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(54) **Title:** INTERNALLY SPRUNG TENSIONER

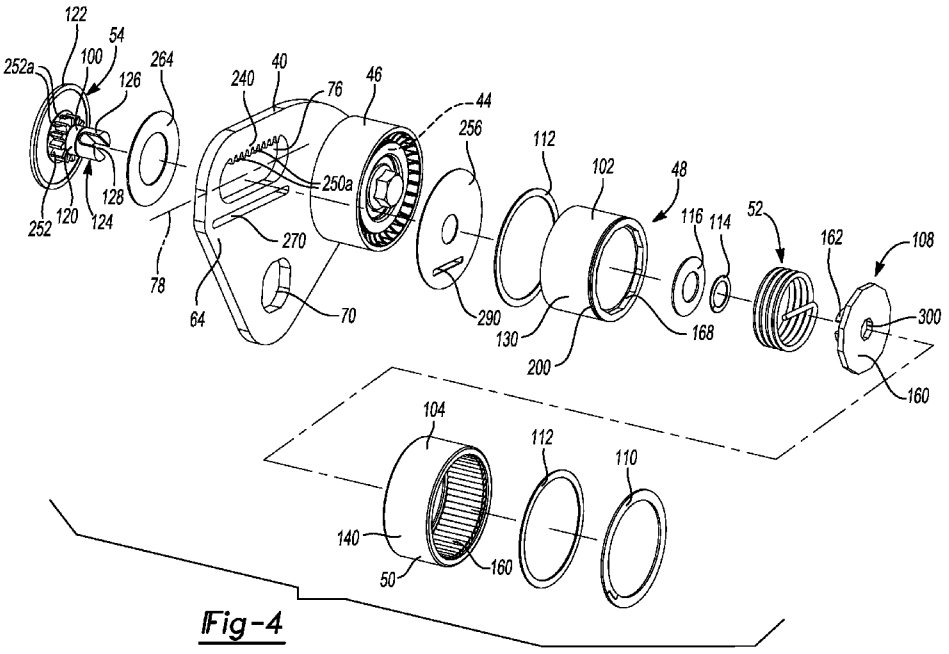


Fig-4

(57) **Abstract:** A tensioner that includes a bracket, a first wheel, a bearing, a second wheel, a torsion spring and a movement control mechanism. The first wheel is coupled to the bracket for rotation about a first rotational axis. The bearing defines a second rotational axis and is movable relative to the bracket such that the second rotational axis is movable relative to the bracket and the first rotational axis. The second wheel is supported by the bearing for rotation about the second rotational axis. The torsion spring is disposed about the second rotational axis and has a first end that is non-rotatably coupled to the bearing. The movement control mechanism is configured to control movement of the second rotational axis relative to the bracket as a function of a magnitude of energy stored in the torsion spring.

[Continued on next page]

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INTERNALLY SPRUNG TENSIONER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 62/789,639 filed January 8, 2019, the disclosure of which is incorporated by reference as if fully set forth in detail herein.

FIELD

[0002] The present disclosure relates to a tensioner and more particularly to an internally sprung tensioner.

BACKGROUND

[0003] This section provides background information related to the present disclosure which is not necessarily prior art.

[0004] Front engine accessory drives (FEAD's) commonly employ a belt that is driven by an engine crankshaft to provide rotary power to various engine accessories, including an alternator or generator. A belt tensioner is employed in on the slack side of the belt in the FEAD to ensure that the belt is tensioned in a desired manner that prevents slippage between the belt and the pulleys about which the belt is wrapped.

[0005] In a FEAD in having a motor/generator unit (i.e., a generator that can be operated as a starter motor to drive the belt and cause corresponding rotation of the engine crankshaft to start the engine), the operation of the motor/generator unit can cause a swapping of the slack and tight sides of the belt. Consequently, a conventional tensioner would not effectively tension the belt of the FEAD when the motor/generator unit is employed to start the engine. Various solutions employing a pair of spring-loaded pulleys have been suggested. Generally, these solutions employ pivoting arms onto which the spring-loaded pulleys are mounted and may include complex spring configurations that can be difficult and/or expensive to manufacture.

SUMMARY

[0006] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[0007] In one form, the present disclosure provides a tensioner that includes a bracket, a first wheel, a bearing, a second wheel, a torsion spring and a movement control mechanism. The first wheel is coupled to the bracket for rotation about a first rotational axis

and can optionally be disposed in a fixed location relative to the bracket. The bearing defines a second rotational axis and is movable relative to the bracket such that the second rotational axis is movable relative to the bracket and the first rotational axis. The second wheel is supported by the bearing for rotation about the second rotational axis. The torsion spring is disposed about the second rotational axis and has a first end that is non-rotatably coupled to the bearing. The movement control mechanism is configured to control movement of the second rotational axis relative to the bracket as a function of a magnitude of energy stored in the torsion spring.

[0008] Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

[0009] The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

[0010] Figure 1 is a perspective view of a first tensioner constructed in accordance with the teachings of the present disclosure, the tensioner being shown in operative association with a front engine accessory drive of an internal combustion engine;

[0011] Figure 1A is a perspective view of an alternately constructed first tensioner, the alternately constructed first tensioner being pivotably mounted to a motor/generator unit;

[0012] Figure 2 is a front perspective view of the first tensioner;

[0013] Figure 3 is a rear perspective view of the first tensioner;

[0014] Figure 4 is an exploded perspective view of the first tensioner;

[0015] Figure 5 is a section view taken through the first tensioner along a translation axis;

[0016] Figure 6 is a perspective view of a portion of the first tensioner illustrating a second axle and a portion of a movement control mechanism;

[0017] Figure 7 is a perspective view of a portion of the first tensioner illustrating an outer bearing/second wheel, bearing elements, a torsion spring and an end plate having a second spring engagement;

[0018] Figure 8 is a perspective view of a portion of the first tensioner illustrating a portion of a second bearing and a torsion spring that is mounted to the second bearing;

[0019] Figure 9 is a perspective view of a portion of the first tensioner illustrating a guide member of the motion control mechanism coupled to an inner bearing member of a second bearing;

[0020] Figure 10 is a perspective view of a portion of the first tensioner illustrating a portion of the motion control mechanism in greater detail;

[0021] Figure 11 is a perspective view of a second tensioner that has a configuration that is similar to that of the first tensioner except for the manner in which a torsion spring is grounded; and

[0022] Figure 12 is a perspective view of a third tensioner that has an alternately constructed motion control mechanism that employs a flexible element that is wound about the second axle rather than a rack and pinion.

[0023] Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

[0024] With reference to Figure 1 of the drawings, a tensioner constructed in accordance with the teachings of the present disclosure is generally indicated by reference numeral 10. The tensioner 10 is shown in operative association with a motor/generator unit (MGU) pulley 12 as part of a front engine accessory drive 14 on an internal combustion engine 16. The front engine accessory drive 14 includes a belt 20, a crankshaft pulley 22, which is coupled to a crankshaft (not specifically shown) for rotation therewith, and a plurality of accessory pulleys 12 and 24, which are drivingly coupled to a rotary engine accessories, such as a motor-generator unit 26 and a power steering pump 28, respectively. It will be appreciated that the belt tensioner 10 can be employed in various other types of belt drive systems and as such, it will be understood that the teachings of the present disclosure are not limited to the particular belt drive system that is shown in the drawings and described herein, or even more generally to front engine accessory drives.

[0025] With reference to Figures 2 through 4, the tensioner 10 can include a bracket 40, a first axle 42, a first bearing 44, a first wheel 46, a second bearing 48, a second wheel 50, a torsion spring 52 and a movement control mechanism 54.

[0026] The bracket 40 can be formed of a suitable material, such as steel plate, heavy sheet steel or cast aluminum or magnesium, for example, and can include a tensioner mount 60, a first wheel mount 62 and a second wheel mount 64. The tensioner mount 60 is configured to permit the bracket 40 to be mounted to a suitable structure, such as the engine 16 (Fig. 1) or the motor-generator unit 26 (Fig. 1A). The tensioner mount 60

could be configured to mount the bracket 40 to the structure in a manner that permits the bracket 40 to pivot about a pivot axis relative to the structure, such as about the rotational axis of the pulley 12 that is mounted to the motor-generator unit 26 (Fig. 1A), or could be configured to mount the bracket to the structure at a fixed location. In the example provided, the tensioner mount 60 includes a mount aperture 70 that is formed with a generally octagonal shape. The mount aperture 70 can receive a mating octagonal shaped hub (not shown) of a bushing (not shown), which can inhibit relative rotation between the bushing and the bracket 40. The hub can be fixed to the tensioner mount 60 in any desired manner to inhibit withdrawal of the hub from the mount aperture 70. A threaded fastener (not shown), which can be threaded into the structure, can be received through the bushing so that the bracket 40 can pivot about the threaded fastener. Alternatively, the mount aperture 70 can be mounted onto a mating boss (not shown) on the structure to inhibit relative rotation between the bracket 40 and the structure. The second wheel mount 64 can define a slotted aperture 76 that extends along a translation axis 78.

[0027] With reference to Figure 5, the first wheel mount 62 is configured to support the first axle 42 such that the first axle 42 defines a first rotational axis 82. In the example provided, the first wheel mount 62 defines an axle aperture 84 formed in a body of the bracket 40 that is configured to receive the first axle 42 such that the first rotational axis 82 is fixed relative to the bracket 40. A shoulder 86 on the first axle 42 can be abutted against a first side of the first wheel mount 62. A bolt 88 can be threadably engaged to a threaded portion 90 of the first axle 42 to generate a clamping force that secures the first axle 42 to the first wheel mount 62. It will be appreciated, however, that the first axle 42 can be secured to the first wheel mount 62 in various other ways, such as welding, and that the first wheel mount 62 could be movably coupled to the tensioner mount 60 so that the first axle 42 and the first rotational axis 82 are movable relative to the bracket 40.

[0028] The first bearing 44 can be mounted radially between the first axle 42 and the first wheel 46 to radially support the first wheel 46 as the first wheel 46 rotates about the first rotational axis 82. The first wheel 46 can be formed of a suitable material, such as plastic or steel, and can define a first engagement surface 94 that is configured to contact the belt 20 (Fig. 1). In the example provided, the first engagement surface 94 is flat (i.e., shaped as a right cylinder) and configured to engage the back (flat, non-poly V) side of a poly-V belt.

[0029] With reference to Figures 4 and 5, the second bearing 48 can include a second axle 100, a shuttle or inner bearing member 102, an outer bearing member 104, a

plurality of bearing elements 106, an end plate 108, a first snap ring 110, a pair of thrust washers 112, a second snap ring 114, and a Bellville spring washer 116. The second axle 100 can have an axle member 120, a flange 122, which that can extend radially outwardly from the axle member 120 and a first spring engagement 124. The axle member 120 can be received through the slotted aperture 76 in the second wheel mount 64 on the bracket 40. The flange 122 can abut a backside of the second wheel mount 64. As is best shown in Figure 6, the first spring engagement 124 can comprise a pair of first fork members 126 that can be disposed on opposite sides of a first tang slot 128 that intersects the second rotational axis 142.

[0030] Returning to Figures 4 and 5, the inner bearing member 102 can be a cup-shaped structure that can have an annular wall 130 and an end wall 132 that can be secured to and substantially close an axial end of the annular wall 130. The annular wall 130 can have an outer cylindrical surface that defines an inner bearing race. The end wall 132 can define an axle aperture 134 through which the axle member 120 can be received.

[0031] The outer bearing member 104 can be received over the inner bearing member 102 and can have an inner cylindrical surface that defines an outer bearing race. The second wheel 50 can be coupled to the outer bearing member 104 for rotation therewith and can define a second engagement surface 140 that is configured to contact the belt 20 (Fig. 1). In the example provided, the second wheel 50 is integrally and unitarily formed with the outer bearing member 104 and the second engagement surface 140 is flat (i.e., shaped as a right cylinder) and configured to engage the back (flat, non-poly V) side of a poly-V belt. It will be appreciated, however, that the second wheel 50 could be formed or assembled onto the outer bearing member 104.

[0032] The bearing elements 106 are disposed between the inner and outer bearing races on the inner and outer bearing members 102 and 104, respectively. In the example provided, the bearing elements 106 are relatively small diameter rollers that provide the second bearing 48 with a needle bearing configuration, but it will be appreciated that other bearing configurations, such as a dual row ball bearing, could be employed in the alternative. As will be discussed in more detail below, the inner and outer bearing members 102 and 104 are coupled to the bracket 40 for rotation about a second rotational axis 142 that can be moved (i.e., translated) relative to the bracket 40 and the first rotational axis 82 along the translation axis 78.

[0033] The end plate 108 can include a plate member 160, which can be coupled to the inner bearing member 102 for rotation therewith about the second rotational axis 142,

and a second spring engagement 162. Any desired means may be employed to non-rotatably couple the end plate 108 to the inner bearing member 102. In the example provided, the plate member 160 has a non-circular perimeter (e.g., 12-sided) that is received into a correspondingly shaped recess 168 that is formed into an axial end of the inner bearing member 102. Receipt of the plate member 160 into the recess 168 inhibits relative rotation between the end plate 108 and the inner bearing member 102. A suitable securing means, such as one or more welds or stakes, can be employed to secure the plate member 160 to the inner bearing member 102 to inhibit the withdrawal of the plate member 160 from the recess 168. With reference to Figures 5 and 7, the second spring engagement 162 can be configured as a projection that extends from the plate member 160 along the second rotational axis 142 into the interior of the inner bearing member 102. The second spring engagement 162 can have a pair of second fork members 170 that can be disposed on opposite sides of a second tang slot 172 that intersects the second rotational axis 142.

[0034] Returning to Figures 4 and 5, the first snap ring 110 can be received in a snap-ring groove 200 in the annular wall 130 of the inner bearing member 102. The first snap ring 110 is disposed axially outboard of the outer bearing member 104 to limit axial movement of the outer bearing member 104 along the second rotational axis 142 in a direction away from the bracket 40. The thrust washers 112 can be received over the inner bearing member 102 and disposed in contact with the opposite axial ends of the outer bearing member 104. One of the thrust washers 112 can be disposed between an axial end of the outer bearing member 104 and the first snap ring 110.

[0035] The second snap ring 114 can be received in a second snap-ring groove 206 formed on the first axle 42. The second snap ring groove 206 is positioned on the first axle 42 on a side of the end wall 132 of the inner bearing member 102 that is disposed opposite the bracket 40 such that the second snap ring 114 is disposed within the interior of the inner bearing member 102. The Bellville spring washer 116 can be received on the first axle 42 and can be disposed between the end wall 132 and the second snap ring 114.

[0036] With reference to Figures 5, 7 and 8, the torsion spring 52 can be received in the interior of the inner bearing member 102 and can engage the first and second spring engagements 124 and 162 such that the torsion spring 52 is disposed in a torque path between the first axle 42 and the inner bearing member 102. In the example provided, the torsion spring 52 includes a first tang 210, a second tang 212 and a plurality of helical coils 214 that are disposed between the first and second tangs 210 and 212. The first tang 210

is received in the first tang slot 128 between the first fork members 126, while the second tang 212 is received in the second tang slot 172 between the second fork members 170.

[0037] With reference to Figure 5, the movement control mechanism 54 is configured to control movement of the second rotational axis 142 relative to the bracket 40 and the first rotational axis 82 as a function of a magnitude of energy stored in the torsion spring 52. With additional reference to Figures 6, 9 and 10, the movement control mechanism 54 in the particular example illustrated includes a rack 250, a pinion 252, a guide 254 and a guide bushing 256. The rack 250 can be fixedly coupled to the bracket 40 and can include a plurality of rack teeth 250a that can be oriented parallel to the translation axis 78. In the example shown, the rack teeth 250a are formed on a side of the slotted aperture 76 that forms the second wheel mount 64, but it will be appreciated that the rack 250 could be formed separately from and coupled to the bracket 40, for example to permit the rack 250 and the bracket 40 to be formed of different materials. The pinion 252 can be fixedly coupled to (e.g., co-formed with) the second axle 100 and can include a plurality of pinion teeth 252a that can meshingly engage the rack teeth 250a. The guide 254 can have a guide member 260 that can be fixedly coupled to the end wall 132 of the inner bearing member 102. The guide member 260 can project from the end wall 132 into a guide member aperture 270 that is formed in the bracket 40. In the example shown, the guide member aperture 270 is a slotted aperture that is parallel to the translation axis 78. Optionally, a thrust washer 264 can be disposed between the flange 122 and the bracket 40, between the bracket 40 and the end wall of the inner bearing member 102, and between the first snap ring 110 and an axial end of the outer bearing member 104. The guide bushing 256 can be received over the second axle 100 between the bracket 40 and the end wall 132 of the inner bearing member 102. A slot 290 (shown in Figure 4) can be formed through the guide bushing 256 and can receive the guide member 260 therethrough.

[0038] Returning to Figures 4 and 5, the second axle 100 can be received through the slotted aperture 76 in the bracket 40 at a location that spaces the second rotational axis 142 apart from the first rotational axis 82 by a maximum distance, and the pinion teeth 252a can be engaged to the rack teeth 250a. Thereafter, and prior to the assembly of the end plate 108 to the inner bearing member 102, the end plate 108 can be rotated (e.g., by inserting a tool [not shown] into a non-circular [e.g., hexagonal] tool aperture 300 in the plate member 160 of the end plate 108) in a first predetermined rotational direction about the second rotational axis 142 that would tend to drive the pinion 252 (through the second

spring engagement 162, the torsion spring 52 and the second axle 100) in a rotational direction that drives the second rotational axis 142 toward the first rotational axis 82. However, because the second axle 100 is already disposed in a position that spaces the second rotational axis 142 toward the first rotational axis 82 by the maximum distance, the pinion 250 cannot rotate in that direction and the second axle 100 is maintained in a stationary (non-rotating) position relative to the bracket 40. Consequently, the first spring engagement 124 is maintained in a stationary condition while the second spring engagement 162 is rotated in the first predetermined rotational direction so that energy is stored in the torsion spring 52. Thereafter, the end plate 108 can be non-rotatably coupled to the inner bearing member 102.

[0039] Because receipt of the guide member 260 (Fig. 10) into the guide member aperture 270 inhibits relative rotation between the inner bearing member 102 and the bracket 40, the energy stored in the torsion spring 52 is transmitted to the first tang 210 (Fig. 8) and tends to drive the second axle 100 about the second rotational axis 142 in a second rotational direction opposite the first rotational direction. Rotation of the second axle 100 about the second rotational axis 142 in the second rotational direction causes the pinion 252 to roll over the rack teeth 250a of the rack 250, which translates the second rotational axis 142 along the translation axis 78 toward the first rotational axis 82. Movement of the second axle 100 along the translation axis 78 toward the first rotational axis 82 ceases when the first and second wheels 46 and 50 are in contact with the belt 20 (Fig. 1) and the force generated by the torsion spring 52 and the movement control mechanism 54 that translates the second rotational axis 78 toward the first rotational axis 82 is in equilibrium with the force that is transmitted from the belt 20 (Fig. 1) to the second wheel 50.

[0040] It will be appreciated that a tool (not shown) could be inserted into a tool aperture 310 formed in the second axle 100 and that the tool could be rotated in the first predetermined rotational direction to drive the pinion 252 (through the second axle 100) across the rack 250 to move the second rotational axis 142 closer to the first rotational axis 82 against the biasing force that is generated by the torsion spring 52.

[0041] In the example of Figure 11, a roller 350 is rotatably disposed on one of the tangs 210a of the torsion spring 52a and the other one of the tangs (not shown) is coupled to the second axle 100a for rotation therewith. The roller 350 “grounds” the tang 210a against a track 352 that is formed in the bracket 40a. In the example shown, the track 352 is defined by a straight or flat sidewall of the slotted aperture 76a. It will be appreciated that

the track could be spaced apart from the slotted aperture 76a and/or that the track 352 could be shaped in any desired manner so as to affect the force applied to the second wheel (not shown) during the travel of the second axle 100a along the translation axis 78.

[0042] In the example of Figure 12, the movement control mechanism 54b does not include a rack and pinon as in the first example but rather a flexible element 370, such as a cable, belt or chain, having a first end 372 that is anchored to the bracket 40b and a second end 374 that is coupled to the second axle 100b for rotation therewith. Rotation of the second axle 100b about the second rotational axis 142 causes the flexible element 370 to wind about or unwind from the second axle 100b depending on the rotational direction in which the second axle 100b is rotated. The radius of the interface between the flexible element 370 and the second axle 100b can change (increase) as it is wound around the second axle 100b and can allow for alternative force during movement of the second axle 100b along the translation axis 78.

[0043] While the several tensioners have been described and illustrated as having a first axle 42 that that is coupled to a bracket 40 such that the first rotational axis 82 (and therefore the first wheel 46) is fixed (stationary) relative to the bracket 40, it will be appreciated that the first axle 42 could be movable relative to the bracket 40 to permit corresponding movement (i.e., translation and/or pivoting) of the first axle 42 and the first wheel 46. For example the first axle 42 and the first wheel 46 can be translatable along a second translation axis that can be coincident, parallel, skewed or transverse to the translation axis 78 about which the second axle 100 and the second wheel 50 translate. Any desired means can be employed to bias the first axle 42 and the first wheel 46 along the second translation axis, including a spring which can act directly or indirectly on the first axle 42 and/or the first wheel 46. Alternatively, a torsion spring (similar to the torsion spring 52) and a movement control mechanism (similar to the movement control mechanism 54) can be employed to provide energy and motion control for the movement of the first axle 42 and the first wheel 46.

[0044] The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure

from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

CLAIMS

What is claimed is:

1. A tensioner comprising:

a bracket;

a first wheel coupled to the bracket for rotation about a first rotational axis;

a bearing that defines a second rotational axis, the bearing being movable relative to the bracket such that the second rotational axis is movable relative to the bracket and the first rotational axis;

a second wheel supported by the bearing for rotation about the second rotational axis;

a torsion spring disposed about the second rotational axis, the torsion spring having a first end that is non-rotatably coupled to the bearing; and

means for controlling movement of the second rotational axis relative to the bracket as a function of a magnitude of energy stored in the torsion spring.

2. The tensioner of Claim 1, wherein the movement controlling means includes a guide that is non-rotatably but slidably coupled to the bracket, and wherein the second rotational axis extends through the guide.

3. The tensioner of Claim 2, wherein the movement controlling means comprises a rack, which is fixedly coupled to the bracket, and a pinion that is meshingly engaged to the rack.

4. The tensioner of Claim 3, wherein a second end of the torsion spring is coupled to the pinion for rotation therewith.

5. The tensioner of Claim 2, wherein the movement controlling means includes a wheel and a linkage, the wheel being coupled to a second end of the torsion spring for rotation about the second rotational axis, the linkage having a first linkage end, which is coupled to the bracket, and a second linkage end that is coupled to the wheel, and wherein a portion of the linkage is wound on the wheel when the second rotational axis is spaced at its furthest point from the first rotational axis.

6. The tensioner of Claim 5, wherein the linkage comprises a cable and/or a plurality of chain links.

7. The tensioner of Claim 1, wherein the bracket defines a track and wherein a second end of the torsion spring is movably disposed on the track.

8. The tensioner of Claim 7, wherein a roller is disposed on the second end of the torsion spring, the roller engaging the track.

9. The tensioner of Claim 1, wherein the first rotational axis is disposed in a fixed location relative to the bracket.

10. The tensioner of Claim 1, wherein the first rotational axis is movable relative to the bracket.

11. The tensioner of Claim 10, further comprising a second torsion spring, which is disposed about the second first axis, and means for controlling movement of the first rotational axis relative to the bracket as a function of a magnitude of energy stored in the second torsion spring.

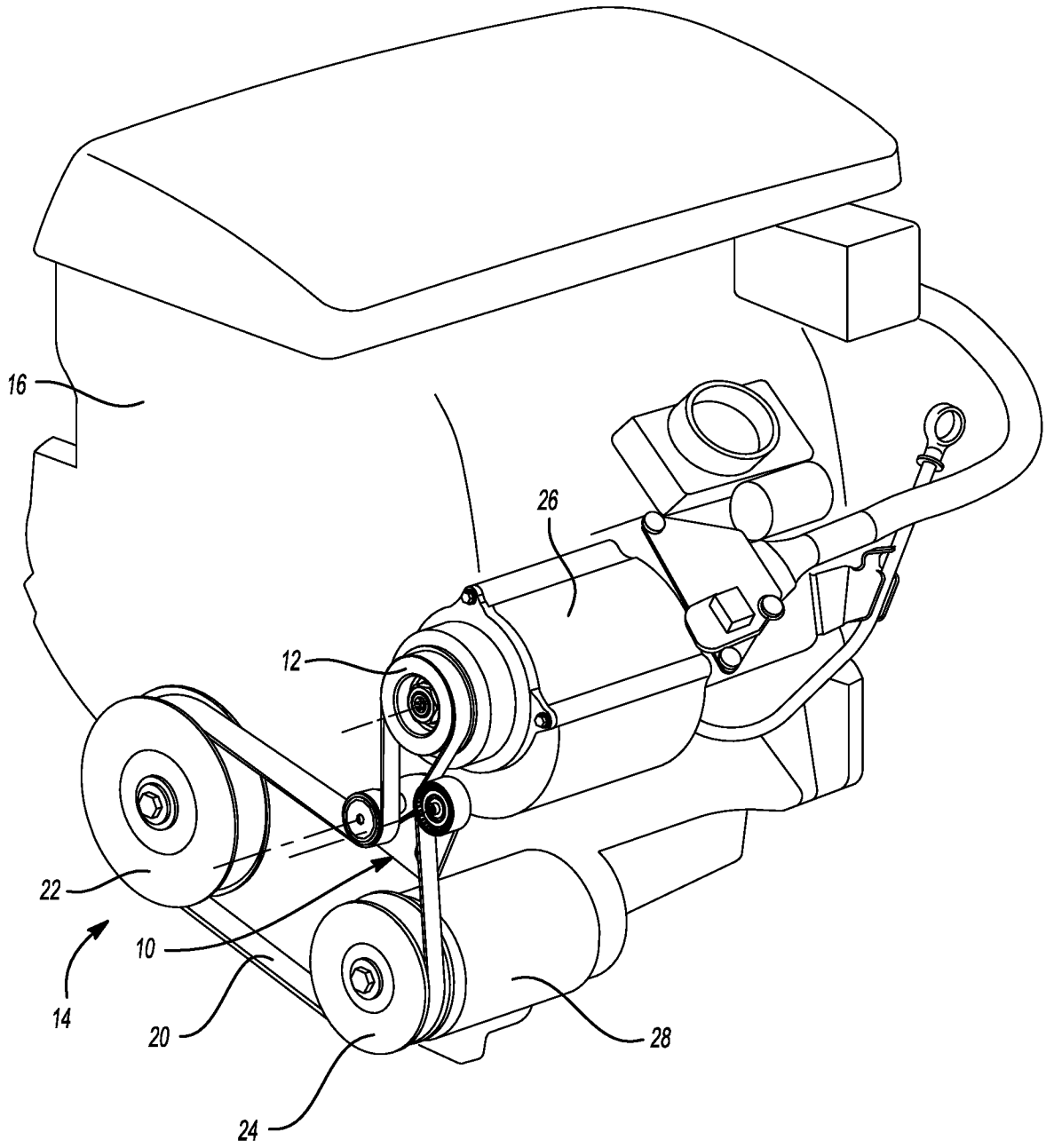


Fig-1

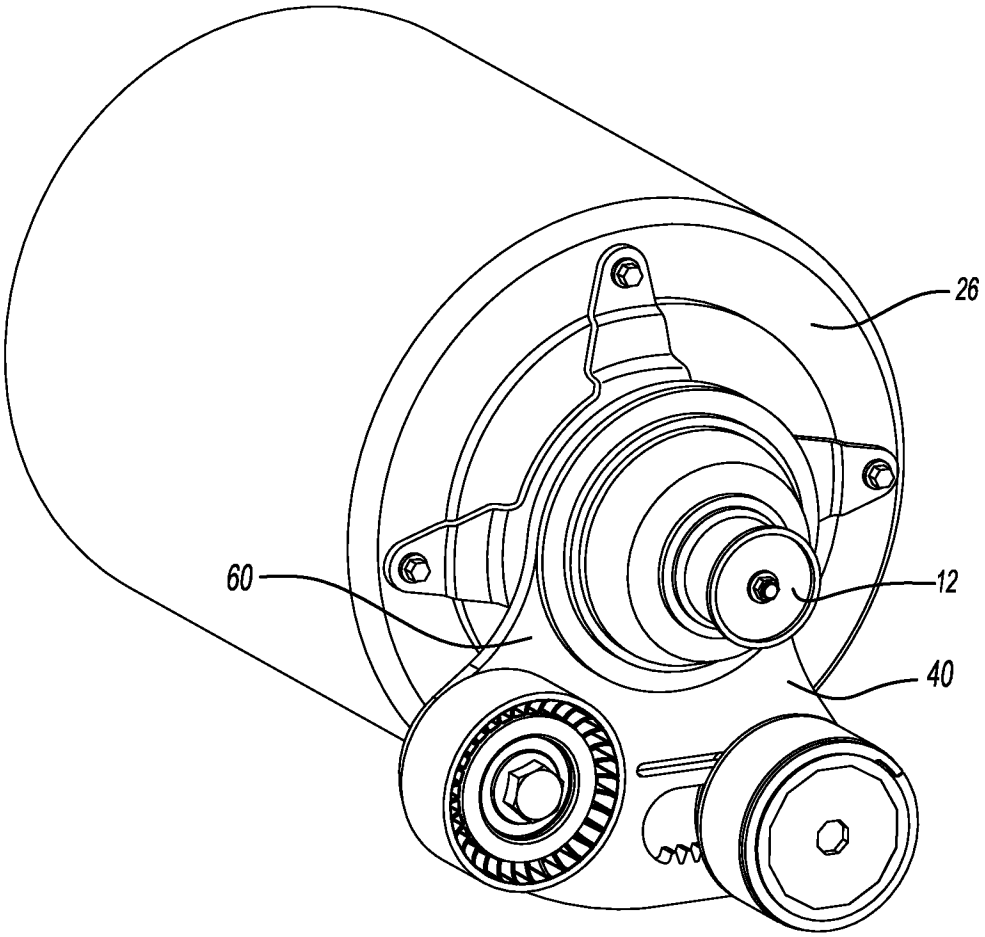


Fig-1A

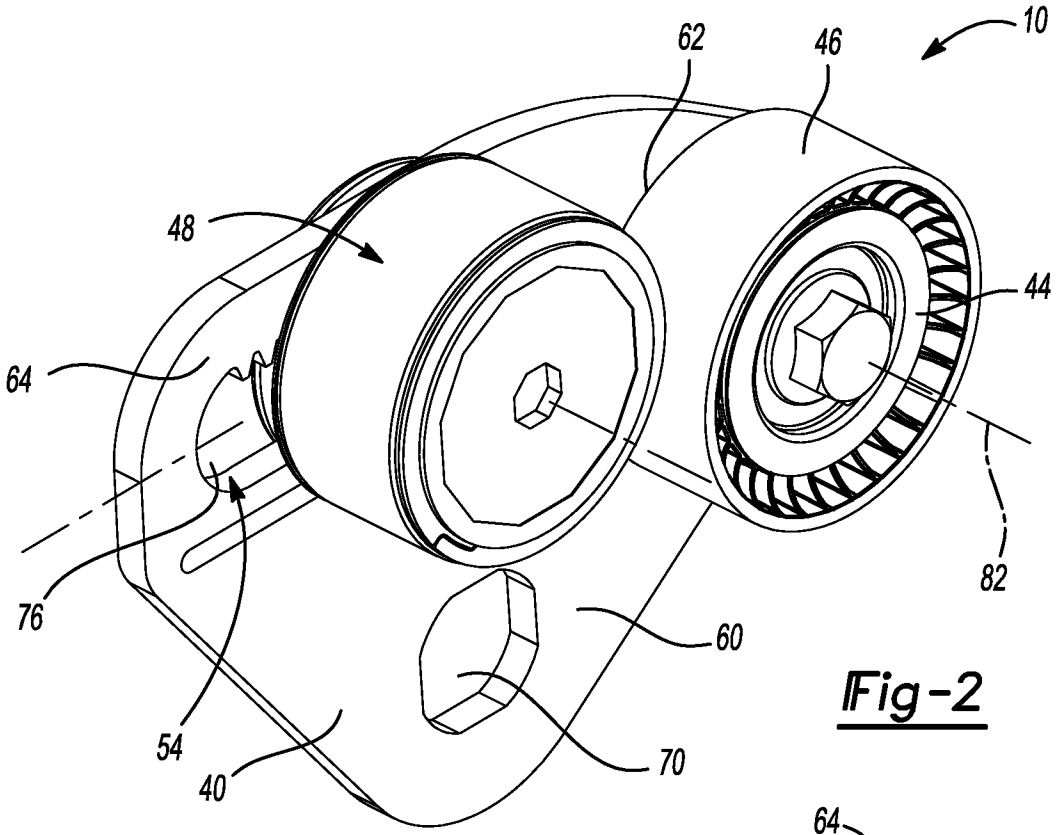


Fig-2

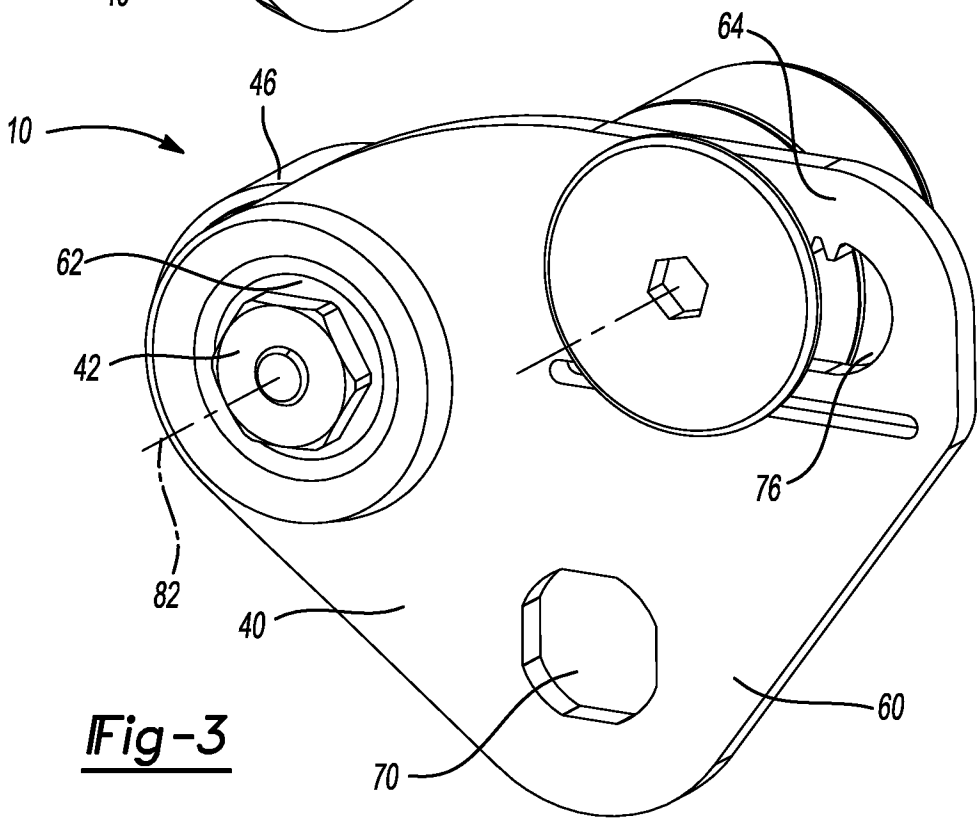


Fig-3

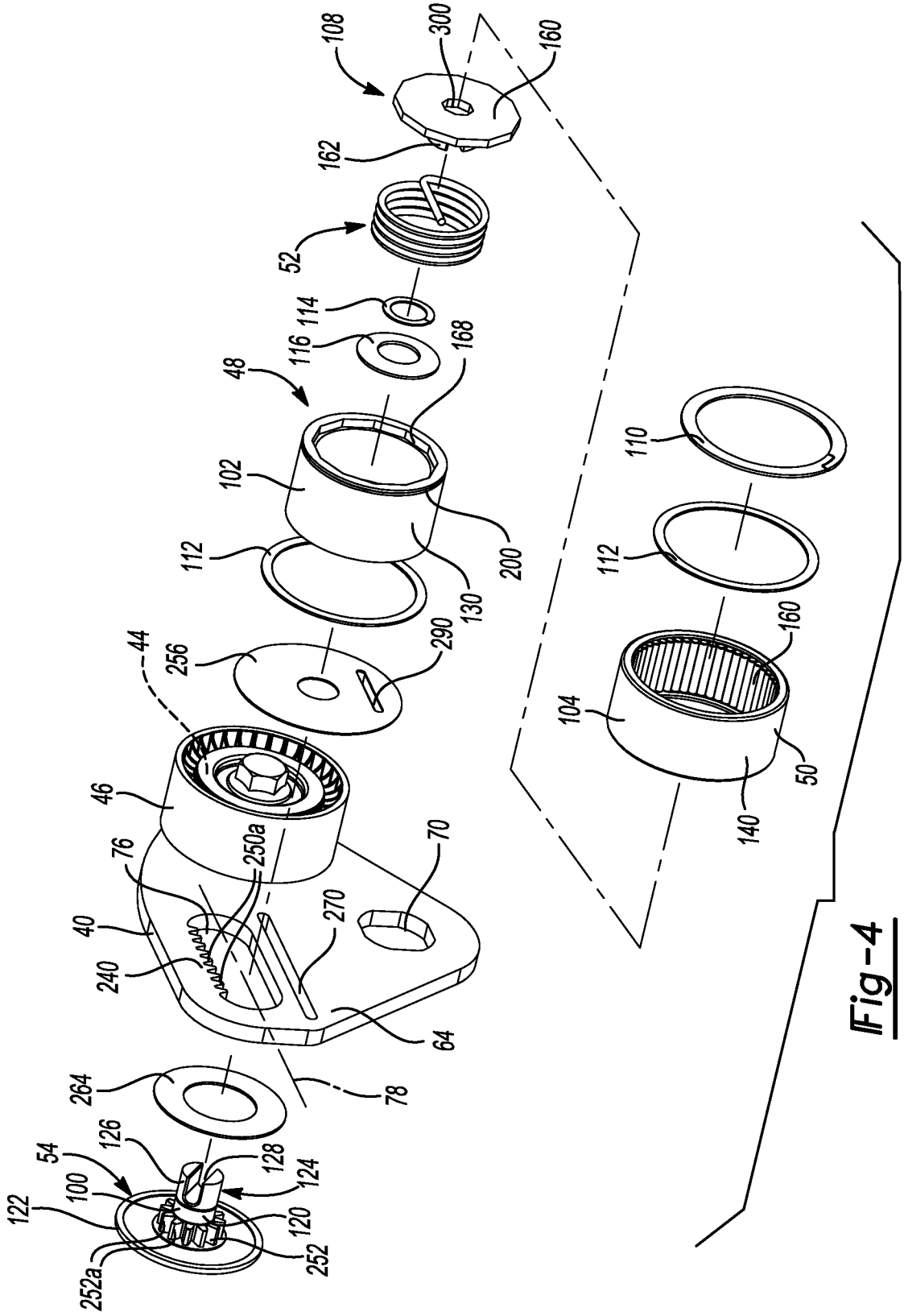

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Fig-4

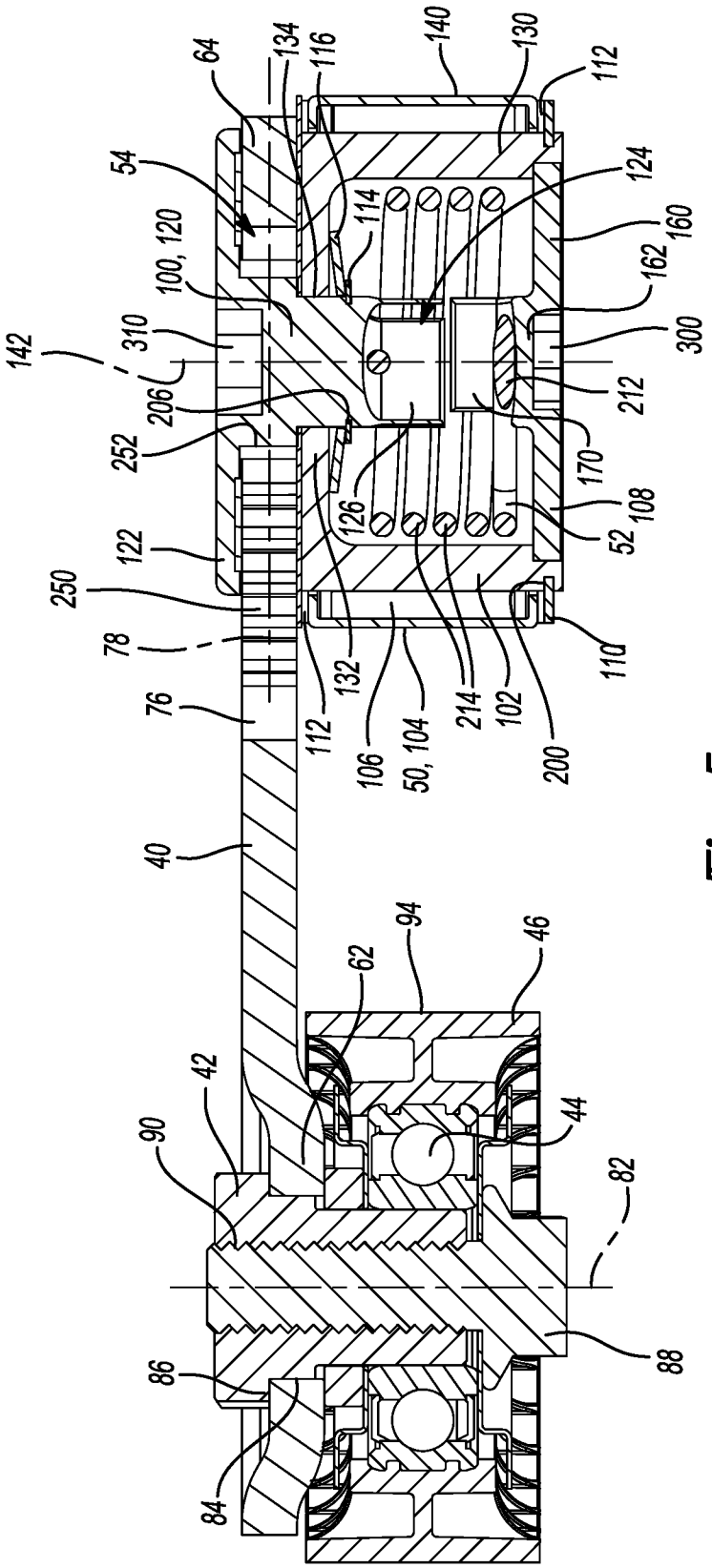

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Fig-5

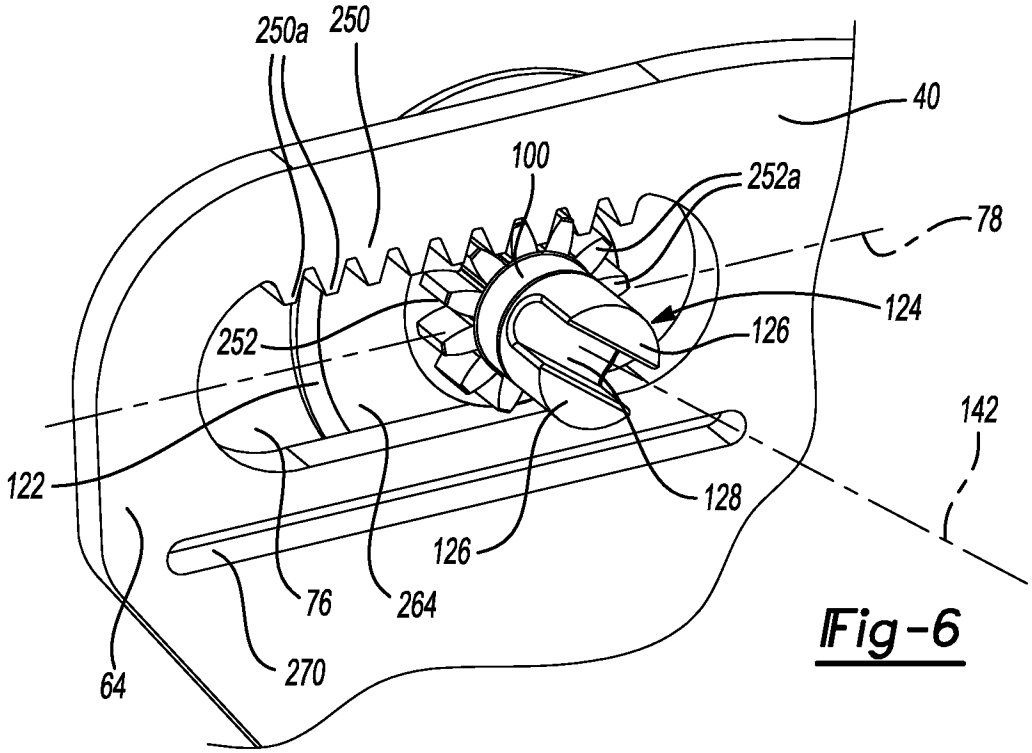

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Fig-6

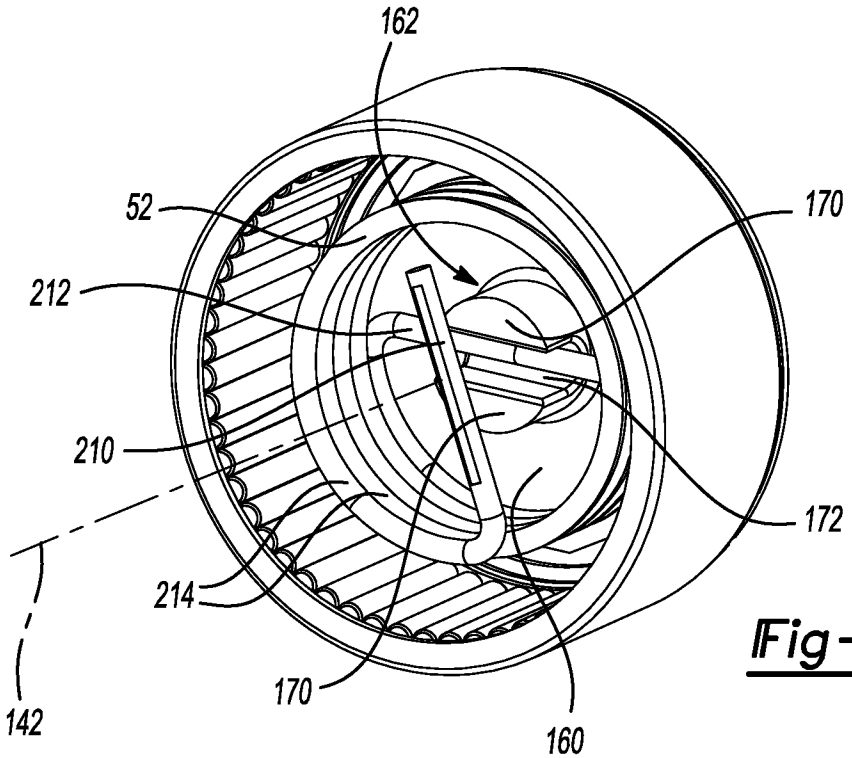

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Fig-7

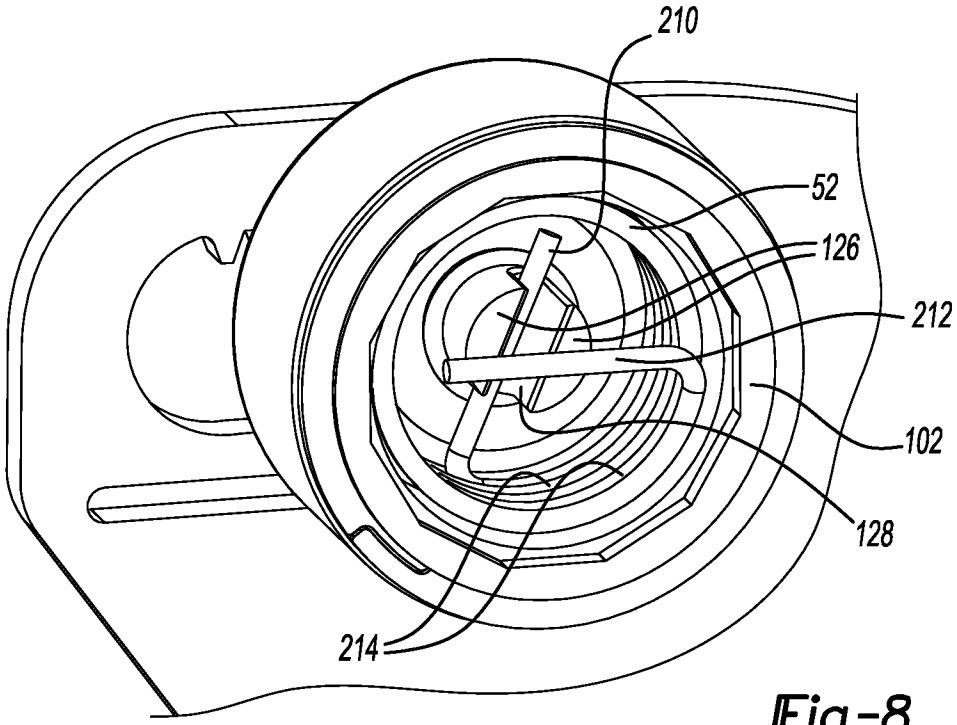


Fig-8

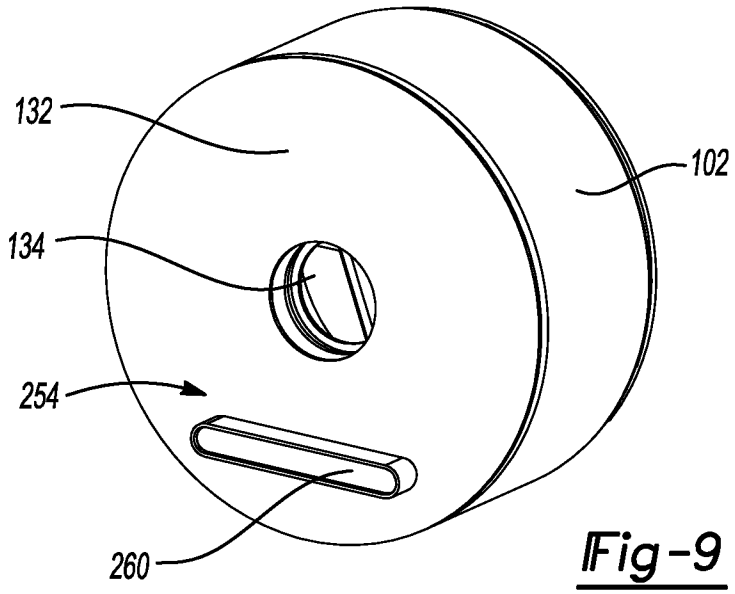


Fig-9

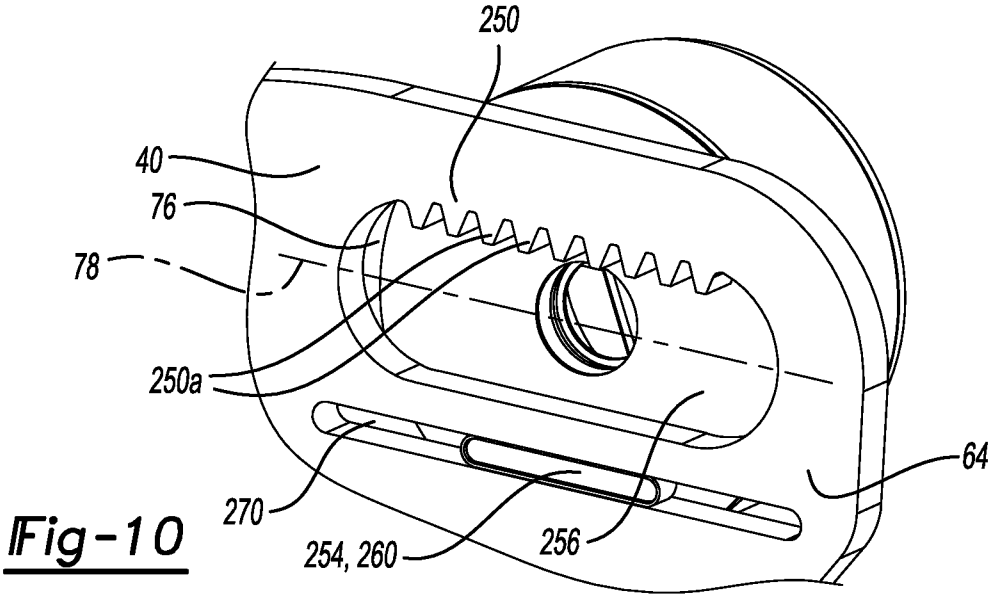


Fig-10

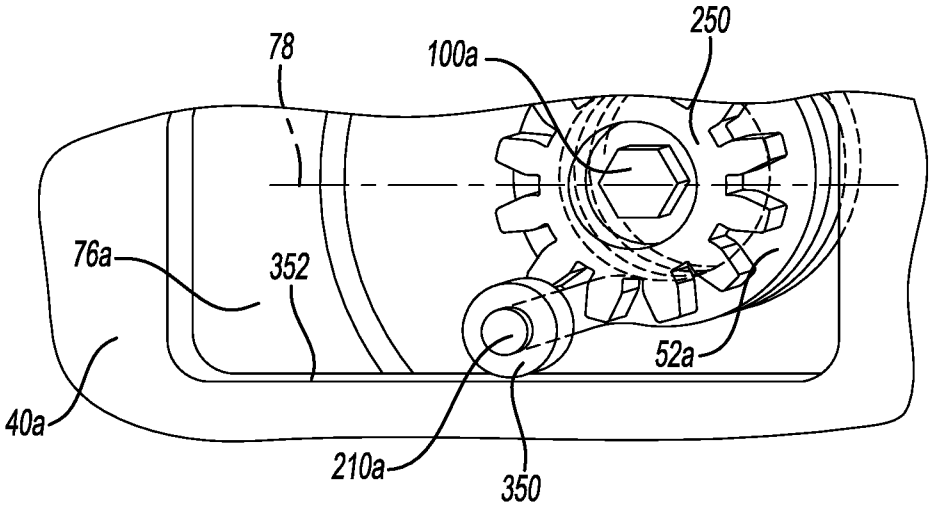


Fig-11

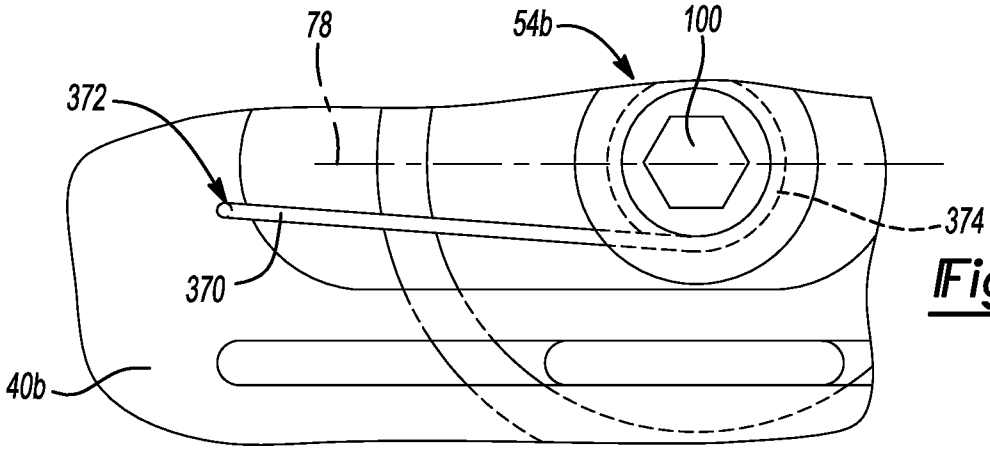


Fig-12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2020/012316

A. CLASSIFICATION OF SUBJECT MATTER

F16H 7/08(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)
F16H 7/08; F16H 7/12; F16H 7/22; F16H 712

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
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: tensioner, torsion spring, wheel, pinion, rack, guide, roller

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2017-0370448 A1 (FORD GLOBAL TECHNOLOGIES, L.L.C.) 28 December 2017 paragraphs [0034]-[0037], [0043] and figures 1, 2	1-6,9-11
A		7,8
Y	US 2017-0248204 A1 (BORGWARNER INC.) 31 August 2017 paragraphs [0021], [0022], [0025] and figures 2-4	1-6,9-11
Y	US 2006-0052194 A1 (GERRING, DOUGLAS G.) 09 March 2006 paragraphs [0026], [0027], [0030], [0031] and figure 2	3-6
A	US 6458055 B1 (BELLAMY-BOOTH, COLIN) 01 October 2002 column 2, lines 16-39 and figures 1, 2	1-11
A	US 4725260 A (KOMOROWSKI et al.) 16 February 1988 column 2, line 59 - column 3, line 51 and figures 1-3	1-11

☐ 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
07 May 2020 (07.05.2020)	**07 May 2020 (07.05.2020)**

Name and mailing address of the ISA/KR	Authorized officer
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International application No.

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