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(71) Applicant (for all designated States except US): APPLIED MATERIALS, INC. [US/US]; 3050 Bowers Avenue, Santa Clara, CA 95054 (US).

(72) Inventors; and
(75) Inventors/Applicants (for US only): MANENS, Antoine, P. [FR/US]; 678 Bellflower Avenue, Apt. 23, Sunnyvale, CA 94086 (US). ETTINGER, Gary, C. [US/US]; 10948 Sycamore Drive, Cupertino, CA 95014 (US). BUTTERFIELD, Paul, D. [US/US]; 1684 Kevin Drive, San Jose, CA 95124 (US). CHANG, Shou-sung [—/US]; P.o. Box 19783, Stanford, CA 94309 (US). MARTINEZ, Ricardo [US/US]; 1512 Swallow Tail Lane, Manteca, CA 95337 (US). KOLLATA, Eashwer [IN/US]; 603 Maestro Court, San Jose, CA 95134 (US). EWALD, Robert, A. [US/US]; 3365 Aptos Rancho Road, Aptos, CA 95003 (US). SUMBRIA, Kuldip [US/US]; 32422 Springwood Drive, Union City, CA 94587 (US).

(74) Agents: SANTISI, Steven, M. et al.; Dugan & Dugan, PC, 245 Saw Mill River Road, Suite 309, Hawthorne, NY 10532 (US).

[Continued on next page]

(54) Title: APPARATUS AND METHODS FOR USING A POLISHING TAPE CASSETTE

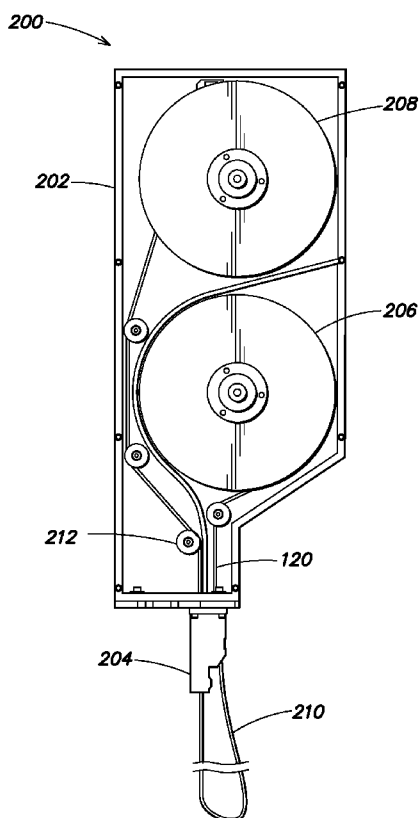


FIG. 2

(57) Abstract: Methods and apparatus are provided for housing a polishing tape adapted to polish a substrate. The invention includes a cassette comprising a body portion; and a head portion, wherein the head portion includes: a pair of guide walls; one or more supply rollers positioned between the guide walls in the head portion; and wherein the guide walls are adapted to guide a polishing tape housed in the body over the one or more supply rollers. Numerous other aspects are provided.



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APPARATUS AND METHODS FOR USING A POLISHING TAPE CASSETTE**RELATED APPLICATIONS**

5 [0001] The present application claims priority to U.S. Provisional Patent Application No. 61/046,453, filed April 21, 2008, and entitled, "APPARATUS AND METHODS FOR USING A POLISHING TAPE CASSETTE" (Attorney Docket No. 11533/L), which is hereby incorporated herein by reference in its
10 entirety for all purposes.

CROSS-REFERENCE TO RELATED APPLICATIONS

[0002] The present application is also related to the following commonly-assigned, co-pending U.S. Patent
15 Applications, each of which is hereby incorporated herein by reference in its entirety for all purposes:

[0003] U.S. Patent Application Serial No. 11/299,295 filed on December 9, 2005 and entitled "METHODS AND
20 APPARATUS FOR PROCESSING A SUBSTRATE" (Attorney Docket No. 10121);

[0004] U.S. Patent Application Serial No. 11/298,555 filed on December 9, 2005 and entitled "METHODS AND
25 APPARATUS FOR PROCESSING A SUBSTRATE" (Attorney Docket No. 10414);

[0005] U.S. Patent Application Serial No. 11/693,695 filed on March 29, 2007 and entitled "METHODS AND APPARATUS
30 FOR POLISHING AN EDGE OF A SUBSTRATE" (Attorney Docket No. 10560);

[0006] U.S. Patent Application Serial No. 60/939,351, filed May 21, 2007, entitled "METHODS AND APPARATUS FOR

POLISHING A NOTCH OF A SUBSTRATE USING AN INFLATABLE
POLISHING WHEEL" (Attorney Docket No. 10674/L);

[0007] U.S. Patent Application Serial No. 60/939,353, filed
5 May 21, 2007, entitled "METHODS AND APPARATUS FOR FINDING A
SUBSTRATE NOTCH CENTER" (Attorney Docket No. 11244/L);

[0008] U.S. Patent Application Serial No. 60/939,343,
filed May 21, 2007, entitled "METHODS AND APPARATUS TO
10 CONTROL SUBSTRATE BEVEL AND EDGE POLISHING PROFILES OF
EPITAXIAL FILMS" (Attorney Docket No. 11417/L);

[0009] U.S. Patent Application Serial No. 60/939,219,
filed May 21, 2007, entitled "METHODS AND APPARATUS FOR
15 POLISHING A NOTCH OF A SUBSTRATE USING A SHAPED BACKING PAD"
(Attorney Docket No. 11483/L);

[0010] U.S. Patent Application Serial No. 60/939,342, filed
May 21, 2007, entitled "METHODS AND APPARATUS FOR REMOVAL OF
20 FILMS AND FLAKES FROM THE EDGE OF BOTH SIDES OF A SUBSTRATE
USING BACKING PADS" (Attorney Docket No. 11564/L);

[0011] U.S. Patent Application Serial No. 60/939,350, filed
May 21, 2007, entitled "METHODS AND APPARATUS FOR USING A
25 BEVEL POLISHING HEAD WITH AN EFFICIENT TAPE ROUTING
ARRANGEMENT" (Attorney Docket No. 11565/L);

[0012] U.S. Patent Application Serial No. 60/939,344, filed
May 21, 2007, entitled "METHODS AND APPARATUS FOR USING A
30 ROLLING BACKING PAD FOR SUBSTRATE POLISHING" (Attorney Docket
No. 11566/L);

5 [0013] U.S. Patent Application Serial No. 60/939,333, filed May 21, 2007, entitled "METHODS AND APPARATUS FOR SUBSTRATE EDGE POLISHING USING A POLISHING ARM" (Attorney Docket No. 11567/L);

10 [0014] U.S. Patent Application Serial No. 60/939,337, filed May 21, 2007, entitled "METHODS AND APPARATUS FOR HIGH PERFORMANCE SUBSTRATE BEVEL AND EDGE POLISHING IN SEMICONDUCTOR MANUFACTURE" (Attorney Docket No. 11809/L);

15 [0015] U.S. Patent Application Serial No. 60/939,212, filed May 21, 2007, entitled "METHODS AND APPARATUS FOR IDENTIFYING A SUBSTRATE EDGE PROFILE AND ADJUSTING THE PROCESSING OF THE SUBSTRATE ACCORDING TO THE IDENTIFIED EDGE PROFILE" (Attorney Docket No. 11695/L);

20 [0016] U.S. Patent Application Serial No. 60/99,228, filed May 21, 2007, entitled "METHODS AND APPARATUS FOR POLISHING A NOTCH OF A SUBSTRATE BY SUBSTRATE VIBRATION" (Attorney Docket No. 11952/L); and

25 [0017] U.S. Patent Application Serial No. 60/939,209, filed May 21, 2007, entitled "METHODS AND APPARATUS FOR CONTROLLING THE SIZE OF AN EDGE EXCLUSION ZONE OF A SUBSTRATE" (Attorney Docket No. 11987/L).

FIELD OF THE INVENTION

30 [0018] The present invention relates generally to electronic device processing, and more particularly to methods and apparatus for using a polishing tape cassette.

BACKGROUND OF THE INVENTION

[0019] During electronic device manufacturing, undesirable materials may build up on the edge of a substrate. The materials may include dielectrics, photoresist and metals used in IC manufacture. Therefore, it may be desirable to clean or polish the bevel and outer edge of the substrate to remove these materials to prepare the substrate for electronic (e.g. semiconductor) device manufacturing. Typically an abrasive polishing tape is applied with some degree of force to polish bevels on the edge of the substrate. Generally contact between the abrasive polishing and portions of the substrate reserved for device fabrication ('device region') is avoided. Typically, a buffer zone or 'edge exclusion zone,' is provided between the device region and the edge of the substrate to protect the device region. Systems, methods and apparatus are needed for efficiently routing and aligning the abrasive tape.

SUMMARY OF THE INVENTION

[0020] In some aspects of the invention, a cassette for housing a polishing tape adapted to polish a substrate. The cassette includes a body portion; and a head portion, wherein the head portion includes: a pair of guide walls; one or more supply rollers positioned between the guide walls in the head portion; and wherein the guide walls are adapted to guide a polishing tape housed in the body over the one or more supply rollers.

[0021] In another aspect of the invention, a system for polishing an edge of a substrate is provided. The system includes a substrate support adapted to support a substrate; a polishing head adapted to press a polishing tape against

an edge of the substrate; and a cassette for housing the polishing tape, the cassette including: a body portion; and
[0022] a head portion, wherein the head portion includes: a pair of guide walls; one or more supply rollers positioned
5 between the guide walls in the head portion; and wherein the guide walls are adapted to guide the polishing tape housed
in the body over the one or more supply rollers.

[0023] In another aspect of the invention, a method is
10 provided. The method includes providing a supply spool including a length of polishing tape; routing the length of
polishing tape over a supply roller positioned between two walls in a head portion of a cassette; and providing a take-
up spool adapted to receive the length of polishing tape
15 from the supply roller, wherein the supply spool and take-up spool are housed in a body portion of the cassette.

[0024] Other features and aspects of the present
invention will become more fully apparent from the following
20 detailed description, the appended claims and the
accompanying drawings.

BRIEF DESCRIPTION OF THE FIGURES

[0025] FIG. 1 is a schematic illustration depicting an
25 example embodiment of a substrate cleaning apparatus
according to the present invention.

[0026] FIG. 2 is a schematic illustration of a tape
cassette according to the present invention.

[0027] FIG. 3A is a schematic illustration of a tape
30 cassette according to the present invention.

[0028] FIG. 3B is a schematic illustration of a tape
cassette according to the present invention.

[0029] FIG. 4 is a flow chart depicting an example application method of embodiments for replacing a tape cassette according to the present invention.

[0030] FIG. 5A is a schematic illustration of a spool including a length of polishing tape according to the present invention.

[0031] FIG. 5B is a schematic illustration of a spool according to the present invention.

[0032] FIG. 6 is a schematic illustration of a cross-section of a spool including a length of polishing tape according to the present invention.

DETAILED DESCRIPTION

[0033] The present invention provides improved methods and apparatus for cleaning and/or polishing an edge of a substrate, for example, before fabrication processes (e.g. deposition and etching processes), are performed. One method of cleaning and polishing a substrate edge (or notch) includes applying an abrasive film or tape ("polishing tape") to the substrate edge, and moving the polishing tape relative to the substrate edge, while the substrate is fixed in a particular position. The force, or pressure, applied to the polishing tape while contacting the substrate edge, as well as the degree of contact between the polishing tape and the substrate edge, may contribute to polishing efficiency. Another factor that may contribute to polishing efficiency is the degree of movement of the polishing tape relative to the substrate edge. In some embodiments, the relative movement may be provided by advancing the polishing tape over a surface of the substrate edge. However, the degree of relative movement between the polishing tape and the substrate edge may be further increased by moving the substrate as the polishing tape is advanced over the surface

of the substrate edge, thereby increasing the polishing efficiency and the cost-effectiveness thereof.

[0034] In some embodiments the polishing tape may be
5 supplied to the substrate edge via a supply spool, while the
used or worn polishing tape may be routed to a take-up
spool. Both the supply spool and the take-up spool may be
housed in a cassette. The cassette may also include one or
10 more rotatable rollers, positioned between the supply and
the take-up spools, to aide in routing or guiding/aligning
the polishing tape through the cassette. In conventional
tape routing systems, the rollers may be flange rollers or
crown rollers, for example. In conventional systems using
15 flange rollers, the flanges may prevent the polishing tape
from migrating off of the rollers. In conventional systems
using crown rollers, the crown roller is convex in shape and
may have a center diameter that is the largest diameter, and
the crown roller is symmetric from that center point. In
20 conventional systems, the polishing tape may tend to stay
centered over the larger center diameter of the crown
rollers. However, the mechanical properties of the
polishing tape (e.g., high level of flexibility) may make
the use of crown and flange rollers problematic. For
25 example, as the flanged roller rotates, the polishing tape
may migrate towards one of the flanges. The migration may
be due to the normal course of rotation or may be due to a
misalignment between the supply spool and the supply roller,
for example. When the polishing tape contacts the rotating
30 flange, the polishing tape may bunch up along the rotating
flange and subsequently, the polishing tape may fold or roll
over itself, thereby impeding the polishing process. Also,
the flexible nature of the polishing tape may cause the

polishing tape to migrate from the largest center of the crown roller.

[0035] Therefore, the present invention provides
5 apparatus and methods for effectively aligning and routing
or guiding the polishing tape. The present invention
provides a smooth flangeless supply roller having a constant
diameter to aide in routing the polishing tape through the
cassette, wherein the cassette includes a body portion and a
10 head portion. The inventive supply roller may be positioned
in the cassette such that the fixed walls of the cassette
head act as guides to prevent the polishing tape from
migrating off of the roller. The supply roller may also be
the same width as the polishing tape to further prevent the
15 migration of the polishing tape to an end of the roller.
The relative motion between the supply roller and the fixed
cassette walls may prevent the polishing tape from bunching
and folding, even when there is a misalignment between the
supply spool and the supply roller, for example. Thus, the
20 cassette head walls may control the location of the
polishing tape and allow a repeatable alignment of the
polishing head.

[0036] Additionally, the present invention provides a
25 method for replacing the used or worn polishing tape in the
cassette. It may be beneficial to provide a method for
quickly replacing the supply and take-up spools, to aide in
efficient throughput while minimizing polishing tool
downtime. As described above, the cassette may include two
30 portions, the body which houses the spools, and the head
which interfaces with the polishing tool, for example, and
through which the polishing tape is routed. In some
embodiments, in a first step, the spools may be disengaged
from the motors. The motors may be used to index or advance

the polishing tape. Then the cassette may be removed from the polishing tool. After removal, the cassette may be opened, and the polishing tape may be disengaged from the rollers in the cassette head. The spools and used polishing tape may then be removed from the cassette. The new supply spool with unused polishing tape and the new take-up spool may be installed in the cassette. The polishing tape may be threaded or routed from the supply spool, through the head and connected to the take-up spool. Then the cassette may be closed and placed back into the tool. While the used or spent cassette is being rebuilt, a fresh or new cassette having an unused polishing tape supply may be inserted into the polishing tool, such that downtime of the tool may be reduced. In another embodiment, the cassette having the used polishing tape may remain in the polishing tool, while the used spools may be replaced with new or unused spools.

[0037] Turning to FIG. 1, a schematic perspective view of an embodiment of a polishing apparatus 100 for polishing a substrate 102 is provided. The polishing apparatus 100 may include a substrate driver 104 (e.g., a servomotor, gear, belt, chain, etc.), which may be mounted on a pedestal 106. A support 108 (e.g., a vacuum chuck) may be coupled (e.g., rigidly) to a shaft (not shown) of the substrate driver 104. The support 108 may support the substrate 102, for example. The substrate driver 104 may rotate the substrate 102, via the support 108, about a center 110 of the substrate 102 or another suitable axis. The substrate driver 104 may be connected to a substrate driver control unit (not shown), which may control the angular displacement, angular velocity, and angular acceleration of the substrate 102. The polishing apparatus 100 may further include a polishing arm 112 aligned in the horizontal plane approximately

tangential to an edge of the substrate 102 and supported by a frame 114. In other embodiments, the polishing arm 112 may be aligned differently, for example, vertically or at an angle with respect to the horizontal plane. The polishing arm 112 may include a polishing head section 116 ('head'). The polishing head 116 may include a backing pad 118, which may be moved towards or away from the substrate 102 by an actuator (e.g., hydraulic actuator, pneumatic actuator, servomotor, etc.) (not shown). Polishing tape 120, may wrap around the polishing head 116, and over the backing pad 118, and be tensioned between spools housed in a cassette 200. In some embodiments, one cassette may be supplied per polishing head 116. The spools may be driven by spool drivers 122, 124 (e.g., servomotors), respectively. The spool drivers 122, 124, may be indexed to precisely control the amount of the polishing tape 120 that is advanced over the polishing head 116 from, for example, the spools, in order to polish the substrate 102.

[0038] In one or more embodiments, the polishing tape 120 may be made from many different materials, such as aluminum oxide, silicon oxide, silicon carbide, etc. Other materials may also be used. In some embodiments, the abrasives used may range, for example, from about 0.5 microns up to about 3 microns in size, or 0.1 microns to 10 microns in size, although other sizes may be used. Different widths of polishing tape 120 ranging from about 0.55 inch to about 1.5 inches may be used, although other polishing tape widths may be used. In one or more embodiments, the polishing tape 120 may be about 0.002 to about 0.02 inches thick and withstand about 1 to 5 lbs. in tension. Other polishing tapes having different thicknesses and tensile strengths may be used.

[0039] Turning to FIG. 2, an exemplary schematic illustration of the cassette 200 is provided. The cassette 200 may include a body portion 202 and a head portion 204. The cassette body 202 may house a supply spool 206 and a take-up spool 208, shown in more detail in FIGS. 5A, 5B and 6. While only one supply and take-up spool 206, 208 are shown herein, other numbers of supply and take-up spools may be used. The supply spool 206 and take-up spool 208 may each include a pair of flanges 500 (FIG. 5A and 5B), coupled to a core 502. The length of polishing tape 120 may be wound around, or unwound from, the core 502. The cassette body 202 may include a selectively removable cover 201 (FIG. 1). The supply spool 206 may store unused polishing tape 120 available to be unwound and pulled into the polishing apparatus 100, positioned adjacent the substrate 102, while the take-up spool 208 may be adapted to receive used and/or worn polishing tape 120. One or both of the supply and take-up spools 206, 208 may be indexed to precisely control the amount of polishing tape 120 that is advanced to the polishing apparatus 100. In alternate embodiments, the polishing tape 120 may be continuously moving. In some embodiments, the take-up spool 208 may advance at a particular speed, and the supply spool 206 may create the tension. A tape loop 210 indicates the portion of polishing tape 120 that is routed around the polishing head 116, shown in FIG. 1. The cassette body 202 may also include a plurality of rollers 212 to further guide and route the polishing tape 120 through the cassette 200.

[0040] The supply and take-up spools 206, 208 may have a diameter of approximately 1 inch and be capable of holding about 500 inches of polishing tape 120, or may be a diameter of approximately 3 inches and be capable of holding about

30,000 inches of polishing tape 120. Other spool dimensions may be used. The spools 206, 208 may be constructed from materials such as polyurethane, polyvinyl difluoride (PVDF), etc. Other materials may also be used. In some embodiments the supply and take-up spools 206, 208 may be formed by selectively coupling two flanges (not shown) to a core (not shown), where the supply of polishing tape 120 is wound around the core, and each of the two flanges is coupled to opposite ends of the core.

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[0041] Turning to FIGs. 3A and 3B, a schematic view of the cassette head 204, with and without the polishing tape 120, respectively, is provided. The cassette head 204 may include a supply roller 300 and a take-up roller 302. Other suitable amounts of supply and take-up rollers may be used. Similarly to the rollers 212 described above with respect to FIG. 2, the supply and take-up rollers 300, 302 may be used to guide the polishing tape 120. The supply roller 300 may be smooth, flat and have a constant diameter, unlike conventional crown rollers, for example. The supply roller 300 may be positioned in the cassette head 204 such that a pair of walls 304 (shown in FIG. 3B) of the cassette head 204 act as a guide adapted to align the polishing tape 120 on the supply roller 300. Unlike the flanges on the flange rollers that rotate with the roller, increasing the polishing tape fold over, the cassette head walls 304 remain relatively stationary with respect to the rotating supply roller 300, which may decrease the polishing tape fold over. Additionally, the supply spool 300 may have a width substantially equal to the width of the polishing tape 120, which may further prevent polishing tape 120 migration. The take-up roller 302 may have a larger width than the supply

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roller 300, as the take-up roller 302 may not be used to align the polishing tape 120.

[0042] Turning to FIG. 4, a flow chart depicting an exemplary method 400 for replacing the used and/or worn/spent polishing tape, after the supply has been exhausted, for example, may be provided. As described above, each of the supply and take-up spools 206, 208 may be coupled to, and driven by, spool drivers 122, 124 (e.g., servomotors). In S102 the supply and take-up spools 206, 208 may be disengaged from the respective spool drivers 122, 124 or motors. In some embodiments the spools and motors may include male and female connectors that are adapted to selectively matably engage the spool to the motor. These male and female connectors may be cone shaped. For example, a cone-shaped female connector 600 is shown in FIG. 6. Other suitable shapes may be used. One of the benefits of a male and female connector is that spools and motors are centered during mating. In some embodiments, additional fastening devices 602 (e.g., a screw) may be used to further secure the spool driver and spool. In some embodiments, the cassette 200 may be further secured to the polishing apparatus 100 by a toggle clamp or cam, for example. In such embodiments, these additional fastening and securing devices may be removed. Then in S104, the cassette 200 may be removed from the polishing apparatus 100. The cassette cover 201 may then be removed from the cassette body 202. In S106 the used and/or worn polishing tape 120 may be removed from the cassette head 204. In some embodiments the cassette head 204 may not include a cover, and consequently, to remove the spent polishing tape therefrom, the polishing tape 120 may be severed from the supply spool 206 and pulled out of the cassette head 204. Then, the spent or used

supply and take-up spools 206, 208 may be removed from the cassette body 202 in S108. Then new supply and take-up spools may be inserted into the cassette body 202 in S110. In S112 the fresh or new supply of polishing tape 120 may then be routed from the new supply spool through the polishing head and fastened to the new take-up spool, following the same path of the used polishing tape 120. The cassette cover 201, if one is provided, may then be replaced in S114. In S116, the rebuilt cassette may be re-installed on the polishing tool 100. Therefore, when the polishing tape supply needs to be replaced, the cassette may be replaced with a second unused or rebuilt cassette while the first original cassette is being rebuilt, thereby reducing the downtime of the polishing tool 100.

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[0043] In an alternate embodiment, the cassette 200 may remain coupled to the polishing tool 100 while the used polishing tape 120 is replaced with new polishing tape. For example, the cassette body cover 201 may be removed from the cassette 200, and one or more flanges 500, 502 (FIG. 5A and 5B) coupled to a core 504 of the used supply and take-up spools 206, 208 may be removed therefrom. Then the used supply core may be replaced with a new supply core including a supply of polishing tape, and the used take-up core having the length of used tape may be replaced with a new empty take-up core. In some embodiments the used supply core may be re-purposed as the new take-up core. The new and unused polishing tape may then be threaded through the cassette body and head, and fastened to the new take-up spool. In some embodiments, the old polishing tape 120 may be used to thread the new polishing tape through the cassette head 204 by adhering a free end of the new polishing tape to the old polishing tape and having the old polishing tape "lead" or

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route the new polishing tape through the cassette head. After the new polishing tape is threaded in the cassette 200, the cassette cover 201 may be replaced.

5 **[0044]** It should be understood that the inventive edge polishing apparatus described herein may be employed in apparatuses other than those adapted for bevel and edge polishing and/or removal of films on substrates. Further, as will be apparent to those of ordinary skill in the art, 10 the apparatus describe herein may be employed to polish and/or remove films on an edge of a substrate supported in any orientation (e.g., horizontal, vertical, diagonal, etc).

[0045] Further, it should be understood that although 15 only examples of cleaning a round substrate are disclosed, the present invention could be modified to clean substrates having other shapes (e.g., a glass or polymer plate for flat panel displays). Further, although processing of a single substrate by the apparatus is shown above, in some 20 embodiments, the apparatus may process a plurality of substrates concurrently.

[0046] The foregoing description discloses only exemplary 25 embodiments of the invention. Modifications of the above disclosed apparatus and methods which fall within the scope of the invention will be readily apparent to those of ordinary skill in the art. Accordingly, while the present invention has been disclosed in connection with exemplary embodiments thereof, it should be understood that other 30 embodiments may fall within the spirit and scope of the invention, as defined by the following claims.

What is claimed is:

1. A cassette for housing a polishing tape adapted to polish a substrate, the cassette comprising:
5 a body portion; and
a head portion, wherein the head portion includes:
a pair of guide walls, and
one or more supply rollers positioned between the
guide walls in the head portion,
10 wherein the guide walls are adapted to guide a
polishing tape housed in the body over the one or more
supply rollers.
2. The cassette of claim 1 wherein the one or more
15 supply rollers rotate relative to the guide walls.
3. The cassette of claim 1 wherein the one or more
supply rollers are flangeless.
- 20 4. The cassette of claim 1 wherein the one or more
supply rollers have a constant diameter.
5. The cassette of claim 1 wherein the guide walls are
adapted to align the polishing tape on the one or more
25 supply rollers.
6. The cassette of claim 1 wherein a width of the one
or more supply spools is substantially the same as a width
of the polishing tape.

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7. A system for polishing an edge of a substrate comprising:

- a substrate support adapted to support a substrate;
- a polishing head adapted to press a polishing tape
5 against an edge of the substrate; and
- a cassette for housing the polishing tape, the cassette comprising:
 - a body portion; and
 - a head portion, wherein the head portion includes:
10 a pair of guide walls;
one or more supply rollers positioned between
the guide walls in the head portion; and
 - wherein the guide walls are adapted to guide the
polishing tape housed in the body over the one or more
15 supply rollers.

8. The system of claim 7 further comprising:

- at least one supply spool positioned within the body
portion and adapted to provide a length of polishing tape to
20 the head portion.

9. The system of claim 8 further comprising:

- at least one take-up spool positioned within the body
portion and adapted to receive a length of polishing tape
25 from the head portion.

10. The system of claim 7 wherein the one or more
supply rollers rotate relative to the guide walls.

- 30 11. The system of claim 7 wherein the one or more
supply rollers are flangeless.

12. A method comprising:
providing a supply spool including a length of
polishing tape;
routing the length of polishing tape over a supply
5 roller positioned between two walls in a head portion of a
cassette; and
providing a take-up spool adapted to receive the length
of polishing tape from the supply roller, wherein the supply
spool and take-up spool are housed in a body portion of the
10 cassette.

13. The method of claim 12 further comprising:
disengaging a spent supply spool from a spool driver
before providing the supply spool including the length of
15 polishing tape.

14. The method of claim 13 further comprising:
re-purposing the spent supply spool as the take-up
spool.
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15. The method of claim 12 further comprising:
adhering the length of polishing tape to an end of
spent polishing tape; and
advancing the adhered length of polishing tape and
25 spent polishing tape through the head portion of the
cassette and to the take-up spool.

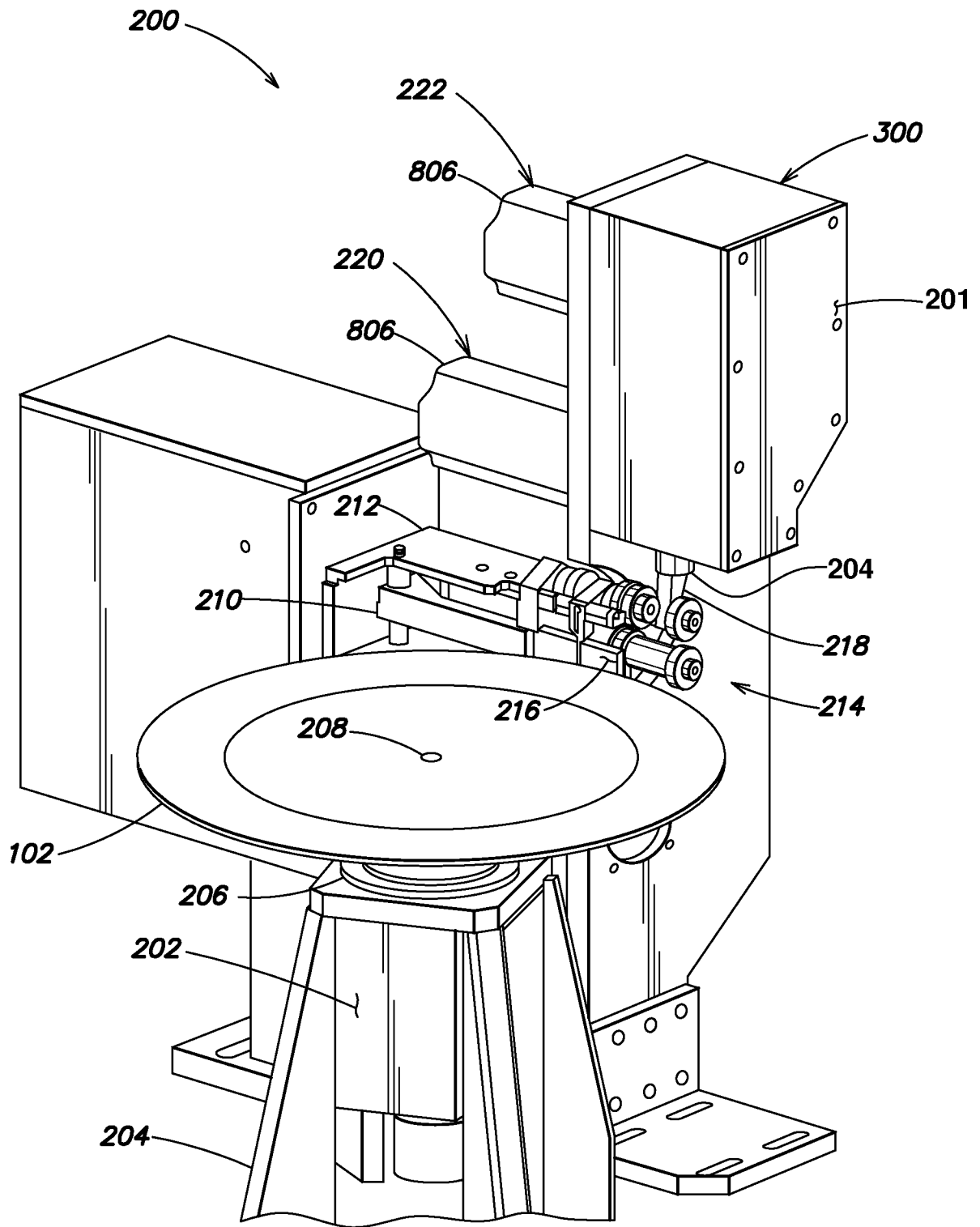


FIG. 1

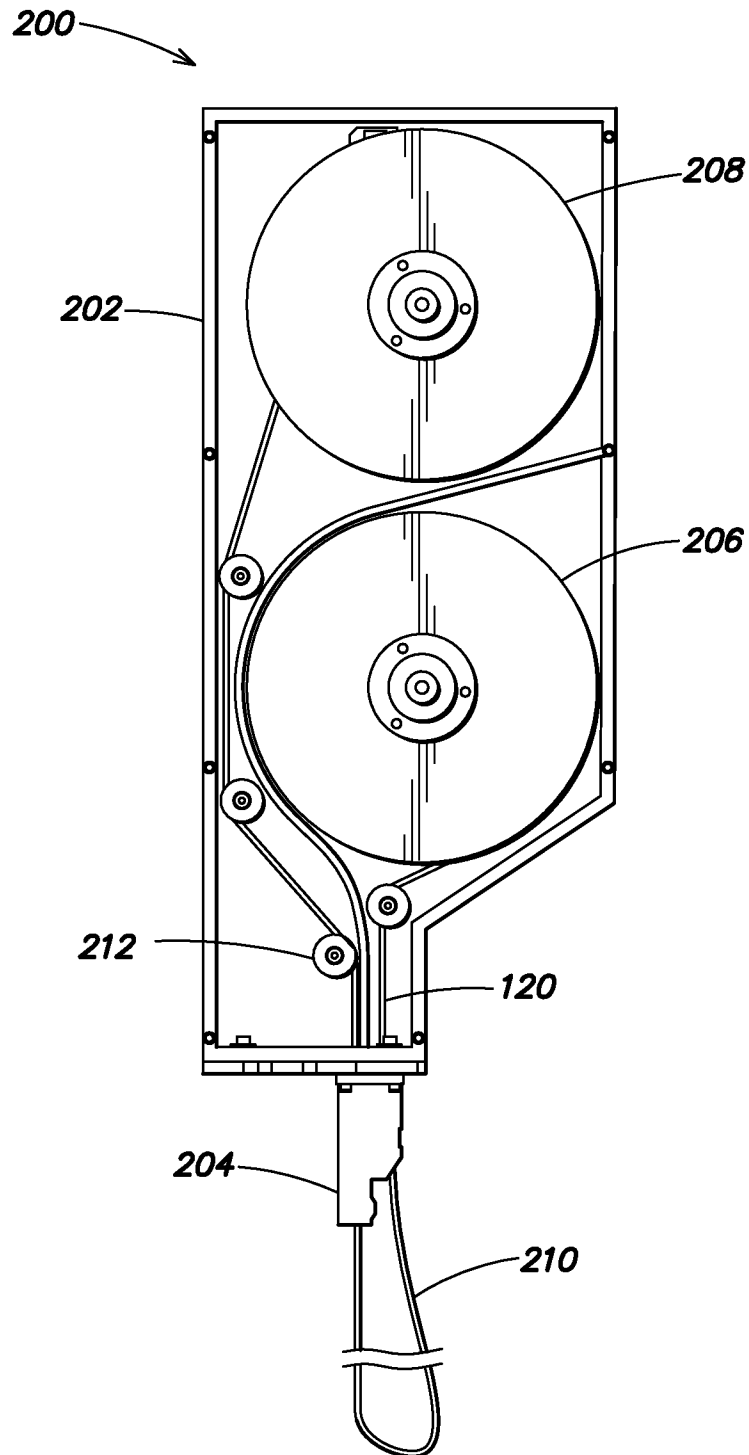


FIG. 2

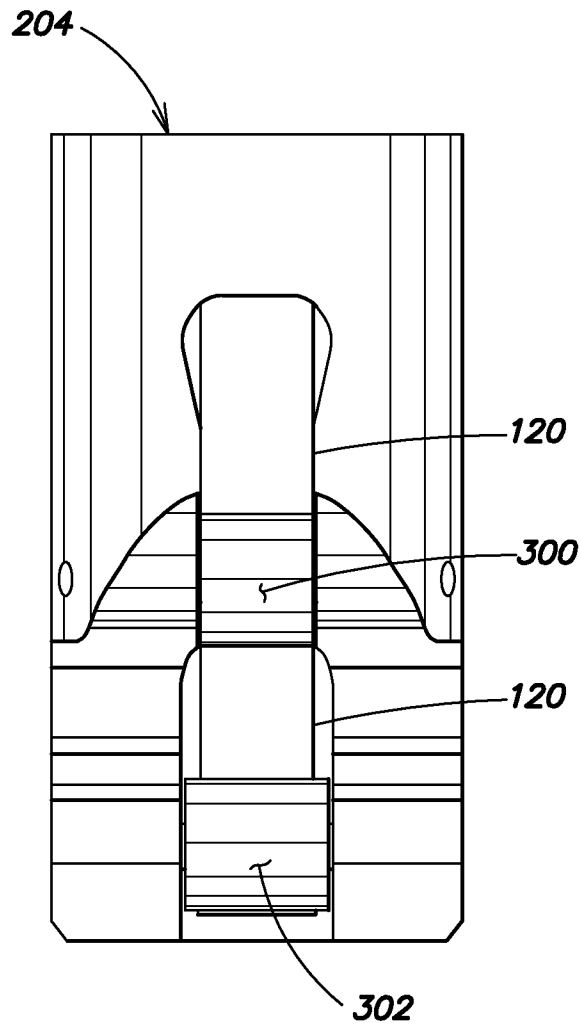


FIG. 3A

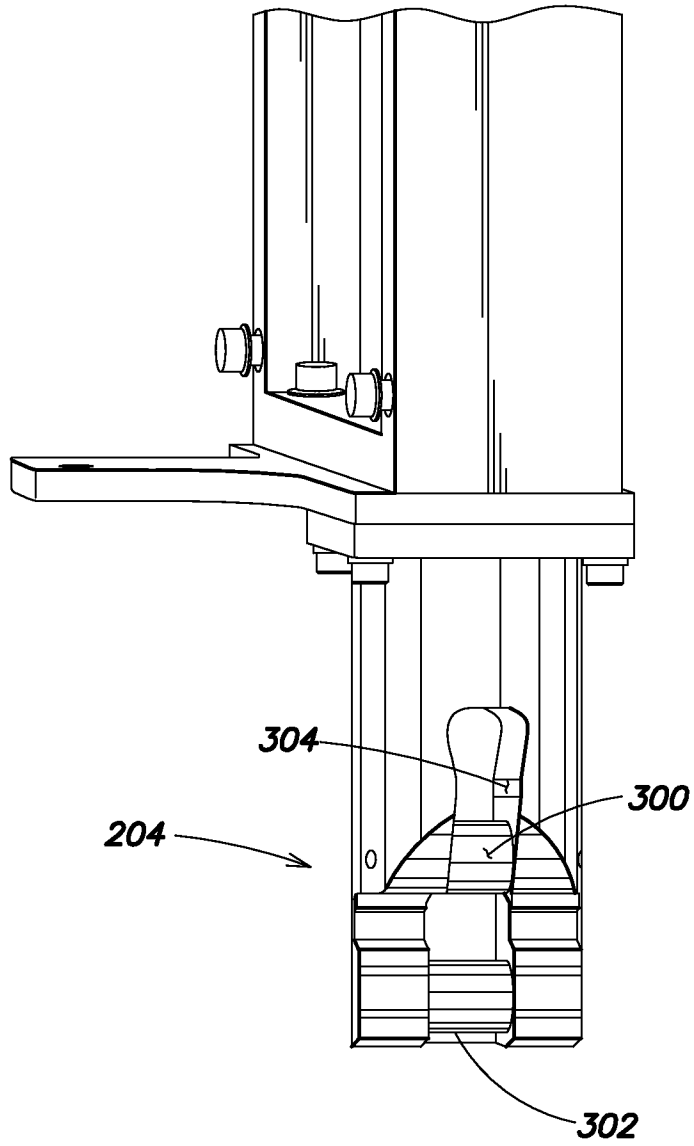


FIG. 3B

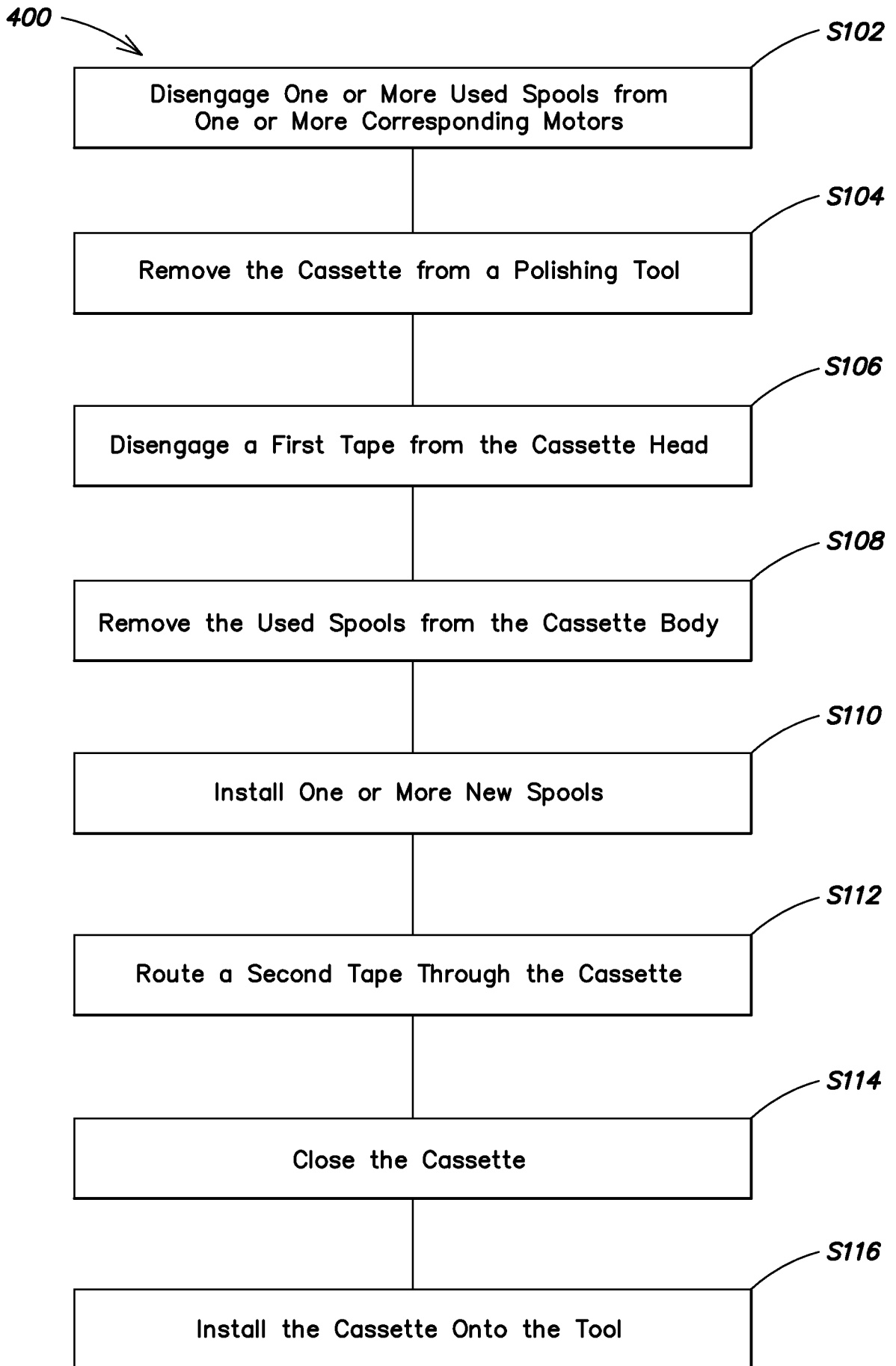


FIG. 4

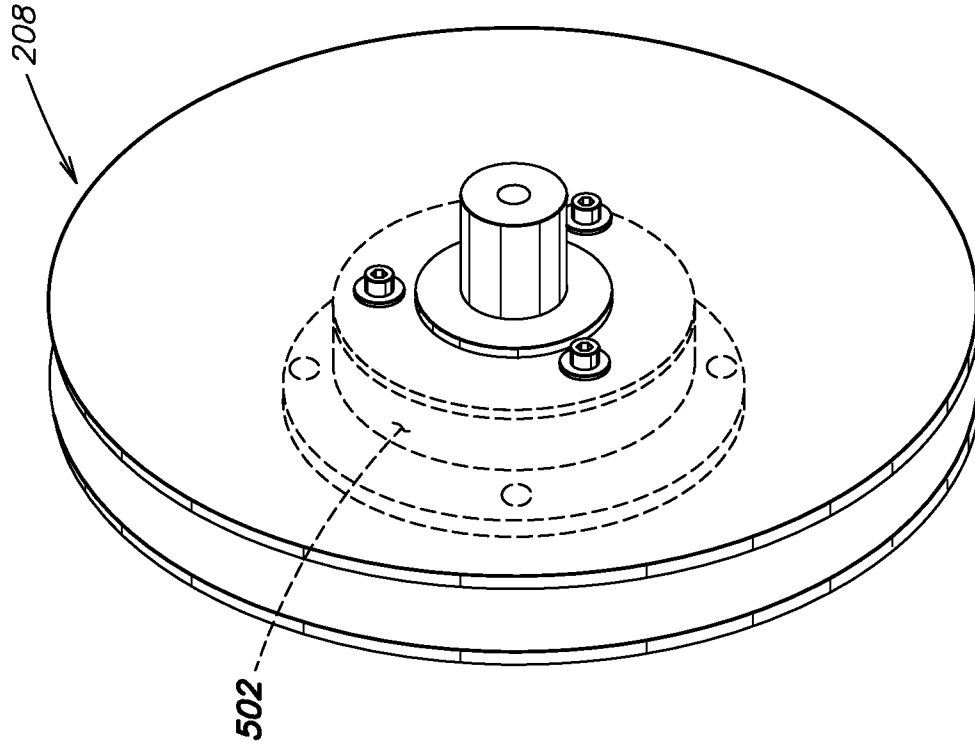


FIG. 5B

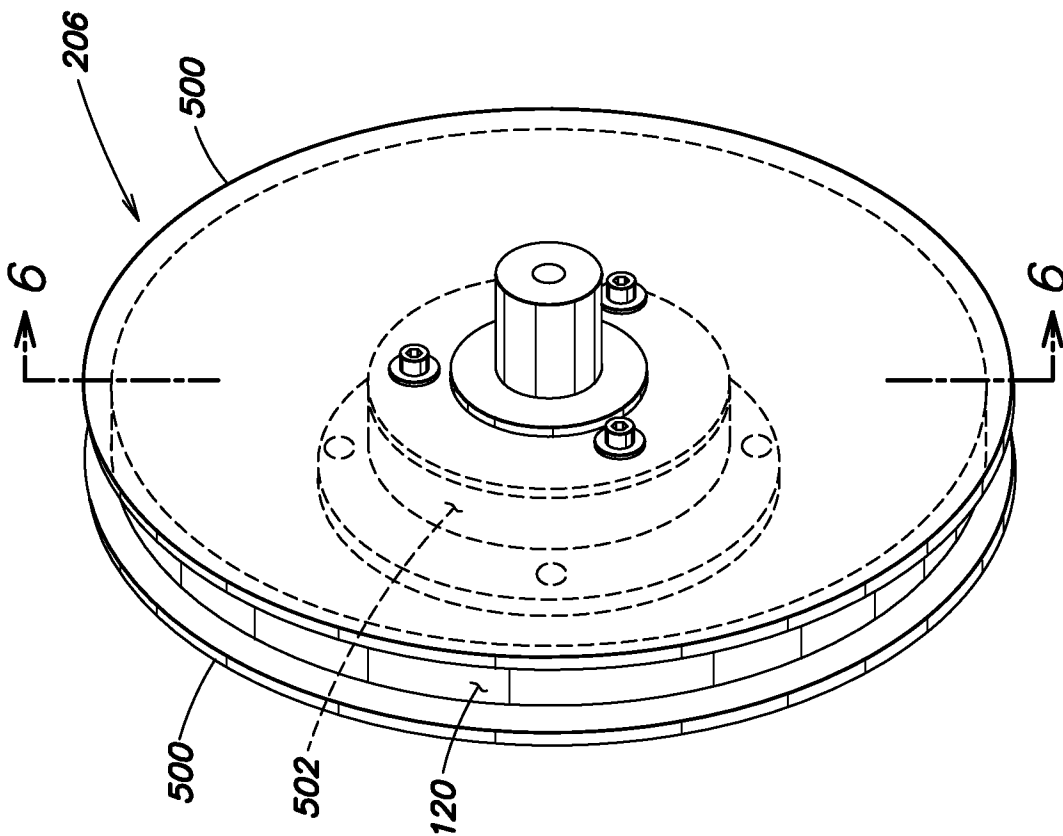


FIG. 5A

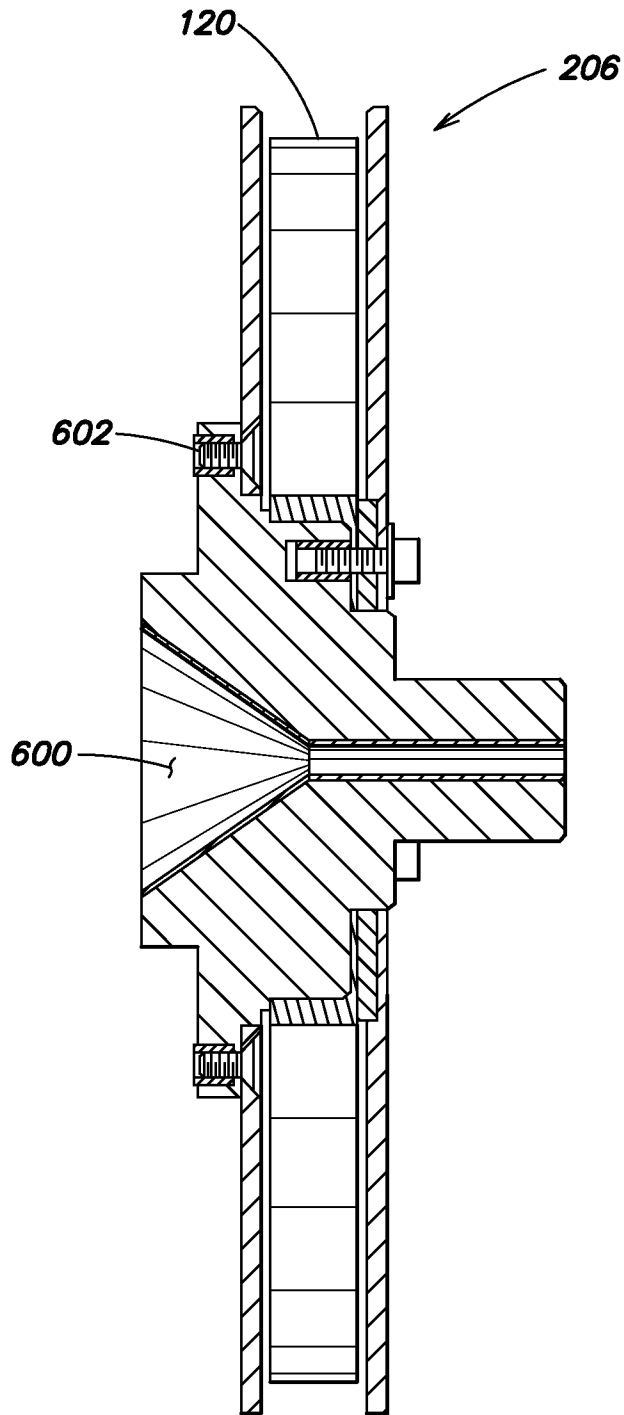


FIG. 6