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Kneidel et al.

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(54) **LOW FRICTION ARC SPRING DAMPER**

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Related U.S. Application Data

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(51) **Int. Cl.**
F16D 3/12 (2006.01)

(52) **U.S. Cl.** **464/67.1**

(58) **Field of Classification Search** 464/66.1, 464/67.1, 68.1, 68.9; 192/203
See application file for complete search history.

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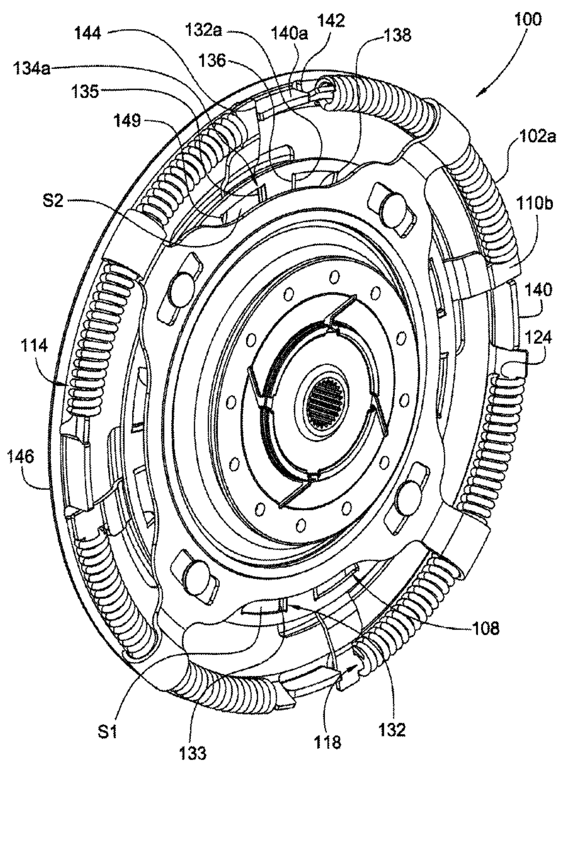
(57) **ABSTRACT**

An arc spring damper, including: a plurality of arc springs, a driving flange having a plurality of driving spring segment, a driven flange having a plurality of driven spring segments, and a ring plate including a plurality of radially extending retention segments. Each arc spring in the plurality of arc springs includes a passageway with first and second openings at first and second longitudinal ends, respectively, for the arc spring. Each driving spring segment includes a circumferentially extending driving portion and each driven spring segment includes a circumferentially extending driven portion. For each spring, a respective driving portion passes through the first opening into the passageway and a respective driven portion passes through the second opening into the passageway. Each radially extending segment from the plurality of radially extending segments is connected to and rotatable with a spring from the plurality of arc springs and radially restrains the arc spring.

7 Claims, 6 Drawing Sheets



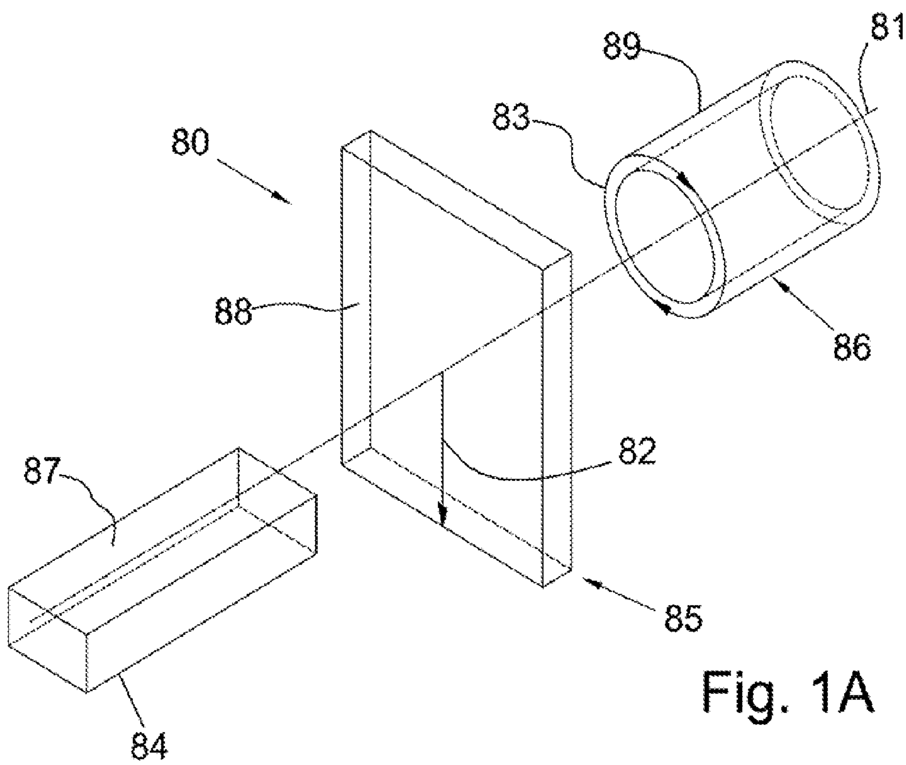


Fig. 1A

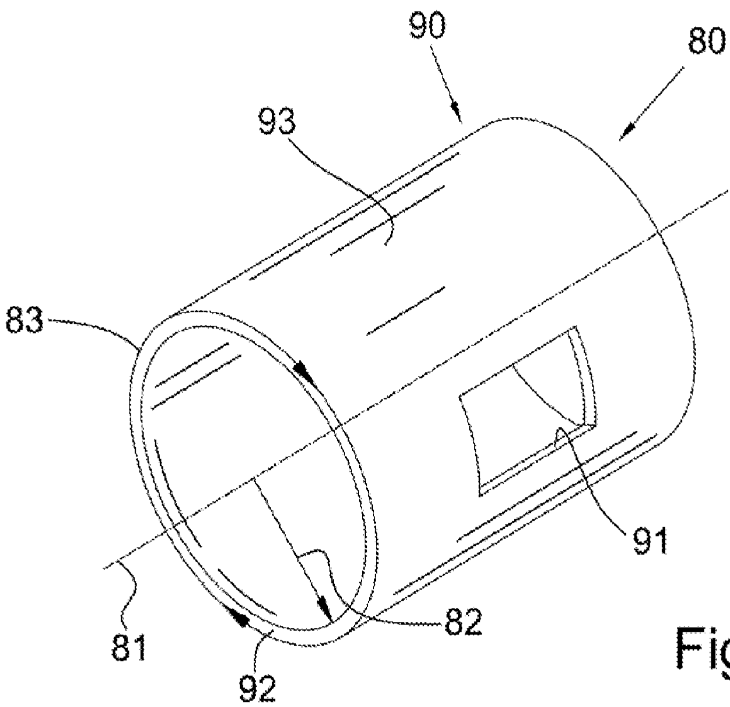
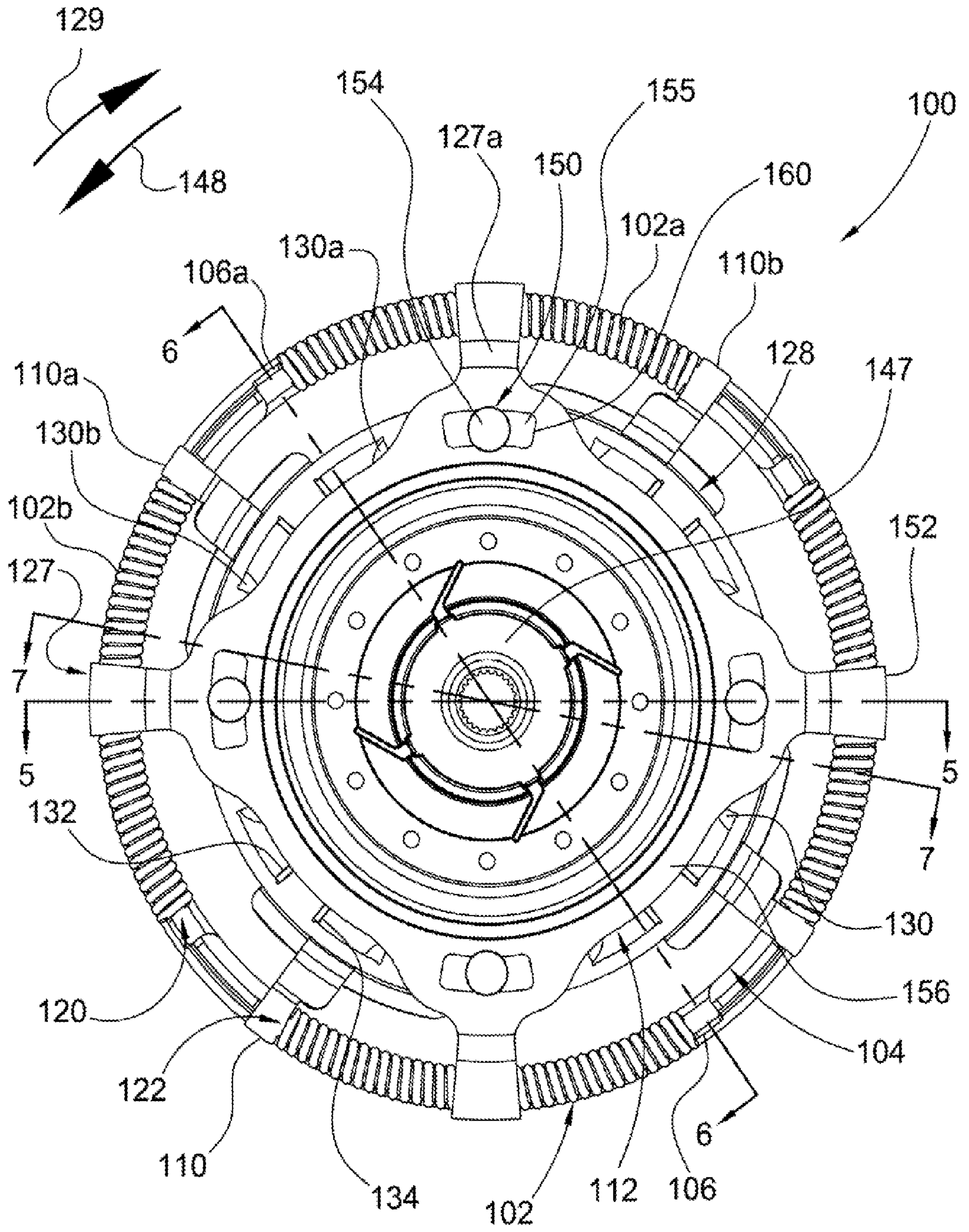


Fig. 1B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102b
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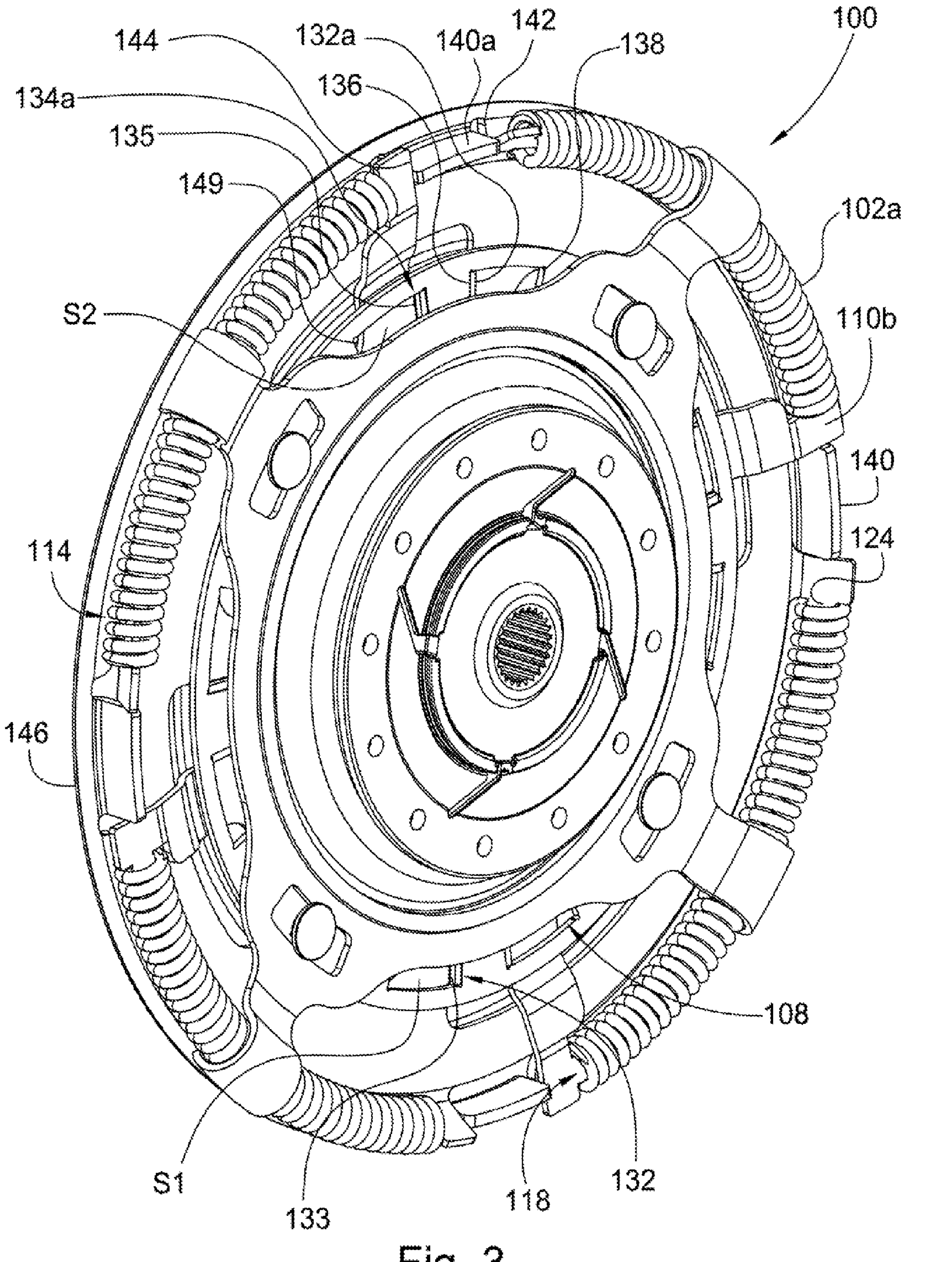
5
7
132
130
156
120
104
122
6
110
134
102
112
106

Fig. 2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118
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Fig. 3

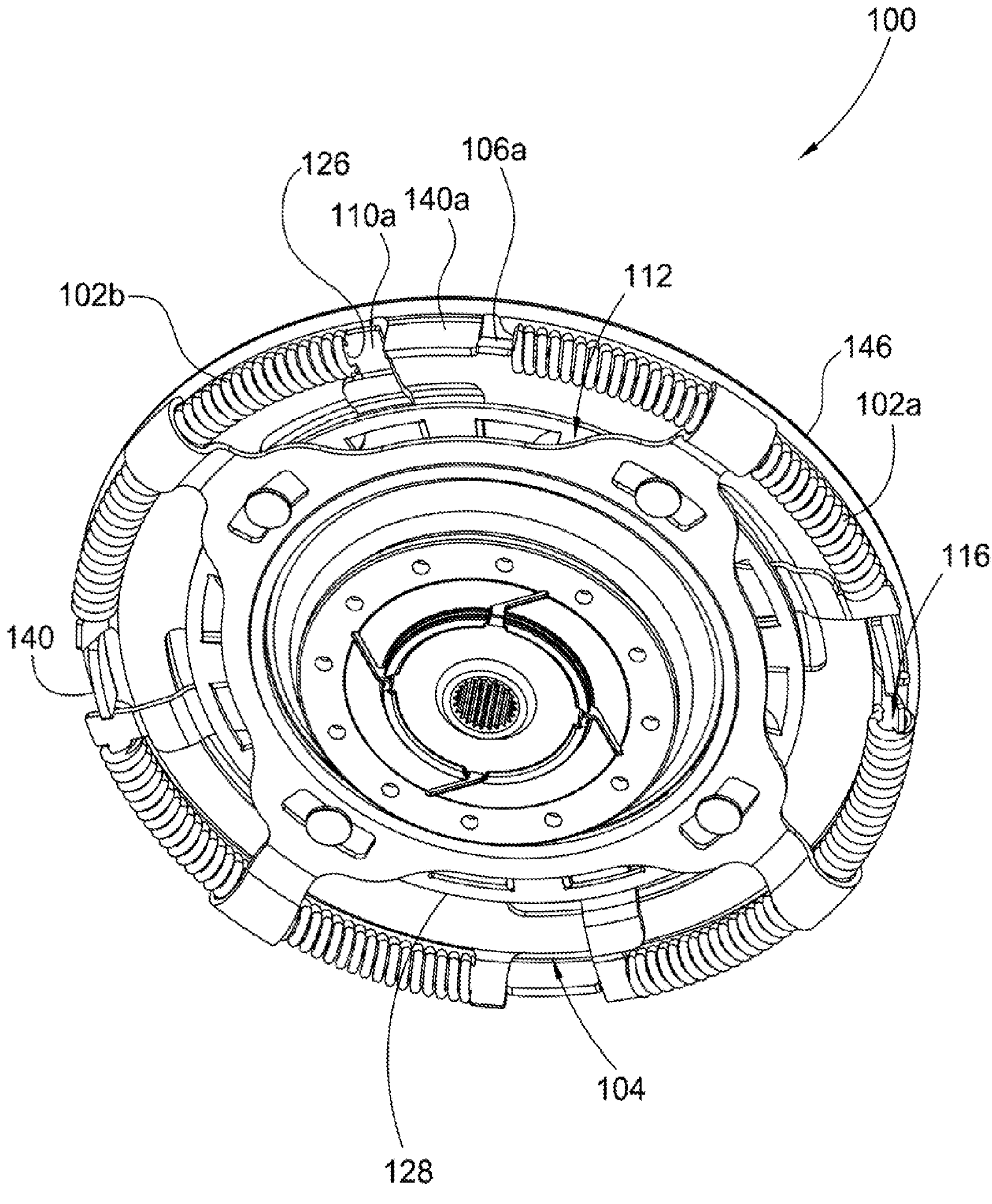

Fig. 4

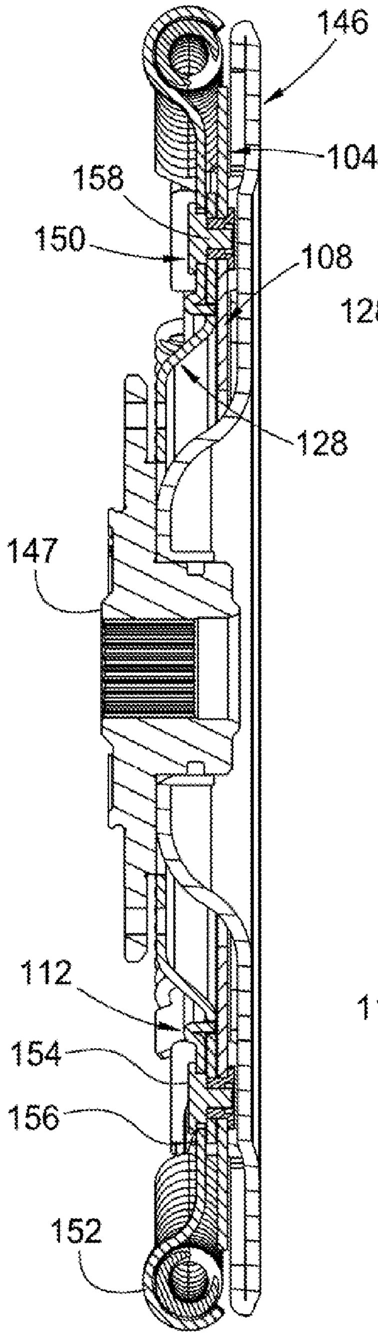

Fig. 5

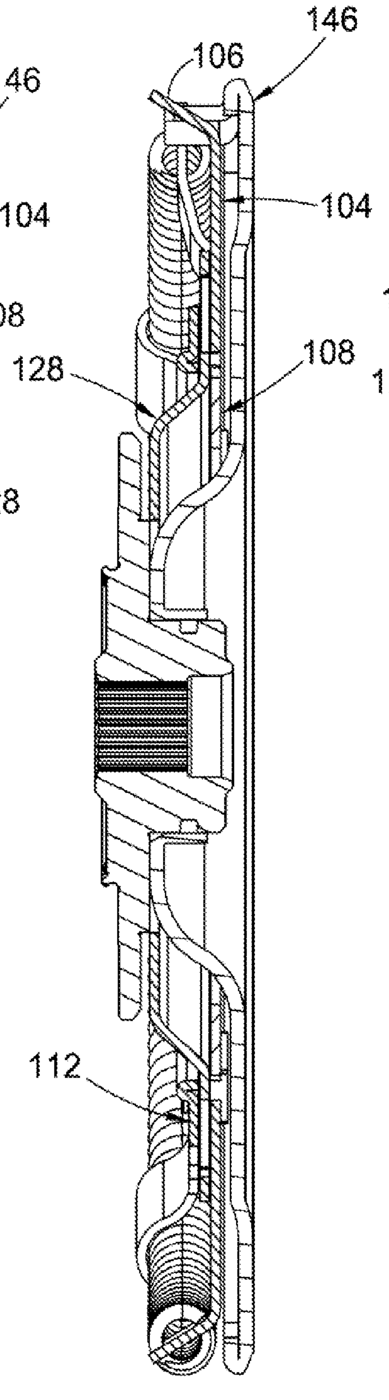

Fig. 6

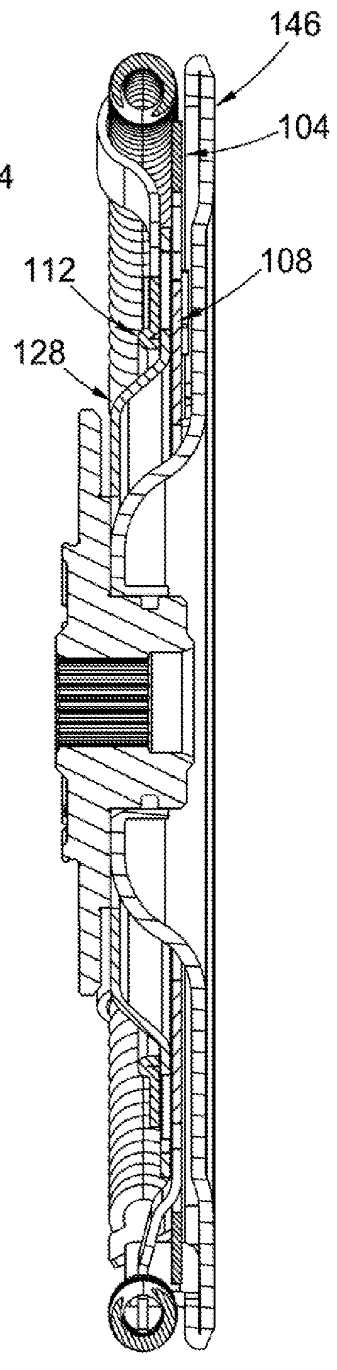

Fig. 7

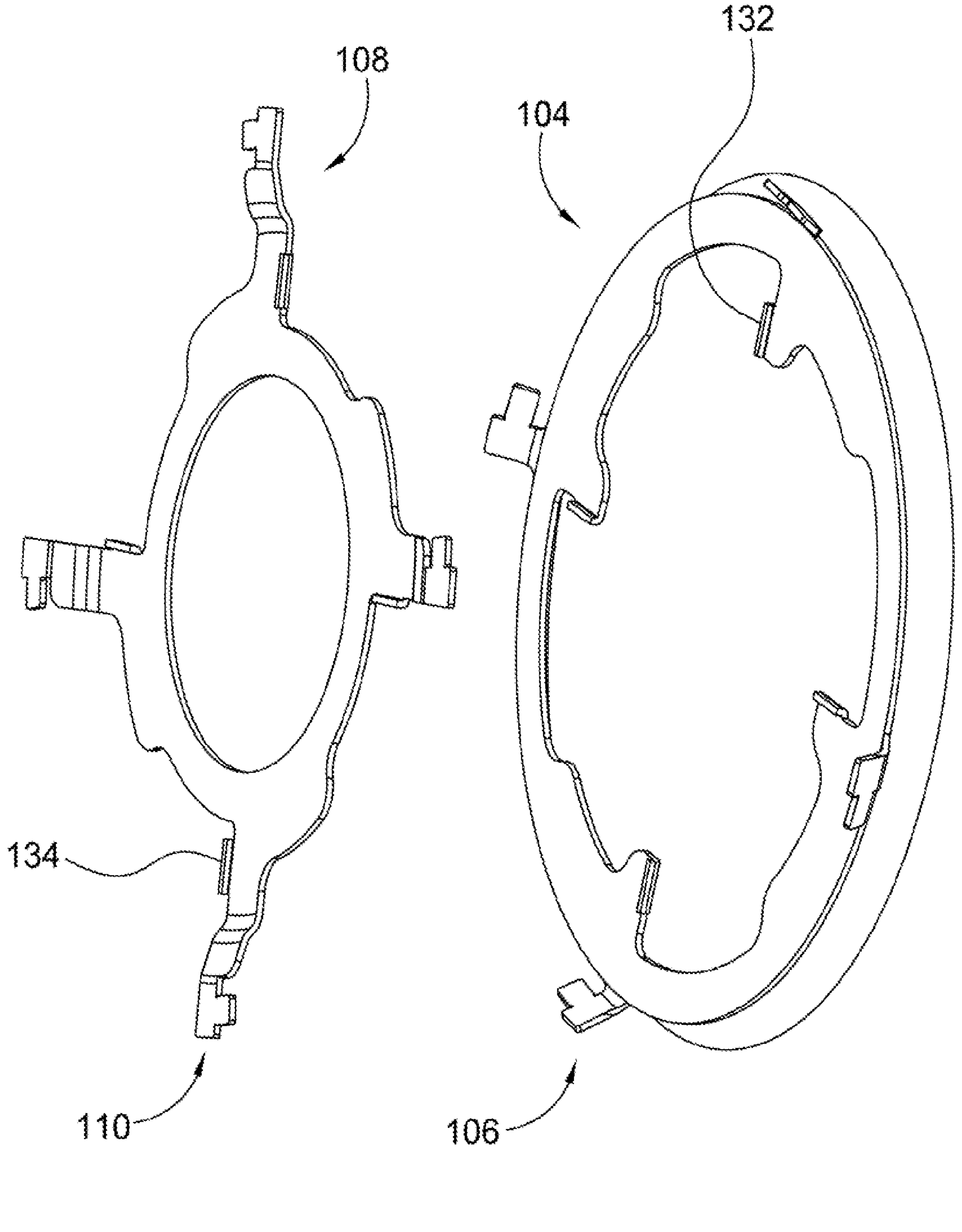

Fig. 8

LOW FRICTION ARC SPRING DAMPER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit under 35 U.S.C. §119(e) of U.S. Provisional Application No. 61/206,055 filed Jan. 27, 2009, which application is incorporated herein by reference.

FIELD OF THE INVENTION

The invention relates to a damper with arc springs that are radially restrained with nominal frictional losses for the springs. The invention also relates to a damper with arc springs and a displaceable driving member.

BACKGROUND OF THE INVENTION

The prior art teaches the use of radial restraining structures for arc springs in a damper that interleave between adjacent coils of the arc springs. The prior art also teaches a non-axially displaceable connection of driving members with a damper using arc springs.

BRIEF SUMMARY OF THE INVENTION

The present invention broadly comprises an arc spring damper, including: a plurality of arc springs, a driving flange having a plurality of driving spring segment, a driven flange having a plurality of driven spring segments, and a ring plate including a plurality of radially extending retention segments. Each arc spring in the plurality of arc springs includes a passageway with first and second openings at first and second longitudinal ends, respectively, for the arc spring. Each driving spring segment includes a circumferentially extending driving portion and each driven spring segment includes a circumferentially extending driven portion. For each arc spring, a respective driving portion passes through the first opening into the passageway and a respective driven portion passes through the second opening into the passageway. Each radially extending segment from the plurality of radially extending segments is connected to and rotatable with an arc spring from the plurality of arc springs and radially restrains the arc spring.

In one embodiment, each radially extending segment axially restrains the arc spring. In one embodiment, the damper includes a plurality of axially extending clutch members and each clutch member from the plurality of clutch members is circumferentially disposed between a respective driving spring segment and a respective driven spring segment and is engageable with the respective driving and driven spring segments. In one embodiment, the damper includes a piston plate including the plurality of axially extending clutch members.

In one embodiment, the damper includes a carrier plate with a plurality of openings and each driving spring segment includes an axially extending driving tab disposed in an opening from the plurality of openings, each driven spring segment includes an axially extending driven tab disposed in an opening from the plurality of openings and the driving and driven tabs are circumferentially displaceable within the respective openings, and engageable with the carrier plate in a circumferential direction. In one embodiment, the engagement of the driving and driven tabs and the carrier plate limits compression of the plurality of arc springs.

It is a general object of the present invention to provide a damper that uses arc springs and restrains the arc springs with a minimum of frictional losses.

These and other objects and advantages of the present invention will be readily appreciable from the following description of preferred embodiments of the invention and from the accompanying drawings and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The nature and mode of operation of the present invention will now be more fully described in the following detailed description of the invention taken with the accompanying drawing figures, in which:

F*igure* **1**A is a perspective view of a cylindrical coordinate system demonstrating spatial terminology used in the present application;

FIG. **1**B is a perspective view of an object in the cylindrical coordinate system of F*igure* **1**A demonstrating spatial terminology used in the present application;

FIG. **2** is a front view of a present invention arc spring damper;

FIG. **3** is a front perspective view of the arc spring damper shown in FIG. **2**;

FIG. **4** is a front perspective view of the arc spring damper shown in FIG. **2**;

FIG. **5** is a cross-sectional view of the arc spring damper shown in FIG. **2** generally along line **5-5** in FIG. **2**;

FIG. **6** is a cross-sectional view of the arc spring damper shown in FIG. **2** generally along line **6-6** in FIG. **2**;

FIG. **7** is a cross-sectional view of the arc spring damper shown in FIG. **2** generally along line **7-7** in FIG. **2**; and,

FIG. **8** is a perspective view of the driving flange and driven flange shown in FIGS. **2** and **3**.

DETAILED DESCRIPTION OF THE INVENTION

At the outset, it should be appreciated that like drawing numbers on different drawing views identify identical, or functionally similar, structural elements of the invention. While the present invention is described with respect to what is presently considered to be the preferred aspects, it is to be understood that the invention as claimed is not limited to the disclosed aspects.

Furthermore, it is understood that this invention is not limited to the particular methodology, materials and modifications described and as such may, of course, vary. It is also understood that the terminology used herein is for the purpose of describing particular aspects only, and is not intended to limit the scope of the present invention, which is limited only by the appended claims.

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which this invention belongs. Although any methods, devices or materials similar or equivalent to those described herein can be used in the practice or testing of the invention, the preferred methods, devices, and materials are now described.

FIG. **1**A is a perspective view of cylindrical coordinate system **80** demonstrating spatial terminology used in the present application. The present invention is at least partially described within the context of a cylindrical coordinate system. System **80** has a longitudinal axis **81**, used as the reference for the directional and spatial terms that follow. The adjectives “axial,” “radial,” and “circumferential” are with respect to an orientation parallel to axis **81**, radius **82** (which is orthogonal to axis **81**), and circumference **83**, respectively.

The adjectives "axial," "radial" and "circumferential" also are regarding orientation parallel to respective planes. To clarify the disposition of the various planes, objects **84**, **85**, and **86** are used. Surface **87** of object **84** forms an axial plane. That is, axis **81** forms a line along the surface. Surface **88** of object **85** forms a radial plane. That is, radius **82** forms a line along the surface. Surface **89** of object **86** forms a circumferential plane. That is, circumference **83** forms a line along the surface. As a further example, axial movement or disposition is parallel to axis **81**, radial movement or disposition is parallel to radius **82**, and circumferential movement or disposition is parallel to circumference **83**. Rotation is with respect to axis **81**.

The adverbs "axially," "radially," and "circumferentially" are with respect to an orientation parallel to axis **81**, radius **82**, or circumference **83**, respectively. The adverbs "axially," "radially," and "circumferentially" also are regarding orientation parallel to respective planes.

FIG. **1**B is a perspective view of object **90** in cylindrical coordinate system **80** of FIG. **1**A demonstrating spatial terminology used in the present application. Cylindrical object **90** is representative of a cylindrical object in a cylindrical coordinate system and is not intended to limit the present invention in any manner. Object **90** includes axial surface **91**, radial surface **92**, and circumferential surface **93**. Surface **91** is part of an axial plane, surface **92** is part of a radial plane, and surface **93** is part of a circumferential plane.

FIG. **2** is a front view of present invention arc spring damper **100**.

FIG. **3** is a front perspective view of arc spring damper **100**.

FIG. **4** is a front perspective view of arc spring damper **100**.

FIGS. **5** through **7** are respective cross-sectional views of arc spring damper **100** generally along lines **5-5**, **6-6**, and **7-7**, respectively, in FIG. **2**. FIG. **8** is a perspective view of the driving flange and driven flange shown in FIGS. **2** and **3**. The following should be viewed in light of FIGS. **2** through **8**. Damper **100** includes a plurality of arc springs **102**, driving flange **104** with a plurality of driving spring segments **106**, driven flange **108** with a plurality of driven spring segments **110**, and ring plate **112**. Each arc spring in the plurality of arc springs, for example, spring **102**A, includes passageway **114** with openings **116** and **118** at longitudinal ends **120** and **122**, respectively, for the arc spring. For example, the passageway is an internal channel formed by the coil structure of the spring. Each driving spring segment includes a circumferentially extending driving portion **124** and each driven spring segment includes a circumferentially extending driven portion **126**.

The ring plate includes a plurality of radially extending retention segments **127**. Each radially extending segment is connected to and rotatable with an arc spring from the plurality of arc springs and radially and axially restrains the arc spring. For example, as the flange and segment **106**A rotate in rotational direction **129**, spring **102**A compresses, causing the coil structure of the spring to shift in direction **129**. Segment **127**A has sufficient contact with spring **102**A so that the segment also rotates in direction **129** to match the shifting/rotation of the portion of spring **102**A with which the segment is in contact. Thus, the ring plate is rotatable with the plurality of arc springs.

Arc spring damper **100** includes carrier plate **128** with plurality of openings **130**. Each driving spring segment includes axially extending driving tab **132** disposed in an opening from the plurality of openings, circumferentially displaceable within the opening, and engageable with the carrier plate in a circumferential direction. Each tab **132** includes portion **133** axially extending from surface S1 of a respective driving spring segment. Each driven spring segment includes axially extending driven tab **134** disposed in an opening from the plurality of openings, circumferentially displaceable within the opening, and engageable with the carrier plate in a circumferential direction. Each tab **134** includes portion **135** axially extending from surface S2 of a respective driven spring segment. For example, driving tab **132**A is disposed in and circumferentially displaceable within opening **130**A and is engageable with surfaces **136** and **138** for the opening. The function of the tabs is further described infra.

Arc spring damper **100** includes a plurality of axially extending clutch members **140**. Each clutch member is circumferentially disposed between adjacent driving and driven spring segments, is engageable with the adjacent spring segments, and is axially displaceable with respect to the adjacent spring segments. For example, member **140**A is circumferentially disposed between spring segments **106**A and **110**A, is engaged with surfaces **142** and **144**, respectively for the spring segments, and is axially displaceable with respect to spring segments **106**A and **110**A. In one embodiment, damper **100** includes piston plate **146**, which includes the clutch members.

The flanges are driven by clutch members **140**. In one embodiment, members **140** are tabs in piston plate **146**. The configuration of members **140** and segments **106** and **110** enables axial displacement of the piston plate with respect to the remainder of the damper, which in turn, facilitates operation of other components, such a clutch (not shown) of which the piston plate forms a part. For example, the clutch could be in a torque path to the damper and the axial displacement of the piston enables opening and closing of the clutch.

The arc springs of damper **100** advantageously provide a low spring rate, which is desirable in a damper. Further, the configuration of segments **127** provide retention, in particular, radial retention, of the arc springs with little of no frictional loss. For example, as described supra, segments **127** and the arc springs rotate in unison, rather than having the arc springs rotate through and against a fixed radial retention structure.

The following is a description of an operation of damper **100**. In a power transmission mode, springs **102** are driven by a flange **104**, in particular, by driving spring segments, for example, segment **106**A, in direction **129**. The driving spring segments and the arc springs are connected via protrusions **124** which extend into the internal space, for example, passageway **114**, formed by the coil structure of the arc coils. Radially extending retention segments **127** constrain, in particular, radially restrain, the arc springs under rotational speed. As noted, as the springs rotate/compress ("wind up"), the respective segments **127** move/rotate along with the springs. Because the respective segments **127** move/rotate along with the springs, there is little or no friction between the respective segments **127** and the arc springs.

The spring force from the driving spring segments is reacted against respective driven spring segments such as segment **110**B. Tabs **132** enable torque to be transferred from the driving flange to the carrier plate. For example, driving torque from tab **140**A causes segment **106**A to displace in direction **129**, compressing spring **102**A. When segment **106**A rotates far enough in direction **129**, protrusion **132**A contacts surface **138** of window **130**A and torque from the driving flange is transferred to the carrier plate via the contact of protrusion **132**A with surface **138**. The carrier plate can then transfer torque, for example, to an output of the damper, by any means known in the art, for example, by connection to hub **147**. The contact of protrusions **132** with surfaces such as

138 also prevents undesirable over-compression of the arc springs, for example, arc spring **102**A is not further compressed once protrusion **132**A contacts surface **138**.

In a coast mode, torque is applied to the damper in direction **148**, opposite direction **129**. Tabs **134** enable torque to be transferred from the driven spring segments to the carrier plate. For example, coasting torque from tab **140**A causes segment **110**A to displace in direction **148**, compressing spring **102**B. When segment **110**A rotates far enough in direction **148**, protrusion **134**A contacts surface **149** of window **130**B. Thereafter, the torque from flange **108** is transferred to the carrier plate via the contact of protrusion **134**A with surface **149**. The contact of protrusions **134** with surfaces such as **149** also prevents undesirable over-compression of the arc springs, for example, arc spring **102**B is not further compressed once protrusion **134**A contacts surface **149**. It should be understood that directions **129** and **148** can be reversed.

In one embodiment, rivets **150** are fixed to plate **128** and extend through respective openings **155** in plate **112**. The diameter of head **154** of the rivet is greater than the radial extent of opening **155**; therefore, the head contacts radial face **156** of plate **112** to axially restrain plate **112**. Sufficient clearance is provided between the head and the face to minimize frictional losses. Body **158** of the rivet is sized to enable movement of the body in opening **155**. By fixing the rivets to plate **128**, the circumferential position of body **158** is limited to a relatively small arc as the carrier plate shifts from a drive to a coast position as described supra. Therefore, the circumferential position of plate **128** is similarly limited. For example, the rotation of plate **128** is halted when body **158** engages end **160** of opening **155**. As a result, segments **127** remain relatively circumferentially centered on the arc springs, for example, segments **127** remain approximately halfway between ends **120** and **122**, optimizing the radial retention function of segments **127**.

Under rotation of the damper, the arc springs, in particular, the circumferentially centered/middle portions of the springs will tend to be displaced radially outward. Therefore, it is necessary to provide radial restraint for the middle portions. Advantageously, retention segments **127** provide such support while causing little or no frictional loss with respect to the movement of the arc springs. Ring **112** is rotationally free with the exception of the connection to the arc springs described supra. Thus, the ring is free to rotate to follow the rotation of the arc springs and create only nominal drag or friction on the arc springs. In one embodiment, ring **112** is formed as a single piece, providing maximum strength while occupying minimal axial space. For example, portion **152** of segments **127**, fits around most of the diameter of the spring, eliminating any restrictions on the design or windup of the spring. The simple design of ring **112** accomplishes the intended function of radially restraining the arc springs without any additional pieces or sub-assembly requirements, which minimizes radial space requirements for the ring and damper **100**.

Thus, it is seen that the objects of the present invention are efficiently obtained, although modifications and changes to the invention should be readily apparent to those having ordinary skill in the art, which modifications are intended to be within the spirit and scope of the invention as claimed. It also is understood that the foregoing description is illustrative of the present invention and should not be considered as limiting. Therefore, other embodiments of the present invention are possible without departing from the spirit and scope of the present invention.

What we claim is:

1. An arc spring damper, comprising:

a plurality of circumferentially curved arc springs, wherein each circumferentially curved arc spring in the plurality of circumferentially curved arc springs includes a circumferentially curved passageway with first and second openings at first and second longitudinal ends, respectively, for said each circumferentially curved arc spring;

a driving flange having a plurality of driving spring segments, each driving spring segment including a circumferentially extending driving portion;

a driven flange having a plurality of driven spring segments, each driven spring segment including a circumferentially extending driven portion; and,

a ring plate including a plurality of radially extending retention segments, wherein:

for each said circumferentially curved arc spring a respective driving portion passes through the first opening into the passageway and a respective driven portion passes through the second opening into the passageway; and

each radially extending segment from the plurality of radially extending segments is connected to a circumferentially curved arc spring from the plurality of circumferentially curved arc springs at a point between the first and second longitudinal ends, is rotatable with the circumferentially curved arc spring from the plurality of circumferentially curved arc springs, and radially restrains the circumferentially curved arc spring.

2. The arc spring damper of claim **1** wherein said each radially extending segment axially restrains the arc spring.

3. The arc spring damper of claim **1** further comprising a plurality of axially extending clutch members, wherein each clutch member from the plurality of clutch members is circumferentially disposed between a respective driving spring segment and a respective driven spring segment and is engageable with the respective driving and driven spring segments.

4. The arc spring damper of claim **3** further comprising a piston plate including the plurality of axially extending clutch members.

5. The arc spring damper of claim **1** further comprising a carrier plate with a plurality of openings and wherein each driving spring segment includes an axially extending driving tab disposed in an opening from the plurality of openings, each driven spring segment includes an axially extending driven tab disposed in an opening from the plurality of openings and wherein the driving and driven tabs are circumferentially displaceable within the respective openings, and engageable with the carrier plate in a circumferential direction.

6. The arc spring damper of claim **1** wherein the engagement of the driving and driven tabs and a carrier plate limits compression of the plurality of arc springs.

7. An arc spring damper, comprising:

a plurality of arc springs, wherein each arc spring in the plurality of arc springs includes a passageway with first and second openings at first and second longitudinal ends, respectively, for the arc spring;

a driving flange having a plurality of driving spring segments, each driving spring segment including a circumferentially extending driving portion and an axially extending driving tab;

a driven flange having a plurality of driven spring segments, each driven spring segment including a circumferentially extending driven portion and an axially extending driven tab;

a ring plate including a plurality of radially extending retention segments;

a piston plate including a plurality of axially extending clutch members; and,

a carrier plate with a plurality of openings, wherein for each said arc spring a respective driving portion passes through the first opening into the passageway and a respective driven portion passes through the second opening into the passageway, wherein each radially extending segment from the plurality of radially extending segments at least partially encloses an arc spring from the plurality of arc springs, is connected to and rotatable with the arc spring, and radially restrains the arc spring, wherein each clutch member from the plurality of clutch members is circumferentially disposed between respective adjacent driving and driven spring segments and is engageable with the respective adjacent driving and driven spring segments, and wherein the axially extending driving and driven tabs are disposed in respective openings from the plurality of openings, are circumferentially displaceable within the opening, and are engageable with the carrier plate in a circumferential direction.

* * * * *