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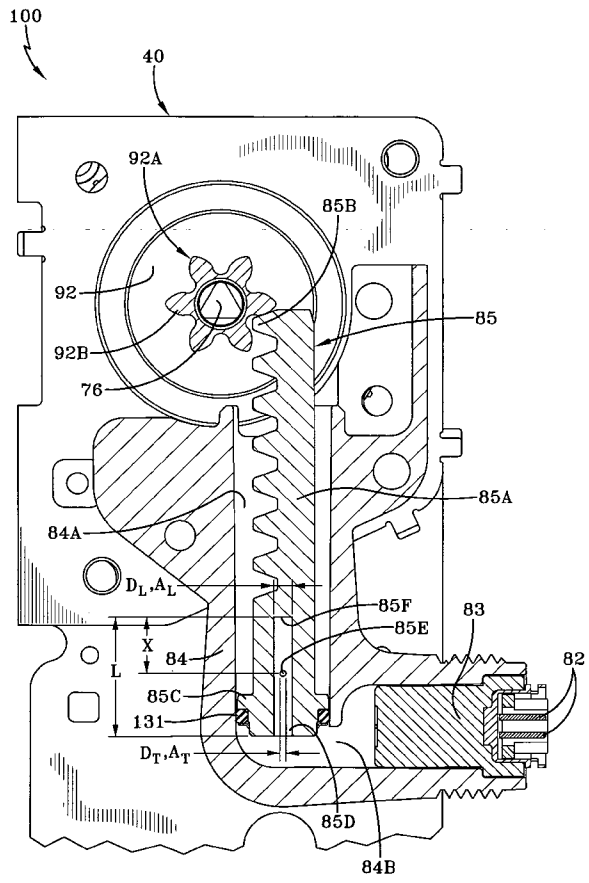
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[Continued on next page]

(54) Title: SEAT BELT RETRACTOR WITH A SEAT BELT PRETENSIONER



FIG−9A

(57) Abstract: A seat belt retractor (100) has a seat belt pretensioner (80) and an energy absorption device (76). The seat belt pretensioner (80) comprising a pyrotechnic device (83) for generating gas (300) that exerts pressure when a vehicle is in emergency situation. A piston (85) is received in and movable within a vertical portion (84A) of an internal chamber of the pretensioner housing (84) and is moved by the pressure exerted by the gas (300). A venting mechanism has a gas passageway in the piston (85) for exhausting the gas (300) from a space filled with the gas to the vertical portion (84A) of an internal chamber of the housing (84) above a sealed end portion (87C) of the piston (85). The gas passageway having a vertical portion (85D) extending in a vertical direction inside the piston (85) to a closed end (85F) and a transverse portion (85E) intersecting the vertical portion (85D) at a distance of at least 10 mm from the closed end (85F) of the gas passageway. A section of the vertical portion (85D) of the gas passageway between the transverse portion (85E) of the gas passageway and the closed end (85F) of the vertically extending portion (85D) of the gas passageway collects and entraps debris and particulate produced by the pyrotechnic device (83) thereby keeping the transverse portion (85E) of the gas passageway open and unobstructed during venting of the gas (300).

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SEAT BELT RETRACTOR WITH A SEAT BELT PRETENSIONER

The present invention relates to a seat belt retractor with a pretensioner.

Seat belt retractors respond to a crash in part by activating a pretensioner that quickly takes up the slack in the seat belt webbing to tightly secure a vehicle occupant. After the rapid tightening has occurred, it is desirable for an energy-absorbing torsion bar inside the seat belt retractor to at least partially relieve the restraining force on the vehicle occupant.

A typical seat belt pretensioner has a pyrotechnic device that generates a rapid rise in gas pressure to push a piston in a cylinder. These seat belt pretensioners are extremely reliable and very fast for removing slack in seat belt webbing. Once activated, the gasses trapped behind piston in the cylinder create an additional resistance to the proper functioning of an energy absorbing device such as a torsion bar, and thus impede the torsion bar's ability to allow the seat belt webbing to unwind properly.

EP 1 243 487 A2 and US 6 575 498 B2 both describe the problem of entrapped gasses from a pyrotechnic seat belt pretensioner. EP 1243487 A2 and US 6 575 498 B2 disclose ways of providing a gas venting mechanism that allows the gases to pass through the sealed end of the piston internally into a rack of the piston where it is vented or exhausted to relieve the gas pressure and to allow the energy absorbing device to perform its function without added resistance.

A problem in each of EP 1 243 487 A2 and US 6 575 498 B2 is the performance of the gas vents can be degraded or even stopped completely if the relatively small vent passages become blocked. In EP 1 243 487 A2 the end of the piston has a very small orifice and the gasses must first pass through that to thereafter expand prior to venting. The use of a pyrotechnic device produces a gas mixture having burnt particulates or metal debris that can partially block or even occlude the entire opening. This can create a degree of unreliability that is unacceptable in such a device.

In US 6 575 498 B2 larger diameter openings are used to create vent passageways, but these require the use of air or gas barricades or plugs to

insure not too much gas is vented prior to initiating movement of the pretensioning piston. These barricades or plugs must be removed from the passages to allow venting. The complexity and timing issues of such a system add to more reliability issues.

The need to reliably exhaust gas to allow the piston to move back down the chamber as the energy absorbing torsion bar tries to allow the seat belt webbing to unwind is critical. The gas venting ideally should occur automatically without requiring additional components and debris blockages of the vent passages must be prevented. The seat belt retractor disclosed herein solves these problems.

FIG. 1 is a perspective view of a seat belt retractor according to the present invention.

FIGs. 2A and 2B are exploded views of the seat belt retractor of FIG. 1.

FIG. 3 is a cross sectional view of the seat belt retractor showing the linearly moveable clutch mechanism in the pre-engagement location.

FIG. 4A is a cross sectional view of the seat belt retractor showing the linearly moveable clutch mechanism prior to engaging an over-clutch.

FIG. 4B is a cross sectional view of linearly moveable clutch plate engaged to the over-clutch wherein the clutch plate is pushed into contact with an end of the spool containing a locking means comprising a plurality of spring loaded balls adapted to lock into recesses in an end of the over-clutch.

FIG. 5A is an enlarged exploded view of the spool and clutch mechanism.

FIG. 5B is a second enlarged exploded view of the spool and clutch mechanism from another perspective showing the other side of the various components.

FIG. 6 is a perspective view of the clutch mechanism with the one cover removed.

FIGs. 7A and 7B show the spool and clutch mechanism, FIG. 7A showing the rotation to engage the over-clutch and spool, while FIG. 7B shows the opposite rotation causing a disengagement of the clutch from the over-clutch and spool.

FIG. 8 is a perspective view of the seat belt retractor with a seat belt pretensioner attached to the retractor frame.

FIG. 9A is a cross sectional view of the seat belt retractor taken along line 9A - seat belt 9A of FIG. 8.

FIG. 9B is the cross sectional view of FIG. 9A after the seat belt pretensioner has been activated.

A seat belt retractor 100 has a frame 40 that holds a spool 50 between two opposing sides 41, 42 of the frame 40. At the left hand side of the seat belt retractor 100 is a biasing spring mechanism 60 that includes a spirally wound biasing spring 62 that provides a bias to the seat belt retractor 100 so that the seat belt (not shown) is always biased toward a wound up position. As a vehicle occupant operates the seat belt by pulling on the seat belt, the spool 50 rotates and the seat belt is pulled outwardly increasing the tension on the biasing spring 62. Interposed between the biasing spring mechanism 60 and shown also on the lower left hand side 41 of the frame 40 is a seat belt pretensioner 80.

At the right side 42 of the frame 40 of the seat belt retractor 100 an outer dust cover 70 is shown that covers a spool locking mechanism of known construction that includes an inertial vehicle sensor and web sensor. The locking mechanism includes a lockcup 74 that is rotationally supported on an axle such as a portion of the torsion bar. The lockcup 74 supports a housing 71 which supports a moveable weight sensor or mass 72. The locking mechanism includes a locking pawl 73 rotationally mated with a frame side 42 and a lock wheel as well as other known components with which the spool 50 can be locked from further rotation in a belt protraction direction during periods of high vehicle deceleration and/or periods of rapid protraction of the seat belt from the spool. Interposed between the dust cover 70 and the seat belt retractor frame 40 is a two-piece clutch housing 29A, 29B that contains a clutch mechanism 10 that can be activated by an electric motor 30.

FIGs. 2A and 2B are exploded views of the seat belt retractor 100. At the upper portion of FIG. 2A a spirally wound biasing spring 62 is pre-wound using a prewinding clip 61 and is attached to the spring cover 66 which is

connected to the housing 63 in such a fashion that a biasing force is always applied to the spool 50 after the prewinding clip 61 is removed. The biasing spring mechanism 60 is connected to an end 76A of a torsion bar 76 by a spring arbor 65 in a known manner. The biasing spring mechanism 60 is then mounted and attached to the frame 40. In between the biasing spring mechanism 60 and the frame 40 is a clutch bracket 90 that holds a clutch housing 92, a locking pawl 94 an O-ring 96 and a retainer washer 98. A seat belt pretensioner 80 including a cap 81, a shorting clip 82, a pyrotechnic device 83 for generating gas and a housing 84 is illustrated. The housing 84 houses a rack 85, an O-ring 86 and a push retainer 87 that are connected to the frame 40 of the seat belt retractor 100 such that during a crash, the pyrotechnic device 83 can be ignited and the rack 85 will engage the clutch housing 92 which drives end 76A of the torsion bar 76 causing a rapid rotation of the spool 50 thus pretensioning the attached seat belt.

In the lower portion of FIG. 2A, on the left hand side of the seat belt retractor frame 40 is a bushing 78, a toothed pilot wheel 77, the torsion bar 76 that extends on one side through a pilot wheel and extends on another side to the lockcup 74. A thrust washer 75 is received on the torsion bar an inertia disk 79 which is part of the weight sensor 72, a calibration spring 210, a return spring 204, a blockout cam 206 and an activation disk 105 vehicle sensor pawl 73, a housing 101 connected by a pivot pin 106. A pin 202, lockbar 201 and wire 200 are shown along with a web sensor pawl 203, a calibration spring 210 and return spring 204, an activation disk 205, blockout cam 206 and other miscellaneous elements 207, 208, 209 are shown, some of which are optional accessories not required in using the present invention per se, but are illustrated to show the entire seat belt retractor 100. These elements are commonly used in seat belt retractors to provide a way of locking the spool 50 during a rapid seat belt protraction and rapid vehicle deceleration which would cause the web sensor to activate or the sensor weight 72 to tip causing the sensor pawl 73 to pivot which initiates the locking of the spool 50 which is not free to rotate relative to the torsion bar 76 and any applied force on the torsion bar 76 could be absorbed thereby.

An electric motor 30 is attached to the lower portion of the seat belt retractor 100 and is encased in a motor sleeve 31. The electric motor is also attached to the clutch mechanism 10 that is encased within a first clutch cover portion 29A and a mating second clutch cover portion 29B. The drive axle 32 of the electric motor 30 is attached to a pinion gear 33 which drives cluster and idle gears 35, 36, 37 each cluster gear 36 and idle gears 35, 37 are mounted and physically attached through the cover portions 29A to the frame side 42 using cluster and idler pins 38. The pins 38 are then engaged using the screws 39. These gears 33, 35, 36, 37 connected directly to the electric motor 30 are connected to a ring gear 34 of the clutch mechanism 10 which is coaxially aligned with the axis of rotation R of the spool 50. In FIGs. 2B, 5A and 5B, the ring gear 34 has a plurality of recesses 110 on an inner diameter into which protrusions 111 on a tubular shaped cylindrical ring 20 is pressed, this cylindrical ring 20 has an outside diameter with a helical thread 21 shown on its outer surface. Attached to the cylindrical ring 20 is a clutch plate 12 having an inside diameter with a complimentary helical thread 11 that mates to the cylindrical ring 20 in such a fashion that as the ring gear 34 is turned by the motion of the electric motor 30. The clutch plate 12 can move along and be moved by the helical thread 21. This is made possible by the use of a drag wire 8 wrapped around the outer circumference of the clutch plate 12 as shown in FIG. 6. The drag wire 8 is a spring type device that provides frictional drag on the clutch plate 12. When assembled into the clutch cover portions 29A, 29B as shown in FIG. 4A, the drag wire 8 is not free to rotate as the ring gear 34 and cylindrical ring 20 rotate. The clutch plate 12 will be driven inwardly absent any rotational motion until it approaches the end of the helical thread 21 of the cylindrical ring 20 in which fashion it will then initiate an increased torsional force which overcomes the drag friction on the drag wire 8 and enables the clutch plate 12 to rotate freely inside the drag wire 8. As a portion of the drag wire 8 is being moved linearly inward and by the forward motion of the electric motor 30 an over-clutch 14 is engaged as shown in FIG. 4B. The over-clutch 14 has a plurality of recesses 16 shown in FIG. 5A on a first side 14A of the over-clutch 14, as the clutch plate 12 approaches it, teeth 13 on the

clutch plate 12 engage these recesses 16 in such a fashion that the clutch plate 12 continues to move towards the spool 50 until the teeth 13 of the clutch plate 12 are fully engaged within the arcuately elongated recesses 15 of the over-clutch 14, as the over-clutch 14 is then rotated along with the spool 50 by the clutch plate 12. In FIGs. 3 and 5B the spool 50 has an end 51 with a plurality of holes 52 adapted to accept an over-clutch springs 53 in each hole 52 and one of a plurality of ball bearings 54 is positioned between the over-clutch spring 53 and the over-clutch 14. On one side of the over-clutch 14 are a plurality of recesses 15 correspondingly aligned with the holes 52 in the end of the spool 50. Upon assembly to the spool 50 the over-clutch 14 has these recesses 16 are aligned with the holes 52 and the spring loaded ball bearings 54 are moved inwardly into the recesses 15 on the over-clutch 14 creating a locking engagement between the over-clutch 14, and the spool 50. The over-clutch 14 is held against the spool 50 by a retainer clip (not shown). When the spool 50 is rotated by the movement of the electric motor 30 in a direction to affect seat belt retraction, which is accomplished by rotation of the gears 33, 35, 36, 37 being connected to the ring gear 34 causes the clutch plate 12 to move linearly inward and engage the over-clutch 14 which are fixed to the spool 50 initiates rotation of the spool 50 to tighten the seat belt webbing.

The activation of the electric motor 30 can occur in many situations including non-crash situations to tighten a loose seat belt about a vehicle occupant or when a sensor indicates that a crash appears imminent and causes a signal to be sent to the electronic control unit 120 to activate the electric motor 30. In such a condition the seat belt will pretighten to ensure that the vehicle occupant is in a safe position and properly secured prior to impact. Should a crash occur which may be sensed by another sensor, the seat belt pretensioner 80 will activate to cause a significant increase in pretension forces to occur further driving the spool 50. The use of an electric motor 30 is provided in the event that a rapid vehicle deceleration is sensed wherein additional restraint of the seat belt and the vehicle occupant is desirable.

Engagement of the spool 50 occurs through a linear movement coaxial with the axis of rotation of the spool 50. Therefore the clutch plate 12 can

engage the spool 50 through the over-clutch 14 in such a fashion that it creates a secure locking system that is independent of the other mechanism throughout the retractor 100. Loads and overloads of the fragile plastic components used throughout the mechanism can be avoided in that a direct linkage is created between the spool 50 and the clutch mechanism 10 and gearing of the electric motor 30 are independent of the other mechanism. This ensures that the seat belt can be pretensioned, by the seat belt pretensioner 80 without unduly stressing any of the other components of the seat belt retractor 100. By reversing the electric motor 30, as shown in FIG. 7B, the seat belt can be unwound and the clutch mechanism 10 will revert back along the helical thread 21 of the cylindrical ring 20, such that as the clutch plate 12 pulls back away from the spool 50 and the pre-attached over-clutch 14 which enables the entire motor-clutch mechanism to disengage from the spool 50. The clutch mechanism 10 is isolated from the normal operation of the seat belt retractor in such a fashion that the electromechanical seat belt retractor can operate as a conventional seat belt retractor without any drag or resistance created by the motor or clutch mechanism 10. This ensures that none of the mechanical systems of a seat belt retractor need to be modified for the incorporation of the motorized clutch mechanism 10 and that there is no additional drag caused by the clutch 10 that is provided without interfering with the normal operation of the seat belt retractor. The entire clutch mechanism 10 is located inside the side 42 of the seat belt frame 40 and the mechanical weight sensing mechanisms are located inside the dust cover 70 that are normally attached to such a seat belt retractor.

In FIG. 8 the seat belt pretensioner 80 is shown attached to the frame 40 of the seat belt retractor 100. The seat belt pretensioner 80 has a cap 81 attached using threads. The cap 81 has an opening exposing a shorting clip 82 to which a wiring harness (not shown) can be attached. The shorting clip 82 is attached to a pyrotechnic device 83, also known as a gas generator, includes a propellant charge and an igniter squib as shown in FIG. 9A. The pyrotechnic device 83 is shown stored in a horizontal portion 84 B of the internal chamber of the housing 84. In a vertical portion 84A of an internal chamber of the

housing 84 is housed a piston 85. The piston 85 has an enlarged flanged end portion 85C with an O-ring seal 131 for engaging the walls of the vertical portion 84A of an internal chamber of the housing 84 in an air tight manner. A rack 85A extends outwardly from the flanged end portion 85C. On one side of the rack 85A there are a plurality of gear teeth 85B. The gear teeth 85B engage a pinion gear 92A that has gear teeth 92B that intermesh with the teeth 85B of the rack 85A when the seat belt pretensioner is activated to move the piston 85 along the vertical portion 84A of an internal chamber of the housing 84 causing the pinion gear 92A and the spool 50 to rotate to take up any belt slack. The end of the torsion bar 76, an energy absorbing device, is in the opening through the pinion gear 92A.

In FIG. 9A a vertically extending portion 85D of a gas passageway extends partially through the lower portions of the piston 85. This passageway extends a substantial distance into the rack 85A to a closed end 85F. The length of the passageway 85D is at least 20 mm and the cross sectional area A_L is generally uniform along the length L and is preferably at least 12.6 mm^2. As shown the cross section is circular with a diameter D_L of at least 4 mm.

A second passageway 85E intersects the vertically extending portion 85D of the gas passageway. The location of the passageway 85E may vary relative to the length of the vertically extending portion 85D of the gas passageway. The intersection is approximately halfway along the length of the vertically extending portion 85D of the gas passageway. The passageway 85E is an exhaust passageway and opens on at least one end thereof to the vertical portion 84A of an internal chamber of the housing 84 such that gasses produced by the pyrotechnic device can pass to reduce the gas pressure in the horizontal portion 84B of the internal chamber of the housing. The transverse vent 85E can pass through one or both sides of the rack 85A and the passageway 85E is very small in comparison to the cross-sectional area of the first passageway 85D. The total area A_T of one or two of the second passageway is less than 7% of the area A_L of the first passageway 85D. The cross-sectional area A_T is 0.8 mm^2 and is of a circular cross section having a

diameter D_T of about 1 mm when only one exhaust vent is used. The diameter D_T is less than 1 mm when two such passageways 85E are employed.

With reference to FIG. 9B, when the pyrotechnic device 83 is activated gas 300 pushes the piston 85 thrusting it upward into the vertical portion 84A of the internal chamber of the housing 84 causing the pinion gear 92A to rotate the spool 50 to remove slack in the seat belt webbing. Upon ignition of the propellant in addition to gas 300 from the propellant a small amount of solid debris 301 is created. This solid debris is propelled up into the vertically extending portion 85D of the gas passageway moving very rapidly past the transverse passage 85E and impacting in the closed end 85F of the vertically extending portion 85D of the gas passageway creating turbulence. The solid debris 301 is lodged at the end 85F of the vertically extending portion 85D of the gas passageway, at least during the time that gas is being generated by the pyrotechnic device 83, and as such the solid debris 301 tends not to block or impede the gas venting through the second transverse passageway 85E. The continued build up of gas pressure creates a blocking action holding the solid debris 301 against the closed end 85F as the gas 300 vents through the side or transverse passageway 85E. By providing a sufficiently large holding space in the volume of the vertically extending portion 85D of the gas passageway beyond the vertically extending portion 85D of the gas passageway, all the debris 301 is entrapped by the onflow of gas 300 trying to leave through the second transverse passageway 85E. In FIG. 9A, the gas venting second passageway 85E is located a distance X of at least 10 mm from the closed end 85F. Similarly the diameter of the vertically extending portion 85D of the gas passageway is at least 4 times greater than the diameter of the second transverse passageway 85E, resulting in an area difference wherein the area A_L is preferably about 10 times greater than the total area A_T.

CLAIMS:

1. A seat belt retractor (100) having a seat belt pretensioner (80) and an energy absorption device (76):

the seat belt pretensioner (80) comprising a pyrotechnic device (83) for generating gas (300) that exerts pressure when a vehicle is in emergency situation; a hollow cylinder for conducting the gas (300) from the pyrotechnic device (83); a piston (85) received in and movable within the a vertical portion (84A) of an internal chamber of the housing (84) and is moved by the pressure exerted by the gas (300), the piston (85) having a rack (85A) formed thereon and an end portion (87C) sealed by an O-ring (131) engaging a wall of the vertical portion (84A) of an internal chamber of the housing (84), the piston (85) and associated rack (85) extending into the vertical portion (84A) of an internal chamber of the housing (84); a pinion gear (92A) for rotating a spool (50) of the seat belt retractor (100) in a direction of retracting the seat belt webbing and removing slack from the seat belt webbing, using the movement of the piston (85) and driven by said rack (85A); and a venting mechanism comprising a gas passageway in the piston (85) for exhausting the gas (300) from a space filled with the gas to the vertical portion (84A) of an internal chamber of the housing (84) above the sealed end portion (87C) of the piston (85), the gas passageway having a vertical portion (85D) extending in a vertical direction inside the piston (85) to a closed end (85F) and a transverse portion (85E) intersecting the vertical portion (85D) at a distance of at least 10 mm from the closed end (85F) of the gas passageway, and being open to the vertical portion 84A of an internal chamber of the housing 84 above the sealed end portion (87C) of the piston (85); and

the energy absorption device comprising a torsion bar (76) for allowing rotation of the spool (50) in a seat belt webbing protraction direction when tension acting on the seat belt webbing exceeds a predetermined value after the seat belt pretensioner has acted to remove slack from the seat belt webbing.

2. A seat belt retractor (100) according to claim 1 wherein the vertical portion (85D) of the gas passageway has a generally uniform cross sectional area A_L along its length and the transverse portion (85E) of the gas passageway has a generally uniform cross sectional area A_T along its length, wherein $A_L \geq 4A_T$.

3. A seat belt retractor (100) according to claim 1 wherein the vertical portion (85D) of the gas passageway has a circular cross section having a diameter of 4 mm or greater.

4. A seat belt retractor (100) according to claim 3 wherein the transverse portion (85E) of the gas passageway has a circular cross section having a diameter of 1 mm or less.

5. A seat belt retractor (100) according to claim 1 wherein a section of the vertical portion (85D) of the gas passageway between the transverse portion (85E) of the gas passageway and the closed end (85F) of the vertically extending portion (85D) of the gas passageway collects and entraps debris and particulate produced by the pyrotechnic device (83) thereby keeping the transverse portion (85E) of the gas passageway open and unobstructed during venting of the gas (300) to the vertical portion (84A) of an internal chamber of the housing (84) above the sealed end portion (87C) of the piston (85).

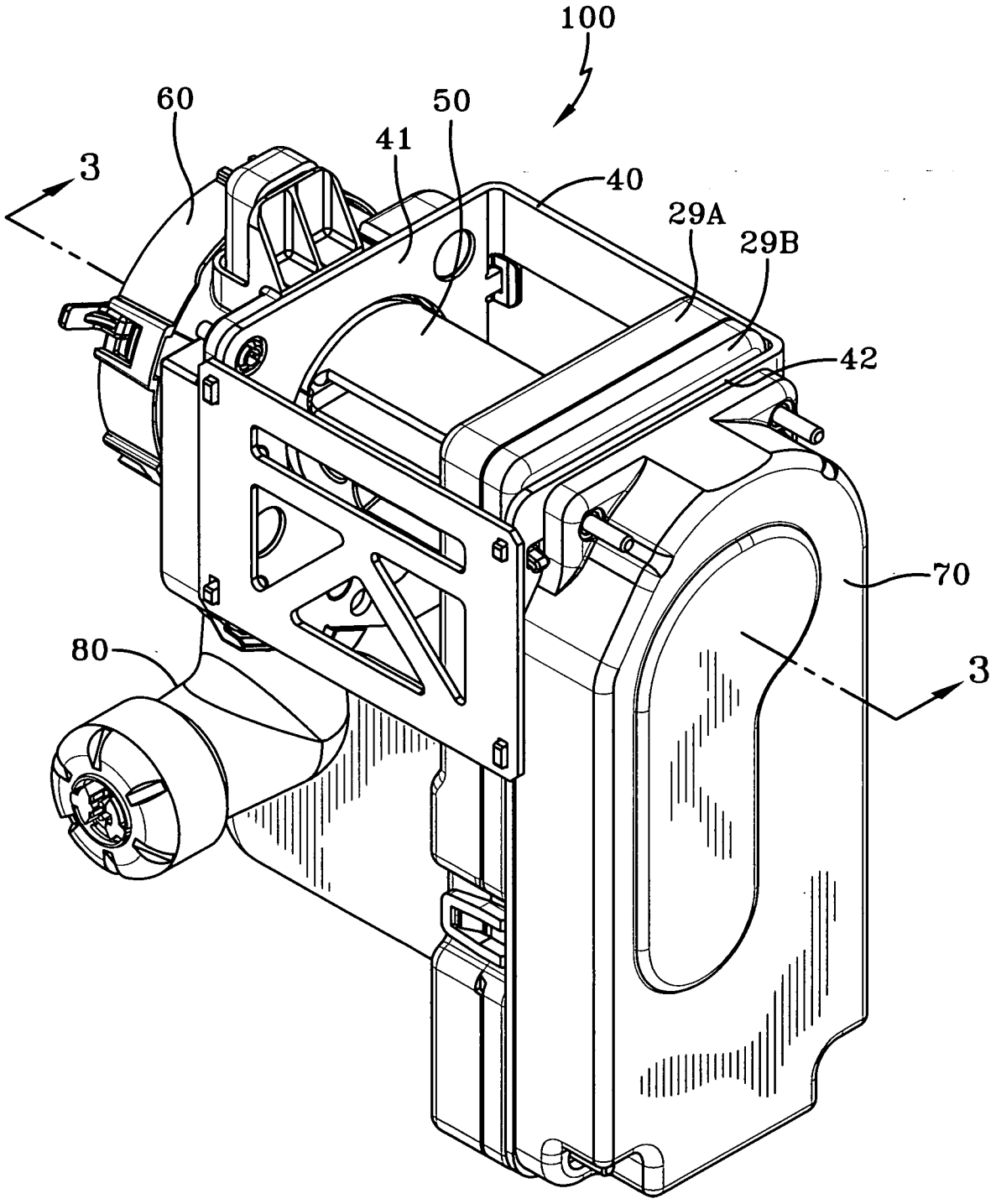


FIG-1

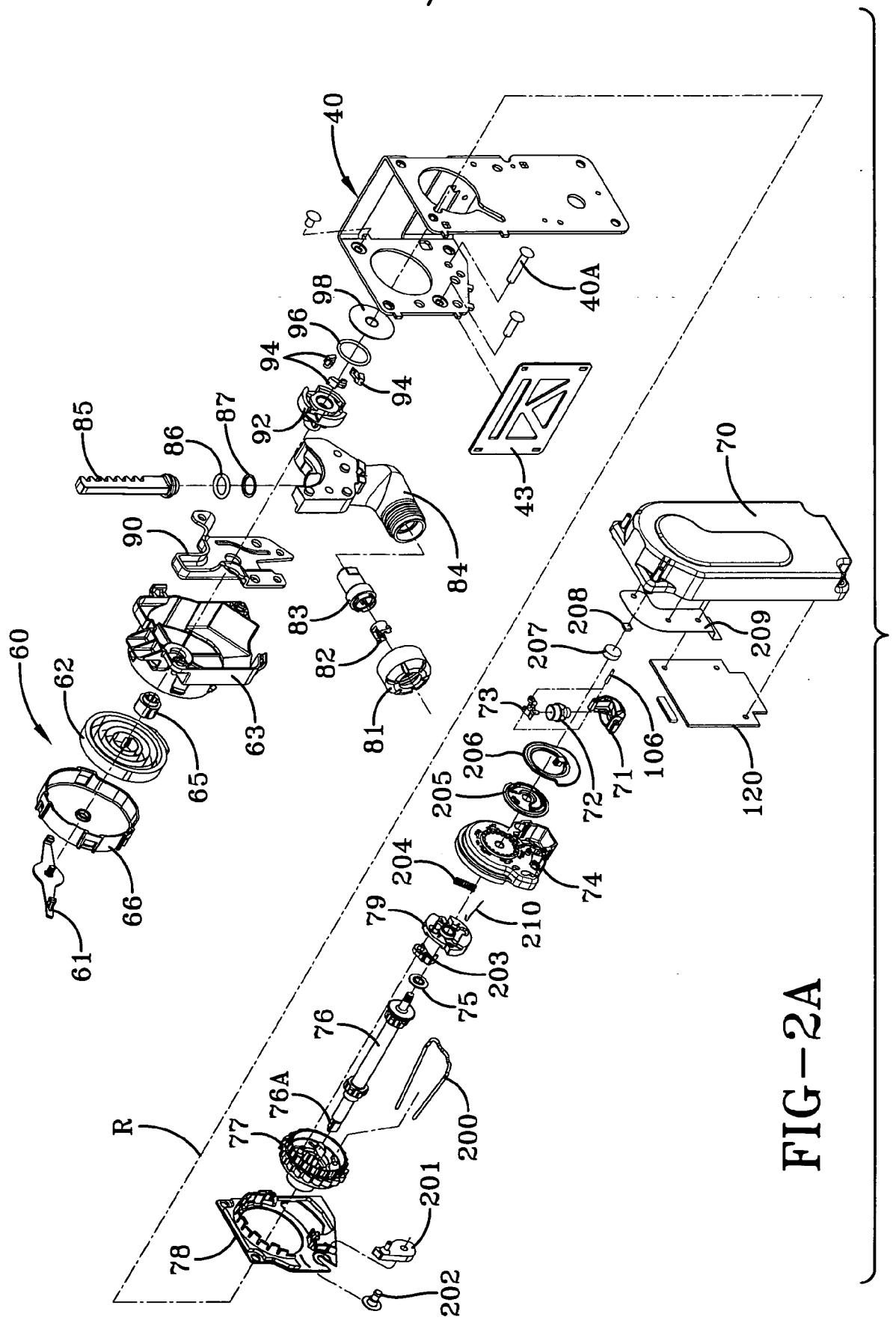

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202
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FIG-2A

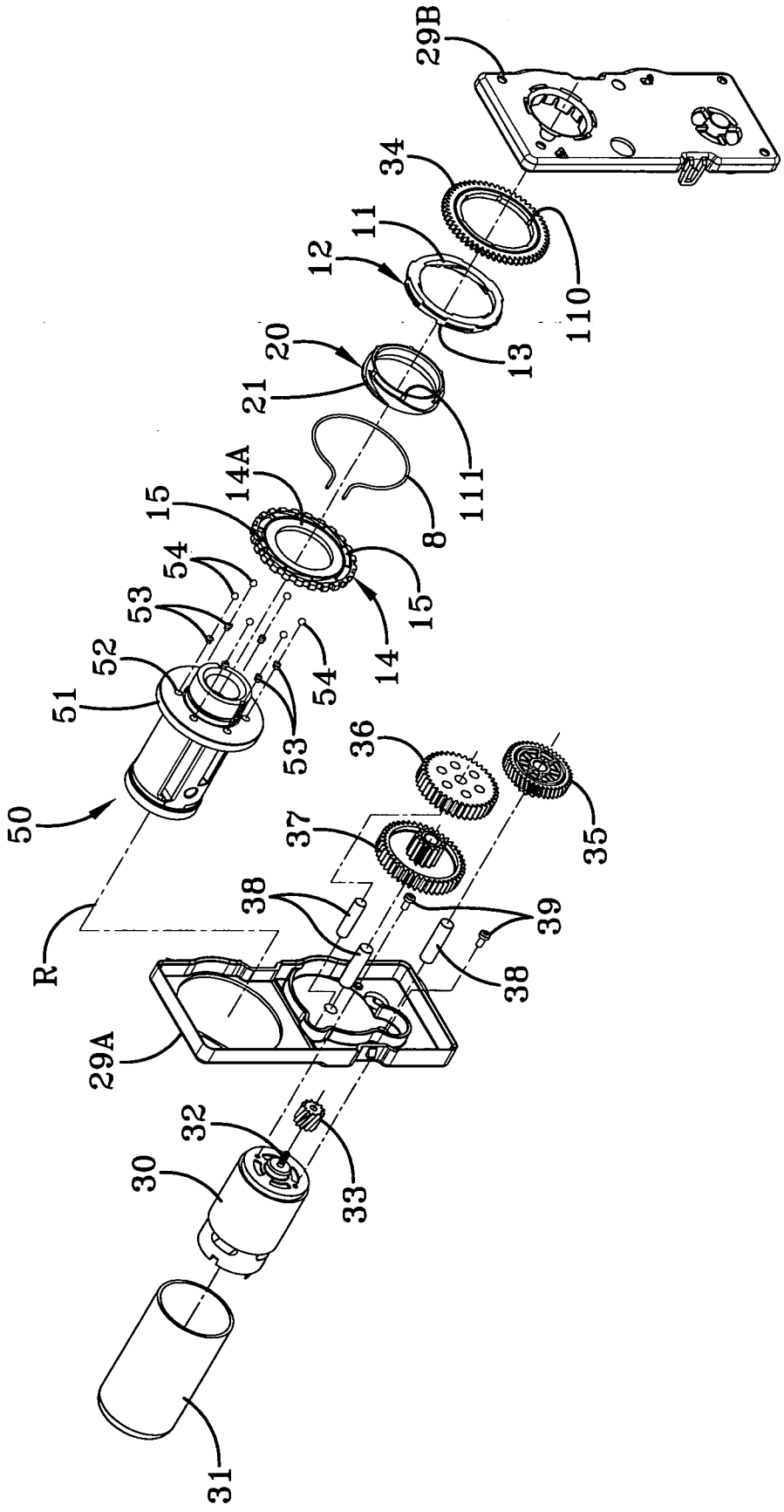

29B
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111
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14A
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50
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29A
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FIG-2B

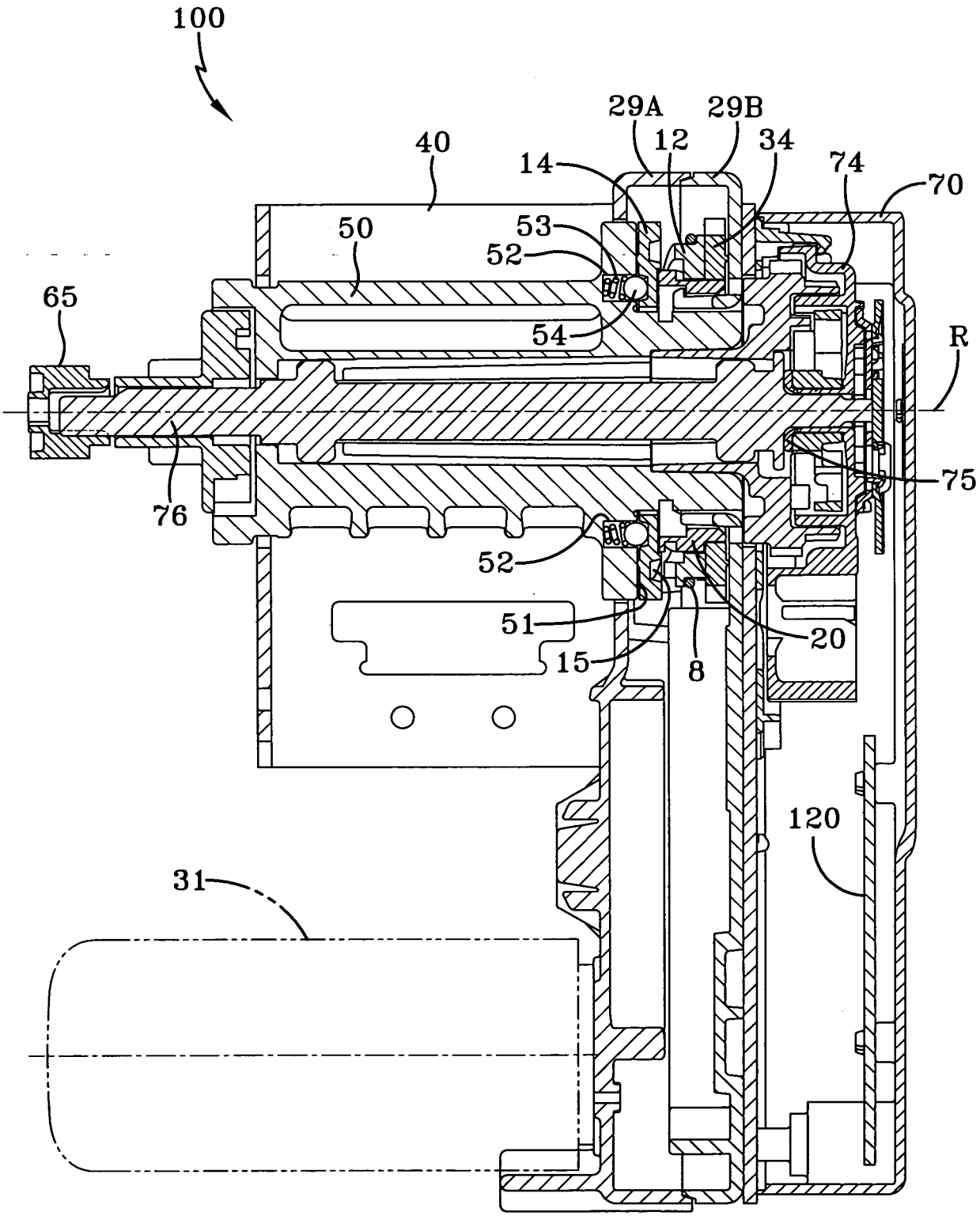

100
29A
29B
12
34
74
70
40
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50
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54
R
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20
15
8
120
31

FIG-3

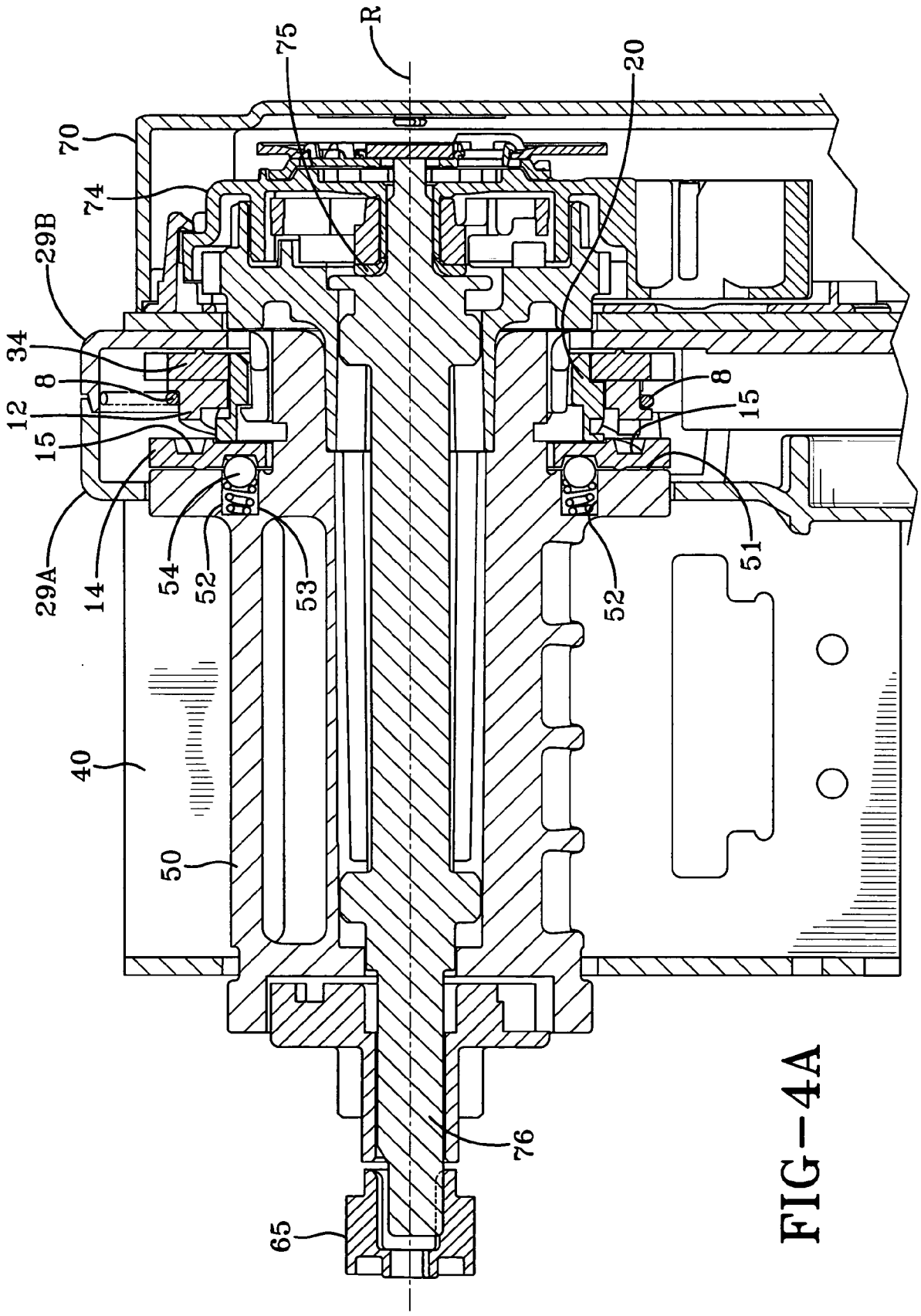


FIG-4A

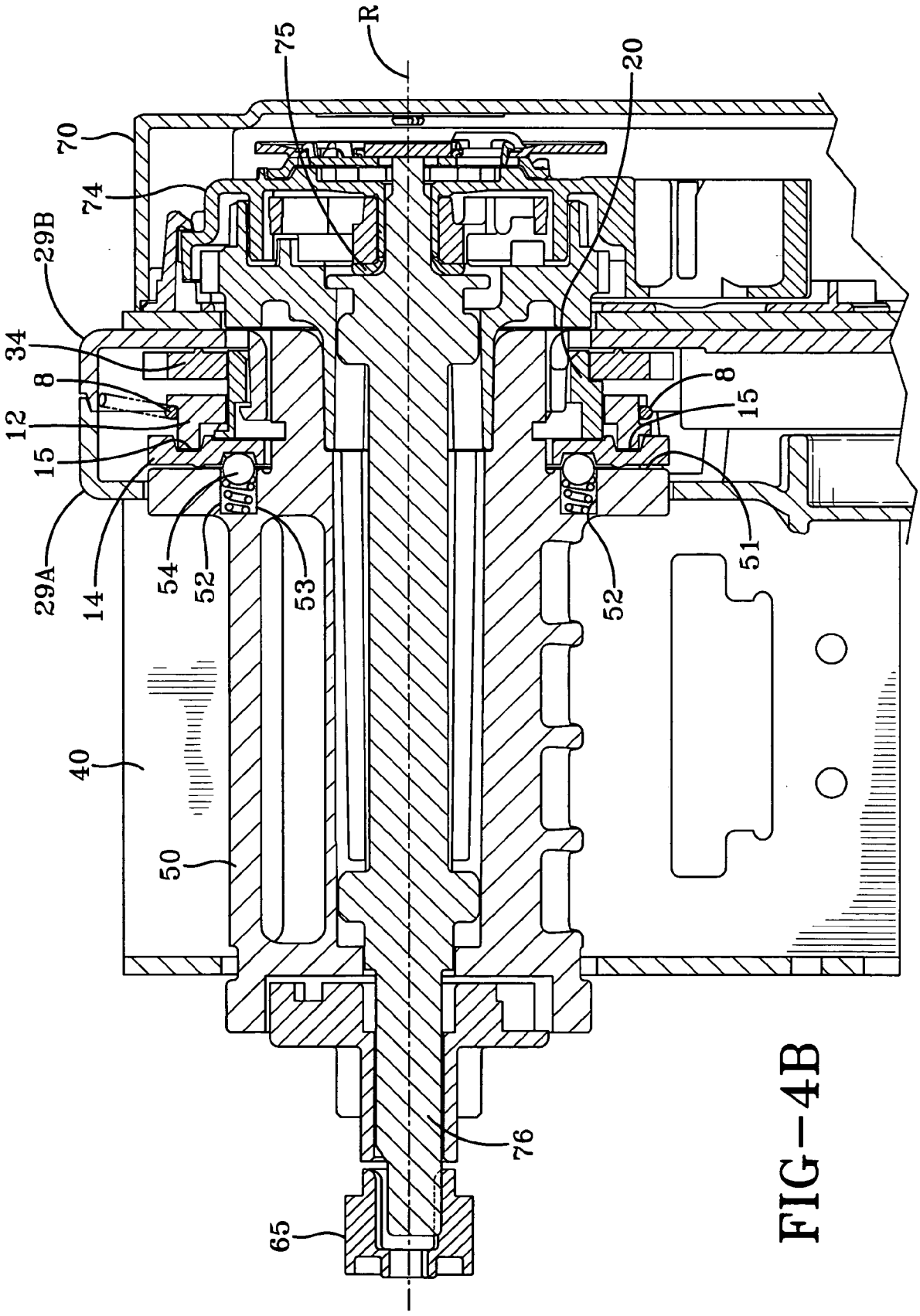


FIG-4B

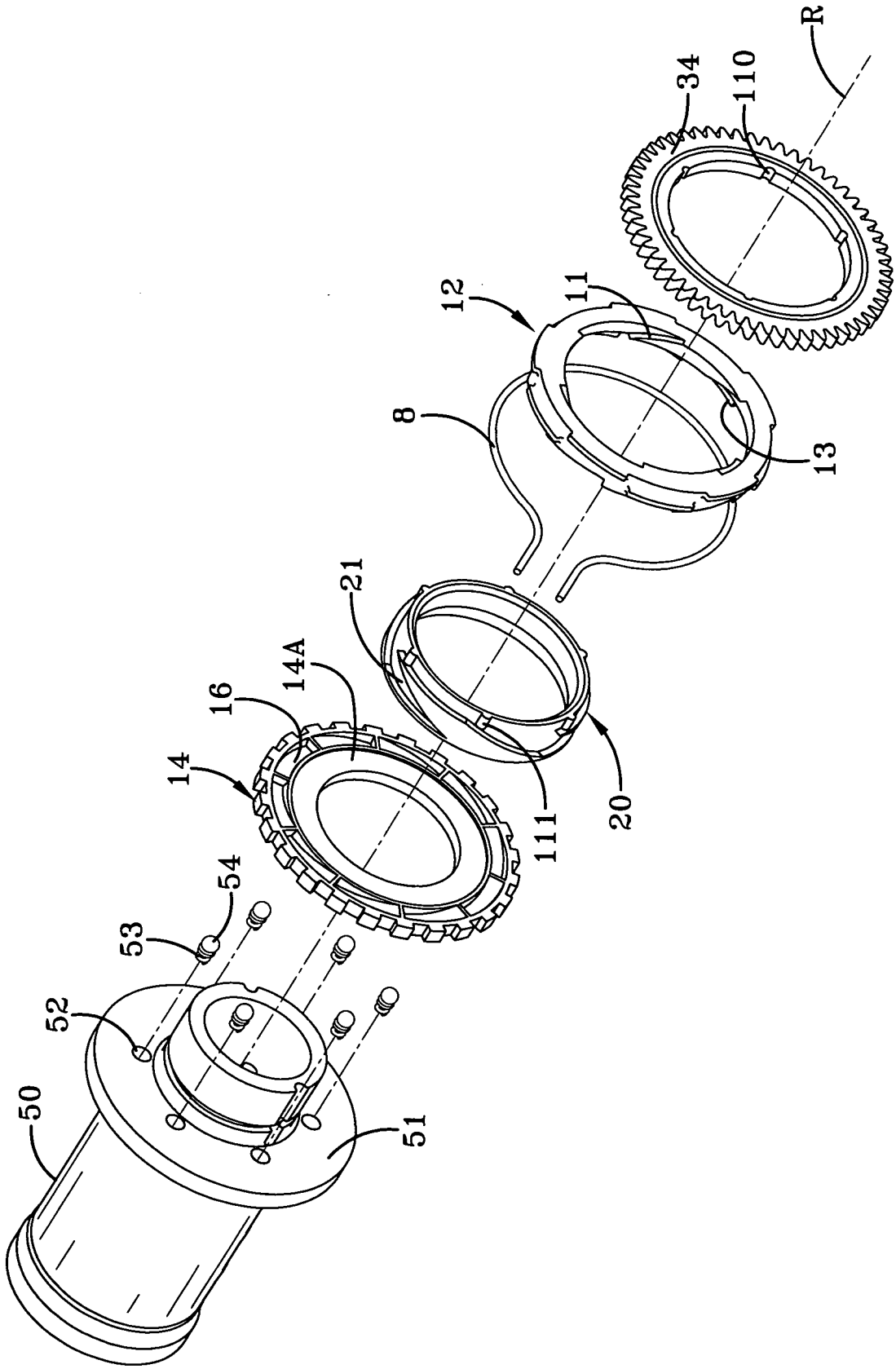


FIG-5A

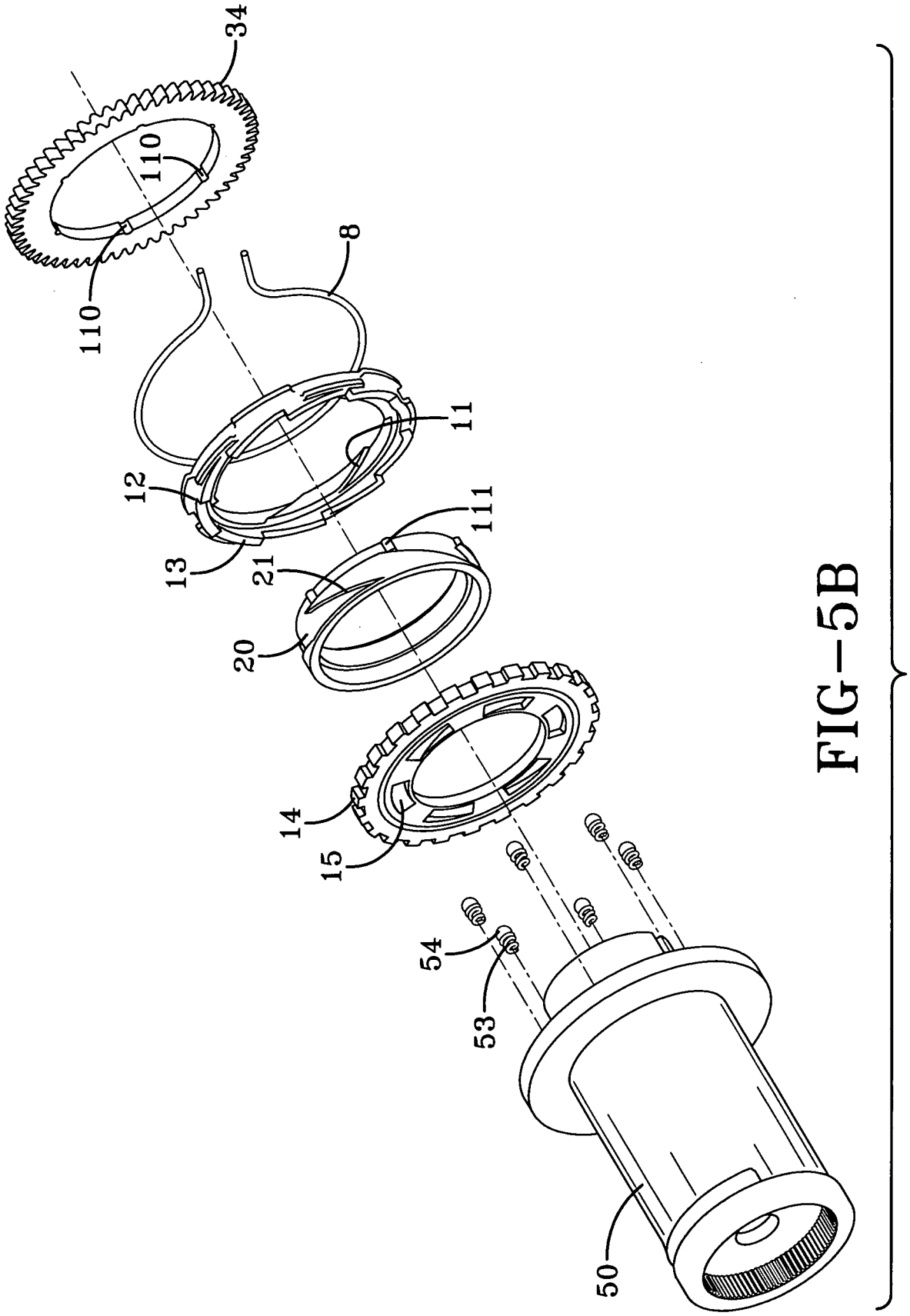


FIG-5B

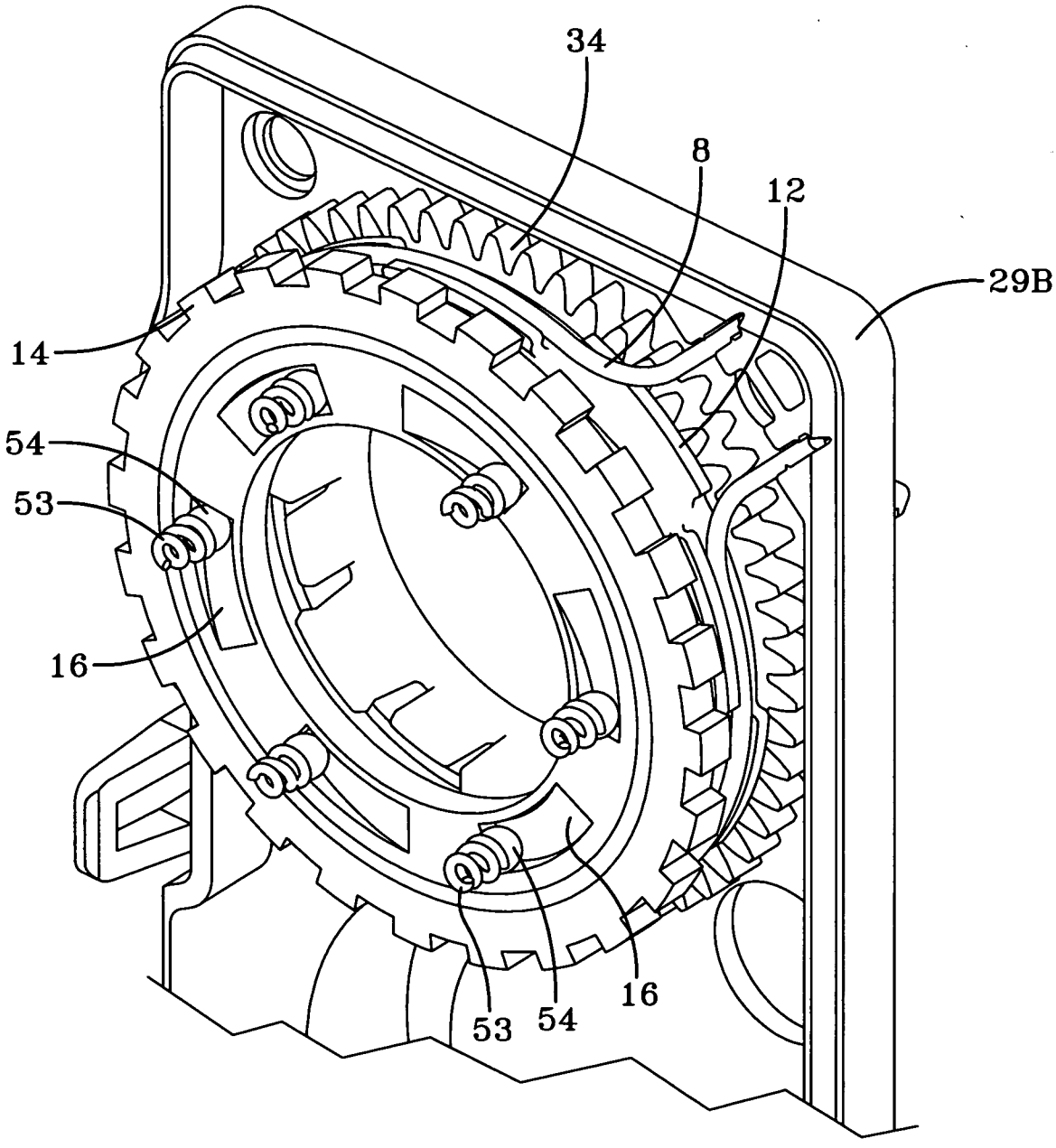


FIG-6

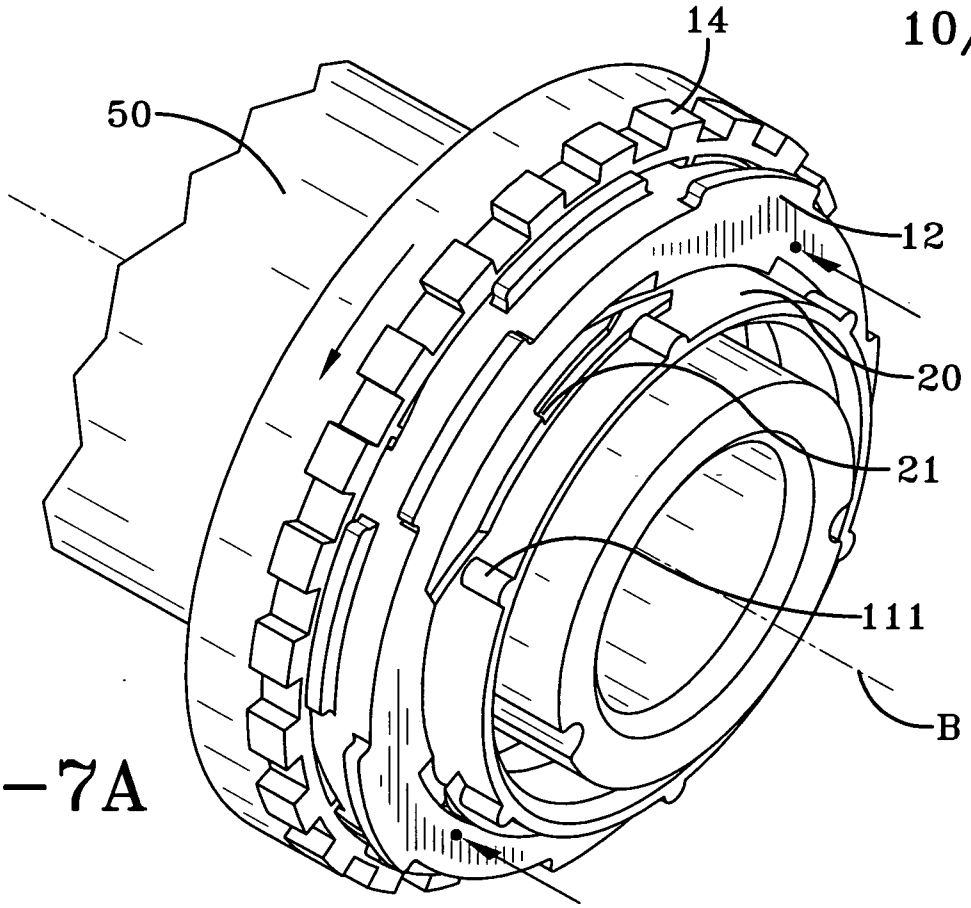


FIG-7A

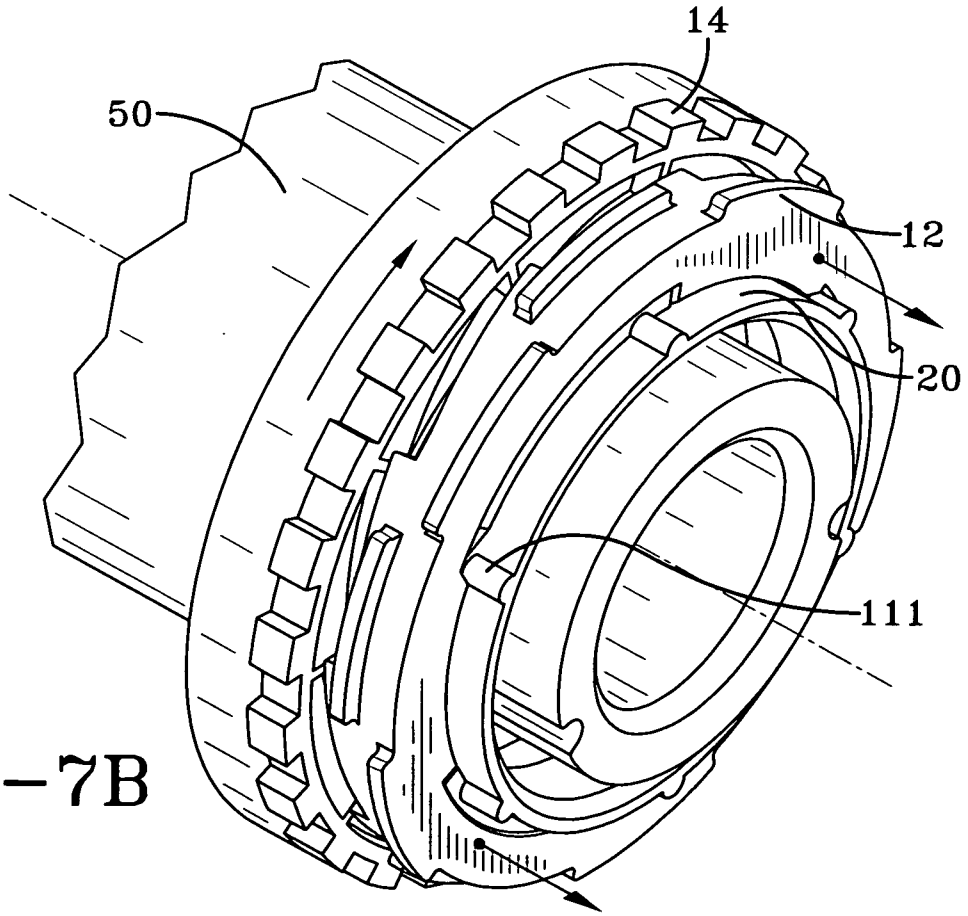


FIG-7B

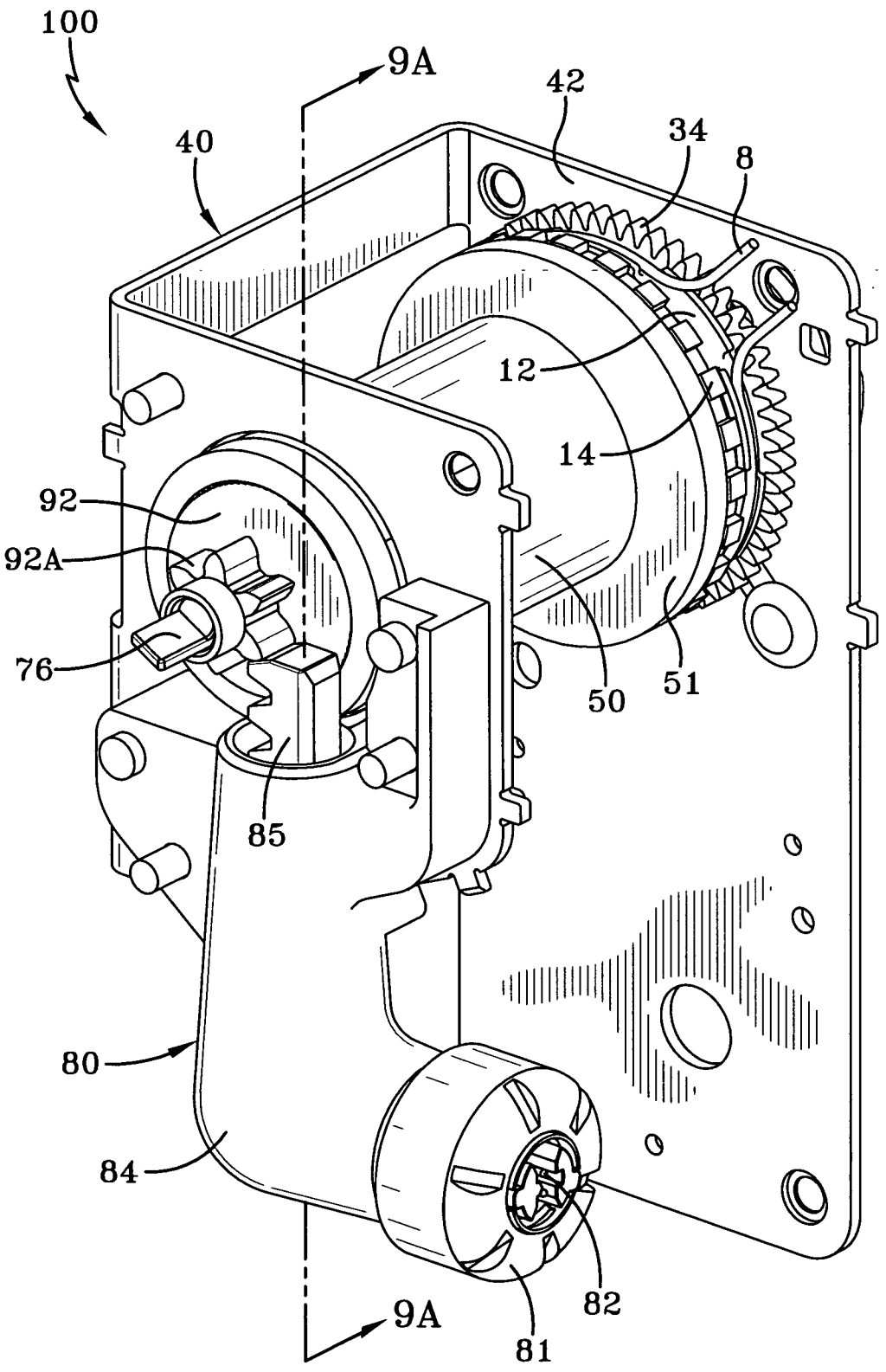


FIG-8

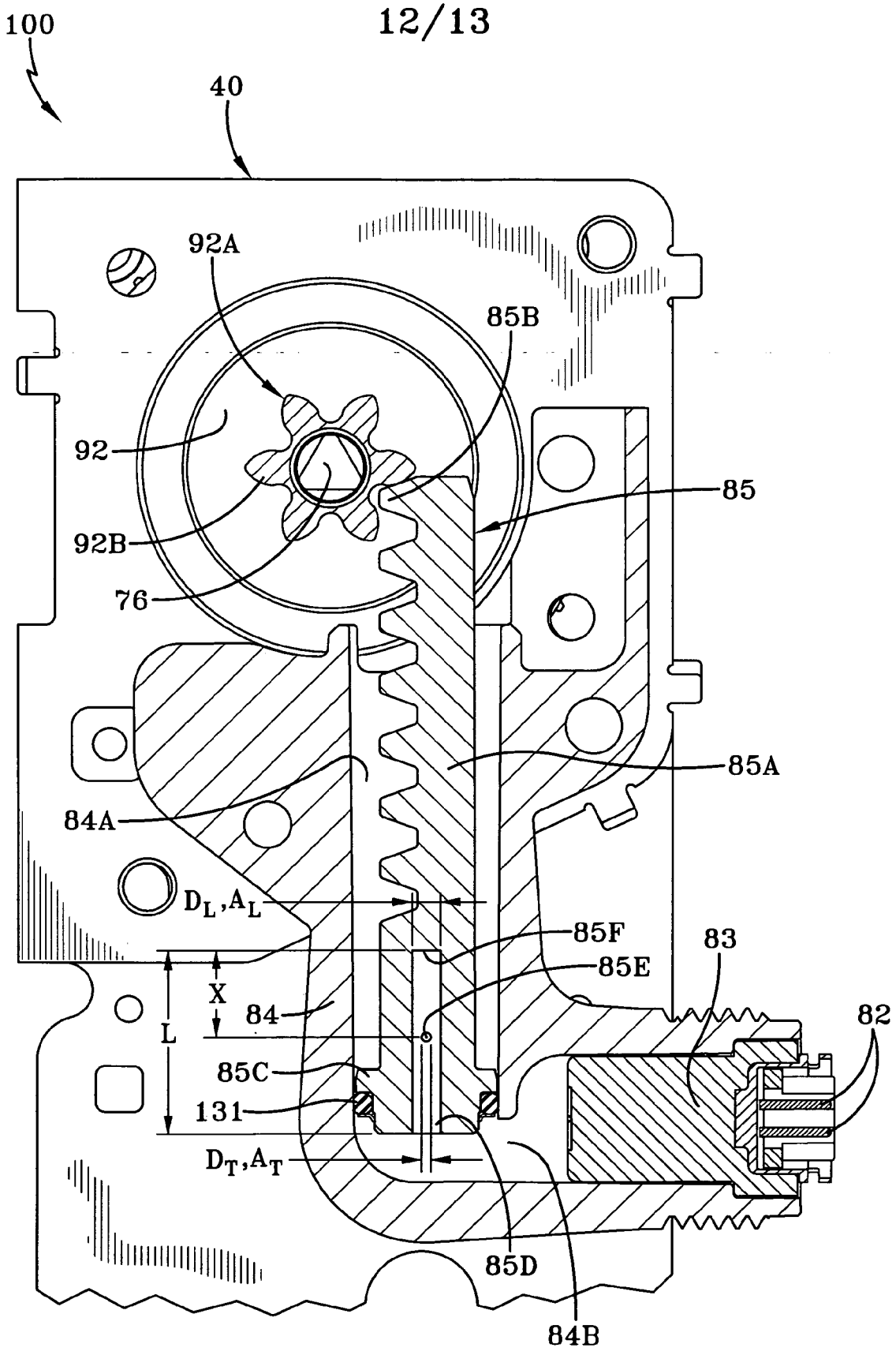

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D_T, A_T
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84B

FIG-9A

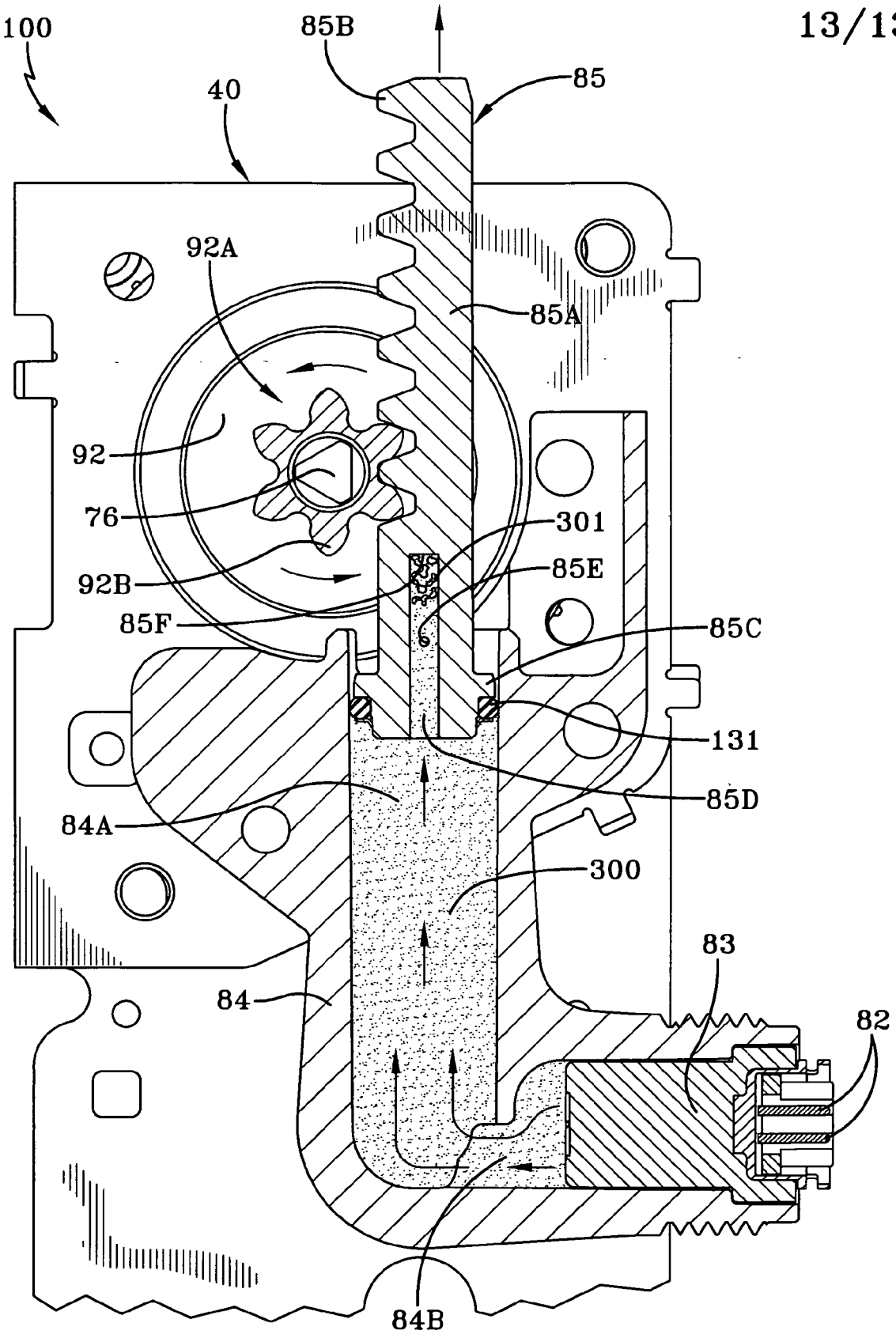

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82
84B

FIG-9B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2008/001035

A. CLASSIFICATION OF SUBJECT MATTER

B60R 22/34(2006.01)i, B60R 22/44(2006.01)i, B60R 22/46(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 8 B60R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Utility models and applications for Utility models since 1975

Japanese Utility models and applications for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

e-KIPASS (KIPO internal) : "belt*" & "pyro*"&(("piston"&"gear") or "torsion*" or "vent*")

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,624,083 A (THOMAS MODINGER et al.) 29 Apr. 1997 see the abstract and Fig 1.	1-5
A	US 5,871,236 A (BARNEY J. BAUER et al.) 16 Feb. 1999 see the abstract and Fig 3.	1-5
A	US 6,460,935 B1 (ELIZABETH REES et al.) 8 Oct. 2002 see the abstract and Fig 1.	1-5
A	US 5,641,131 A (JOHANNES SCHMID et al.) 24 Jun. 1997 see the abstract and Fig 2.	1-5
A	US 5,443,222 A (THOMAS MODINGER et al.) 22 Aug. 1995 see the abstract and Fig 1.	1-5

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 MAY 2008 (28.05.2008)	**28 MAY 2008 (28.05.2008)**

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Authorized officer

HAM, Joung Hyun

Telephone No. 82-42-481-5458

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2008/001035

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US05624083	29.04.1997	DE4222993A1	20.01.1994
		EP00582096A1	09.02.1994
		EP00582096B1	05.06.1996
		ES2049202T1	16.04.1994
		ES2049202T3	16.10.1996
		JP06156187	03.06.1994
		JP2500192B2	29.05.1996
US05871236	16.02.1999	none	
US06460935	08.10.2002	DE69812610C0	30.04.2003
		DE69812610T2	27.11.2003
		EP00984875A1	15.03.2000
		EP00984875B1	26.03.2003
		EP0984875A1	15.03.2000
		EP984875A1	15.03.2000
		EP984875B1	26.03.2003
		GB2330334A1	21.04.1999
		GB9711348A0	30.07.1997
		US2003047931AA	13.03.2003
		US6460935B1	08.10.2002
		US6460935BA	08.10.2002
		WO9855345A1	10.12.1998
US05641131	24.06.1997	DE4415103A1	27.04.1995
		DE5940570400	20.05.1998
		EP00649779A2	26.04.1995
		EP649779A3	06.03.1996
		EP649779B1	15.04.1998
		ES2076911T1	16.11.1995
		ES2076911T3	16.08.1998
		JP2538193B2	25.09.1996
		JP7156751A2	20.06.1995
US05443222	22.08.1995	DE4222993A1	20.01.1994
		EP00582096A1	09.02.1994
		EP00582096B1	05.06.1996
		ES2049202T1	16.04.1994
		ES2049202T3	16.10.1996
		JP2500192B2	29.05.1996
		JP6156187A2	03.06.1994
		US05624083	29.04.1997