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(54) **ROTARY KNOB WITH NOISELESS FEEDBACK**

(57) A rotary knob (10) comprises a base (12), a cylindrical core (14) attached to the base and defining a rotational axis, a bearing (16) supported on the core, a grip portion (18) supported by the bearing for rotation about the rotational axis (A), conversion means (20) for converting the rotary movement of the grip portion into an output signal, and a feedback device for providing haptic feedback to the user via the grip portion and comprising a detent ring (19) configured for rotation with the grip portion about the rotational axis and resilient means configured to engage the detent ring.

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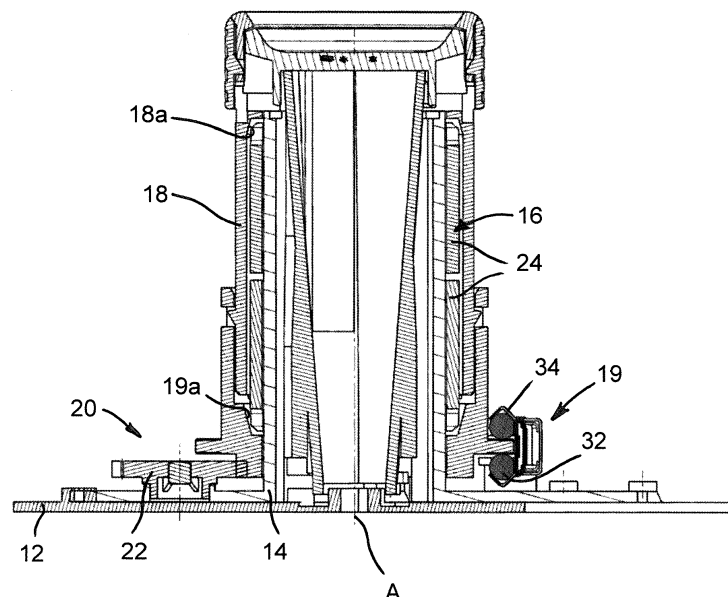


FIG. 1A

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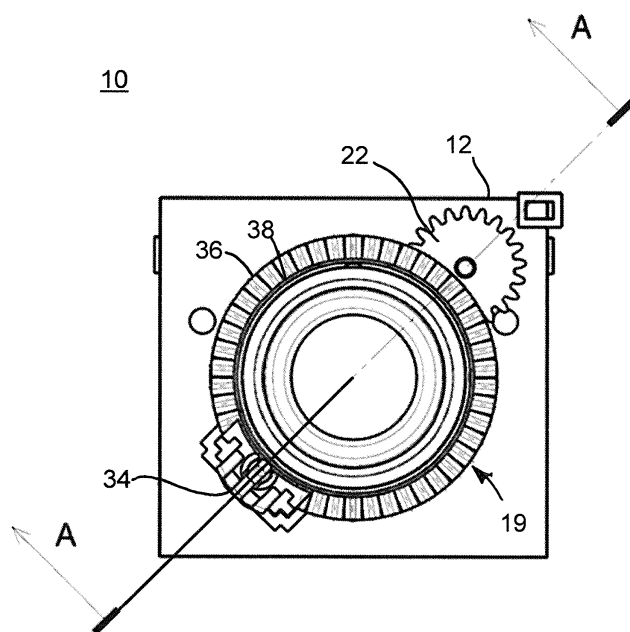


FIG. 1B

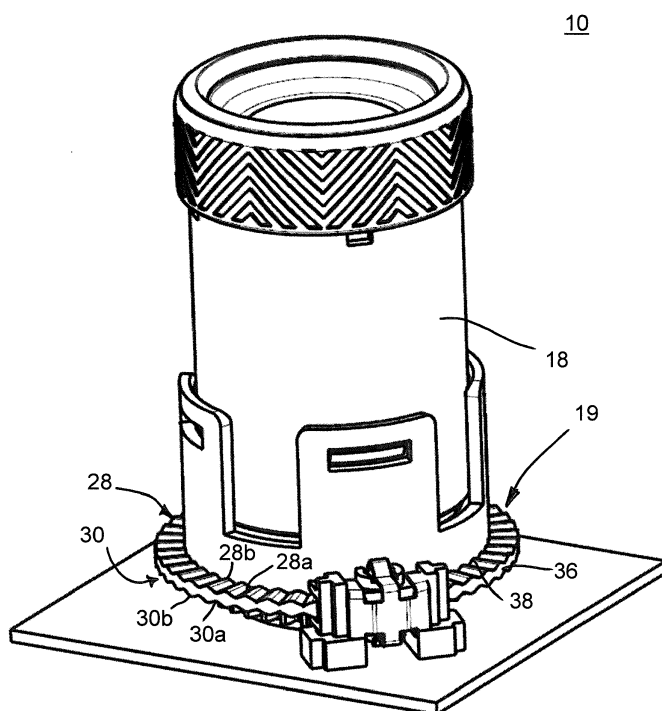


FIG. 1C

Description

[0001] The present invention relates to rotary knobs, and more particularly to rotary knobs that serve as input devices for automotive systems.

[0002] Rotary knobs are used to control many of the systems found in modern vehicles, such as air conditioning, audio, navigation and infotainment systems. For example, a rotary knob can be rotated by the user to control the volume of the audio system. Generally speaking, rotary knobs comprise a base, such as a printed circuit board (PCB), a cylindrical core attached to the base that defines a rotational axis for the knob, a bearing supported on the core, a grip portion supported by the bearing for rotation about the rotational axis and conversion means for converting the rotary movement of the grip portion into an output signal.

[0003] Some knobs are designed to provide haptic feedback or tactile feedback, i.e. force, vibration and/or motion, via the grip portion when a user rotates the knob. Haptic feedback can be useful when rotating the knob to a desired position, for example in order to select a particular mode or function. Haptic feedback has also been found to influence the user's perception of quality or luxury. One aspect that has been shown to negatively influence this perception is the noise and/or friction generated by haptic feedback systems, especially when the knob is rapidly rotated.

[0004] Accordingly, there remains a need for improved rotary knobs that generate less friction and noise while accounting for the other numerous design requirements that are prevalent in the automotive industry, such as cost, ergonomics, manufacturability or packaging.

[0005] Claim 1 provides a rotary knob that includes a base, a cylindrical core attached to the base and that defines a rotational axis, a bearing supported on the core and a grip portion supported by the bearing for rotation about the rotational axis. The grip portion is configured for manipulation by a

user. The knob also comprises conversion means for converting the rotary movement of the grip portion into an output signal and a feedback device for providing haptic feedback to the user via the grip portion. The feedback device comprises a detent ring configured to rotate with the grip portion about the rotational axis and resilient means for engaging the detent ring. The detent ring comprises a first pattern of alternating grooves and ridges and a second pattern of alternating grooves and ridges that each extend substantially in parallel to the respective grooves and ridges of the first pattern, and the resilient means are biased towards each of the first and second patterns of the detent ring.

[0006] In other words, the detent ring comprises first and second patterns provided at two opposing surfaces of the detent ring. Rotation of the grip portion and the detent ring causes the resilient means to deflect and strike the grooves and ridges of the first and second patterns. As the grooves and ridges of the first and second

patterns are aligned with one another, the resilient means strike the detent ring with the same impact from both sides, which suppresses vibration and noise. The shape, the size and the number of ridges and grooves may be adjusted to modify the torque profile of the feedback device based on customer specifications. Furthermore, the contact between the resilient means and both sides of the detent ring leads to uniform haptic feedback peaks.

[0007] Embodiments of the rotary knob are defined by the dependent claims and described in the following disclosure.

[0008] In accordance with one embodiment, the respective grooves and ridges of the first and second patterns of the detent ring may extend from one edge of the detent ring to an opposite edge. Therefore, the grooves and ridges of the first and second patterns extend continuously across the respective surfaces of the detent ring and give the aforementioned edges of the detent ring a fluted, wavy or zigzag shape.

[0009] In one embodiment, the grooves and ridges of the first and second patterns extend perpendicularly to the rotational axis, so the detent ring itself extends perpendicularly from a surface of the grip portion in the manner of a ridge or a flange. The flange has opposing sides that are spaced apart in the axial direction, and the first and second patterns are provided on each of the opposing sides of the detent ring.

[0010] Configuring the detent ring as a rim or flange may make it possible to reduce the overall axial height of the knob, which can be useful in terms of packaging considerations.

[0011] In another embodiment, the grooves and ridges of the first and second patterns of the detent ring may extend in parallel to the rotational axis so that the first and second patterns are provided at an inner peripheral surface and outer peripheral surface of a cuff-shaped detent ring that is arranged coaxially to the grip portion. In this configuration, the biasing force of the resilient means is also directed in the radial direction and is independent from axial movement of the grip portion. Therefore, the grip portion can be configured to slide along the rotational axis and commute a switch mounted at the base or PCB similarly to a computer key.

[0012] Resilient means may be provided at a single angular position relative to the rotational axis of the knob, or may also include a plurality of resilient means spaced apart from one another at different angular positions relative to the rotational axis.

[0013] In one embodiment, the resilient means comprise a first spring element biased towards the first pattern of the detent ring and a second spring element biased towards the second pattern of the detent ring. The first and second spring elements may each comprise a projection facing the respective first or second pattern of the detent ring. The projection may be configured to strike the ridges and grooves of the pattern as the spring element deflects, i.e. come into contact with the surface of the detent ring. Spring elements that are configured to

strike the surface of the detent ring reduce the total number of parts needed to realize the resilient means. While the aforementioned projection can have any suitable shape, a hemispherical projection is suited for striking the surface of the detent ring while reducing sliding friction.

[0014] In a further embodiment, the first and second spring elements of the resilient means may be connected at one end to form a resilient clip that reaches around a free edge of the detent ring, while an opposite edge from the free edge connects the detent ring to the grip portion. The clip design reduces the number of parts necessary for the resilient means and can easily be assembled by hand.

[0015] In another embodiment, the knob may include a housing surrounding the detent ring, with each of the first and second spring elements comprising at least one stabilizing member for stabilizing the spring element relative to the detent housing. The stabilizing members prevent the spring elements from scraping against the stationary detent housing as the grip portion is rotated, which further suppresses the generation of noise.

[0016] In one embodiment, the resilient member comprises at least two ball bearings, with each of the spring elements configured to bias a respective ball bearing against the first or the second pattern of the detent ring. While spring elements that directly strike the surfaces of the detent ring tend to slide across the surface and generate sliding friction, ball bearings can roll along the ridges and grooves and reduce sliding friction. Ball bearings are also able to come to rest at the bottom of a groove without play, which makes them suited for small and precise rotational movements of the grip portion.

[0017] In a further embodiment including a housing for the detent ring, the housing may define a ball channel for receiving each of the ball bearings of the resilient means. The ball bearings are received in a respective ball channel so that they can roll across the ridges and grooves of the first and second patterns, but are otherwise prevented from moving relative to the surfaces of the detent ring. The reduced freedom of movement of the balls suppresses play and sliding friction, which reduces noise generated by the ball bearings.

[0018] In one embodiment, each spring element biases a ball bearing toward a respective pattern of the detent ring at two points of contact. Alternatively, it is also possible for the spring element to include a projection that biases the ball bearing towards the detent pattern at a single point of contact. While the single point of contact offers a simple design, two points of contact reduce the friction forces acting on the ball bearing and allow it to rotate more smoothly.

[0019] Additionally, each of the grooves of the first and second patterns may comprise first and second lateral projections that are spaced apart from each other and intersect the groove. The lateral projections contact the ball bearing at two points of contact, as opposed to the single point of contact with the surface of the detent ring

when there are no lateral projections. The increased number of points of contact with the detent ring leads to larger friction forces acting on the ball bearings that slow the movement of the ball as it rolls downward from a ridge towards an adjacent groove. The slower movement results in a smaller impact force against the pattern of the detent ring and further suppresses the generation of noise.

[0020] In one embodiment, the respective ridges of the first and second patterns of the detent ring may be formed by a plurality of pyramid-shaped projections spaced apart from one another in the circumferential direction. For example, each projection may include two opposing triangular sides and two trapezoidal sides. In this embodiment, the respective grooves of the first and second detent patterns are formed by the spaces between two adjacent projections.

[0021] The detent ring and the grip portion may be configured for snap-fit connection to one another. Additionally, the bearing may comprise first and second cages for receiving a plurality of rolling elements and one or more spring members that bias the first and second cages apart from one another along the rotational axis. An outer cylindrical surface of the core may form an inner race for the rolling elements, while the grip portion and detent ring each define an inner slanted surface configured to form an outer race for the rolling elements. Such a bearing may eliminate axial play of the grip portion along the rotational axis to further reduce the generation of noise.

[0022] These and other features, aspects and advantages are described below with reference to the drawings. In the drawings, like reference characters denote corresponding features consistently throughout similar embodiments.

- | | |
|----------------|---|
| Figure 1 | shows various views of a rotary knob in accordance with the present disclosure. |
| Figure 2 | is a partial enlarged isometric view of one example of a detent ring. |
| Figure 3 | is a partial cross-sectional drawing showing different possible arrangements of the detent ring and the resilient means for engaging the detent ring. |
| Figure 4 | shows a schematic torque profile for a rotary knob in accordance with the present disclosure. |
| Figures 5 to 7 | are cross-sectional views of different examples of resilient means. |
| Figure 8 | shows a further example of a detent ring in combination with the resilient |

means shown in Figure 7.

Figure 9 illustrates the relative movement between the resilient means and the detent ring shown in Figure 8.

Figure 10 includes torque profiles for the resilient means and detent ring shown in Figures 7 to 9.

Figure 11 shows an enlarged view of a further detent ring and a single ball bearing arranged on the surface of the detent ring.

[0023] Figures 1A to 1C shows a first embodiment of a rotary knob 10 that includes a base 12, for example a PCB, a cylindrical core 14 attached to the base 12 and that defines a rotational axis A, a bearing 16 supported on the core 14, and a grip portion 18 supported by the bearing 16 for rotation about the rotational axis A. A bottom section of the grip portion 18 snaps together with a detent ring 19, as shown in Figure 1C, so that the grip portion 18 and the detent ring 19 rotate together about the rotational axis A.

[0024] The knob 10 shown in Figure 1 may be used as a volume control knob for a vehicle audio system. However, the rotary knob 10 is not restricted to automotive applications and can be used in any application in which rotary input is used to control a system.

[0025] The knob 10 further comprises conversion means 20 for converting the rotary movement of the grip portion 18 into an output signal. In the illustrated example, the conversion means 20 comprise a gear 22 mounted for rotation to the base 12 (see Figure 1B). The teeth of gear 22 mesh with teeth provided at the lower outer circumferential surface of the detent ring 19. As a user rotates the grip portion 18, the gear 22 is also rotated, and a magnetic sensor (not shown) mounted on the base 12 converts the rotation of the gear 22 into an output signal.

[0026] However, it is also possible for the conversion means 20 to be realized in the form of encoders, potentiometers or other custom-made solutions. An example of a custom-made solution is a light barrier used in conjunction a toothed ring. Appropriate conversion means 20 may be selected based on whether a particular embodiment requires the absolute angular position of the grip portion 18 as an output signal, or only the relative angular position of the grip portion 18.

[0027] The bearing 16 comprises first and second cages 24 that are configured to receive a plurality of rolling elements (not shown) and are biased apart from one another along the direction of the rotational axis A by a spring member (also not shown). An outer cylindrical surface of the core 14 serves as an inner race for the rolling elements, while slanted inner cylindrical surfaces 18a, 19a of the grip portion 18 and the detent ring 19 form an outer race for the rolling elements.

[0028] While the illustrated bearing 16 support the grip portion 18 and the detent ring 19 without play along the axial direction, other types of bearings, for example a simple bushing, can also be used. In this case, the grip portion 18 and the detent ring 19 may also be formed integrally, i.e. as a single part, for example as an injection molded part.

[0029] The detent ring 19 forms part of a feedback device for providing haptic feedback, for example vibrations, to the user via the grip portion 18. The detent ring 19 comprises a first pattern 28 of alternating grooves 28a and ridges 28b and a second pattern 30 of alternating grooves 30a and ridges 30b that each extend substantially in parallel to the respective grooves 28a and ridges 28b of the first pattern 28 and perpendicular to the rotational axis A (see in particular Figure 1C).

[0030] The feedback device further comprises resilient means configured to engage the detent ring 19 and are biased towards each of the first and second patterns 28, 30 of the detent ring 19. The resilient means are shown in cross-section in Figure 1A, and include two ball bearings 32 that are each biased against a surface of the detent ring 19 by a corresponding spring arm 34. Adjacent ends of the spring arms 34 are connected to one another to form a resilient clip that reaches around a free edge 36 of the detent ring 19, while an opposing edge 38 of the detent ring 19 is connected to the grip portion 18 (see Figures 1B and 1C). The spring arms 34 bias the ball bearings 32 in the axial direction shown in Figure 1A, i.e. against opposing surfaces of the detent ring 19. As the grip portion 18 and the detent ring 19 are rotated about the rotational axis A, the spring arms 34 deflect and cause the ball bearings 32 to roll along the surface of the first and second patterns 28, 30 and strike the respective grooves 28a, 30a and ridges 28b, 30b to provide haptic feedback to the user.

[0031] While Figure 1B shows a single feedback device arranged at the periphery of the detent ring 19, it is also possible to provide multiple feedback devices that are spaced apart from one another along the periphery of the detent ring 19.

[0032] Figure 2 shows an enlarged, partial isometric view of the first pattern 28 of the detent ring 19, which corresponds to the pattern of the detent ring 19 shown in Figure 1. In the illustrated embodiment, the respective grooves 28a, 30a and ridges 28b, 30b of the first and second patterns 28, 30 extend perpendicularly to the rotational axis A and therefore in the radial direction. Furthermore, the respective grooves 28a, 30a and ridges 28b, 30b extend from the free edge 36 to the opposing edge 38, such that the edges 36, 38 have a fluted, wavy or zigzag shape. The detent ring 19 forms a rim or a flange that extends radially with respect to the grip portion 18, and the grooves 28a, 30a and ridges 28b, 30b extend along the entire surface of the rim flange in the radial direction. However, it is also possible for the grooves 28a, 30a and ridges 28b, 30b to only

extend across a portion of the surfaces of the detent ring 19.

[0033] Figure 2 shows that the grooves 28a, 30a and ridges 28b, 30b have a substantially constant width in the radial direction. However, it is also possible for the width to increase along the radial direction as shown in more detail in Figure 8B. In the illustrated embodiment, the grooves 28a, 30a and ridges 28b, 30b are also shown as having a small radius whose size can be adjusted according to the desired torque characteristics and haptic feedback of the particular application.

[0034] Figure 3A shows a partial cross-section through an embodiment that is similar to the embodiment shown in Figures 1 and 2. The embodiment of Figure 3A also includes a detent ring 19 configured in the shape of a flange and having ridges 28b, 30b that extend in the radial direction. The resilient member also includes a pair of ball bearings 32 that are biased against the first and second patterns 28, 30 of the detent ring 19. However, unlike the previous embodiment, the resilient member includes a pair of separate leaf springs 40 that are biased within a detent housing 42 that surrounds the resilient member. The leaf springs 40 press the ball bearings 32 towards the detent ring 19 in a similar manner to the spring arms 34 of Figures 1 and 2.

[0035] Figure 3B is a partial cross-section 3 at a further embodiment that is substantially similar to the embodiment shown in Figure 3A. However, in Figure 8B, the grooves 28a, 30a and ridges 28b, 30b of the detent ring 19 extend parallel to the rotational axis A and are arranged at an outer peripheral surface 44 and an inner peripheral surface 46 of the detent ring 19. In this embodiment, the leaf springs 40 bias the pair of ball bearings 32 in the radial direction perpendicular to the rotational axis A, so the biasing force is not affected by a movement of the detent ring 19 along the rotational axis A, as indicated by the double arrow in Figure 3B. Therefore, the detent ring 19 can be configured to move up and down and commute an electrical switch 48 mounted on the base 12 in the same way as a computer key.

[0036] Figure 4 shows a schematic torque profile that is generally applicable to all of the embodiment shown in Figures 1 to 3. As the grip portion 18 and the detent ring 19 are rotated about the rotational axis A, the ball bearings 32 roll from groove 28a, 30a to ridge 28b, 30b to form the wave pattern shown in Figure 4. Depending on the desired characteristics of the particular application, the shape and number of grooves 28a, 30a and ridges 28b, 30b of the first and second patterns 28, 30 can be modified to change the torque profile of the feedback device. The profile shown in Figure 4 repeats as the grip portion 18 and the detent ring 19 are rotated about the rotational axis A to provide uniform haptic feedback peaks.

[0037] Referring now to Figures 5 to 7, different aspects of the resilient member of the feedback device will be discussed. Each of the resilient members shown in Figures 5 and 7 can be combined with the detent rings

of the present disclosure.

[0038] Figure 5 shows an isometric cross-section through a feedback device including a resilient member with two spring arms 34 that are attached at one end to form a resilient clip that encircles the free edge 36 of the detent ring 19. Opposite their connected ends, each spring arm 34 is provided with a rounded projection 50 that presses against and biases the ball bearings 32 toward the respective pattern 28, 30 of the detent ring 19. In this example, the projection 50 forms a single point of contact between the ball bearing 32 in the spring arms 34 of the resilient member.

[0039] The detent housing 42 forms a pair of ball channels 52, for rotatably receiving the pair of ball bearings 32. The ball channels 52 allow the ball bearings 32 to spin or roll about an axis that is perpendicular to the rotational axis A while preventing other movement of the ball bearings 32 to suppress rattle or noise within the feedback device.

[0040] Figure 6 shows a further embodiment of a feedback device that includes a pair of leaf springs 40 that are biased within the detent housing 42. Unlike the previously illustrated embodiments, the feedback device shown in Figure 6 does not include ball bearings 32. Rather, each leaf spring 40 is provided with a hemispherical projection 54 that is biased against the detent ring 19. While Figure 6 shows the leaf springs 40 separate from one another, the leaf springs 40 could also be connected at one end to form a resilient clip.

[0041] Figure 7 shows a further example of a feedback device whose resilient means also include a pair of connected spring arms 34 and a pair of ball bearings 32. Each spring arm 34 is connected to a stabilizing member 56 that is configured to engage an outer surface of the detent housing 42. Unlike the spring arms 34, the stabilizing members 56 remain stationary and do not come into contact with the ball bearings 32. However, the stabilizing members 56 prevent angular movement of the spring arms 34 against a corresponding channel 58 provided in the detent housing 42, which can cause a scraping noise.

[0042] A further aspect of the resilient member illustrated in Figure 7 is that each of the spring arms 34 is configured to touch the ball bearing 32 at two points of contact C. The two points of contact C may stabilize the ball bearings 32 in the radial direction and also lessen the frictional forces exerted on the ball bearings 32, which improves their ability to roll against the surfaces of the detent ring 19 without generating noise.

[0043] Figure 8 shows a further example of a feedback device in accordance with another embodiment. This embodiment includes a resilient member and a ball bearing 32 that are similar to the ones shown in Figure 7. Figure 8 also shows a detent ring 19 having a first pattern 28 with grooves 28a and ridges 28b that extend in the radial direction. The width of each groove 28a gradually increases in the radial direction, and each groove 28a is

intersected by a pair of lateral projections 60. The lateral projections 60 are aligned with one another to form a circular path for the ball bearings 32 about the rotational axis A. The interaction between the ball bearings 32 and the lateral projections 60 will be described in more detail with reference to Figure 9.

[0044] Figure 9A shows the ball bearing 32 after it has left a position at rest that is aligned with groove 28a. In Figure 9, the lateral projections 60 arranged on either side of the ball bearing 32 prevent the ball bearing 32 from coming into contact

with the groove 28a. As the ball bearing 32 continues to roll and nearly reaches the adjacent ridge 28b (Figure 9A), the ball bearing 32 is no longer in contact with the lateral projections 60, and there is a single point of contact C between the ball bearing 32 and the ridge 28b. The ball bearing 32 then crests the ridge 28b and begins to roll down towards the next groove 28a, where it is caught again by the next pair of lateral projections 60 (Figure 9C). The lateral projections 60 slow the downward movement of the ball bearing 32 towards the groove 28a, and lessen the impact with which the ball bearing 32 strikes the surface of the pattern 28. The ball bearing 32 continues its downward movement until it comes to rest, as shown in Figure 9D. Due to the lateral projections 60, the ball bearing 32 does not come into contact with the groove 28a, even in the position shown in Figure 9D.

[0045] Figure 10A shows a schematic torque profile that corresponds to the pattern shown in Figures 8 and 9. The steep slope indicated by the region R indicates the portion of travel when the ball bearing 32 is not held by the lateral projections 60, so there is only a single point of contact between the ball bearing 32 and the surface of the detent ring 19. The single point of contact reduces friction and enables faster travel of the ball bearing 32, whereas the lateral projections 60 slow the movement of the ball outside of region R. Figure 10B overlays the profiles of Figures 4 and 10A to illustrate the difference of the detent pattern shown in Figure 8.

[0046] Figure 11 shows yet another example of a detent ring 19 in which the grooves 28a, 30a and ridges 28b, 30b are formed by a plurality of pyramid-shaped projections 62 that are arranged in the peripheral direction of the detent ring 19. Each pyramid-shaped projection 62 has two rectangular sides and two triangular sides. The grooves 28a, 30a are also flanked by a pair of lateral projections 60 that form a circular path for the ball bearing 32 about the rotational axis A. Unlike the pattern 28 shown in Figure 2, the grooves 28a, 30a and ridges 28b, 30b shown in Figure 11 do not extend along the entire surface of the flange-shaped detent ring.

Reference numerals

[0047]

10 rotary knob
12 base

14 core
16 bearing
18 grip portion
18a slanted inner surface
5 19 detent ring
19a slanted inner surface
20 conversion means
22 gear
24 rolling element cage
10 28 first pattern
28a grooves
28b ridges
30 second pattern
30a grooves
15 30b ridges
32 ball bearing
34 spring arm
36 free edge of the detent ring
38 opposite edge from the free edge
20 40 leaf springs
42 detent housing
44 outer peripheral surface of the detent ring
46 inner peripheral surface of the detent ring
48 electrical switch
25 50 projection
52 ball channel
54 hemispherical projection
56 stabilizing member
58 channel
30 60 lateral projection
62 pyramid-shaped projection
A rotational axis
C point of contact
R region
35

Claims

1. A rotary knob (10) comprising:

a base (12);
a cylindrical core (14) attached to the base (12) and defining a rotational axis (A);
a bearing (16) supported on the core (14);
a grip portion (18) supported by the bearing (16) for rotation about the rotational axis (A);
conversion means (20) for converting the rotary movement of the grip portion (18) into an output signal; and
a feedback device for providing haptic feedback to the user via the grip portion (18) and comprising a detent ring (19) configured for rotation with the grip portion (18) about the rotational axis (A), and resilient means configured to engage the detent ring (19),
wherein the detent ring (19) comprises a first pattern (20) of alternating grooves (28a) and ridges (28b) and a second pattern (30) of alter-

- nating grooves (30a) and ridges (30b) that each extend substantially in parallel to the respective grooves (28a) and ridges (28b) of the first pattern (28), and
wherein the resilient means are biased towards each of the first and second patterns (28, 30).
2. The rotary knob (10) in accordance with claim 1, wherein the respective grooves (28a, 30a) and ridges (28b, 30b) of the first and second patterns (28, 30) extend from one edge (36) of the detent ring (19) to an opposite edge (38) of the detent ring (19).
 3. The rotary knob (10) in accordance with claim 1 or claim 2, wherein the grooves (28a, 30a) and ridges (28b, 30b) of the first and second patterns (28, 30) extend perpendicularly to the rotational axis (A).
 4. The rotary knob (10) in accordance with claim 1 or claim 2, wherein the grooves (28a, 30a) and ridges (28b, 30b) of the first and second patterns (28, 30) extend in parallel to the rotational axis (A).
 5. The rotary knob (10) in accordance with any one of the preceding claims, wherein the resilient means comprise a first spring element (34, 40) biased towards the first pattern (20) of the detent ring (19) and a second spring element (34, 40) biased towards the second pattern (30) of the detent ring (19).
 6. The rotary knob (10) in accordance with claim 5, wherein each of the spring elements (34, 40) comprises a projection (50, 54) that faces the respective first or second pattern (28, 30) of the detent ring (19).
 7. The rotary knob (10) in accordance with claim 5 or claim 6, wherein the first and second spring elements (34, 40) are connected to one another at one end to form a resilient clip.
 8. The rotary knob (10) in accordance with claim 7, further comprising a housing (42) surrounding the detent ring (19), wherein each of the first and second spring elements (34, 40) comprises at least one stabilizing member (56) for stabilizing the spring element (34, 40) relative to the housing (42).
 9. The rotary knob (10) in accordance with any one of claims 5 to 8, wherein each of the spring elements (34) is configured to bias a ball bearing (32) against the respective first or second pattern (28, 30) of the detent ring (19).
 10. The rotary knob (10) in accordance with claim 9, further comprising a housing (42) surrounding the detent ring (19), wherein the housing (42) defines a ball channel (52) for receiving each of the ball bearings (32) of the resilient means.
 11. The rotary knob (10) in accordance with claim 9 or claim 10, wherein each spring element (34) defines two points of contact (C) with each ball bearing (32).
 12. The rotary knob (10) in accordance with claim 11, wherein each of the grooves (28a, 30a) of the first and second patterns (28, 30) comprises first and second lateral projections (60) that are spaced apart from each other and intersect the groove (28a, 38).
 13. The rotary knob (10) in accordance with any one of claims 3 to 12, wherein the respective ridges (28b, 30b) of the first and second patterns (28, 30) are formed by a plurality of pyramid-shaped projections (62) spaced apart from one another in the peripheral direction, while the respective grooves (28a, 30a) of the first and second patterns (28, 30) are formed by the space between two adjacent projections (62).
 14. The rotary knob (10) in accordance with any one of the preceding claims, wherein the detent ring (19) and the grip portion (18) are configured for snap-fit connection to one another.
 15. The rotary knob (10) in accordance with claim 14, wherein the bearing (16) comprises first and second cages (24) for receiving a plurality of rolling elements and one or more spring members that bias the first and second cages (24) apart from one another along the rotational axis (A), wherein an outer surface of the core (14) forms an inner race for the rolling elements and wherein the grip portion (18) in the detent ring (19) each define an inner slanted surface (18a, 19a) configured to form an outer race for the rolling elements.

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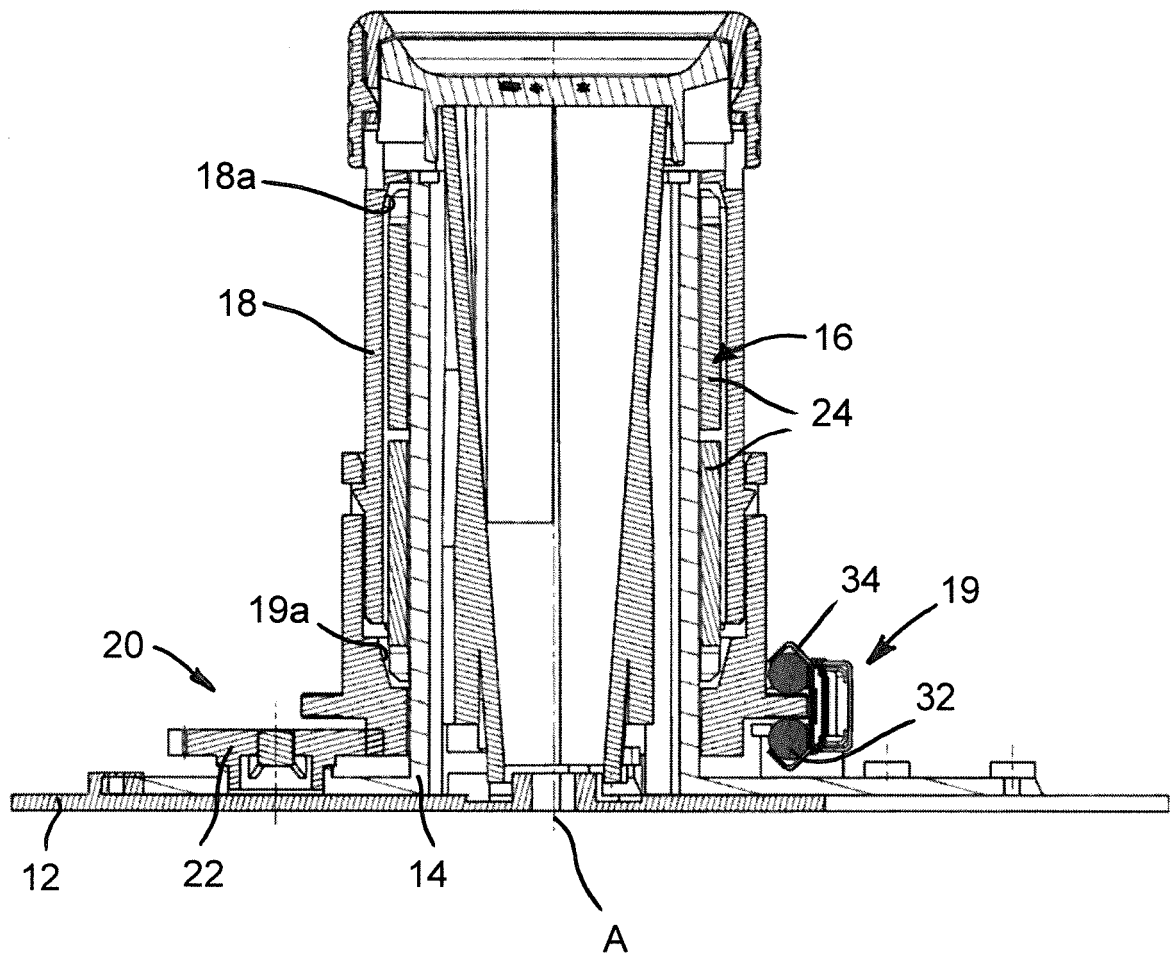


FIG. 1A

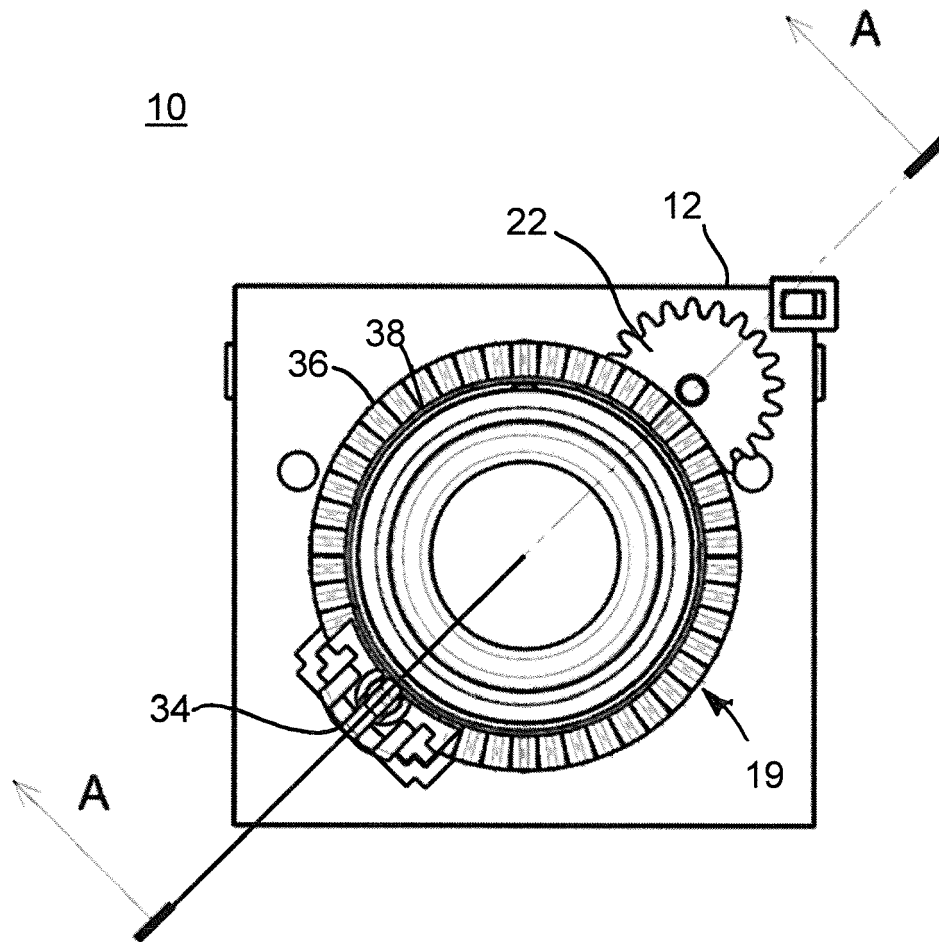


FIG. 1B

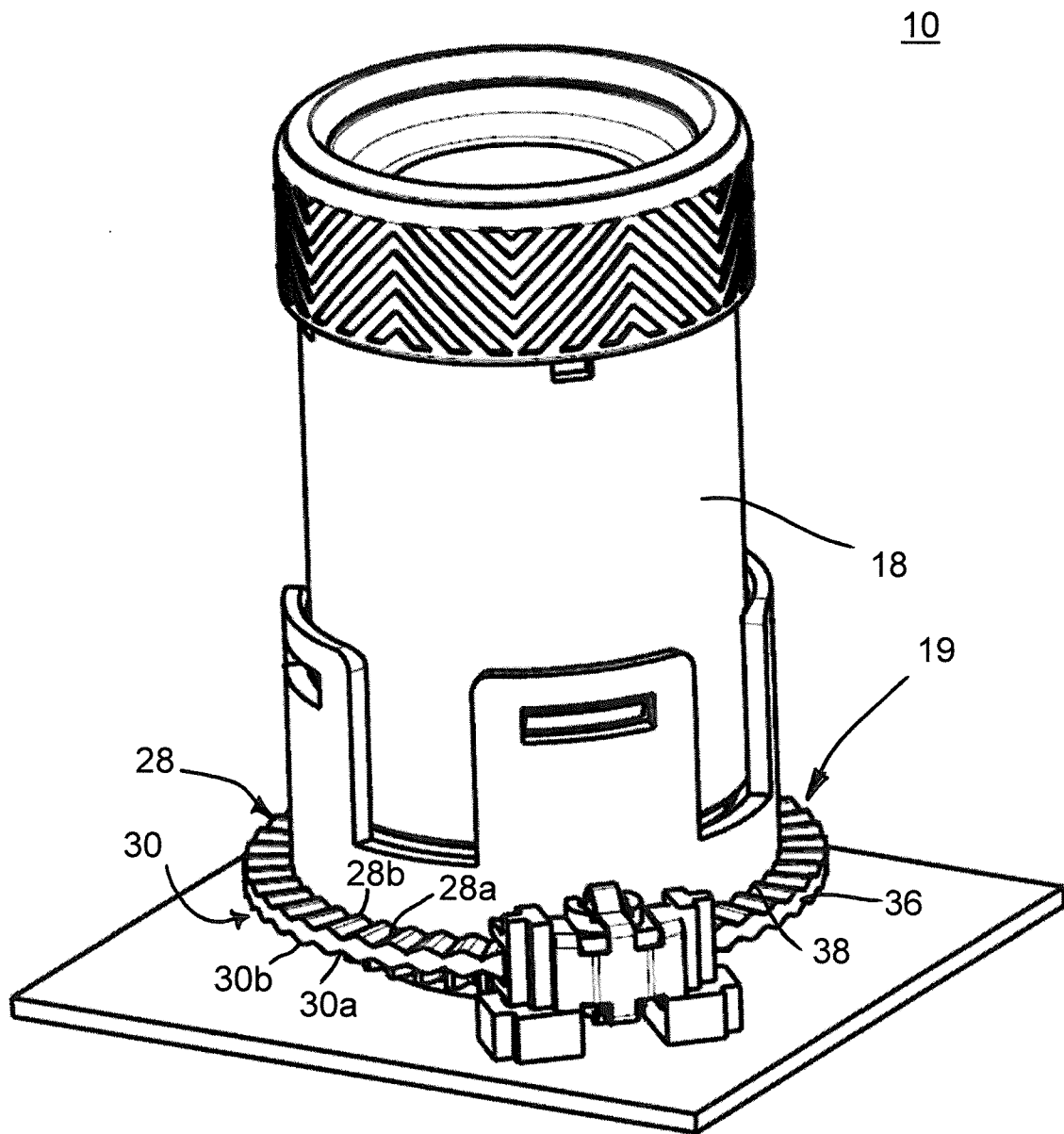


FIG. 1C

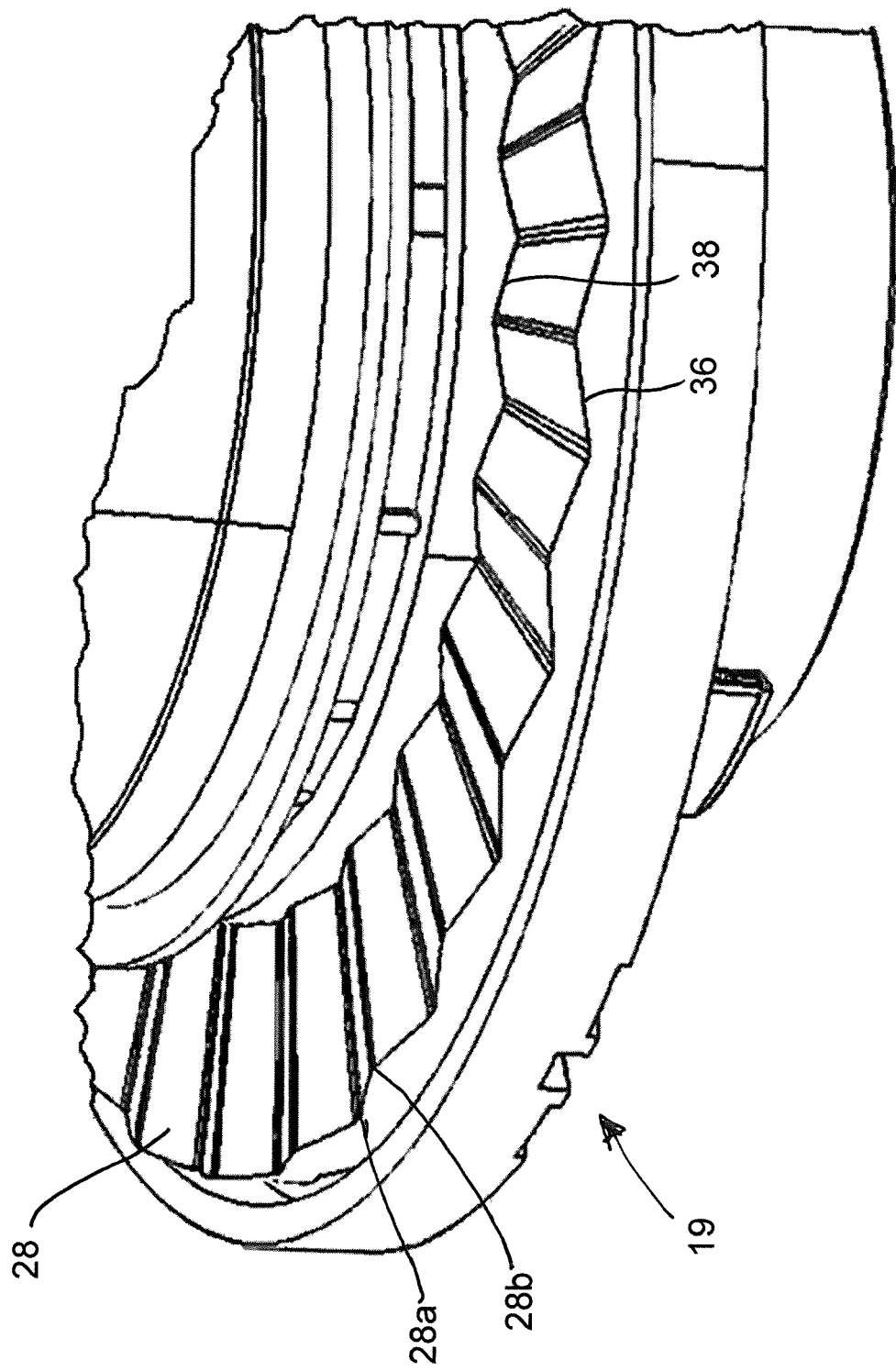


FIG. 2

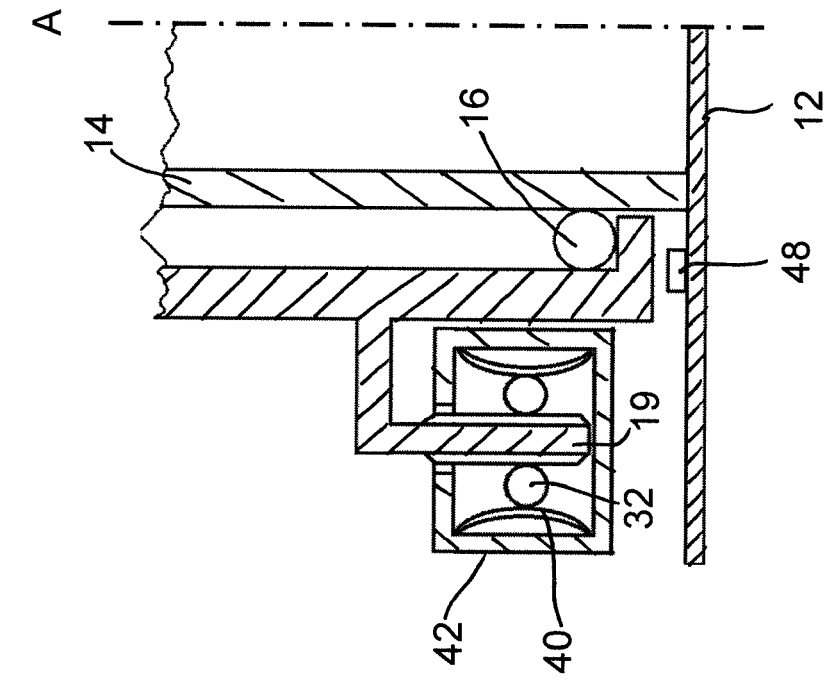


FIG. 3A

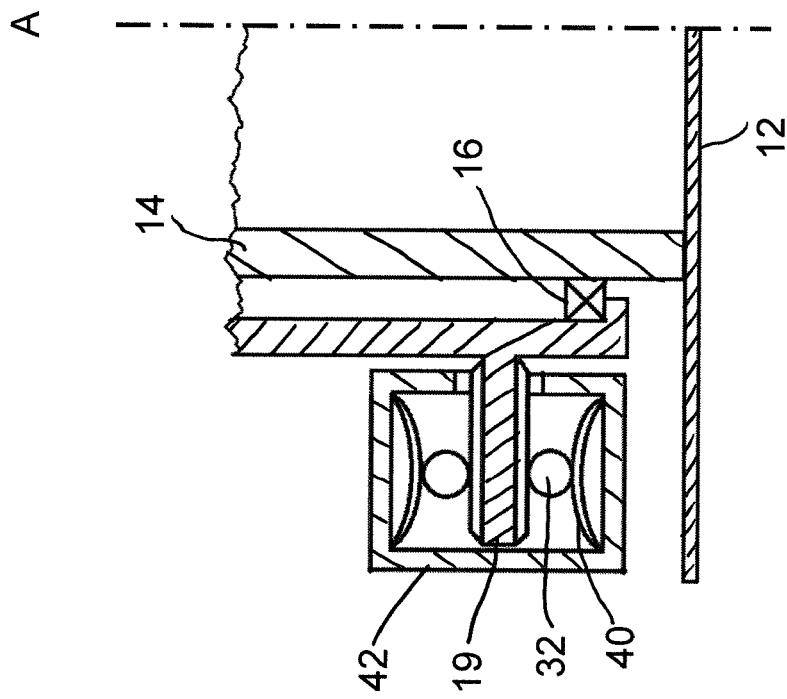


FIG. 3B

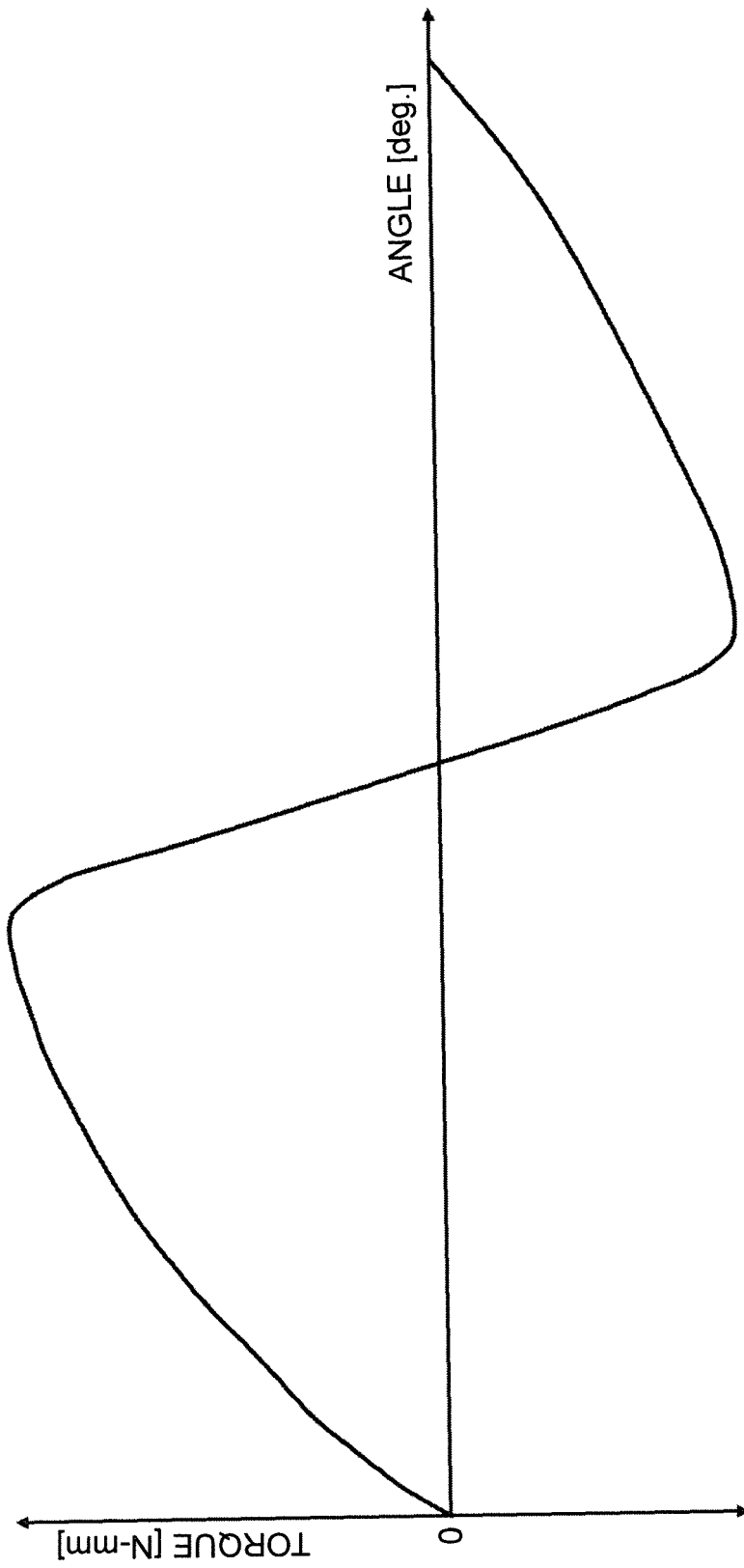


FIG. 4

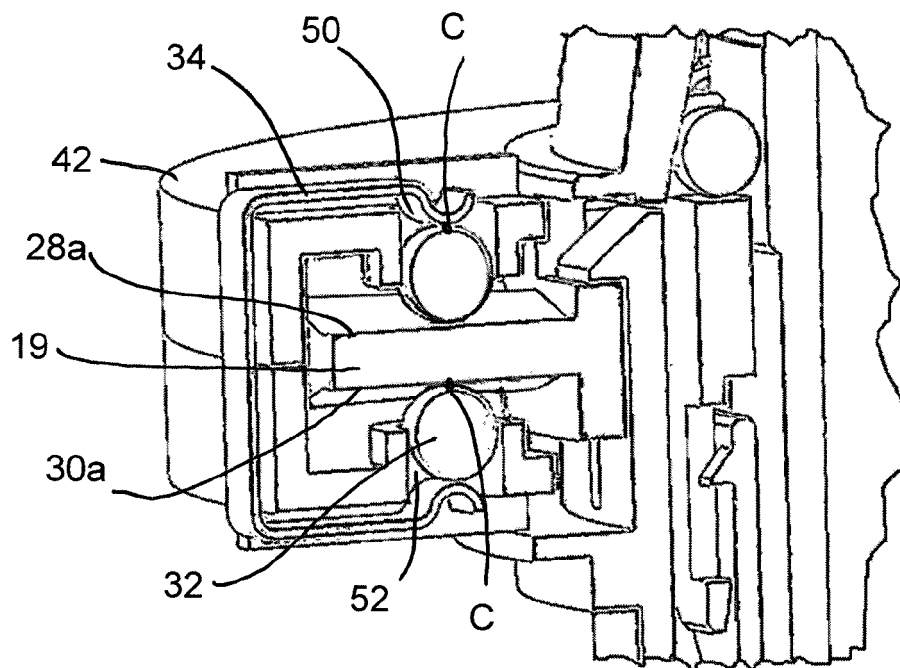


FIG. 5

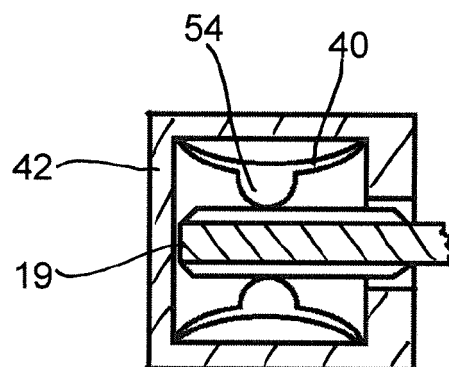


FIG. 6

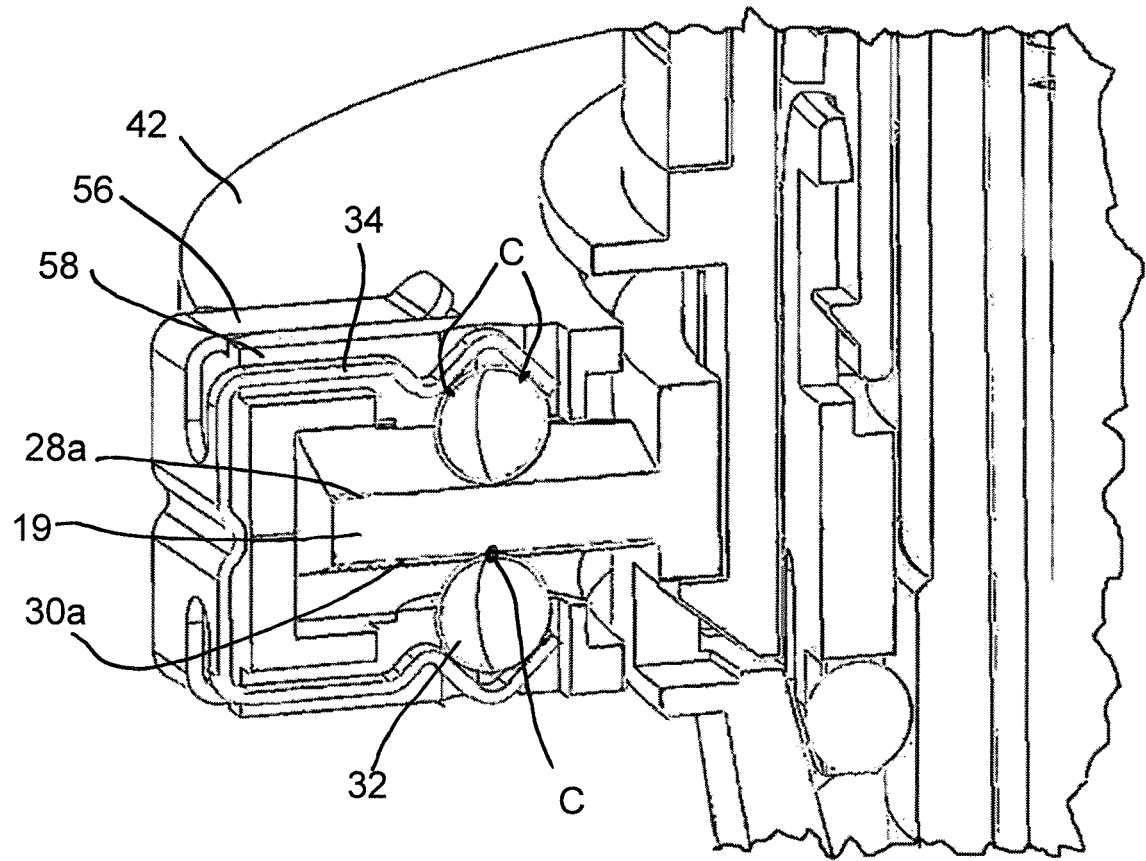


FIG. 7

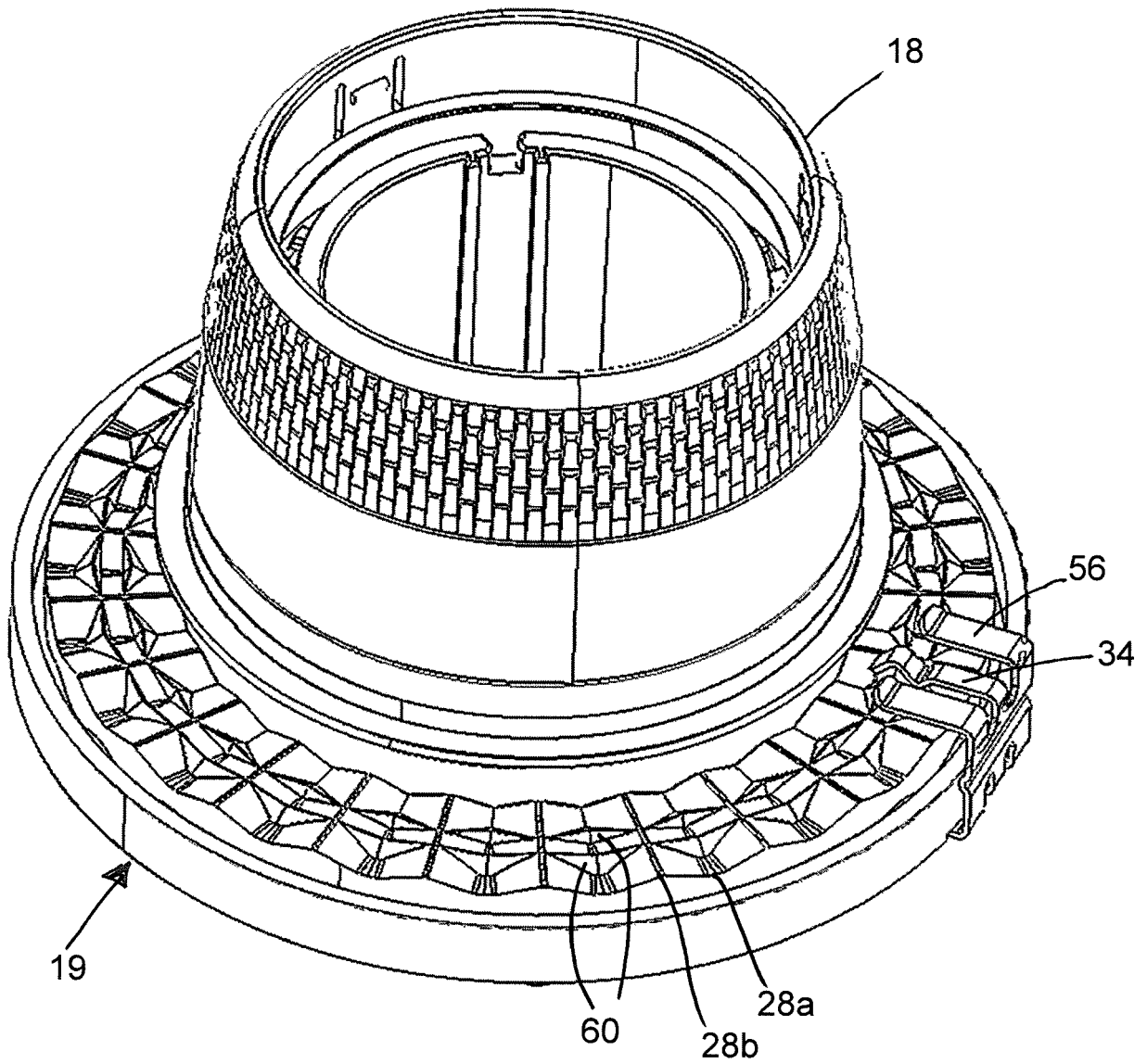


FIG. 8A

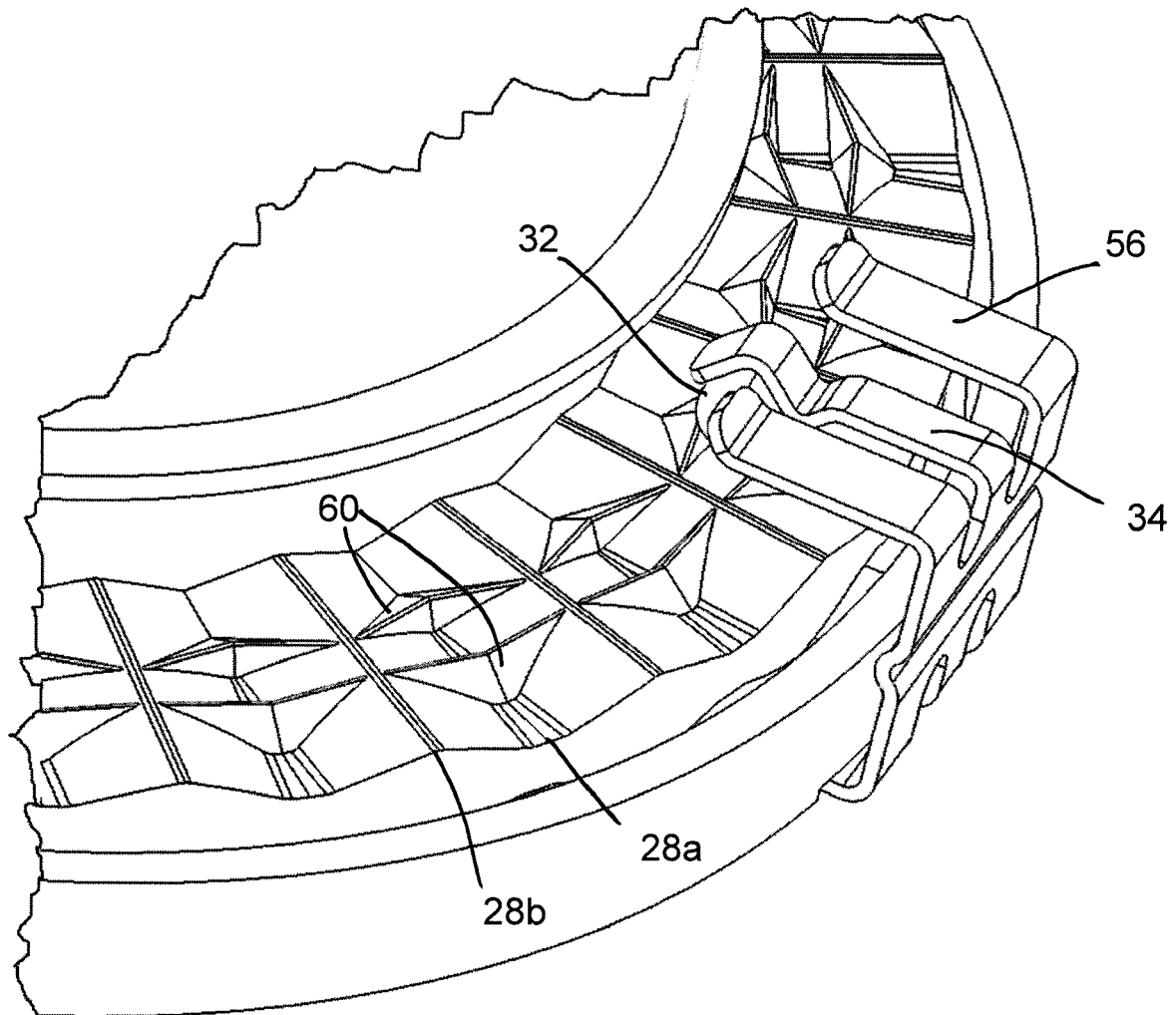


FIG. 8B

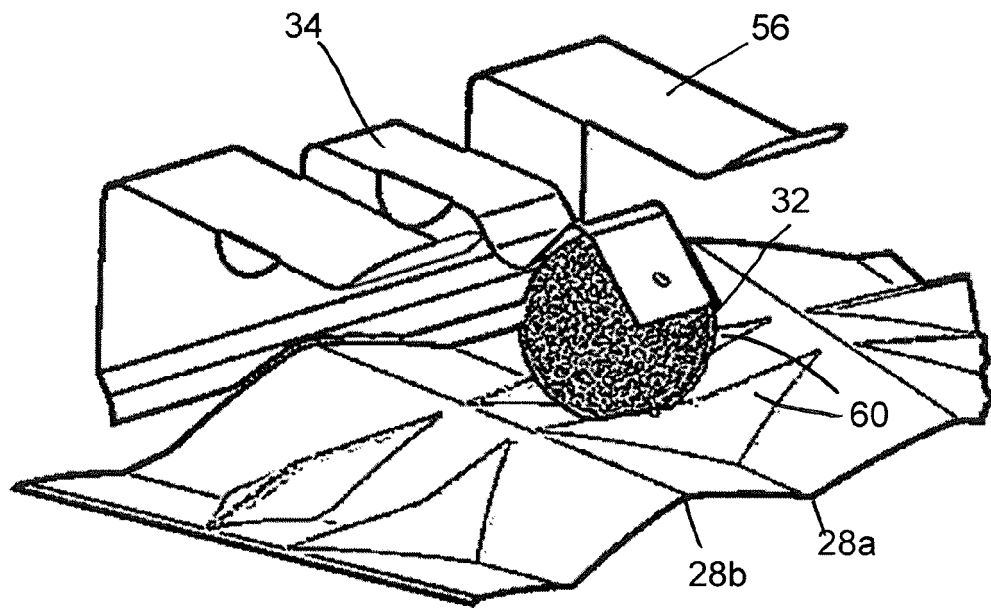


FIG. 9A

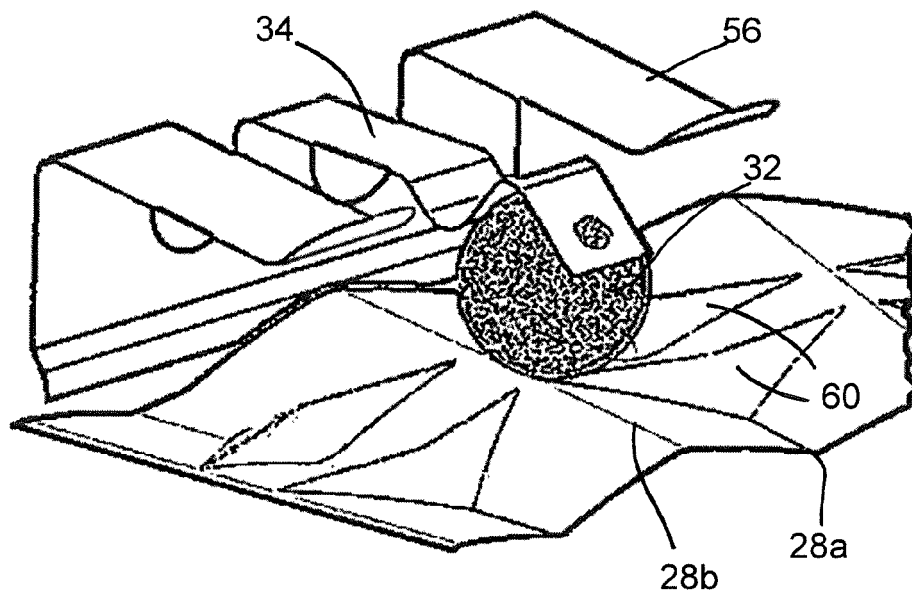


FIG. 9B

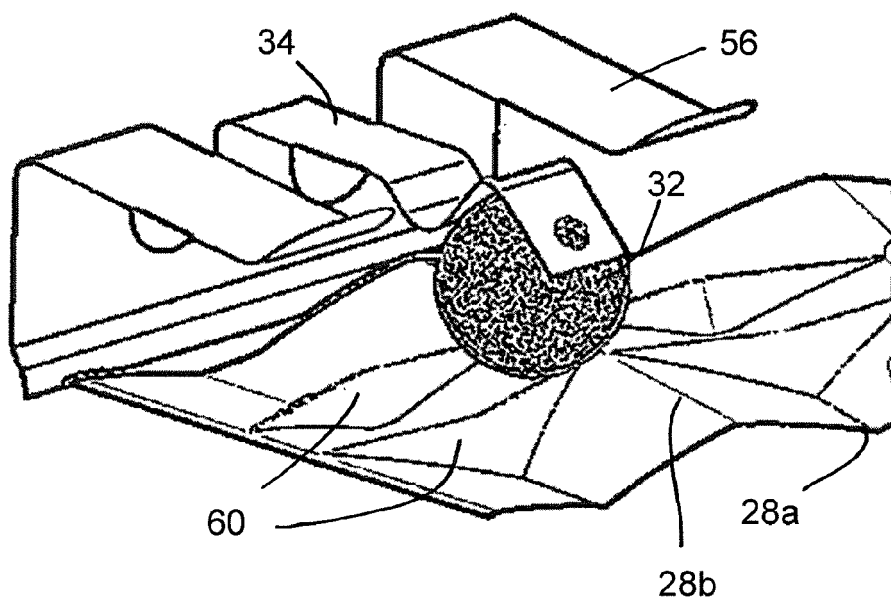


FIG. 9C

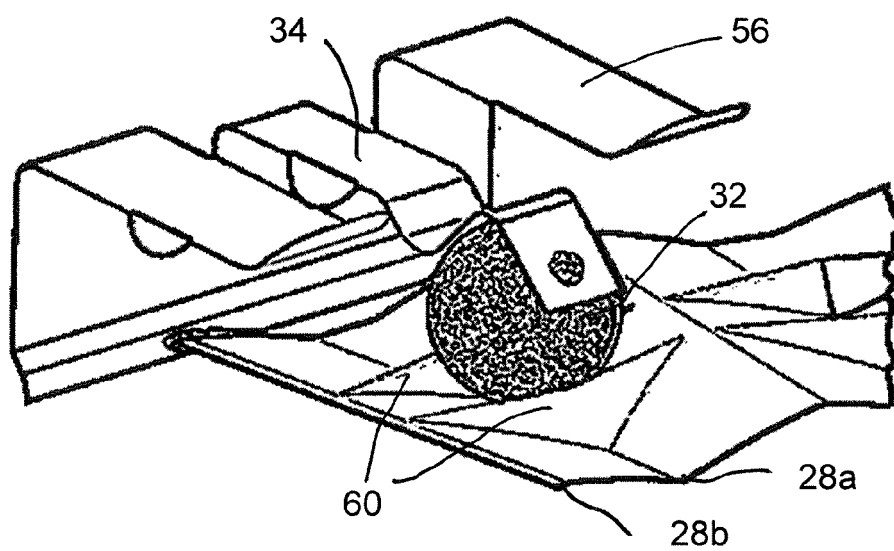


FIG. 9E

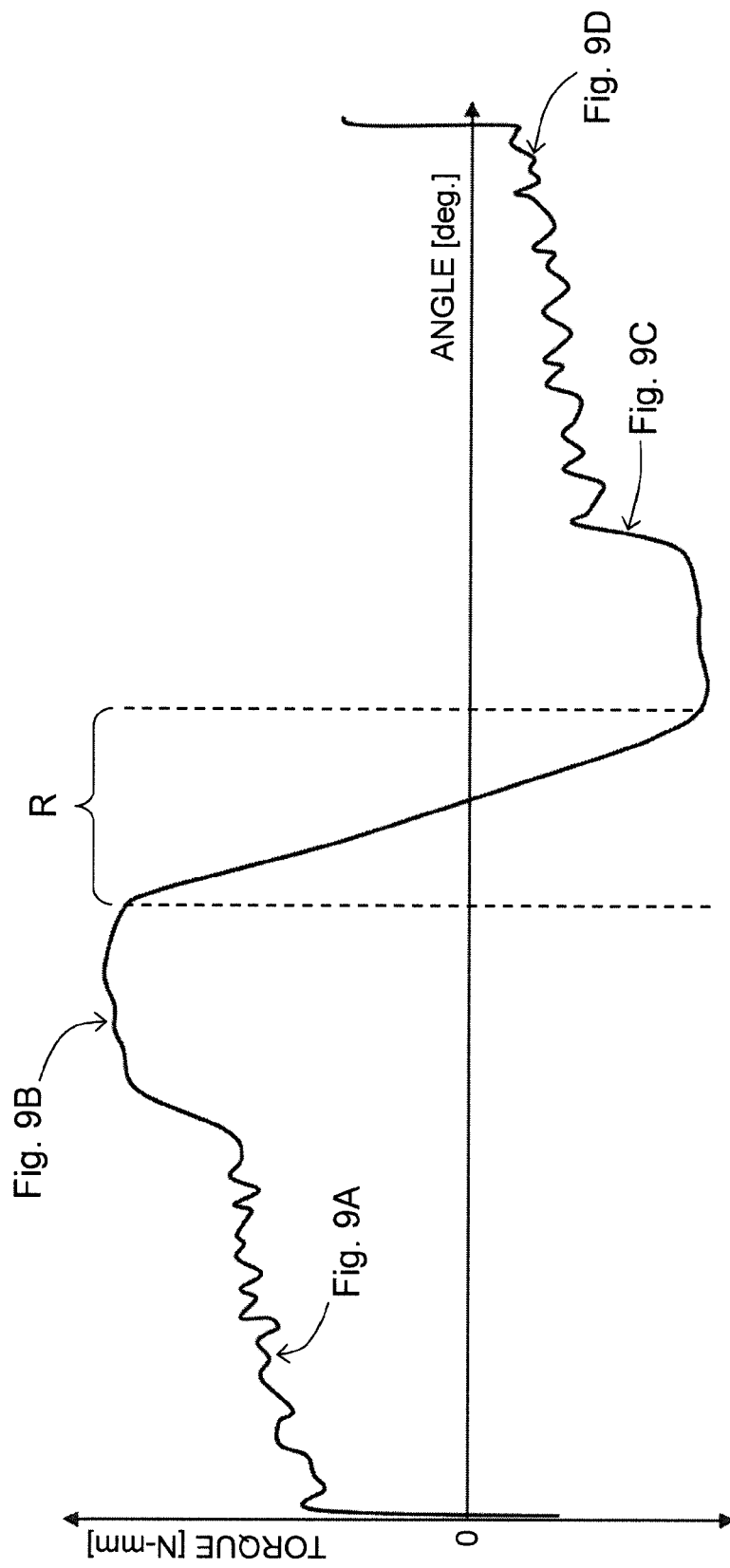


FIG. 10A

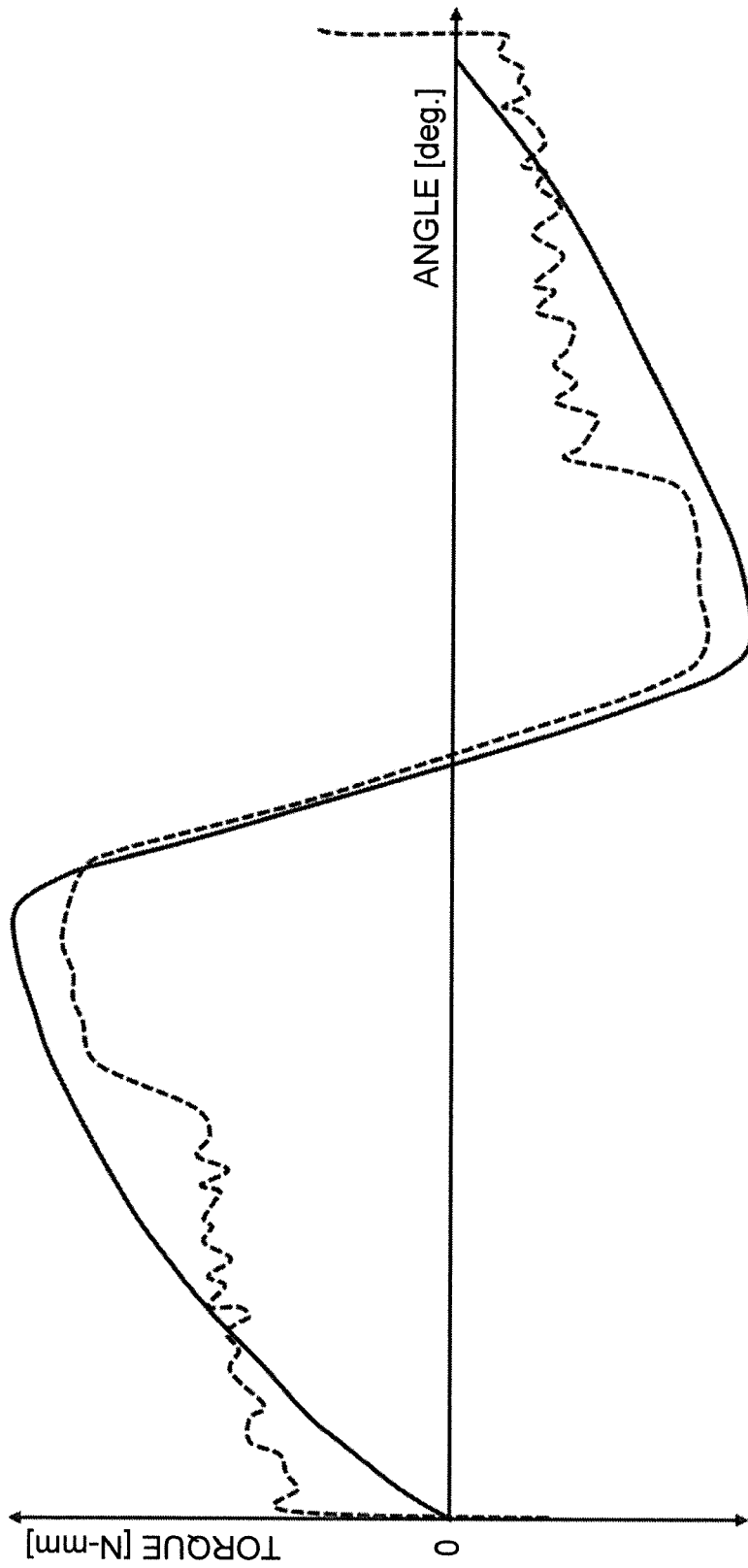


FIG. 10B

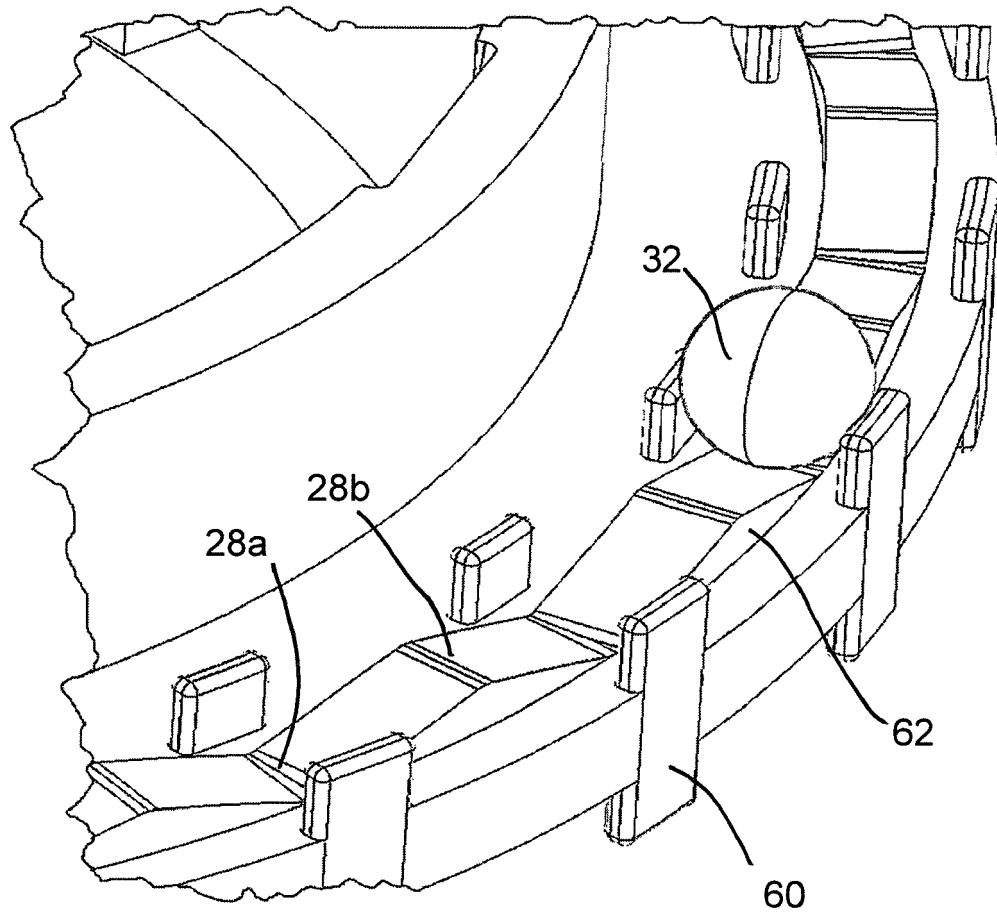


FIG. 11



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