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(54) **SUPPORT STRUCTURE FOR MULTIPLE WORKPIECE SUPPORT ROLLERS**

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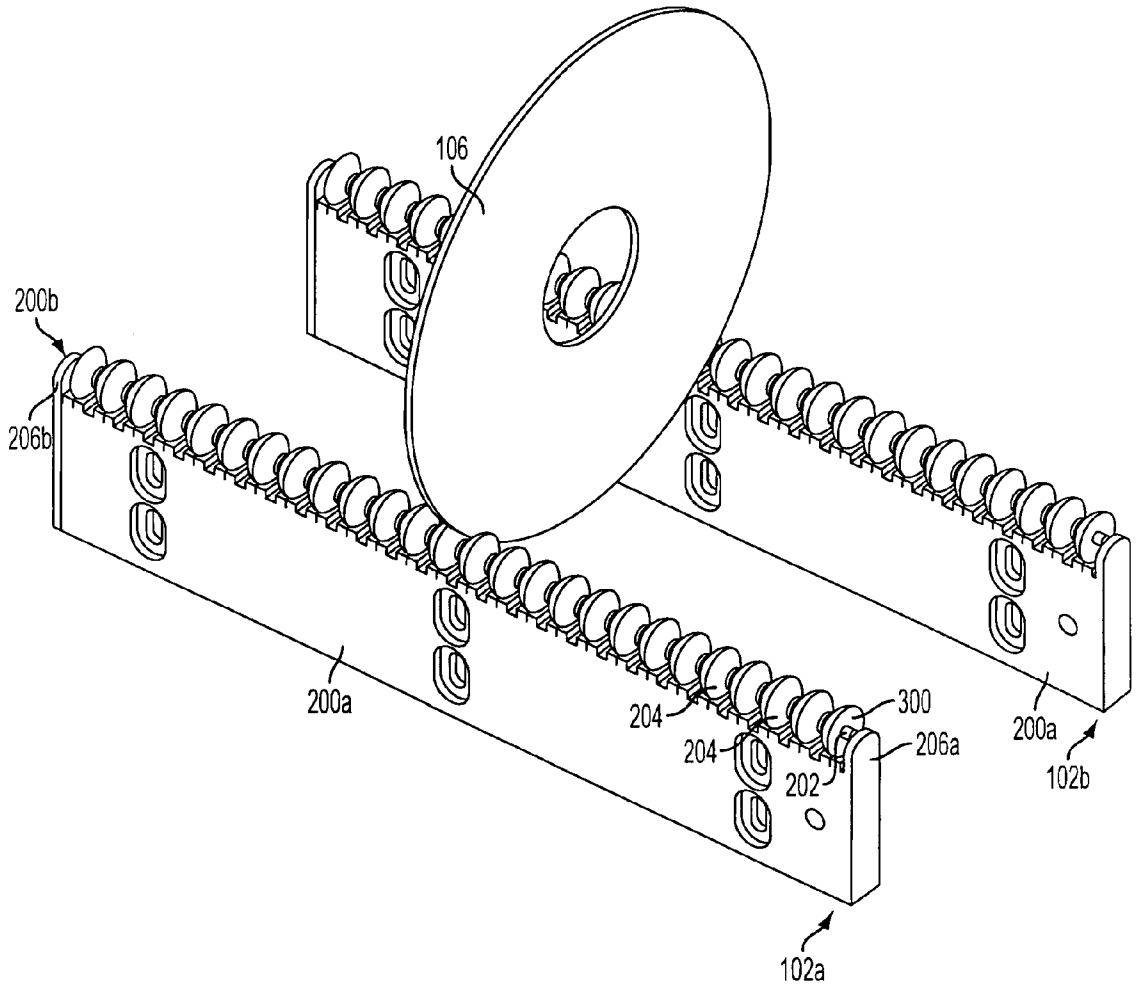
(57) **ABSTRACT**

Apparatuses for supporting a workpiece are disclosed. In one example, the apparatus includes a plurality of shaft supports. The apparatus further includes a shaft defined between the shaft supports, the shaft extending through an aperture defined in each of the plurality of shaft supports. Further included in the apparatus is a plurality of rollers defined to rotate about the shaft, the rollers defined between the plurality of shaft supports.



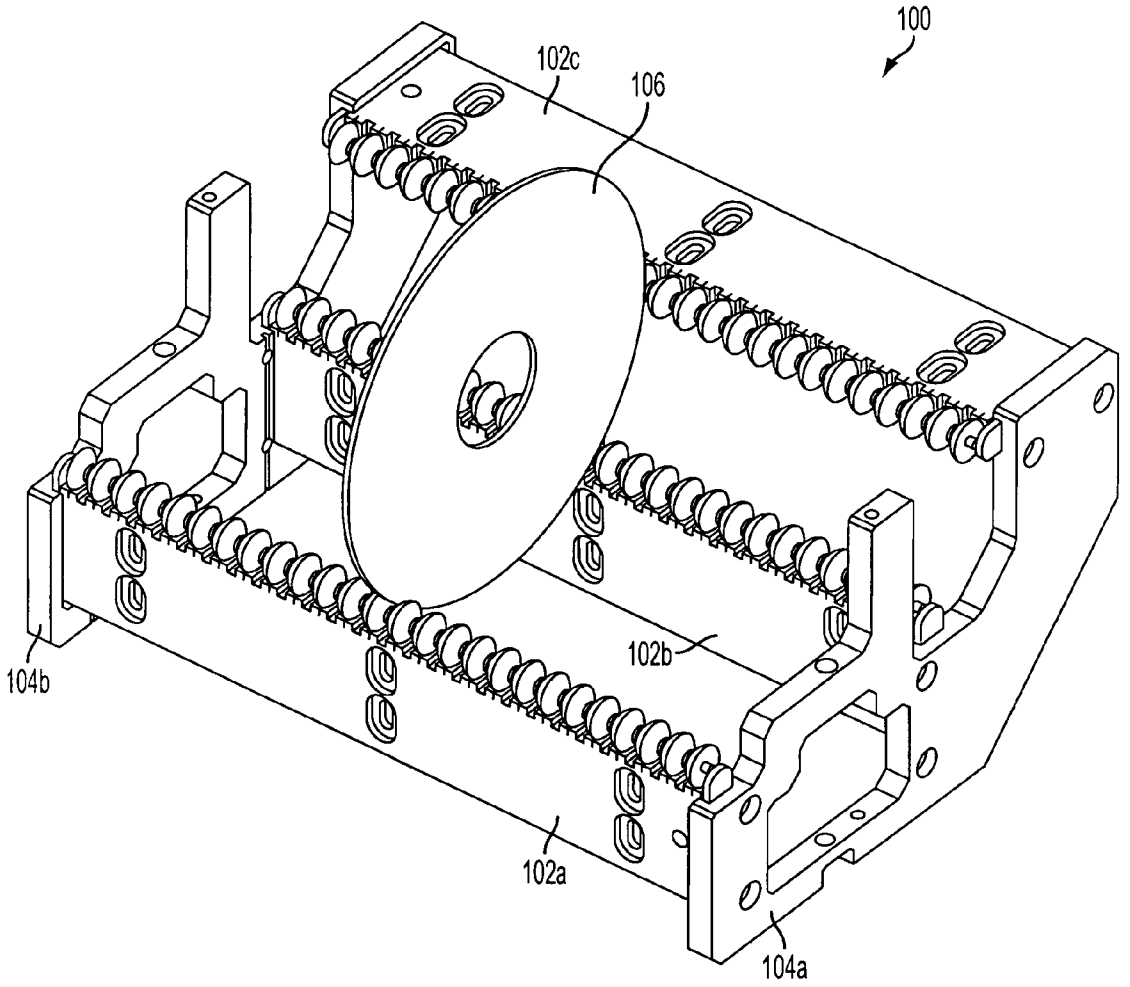


FIG. 1A

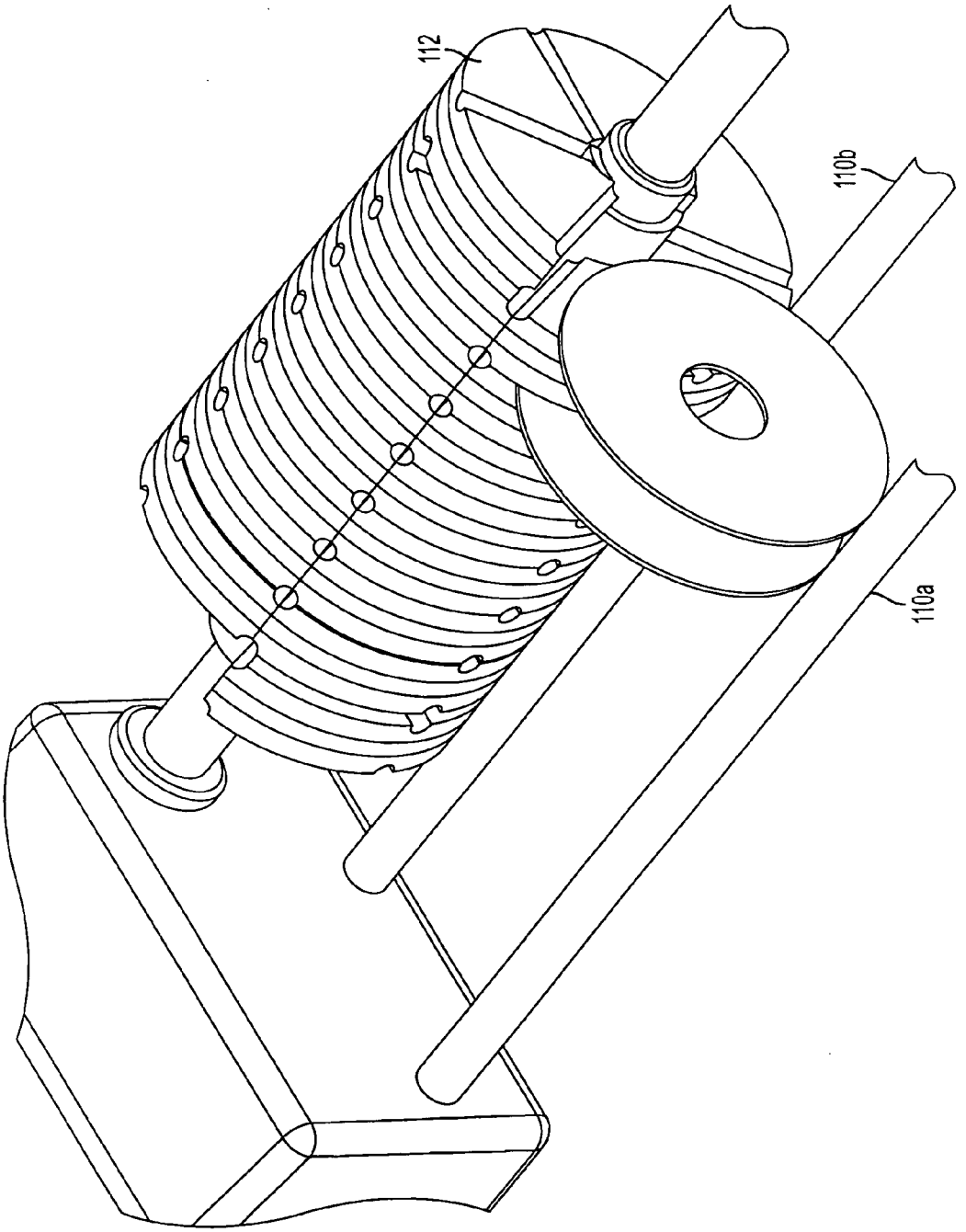


FIG. 1B

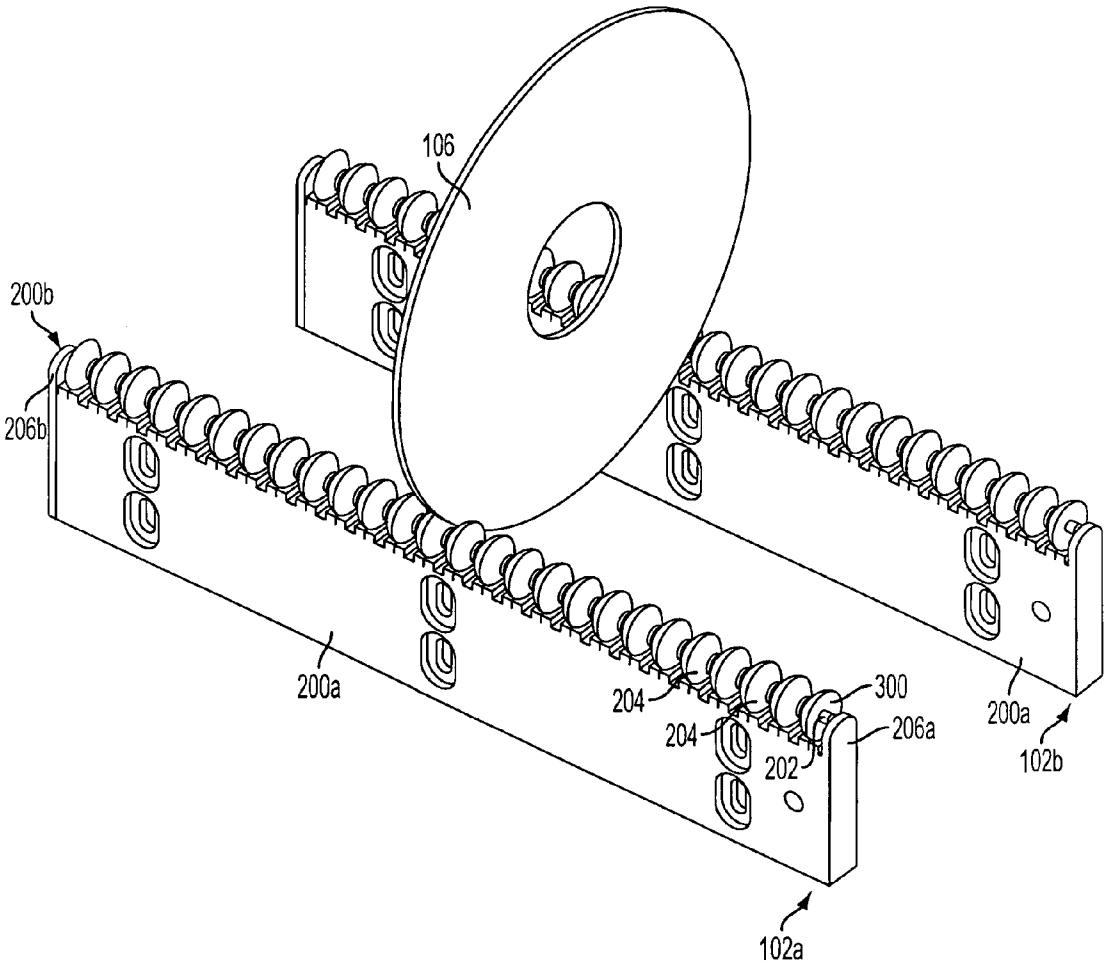


FIG. 2

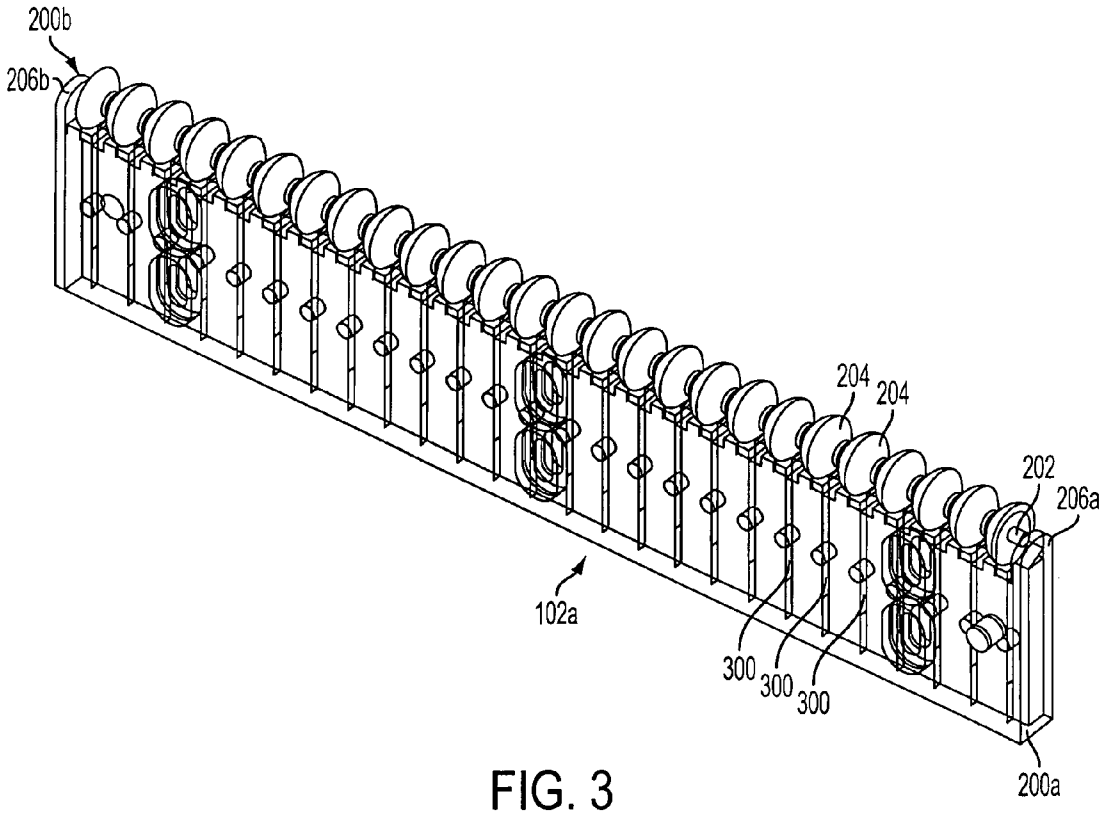


FIG. 3

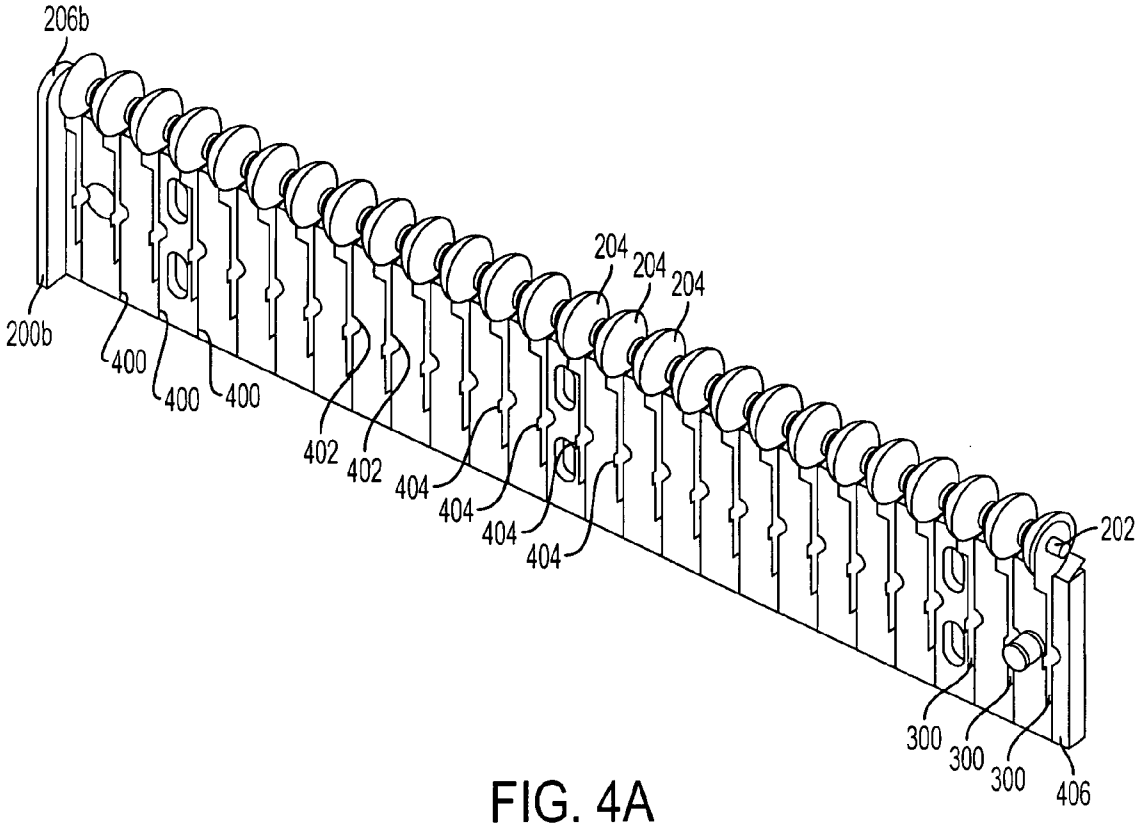

206b
200b
400
400
400
402
402
404
404
404
404
204
204
204
202
300
300
300
406

FIG. 4A

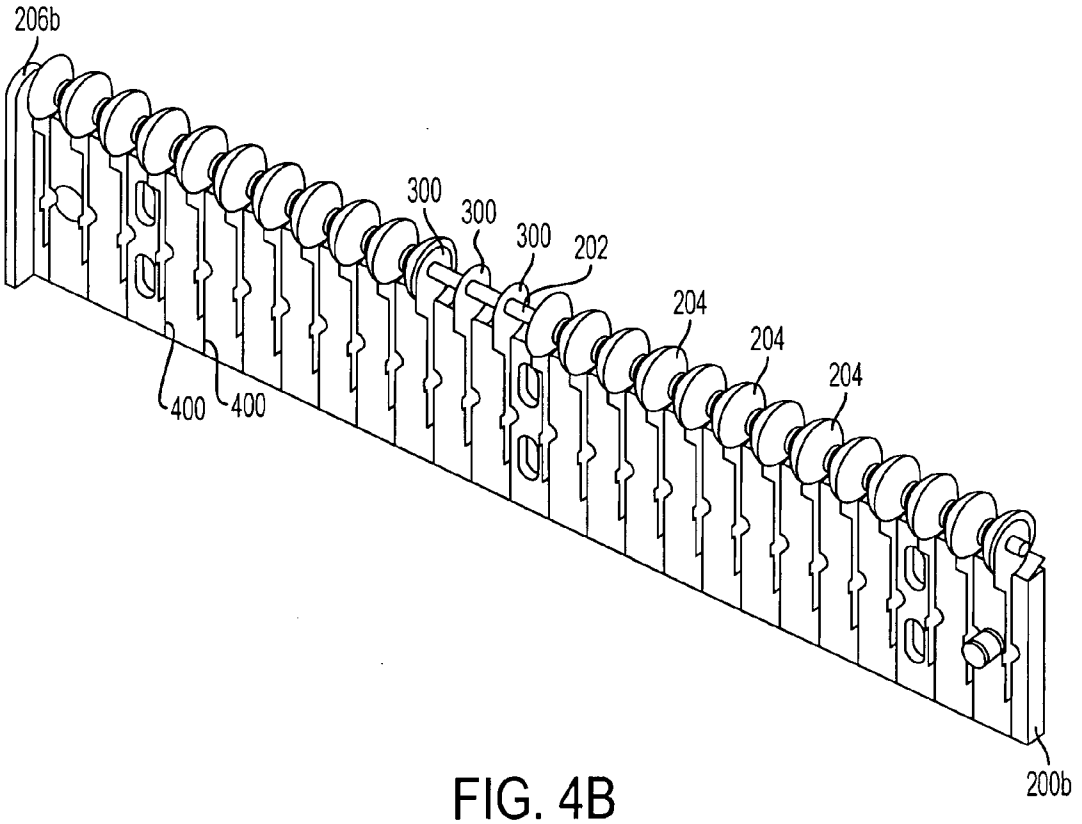


FIG. 4B

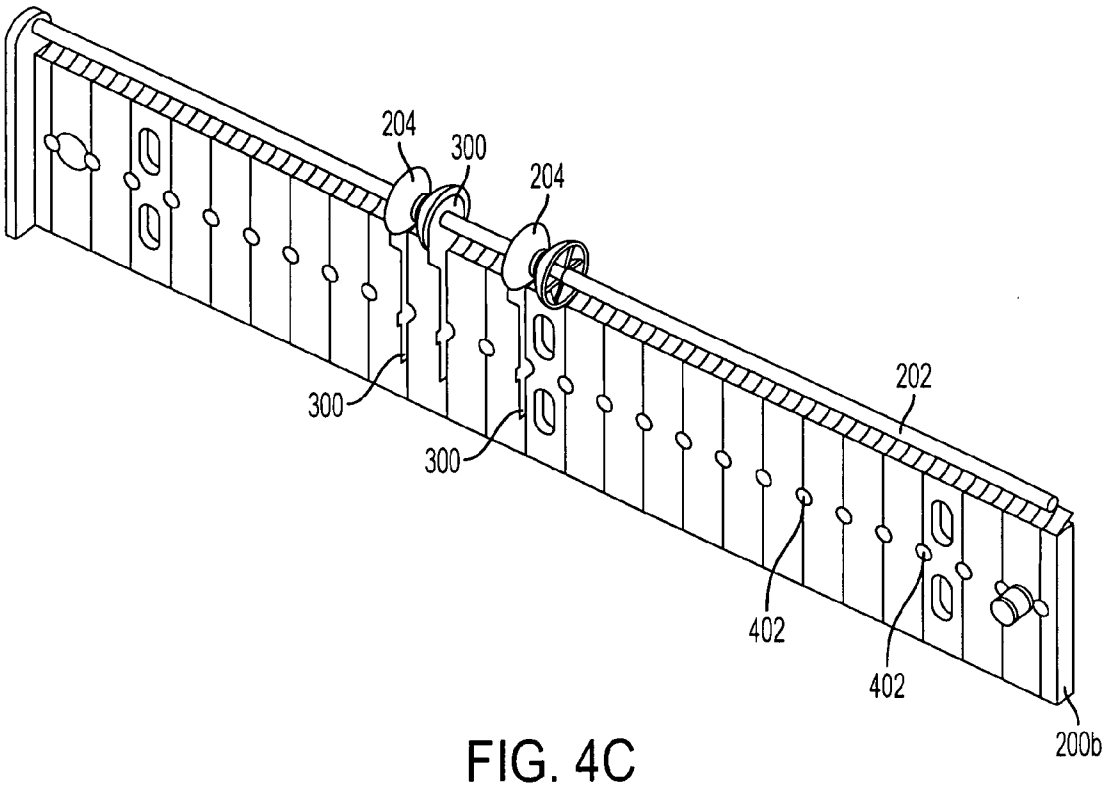


FIG. 4C

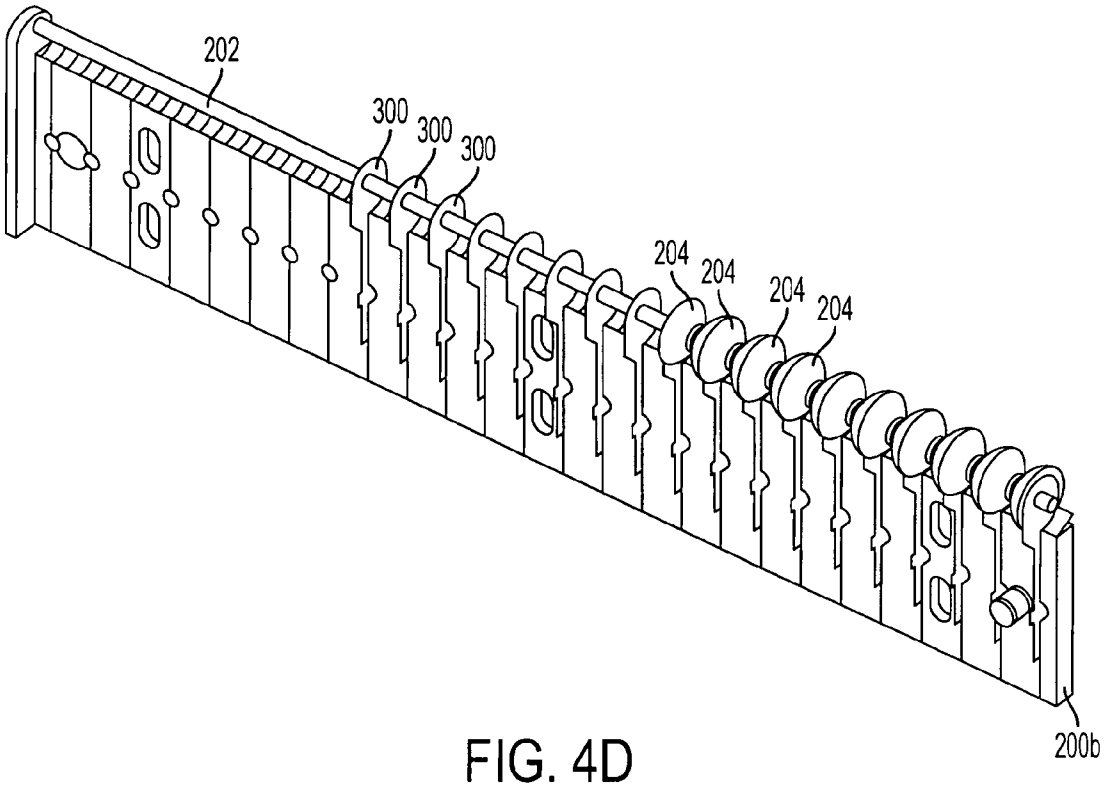


FIG. 4D

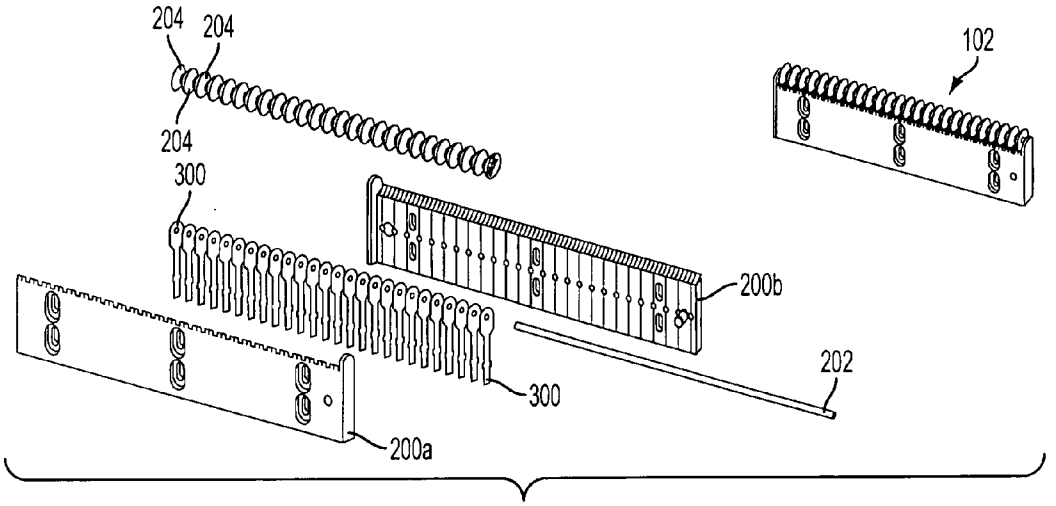

204
204
204
300
102
200b
202
300
200a

FIG. 5

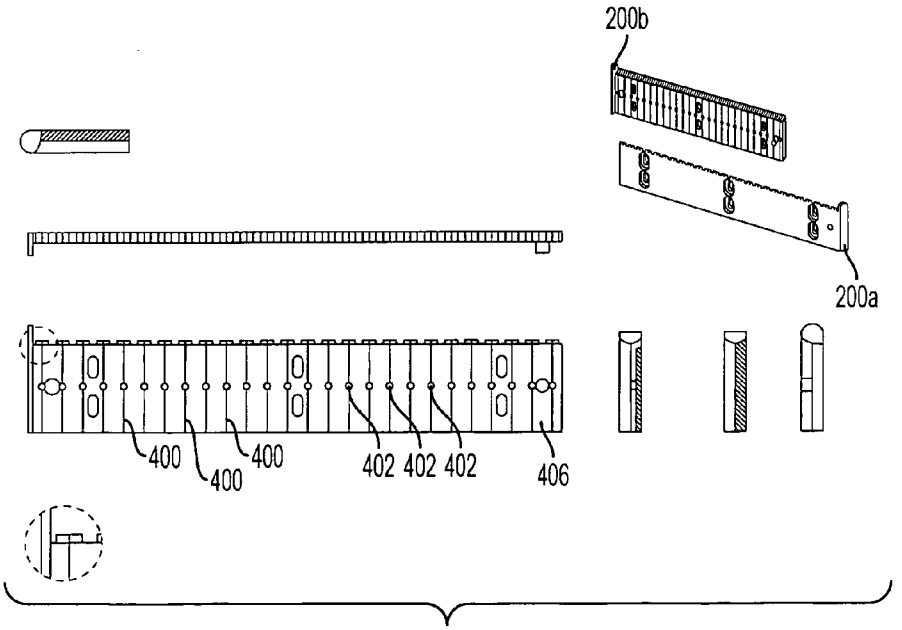

200b
200a
400
400
400
402 402 402
406

FIG. 6

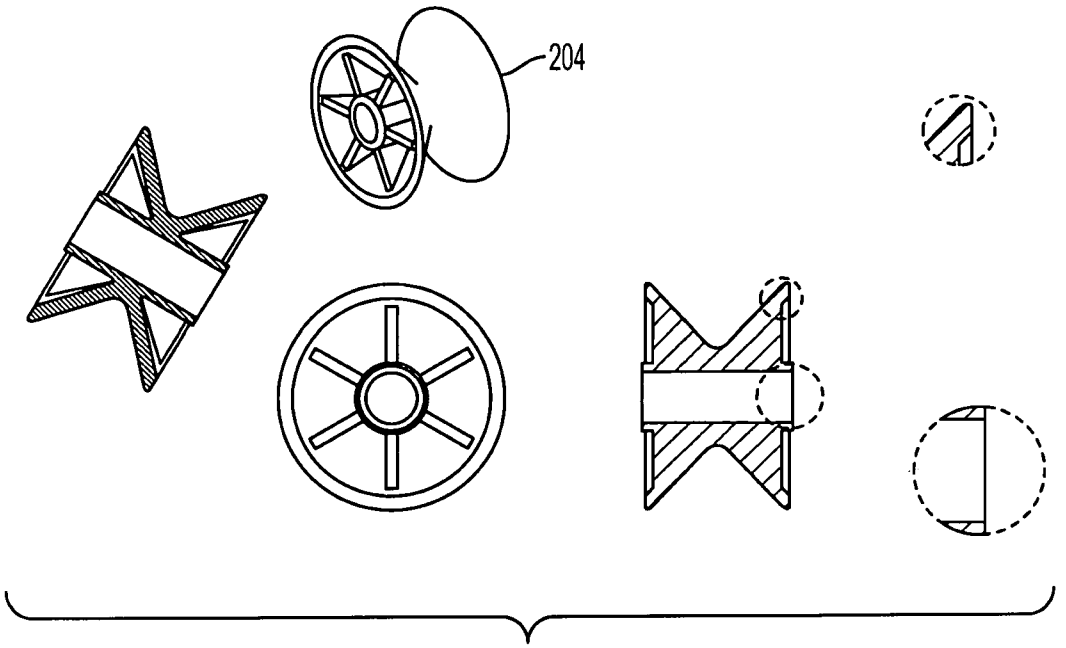


FIG. 7

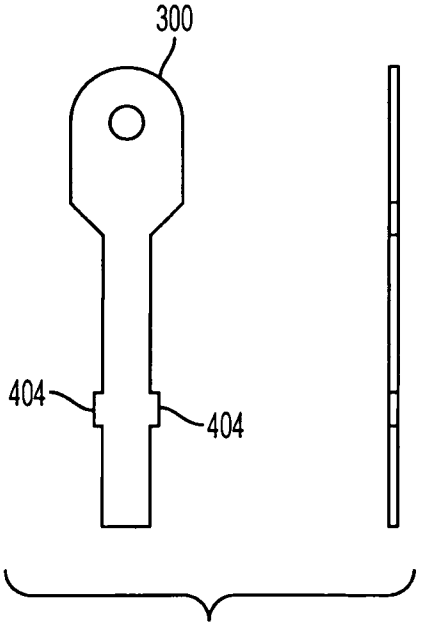


FIG. 8

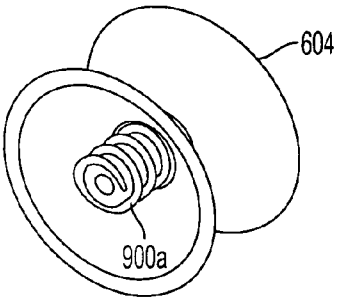


FIG. 9A

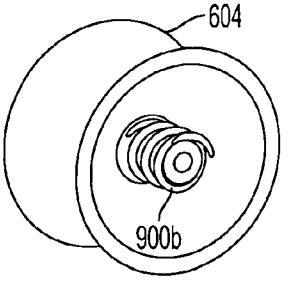


FIG. 9B

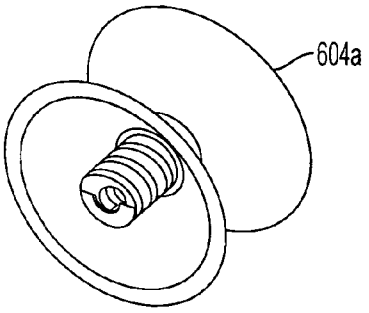


FIG. 9C

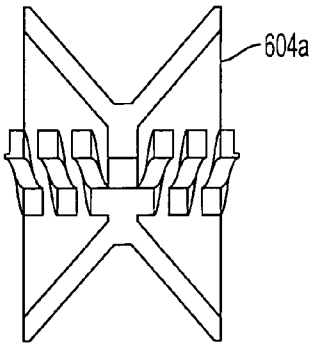


FIG. 9D

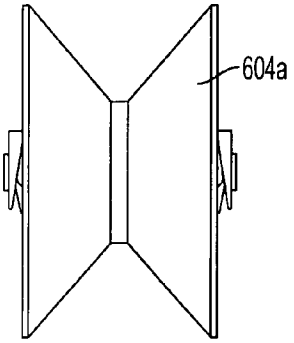


FIG. 9E

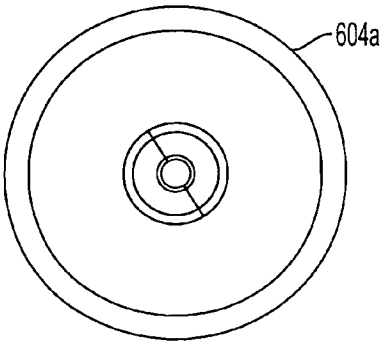


FIG. 9F

SUPPORT STRUCTURE FOR MULTIPLE WORKPIECE SUPPORT ROLLERS

BACKGROUND

[0001] Many processes for semiconductor and disk manufacturing require extremely clean workpieces before the processes may start. For example, particulates or contaminates that attach to or form on the workpiece before processing may eventually cause defects in the workpiece. When the workpieces are disks to be processed, such particulates or contaminates may be hydrophobic or hydrophyllic, and may include layers: e.g., thin oxide surface layers; surface asperities such as scratches, nodules, and ridges that may be induced by a prior polishing operation; materials adhered to the workpiece due to the polishing operation; and loosely adhered particles from the environment in which the workpiece has been stored. These particulates or contaminates may also be aged, and thus be more stable and more difficult to remove before the processing. Cleaning, then, is a process intended to remove substantially all of such particulates or contaminates from workpieces before processing, such as processing of magnetic media or semiconductor workpieces. A clean workpiece is thus a workpiece from which substantially all of such particulates or contaminates have been removed before processing.

[0002] Therefore, there is a need for improving techniques for cleaning workpieces, such as those workpieces that present problems and require removal of substantially all of such particulates or contaminates from the workpieces before processing. Moreover, these improved techniques must allow cleaning of a workpiece to be done quickly so as to reduce the cost of capital equipment for the cleaning.

[0003] What is needed then, is apparatus configured to clean workpieces quickly, yet during the cleaning operation of one workpiece, to increase the time provided for contact at the brush-workpiece interface according to characteristics of the workpiece. What is also needed is apparatus configured to clean a group of workpieces, wherein all workpieces of the group are cleaned by the same apparatus,. It is within this context that embodiments of the invention arise.

SUMMARY OF THE INVENTION

[0004] Broadly speaking, embodiments of the present invention fill these needs by providing methods of and apparatus configured to support the efficient cleaning of the workpieces. In one embodiment, an apparatus for supporting a workpiece is provided. The apparatus includes a plurality of shaft supports and a shaft defined between the shaft supports. The shaft extends through an aperture defined in each of the plurality of shaft supports. Additionally, there are a plurality of rollers defined to rotate about the shaft where the rollers are defined between the plurality of shaft supports.

[0005] In another embodiment, an apparatus for supporting a semi-conductor substrate is disclosed. The apparatus includes a first carrier that has a plurality of support slots formed on an interior face. The apparatus also includes a second carrier that opposes the first carrier, the second carrier having a plurality of support slots on an interior face. Also included in the apparatus is a plurality of shaft supports that are positioned within the support slots. Each of the shaft supports has an aperture that extends from respective carriers. The apparatus further includes a shaft that is defined through the apertures along a length of the respective carriers. Additionally, the apparatus includes a plurality of rollers defined to rotate about the shaft where the rollers are defined between the plurality of shaft supports.

[0006] In still another embodiment, a substrate cleaning apparatus is disclosed. The apparatus includes a brush member that has an axis of rotation and further has scrubbing material to clean a substrate. The apparatus also includes a support member that supports a substrate in contact with the brush. The support member includes a shaft that is defined through apertures on a plurality of shaft supports. The shaft configured to extend through an aperture defined in each of the plurality of shaft supports. Additionally, the shaft has a plurality of rollers defined between the plurality of shaft supports where the plurality of rollers are further defined to rotate about the shaft.

[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**A is an exemplary illustration of a support structure in accordance with one embodiment of the present invention.

[0010] FIG. **1**B is a simplified schematic diagram illustrating a cleaning apparatus that the support structure may be integrated with, in accordance with one embodiment of the invention.

[0011] FIG. **2** is a schematic illustrating roller assemblies along with the disc in accordance with one embodiment of the present invention.

[0012] FIG. **3** is an exemplary illustration of the roller assembly where one of the carriers has been made semi-transparent in order to show carrier features, in accordance with one embodiment of the present invention.

[0013] FIGS. **4**A through **4**D are an exemplary rendering of the carrier with various numbers of supports and rollers to show various aspects of the interaction between parts, in accordance with one embodiment of the present invention.

[0014] FIG. **5** includes an exploded view of the roller assembly in accordance with one embodiment of the present invention.

[0015] FIG. **6** is schematic illustrating various views of the carrier in accordance with one embodiment of the present invention

[0016] FIG. **7** includes exemplary views of a roller, in accordance with one embodiment of the present invention.

[0017] FIG. **8** is a schematic of an exemplary shaft support, in accordance with one embodiment of the present invention.

[0018] FIGS. **9**A-**9**F illustrate alternate rollers that incorporate a spring in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION

[0019] The embodiments described below relate to apparatus for supporting a workpiece during cleaning. 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 workpiece 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 workpiece. In one embodiment, the support may be used to convey the work pieces during a scrubbing operation. For example, the support can be utilized for a cleaning operation with a spiral scrubbing operation and apparatus as described in U.S. patent application Ser. No. 11/862,170. The support acts as a carriage that allows the discs or workpieces to rotate about an axis with some compliancy and contemporaneously accommodates the linear movement of the workpieces.

[0020] FIG. **1**A is an exemplary illustration of a support structure **100** in accordance with one embodiment of the present invention. The support structure **100** includes frame **104***a* and frame **104***b* along with roller assemblies **102***a*, **102***b*, and **102***c* disposed between opposing surfaces of frames **104***a* and **104***b*. Removable fasteners can be used to secure the roller assemblies **102***a*, **102***b* and **103***c* between the opposing surfaces of frame **104***a* and **104***b*. In one embodiment, the removable fasteners are machine screws while other embodiments employ other known types of fasteners. Roller assemblies **102***a* and **102***b* support a disc **106** vertically while roller assembly **102***c* supports the disk **106** horizontally. In some embodiments, a moveable fourth roller assembly (not shown) is used to hold the disc **102** in place during cleaning operations. The moveable fourth roller assembly can be secured to the frames **104***a* and **104***b* or be part of a separate assembly.

[0021] While illustrated with a disc **106**, the roller assemblies are configured to accommodate multiple discs that are placed into the support structure **100** by an automated carrier moving between roller assembly **102***a* and roller assembly **102***b*. The distance between roller assembly **102***a* and roller assembly **102***b* defines the width of a support nest (not shown). Features of the roller assembly **102***a* and **102***b* enable support nests that can accommodate large diameter discs while in other configurations enabling accommodation of smaller diameter discs. Note that the relative size of the support structure **100** shown in FIG. **1** is not intended to be limiting. The support structure **100** can be modified in order to accommodate more or fewer discs.

[0022] FIG. **1**B is a simplified schematic diagram illustrating a cleaning apparatus that the support structure **100** may be integrated with, in accordance with one embodiment of the invention. The support structure **100** is configured to replace supports **110***a* and **110***b* in order to expose discs within the support structure **100** to be processed with brush apparatus **112**. In one embodiment, the apparatus **112** is a spiral scrubber that conditions the surface of the discs by removing residual particular matter. For additional information regarding the spiral scrubber, see U.S. patent application Ser. No. 11/862,170, the contents of which are incorporated herein by reference.

[0023] As the roller assembly **102** of the support structure **100** allows the discs to rotate, the entire surface of the discs can be exposed to the apparatus **112**. Additionally, the v-shape groove of the individual rollers encourages even spacing of the discs and minimizes contact with the disc. In other embodiments, the apparatus **112** is a cleaning apparatus with evenly spaced cleaning surfaces that are not in a spiral configuration. In one embodiment the cleaning apparatus is a brush with slits that enable the brush to scrub opposing surfaces of a disc or substrate. The rotation of apparatus **112** imparts linear forces so that the carriage or support structure translates along a length of the brush of the scrubbing apparatus. It should be noted, that the support structure can be moved into position onto a processing tool via a robot in order to minimize human contact and possible contamination points.

[0024] FIG. **2** is a schematic diagram illustrating roller assemblies **102***a* and **102***b* along with disc **106** in accordance with one embodiment of the present invention. The roller assembly **102***a* includes a carrier **200***a*, a carrier **200***b*, a shaft **202** and multiple rollers **204**. The carriers **200***a* and **200***b* include a shaft stop **206***a* and **206***b*. The shaft stops **206***a* and **206***b* are located on the end of the respective carriers **200***a* and **200***b* and keep the shaft **202** from sliding out of the roller assembly **102**. In one embodiment the carriers **200***a* and **200***b* are formed based on a common design and mated together so the shaft stops **206***a* and **206***b* are on opposing ends of the roller assembly **102***a*.

[0025] In FIG. **2**, a single support **300** is visible. However, multiple supports **300** are located between the carriers **200***a* and **200***b* in order to support the shaft **202** between the rollers **204**. An aperture of the support **300** is shown protruding from the carriers **200***a* and **200***b*. Location of the support **300** within the carriers **200***a* and **200***b* defines the location of the aperture. In the embodiment illustrated, the aperture is a hole within the support **300** and the shaft **202** is threaded through the aperture. In other embodiments, the aperture can be a portion of a cutout such as a semi-circle so the shaft **202** rests on the support **300**. As will be discussed below, features formed on interior faces of the carriers **200***a* and **200***b* and features of the support **300** promote accurate placement of the supports **300** to minimize deflection of the shaft **202**.

[0026] FIG. **3** is an exemplary illustration of the roller assembly **102***a* where carrier **200***a* has been made semi-transparent in order to show features within carriers **200***a* and **200***b*, in accordance with one embodiment of the present invention. The carriers **200***a* and **200***b* include features on an inside face that accommodate multiple shaft supports **300**. Individual rollers **204** are supported and located on the shaft **202** between the shaft supports **300**. In one embodiment, the v-shape of the individual rollers **204** assists in maintaining the discs evenly spaced. Similarly, the v-shape of the individual rollers **204** prevents excessive lateral movement of the discs that can damage the surface of the discs. The shaft supports **300** constrain the movement of the rollers **204** and provide support for the shaft **202**. Shaft supports **300** prevent flexing of the shaft **202** and allow the diameter of the shaft **202** to be minimized. In one embodiment, the shaft material is a rigid material such as stainless steel. In other embodiments, alternate materials can be used such as titanium. The particular shaft materials examples provided are exemplary and should not be construed as limiting.

[0027] By minimizing the diameter of the shaft **202**, rollers **204** can be of a smaller diameter. The user of smaller diameter rollers enables support nests that can accommodate smaller diameter discs while still allowing a cleaning apparatus, such as the spiral brush apparatus to access the surface of the discs. In one embodiment, rollers **204** are composed of a compliant material formed over a rigid sleeve that may slightly deform to conform to an edge of the discs. An exemplary material for the rollers is, but is not limited to urethane.

[0028] FIGS. **4**A through **4**D are an exemplary rendering of the carrier **200***b* with various numbers of shaft supports **300** and rollers **204** to illustrate various aspects of the interaction between parts, in accordance with one embodiment of the present invention. In FIG. **4**A, the carrier **200***a* has been removed leaving only carrier **200***b* along with supports **300**, rollers **204**, and the shaft **202**. Without carrier **200***a* and the associated shaft stop **206***a*, one end of the shaft **202** is clearly visible. Additionally, support slots **400** are visible within the inside face **406** of the carrier **200***b*. The support slots **400** accommodate the shaft supports **300** and can include a shaft support locator **402** or keying feature to accurately locate the shaft supports **300** within the support slot **400**. Similarly, the shaft supports **300** have a locator **404** or key feature that is aligned with the shaft support locator **402**. As the shaft **202** is supported by the shaft supports **300**, accurate location of the supports can assist in preventing flexing or undulations within the shaft **202**.

[0029] FIG. **4**B is a representative illustration showing the removal of some rollers **204** in order to provide a view of the shaft supports **300** and the shaft **202** while installed in the carrier **200***b*, in accordance with one embodiment of the present invention. Removal of some of the rollers reveals that the shaft supports **300** are anchored within the carrier **200***b* and help prevent lateral movement of the rollers **204** along the length of the shaft **202**. In one embodiment, the thickness of the supports **300** is minimized in order to maximize the width of the rollers. Maximizing the width of the rollers allows the discs to be spaced far enough apart so a process, such as scrubbing can be conducted on the surfaces of the discs. In various embodiments, the thickness of the supports **300** is within a range of about 0.005 to 0.02 inches. In one embodiment, the thickness of the supports **300** is 0.01 inches and the supports **300** are fabricated from stainless steel. The use of stainless steel for supports **300** should not be considered limiting as alternate materials for supports **300** can be used.

[0030] FIG. **4**C is another representative illustration of the carrier **200***b* in accordance with one embodiment of the present invention. FIG. **4**C illustrates the shaft **202** running through a roller **204** between two shaft supports **300** along with a roller **204** being supported by a single shaft support **300**. In this embodiment, the rollers are able to spin on the shaft while lateral movement is restricted by the shaft supports **300**. As will be discussed later, other embodiments of the rollers incorporate or include spring elements that enable the rollers **204** to center themselves between the shaft supports **300**. FIG. **4**C also provides a view of the shaft support locators **402** that accommodate the support locator.

[0031] FIG. **4**D illustrates still another schematic of various components being installed in the carrier **200***b*, in accordance with an embodiment of the present invention. This illustration shows the shaft **202** along with a portion of the carrier **200***b* without shaft supports **300**, a portion of the carrier **200***b* with shaft supports **300**, and a portion of the carrier **200***b* with both shaft supports **300** and rollers **204**. The rollers **204** are independently supported between the shaft supports **300** and can each rotate independently of another. Being able to rotate independently of the other allows the rollers **204** to accommodate variations of disc rotational speeds and movement within a set of multiple discs being processed. The use of individual rollers **204** also reduces potential damage to discs along with reducing roller wear and particle generation during an exemplary cleaning operation. Shaft supports **300** may be disposed between each roller **204** or periodically after some number of rollers.

[0032] FIG. **5** is an exploded view of the roller assembly **102** in accordance with one embodiment of the present invention. This illustration provides a relative view of the carriers **200***a* and **200***b*, along with the shaft **202**, rollers **204** and shaft supports **300**. In various embodiment, shaft **202** is composed of stainless steel and has a diameter within a range of about 1 mm to about 3 mm. In one particular embodiment, the shaft **202** has a diameter of about 2 mm. Stainless steel has been listed as an exemplary material for the shaft **202** because the material minimizes the potential to generate contaminates. The use of stainless steel as the shaft **202** material should not be construed as limiting as other materials that minimize contaminate generation can also be used.

[0033] FIG. **6** is a schematic illustrating various views of the carriers **200***a* and **200***b* in accordance with one embodiment of the present invention. FIG. **6** illustrates that the carrier **200***a* and **200***b* are formed from a common design with carrier **200***b* being positioned to mirror carrier **200***b*. The support slots **400** along with the shaft support locators **402** can be seen formed on the inside face **406** of the carrier **200***a* and **200***b*.

[0034] FIG. **7** includes exemplary views of a roller **204**, in accordance with one embodiment of the present invention. The roller **204** is intended to be merely an example and should not be considered limiting. Other embodiments of rollers can include integrated ball bearings or replaceable bearings to reduce particle generation from friction between the roller and the shaft. Roller **204** is shaped as a v-shaped outer surface disposed around a slot accommodating the shaft. Triangular supports extend from a center region of the roller outward.

[0035] FIG. **8** is a schematic of an exemplary shaft support **300**, in accordance with one embodiment of the present invention. In this figure, the support locator **404** is illustrated as having a lower extension member with a wider head disposed thereon. An aperture within the head portion is configured to receive a shaft therethrough. As previously discussed, the support locator **404** is matched with the carrier locator (not shown) in order to accurately locate the shaft support **300**. With the shaft supports **300** being accurately located and supported, a shaft with a minimal diameter can be used because deflection of the shaft from the supports is minimized.

[0036] FIGS. **9**A-**9**F illustrate alternate rollers **604** that incorporate a spring **900** in accordance with one embodiment of the present invention. In FIGS. **9**A and **9**B, the roller **604** accommodates a spring **900***a* while in FIGS. **9**C-**9**F the roller **604***a* includes an integrated spring. In each embodiment, the spring centers the roller between supports (not shown). While both of the embodiments illustrated rely on coil springs, other embodiments can rely on different types of spring or even compliant materials such as, but not limited to compliant elastomerics. Additionally, movement of the disc can be accommodated by the springs so as to reduce uneven loading of the roller on the shaft. This can result in reduced particulate generation and reduced wear on the rollers. Furthermore, the potential for damaging the edges of discs can be reduced with the motion compliance afforded by the use of spring on the rollers.

[0037] 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.

For example, in an alternative embodiment, the supports are insert molded into a one-piece component that has a single shaft stop added after the installation of the rollers and the shaft.

[0038] 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 workpiece, comprising:
a plurality of shaft supports;
a shaft defined between the shaft supports, the shaft extending through an aperture defined in each of the plurality of shaft supports; and
a plurality of rollers defined to rotate about the shaft, the rollers defined between the plurality of shaft supports.

2. An apparatus as defined in claim **1**, further comprising:
a first carrier and a second carrier, each carrier having a plurality of matching support slots formed on an interior face of the first and second carriers.

3. An apparatus as defined in claim **2**, wherein the shaft supports are positioned within the support slots defined on the interior face of the first and second carriers.

4. An apparatus as defined in claim **3**, wherein the support slots include a keying feature to align the aperture of the shaft support.

5. An apparatus as defined in claim **2**, wherein each carrier has a shaft stop, the shaft stop being configured to retain the shaft between the shaft stop of each carrier.

6. An apparatus as defined in claim **1**, wherein compliant members are mounted along the shaft between each of the plurality of rollers and the respective shaft supports.

7. An apparatus for supporting a substrate, comprising:
a first carrier having a plurality of support slots formed on an interior face;
a second carrier opposing the first carrier, the second carrier having a plurality of support slots on an interior face;
a plurality of shaft supports being positioned within the support slots, each of the shaft supports having an aperture that extends from respective carriers;
a shaft being defined through the apertures along a length of the respective carriers; and
a plurality of rollers defined to rotate about the shaft, the rollers defined between the plurality of shaft supports.

8. An apparatus as defined in claim **7**, wherein the support slots include a keying feature to align the aperture of the shaft support.

9. An apparatus as described in claim **8**, wherein the shaft supports have a key feature that corresponds to the keying feature of the support slots.

10. An apparatus as described in claim **9**, wherein the key feature is located on an opposite end of the aperture.

11. An apparatus as described in claim **7**, wherein the plurality of rollers include an integrated compliant member.

12. An apparatus as described in claim **9**, wherein the key feature extends past the interior face of the carrier.

13. An apparatus as described in claim **7**, wherein the shaft has a diameter of about two millimeters.

14. A substrate cleaning apparatus, comprising:
a brush member having an axis of rotation, the brush member including a scrubbing material; and
a support member for supporting a substrate in contact with the brush, the support member including a shaft defined through apertures on a plurality of shaft supports, the shaft extending through an aperture defined in each of the plurality of shaft supports, the shaft having a plurality of rollers defined between the plurality of shaft supports, the plurality of rollers further defined to rotate about the shaft, the shaft having an rotational axis that is parallel to the axis of rotation of the brush.

15. A substrate cleaning apparatus as defined in claim **14**, wherein the support member further comprises:
a first carrier and an opposing second carrier, each carrier having a plurality of matching support slots formed on an interior face of the first carrier and the opposing second carrier.

16. A substrate cleaning apparatus as defined in claim **15**, wherein the shaft supports are positioned within the support slots defined on the interior face of the first carrier and the opposing second carriers.

17. A substrate cleaning apparatus as defined in claim **16**, wherein the support slots include a keying feature to align the aperture of the shaft support.

18. A substrate cleaning apparatus as defined in claim **14**, wherein the shaft has a diameter of about two millimeters.

19. A substrate cleaning apparatus as defined in claim **14**, wherein the support member further comprises:
a plurality of compliant members being disposed along the shaft, the plurality of compliant members being positioned between the plurality of shaft supports and the plurality of rollers.

20. A substrate cleaning apparatus as defined in claim **14**, wherein the brush member includes a plurality of slits that enables the brush member to scrub opposing surfaces of the substrate.

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