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(54) **FRICITION CONTROLLED DAMPER FOR A TORQUE TRANSMISSION DEVICE**

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**F16H 37/00** (2006.01)  
**F16D 3/14** (2006.01)  
**B60K 17/28** (2006.01)

(52) **U.S. Cl.**  
CPC .. **F16D 3/14** (2013.01); **B60K 17/28** (2013.01)

(58) **Field of Classification Search**  
CPC ..... **F16D 3/12**; **F16D 3/14**  
USPC ..... **74/15.6**; **192/70.17**  
See application file for complete search history.

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*Primary Examiner* — Paul N Dickson

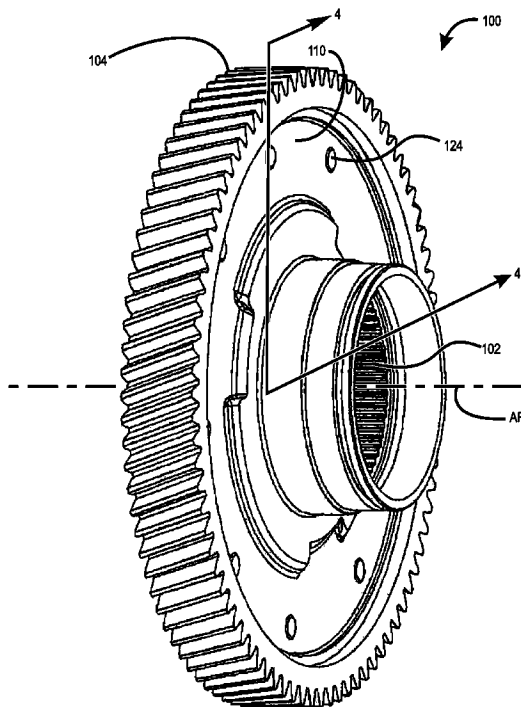
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(57) **ABSTRACT**

A flange forming an input for the device and including a damper stop tab extending radially outward; a plate including first and second curved slots; and a curved friction assembly including a first end disposed in the first curved slot, a second end disposed in the second curved slot, at least one curved engagement plate including an engagement tab extending radially inward, at least one curved friction plate rotationally fixed to the plate, and a resilient element urging the at least one curved engagement plate and the at least one curved friction plate into contact. The device includes at least one elastic element engaged with the flange.

**17 Claims, 6 Drawing Sheets**



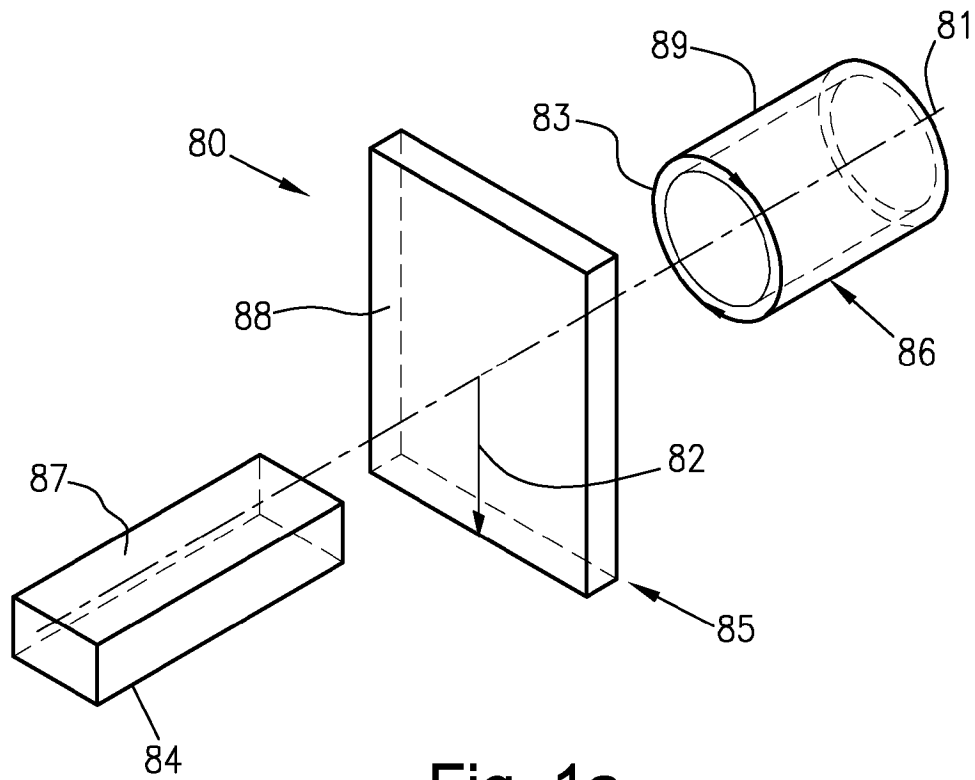


Fig. 1a

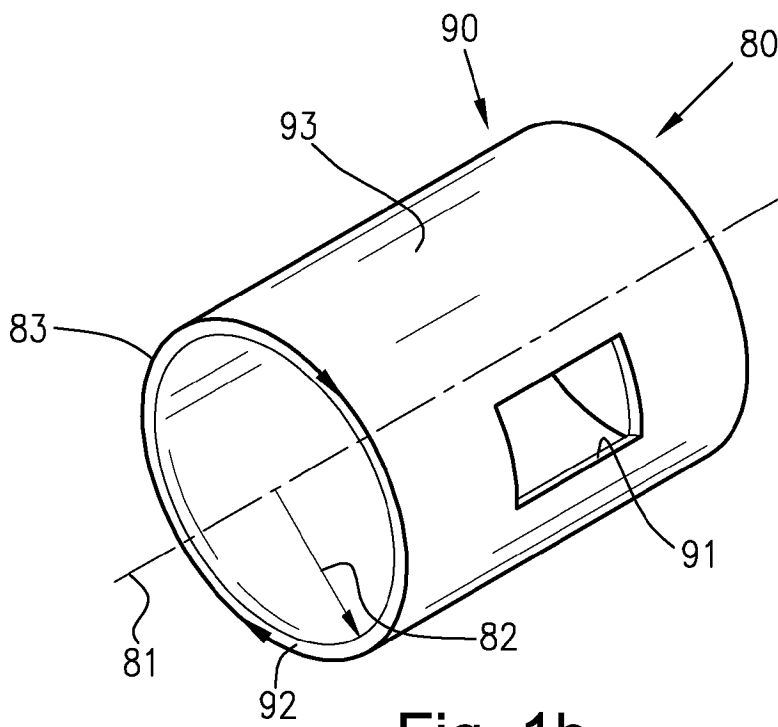


Fig. 1b

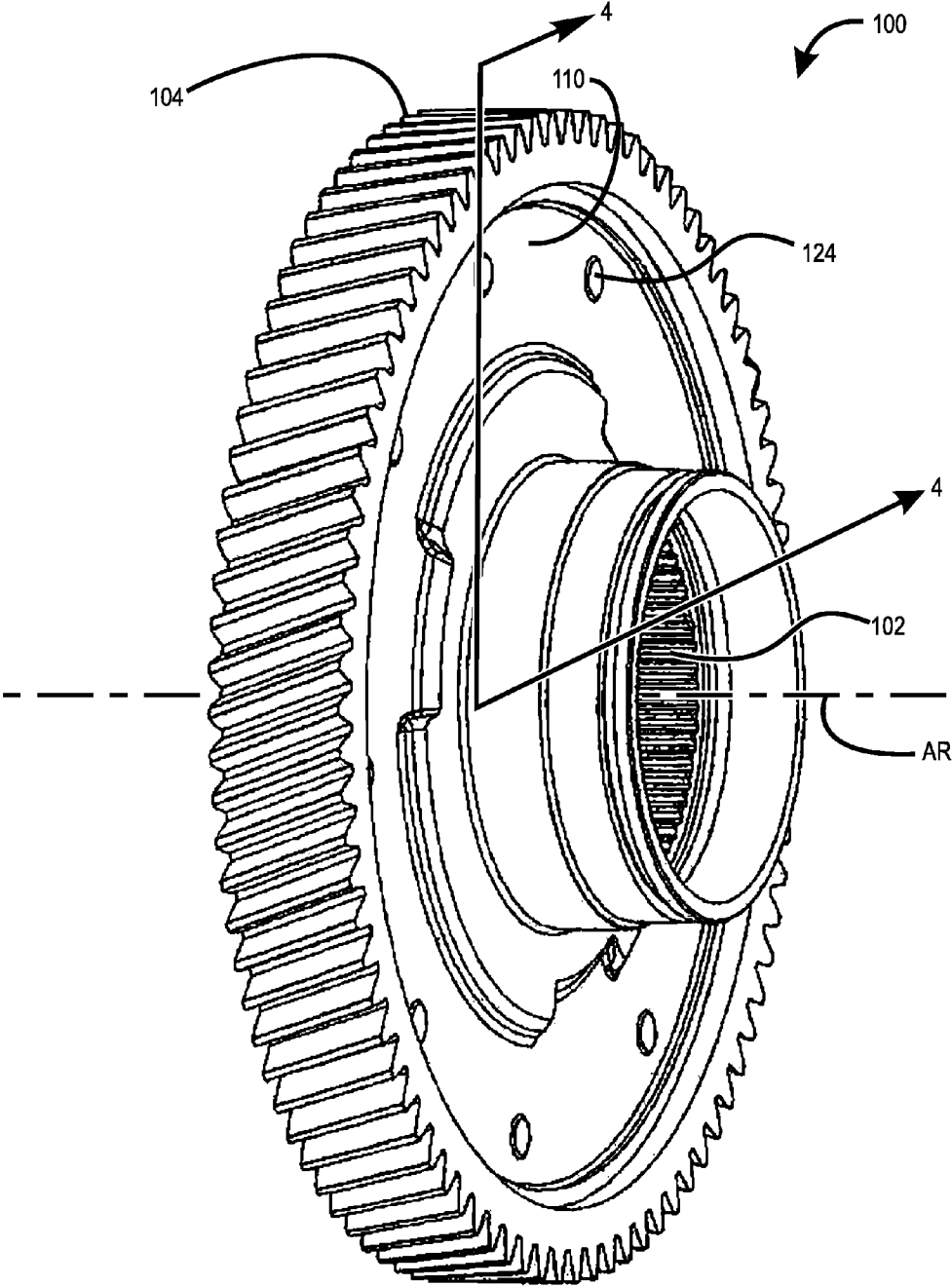


Fig. 2

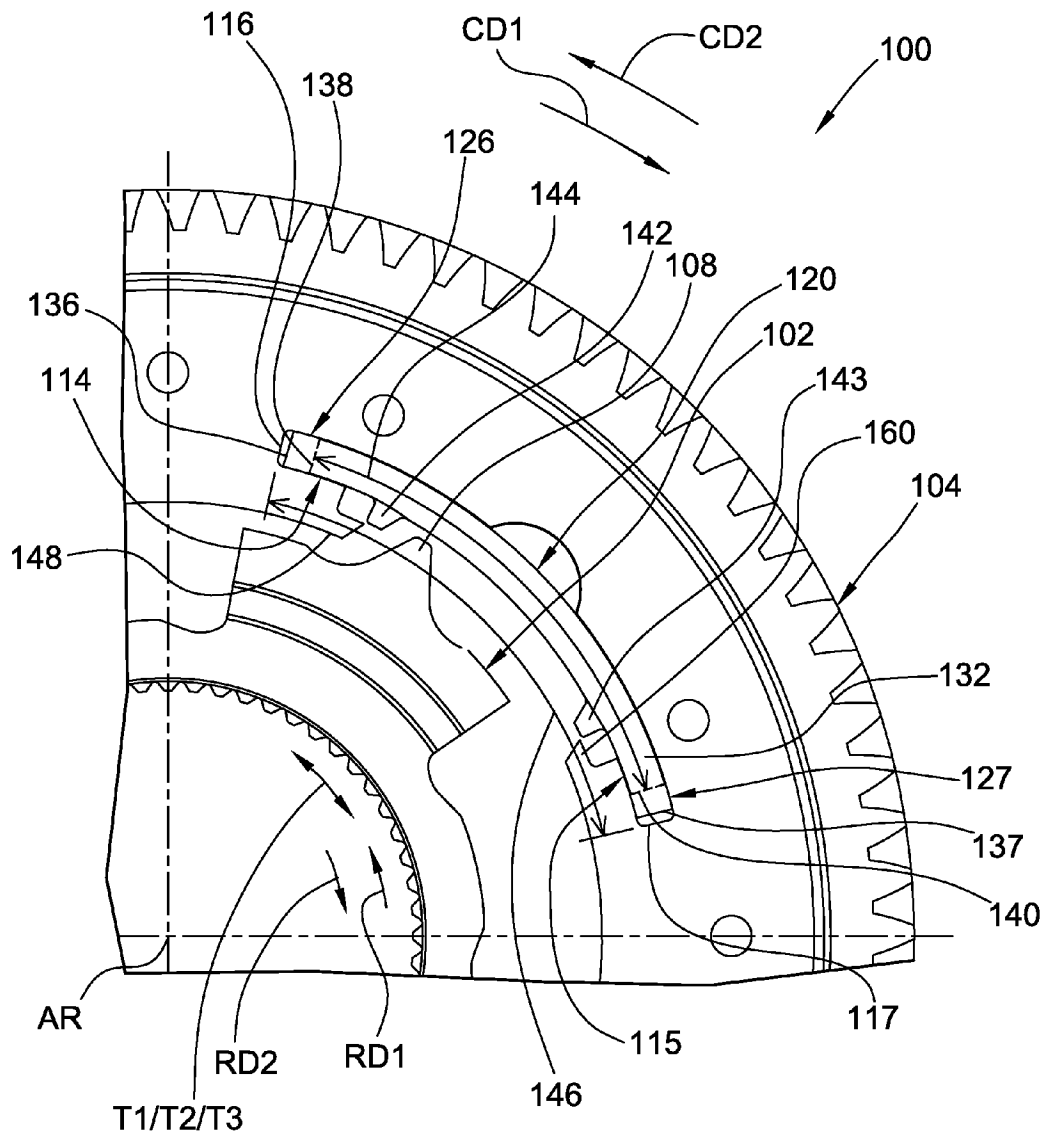


Fig. 3

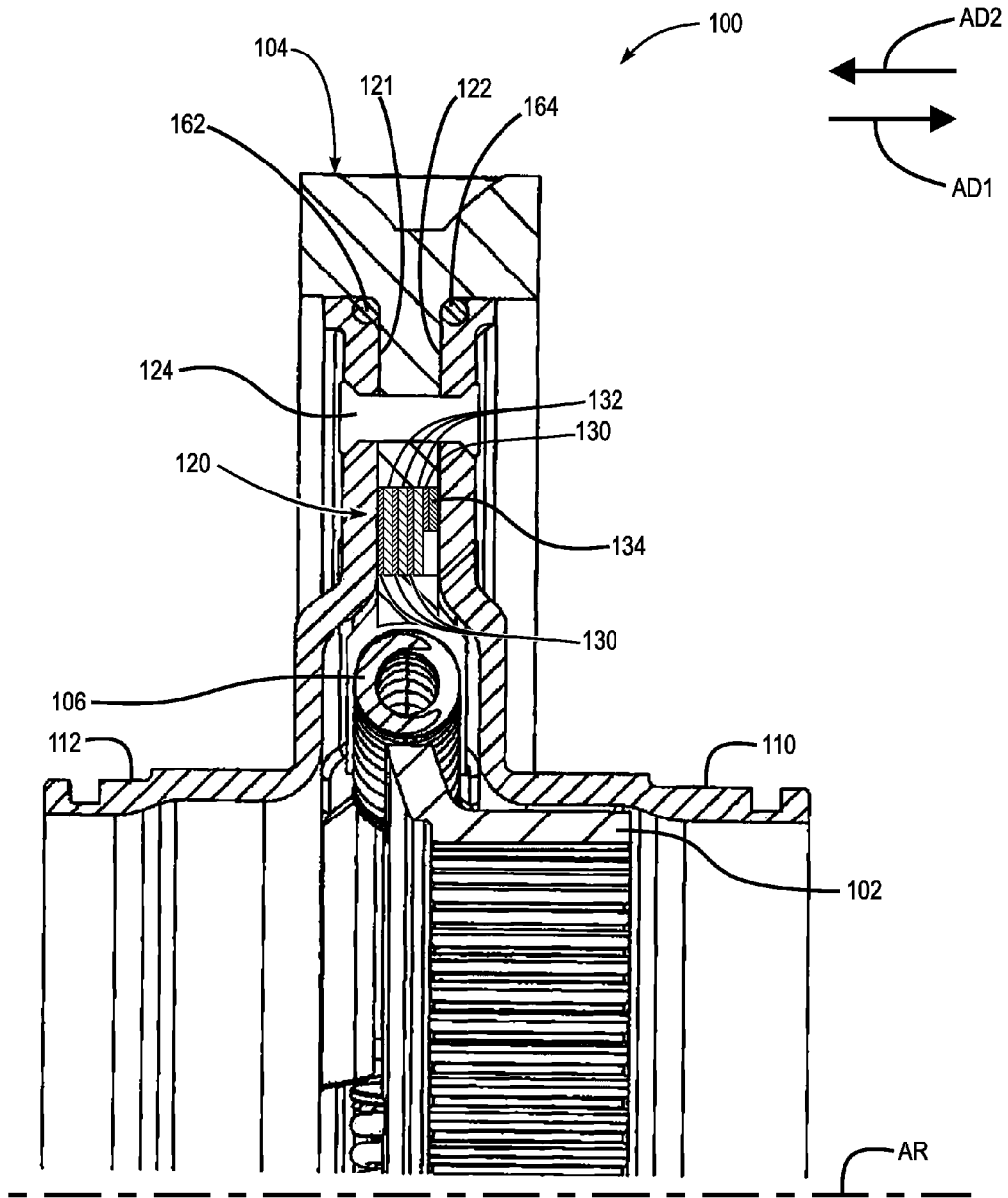


Fig. 4

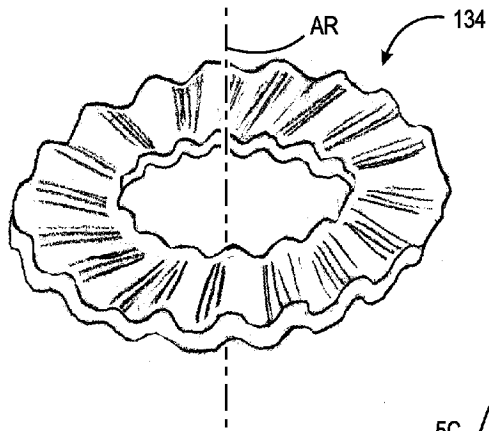


Fig. 5A

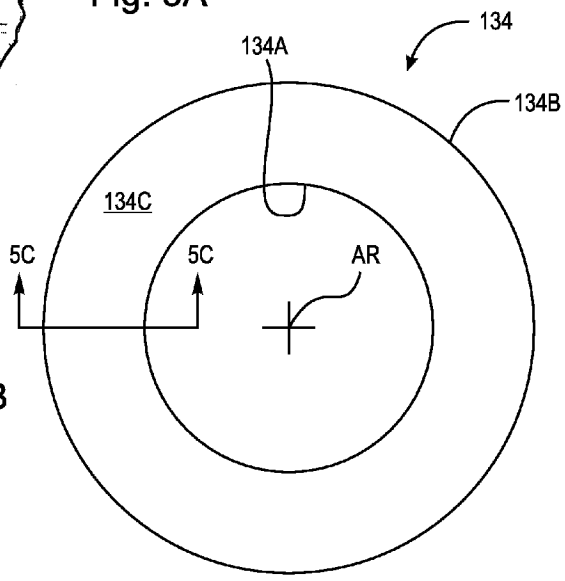


Fig. 5B

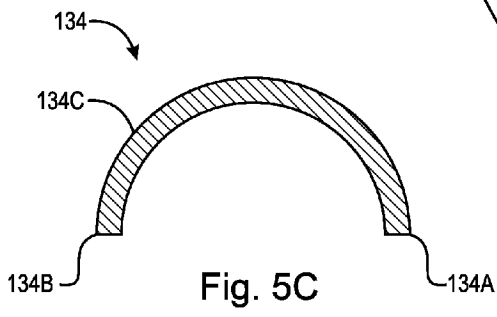


Fig. 5C

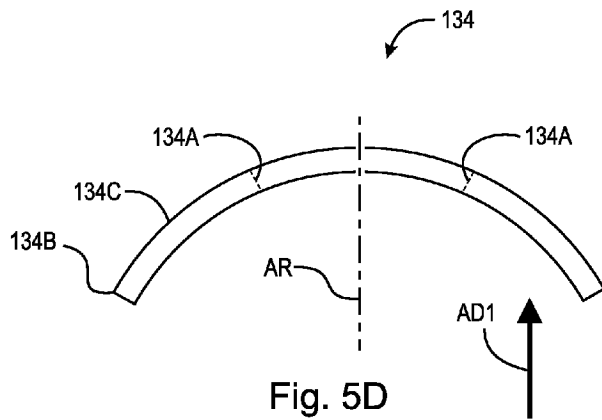


Fig. 5D

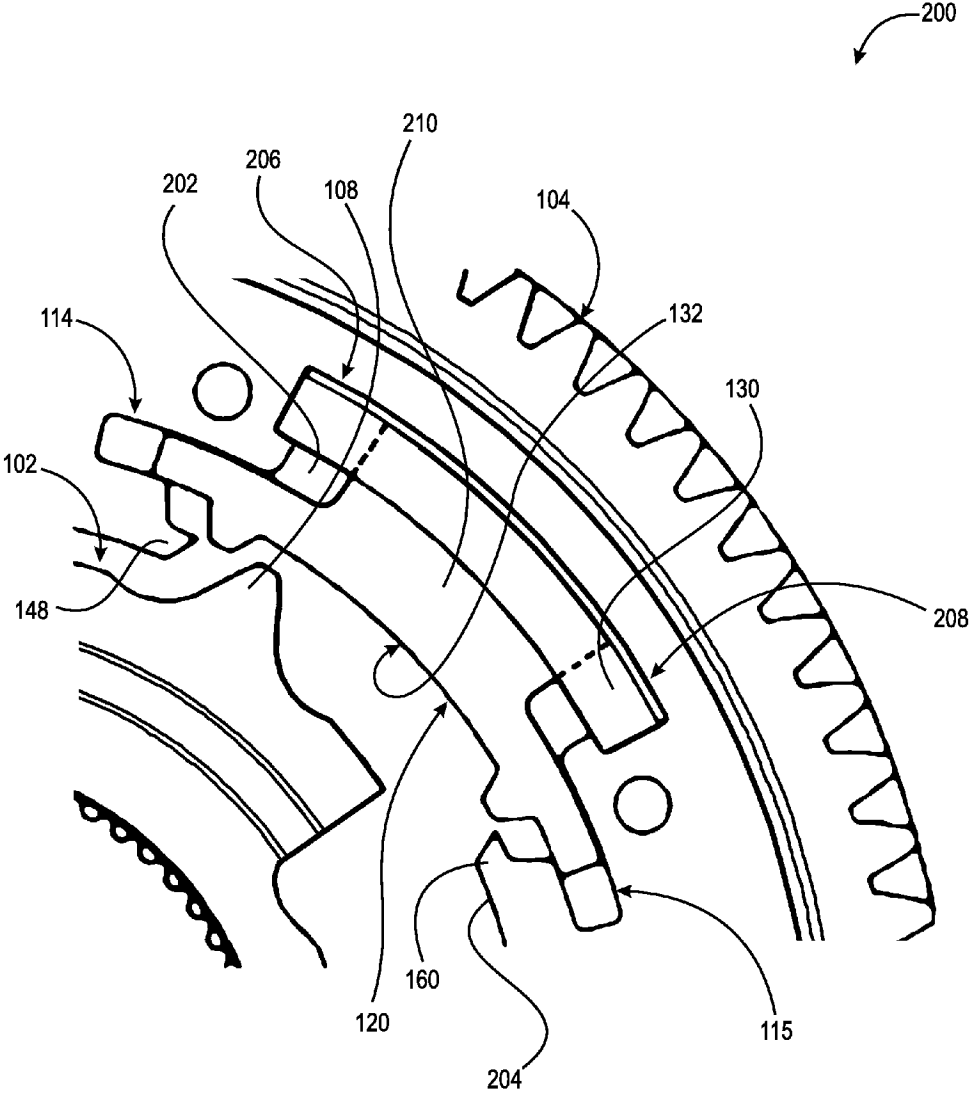


Fig. 6

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## FRICION CONTROLLED DAMPER FOR A TORQUE TRANSMISSION DEVICE

### CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit under 35 U.S.C. §119 (e) of U.S. Provisional Patent Application No. 61/749,616, filed Jan. 7, 2013, which application is incorporated herein by reference in its entirety.

### TECHNICAL FIELD

The invention relates generally to a torsion damper, and more specifically to a torsion damper for a transmission power take-off.

### BACKGROUND

Typically, a power take off (PTO) gear is designed to transmit engine torque to various accessories, such as a fire truck water pump or a hydraulic cylinder for a dump truck via a transmission. During idling of an engine for a vehicle housing the transmission, angular fluctuations occur between a PTO at the transmission and the PTO gear. The angular fluctuations cause undesirable audible noise in the PTO gear, for example, an input element of the PTO gear oscillates with respect to an output element, such as a ring gear, causing the input element to bang against the output element. Further, during start-up of the engine undesirable noise occurs when the engine and transmission system, including the PTO gear, are in a resonance condition. For example, the input element can contact the output element at a frequency of about 10 Hz.

Commonly owned U.S. Patent Application Publication No. 2010/0252390 discloses a power take off gear using elastic elements to dampen undesirable vibration associated with the idle condition. However, due to the relatively low spring rate for the elastic elements, the elastic elements do not attenuate the resonance condition or prevent the undesirable noise associated with engine start-up.

Bumper springs have been used in systems where a second damper stage is required. Bumper springs become active when a built in degree of travel is reached. Once bumper springs are engaged the first stage springs work in parallel to the bumper springs resulting in higher capacity. Friction control plates have been used in parallel with a spring package to provide friction at large travel angles. Friction control plates are generally axially loaded plates located parallel to the main torque path made of material with durable wear properties such as high carbon steel or Teflon. The axial load is generated by a diaphragm spring. A defined amount of lash is built into the system so that the friction control plates do not engage until a certain travel is reached.

Both bumper springs and friction control plates can require increased amount of axial and radial space in a design. Bumper springs only provide a fully elastic element without impact absorption characteristics. Thus, the springs capture vibration energy in the system instead of absorbing the energy. The effectiveness of friction control plates is limited by the applied axial force and the number of friction surfaces.

### SUMMARY

According to aspects illustrated herein, there is provided a torque transmitting device including: a flange forming an input for the device and including a damper stop tab extending radially outward; a plate including first and second curved

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slots; and a curved friction assembly including a first end disposed in the first curved slot, a second end disposed in the second curved slot, at least one curved engagement plate including an engagement tab extending radially inward, at least one curved friction plate rotationally fixed to the plate, and a resilient element urging the at least one curved engagement plate and the at least one curved friction plate into contact. The device includes at least one elastic element engaged with the flange.

According to aspects illustrated herein, there is provided a torque transmitting device including: a flange forming an input for the device and including a damper stop tab extending radially outward; a plate including first and second curved slots; and a curved friction assembly including at least one curved engagement plate. The engagement plate includes an engagement tab extending radially inward and at least partially circumferentially aligned with the damper stop tab, is at least partially rotatable with respect to the plate, and is at least partially disposed in the first and second curved slots. The friction assembly includes at least one curved friction plate: rotationally fixed to the plate; at least partially disposed in the first and second curved slots; and in contact with the at least one curved engagement plate. The friction assembly includes a resilient element: in contact with one of the at least one curved engagement plate or the at least one curved friction plate; and urging the one of the at least one curved engagement plate or the at least one curved friction plate into contact with the other of the at least one curved engagement plate or the at least one curved friction plate. The friction assembly includes at least one elastic element engaged with the flange. The flange is at least partially rotatable with respect to the plate such that the damper stop tab is engageable with the engagement tab.

According to aspects illustrated herein, there is provided a power take off gear including: a flange forming an input for the device and including a damper stop tab extending radially outward; a ring gear including a cavity opening to an inner circumference of the ring gear, first and second circumferentially curved slots open to the cavity, and third and fourth circumferentially curved slots radially outward from the first and second curved slots and open to the cavity; and a circumferentially curved friction assembly including: at least one circumferentially curved engagement plate including an engagement tab extending radially inward and at least partially disposed in the cavity and the first and second circumferentially curved slots; at least one circumferentially curved friction plate rotationally fixed to the ring gear and at least partially disposed in the cavity and the third and fourth circumferentially curved slots; and a resilient element urging the at least one circumferentially curved engagement plate and the at least one circumferentially curved friction plate into contact. The gear includes at least one elastic element engaged with the flange and the first and second cover plates. For first torque applied to the flange in a rotational direction at a first magnitude, the flange is arranged to rotate with respect to the ring gear in the rotational direction such that: the damper stop tab contacts the engagement tab; the flange displaces the at least one circumferentially curved engagement plate in the rotational direction; and frictional engagement of the at least one circumferentially curved engagement plate with the at least one circumferentially curved friction plate dissipates at least a portion of the first torque to dampen the rotation of the flange in the first rotational direction.

### 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 figures, in which:



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FIG. 1A is a perspective view of a cylindrical coordinate system demonstrating spatial terminology used in the present application;

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

FIG. 2 is a perspective front view of a torque transmission device with a friction controlled damper;

FIG. 3 is a partial front view of a torque transmission device with a friction controlled damper in a no-load state with a damper with a cover plate and elastic elements removed;

FIG. 4 is a partial cross-sectional view of the torque transmission device with a friction controlled damper of FIG. 2;

FIGS. 5A through 5D are respective views of a resilient element for a friction assembly; and,

FIG. 6 is a partial front view of a torque transmission device with a friction controlled damper in a no-load state with a damper with a cover plate and elastic elements removed.

#### DETAILED DESCRIPTION

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 aspect. The present invention is intended to include various modifications and equivalent arrangements within the spirit and scope of the appended claims.

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. 1A 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 par-

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allel 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. 1B is a perspective view of object **90** in cylindrical coordinate system **80** of FIG. 1A 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 a circumferential surface.

FIG. 2 is a perspective front view of torque transmission device **100** with a friction controlled damper.

FIG. 3 is a partial front view of torque transmission device **100** with a friction controlled damper in a no-load state with a damper with a cover plate and elastic elements removed.

FIG. 4 is a partial cross-sectional view of torque transmission device **100** with a friction controlled damper of FIG. 2. The following should be viewed in light of FIGS. 2 through 4. By “no-load state” we mean that the flange described below is either free of a torque load or a torque loads is rotationally balanced (equal torque loads in directions RD1 and RD2 described below). Torque transmission device **100** with a friction controlled damper includes flange **102**, plate **104**, and at least one elastic element **106**. In an example embodiment, device **100** includes cover plates **110** and **112**. Flange **102** provides an input site for device **100** and includes damper stop tabs **108** forming a portion of an outer radial contour of device **100**. Element **106** is drivingly engaged with flange **102** and cover plates **110** and **112**. Cover plates **110** and **112** are fixedly secured to radially disposed sides **122** and **121** of plate **104** by any means known in the art, for example, rivet **124**. As further described below, plate **104** is at least partially rotatable with respect to flange **102**, for example, about axis of rotation AR for device **100**.

In an example embodiment, device **100** is a power take off gear and plate **104** is a ring gear for the power take off gear. The discussion below is directed to the example of power take off gear **100**.

Plate **104** includes curved slots **114** and **115** with ends **116** and **117**, respectively. Gear **100** includes friction assembly **120** which includes ends **126** and **127** disposed in slots **114** and **115**, respectively. Assembly **120** includes at least one curved friction plate **130**, at least one curved engagement plate **132**, and curved resilient element **134**. Plates **130** and **132** and element **134** are curved in a circumferential direction. Plates **130** and **132** are at least partially axially aligned. Plate **130** includes ends **136** and **137** disposed in slots **114** and **115**, respectively, and plate **132** includes ends **138** and **140** disposed in slots **114** and **115**, respectively. In an example embodiment, resilient element **134** is non-rotatably connected to plate **104**. Resilient element **134** urges the engagement and friction plates into contact. In an example embodiment, assembly **120** includes respective pluralities of plates **130** and **132** alternating (interleaved) in an axial direction, such as AD1. Plates **130** are non-rotatably connected to plate **104**. In an example embodiment, cover plates **110** and **112** are in contact with assembly **120** and axially retain assembly **120**. Plates **130** and **132** are generally flat plates made of material

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with durable wear properties, such as high carbon steel or Teflon. At least one of plates **130** and **132** may include a bonded friction material ring.

Engagement plate **132** includes engagement tabs **142** and **143** extending radially inward and circumferentially aligned with damper stop tab **108**. In an example embodiment, circumferential length, or extent, **144** of plate **132** is less than circumferential length, or extent, **146** from end **116** to **117**. Thus, plate **132** is circumferentially displaceable within slots **114** and **115**.

For torque **T1** applied to the flange in rotational direction **RD1** at a first magnitude, the flange is arranged to rotate with respect to the ring gear in direction **RD1**, for example, by at least partially compressing element **106**, such that tab **108** contacts tab **142**. In turn, the flange displaces the engagement plate in direction **RD1** and frictional engagement of the engagement and friction plates (due to force applied by element **134**) dissipates at least a portion of the first torque to dampen the rotation of the flange in the first rotational direction, as further described below.

For torque **T2** applied to the flange in direction **RD1** and at a second magnitude, greater than the first magnitude, the flange is arranged to rotate with respect to the ring gear further in direction **RD1** such that tab **108** contacts the ring gear at contact portion **148** and **T2** is transmitted to the ring gear in direction **RD1**. Thus, the flange rotates the ring gear in direction **RD1**.

FIGS. **5A** through **5D** are respective views of a resilient element for friction assembly **120**. In an example embodiment shown in the perspective view of FIG. **5A**, resilient element **134** is a wave plate, that is, the plate undulates in an axial direction along a circumferential direction. In an example embodiment shown in the top view of FIG. **5B** and the cross-sectional view of FIG. **5C** generally along line **5C-5C** in FIG. **5B**, to increase load capacity, resilient element **134** is curved in a cross-section taken along a line orthogonal to axis **AR**. For example, inner edge **134A** and outer edge **134B** are co-planar orthogonal to axis **AR** and body **134C** is curved in an axial direction between the inner and outer edges. In an example embodiment shown in the side view of FIG. **5D**, to increase load capacity, resilient element **134** is bowed in an axial direction. For example, the inner and outer edges are non-planar orthogonal to axis **AR**. In an example embodiment (not shown), the respective configurations of the resilient element in FIGS. **5B** and **5C** are combined.

The discussion regarding torques **T1** and **T2** in direction **RD1** is applicable to torques **T1** and **T2** applied to the flange in direction **RD2**, opposite direction **RD1**. That is, for torque **T1** applied to the flange in a direction **RD2**, the flange is arranged to rotate with respect to the ring gear in direction **RD2**, for example, by at least partially compressing element **106**, such that tab **108** contacts radially inwardly extending tab **143** of the engagement plate. In turn, the flange displaces the engagement plate in direction **RD2** and frictional engagement of the engagement and friction plates (due to force applied by element **134**) dissipates at least a portion of the first torque to dampen the rotation of the flange in the second rotational direction. For torque **T2** applied to the flange in direction **RD2**, tab **108** is arranged to contact the ring gear at contact portion **160** to transmit **T2** to the ring gear and displace the ring gear in direction **RD2**.

For torque **T3** applied to the flange in direction **RD1** or **RD2** and below the first magnitude, the flange is arranged to rotate with respect to the ring gear in direction **RD1** or **RD2** such that element **106** is at least partially compressed and tab **108** and tabs **142** or **143** are separated by respective spaces in a

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circumferential direction. Thus, lower magnitude torque is "absorbed" by element **106** without activating assembly **120**.

In an example embodiment, cover plates **110** and **112** are sealed to the ring gear at respective radially outer circumferences of cover plates **110** and **112**, for example, by seals **162** and **164**, respectively.

FIG. **6** is a partial front view of power take off gear **200** in a no-load state with a damper with a cover plate and elastic elements removed. The description for device **100** in FIGS. **2** through **4** is applicable to torque transmission device **200** with a friction controlled damper and FIG. **6** except as noted below. In the example of FIG. **6**, device **200** is a power take off gear. In gear **200**, the ring gear includes cavity **202** opening to inner circumference **204** of the ring gear and circumferentially curved slots **206** and **208** open to the cavity and located radially outward from slots **114** and **115**. Friction plate **130** is at least partially disposed in the cavity and slots **206** and **208**. Engagement plate **132** is at least partially disposed in the cavity and in slots **116** and **117**. In particular, portion **210** of the engagement plate is disposed in the cavity, is at least partially axially aligned with plate **130**, and is at least partially circumferentially aligned with slots **206** and **208**. The frictional engagement described above occurs between portion **210** and plate **130**. In an example embodiment, the contact area between the engagement and friction plates is increased in gear **200**. By increasing the contact area between the engagement and friction plates, the friction torque in assembly **120** is increased as torque **T1** is applied, providing increased dampening capacity.

The following provides further detail regarding devices **100** and **200**. To simplify the presentation, the following discussion is directed to device **100**; however, it should be understood that the discussion is applicable to device **200** as well. Device **100** provides an impact damper (assembly **120**) parallel to the spring damper (element **106**) while minimizing the number of components and required axial space. Device **100** enables a soft first stage is with large travel (compressing elements **106**), along with a higher second stage with small travel (frictional engagement of the engagement and friction plates). Advantageously, device **100** provides dampening without increasing an axial extent of plate **104**. Thus, device **100** can be used for applications in which space is too restrictive to use conventional second stage options such as bumper springs.

It will be appreciated that various of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Various presently unforeseen or unanticipated alternatives, modifications, variations, or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.

What is claimed is:

1. A torque transmitting device, comprising:
  - a flange forming an input for the device and including a damper stop tab extending radially outward;
  - a plate including first and second curved slots;
  - a curved friction assembly including:
    - a first end disposed in the first curved slot;
    - a second end disposed in the second curved slot;
  - at least one curved engagement plate including an engagement tab extending radially inward;
  - at least one curved friction plate rotationally fixed to the plate; and,
  - a resilient element urging the at least one curved engagement plate and the at least one curved friction plate into contact; and
  - at least one elastic element engaged with the flange.

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2. The torque transmitting device of claim 1, wherein:  
for first torque applied to the flange in a rotational direction  
at a first magnitude, the flange is arranged to rotate with  
respect to the plate in the rotational direction such that:  
the damper stop tab contacts the engagement tab;  
the flange displaces the at least one curved engagement  
plate in the rotational direction; and,  
frictional engagement of the at least one curved engage-  
ment plate with the at least one curved friction plate  
dissipates at least a portion of the first torque to dampen  
the rotation of the flange in the rotational  
direction.

3. The torque transmitting device of claim 2, wherein for  
second torque applied to the flange in the rotational direction  
and at a second magnitude, greater than the first magnitude,  
the flange is arranged to rotate with respect to the plate in the  
rotational direction such that:

the damper stop tab contacts the plate; and,  
the second torque is transmitted to the plate in the rotational  
direction.

4. The torque transmitting device of claim 1, wherein the  
resilient element is curved in a cross-section taken along a  
line orthogonal to an axis of rotation for the device.

5. The torque transmitting device of claim 1, wherein the  
resilient element is bowed in an axial direction such that  
radially inner and outer edges of the resilient element are  
non-planar orthogonal to an axis of rotation for the device.

6. The torque transmitting device of claim 1, wherein:  
the at least one engagement plate includes a plurality of  
engagement plates; or,  
the at least one friction plate includes a plurality of friction  
plates.

7. The torque transmitting device of claim 1, wherein:  
the at least one engagement plate includes a plurality of  
engagement plates;  
the at least one friction plate includes a plurality of friction  
plates; and,  
respective engagement plates alternate with respective  
friction plates in an axial direction.

8. The torque transmitting device of claim 1, further com-  
prising first and second cover plates fixedly secured to the  
plate and in contact with the circumferentially curved friction  
assembly.

9. The torque transmitting device of claim 1, wherein the  
torque transmitting device is a power take off gear.

10. A torque transmitting device comprising:  
a flange forming an input for the device and including a  
damper stop tab extending radially outward;  
a plate including first and second curved slots;  
a curved friction assembly including:

at least one curved engagement plate:  
including an engagement tab extending radially  
inward and at least partially circumferentially  
aligned with the damper stop tab;  
at least partially rotatable with respect to the plate;  
and,  
at least partially disposed in the first and second  
curved slots;

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at least one curved friction plate:  
rotationally fixed to the plate;  
at least partially disposed in the first and second  
curved slots; and,  
in contact with the at least one curved engagement  
plate; and,

a resilient element:  
in contact with one of the at least one curved engage-  
ment plate or the at least one curved friction plate;  
and

urging the one of the at least one curved engagement  
plate or the at least one curved friction plate into  
contact with the other of the at least one curved  
engagement plate or the at least one curved friction  
plate; and

at least one elastic element engaged with the flange,  
wherein:

the flange is at least partially rotatable with respect to the  
plate such that the damper stop tab is engageable with  
the engagement tab.

11. The torque transmitting device of claim 10, wherein for  
first torque applied to the flange in a rotational direction at a  
first magnitude, the flange is arranged to rotate with respect to  
the plate in the rotational direction such that:

the damper stop tab contacts the engagement tab; and,  
the flange displaces the at least one curved engagement  
plate in the rotational direction.

12. The torque transmitting device of claim 11, wherein for  
second torque applied to the flange in the rotational direction  
and at a second magnitude, greater than the first magnitude,  
the flange is arranged to rotate with respect to the plate in the  
rotational direction such that:

the damper stop tab contacts the ring gear; and,  
the second torque is transmitted to the plate in the rotational  
direction.

13. The torque transmitting device of claim 10, wherein the  
at least one engagement plate includes:

a first circumferential end disposed in the first curved slot;  
and,  
a second circumferential end disposed in the second curved  
slot.

14. The torque transmitting device of claim 10, wherein the  
at least one friction plate includes:

a first circumferential end disposed in the first curved slot;  
and,  
a second circumferential end disposed in the second curved  
slot.

15. The torque transmitting device of claim 10, wherein:  
the at least one engagement plate includes a plurality of  
engagement plates; or,  
the at least one friction plate includes a plurality of friction  
plates.

16. The torque transmitting device of claim 10, further  
comprising first and second cover plates fixedly secured to the  
plate and in contact with the curved friction assembly.

17. The torque transmitting device of claim 10, wherein the  
torque transmitting device is a power take off gear.

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