orientation and wherein the work piece is supported below a midline of the work piece.

18. A method for cleaning a work piece, comprising:
raising a work piece submerged in a cleaning bath toward a bath fluid/air interface;
lifting the work piece from a support with a transition arm located above the fluid/air interface;
following a bottom edge of the work piece with a wicking device moveably attached to the support, the wicking device contacting the bottom edge; and
halting movement of the wicking device after a top portion breaks the bath fluid/air interface.

19. The method of claim **18**, wherein the wicking device is one of buoyant or spring force.

20. The method of claim **18**, wherein a force exerted by the wicking device is insufficient to lift the work piece.

21. The method of claim **18**, wherein a plurality of work pieces are submerged and each work piece is associated with an independently moveable wicking device.

22. The method of claim **18**, wherein the support remains submerged during the lifting the following and the halting.

* * * * *