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(54) Title: GEAR, MOTOR-GEAR UNIT, VEHICLE, GENERATOR WITH A GEAR, AND FORCE TRANSMITTING ELEMENT

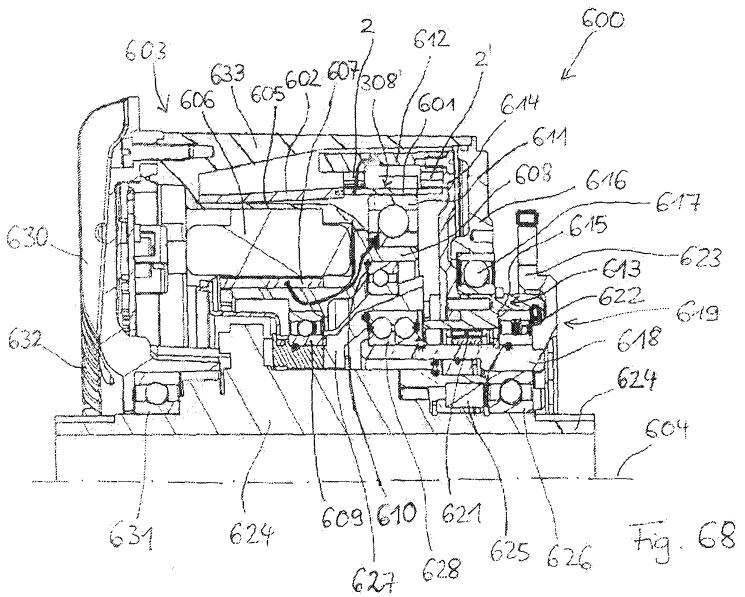

Fig. 68

(57) Abstract: The application discloses a harmonic pin drive which comprises at least one outer ring gear with inner teeth that are adapted to the shape of pins of a pin ring, a transmitter for connecting to a rotor of an electric motor, a ball bearing that is supported on the transmitter and an arrangement of flexible means. The flexible means are distributed essentially on the circumference of a radius and the flexible means are provided for attachment to a casing. Furthermore, the flexible means comprise openings for inserting pins of the pin ring. Furthermore, an output shaft is provided for receiving a rotation of the outer ring gear.

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GEAR, MOTOR-GEAR UNIT, VEHICLE, GENERATOR WITH A GEAR, AND FORCE-TRANSMITTING ELEMENT

The present application relates to a gear having an input shaft and an output shaft. More particularly, the present application relates to a motor-gear unit with such a gear and to a motor vehicle with such a motor-gear unit. The present application also relates to an electric generator with a drive unit such as an internal combustion engine or such as a propeller for water or wind, further having a generator unit for generating electricity and having a gear in accordance with the application.

The present application provides an improved gear, motor-gear unit, vehicle, generator with a gear, and force-transmitting element.

Throughout this specification, unless the context requires otherwise, the word "comprise" and variations such as "comprises" and "comprising" will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

The gear has an input shaft and an output shaft and also an outer wheel and an inner wheel which is positioned concentrically in relation to the outer wheel and often inside the outer wheel. There is also a ring-shaped or cylindrical or elliptic traction provided that extends between the outer wheel and the inner wheel. A revolving transmitter lifts or drags the traction means away from the outer periphery of the inner wheel and pushes it onto the inner periphery of the outer

wheel. This is a simple and reliable setup for a gearbox, which can provide high gear ratios.

The revolving transmitter comprises an oval disc which is connected to the input shaft Furthermore, the revolving transmitter comprises a flexible bearing, which is provided on an outer circumference of the oval disk, wherein the traction means is in contact with the flexible bearing.

There are many ways for connecting the input shaft and the output shaft to the gear. It is especially advantageous to connect the input shaft to the transmitter and to connect the output shaft is to the inner wheel or to the outer wheel. The wheel, which is not connected to the output shaft needs then to be kept steady or connected with a housing of the gear.

The gear can be provided as a one row gear design wherein the traction means has one single radial section that is provided both for the contact with the outer wheel and for the inner wheel. In the one row gear design, the transmitter often contacts the traction means from within the gap between the inner wheel and the outer wheel. The transmitter, the inner wheel, the outer wheel as well as the traction means respectively the pressure means are located essentially in the same axial plane, which makes the design axially symmetric.

In an axially asymmetric two row gear design, the inner wheel and the outer wheel are often located in different axial planes, wherein the transmitter is either located in the axial plane of the inner wheel or in the axial plane of the outer wheel. The traction means then extends axially between the axial planes of the inner wheel and the outer wheel, contacting

both the inner wheel and the outer wheel at different sections of their respective circumferences.

In a three row gear design, the two pairs of an inner wheel and an outer wheel are often located in different axial planes, wherein the transmitter is located in a third axial plane between the two pairs of an inner wheel and an outer wheel. One can also think of a three row gear design with two inner wheels and one outer wheel or - alternatively - also with two outer wheels and one inner wheel. In a further alternative, it is also possible to provide a double row transmitter with two transmitter sections, wherein each transmitter section is provided in an axial plane, which is different from the axial plane of the inner wheel. The traction means then extends axially between the axial planes of the outer wheels and the inner wheel, contacting both the inner wheel and the outer wheels at different sections of their respective circumferences.

It is also possible to provide an axially symmetric three row gear design with two outer wheels and one inner wheel, that are located in different axial planes, wherein the transmitter is located in the axial plane of the inner wheel. It is then also possible to provide a double row transmitter with two transmitter sections, wherein each transmitter section is provided in the axial plane of each outer wheel. The traction means then extends axially between the axial planes of the inner wheels and the outer wheel, contacting both the inner wheels and the outer wheel at different sections of their respective circumferences.

The traction means may also comprise at least one continuous elliptic traction element that can also be a deformable circular ring or cylinder. Such a traction means is easy to manufacture, especially if the traction element is provided in the form of a flexible belt, possibly with teeth. Such a traction element is often made from plastic or rubber, which provided on a metal meshing or a woven or non-woven fabric.

In a very advantageous form, the traction element comprises a thin and flexible spline element, that is possibly provided with teeth and it can also be made from plastic. The flexible spline element may comprise a multitude of pins that stand proud of or protrude from at least one axial surface of the spline element and that are coaxially arranged with the flexible spline element. With such a traction element, extremely high gear ratios can be achieved because the difference between the diameter of the outer wheel and the diameter of the inner wheel can be made almost as small as the diameter of the pins.

The transmitter or the transmitters may be positioned on a rotatable transmitter carrier by mounting them concentrically in relation to the outer wheel and the inner wheel. As said before, the transmitter carrier is preferably connected to the input shaft or to the output shaft for achieving high transmission ratios.

The transmitters can be each mounted on a shaft such that they are able to rotate while the shafts are provided on the transmitter carrier. Alternatively, the transmitter may be fixed to the transmitter carrier, wherein the traction means comprises

a multitude of rotatable contact elements such as rollers on chain bolts.

The rotation axis of the transmitter may essentially coincide with the rotation axis of the transmitter carrier, wherein a contact surface of the transmitter facing towards the traction means is provided with an essentially elliptic shape. Providing an essentially elliptic shape includes that a non-circular flat surface is provided which is round such that a bearing or a number of balls can be arranged between the contact surface and the traction means.

In one possible use of the gear, an electric motor is provided, a rotor of the electric motor being connected to the input shaft of the gear. For lightweight vehicles, often a DC brushless motor with a radial gap is provided, but other types of motors and also internal combustion engines apply as well, as described below with the embodiments. The DC brushless motor is easy to provide with the gear of the application because the gear housing can be the motor housing at the same time.

A vehicle, in particular a two- or three-wheeled vehicle, can be equipped with such a motor-gear unit, wherein at least one driven wheel of the vehicle is connected to the output shaft of the gear.

The gear may also be used for an electric generator with a drive unit such as an internal combustion engine or a propeller for water or wind and with a generator unit for generating electricity. An input shaft of the gear is then connected to the drive unit and an output shaft of the gear being connected to an input shaft of the generator.

2011311151 08 Jun 2015

An advantageous transmitter assembly for contacting a traction means in a gear comprises one or more first transmitter elements and one or more a second transmitter elements that are provided on a rotatable transmitter carrier that is mounted

concentrically in relation to the outer wheel and the inner wheel and that is preferably being connected to the input shaft or to the output shaft for achieving high transmission ratios. The transmitter elements are each mounted on a shaft such that they can rotate on the transmitter carrier. The first transmitter element and the second transmitter element are provided eccentrically from the rotation axis of the transmitter carrier. Such an arrangement allows for new shapes of the transmitter, which provides some extra degrees of freedom for the design of a gear.

It is then possible to tighten or tension the transmitter with the two transmitter elements by shifting them with respect to each other. A guide for shifting the first transmitter element with respect to the second transmitter element may therefore be provided, as well as transmitter adjustment slits with a guiding element, the guiding elements being either provided in carrier adjustment slits in the transmitter carrier or the guiding elements being taken up by guiding slits in adjacent transmitter elements.

In an alternative form, the gear of the application is provided with an input shaft and with an output shaft, wherein the at least one revolving transmitter pushes the pressure means away from the inner periphery of the outer wheel and pushes the pressure means onto the outer periphery the inner wheel.

This gear is very similar to the other alternative where the transmitter shifts the traction means away from the outer periphery of the inner wheel into the inner periphery the outer wheel. Most of the design elements of the other gear can be used for the gear with the pressure means, except that the pressure means needs to be able to transmit compressive forces. This is why many chains with movable links cannot be used as a pressure means.

The application also provides a thin and flexible spline element for a gear, the spline element comprising a multitude of pins that stand proud of or protrude from at least one axial surface of the spline element and that are coaxially arranged with the flexible spline element. The multitude of pins may also stand proud of both axial surfaces of the spline element. A flexible spline element in which the multitude of pins are provided in a multitude of axial cylindrical orifices is easy to manufacture. It has turned out that it is advantageous to make the pins from steel, that is later hardened, and the spline element from aluminium.

The application further discloses a harmonic pin drive. The harmonic pin drive comprises at least one outer ring gear with inner teeth that are adapted to the shape of pins of a pin ring, a transmitter for connecting to a rotor of an electric motor, a ball bearing that is supported on the transmitter and an arrangement of flexible means. The flexible means is distributed essentially on the circumference of a radius and is provided for attachment to a casing. The flexible means comprise openings for inserting pins of the pin ring, and an output shaft for receiving a rotation of the outer ring gear via further transmission elements such as freewheels and rotating elements.

In this embodiment, a high reduction ratio can be achieved. Unlike in some of the other embodiments, an inner wheel is not needed. Thereby, weight and space is saved. The reaction force of the outer ring is taken up by the flexible means. In addition, the flexible means with which the pins are connected allow for a radial motion of the pins of the pin ring. The radial motion is caused by the motion of the transmitter part which is driven by the rotor of the motor.

A pin ring is used that can be lightweight and robust. The pin ring is advantageous over a chain in that it comprises less moving parts and needs less lubrication.

According to one alternative, the transmitter which drags the pin ring into the outer ring gear comprises an oval shaped portion on which the ball bearing is supported. This is advantageous in that the shape of the oval can be adapted to have a small gap between pin ring and outer gear, for example.

According to a second alternative, the transmitter comprises a circular portion that is eccentrically supported with respect to a rotation axis of the rotor. This is advantageous in that the ball bearing does not need to be a flexible ball bearing.

Specifically, the harmonic pin drive may comprise two outer ring gears in which the pin ring engage to provide a more even force distribution than with just one outer ring gear.

Similarly, the application also discloses a harmonic pin gear comprising. The harmonic pin gear comprises at least one outer ring gear with inner teeth, a transmitter for connecting to an input shaft, a ball bearing that is supported on the

2011311151 08 Jun 2015

transmitter, an arrangement of flexible means. The flexible means are distributed essentially on the circumference of a radius and the flexible means are provided for attachment to a casing of the harmonic pin drive. Furthermore, the pin gear comprises a pin ring with pins, wherein the pins of the pin ring are connected to the flexible means and at least one of the pins engages into an inner tooth of the outer ring gear. Furthermore, the pin gear comprises an output shaft for receiving a rotation of the outer ring gear via further transmission elements such as freewheels and rotating elements.

The pins and the resilient means may be made of one piece or the resilient means may comprises openings in which the pins of the pin ring are inserted. In the first case, a robust connection is achieved whereas in the second case the pin ring can be manufactured separately.

Similarly to the harmonic pin drive the transmitter of the harmonic pin gear may comprise an oval shaped portion or it may also comprise a circular portion that is eccentrically supported with respect to a rotation axis of the rotor.

Similarly to the harmonic pin drive, the harmonic pin gear may also comprise two outer ring gears.

The application further discloses a multi-layer pin ring for a harmonic pin drive. The multi-layer pin ring comprises an outer steel ring and a reception ring which is fixed to the outer steel ring. The reception ring is arranged radially inwards to the outer steel ring, wherein the reception ring comprises round openings which are adapted to take up pins.

2011311151 08 Jun 2015

By using the two layer structure, the inner layer can be adapted for good flexibility while the inner layer can be adapated to take up the pins. The inner layer can be made of a cheaper material such as plastic as the outer layer already provides stability. The multi-layer pin ring can be used advantageously in the harmonic pin gear or the harmonic pin drive, for example.

Furthermore, the multi-layer pin ring may be designed as three layer pin ring with an inner layer. The inner layer is designed as an outer bearing surface for guiding balls of a ball bearing, wherein the outer bearing surface is arranged radially inwards to the reception ring and is fixed to the reception ring. Thereby, the ball bearing can be provided as a lightweight incomplete ball bearing without outer ring.

In particular the round openings for taking up the pins may be distributed at essentially equal distances along a circumference.

Furthermore pins may be provided in the openings of the reception ring which protrude from the reception ring on two opposite sides. Thereby, the protruding portions of the pins can be used to engage into respective pin rings of a harmonic pin ring gear.

Furthermore, the round openings of the multi-layer pin ring according to the application may form an insertion slit on an inner side of the reception ring. Thereby it is easy to insert or to remove the pins from the inside.

2011311151 08 Jun 2015

Moreover the application provides a motor-gear unit with a harmonic pin drive or a harmonic pin gear according to the application. Therein, an electric motor is provided and a rotor of the electric motor is connected to the transmitter of the harmonic pin drive or the harmonic pin gear via an input shaft. The high reduction ration of the harmonic pin drive is advantageous to drive the electric motor in a regime with a high revolution and outputting a lower output frequence, for example for an electric bicycle or for obtaining a high torque.

In particular, the electric motor may be designed as a DC brushless motor with a radial gap.

The application furthermore discloses a motor-gear unit with a harmonic pin gear of harmonic pin drive wherein an internal combustion engine is provided and an output shaft of the engine is connected to the transmitter via an input shaft of the harmonic pin gear.

Furthermore the application discloses a vehicle which comprises a motor-gear unit according to the application in which at least one driven wheel of the vehicle is connected to the output shaft of the harmonic pin gear.

Moreover, the application also discloses an electric generator with a drive unit, with a generator unit and with a harmonic pin drive or a harmonic pin gear according to the application., The transmitter of the harmonic pin drive or of the harmonic pin gear is connected to the drive unit via an input shaft and an output shaft of the harmonic pin drive is connected to an input shaft of the generator. Especially in a

wind powered generator, the conversion from a low to a high revolution rate which is done by the harmonic pin drive, is advantageous for power generation.

Specifically, in accordance with the present invention there is provided gear comprising an input shaft and an output shaft, the gear further comprising the following elements:

- an outer wheel, an inner wheel which is positioned co centrically in relation to the outer wheel and a traction means extending between the outer wheel and the inner wheel, and
- at least one revolving transmitter which lifts the traction means from the outer periphery of the inner wheel and pushes it onto the inner periphery of the outer wheel, wherein the revolving transmitter comprises an oval disc, the oval disk being connected to the input shaft, and a flexible bearing, which is provided on an outer circumference of the oval disk, wherein the traction means is in contact with the flexible bearing.

Preferably the gear is characterised in that the input shaft is connected to the transmitter.

Preferably the gear is characterised in that the output shaft is connected to the inner wheel.

Preferably the gear is characterised in that the output shaft is connected to the outer wheel.

Preferably the gear is characterised in that the traction means comprises at least one continuous elliptic traction element.

Preferably the gear is characterised in that the traction element comprises a flexible belt.

Preferably the gear is characterised in that the traction element comprises a flexible spline element.

Preferably the gear is characterised in that the flexible spline element comprises a multitude of pins that protrudes from at least one axial surface of the spline element and that are coaxially arranged with the flexible spline element.

Preferably the gear is characterised in that the transmitter is positioned on a rotatable transmitter carrier.

Preferably the gear is characterised in that the transmitter is fixed to the transmitter carrier, wherein the traction means comprises a multitude of rotatable contact elements.

Preferably the gear is characterised in that the transmitter is rotatably provided on the transmitter carrier.

Preferably the gear is characterised in that the rotation axis of the transmitter essentially coincides with the rotation axis of the transmitter carrier, wherein a contact surface of the transmitter facing towards the traction means is provided with an essentially elliptic shape.

Also in accordance with the present invention there is provided a motor-gear unit with a gear as described above, characterised in that an electric motor is provided, a rotor of the electric motor being connected to the input shaft of the gear.

Preferably the motor-gear unit is characterised in that the electric motor is a DC brushless motor with a radial gap.

Preferably the motor-gear unit is characterised in that an internal combustion engine is provided, an output shaft of the engine being connected to the input shaft of the gear.

In addition, also in accordance with the present invention there is provided a vehicle comprising a motor-gear unit as described above, characterised in that at least one driven wheel of the vehicle is connected to the output shaft of the gear.

Still further, in accordance with the present invention, there is provided an electric generator with a drive unit and with a generator unit and with a gear as described above, an input shaft of the gear being connected to the drive unit and an output shaft of the gear being connected to an input shaft of the generator.

The embodiments of the application are explained in further detail with reference to the following figures, in which

Fig. 1 shows a front view of a motor-gear unit as disclosed in the application,

Fig. 2 shows a section through the motor-gear unit illustrated in Fig. 1 along the line of intersection marked J-J in Fig. 1,

Fig. 3 shows a section through the motor-gear unit illustrated in Fig. 1 along the line of intersection marked F-F in Fig. 1,

Fig. 4 shows a top view of the motor-gear unit illustrated in Fig. 1,

2011311151 08 Jun 2015

Claims

1. Gear comprising an input shaft and an output shaft, the gear further comprising the following elements:
- an outer wheel, an inner wheel which is positioned concentrically in relation to the outer wheel and a traction means extending between the outer wheel and the inner wheel, and
- at least one revolving transmitter which lifts the traction means from the outer periphery of the inner wheel and pushes it onto the inner periphery of the outer wheel, wherein the revolving transmitter comprises an oval disc, the oval disk being connected to the input shaft, and a flexible bearing, which is provided on an outer circumference of the oval disk, wherein the traction means is in contact with the flexible bearing.

2. Gear according to claim 1,
characterised in that
the input shaft is connected to the transmitter.

3. Gear according to one of the claims 1 to 2,
characterised in that
the output shaft is connected to the inner wheel.

4. Gear according to one of the claims 1 to 2,
characterised in that
the output shaft is connected to the outer wheel.

5. Gear according to one of the claims 1 to 4,
characterised in that

2011311151 08 Jun 2015

the traction means comprises at least one continuous elliptic traction element.

6. Gear according to claim 5, characterised in that the traction element comprises a flexible belt.

7. Gear according to claim 5, characterised in that the traction element comprises a flexible spline element.

8. Gear according to claim 7, characterised in that the flexible spline element comprises a multitude of pins that protrudes from at least one axial surface of the spline element and that are coaxially arranged with the flexible spline element.

9. Gear according to one of the aforementioned claims, characterised in that the transmitter is positioned on a rotatable transmitter carrier.

10. Gear according to claim 9, characterised in that the transmitter is fixed to the transmitter carrier, wherein the traction means comprises a multitude of rotatable contact elements.

11. Gear according to claim 11, characterised in that

2011311151 08 Jun 2015

the transmitter is rotatably provided on the transmitter carrier.

12. Gear according to claim 11,
characterised in that
the rotation axis of the transmitter essentially coincides with the rotation axis of the transmitter carrier,
wherein a contact surface of the transmitter facing towards the traction means is provided with an essentially elliptic shape.

13. Motor-gear unit with a gear according to one of the aforementioned claims,
characterised in that
an electric motor is provided, a rotor of the electric motor being connected to the input shaft of the gear.

14. Motor-gear unit according to claim 13,
characterised in that
the electric motor is a DC brushless motor with a radial gap.

15. Motor-gear unit with a gear according to one of the claims 1 to 12,
characterised in that
an internal combustion engine is provided, an output shaft of the engine being connected to the input shaft of the gear.

16. Vehicle comprising a motor-gear unit according to one of claims 13 to 15,

2011311151 08 Jun 2015

characterised in that at least one driven wheel of the vehicle is connected to the output shaft of the gear.

17. Electric generator with a drive unit and with a generator unit and with a gear according to one of the claims 1 to 12, an input shaft of the gear being connected to the drive unit and an output shaft of the gear being connected to an input shaft of the generator.

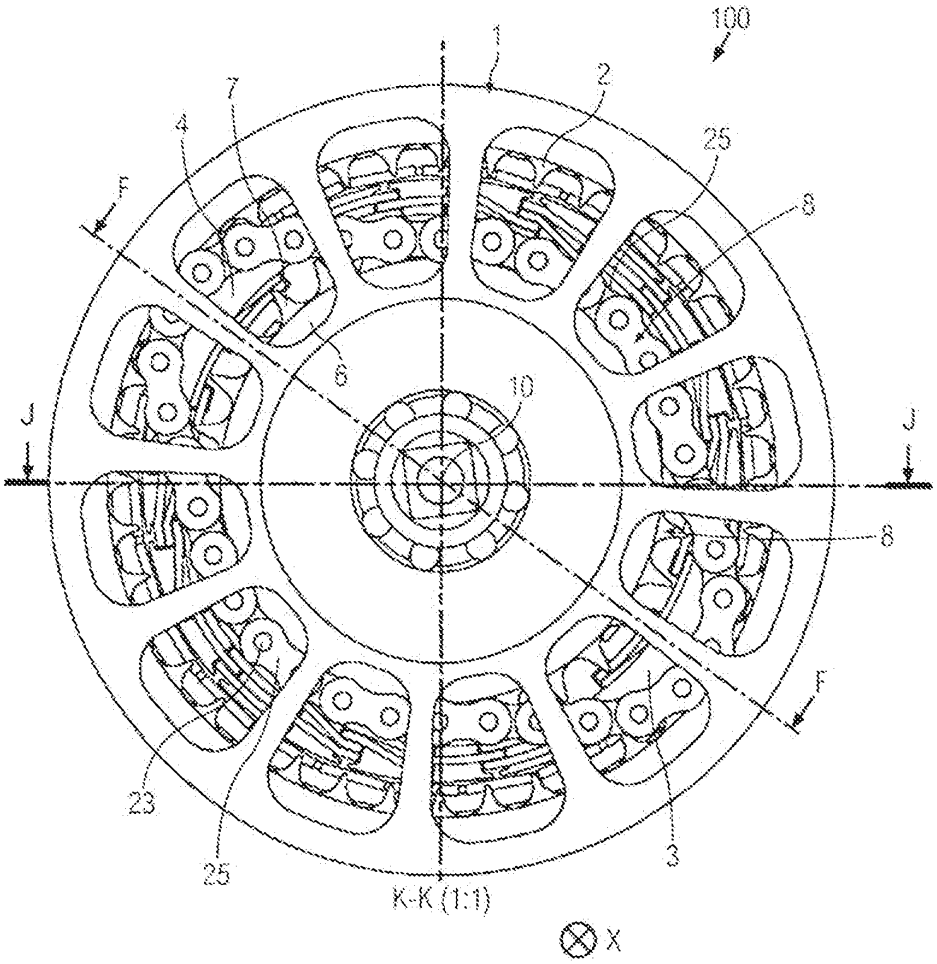

FIG. 1

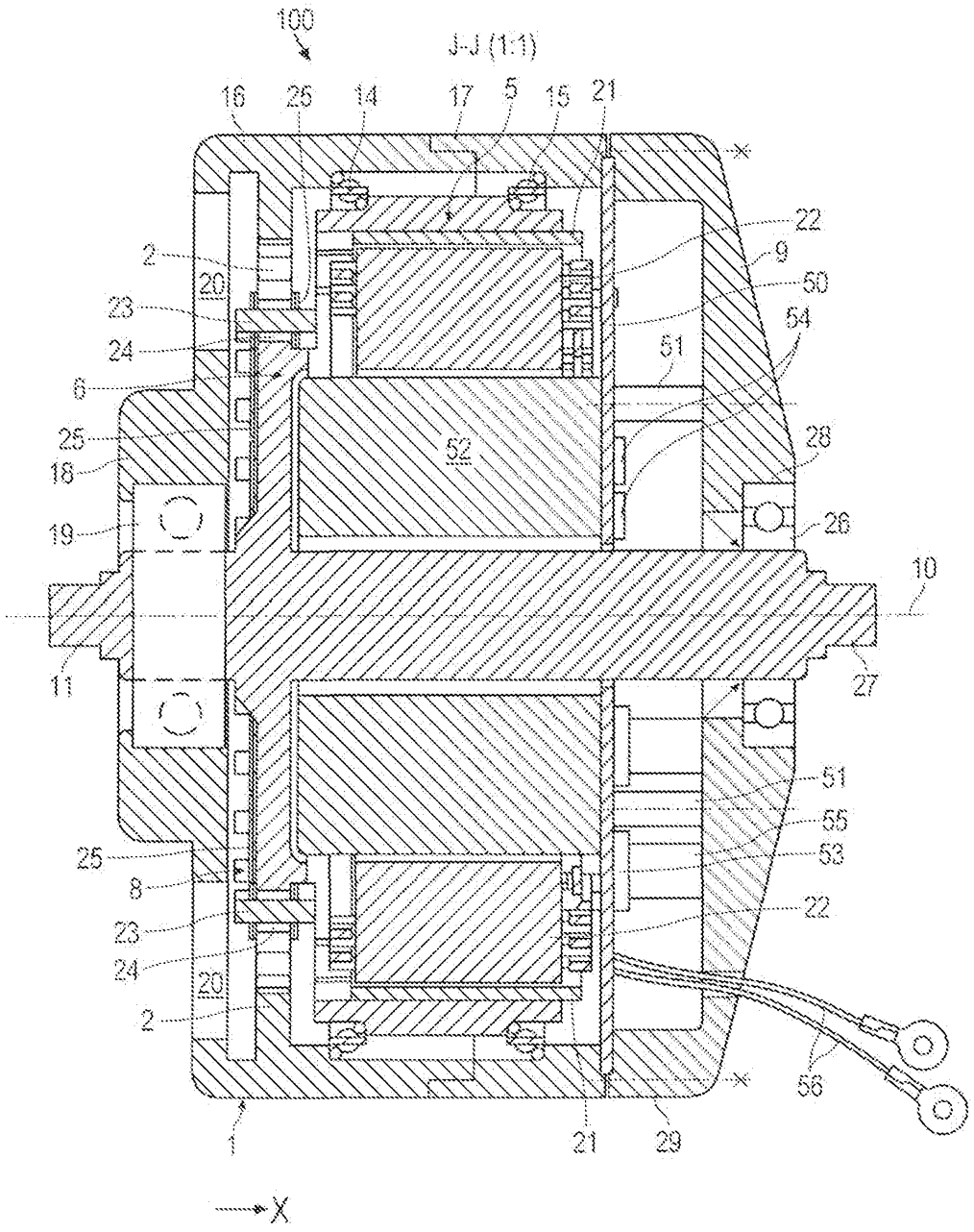
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FIG. 2

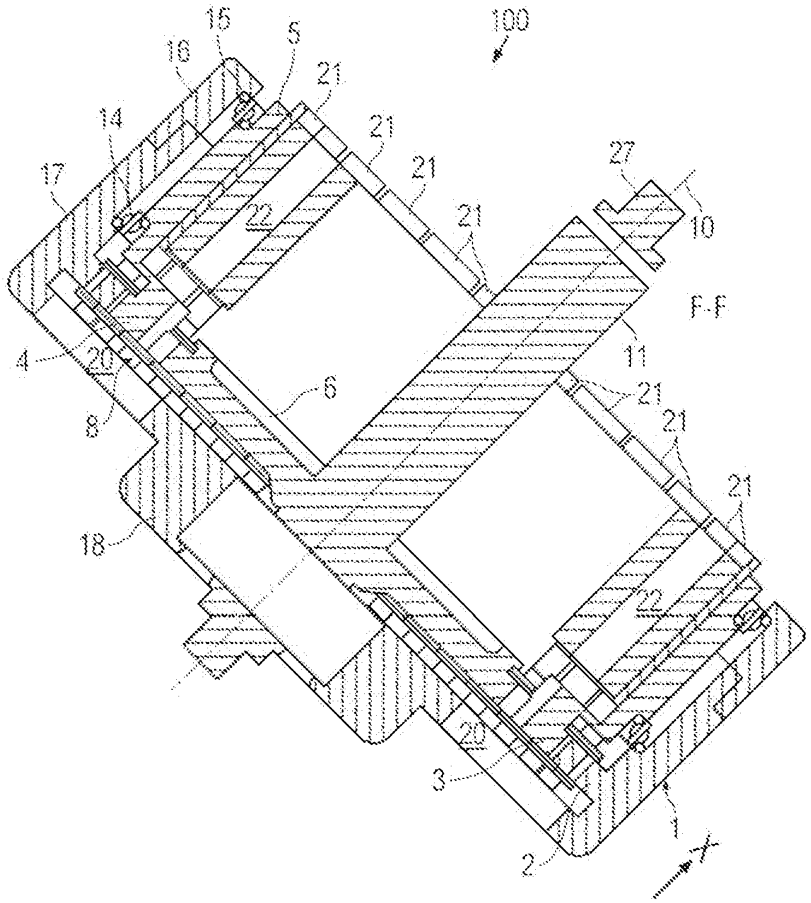
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FIG. 3

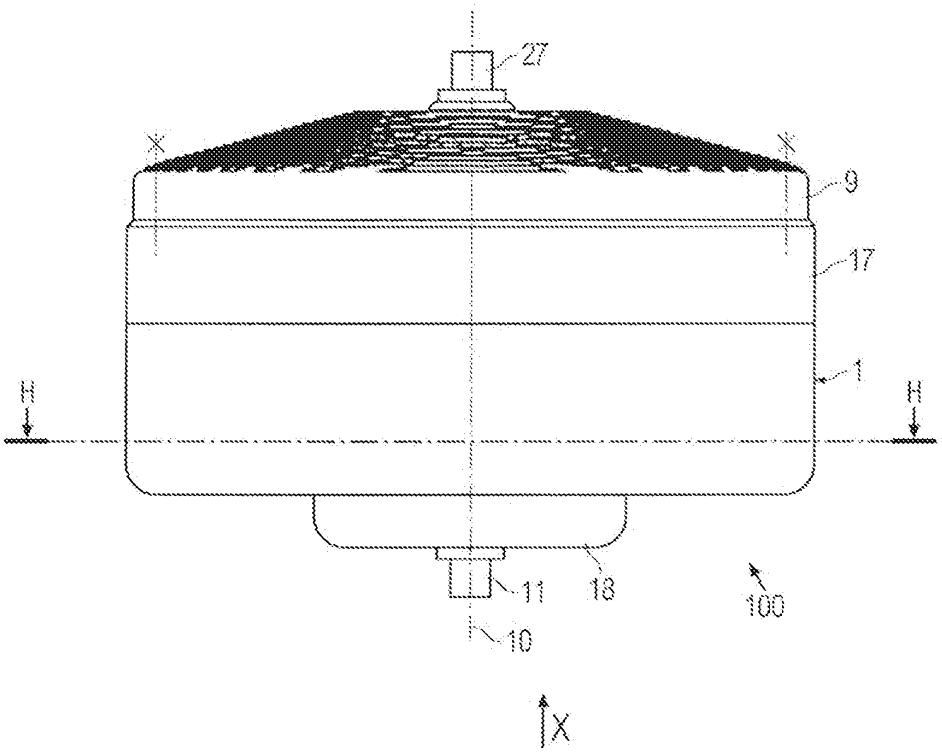


FIG. 4

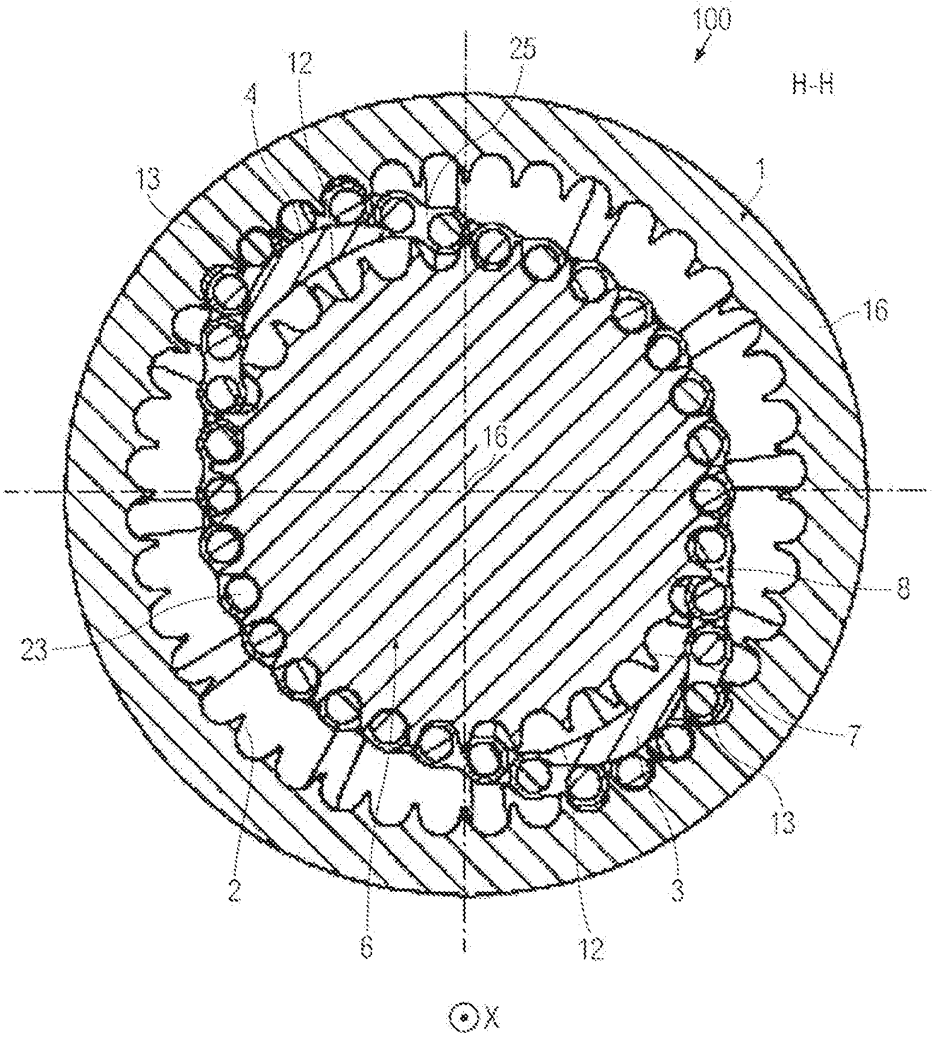


FIG. 5

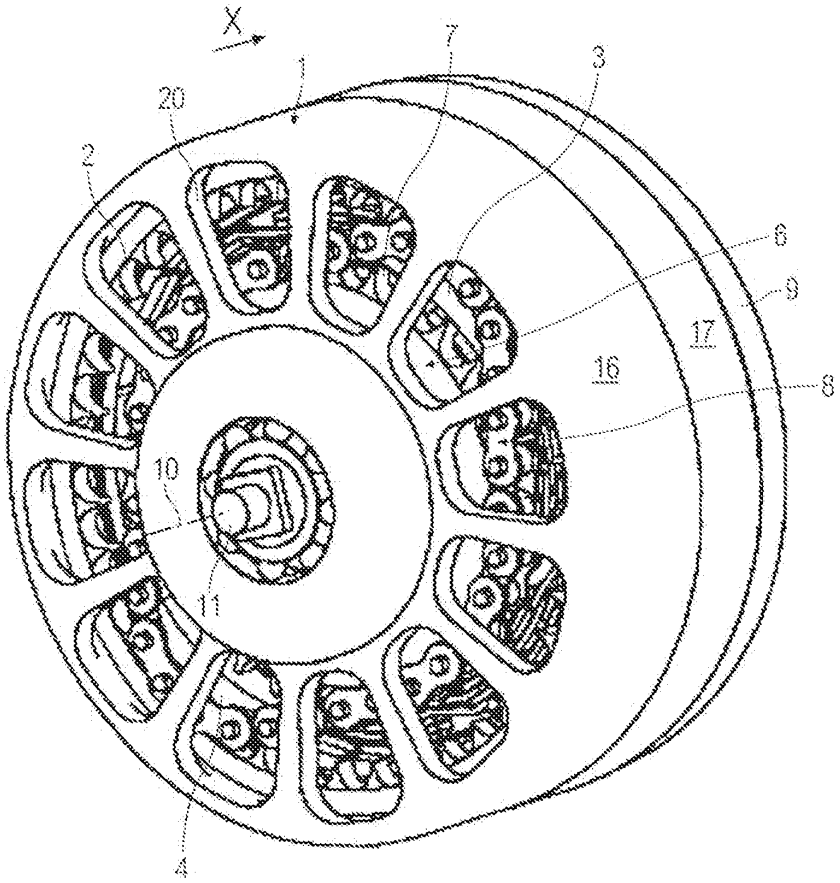


FIG. 6

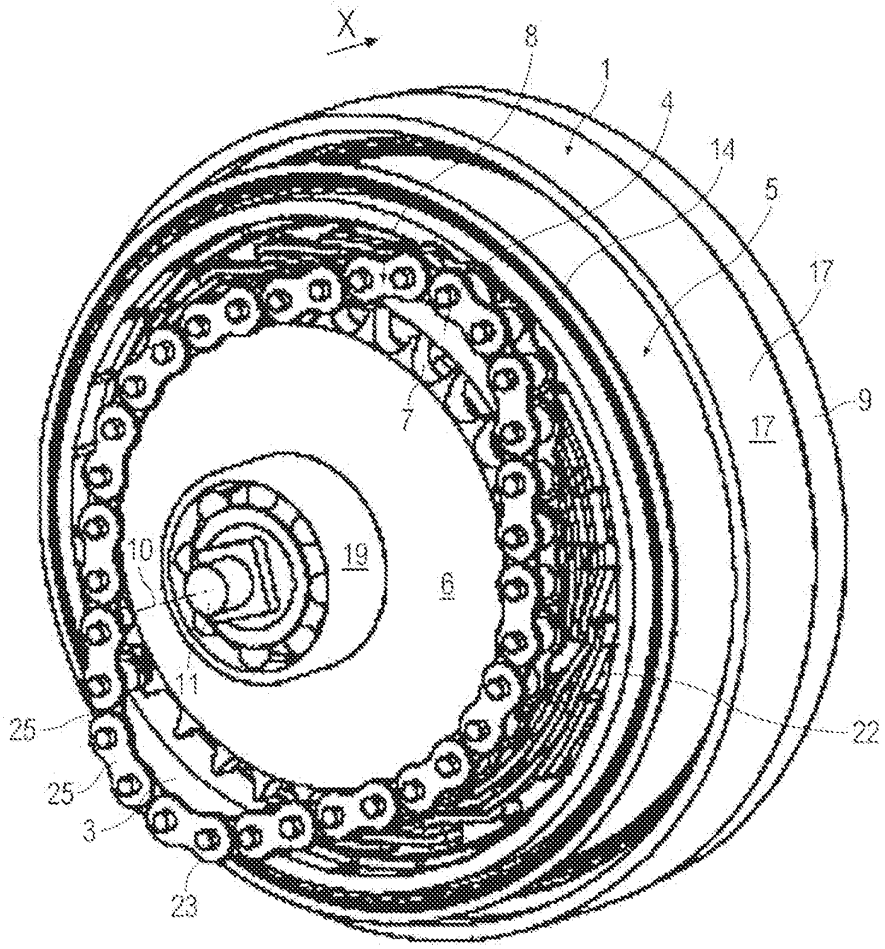


FIG. 7

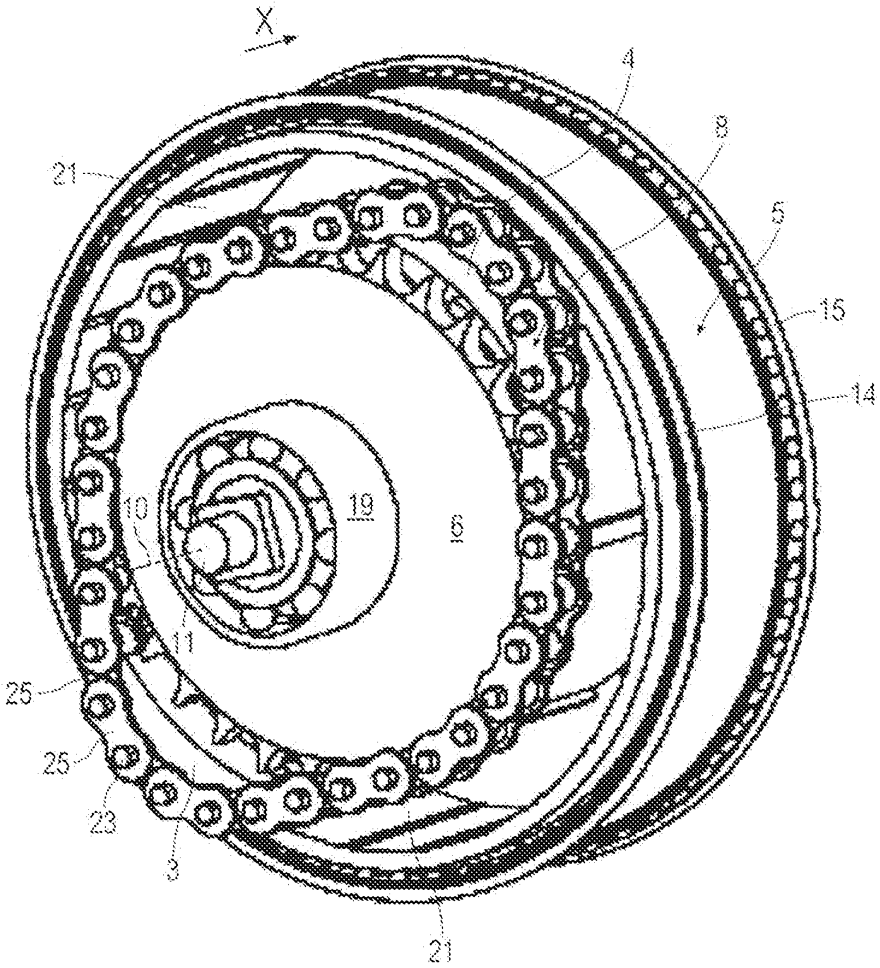


FIG. 8

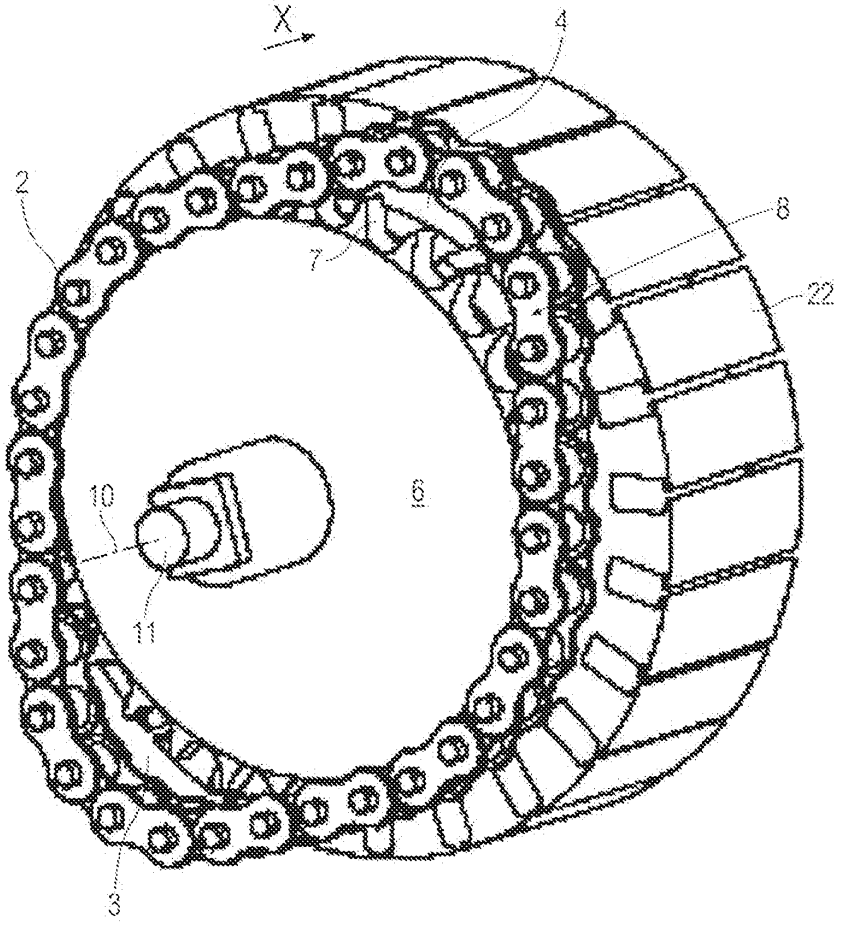


FIG. 9

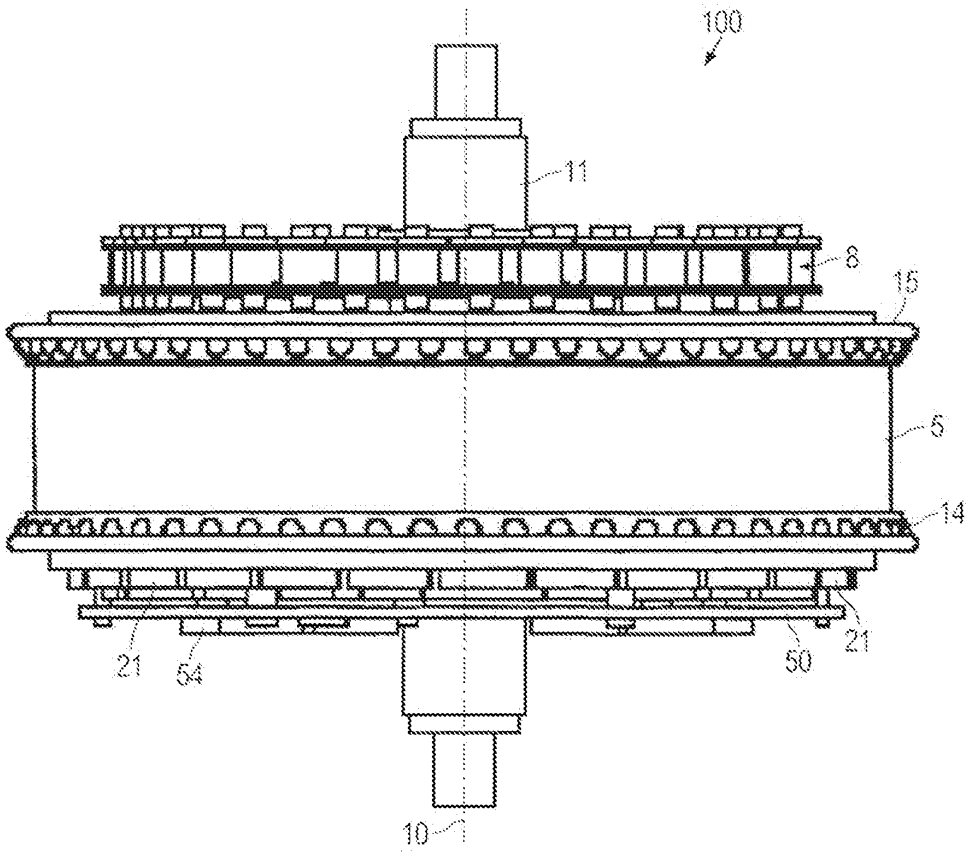


FIG. 10

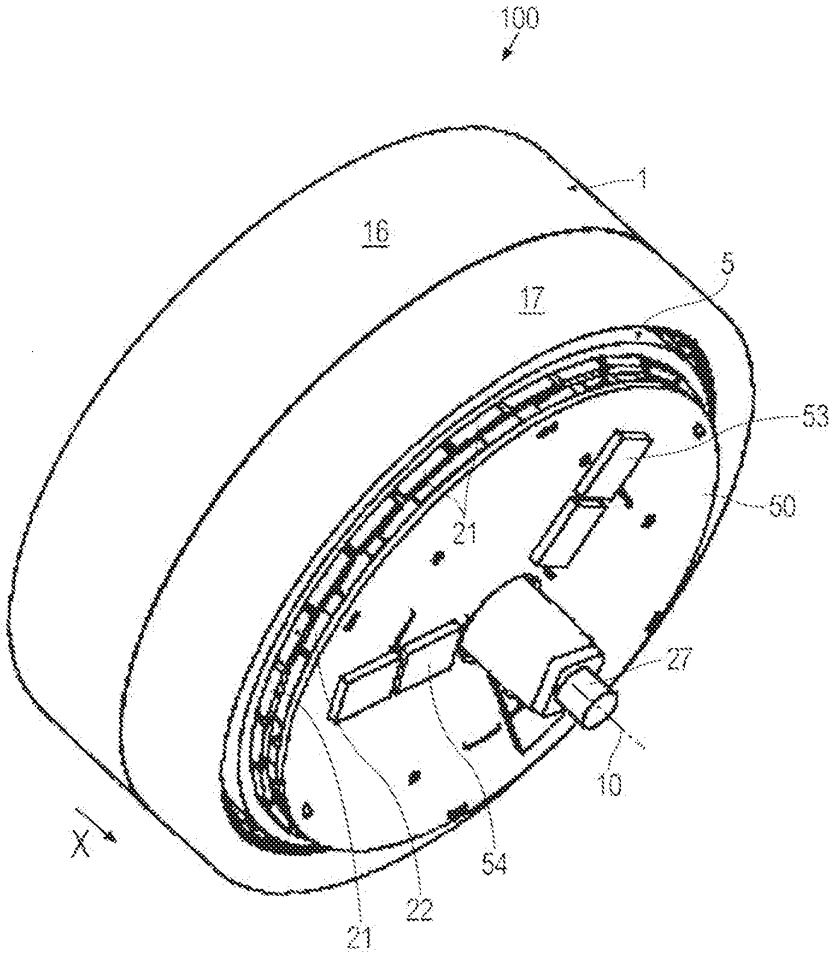


FIG. 11

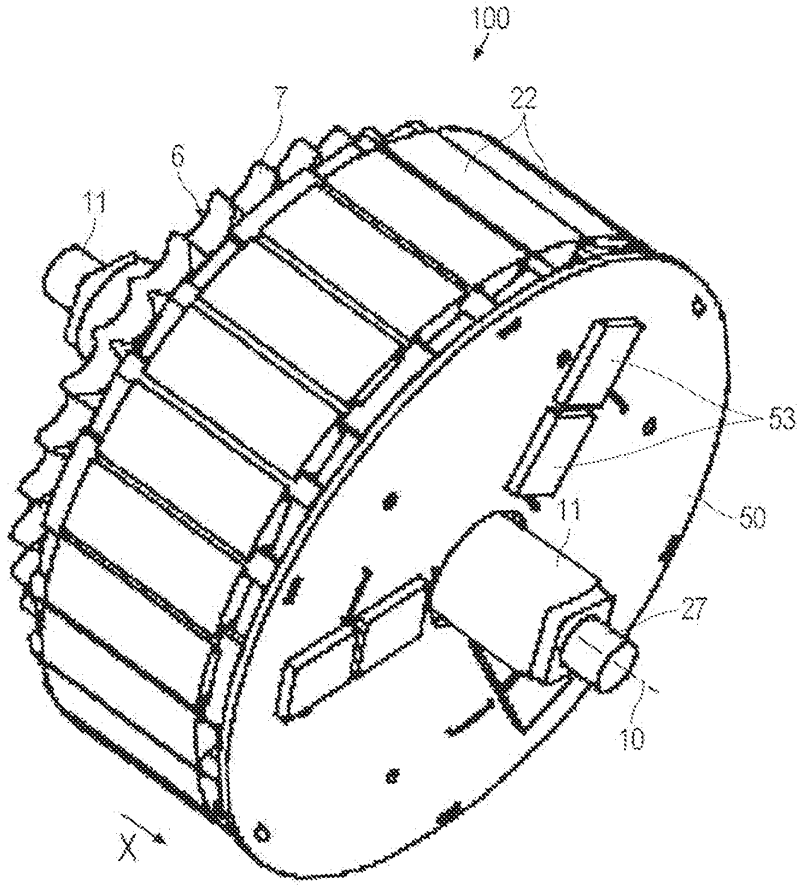


FIG. 12

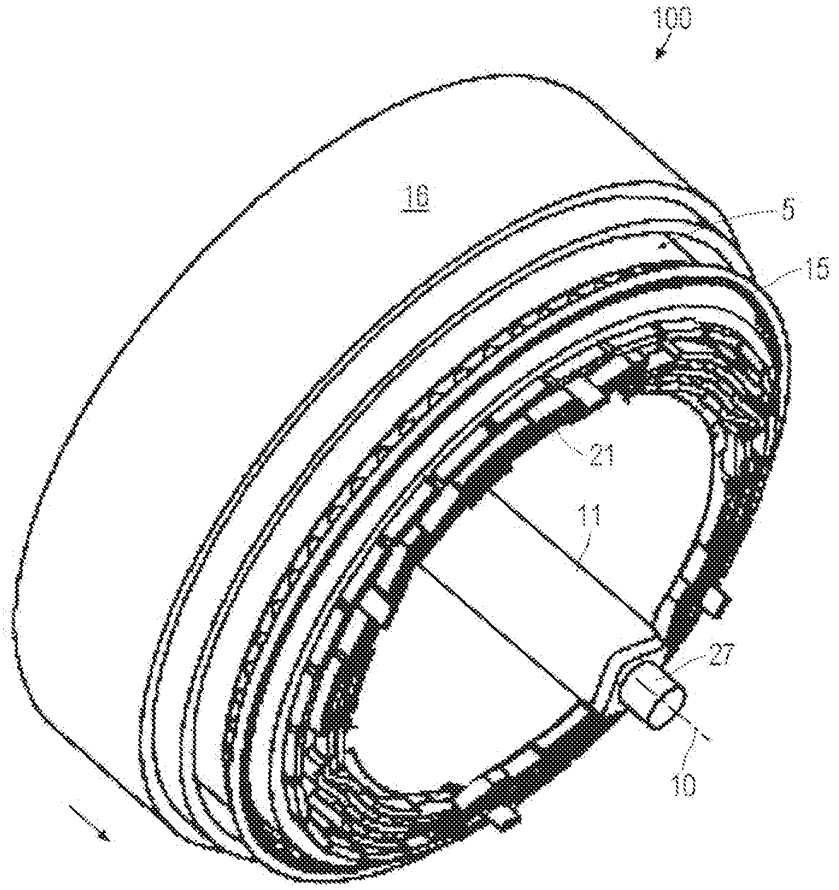


FIG. 13

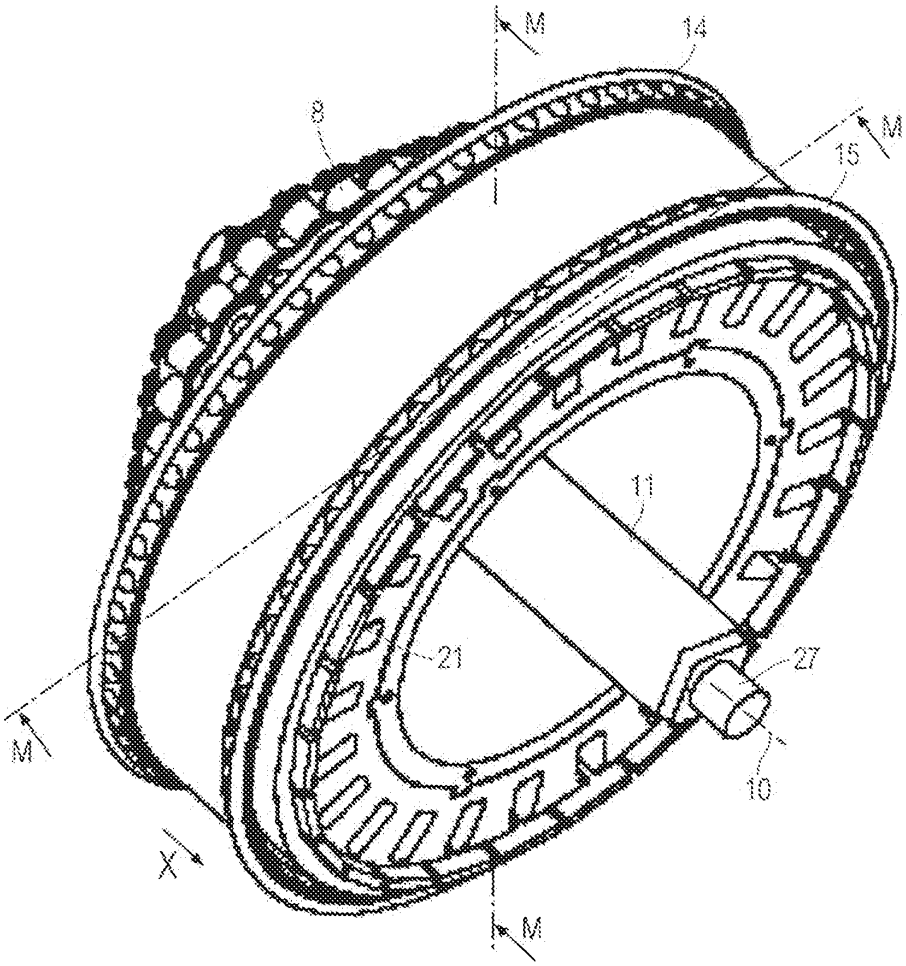


FIG. 14

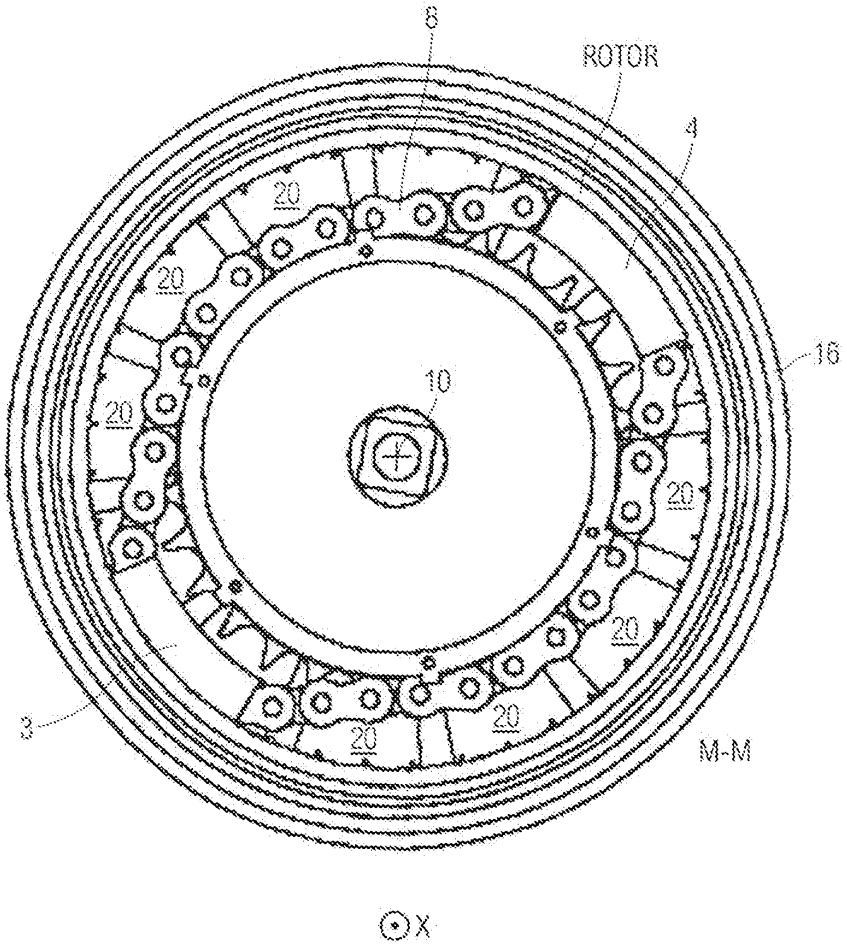


FIG. 15

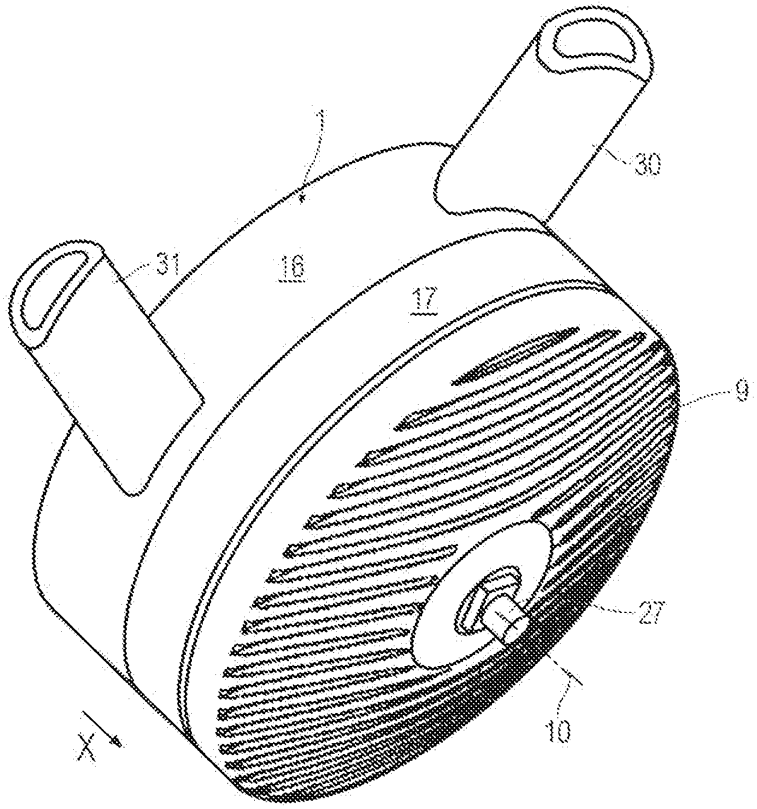


FIG. 16

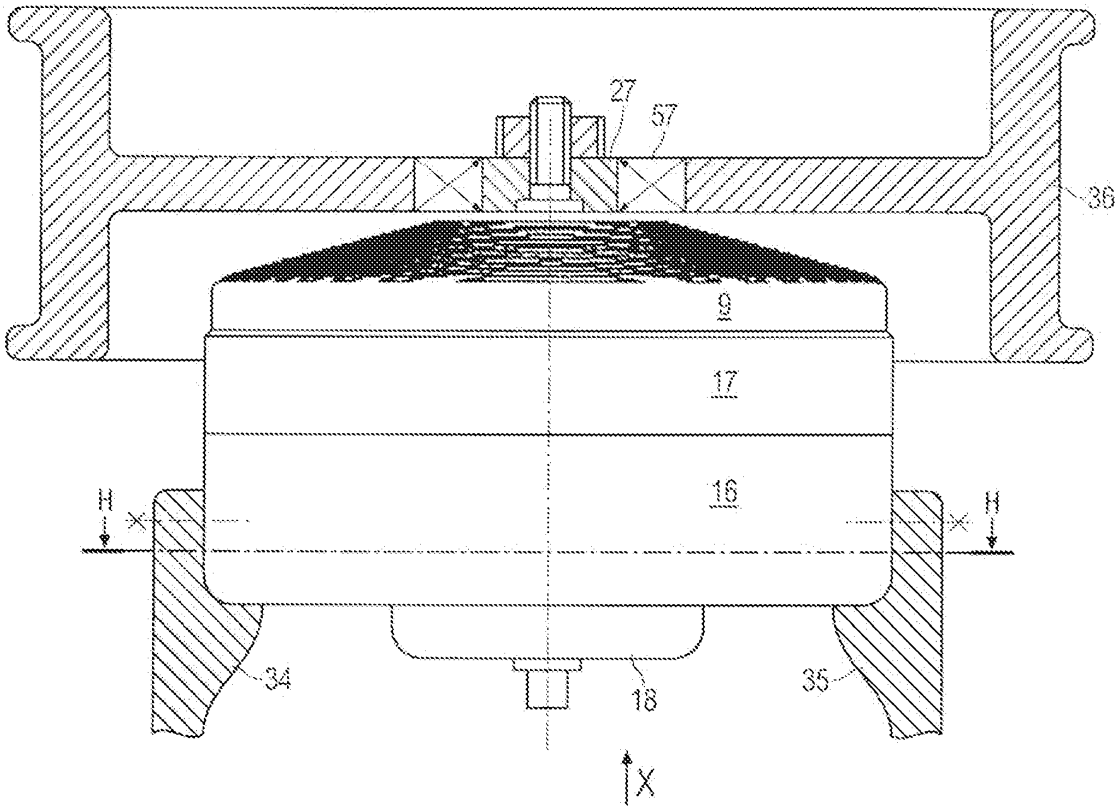


FIG. 17

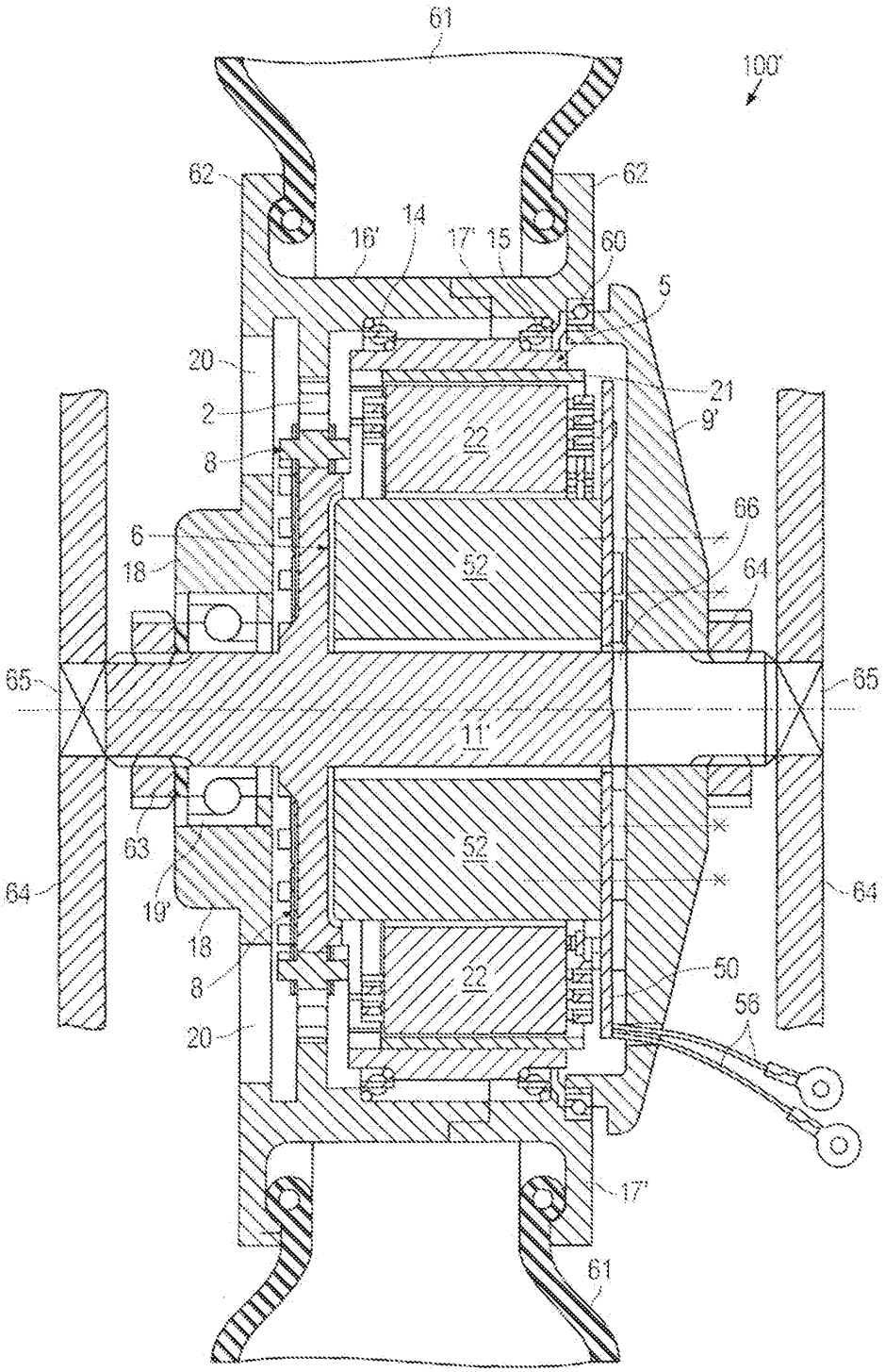

61
100'
62
62'
16'
14
17'
15
60
5
20
21
2
9'
22
8
6
66
18
52
64
65
65
11'
63
52
64
64
19'
18
8
22
50
56
20
17'
61

FIG. 18

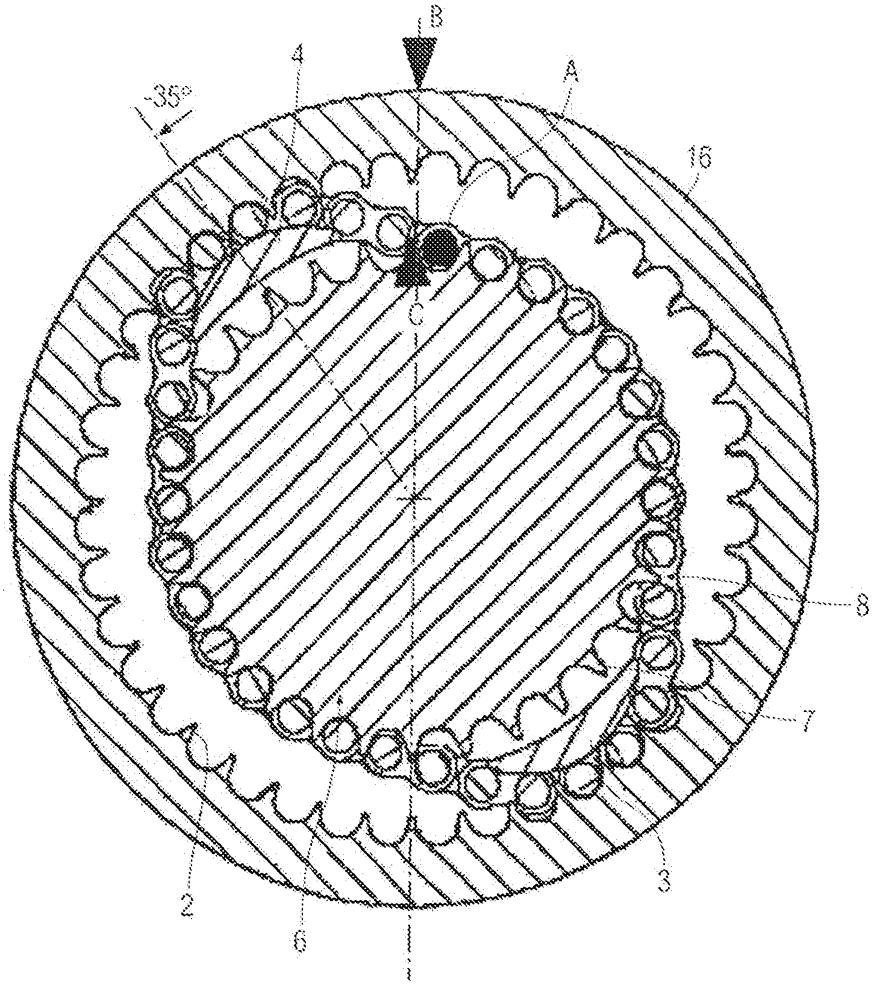


FIG. 19

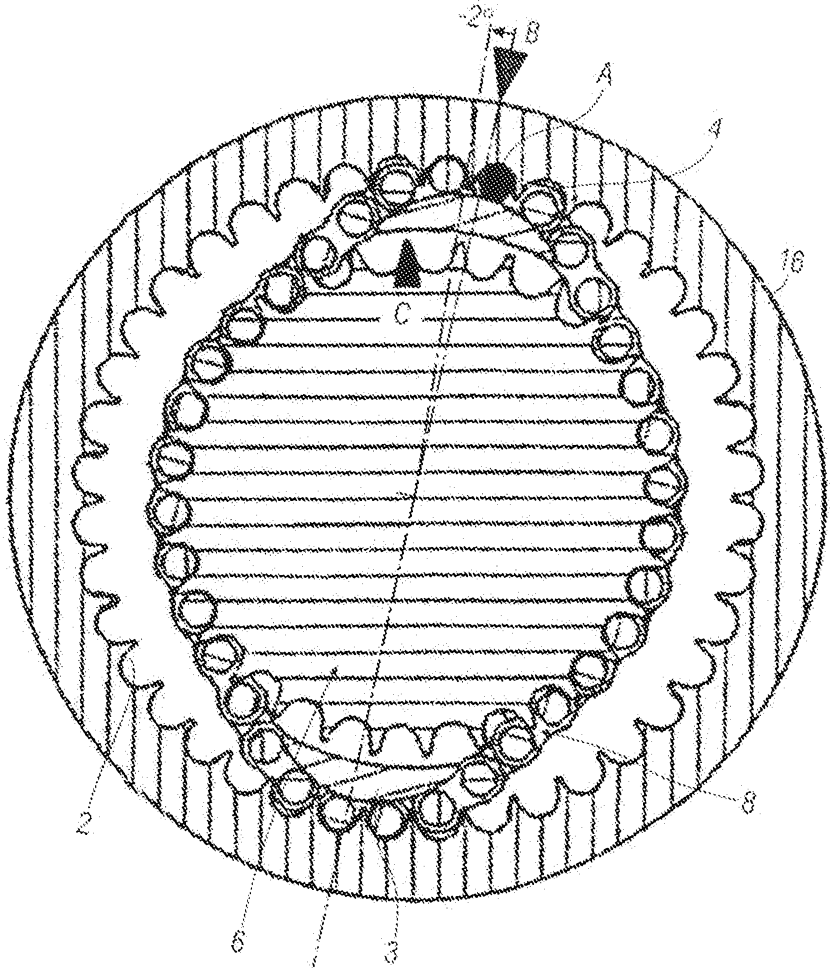


FIG. 20

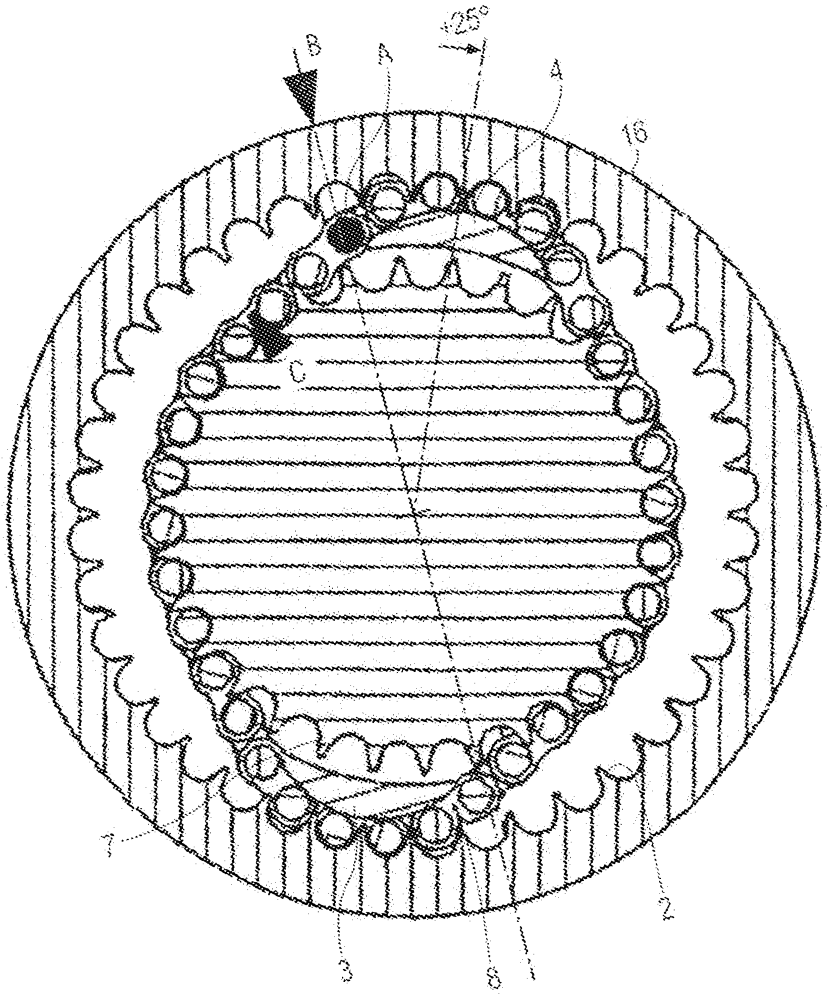


FIG. 21

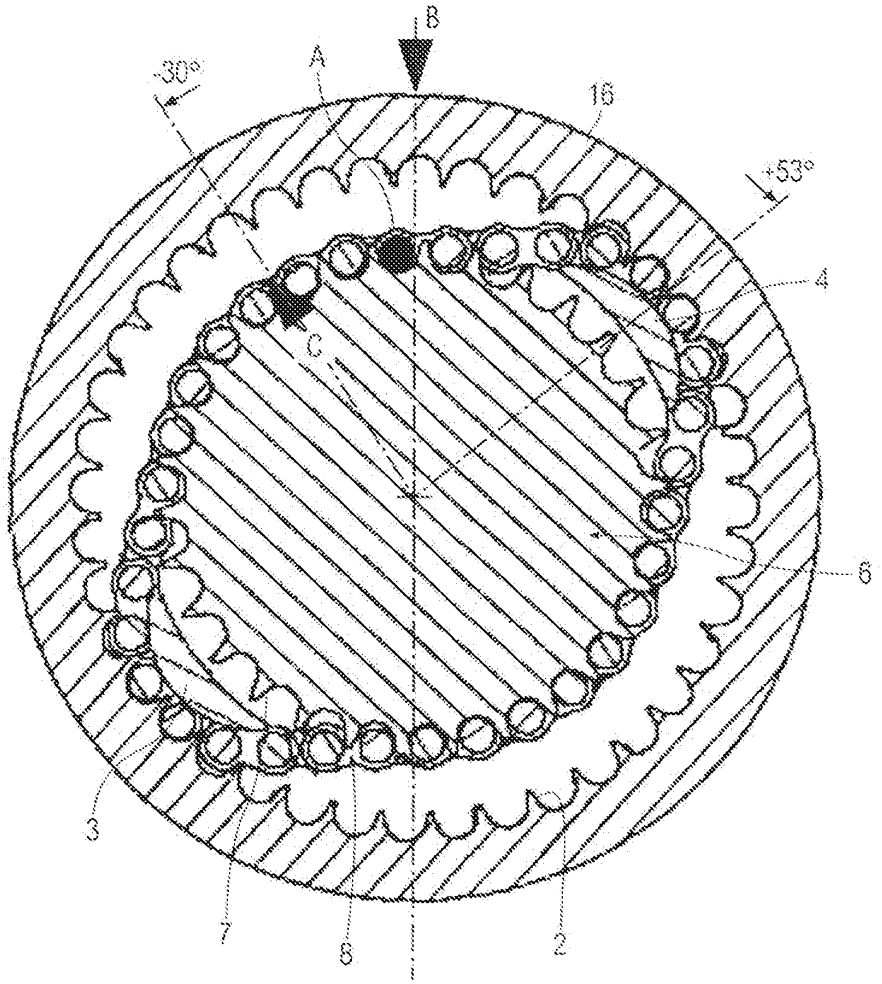


FIG. 22

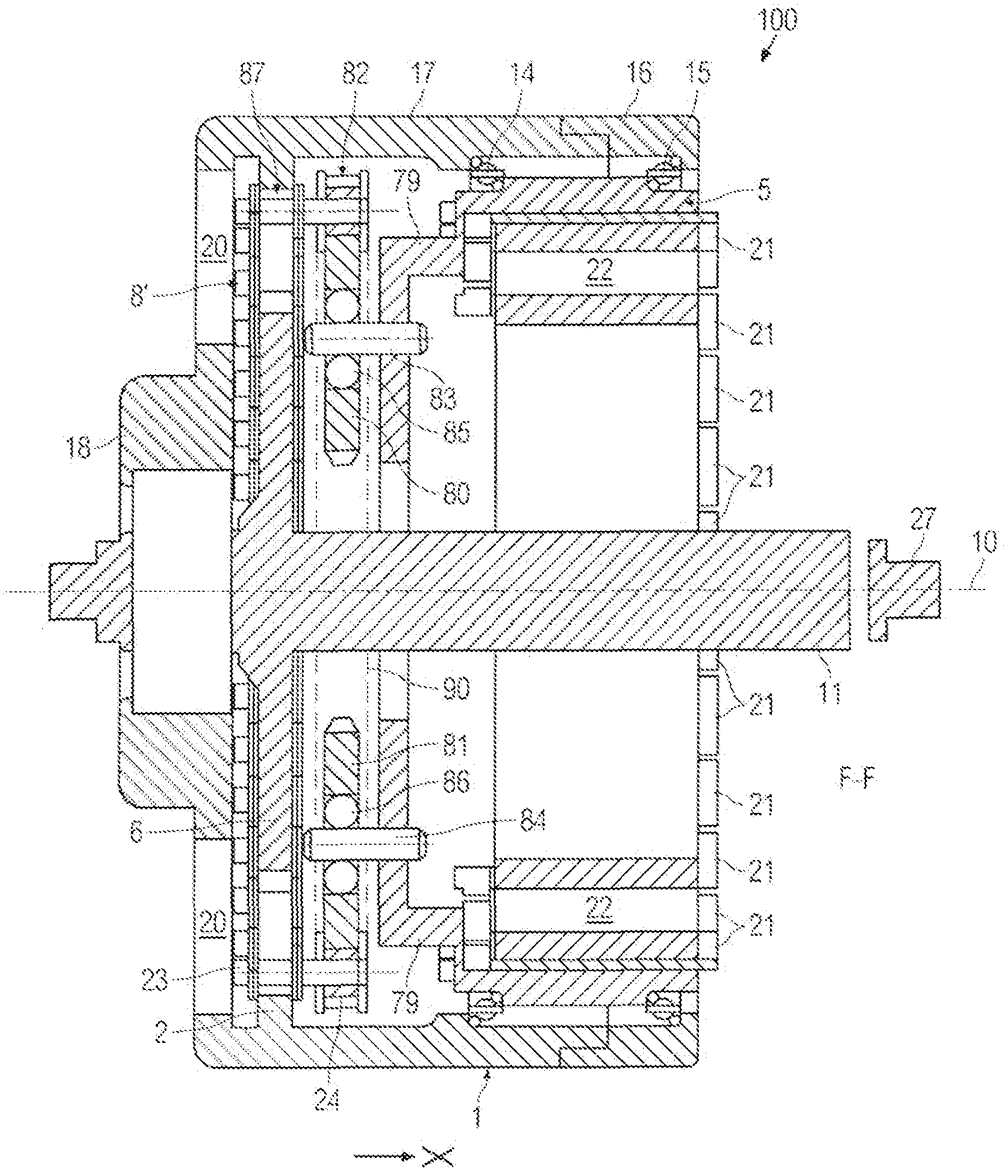

100
87
82
17
14
16
15
79
5
20
21
22
8'
21
83
21
85
18
80
21
27
10
11
90
21
81
F-F
86
21
6
84
21
20
22
21
23
79
2
24
1
X

FIG. 23

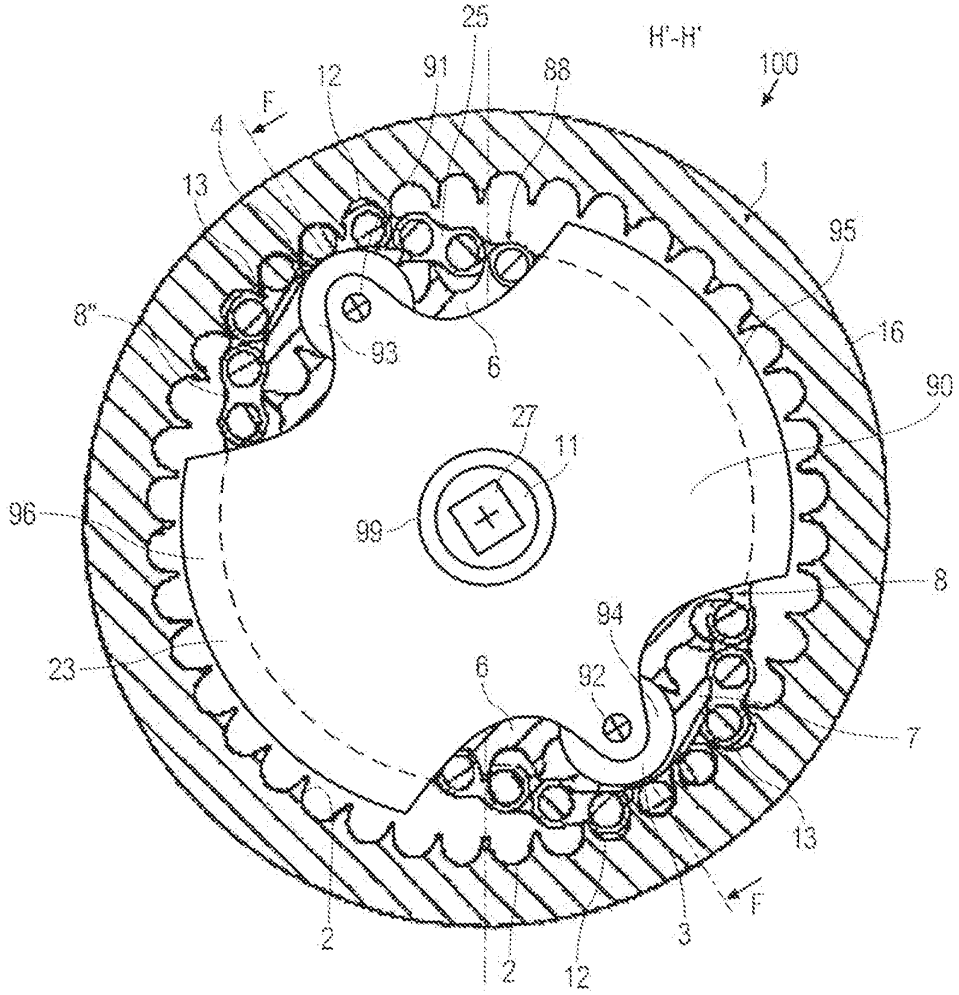

H'-H'
100
25
91
88
12
F
4
13
1
95
8"
93
6
16
90
27
11
99
96
8
94
23
6
92
7
13
F
2
2
12
3

FIG. 24

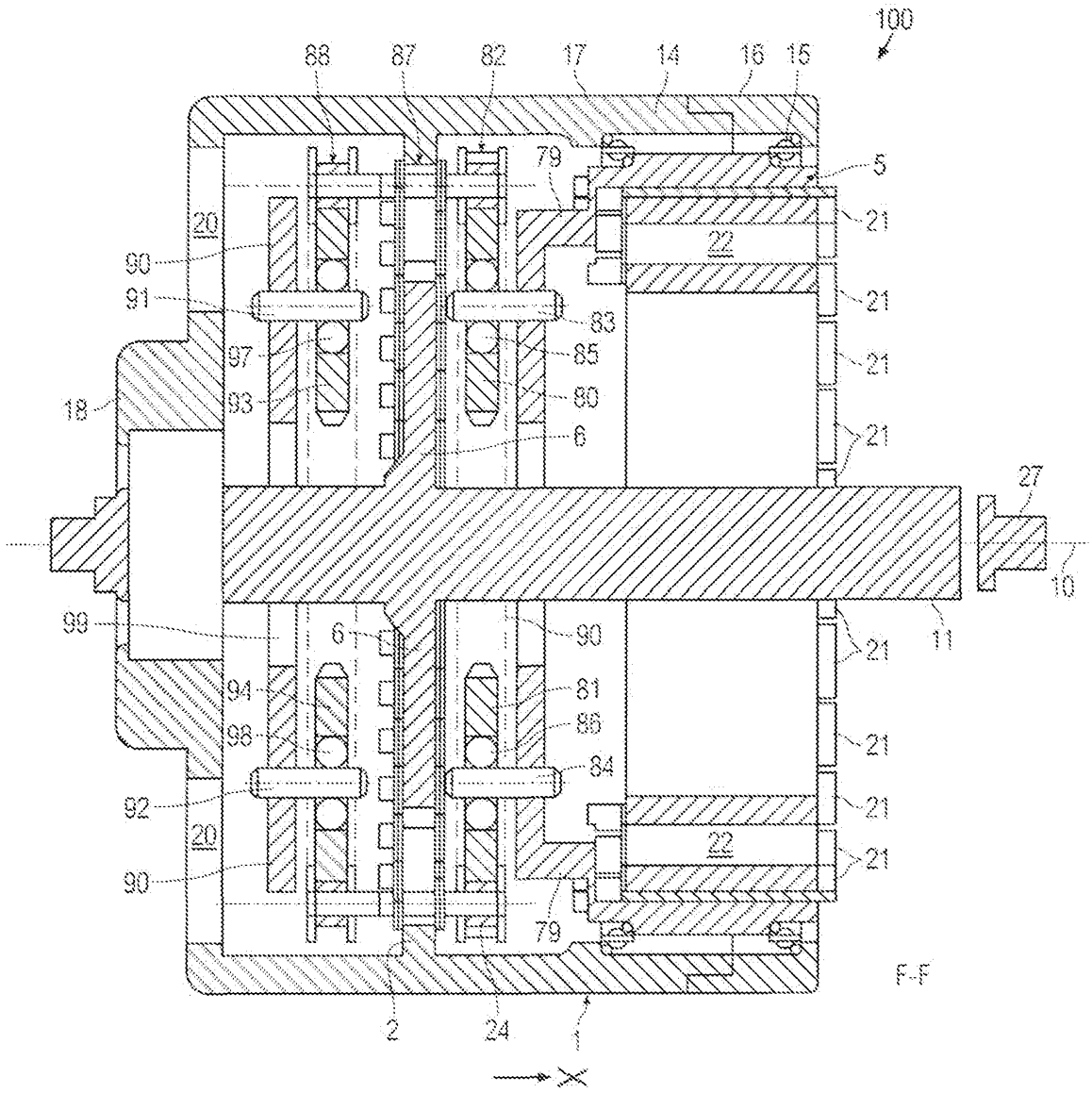

100
88
87
82
17
14
16
15
79
5
21
22
20
90
91
83
85
97
93
80
6
18
27
10
11
99
94
81
86
98
84
92
F-F
2
24
1

FIG. 25

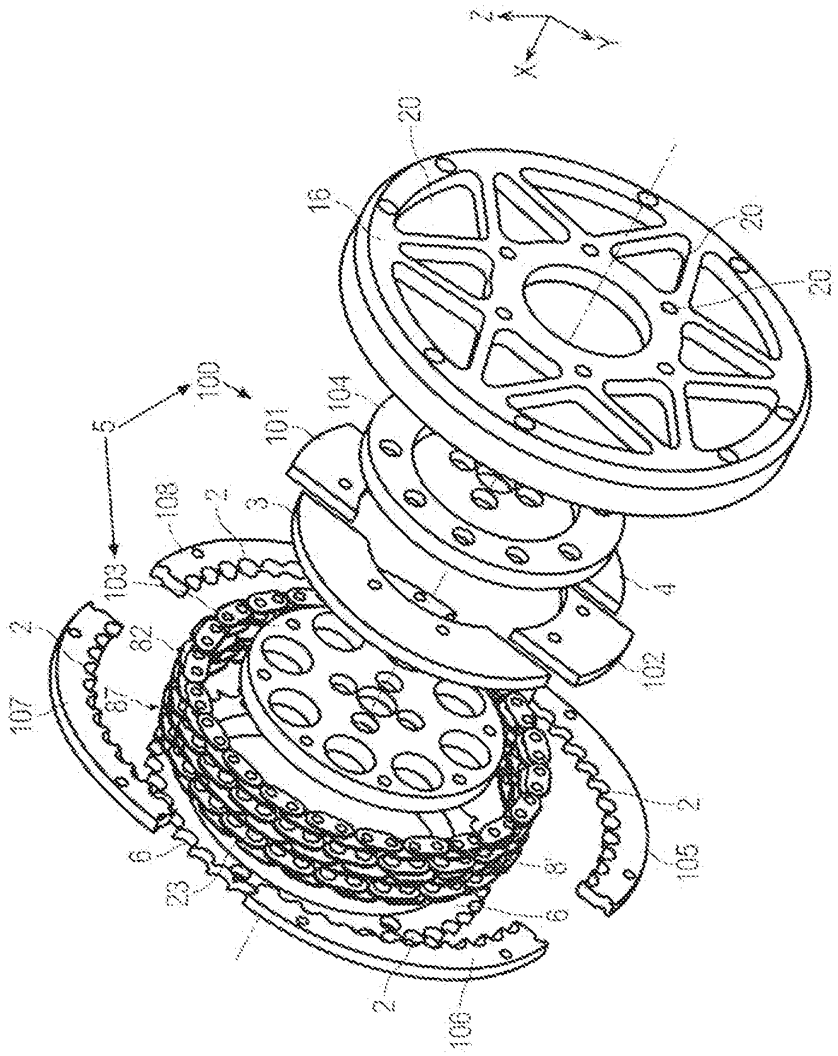

Z
Y
X
20
16
20
20
100
5
101
104
108
2
3
103
4
82
2
102
107
87
2
6
8
23
6
105
2
106

FIG. 26

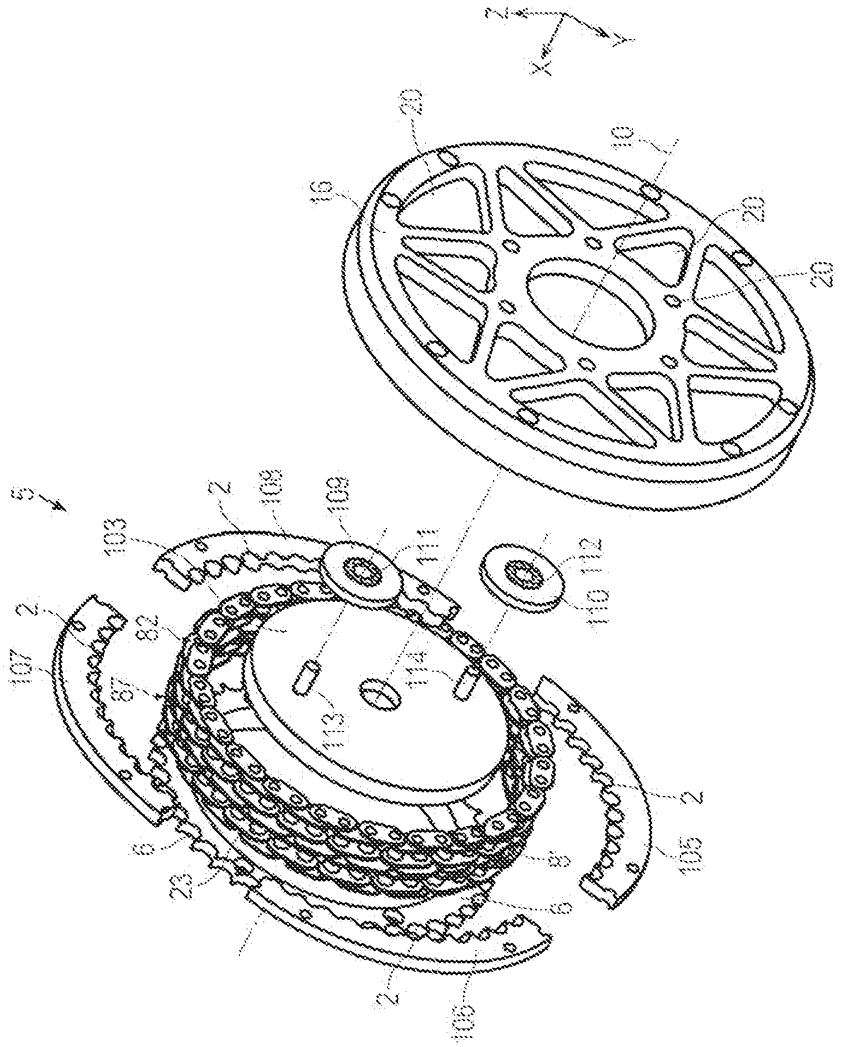

Z
Y
X
20
19
16
20
20
S
2
108
109
103
111
110 112
114
113
107
2
82
87
2
105
6
8
23
6
2
106

FIG. 27

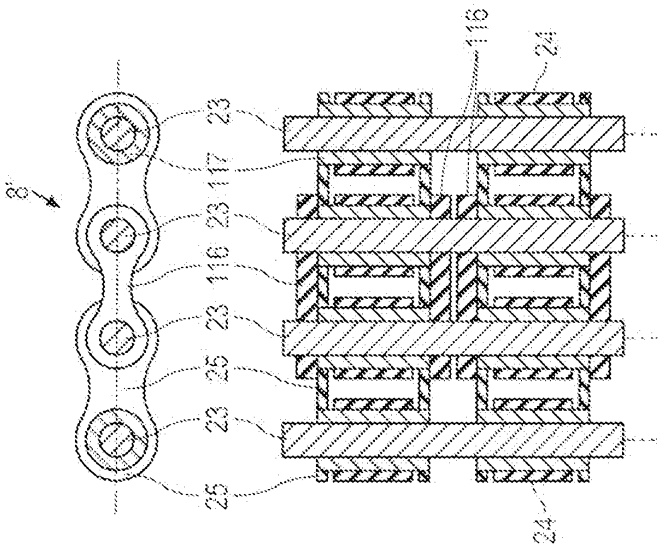


FIG. 28

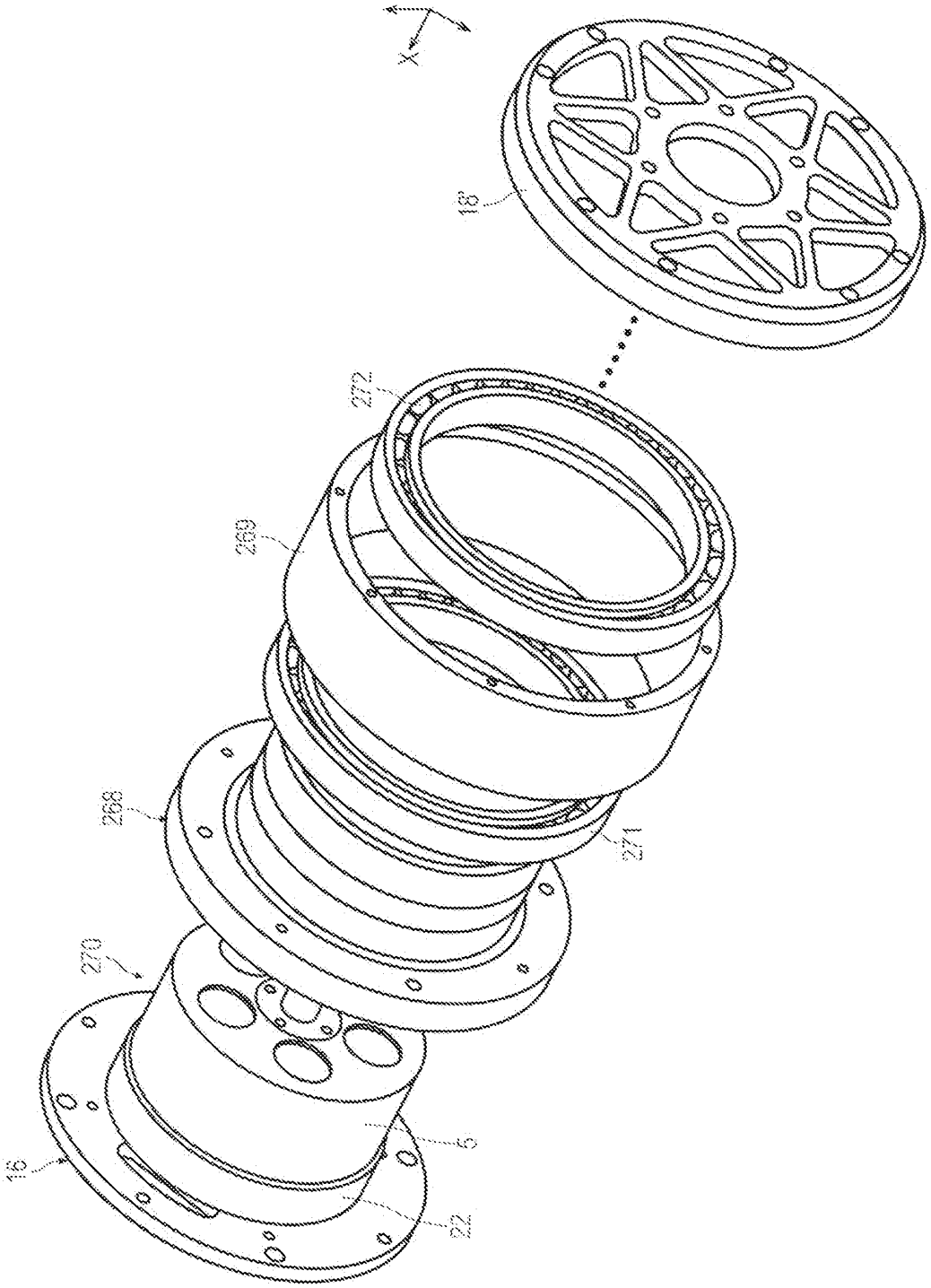


FIG. 29

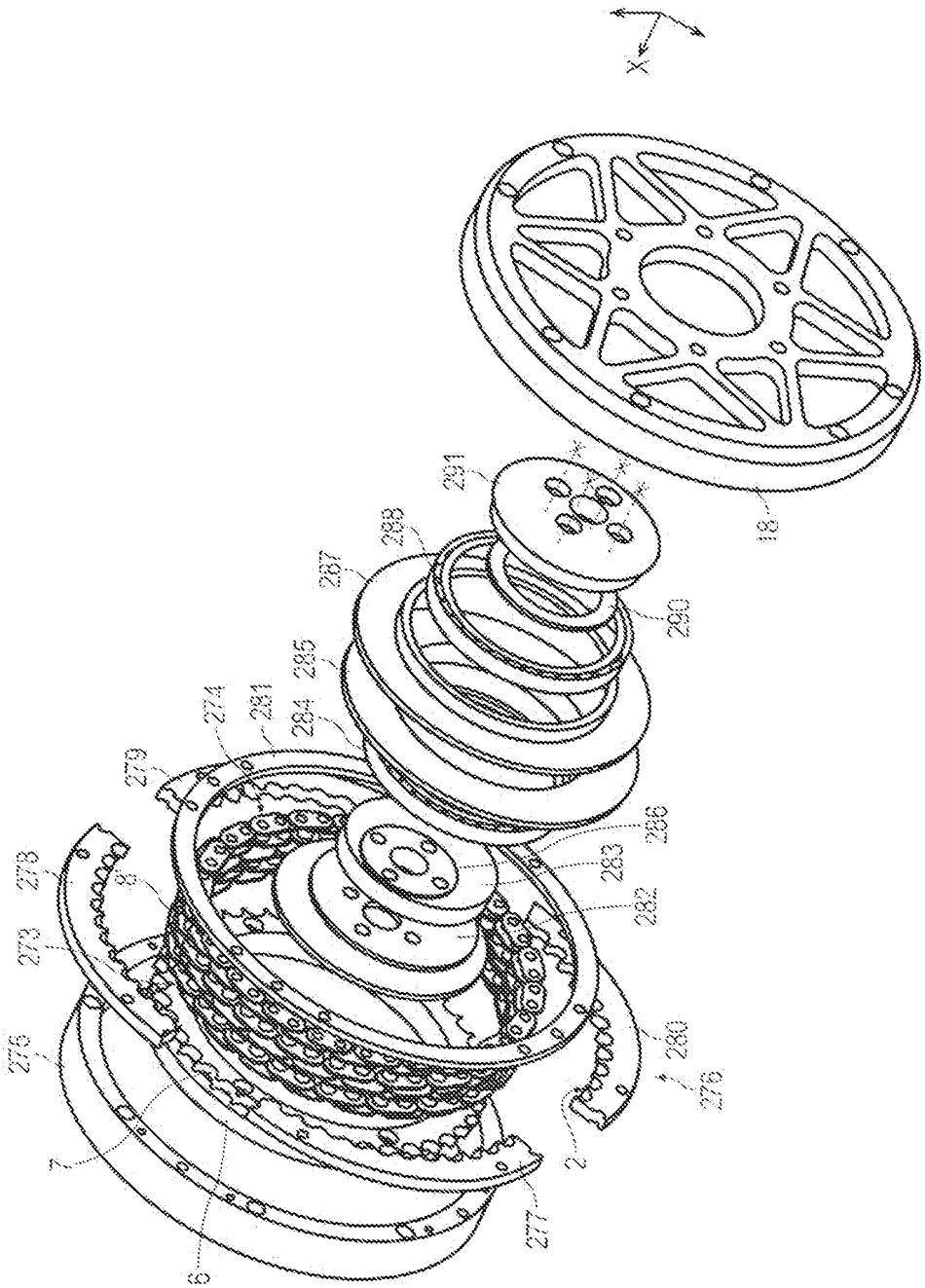

X
18
291
288
267
290
285
274
281
284
279
286
283
282
273
278
8
273
276
7
6
277
2
280
276

FIG. 30

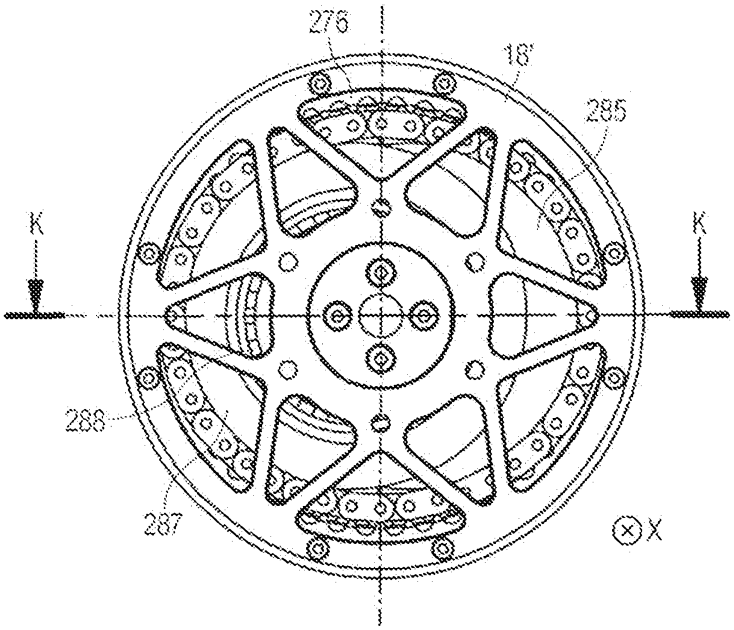

276
18'
285
K
K
288
287
X

FIG. 31

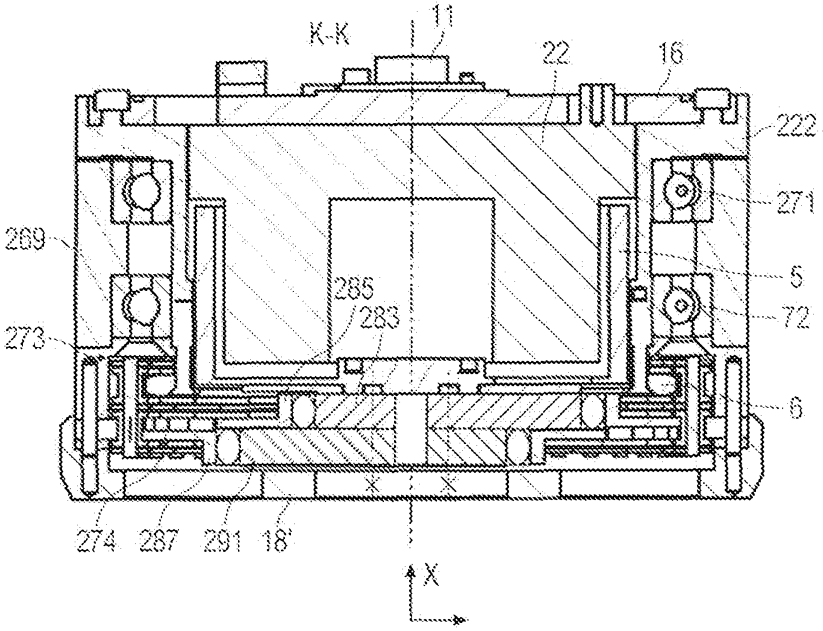

K-K
11
22
16
222
271
269
5
285
283
72
273
6
274
287
291
18'
X

FIG. 32

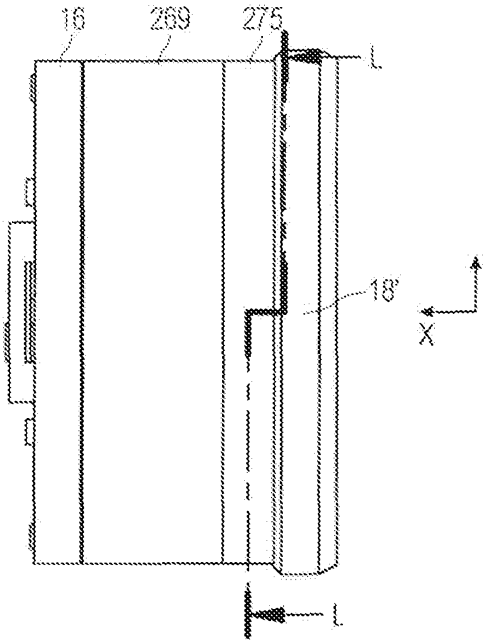


FIG. 33

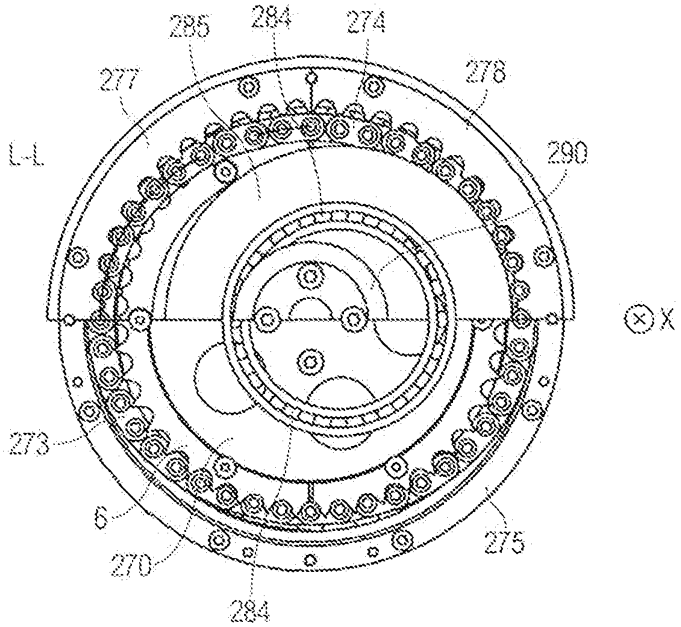


FIG. 34

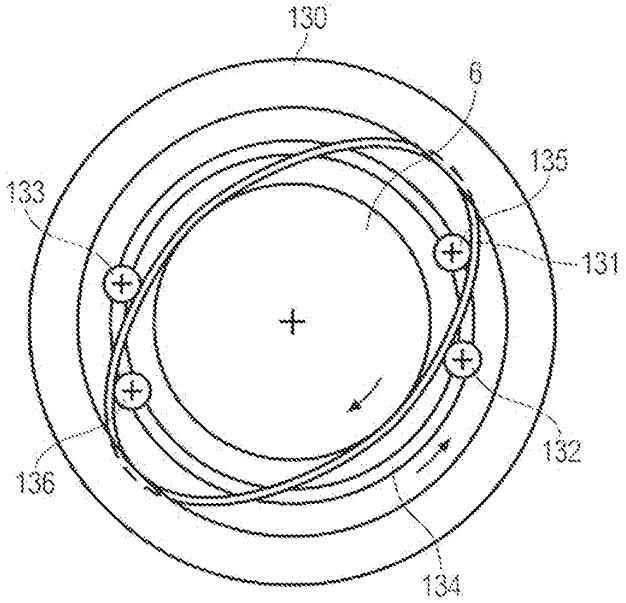


FIG. 35

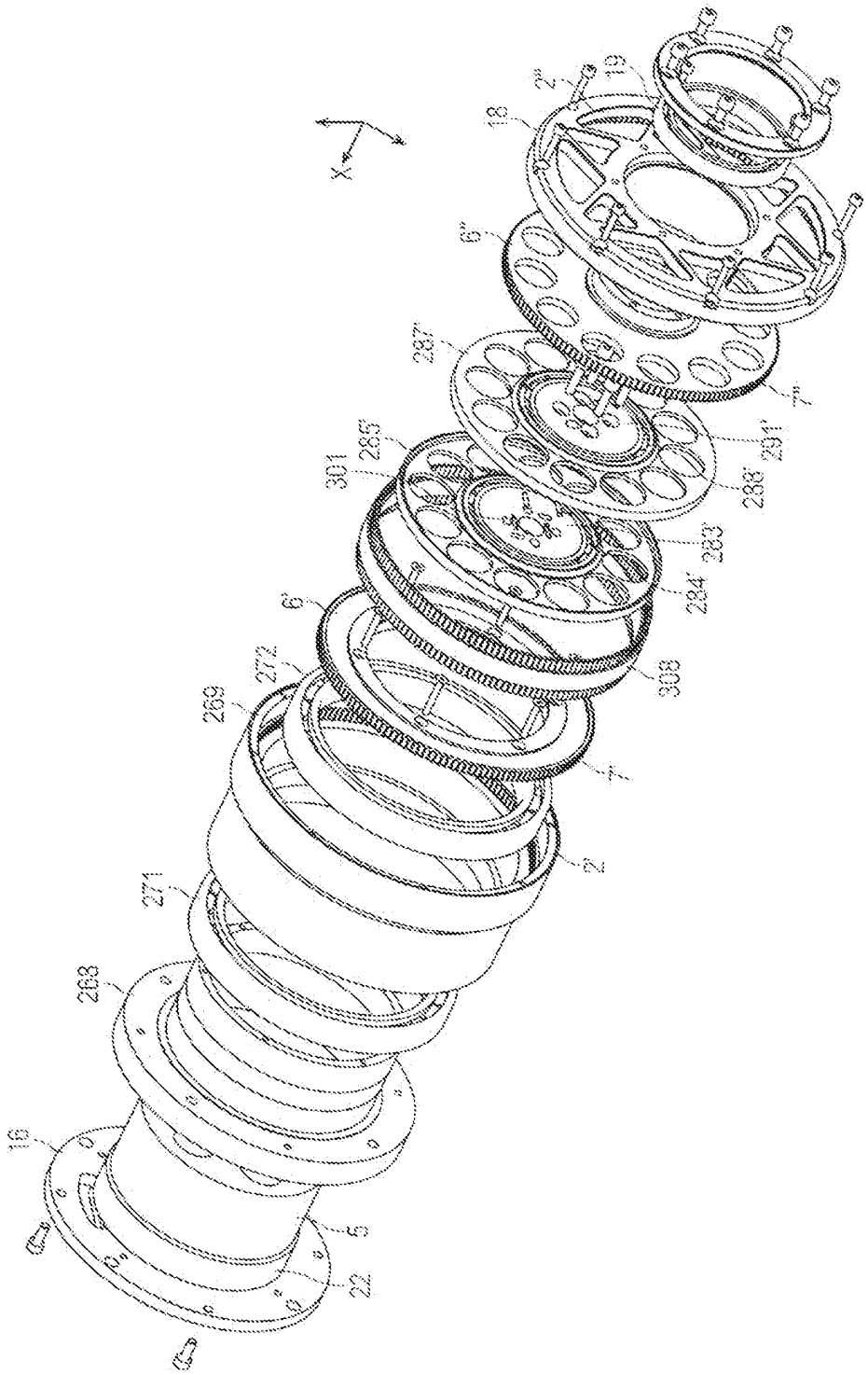

X
18
19
2"
6"
287'
291'
288'
283'
284'
303
301
285'
6'
272
269
271
263
16
5
22
2
7'

FIG. 36

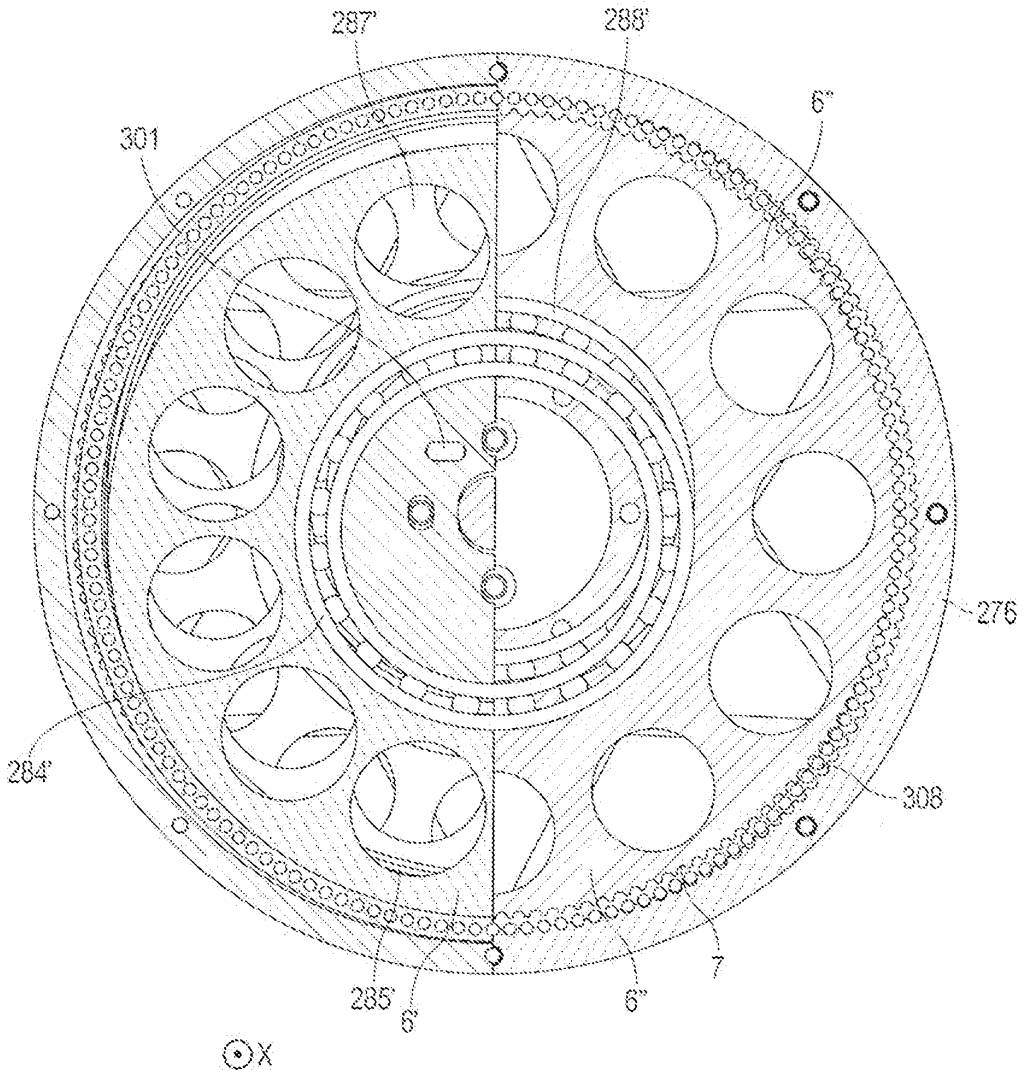


FIG. 37

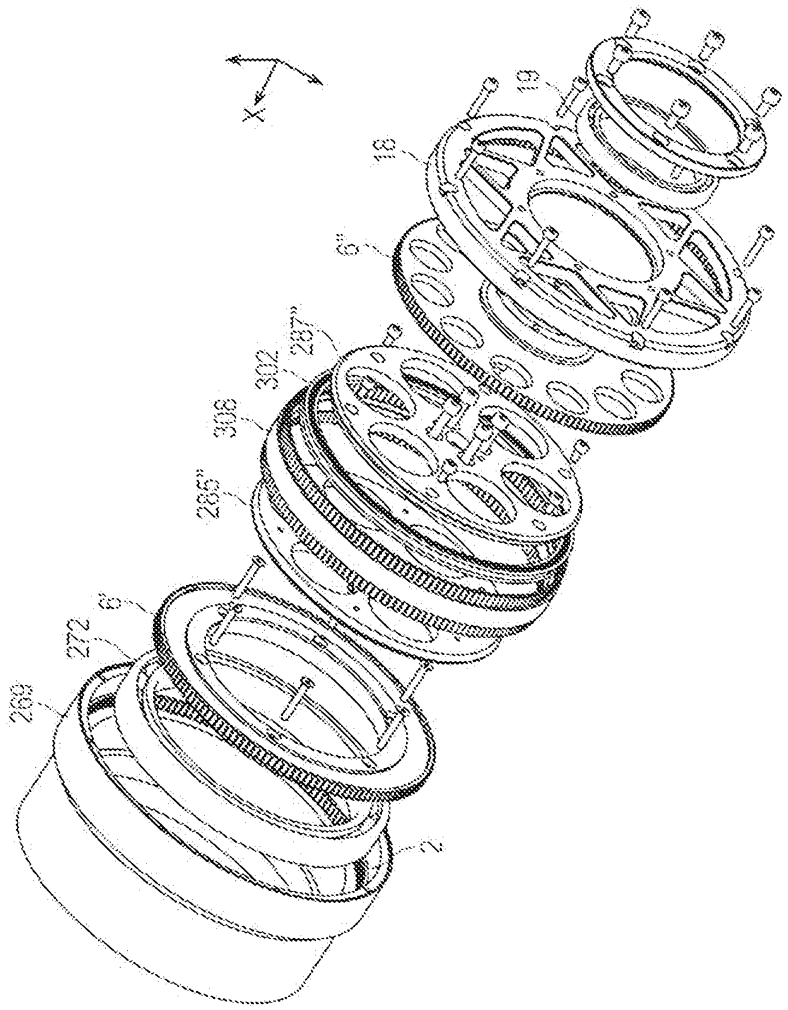


FIG. 38

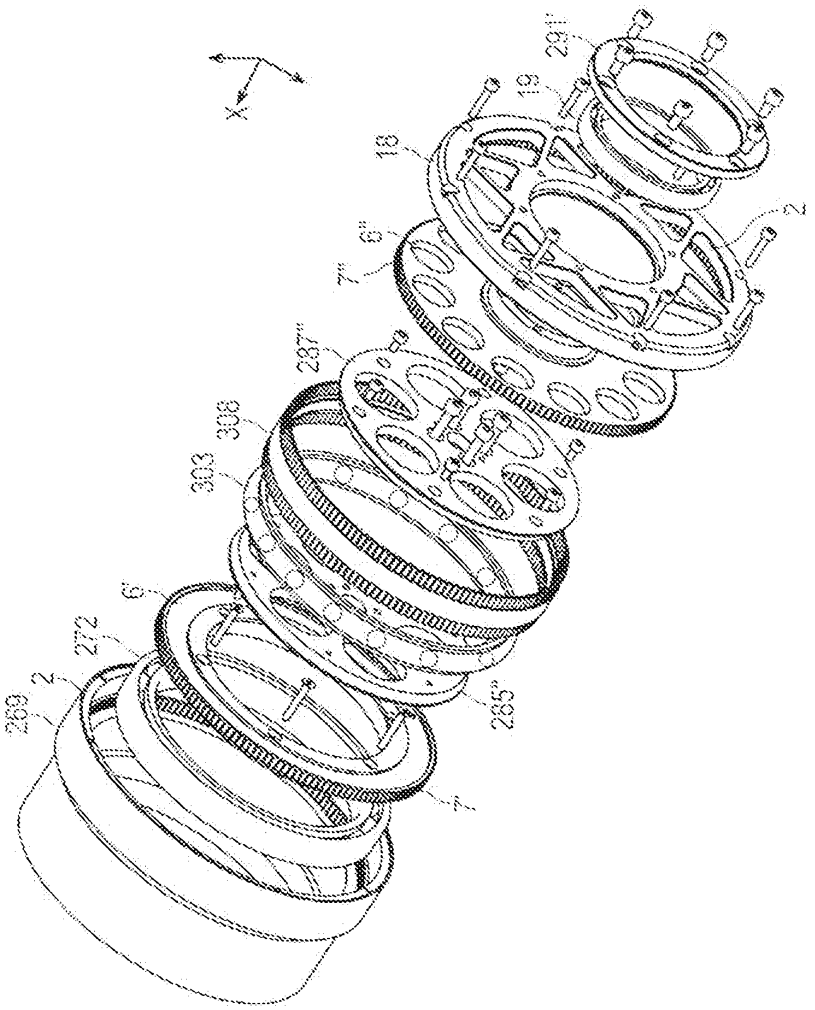


FIG. 39

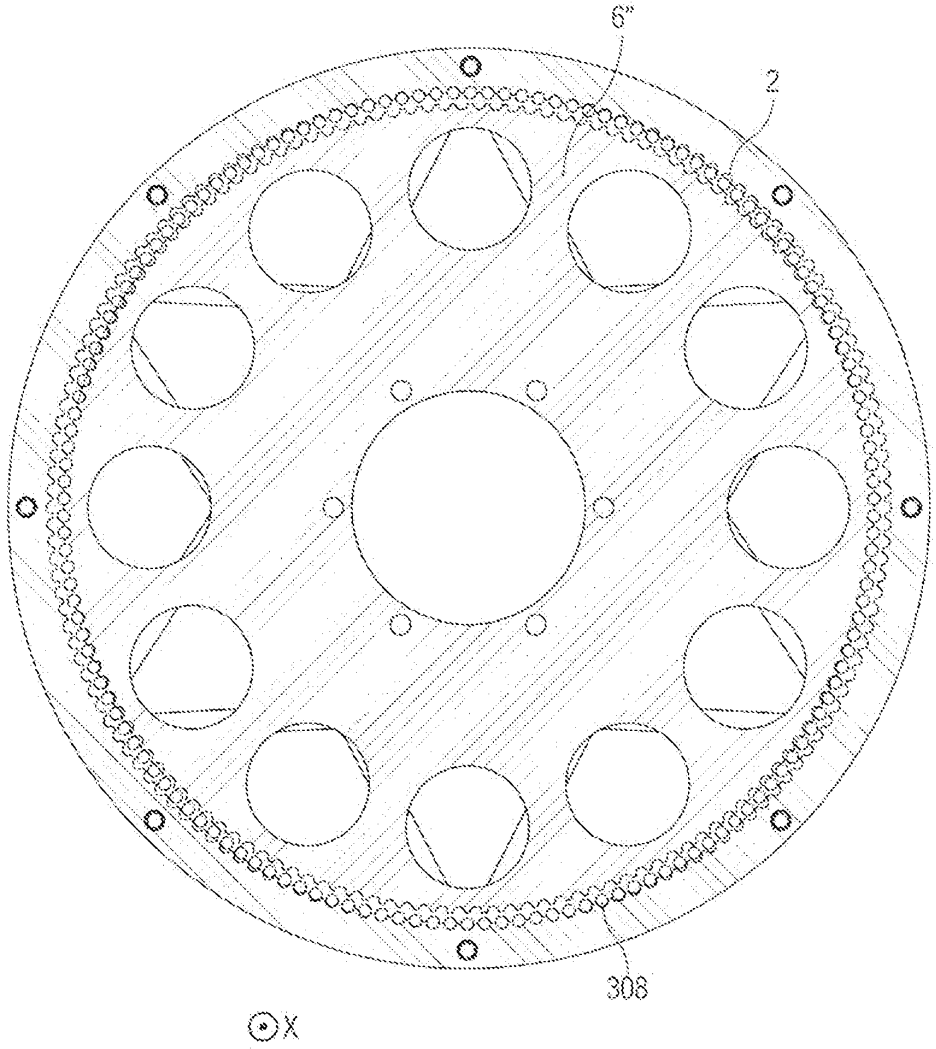


FIG. 40

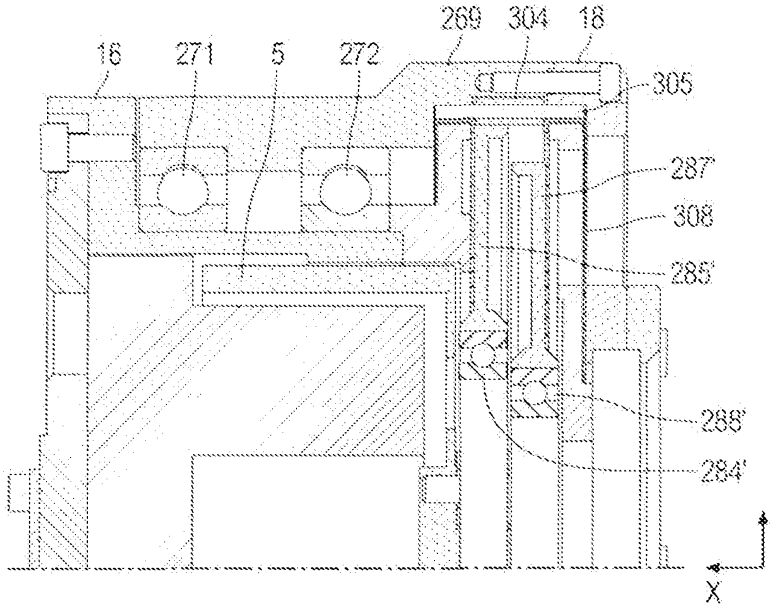

269
304
18
16
271
5
272
305
287'
308
285'
288'
284'
X

FIG. 41

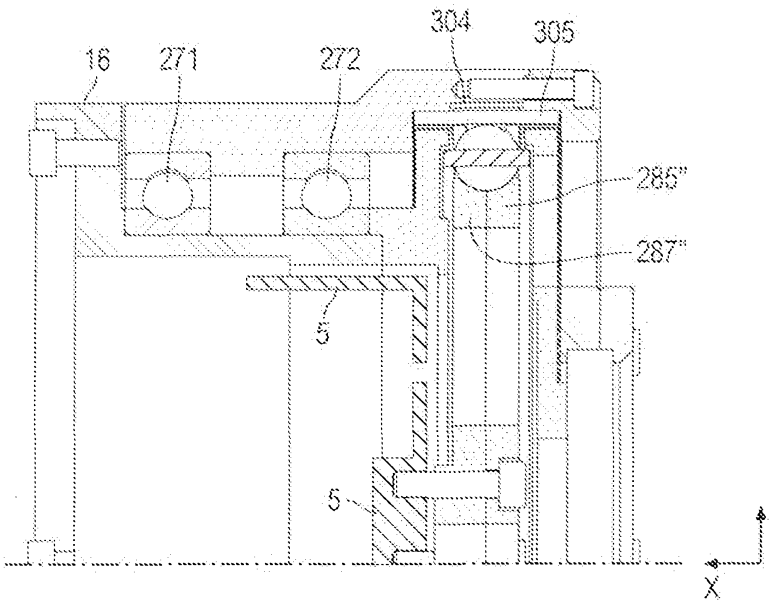

304
305
16
271
272
285"
287"
5
5
X

FIG. 42

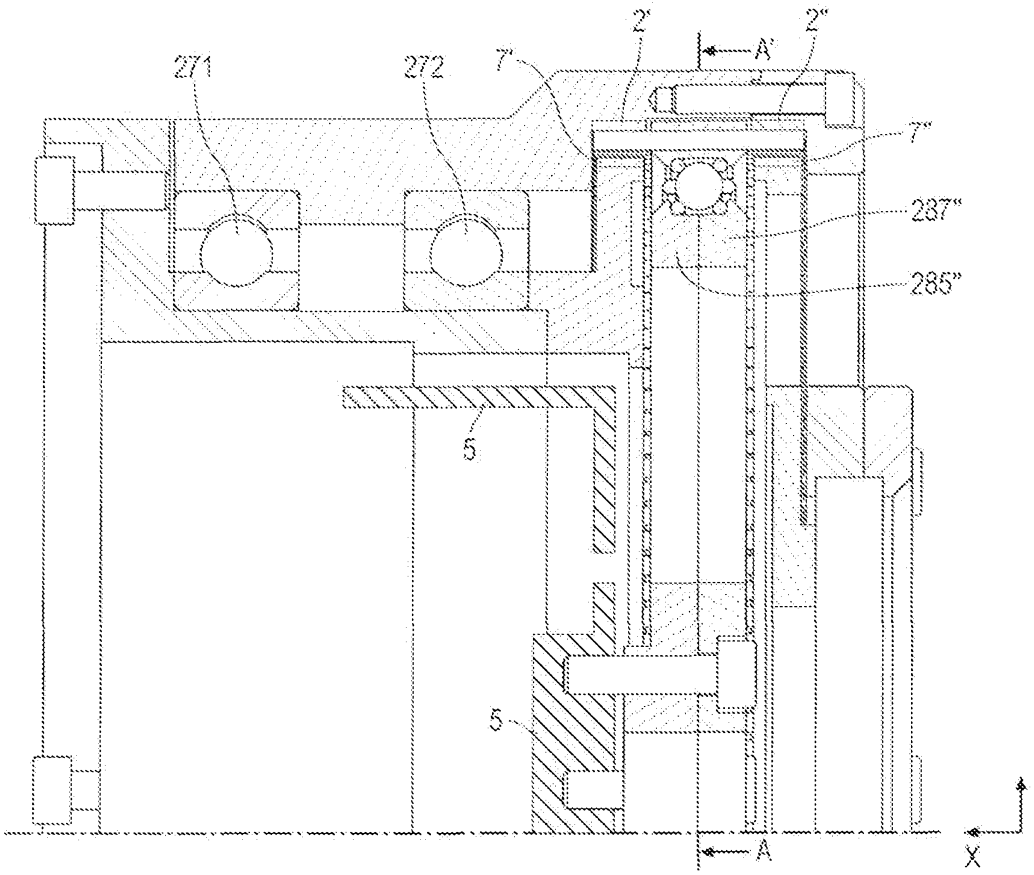


FIG. 43

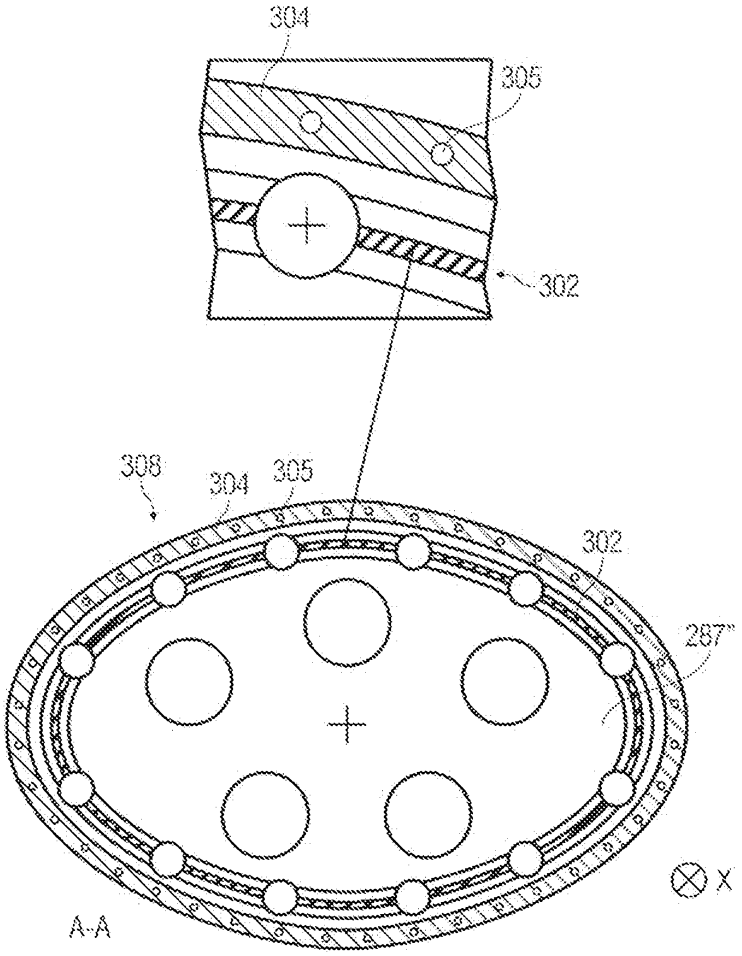


FIG. 44

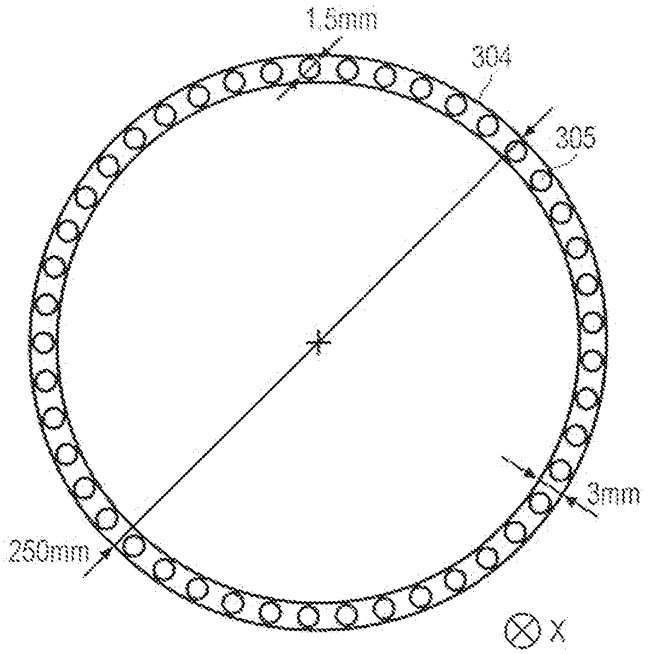


FIG. 45

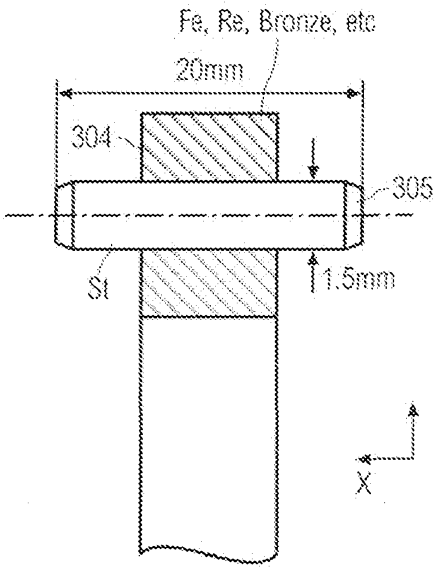


FIG. 46

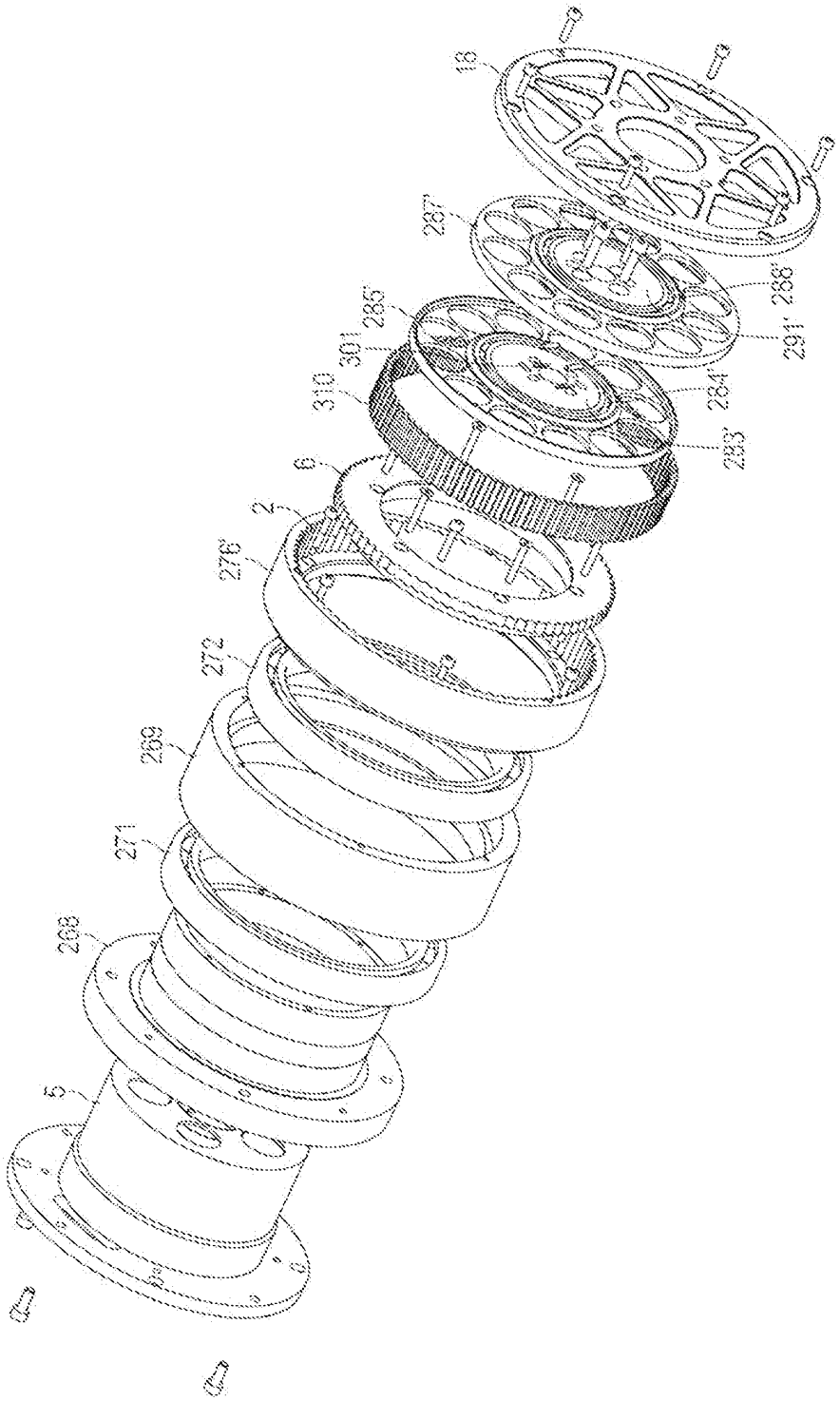


FIG. 47

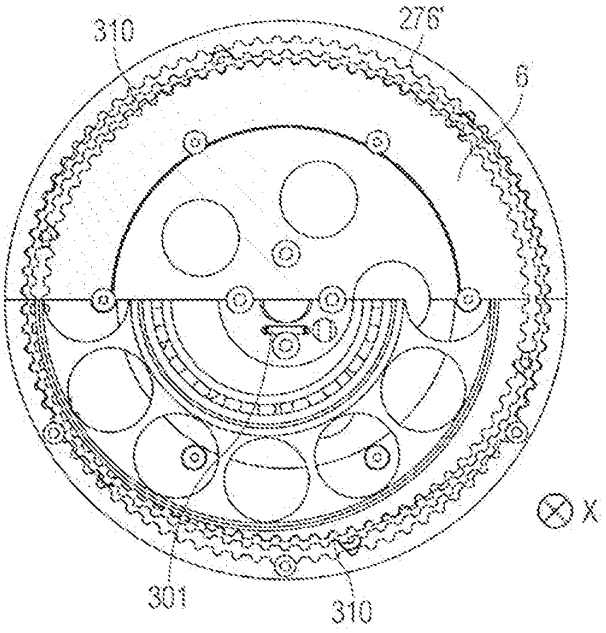


FIG. 48

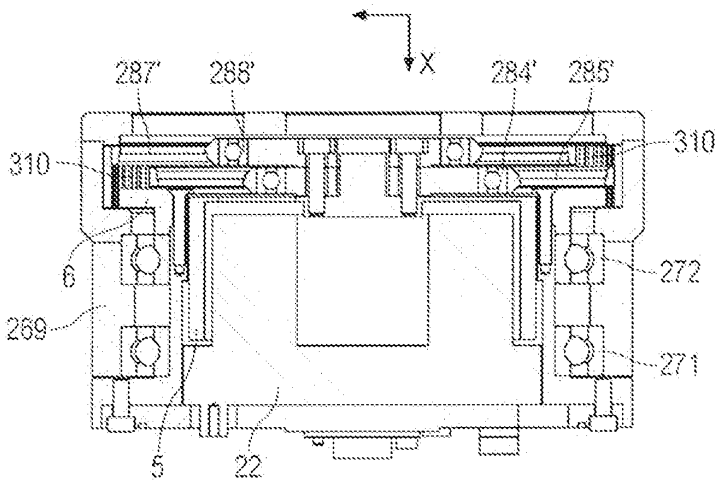


FIG. 49

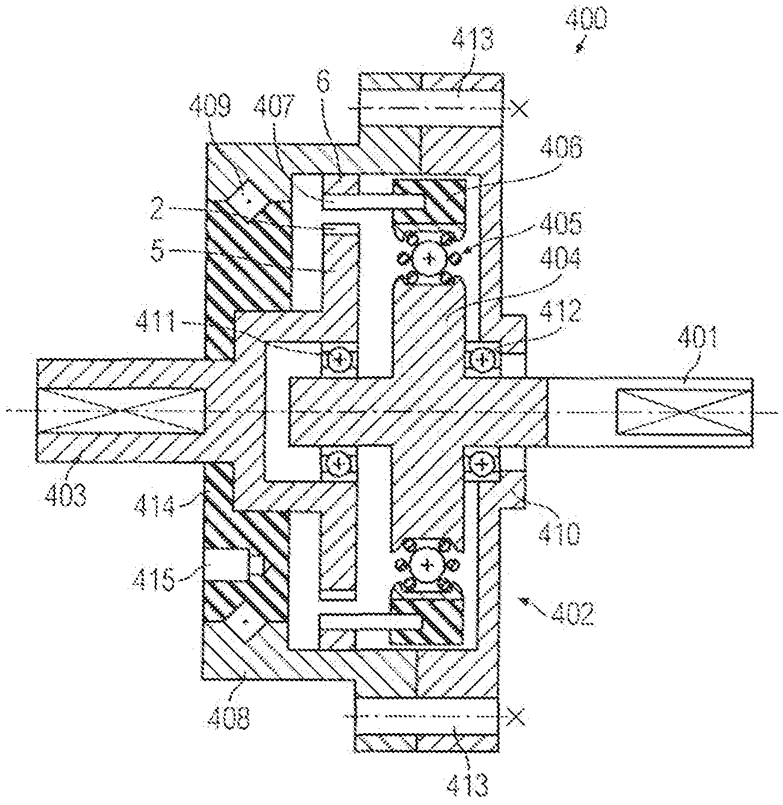

400
413
6
409
407
406
2
405
5
404
411
412
401
403
414
410
415
402
408
413

FIG. 50

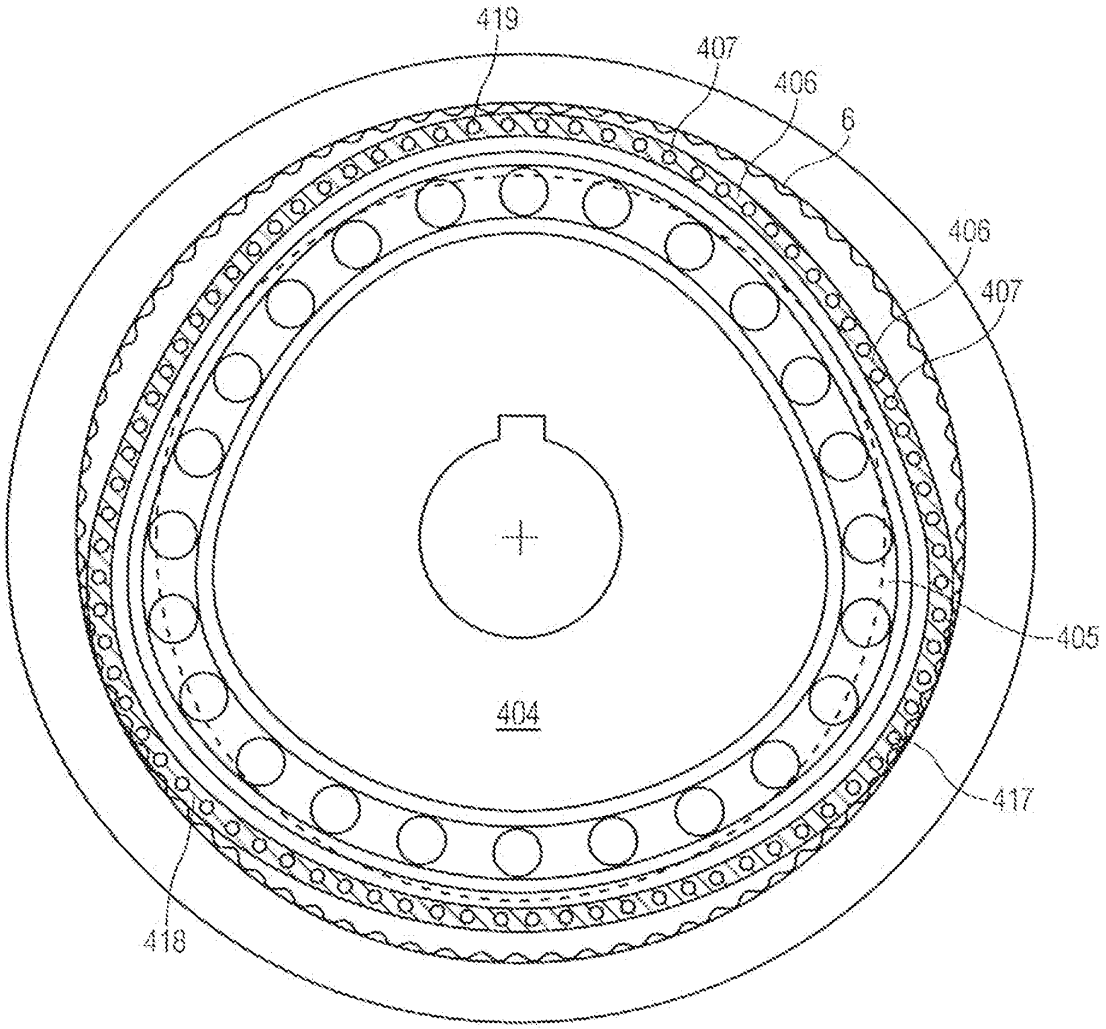


FIG. 51

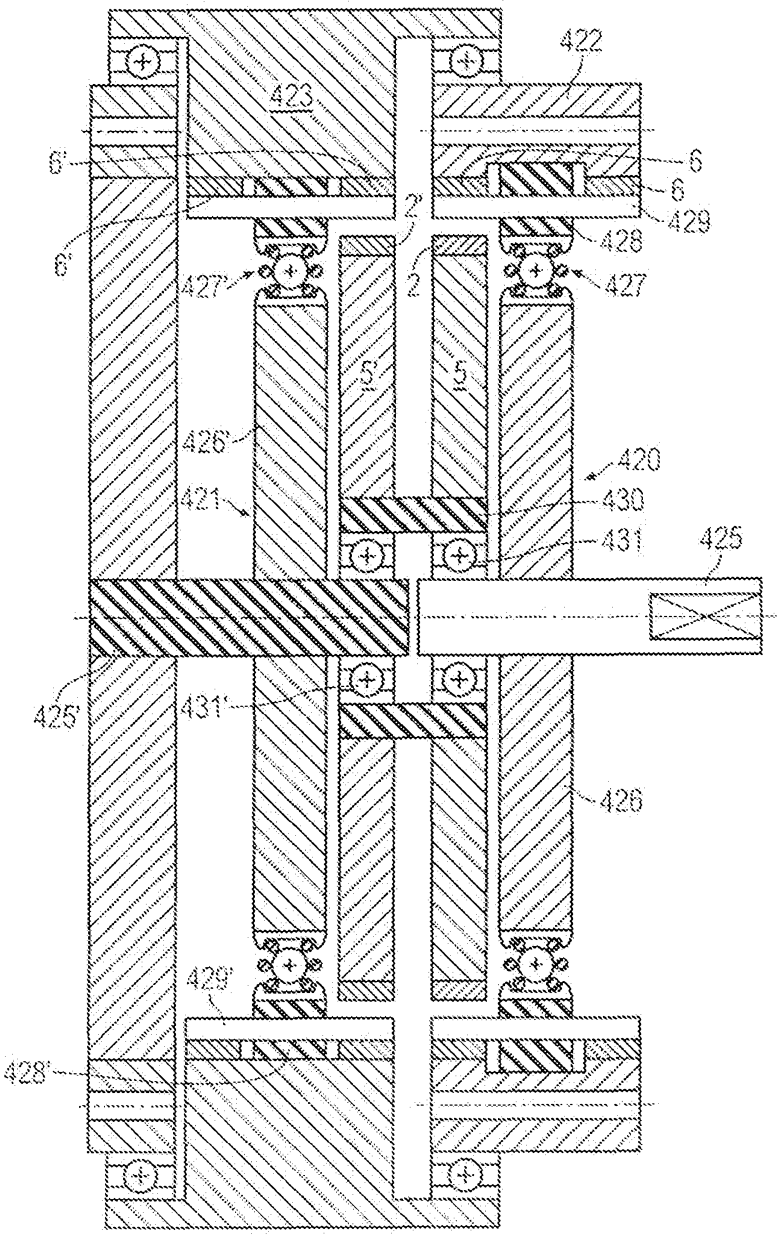

422
423
6'
6
6
429
2'
428
6'
427'
2
427
5'
5
426'
420
421
430
431
425
425'
431'
426
429'
428'

FIG. 52

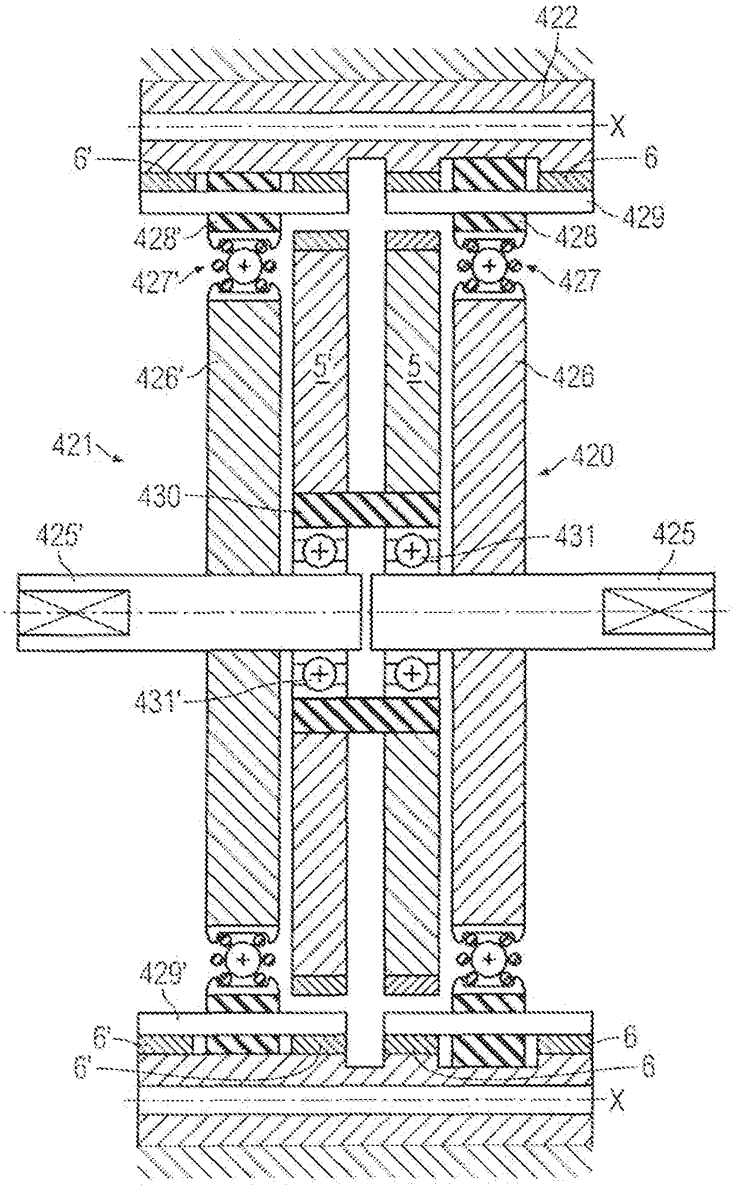

422
X
6'
6
429
428'
428
427'
427
426'
5'
5
426
421
420
430
431
425'
425
431'
429'
6'
6
6'
6
X

FIG. 53

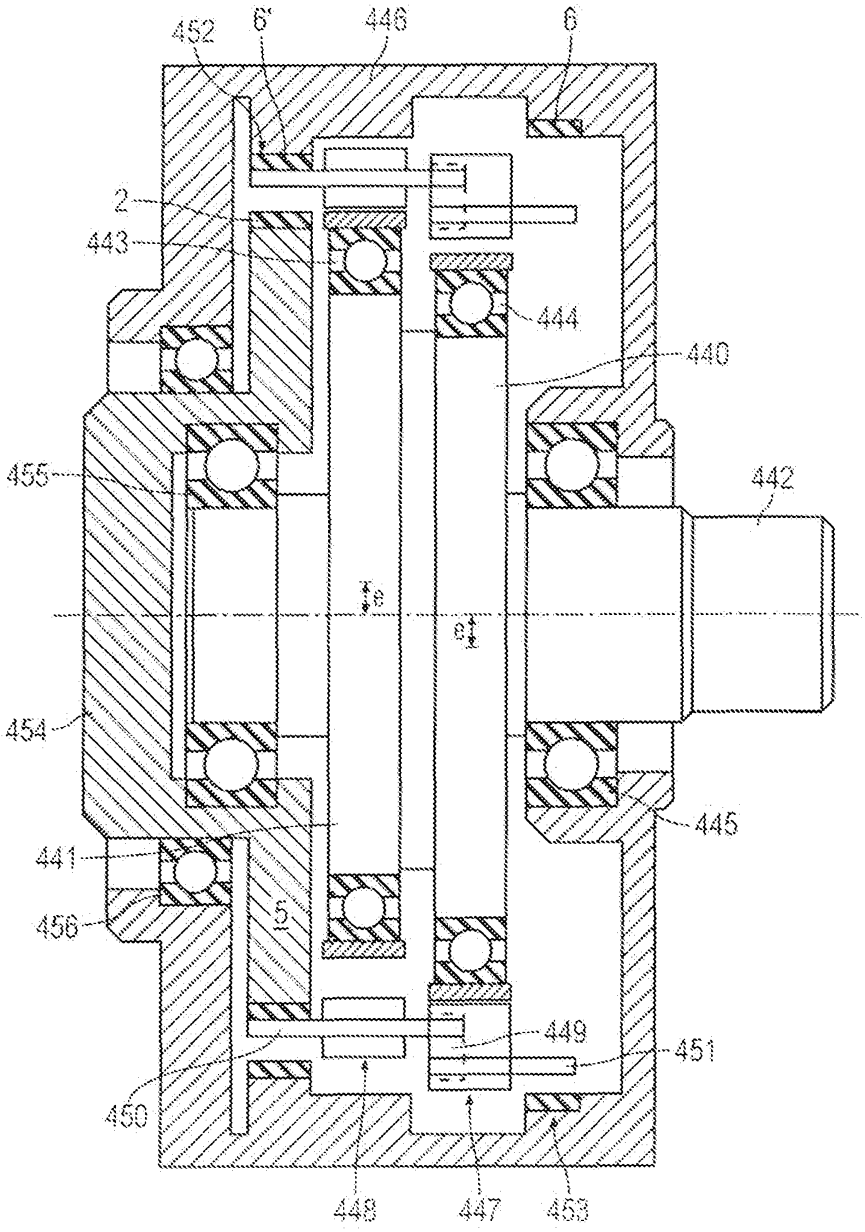

452
6'
446
6
2
443
444
440
455
442
454
445
441
456
5
449
451
450
448
447
453

FIG. 54

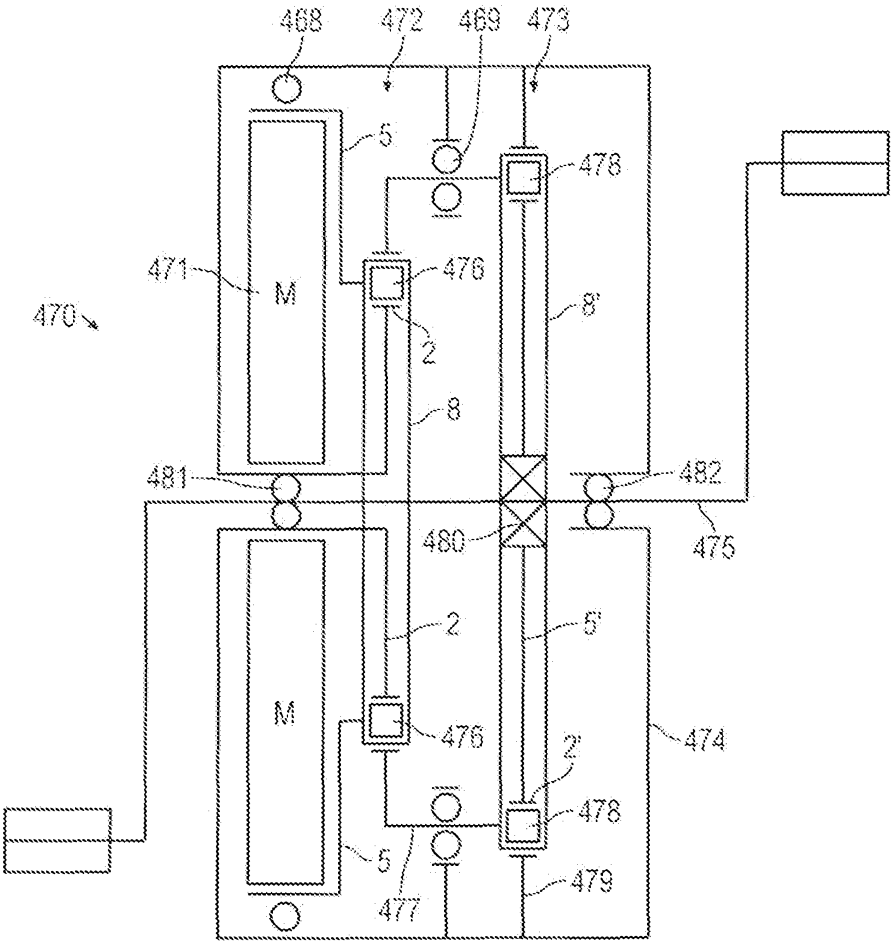

468
472
469
473
5
478
471
M
476
8'
470
2
8
481
482
480
475
2
5'
M
476
474
2'
478
5
477
479

FIG. 55

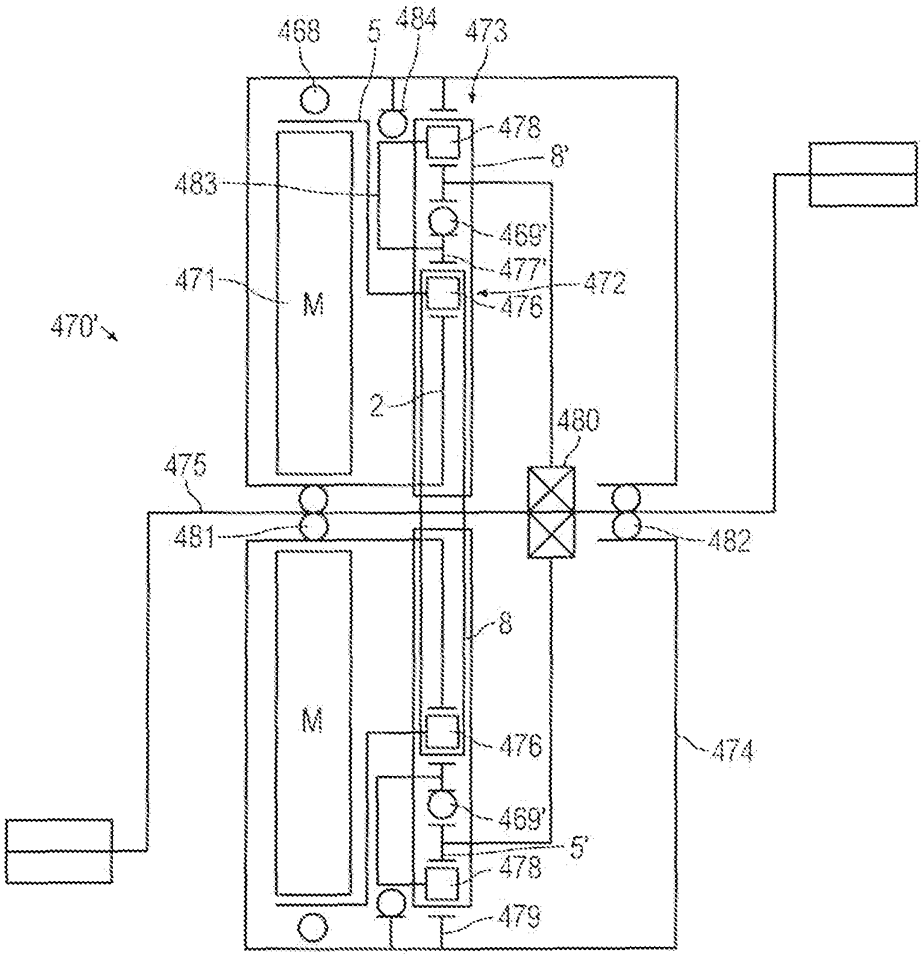

468
5
484
473
478
8'
483
469'
477'
472
471
M
476
470'
2
460
475
481
482
8
M
476
474
469'
5'
478
479

FIG. 56

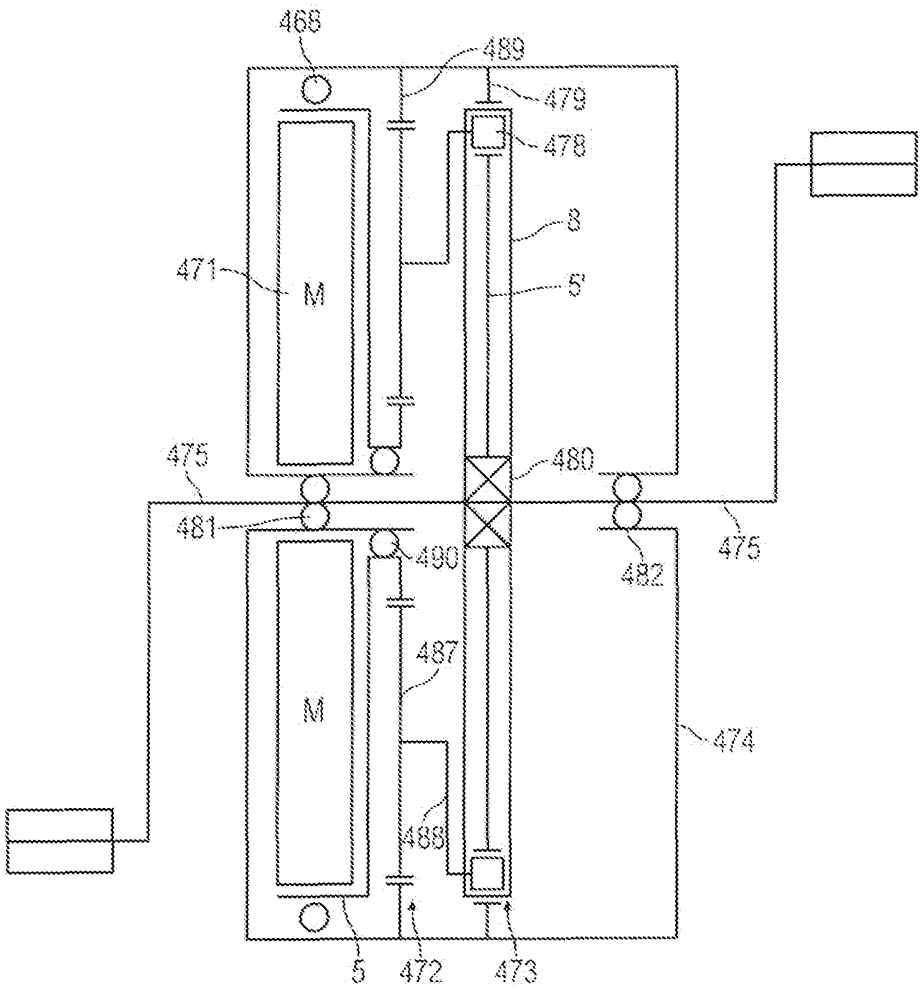
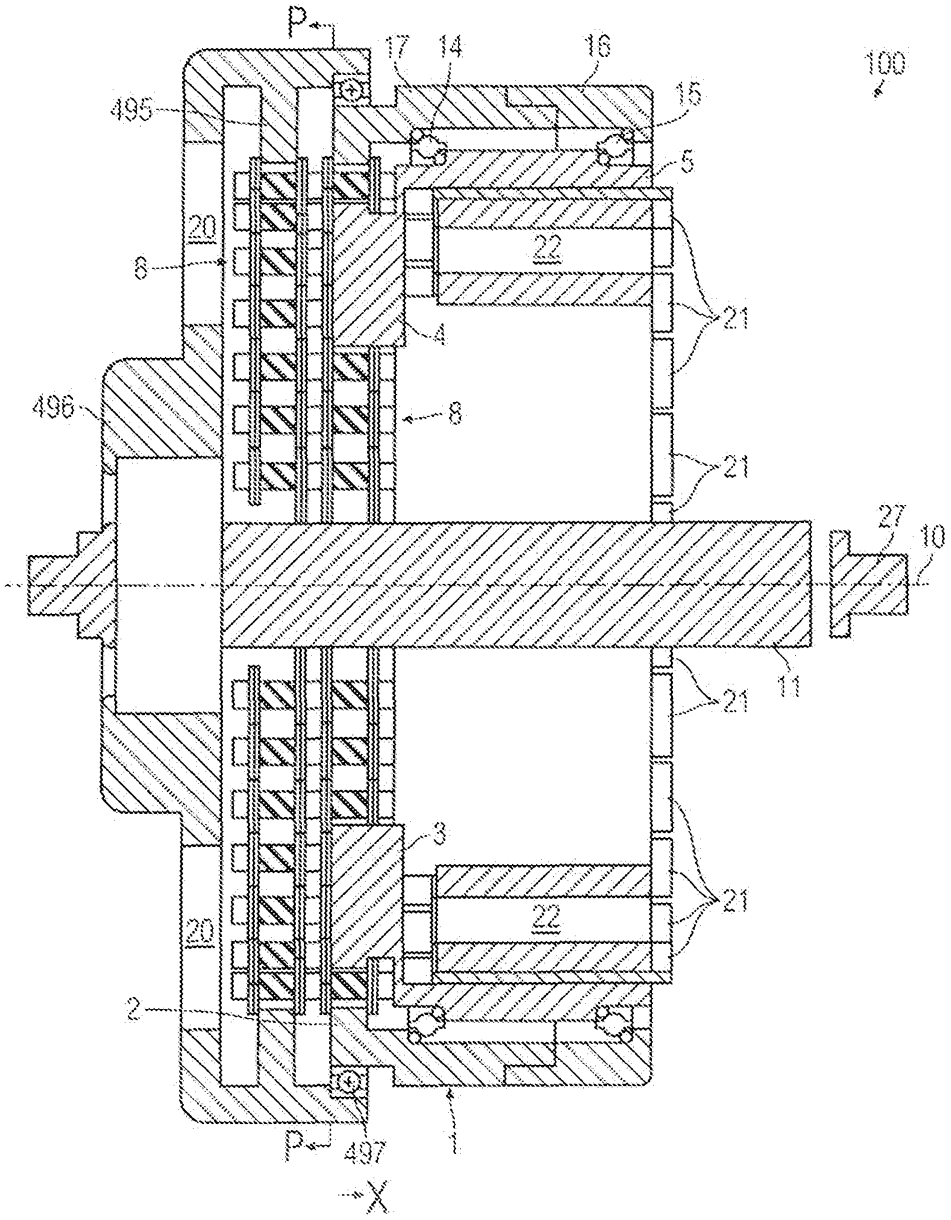

468
489
479
478
8
471
M
5'
475
480
481
490
482
475
487
M
474
488
5
472
473

FIG. 57


P
17
14
16
100
15
495
5
20
22
6
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4
496
8
21
27
10
11
21
3
21
22
20
2
P
497
1
X

FIG. 58

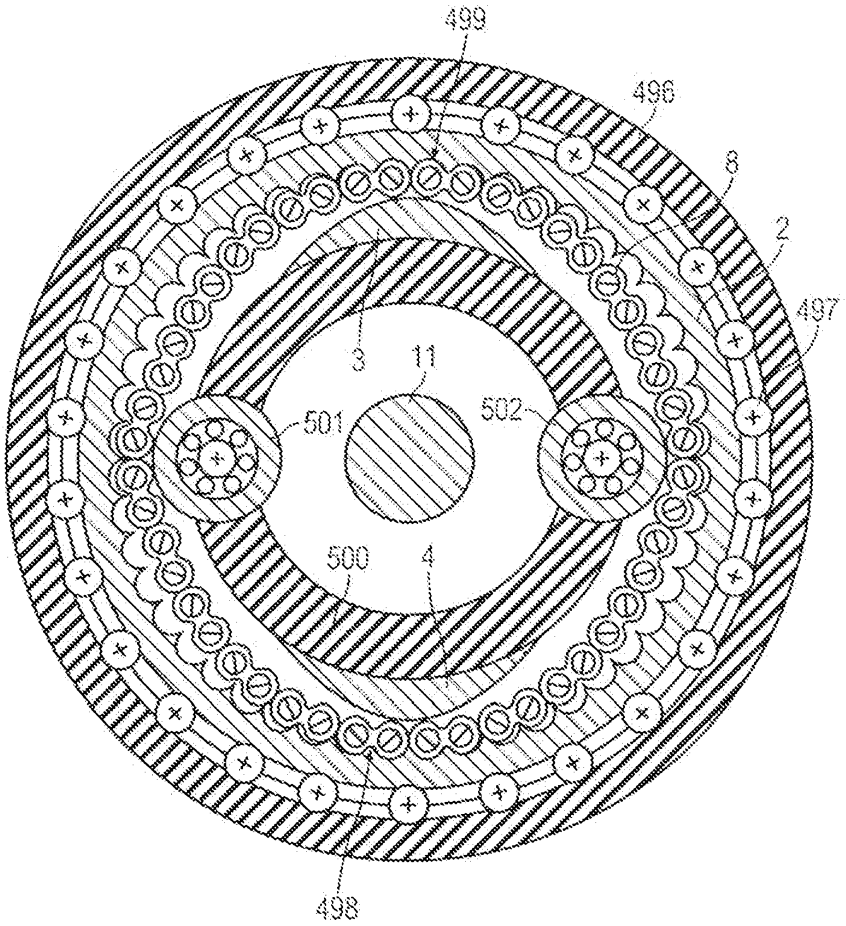

FIG. 59

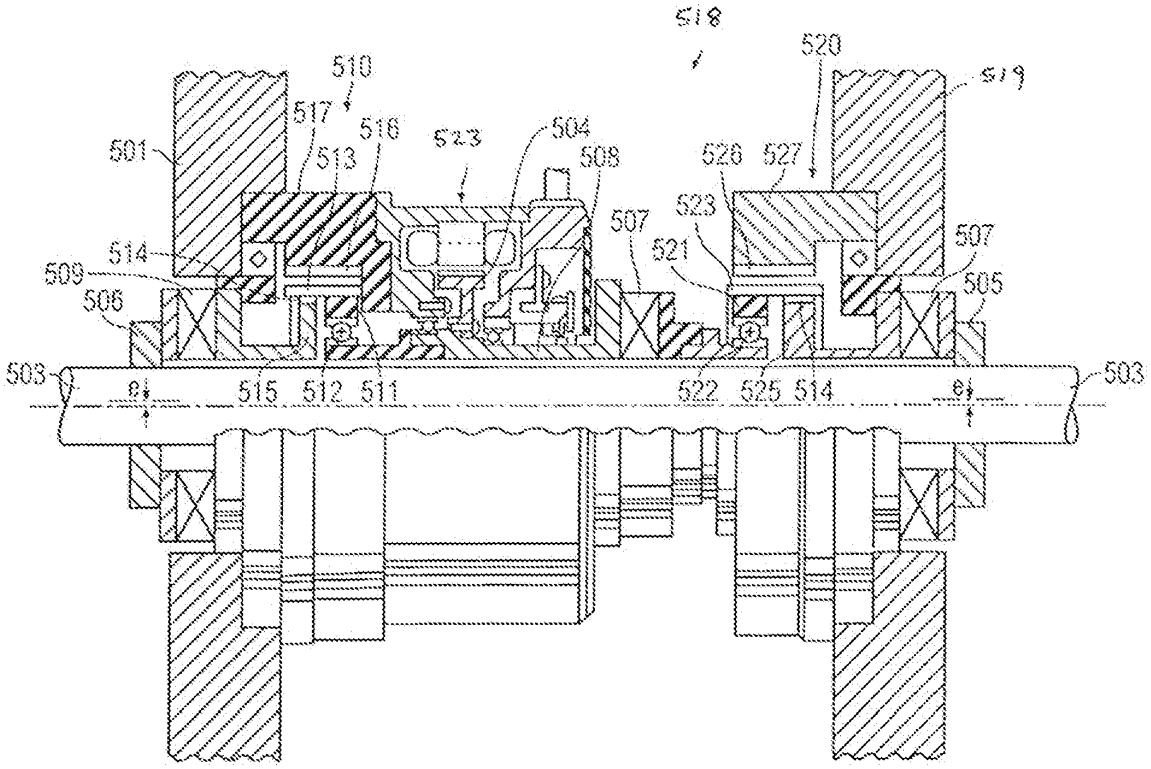
518
520
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FIG. 60

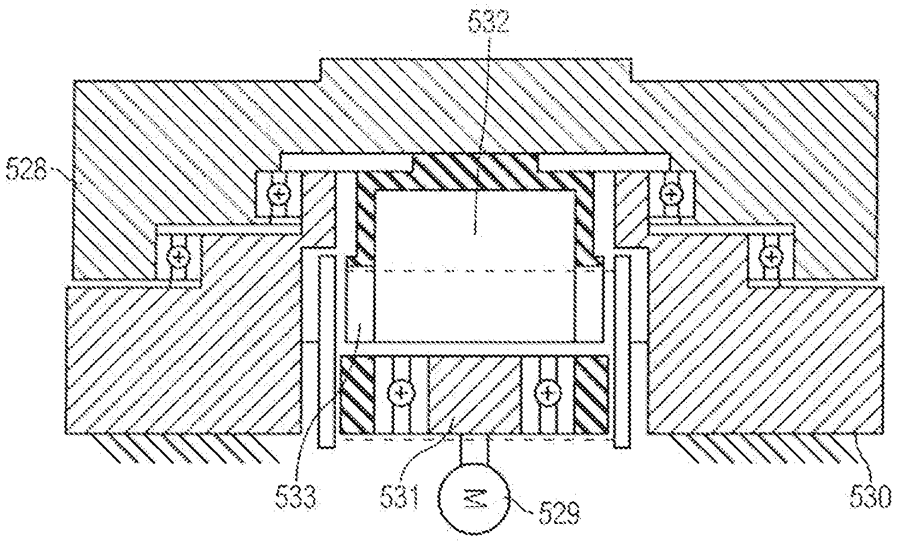


FIG. 61

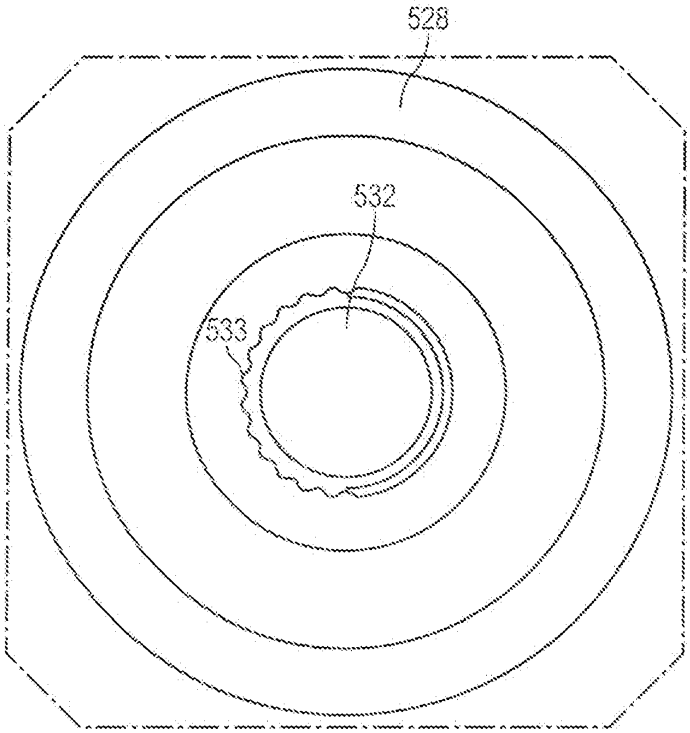


FIG. 62

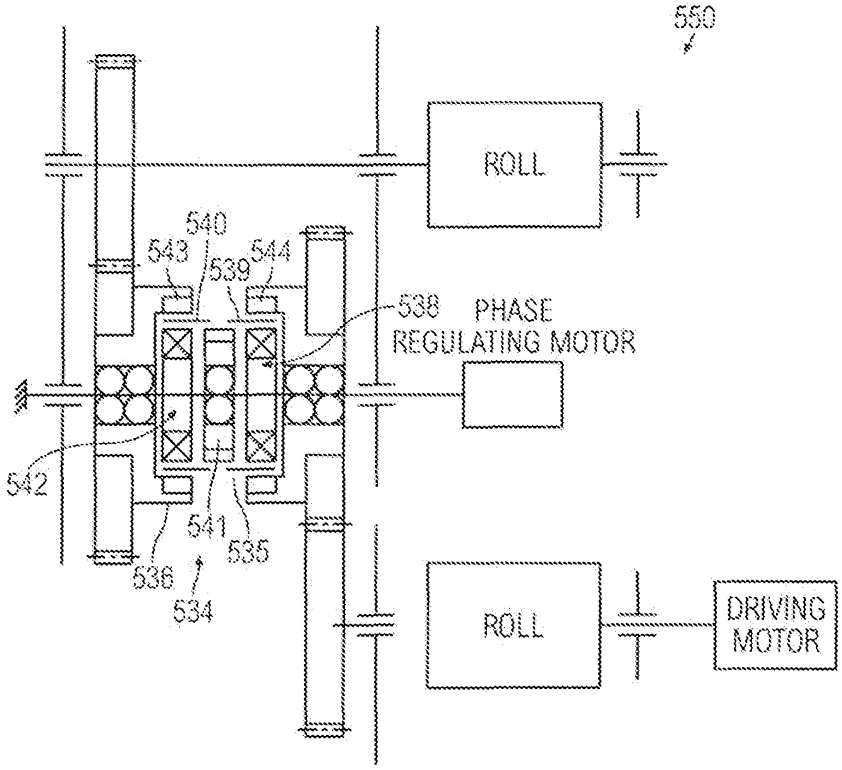

550
ROLL
540
543
539
544
538
PHASE
REGULATING MOTOR
542
541
535
536
534
ROLL
DRIVING
MOTOR

FIG. 63

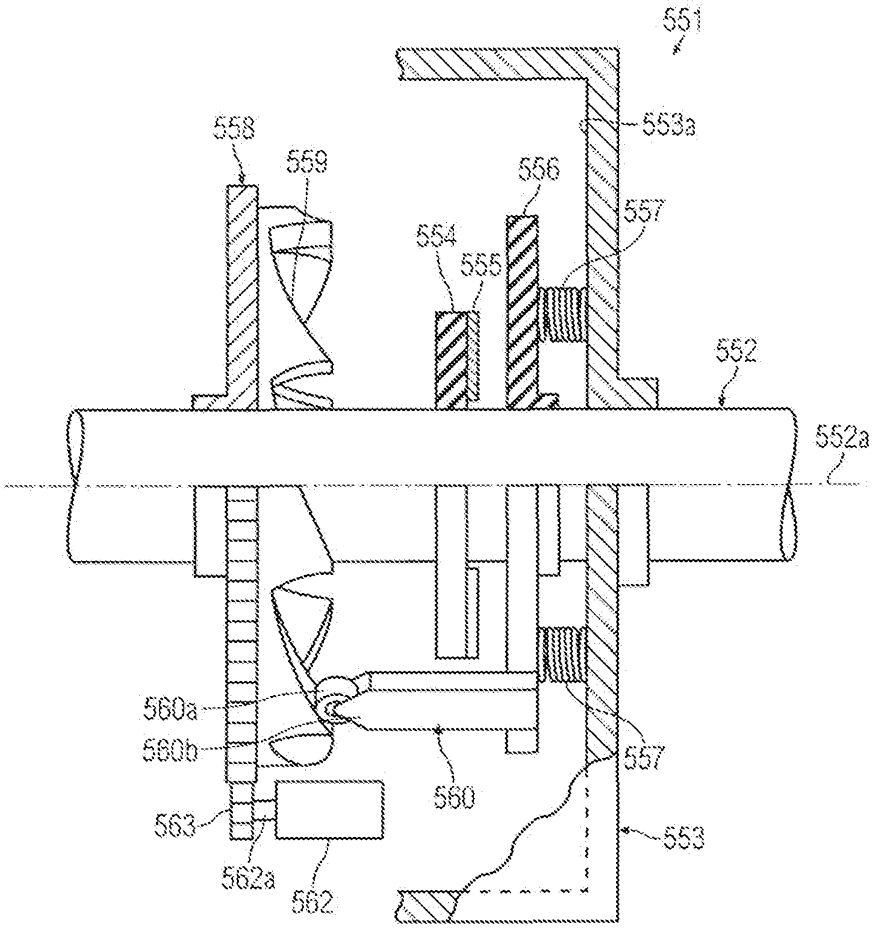

551
553a
558
559
556
557
554
555
552
552a
560a
560b
560
557
563
562a
562
553

FIG. 64

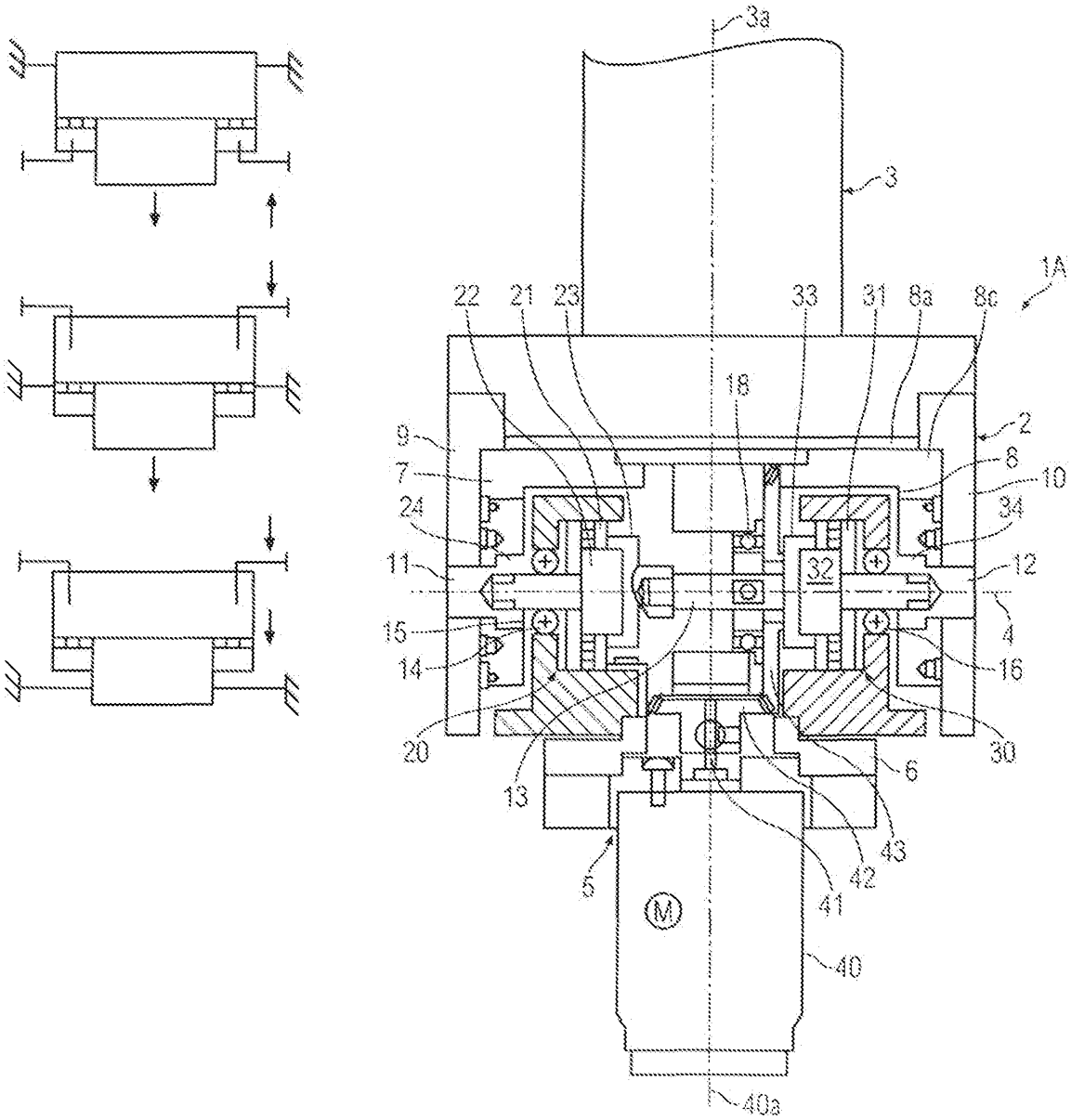

3a
3
1A
22
21
23
33
31
8a
8c
18
2
9
8
7
10
24
34
11
32
12
4
15
16
14
20
30
6
13
43
42
5
41
M
40
40a

FIG. 65

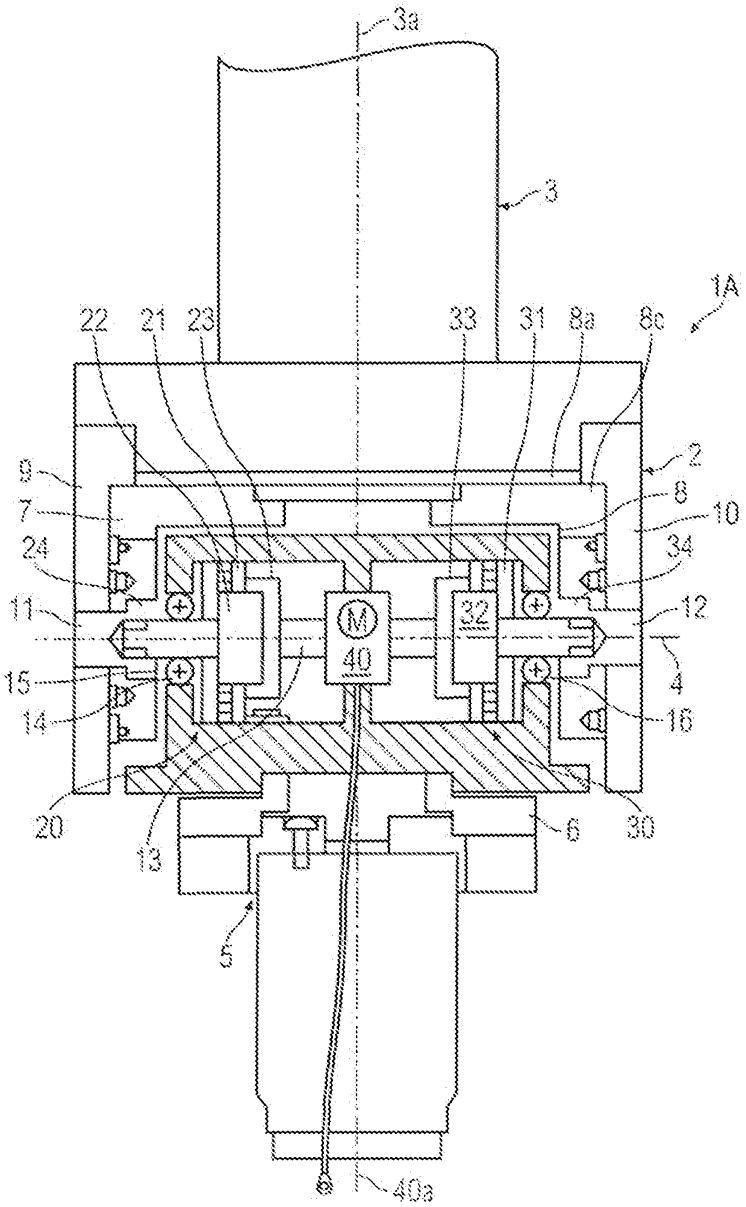

3a
3
1A
22
21
23
33
31
8a
8c
2
9
8
7
10
24
34
11
M
40
32
12
4
15
14
16
20
13
6
30
5
40a

FIG. 66

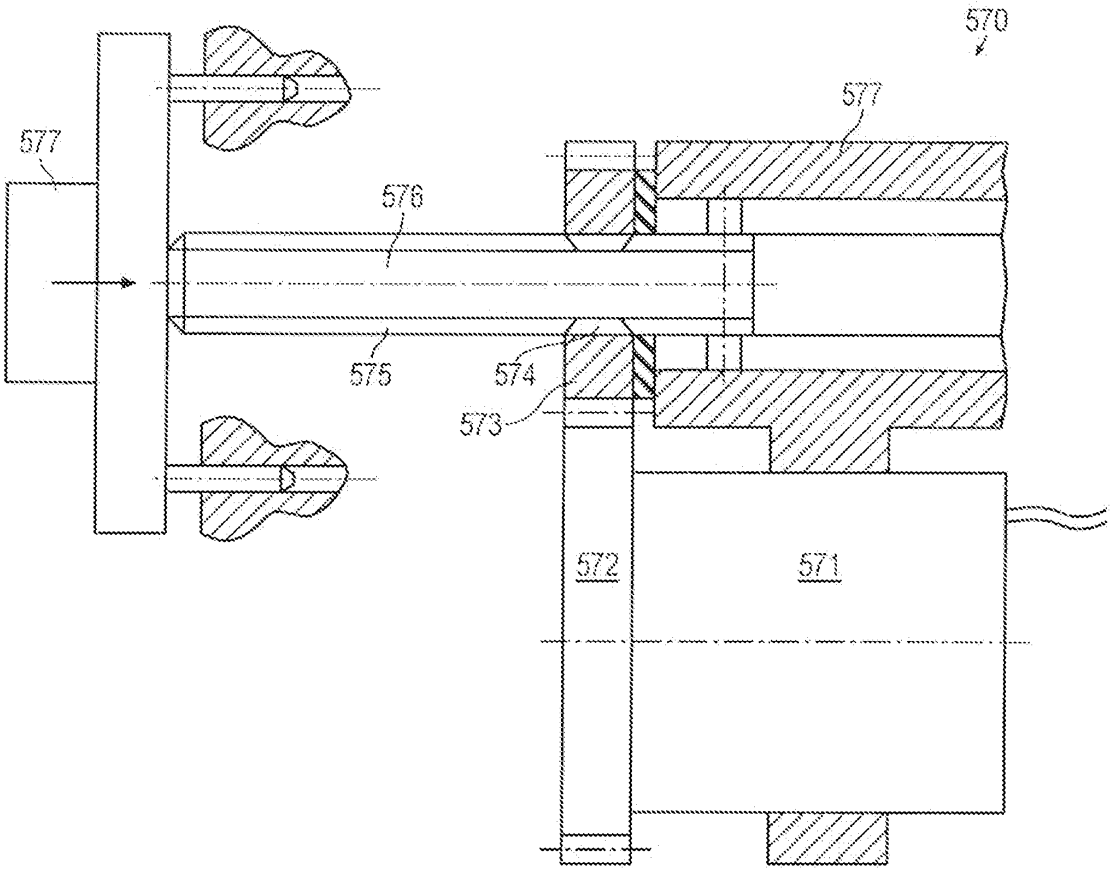
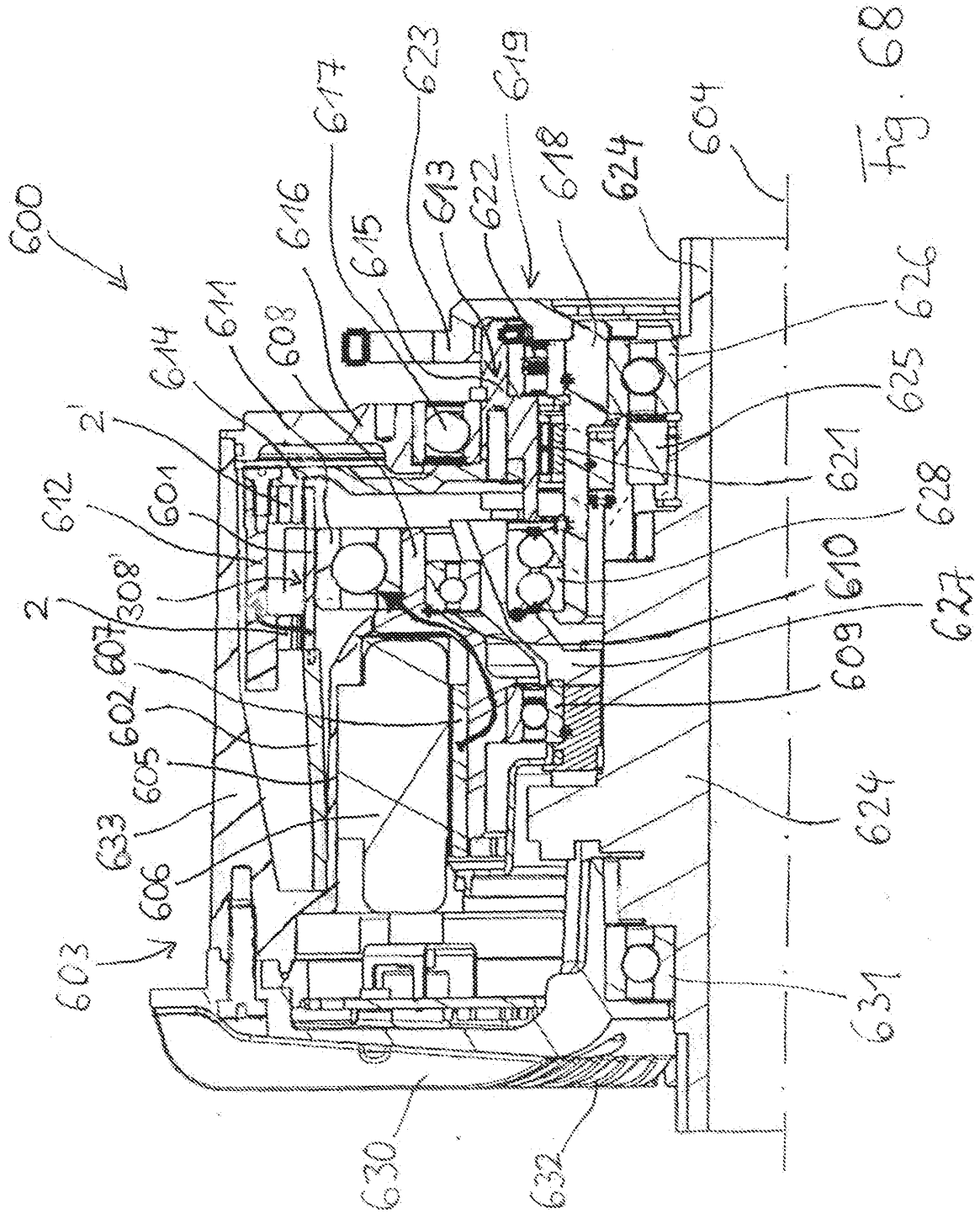


FIG. 67


600
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631
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633
2
2'
308'

Fig. 68

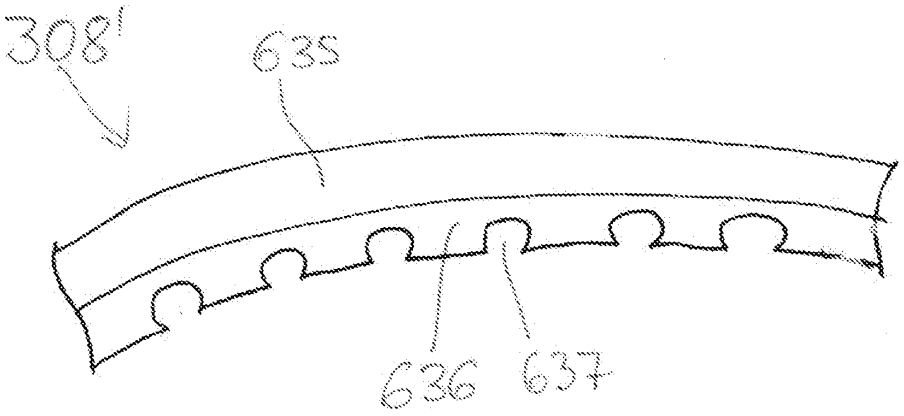

Fig. 69

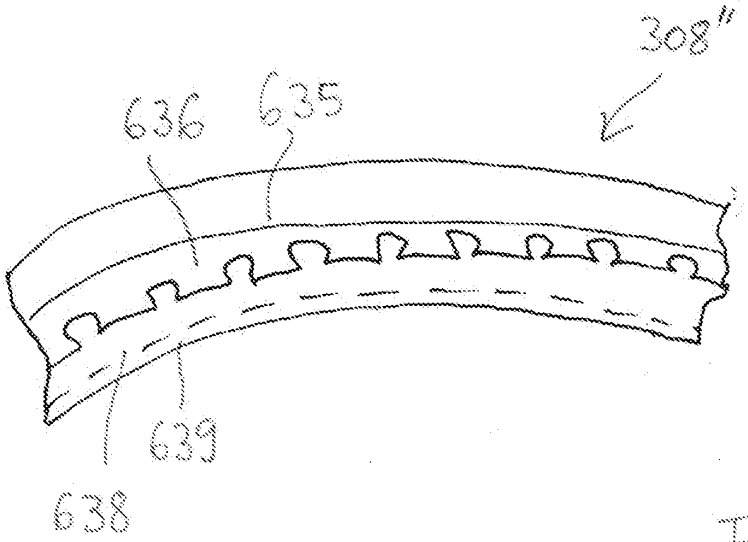

Fig. 70

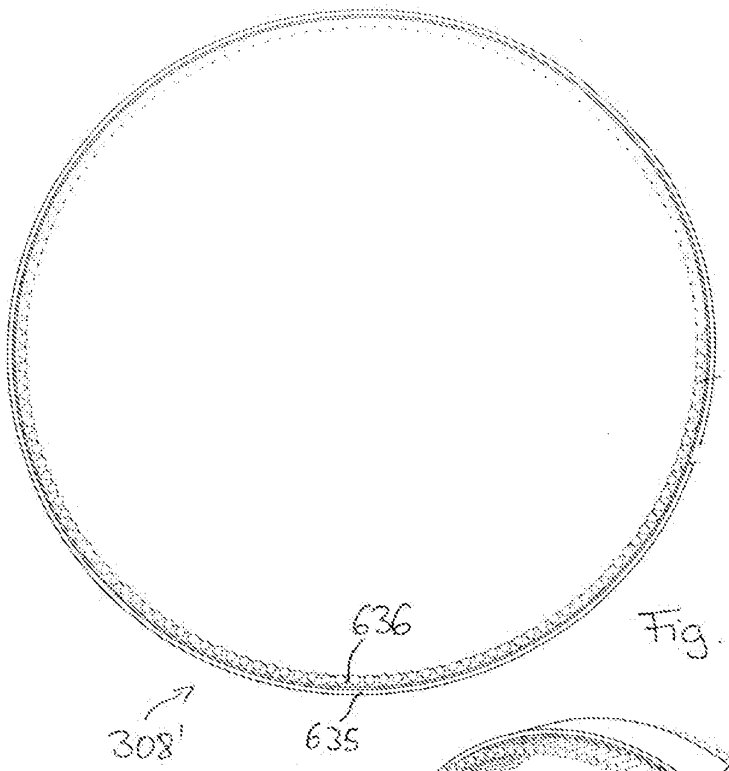

Fig. 71

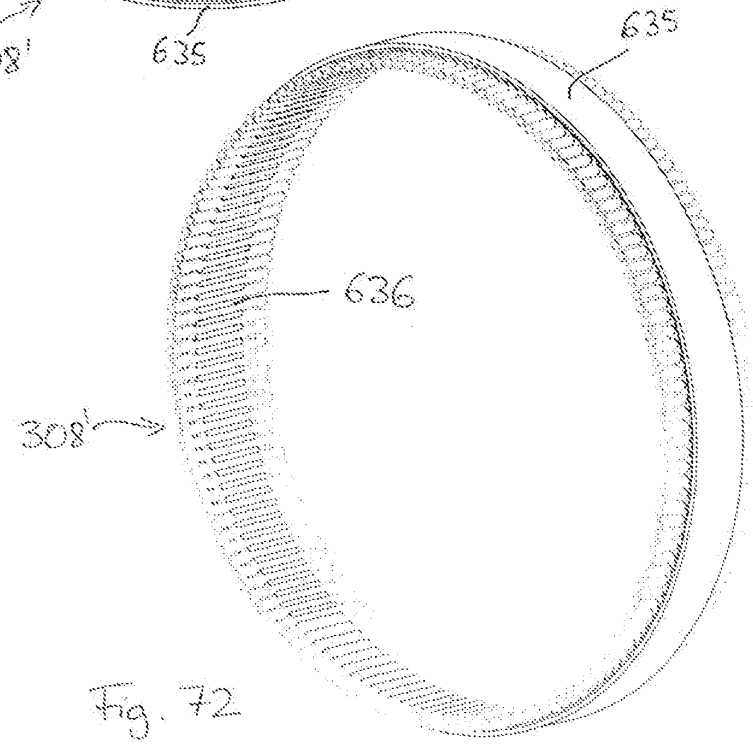

Fig. 72