

CLAIMS

What is claimed is:

1. An apparatus comprising:
 - 5 a ring structure having a circular opening defining a ring center axis; and
 - a plurality of roller mechanisms that are connected with the ring structure, each roller mechanism having:
 - a) a non-compliant support structure,
 - b) an axle,
 - 10 c) a roller configured to rotate about a corresponding axis of rotation relative to the non-compliant support structure of that roller mechanism and supported by the axle of that roller mechanism within that roller mechanism,
 - d) a cantilever beam structure extending inward from the non-compliant support structure of that roller mechanism towards the ring center axis, wherein:
 - 15 the cantilever beam structure of that roller mechanism has a slot at a radially inward end and having length along a radial direction relative to the ring center axis and a width along a direction parallel to the ring center axis,
 - the length of the slot of that roller mechanism is larger than the width of the slot of that roller mechanism, and
 - 20 the width of the slot of that roller mechanism is larger than a portion of the axle of that roller mechanism located therein, and
 - e) a spring element configured to urge the axle for that roller mechanism toward the ring center axis, wherein the roller of that roller mechanism is positioned so as to not overlap with the ring structure when viewed along an axis perpendicular to
 - 25 the ring center axis.
2. The apparatus of claim 1, wherein the spring element of each roller mechanism is a coil spring.
- 30 3. The apparatus of claim 1, wherein the spring element of each roller mechanism is a cantilevered beam spring.

4. The apparatus of claim 1, wherein the spring element of each roller mechanism is a leaf spring.
5. The apparatus of claim 1, wherein:
- 5 the minimum distance between the non-compliant support structures of at least two of the roller mechanisms is larger than a first distance,
- the circular opening has a diameter that is less than the first distance, and
- the first distance is selected from the group consisting of: 200 mm, 300 mm, and 450 mm.
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6. The apparatus of claim 1, wherein the rollers are all positioned entirely outside of the circular opening when viewed along the ring center axis.
7. The apparatus of claim 1, wherein there are three roller mechanisms that are
- 15 spaced at locations $120^{\circ} \pm 10^{\circ}$ apart from one another about the ring center axis.
8. The apparatus of claim 1, wherein each roller mechanism further includes a yoke, wherein:
- the yoke of that roller mechanism engages the axle of that roller
- 20 mechanism, and
- the spring element of that roller mechanism is configured to apply a force to the yoke of that roller mechanism that urges the yoke of that roller mechanism, and thus the axle of that roller mechanism and the roller of that roller mechanism, towards the ring center axis.
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9. The apparatus of claim 8, wherein each roller mechanism further includes a cantilever beam spring and, for each roller mechanism:
- a first end of the cantilever beam spring of that roller mechanism is interfaced with a portion of the non-compliant support structure of that roller mechanism,
- 30 a second end of the cantilever beam spring of that roller mechanism is interfaced with the yoke of that roller mechanism, and

the cantilever beam spring of that roller mechanism is configured to bend when the yoke of that roller mechanism is translated away from the ring center axis.

10. The apparatus of claim 8, wherein each roller mechanism further includes a leaf spring and, for each roller mechanism, the yoke of that roller mechanism has a first end that is positioned so as to deflect the leaf spring of that roller mechanism when the yoke of that roller mechanism is translated radially outward relative to the ring center axis.

10 11. The apparatus of claim 8, wherein, for each roller mechanism:

a first side of the leaf spring of that roller mechanism is supported by two spaced-apart support features of that roller mechanism, and

the first end of the yoke of that roller mechanism is configured to contact a second side of the leaf spring of that roller mechanism opposite the first side of that leaf spring at a location midway between the spaced-apart support features of that roller mechanism.

12. The apparatus of claim 9, wherein the cantilever beam spring is a hollow tube.

20 13. The apparatus of claim 9, wherein the cantilever beam spring is a ceramic capillary tube.

14. The apparatus of claim 9, wherein, for each roller mechanism:

the cantilever beam spring of that roller mechanism is interfaced with a first end of the yoke of that roller mechanism, and

a second end of the yoke of that roller mechanism opposite the first end of the yoke of that roller mechanism includes an axle interface that is configured to rotatably support the axle of that roller mechanism.

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15. The apparatus of claim 1, wherein, for each roller mechanism:
- the cantilever beam structure of that roller mechanism has a minimum contact area feature disposed at an end thereof that is closest to the ring center axis, and
- the minimum contact area feature of the cantilever beam structure of that roller
- 5 mechanism is located closer to the ring center axis than the roller of that roller mechanism.
16. The apparatus of claim 1, wherein, for each roller mechanism:
- at least the cantilever beam structure of that roller mechanism includes a
- 10 corresponding bore that extends along a corresponding bore axis that extends along a radial direction relative to the ring center axis, and
- the spring element of that roller mechanism is a coil spring that is located at least partially within the bore.
- 15 17. The apparatus of claim 16, wherein, for each roller mechanism:
- the axle for that roller mechanism has a length along the corresponding axis of rotation for the roller of that roller mechanism that is less than a width of the yoke for that roller mechanism along the corresponding axis of rotation for the roller for that roller mechanism,
- 20 the roller for that roller mechanism has a width along the corresponding axis of rotation of that roller that is less than the width of the yoke for that roller mechanism along the corresponding axis of rotation of that roller,
- the yoke for that roller mechanism has two protruding portions that overlap both the roller and the axle for that roller mechanism when viewed along the
- 25 corresponding axis of rotation for the roller of that roller mechanism, and
- both the roller and the axle for that roller mechanism are interposed between the two protruding portions of the yoke for that roller mechanism.
18. The apparatus of claim 16, wherein the coil spring is made of nickel or a nickel-
- 30 dominant alloy.
19. The apparatus of claim 16, wherein the coil spring is made of a ceramic material.