US007757829B2

(12) United States Patent
Hemphill et al.

(10) Patent No.: US 7,757,829 B2
(45) Date of Patent: Jul. 20, 2010

(54) FRICTIONALLY GUIDED RADIAL ONE-WAY CLUTCH

(75) Inventors: **Jeffrey Hemphill**, Copley, OH (US); **Philip George**, Wooster, OH (US); **James Habegger**, Wooster, OH (US)

(73) Assignee: **LuK Lamellen und Kupplungsbau Beteiligungs KG**, Buehl (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 444 days.

(21) Appl. No.: **11/811,809**

(22) Filed: **Jun. 12, 2007**

(65) **Prior Publication Data**

US 2007/0284210 A1 Dec. 13, 2007

Related U.S. Application Data

(60) Provisional application No. 60/813,150, filed on Jun. 13, 2006.

(51) **Int. Cl.**
F16D 33/00 (2006.01)
F16D 41/063 (2006.01)

(52) **U.S. Cl.** .... **192/45.1**; 60/345; 192/41 R; 192/46; 192/53.1

(58) **Field of Classification Search** 60/345; 192/39
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,300,003	A *	1/1967	Peterson et al.	192/46
4,164,130	A *	8/1979	Hammer	192/46
6,148,979	A *	11/2000	Roach et al.	192/45.1
6,539,825	B1 *	4/2003	Lin	81/60
7,044,029	B1 *	5/2006	Hopper et al.	81/60
2003/0213342	A1 *	11/2003	Wu	81/60
2007/0045076	A1	3/2007	Brees et al.	
2007/0137977	A1	6/2007	Peri et al.	
2007/0220874	A1	9/2007	Hemphill et al.	
2007/0220876	A1	9/2007	Brees	
2007/0220877	A1	9/2007	George et al.	
2007/0224042	A1	9/2007	Brees et al.	
2008/0053784	A1 *	3/2008	Davis	192/41 A
2008/0149447	A1 *	6/2008	Davis	192/45.1

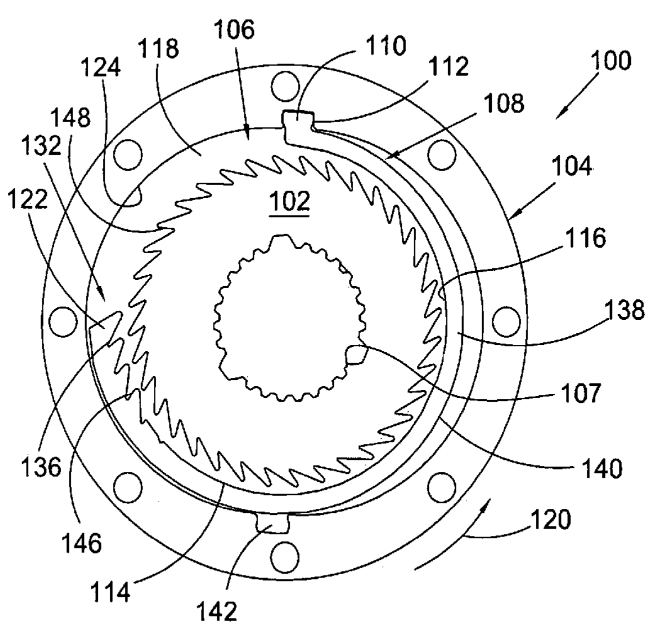
* cited by examiner

Primary Examiner—Rodney H Bonck
(74) *Attorney, Agent, or Firm*—Simpson & Simpson, PLLC

(57) **ABSTRACT**

The present invention broadly comprises a radial one-way clutch for an automotive device, including: a first annular element; a second annular element arranged for rotational connection to a torque transmitting element in the device; at least one engagement element radially disposed between the first and second annular elements and having at least one first interlocking feature; and an annular frictional element frictionally engaged with the engagement element. One of the first and second annular elements includes at least one second interlocking feature and is rotationally locked with the frictional element. In a first rotational direction, the frictional engagement urges the engagement element to radially displace to engage the interlocking features to rotationally connect the first and second annular elements. In a second rotational direction, the frictional engagement is arranged to urge the engagement element to radially displace such that the first and second annular elements are rotationally independent.

25 Claims, 14 Drawing Sheets



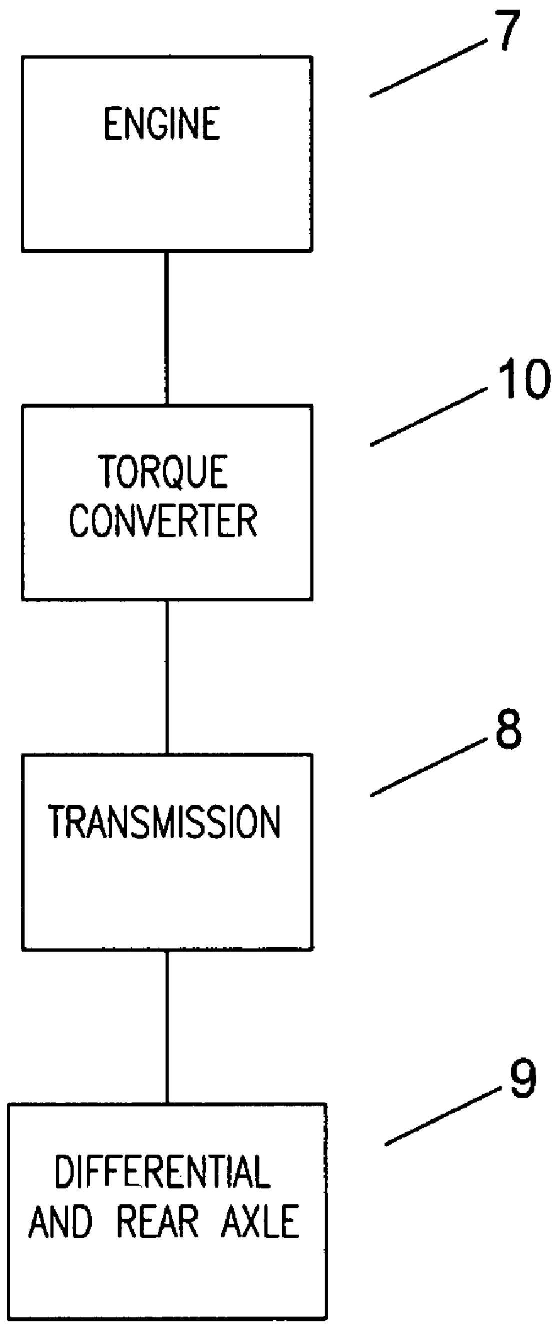

ENGINE
7
TORQUE CONVERTER
10
TRANSMISSION
8
DIFFERENTIAL AND REAR AXLE
9

Fig.1

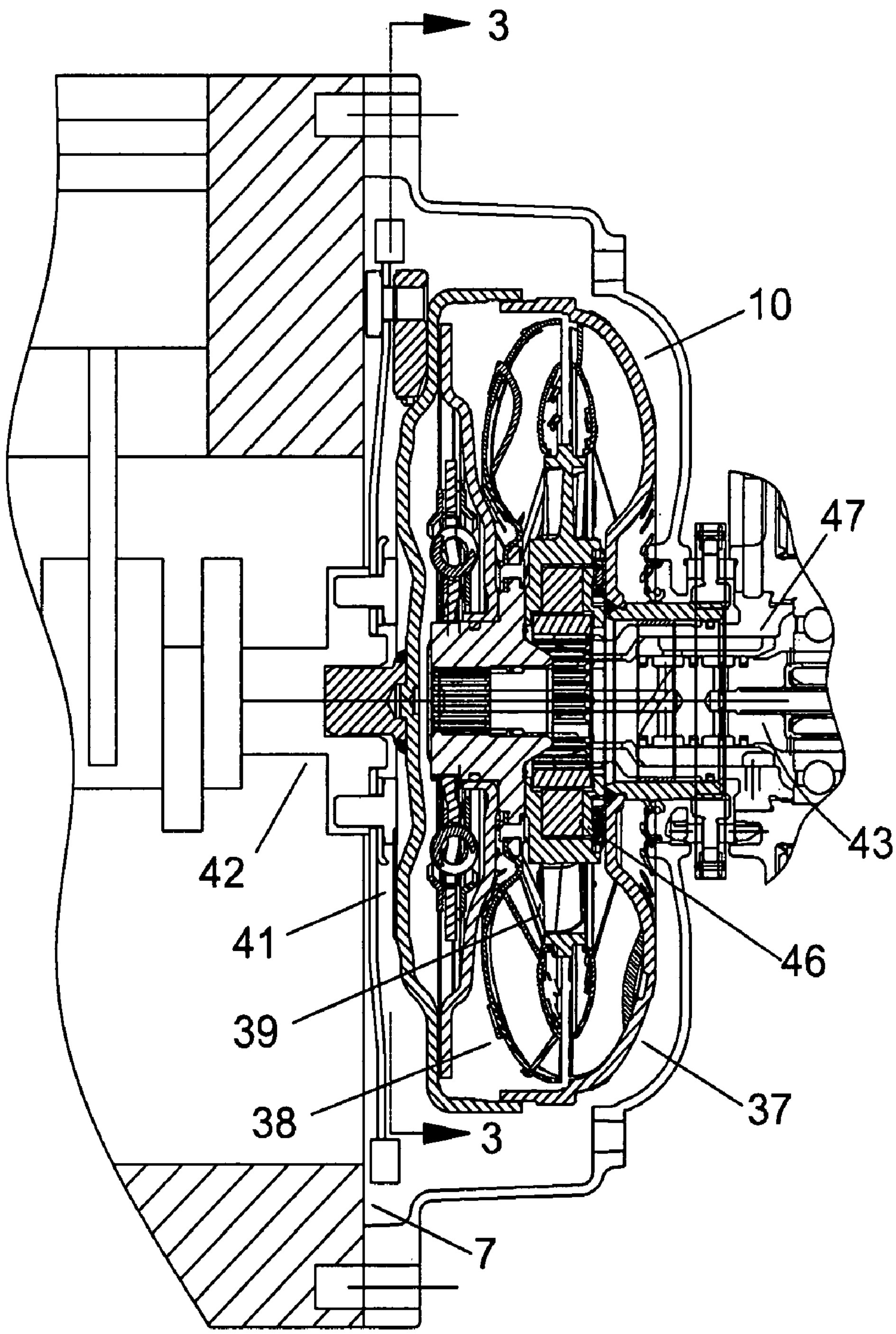


Fig.2

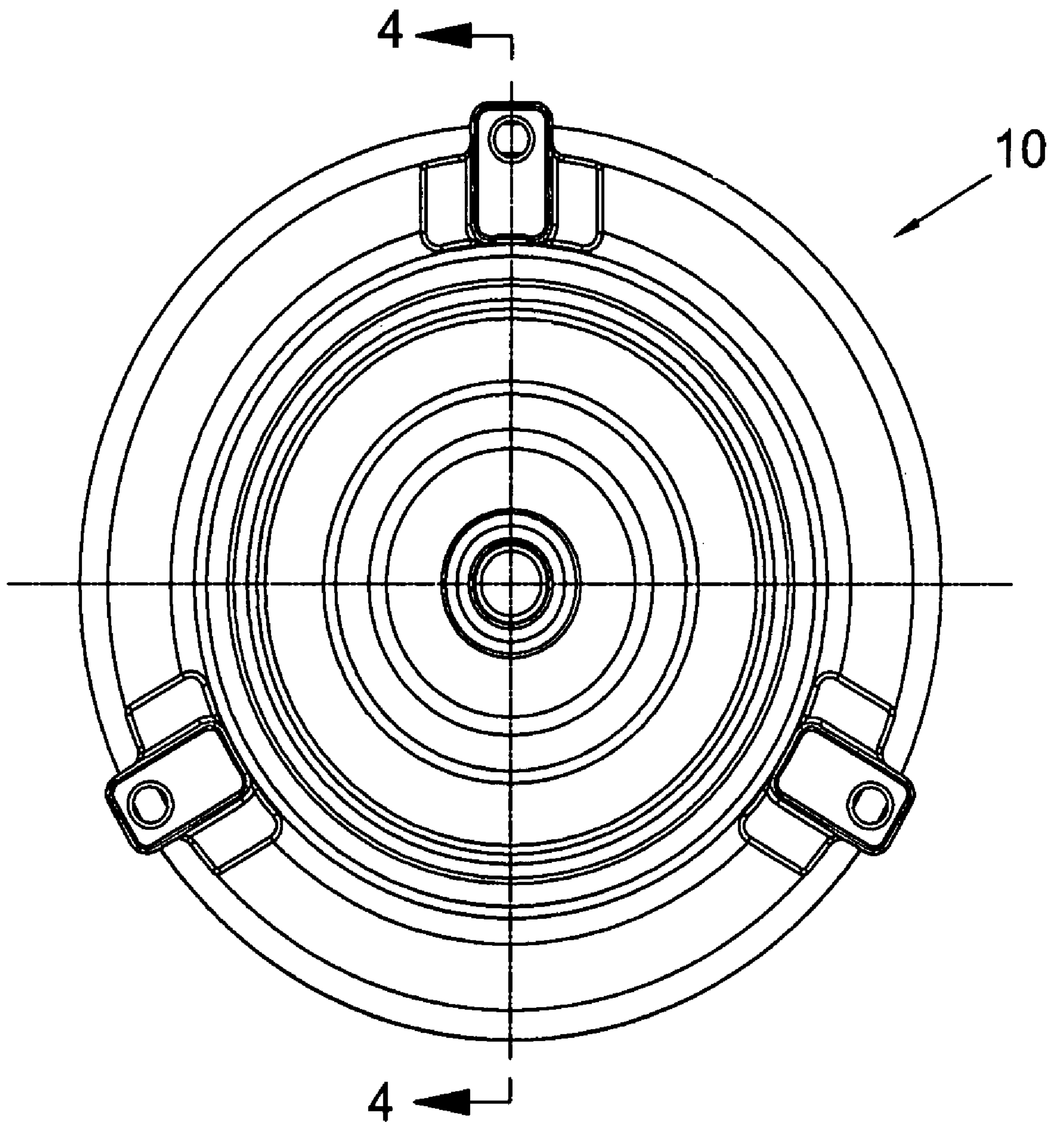


Fig.3

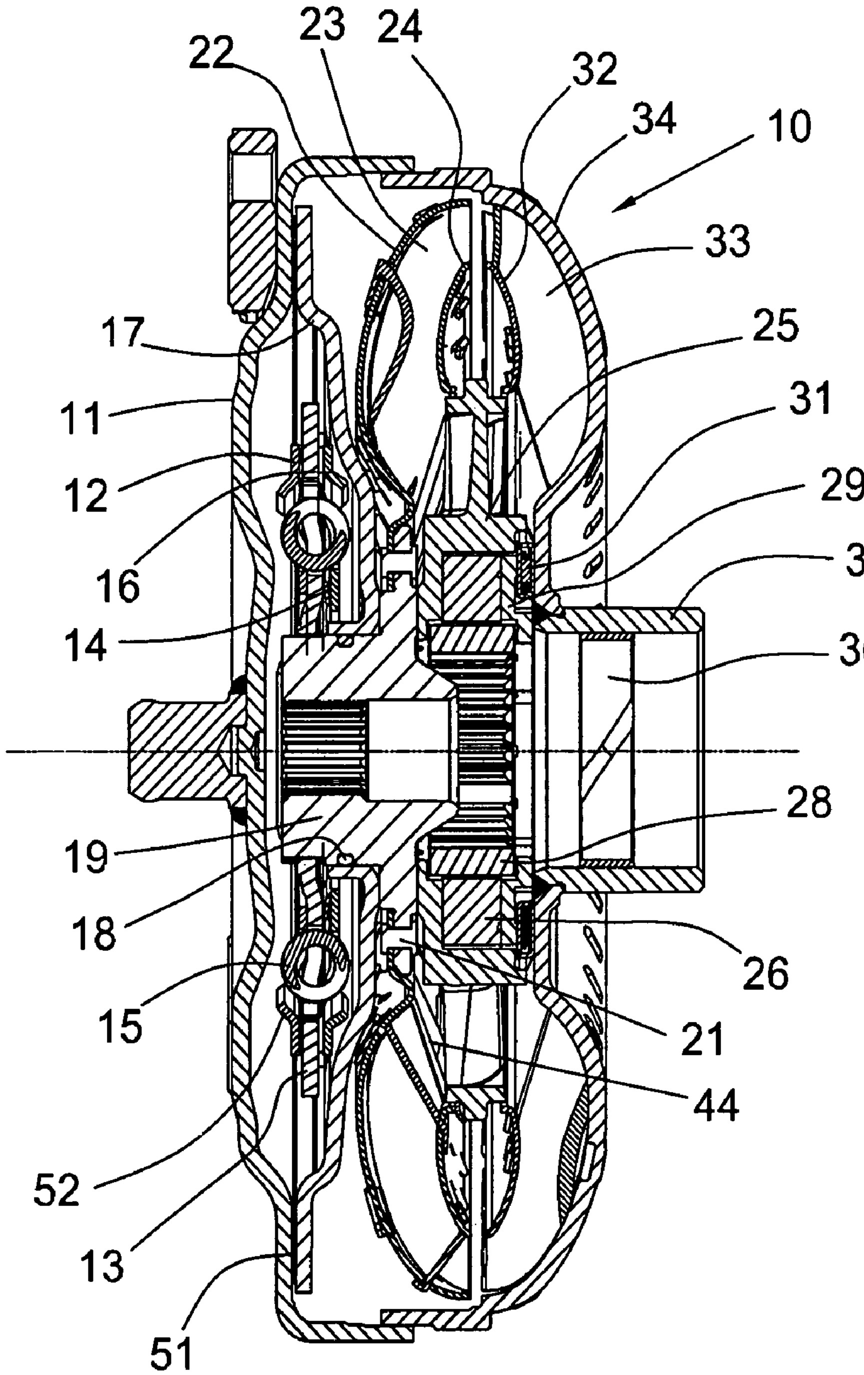

22
23
24
32
34
10
33
17
25
11
31
12
29
16
35
14
36
19
28
18
26
15
21
44
52
13
51

Fig.4

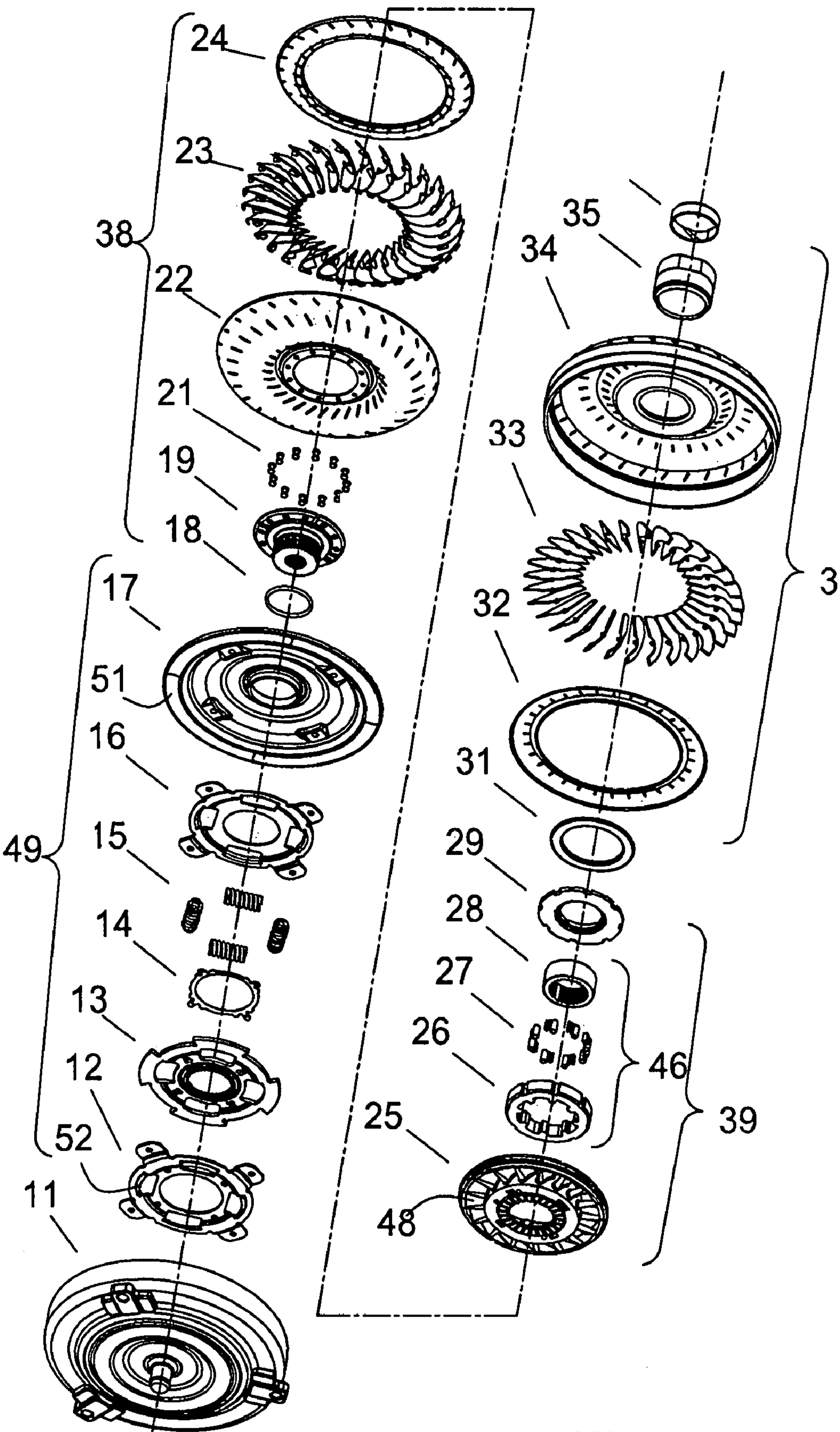

24
23
38
22
21
19
18
17
51
16
15
49
14
13
12
52
11
35
34
33
32
37
31
29
28
27
26
46
39
25
48

Fig.5

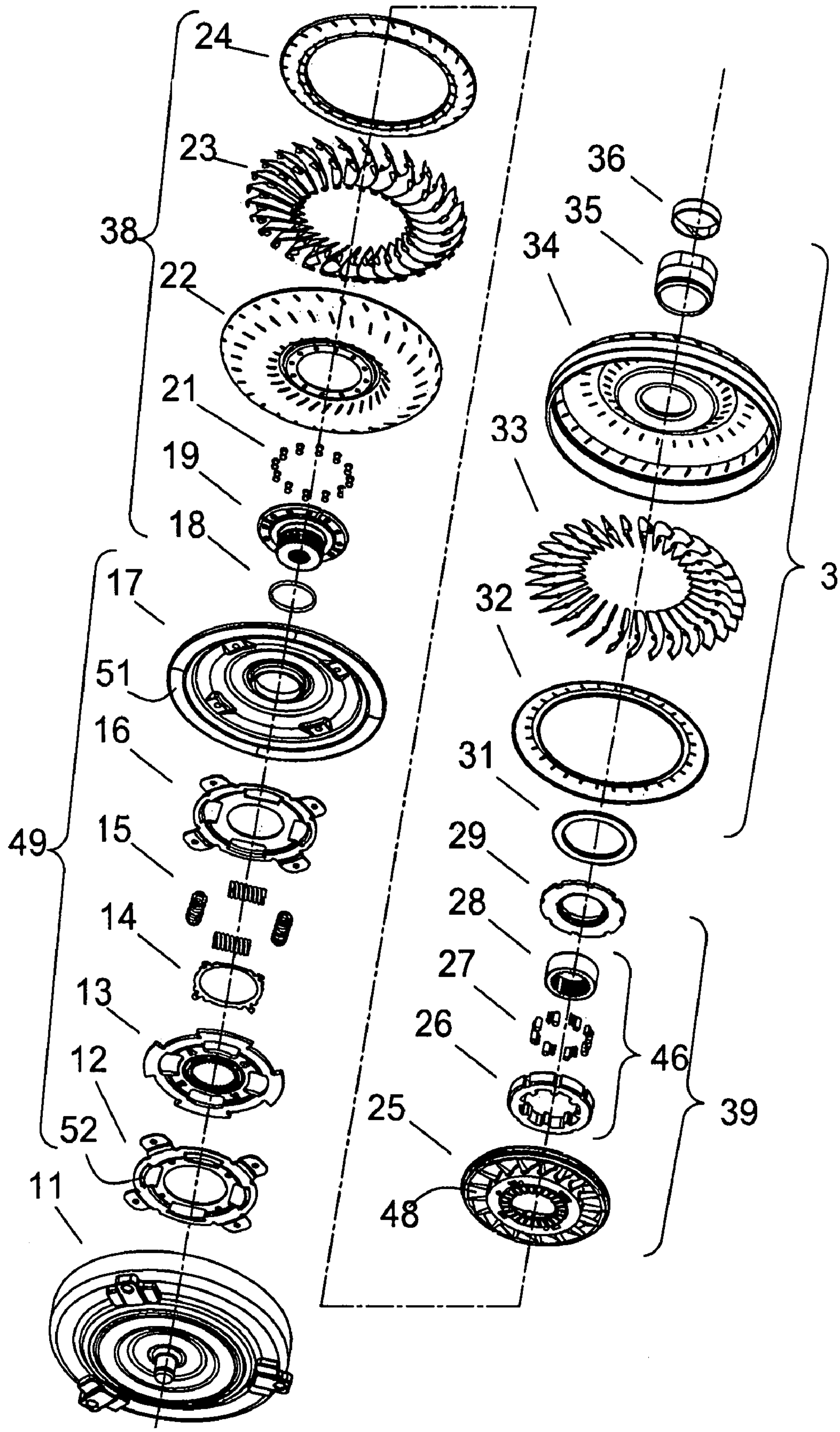

24
23
38
22
21
19
18
17
51
16
15
49
14
13
12
52
11
36
35
34
33
37
32
31
29
28
27
26
46
39
25
48

Fig.6

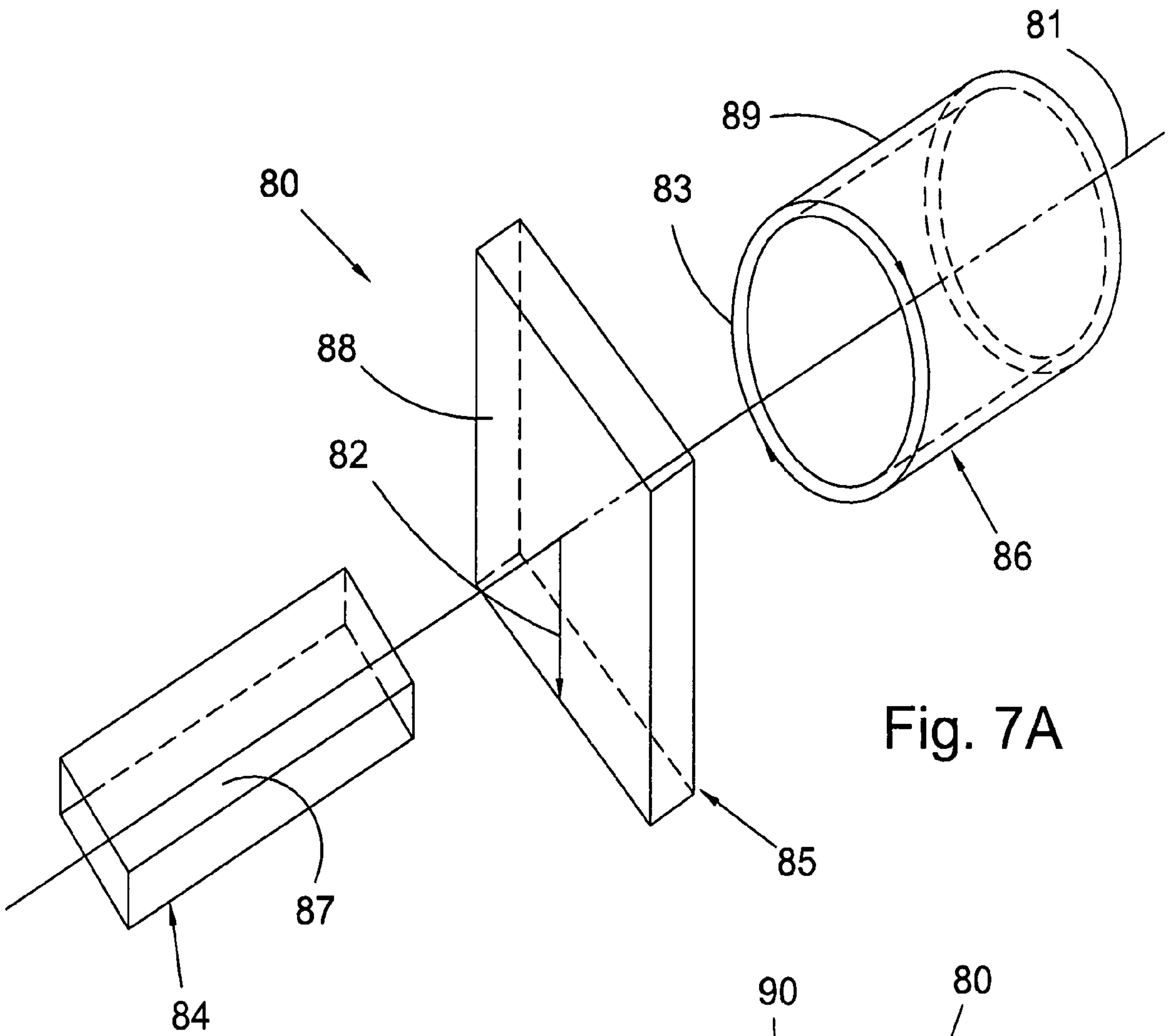


Fig. 7A

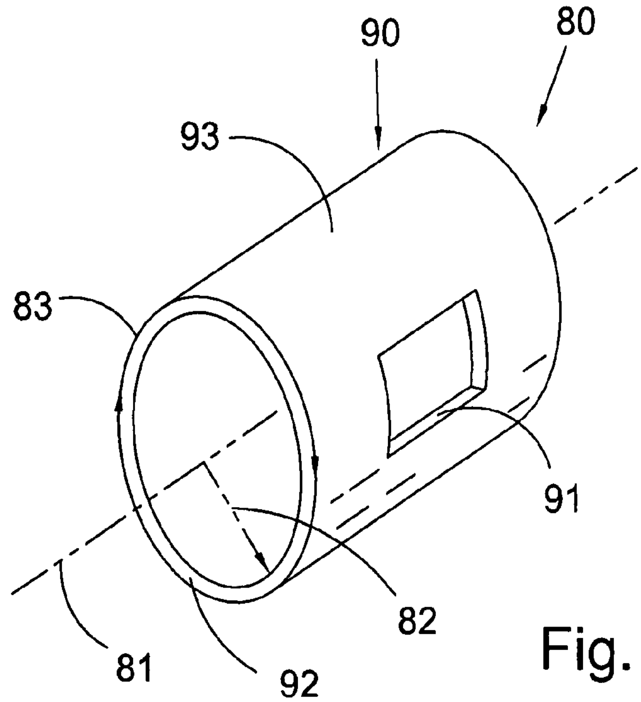


Fig. 7B

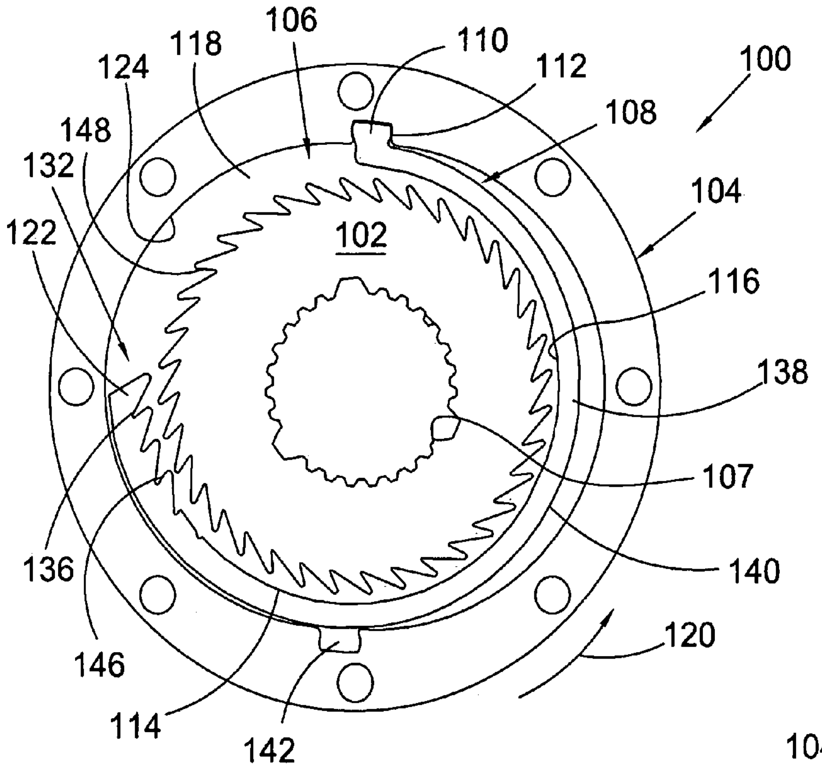

106
110
118
112
124
100
148
108
132
102
104
122
116
138
107
136
140
146
120
114
142

Fig. 8

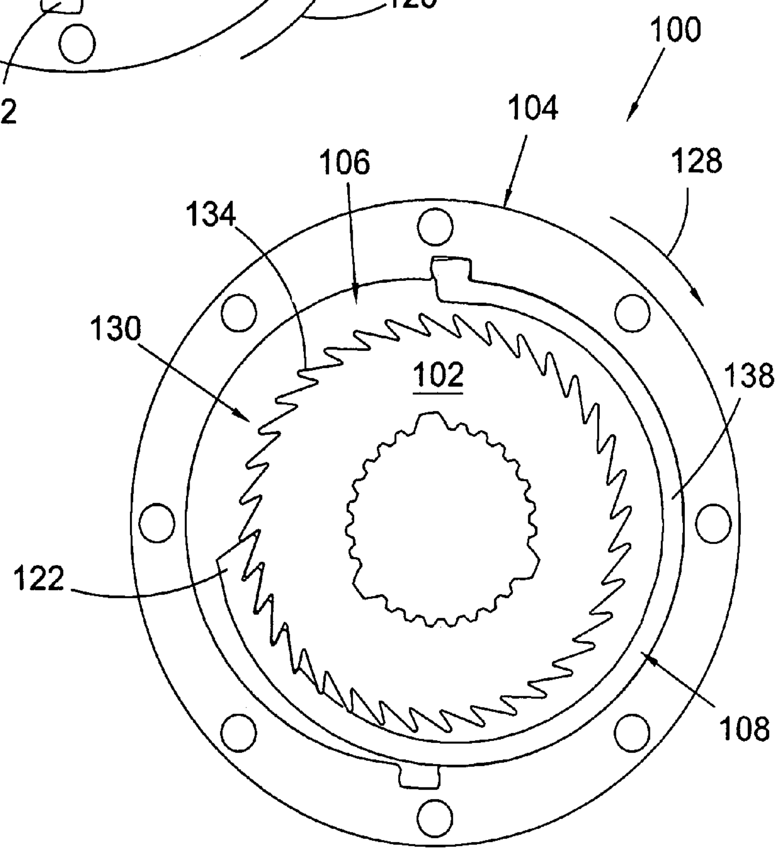

100
104
106
128
134
130
102
138
122
108

Fig. 9

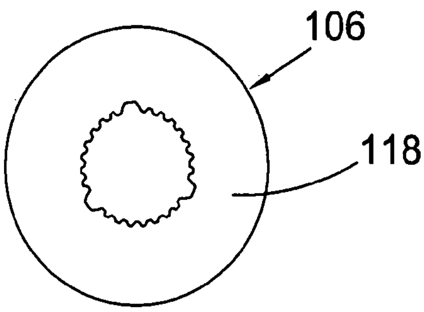


Fig. 10

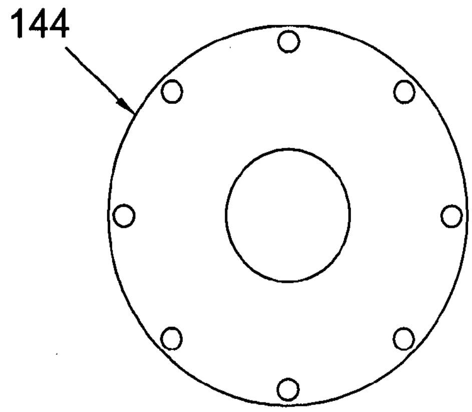


Fig. 11

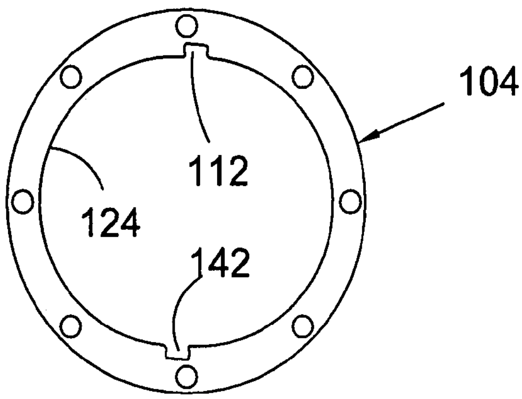


Fig. 12

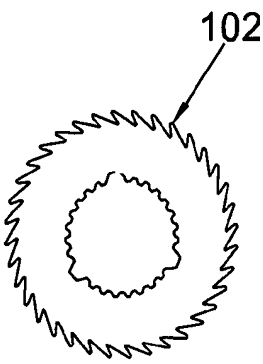


Fig. 13

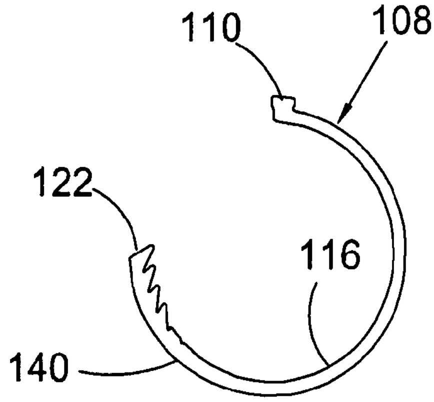


Fig. 14

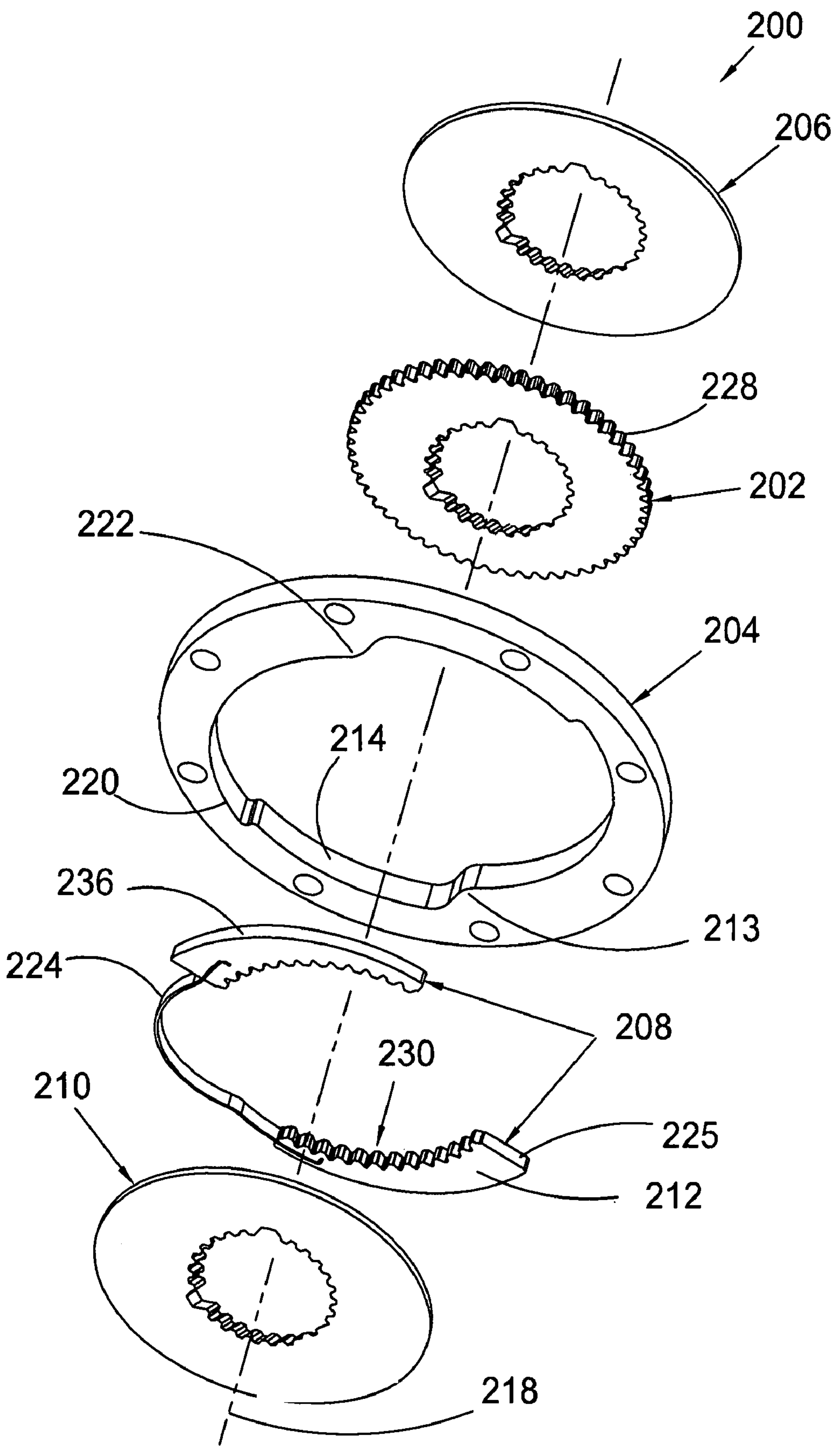

200
206
228
202
222
204
214
220
236
213
224
208
230
210
225
212
218

Fig. 15

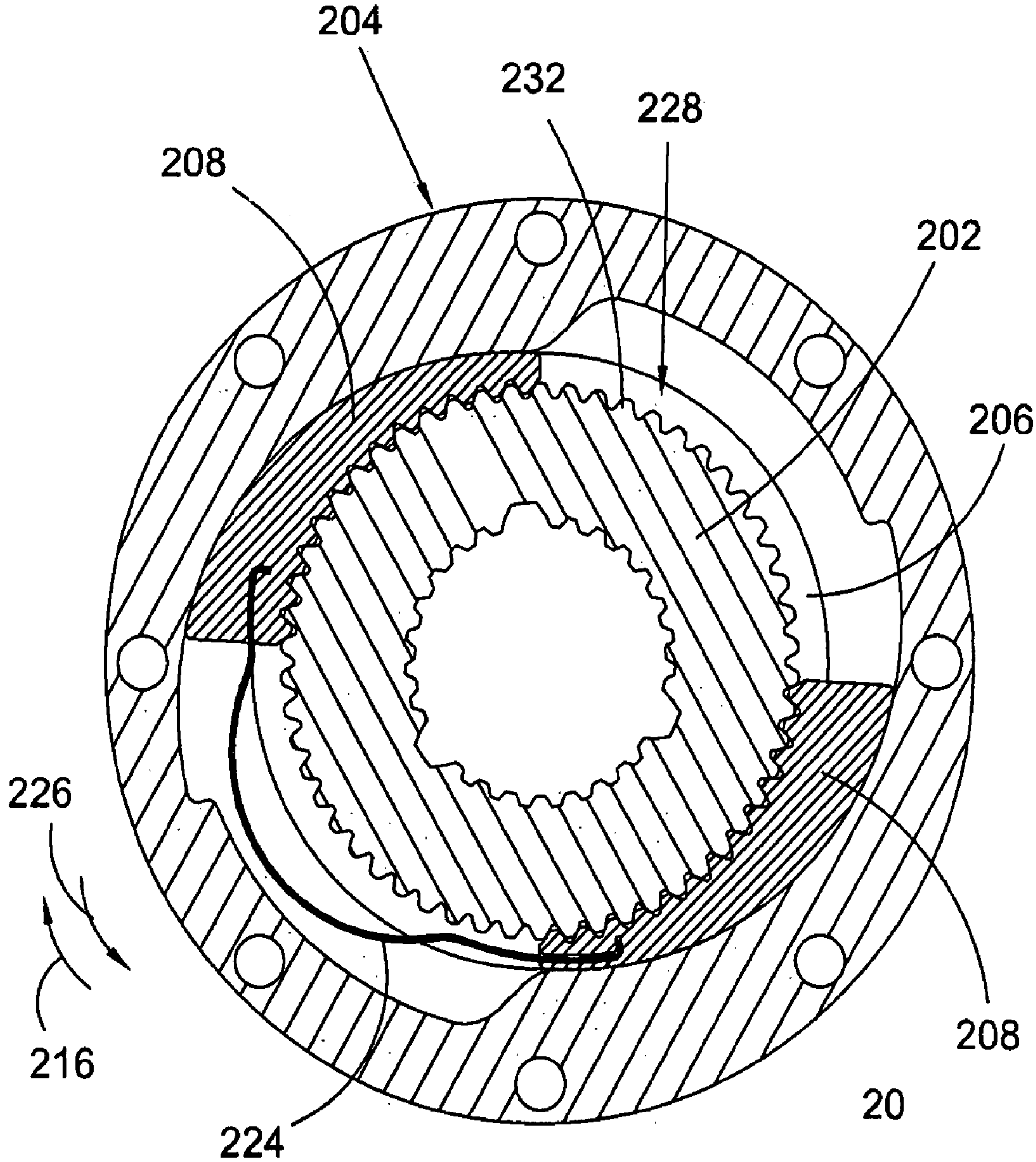


Fig. 16

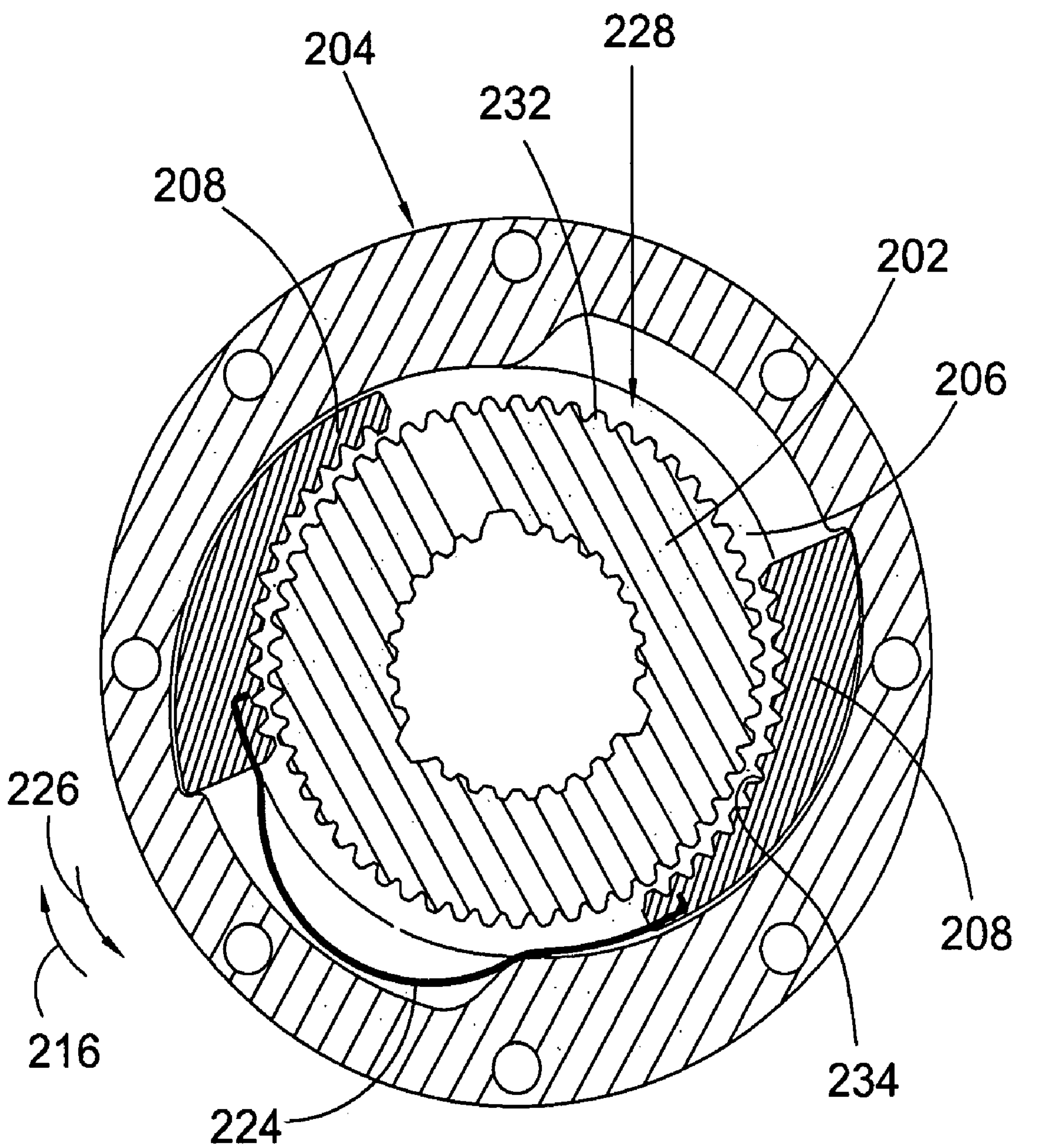


Fig. 17

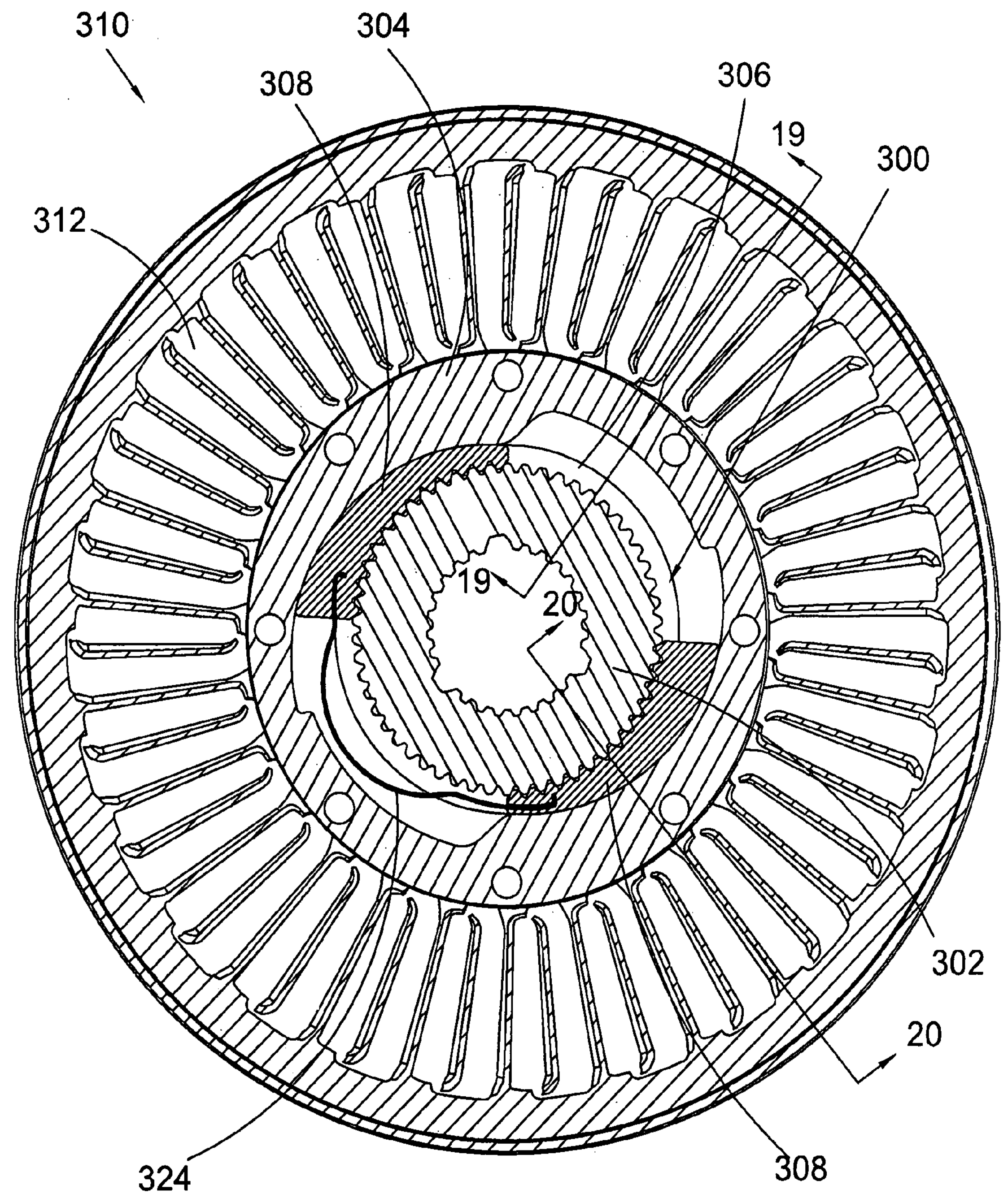


Fig. 18

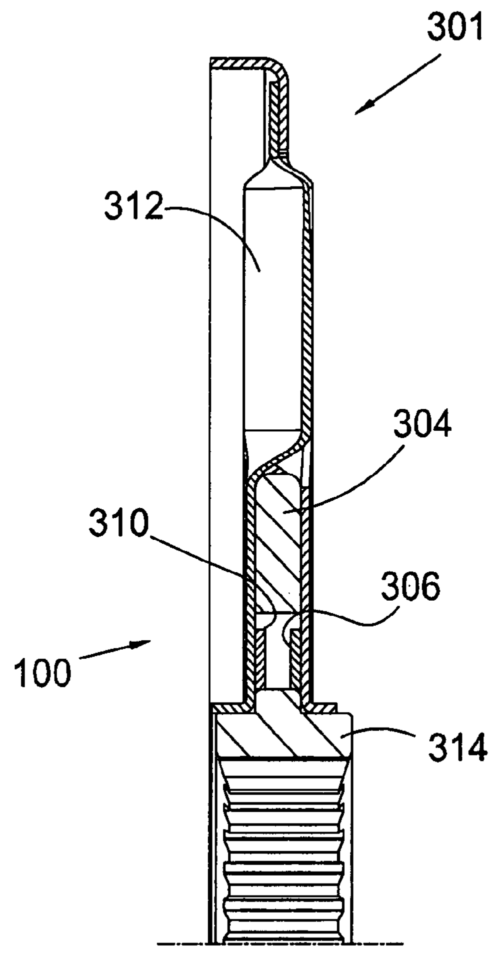


Fig. 19

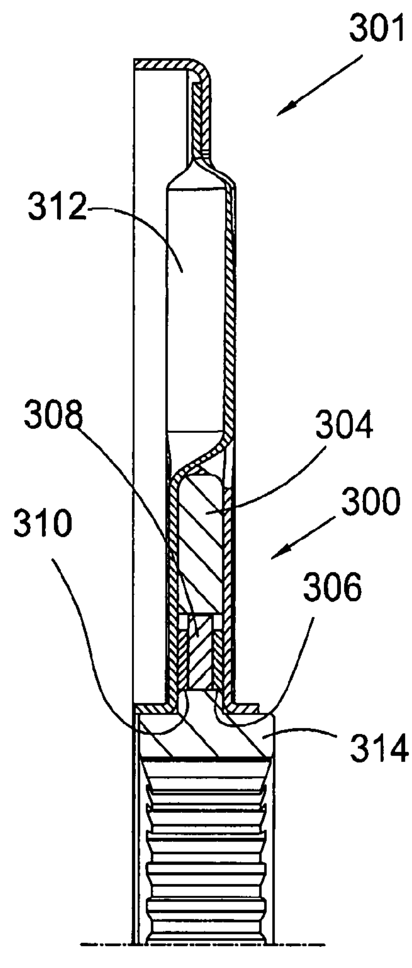


Fig. 20

FRICTIONALLY GUIDED RADIAL ONE-WAY CLUTCH

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit under 35 U.S.C. §119 (e) of U.S. Provisional Application No. 60/813,150 filed Jun. 13, 2006.

FIELD OF THE INVENTION

The invention relates to improvements in apparatus for transmitting force between a rotary driving unit (such as the engine of a motor vehicle) and a rotary driven unit (such as the variable-speed transmission in the motor vehicle). In particular, the invention relates to a radial one-way clutch. Even more specifically, the invention relates to a radial one-way clutch for a stator in a torque converter using friction to guide the engagement process.

BACKGROUND OF THE INVENTION

FIG. **1** illustrates a general block diagram showing the relationship of the engine **7**, torque converter **10**, transmission **8**, and differential/axle assembly **9** in a typical vehicle. It is well known that a torque converter is used to transmit torque from an engine to a transmission of a motor vehicle.

The three main components of the torque converter are the pump **37**, turbine **38**, and stator **39**. The torque converter becomes a sealed chamber when the pump is welded to cover **11**. The cover is connected to flexplate **41** which is, in turn, bolted to crankshaft **42** of engine **7**. The cover can be connected to the flexplate using lugs or studs welded to the cover. The welded connection between the pump and cover transmits engine torque to the pump. Therefore, the pump always rotates at engine speed. The function of the pump is to use this rotational motion to propel the fluid radially outward and axially towards the turbine. Therefore, the pump is a centrifugal pump propelling fluid from a small radial inlet to a large radial outlet, increasing the energy in the fluid. Pressure to engage transmission clutches and the torque converter clutch is supplied by an additional pump in the transmission that is driven by the pump hub.

In torque converter **10** a fluid circuit is created by the pump (sometimes called an impeller), the turbine, and the stator (sometimes called a reactor). The fluid circuit allows the engine to continue rotating when the vehicle is stopped, and accelerate the vehicle when desired by a driver. The torque converter supplements engine torque through torque ratio, similar to a gear reduction. Torque ratio is the ratio of output torque to input torque. Torque ratio is highest at low or no turbine rotational speed (also called stall). Stall torque ratios are typically within a range of 1.8-2.2. This means that the output torque of the torque converter is 1.8-2.2 times greater than the input torque. Output speed, however, is much lower than input speed, because the turbine is connected to the output and it is not rotating, but the input is rotating at engine speed.

Turbine **38** uses the fluid energy it receives from pump **37** to propel the vehicle. Turbine shell **22** is connected to turbine hub **19**. Turbine hub **19** uses a spline connection to transmit turbine torque to transmission input shaft **43**. The input shaft is connected to the wheels of the vehicle through gears and shafts in transmission **8** and axle differential **9**. The force of the fluid impacting the turbine blades is output from the turbine as torque. Axial thrust bearings **31** support the components from axial forces imparted by the fluid. When output torque is sufficient to overcome the inertia of the vehicle at rest, the vehicle begins to move.

After the fluid energy is converted to torque by the turbine, there is still some energy left in the fluid. The fluid exiting from small radial outlet **44** would ordinarily enter the pump in such a manner as to oppose the rotation of the pump. Stator **39** is used to redirect the fluid to help accelerate the pump, thereby increasing torque ratio. Stator **39** is connected to stator shaft **45** through one-way clutch **46**. The stator shaft is connected to transmission housing **47** and does not rotate. One-way clutch **46** prevents stator **39** from rotating at low speed ratios (where the pump is spinning faster than the turbine). Fluid entering stator **39** from turbine outlet **44** is turned by stator blades **48** to enter pump **37** in the direction of rotation.

The blade inlet and exit angles, the pump and turbine shell shapes, and the overall diameter of the torque converter influence its performance. Design parameters include the torque ratio, efficiency, and ability of the torque converter to absorb engine torque without allowing the engine to "run away." This occurs if the torque converter is too small and the pump can't slow the engine.

At low speed ratios, the torque converter works well to allow the engine to rotate while the vehicle is stationary, and to supplement engine torque for increased performance. At high speed ratios, the torque converter is less efficient. The torque ratio of the torque converter gradually reduces from a high of about 1.8 to 2.2, to a torque ratio of about 1 as the turbine rotational speed approaches the pump rotational speed. Torque ratio of 1 is called the coupling point. At this point, the fluid entering the stator no longer needs to be redirected, and the one-way clutch in the stator allows it to rotate in the same direction as the pump and turbine. Because the stator is not redirecting the fluid, torque output from the torque converter is the same as torque input. The entire fluid circuit will rotate as a unit.

Maximum torque converter efficiency is limited to 92-93% based on losses in the fluid. Therefore torque converter clutch **49** is employed to mechanically connect the torque converter input to the output, improving efficiency to near 100%. Clutch piston plate **17** is hydraulically applied when commanded by the transmission controller. Piston plate **17** is sealed to turbine hub **19** at its inner diameter by o-ring **18** and to cover **11** at its outer diameter by friction material ring **51**. These seals create a pressure chamber and force piston plate **17** into engagement with cover **11**. This mechanical connection bypasses the torque converter fluid circuit.

The mechanical connection of torque converter clutch **49** transmits many more engine torsional fluctuations to the drivetrain. As the drivetrain is basically a spring-mass system, torsional fluctuations from the engine can excite natural frequencies of the system. A damper is employed to shift the drivetrain natural frequencies out of the driving range. The damper includes springs **15** in series to lower the effective spring rate of the system, thereby lowering the natural frequency.

Torque converter clutch **49** generally comprises four components: piston plate **17**, cover plates **12** and **16**, springs **15**, and flange **13**. Cover plates **12** and **16** transmit torque from piston plate **17** to compression springs **15**. Cover plate wings **52** are formed around springs **15** for axial retention. Torque from piston plate **17** is transmitted to cover plates **12** and **16** through a riveted connection. Cover plates **12** and **16** impart torque to compression springs **15** by contact with an edge of a spring window. Both cover plates work in combination to support the spring on both sides of the spring center axis.

Spring force is transmitted to flange **13** by contact with a flange spring window edge. Sometimes the flange also has a rotational tab or slot which engages a portion of the cover plate to prevent over-compression of the springs during high torque events. Torque from flange **13** is transmitted to turbine hub **19** and into transmission input shaft **43**.

Energy absorption can be accomplished through friction, sometimes called hysteresis, if desired. Hysteresis includes friction from windup and unwinding of the damper plates, so it is twice the actual friction torque. The hysteresis package generally consists of diaphragm (or Belleville) spring **14** which is placed between flange **13** and one of cover plates **16** to urge flange **13** into contact with the other cover plate **12**. By controlling the amount of force exerted by diaphragm spring **14**, the amount of friction torque can also be controlled. Typical hysteresis values are in the range of 10-30 Nm.

Modern automotive design creates constant pressure to reduce the size of torque converters, in particular, the axial length of a torque converter. As well, the increasingly competitive nature of the automotive market demands that the complexity and cost of torque converter components be reduced at every opportunity. An intermediary element(s) in a one-way clutch must sustain the torque delivered by the rotating element of the clutch. For example, for a clutch with a rotating member and a fixed member; to sustain the torque, the intermediary element(s) must have a certain amount of surface area in contact with, the rotating and fixed members of the clutch. It is known to use roller or sprag clutches for a one-way clutch. The rollers are axially aligned and the relatively small portion of the rollers in contact with the clutch races must be designed to bear the force associated with the operation of the clutch, particularly in the locked mode. Unfortunately, to account for the forces, the axial length of the rollers must be made relatively long, increasing the axial width of the clutch. Also, roller and sprag clutches are relatively complex and include a large number of precision elements.

Thus, there is a long-felt need for a one-way clutch for a stator in a torque converter having a reduced axial length and using more cost-effective components and processes.

BRIEF SUMMARY OF THE INVENTION

The present invention broadly comprises a radial one-way clutch for an automotive device, including: a first annular element; a second annular element arranged for rotational connection to a torque transmitting element in the automotive device; at least one engagement element radially disposed between the first and second annular elements and having at least one first interlocking feature; and an annular frictional element frictionally engaged with the at least one engagement element. One of the first and second annular elements includes at least one second interlocking feature and is rotationally locked with the annular frictional element. In a first rotational direction, the frictional engagement is arranged to urge the at least one engagement element to radially displace to engage the at least one first and second interlocking features to rotationally connect the first and second annular elements. In a second rotational direction, the frictional engagement is arranged to urge the at least one engagement element to radially displace such that the first and second annular elements are rotationally independent.

In some aspects, in the first direction, the frictional contact is arranged to urge the at least one engagement element radially inward and in the second direction, the frictional contact is arranged to urge the at least one engagement element radially outward. In some aspects, in the first direction, the frictional contact is arranged to urge the at least one engagement element radially outward and in the second direction, the frictional contact is arranged to urge the at least one engagement element radially inward.

In some aspects, the second element is arranged to transmit a force in the first direction, and the frictional contact is arranged to absorb at least a portion of the force. In some aspects, the at least one engagement element comprises an area arranged to engage one of the first and second annular elements, and a circumferential extent of the area is greater than an axial extent of the area. The second interlocking feature is formed complimentarily with respect to the first interlocking feature. In the first rotational direction, the at least one first and second interlocking features are arranged to matingly engage to rotationally lock the one of the first and second annular elements and the at least one engagement element. In the second direction, the at least one first and second interlocking feature are free of contact.

In some aspects, the first interlocking feature includes one of a radial protrusion or radial recess and the second interlocking feature includes the other of the radial protrusion or the radial recess. In some aspects, the device includes fluid disposed between the at least one first and second interlocking features, and one of the at least one first and second interlocking features is arranged to displace the fluid. Then, the second element is arranged to transmit a force in the first direction, and the displacement of the fluid is arranged to absorb at least a portion of the force. In some aspects, the clutch includes first and second side plates disposed on opposite radial sides of the engagement element and arranged to at least partially contain the fluid between the at least one first and second interlocking features.

In some aspects, one of the first or second annular elements includes at least one circumferential surface tapering radially toward the first interlocking features in the second direction. In the first direction, the frictional engagement causes the at least one engagement element to slide along the circumferential surface, and the circumferential surface is arranged to urge the at least one engagement element radially toward the first interlocking features.

In some aspects, the clutch includes at least one first biasing element connected to the at least one engagement element and urging the at least one engagement element radially outward. In some aspects, in the second direction, the at least one engagement element is arranged to slide along the circumferential surface to disengage from the first interlocking features. In some aspects, the second element is arranged to transmit energy in the first direction and the at least one engagement element is elastically deformable to absorb at least a portion of the energy.

In some aspects, the second element is arranged to transmit energy in the first direction, the at least one engagement element includes first and second engagement elements connected by at least one elastically deformable element, and the at least one elastically deformable element is arranged to absorb at least a portion of the energy. In some aspects, the clutch includes an annular elastically deformable element in contact with the first and second engagement elements and applying axial pressure to the first and second engagement elements.

In some aspects, the second element is arranged to transmit a force in the first rotational direction and the second element is arranged to apply the force to the at least one engagement element in a substantially circumferential direction. In some aspects, the at least one engagement element is rotationally connected to the second annular element. In some aspects, the first annular element is non-rotatable or rotatable.

The present invention also broadly comprises a radial one-way clutch in a stator for a torque converter, including a hub for the stator, the hub including at least one radial protrusion; an annular element rotationally connected to blades for the stator; an annular frictional element rotationally locked with the hub; and at least one elastically deformable engagement element radially disposed between the hub and annular element, rotationally connected to the annular element, frictionally engaged with the frictional element, having at least one radial recess, and preloaded in a first radial direction. In the first rotational direction, the frictional engagement urges the at least one engagement element radially inward so that the at least one radial protrusion and recess lockingly engage to rotationally lock the hub and the annular element. In a second rotational direction, the frictional engagement urges the at least one engagement element radially outward so that the hub and the annular element are rotationally independent.

The present invention further broadly comprises a radial one-way clutch in a stator for a torque converter, including: a hub for the stator, the hub with at least one radial recess; an annular element, rotationally connected to blades for the stator and having at least one circumferential surface tapering radially inward in a first rotational direction; an annular frictional element rotationally fixed with the hub; at least one engagement element with at least one radial protrusion, the at least one engagement element radially disposed between the hub and the annular element and frictionally engaged with the frictional element; and at least one biasing element urging the at least one engagement element radially outward. In the first direction, the frictional engagement urges the at least one engagement element along the circumferential surface in the first direction, and the circumferential surface is arranged to urge the at least one engagement element radially inward to engage the at least one radial protrusion and recess to rotationally lock the hub and the angular element. In a second rotational direction, the frictional engagement urges the at least one engagement element along the circumferential surface so that the at least one engagement element displaces radially outward and the hub and the annular element are rotationally independent.

The present invention still further broadly comprises a radial one-way clutch for an automotive device, including: a first annular element; a second annular element arranged for rotational connection to a torque transmitting element in the automotive device; at least one engagement element radially disposed between the first and second annular elements and having at least one first interlocking feature; and an annular frictional element frictionally engaged with the at least one engagement element. One of the first and second annular elements includes at least one second interlocking feature and is rotationally locked with the annular frictional element. In a first rotational direction, the frictional engagement is arranged to urge the at least one engagement element to radially displace to rotationally connect with the first and second annular elements and torque from the second element is applied to the at least one engagement element in a substantially circumferential direction. In a second rotational direction, the frictional engagement is arranged to urge the at least one engagement element to radially displace such that the first and second annular elements are rotationally independent.

It is a general object of the present invention to provide a radial one-way clutch having a reduced axial width for use in automotive components.

It is another object of the present invention to provide a radial one-way clutch using stamped components for use in automotive components.

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:

FIG. **1** is a general block diagram illustration of power flow in a motor vehicle, intended to help explain the relationship and function of a torque converter in the drive train thereof;

FIG. **2** is a cross-sectional view of a prior art torque converter, shown secured to an engine of a motor vehicle;

FIG. **3** is a left view of the torque converter shown in FIG. **2**, taken generally along line **3-3** in FIG. **2**;

FIG. **4** is a cross-sectional view of the torque converter shown in FIGS. **2** and **3**, taken generally along line **4-4** in FIG. **3**;

FIG. **5** is a first exploded view of the torque converter shown in FIG. **2**, as shown from the perspective of one viewing the exploded torque converter from the left;

FIG. **6** is a second exploded view of the torque converter shown in FIG. **2**, as shown from the perspective of one viewing the exploded torque converter from the right;

FIG. **7**A is a perspective view of a cylindrical coordinate system demonstrating spatial terminology used in the present application;

FIG. **7**B is a perspective view of an object in the cylindrical coordinate system of FIG. **7**A demonstrating spatial terminology used in the present application;

FIG. **8** is a front view of a present invention radial one-way clutch in a free-wheel mode;

FIG. **9** is a front view of a present invention radial one-way clutch in a lock-up mode;

FIGS. **10** through **14** are respective front views of components for the one-way clutch shown in FIGS. **8** and **9**;

FIG. **15** is a front exploded front view of a present invention radial one-way clutch;

FIG. **16** is a front cross-sectional view through the torque transmitting element of the radial one-way clutch shown in FIG. **15** in a lock-up mode;

FIG. **17** is a front cross-sectional view through the torque transmitting element of the radial one-way clutch shown in FIG. **15** in a free-wheel mode;

FIG. **18** is a front cross-sectional view of a present invention radial one-way clutch in a stator for a torque converter;

FIG. **19** is a partial cross-sectional view of the clutch shown in FIG. **18** along line **19-19** in FIG. **18**; and,

FIG. **20** is a partial cross-sectional view of the clutch shown in FIG. **18** along line **20-20** in FIG. **18**.

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. **7**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**), or circumference **83**, respectively. The adjectives "axial," "radial" and "circumferential" refer to 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" refer to an orientation parallel to axis **81**, radius **82**, or circumference **83**, respectively. The adverbs "axially," "radially," and "circumferentially" refer to an orientation parallel to respective planes.

FIG. **7**B is a perspective view of object **90** in cylindrical coordinate system **80** of FIG. **7**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 is 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. **8** is a front view of present invention radial one-way clutch **100** in a free-wheel mode. Radial one-way clutch **100** includes annular elements **102** and **104** and annular frictional element **106**. In some aspects, element **102** is arranged to be rotationally fixed. For example (not shown), element **102** is a hub rotationally connected to a non-rotatable shaft. By rotational connection, we mean that the hub and the shaft are connected such that the two components rotate together, that is, the two components are fixed with respect to rotation. Rotationally connecting two components does not necessarily limit relative movement in other directions. For example, it is possible for two components that are rotationally connected to have axial movement with respect to each other via a spline connection. However, it should be understood that rotational connection does not imply that movement in other directions is necessarily present. For example, two components that are rotationally connected can be axially fixed one to the other. The preceding explanation of rotational connection is applicable to the discussions infra.

In some aspects, element **102** is arranged to be rotatable. For example (not shown), element **102** is a hub rotationally connected to a rotatable shaft. In some aspects, element **102** is integrally formed with a hub. For example, element **102** in FIG. **8** includes inner spline **107** for connection to another component, such as a shaft (not shown). In the discussion that follows, it is assumed that element **102** is rotationally fixed.

Element **104** is arranged for rotational connection to a torque transmitting assembly or component. For example, in some aspects (not shown), clutch **100** is used in a stator for a torque converter and element **104** is rotationally connected to blades for the stator. Element **106** is rotationally locked with element **102**. By rotationally locked, we mean that the two components are rotationally synchronized and the two components are fixed with respect to rotation. Components do not need to be directly connected to be rotationally locked. For example, if one component is made to be non-rotatable, the other component also is non-rotatable. In some aspects, element **106** is arranged for direct connection to a shaft. In some aspects (not shown), element **106** is rotationally connected to a hub or element **102** or is integral with element **102**.

Clutch **100** also includes at least one engagement element **108** radially disposed between said annular elements **102** and **104**. In general, frictional element **106** is rotationally connected to whichever of annular elements **102** or **104** is not connected to engagement element **108**. Element **108** is rotationally connected to element **104**, for example, end **110** is disposed in notch **112**. It should be understood that any means known in the art can be used to rotationally connect elements **108** and **104**. In the configuration shown, element **106** is rotationally locked with element **102**, and therefore, rotationally fixed, or non-rotatable. Element **108** is rotationally connected to element **104**, and therefore is rotatable. There is frictional contact between elements **106** and **108**. In some aspects, the frictional contact is between a relatively small portion of element **108** and element **106**, for example, at point **114** on inner circumference **116** of element **108** and radial surface **118** of element **106**. It should be understood that the frictional contact can be at other points along element **108** or at multiple points on element **108**. In rotational direction **120**, a direction associated with a free-wheel mode for clutch **100**, annular elements **102** and **104** are arranged to be rotationally independent. Specifically, element **104** rotates in direction **120**, element **108** also rotates in the same direction, and the frictional contact between rotationally fixed element **106** and rotating element **108** urges element **108** to radially displace. In those aspects in which both elements **102** and **104** are rotatable, element **102** rotating at a lesser rate than element **104**, creates a relative difference in rotational speed that enables the frictional contact between element **108** and element **106**. In FIG. **8**, the radial displacement is outward. For example, end **122** moves outward until the end contacts inner circumference **124** of element **104**. Thus, the frictional contact is sufficient to engage element **108** with element **106** and to urge element **108** to move radially with respect to element **106**. With element **108** disposed against surface **124**, element **104** is free to rotate without engaging elements **102** or **106**. That is, elements **102** and **104** are rotationally independent.

FIG. **9** is a front view of present invention radial one-way clutch **100** in a lock-up mode. The following should be viewed in light of FIGS. **8** and **9**. In rotational direction **128**, associated with a lock-up mode, engagement element **108** is arranged to rotationally connect with annular elements **102** and **104**. For example, element **104** rotates in direction **128**, element **108** also rotates in the same direction, and the frictional contact between elements **106** and **108** urges element **108** to radially displace. In FIG. **9**, the radial displacement is inward. For example, end **122** moves inward until elements **102** and **108** lock.

To enable the locking of elements **102** and **108**, element **102** includes interlocking features **130** and element **108** includes interlocking features **132**. Features **130** and **132** are complimentarily formed so that the features mating engage, or mesh together. In some aspects, features **130** and **132** are radial protrusions and recesses or radial recesses and protrusions, respectively. For example, protrusion **134** extends radially outward from element **102** and recess **136** recedes radially outward in element **108**. Given the symmetry of the interlocking features it is understood that elements **102** and **108** can both be understood to include both protrusions and recesses. Frictional element **106** is rotationally locked with whichever of elements **102** or **104** includes interlocking features.

Clutch **100** is arranged to attenuate the energy, for example, the noise, associated with the rotational locking of elements **102**, **104**, and **108**. For example, the frictional contact between elements **106** and **18** absorbs portions of the torque transmitted by element **104**. That is, some of the torque is required to overcome the frictional contact. In some aspects, element **108** is an elastically deformable element, for example, a spring and the tension in the spring resists movement in the locking direction. When the interlocking features first mate, portion **138**, on circumference **140** of element **108**, is not in contact with element **104**. As torque is transmitted from element **104** to element **102**, element **108** is driven in direction **120**, element **108** absorbs a portion of the torque from element **104**, cushioning portion **138** as the portion is driven into contact with element **104** as shown in FIG. **9**. Thus, some of the torque is dispelled to overcome the preload and move element **108**. In general, circumferences **124** and **140** have smooth surfaces.

In some aspects (not shown), clutch **100** is located in a fluid-filled device and the fluid is disposed between the interlocking features in the free-wheel mode. As torque transmitted by element **104** in the locking mode causes the interlocking features to move together (matingly engage), the protrusions displace fluid from the recesses. The displacement action absorbs a portion of torque from element **104**. In some aspects (not shown), clutch **100** is disposed in a device, such as a stator, with side plates disposed on opposite radial sides of the clutch. That is, the plates axially sandwich the clutch. The plates at least partially contain the fluid between the interlocking features. The plates restrict the passage of fluid out of the recesses, increasing the amount of energy (torque from element **104**) needed to displace the fluid.

In some aspects (not shown), clutch **100** includes more than one engagement element. For example, a second engagement element could be rotationally connected at notch **142** in element **104**. In this case, the lengths of the engagement elements are modified to enable overlapping of the engagement elements.

FIGS. **10** through **14** are respective front views of components for one-way clutch **100** shown in FIGS. **8** and **9**. In some aspects, backing plate **144** is disposed behind element **104** and element **104** is rotationally connected to plate **144**. In some aspects, plate **144** transmits torque to element **104**.

FIG. **15** is a front exploded front view of present invention radial one-way clutch **200**. Radial one-way clutch **200** includes annular elements, or plates, **202** and **204** and annular frictional element, or plate, **206**. The discussion in the descriptions of FIGS. **8** and **9** regarding the rotational arrangements of element **102** is applicable to element **202**. That is, is some aspects, element **202** is a hub rotationally connected to a non-rotatable shaft and in some aspects, element **202** is arranged to be rotatable. In the discussion that follows, it is assumed that element **202** is rotationally fixed.

The discussion in the descriptions of FIGS. **8** and **9** regarding the rotational arrangements of element **104** is applicable to element **204**. That is, in some aspects, element **104** is arranged for rotational connection to a torque transmitting assembly or component. Element **206** is rotationally locked with element **202**. In some aspects, element **206** is arranged for direct connection to a shaft. In some aspects (not shown), element **206** is rotationally connected to a hub or element **202** or is integral to element **202**.

Clutch **200** also includes engagement elements **208** radially disposed between annular elements **202** and **204**. Element **208** is not directly connected to elements **202** or **204**. In the configuration shown, element **206** is rotationally locked with element **202**, and therefore, rotationally fixed, or non-rotatable. Elements **208** are rotatable. End plate **210** is rotationally locked with element **202**. In some aspects (not shown) an annular elastically deformable element, for example, a diaphragm spring, is axially disposed between plate **210** and elements **208**. The deformable element is in contact with the radial surface of elements **208**, for example, surface **212**, and exerts an axial pressure on elements **208**. This pressure holds elements **208** in axial alignment and creates a frictional contact with plate **206**.

FIG. **16** is a front cross-sectional view through element **204** in radial one-way clutch **200** shown in FIG. **15** in a lock-up mode.

FIG. **17** is a front cross-sectional view through element **204** in radial one-way clutch **200** shown in FIG. **15** in a lock-up mode. The following should be viewed in light of FIGS. **15** through **17**. Plate **204** includes radial ramps **213** on circumferential surface **214**. The ramps taper radially inward in direction **216**, the direction associated with a free-wheel mode. For example, surface **214** becomes radially closer to longitudinal axis **218** moving in direction **216** from point **220** to point **222**. Clutch **200** also includes biasing element **224** connected to elements **208**. The biasing element acts to urge the engagement elements radially outward. Any biasing element known in the art, such as a spring, can be used for element **224**. In some aspects, more than one biasing element is used. For example, a second biasing element can be connected to ends **225** of elements **208**, that is, radially opposite the biasing elements shown in the figures.

Referring to FIG. **16**, in rotational direction **226**, associated with a lock-up mode, engagement element **208** is arranged to rotationally connect with annular element **202** so as to rotationally connect elements **202** and **204**. In rotational direction **226**, the frictional contact between elements **206** and **208** urges element **208** to radially displace. In FIG. **16**, the radial displacement is inward. Specifically, the frictional engagement of plate **206** and elements **208** causes the elements to slide along the ramps and circumferential surface **214**. The inwardly tapering circumferential surface is arranged to urge the engagement elements radially inward. That is, the circumferential surface is arranged to urge the engagement elements and plate **202** into a rotational lock.

Referring to FIG. **17**, in rotational direction **216**, the direction associated with a free-wheel mode for clutch **200**, annular elements **202** and **204** are arranged to be rotationally independent. Specifically, the frictional engagement of plate **206** and elements **208** causes the elements to slide along the ramps and circumferential surface **214**. Thus, biasing element **224** and inwardly tapering circumferential surface **214** are arranged to urge the engagement elements radially outward, or to radially displace, and elements **202** or **204** are rotationally independent.

To enable the locking of elements **202** and **208**, element **202** includes interlocking, features **228** and element **208** includes interlocking features **230**. Features **228** and **230** are complimentarily formed so that the features mating engage, or mesh together. In some aspects, features **228** and **230** are radial protrusions, and recesses or radial recesses and protrusions, respectively. For example, protrusion **232** extends radially outward from element **202** and recess **234** recedes radially outward in element **208**. Given the symmetry of the interlocking features it is understood that elements **202** and **208** can both be understood to include both protrusions and recesses. As with element **106** in FIGS. **8** and **9**, element **206** is rotationally locked with whichever of elements **202** or **204** includes interlocking features.

Clutch **200** is arranged to attenuate the energy, for example, the noise, associated with the rotational locking of elements **202**, **204**, and **208**. For example, the frictional contact between elements **206** and **208** absorbs portions of the torque transmitted by element **204**. The friction generated by the sliding of the engagement elements with the tamps on element **204** also absorbs a portion of the torque. That is, some of the torque is required to overcome the frictional contact. Biasing element **224** also presents a force opposing the torque. That is, the biasing element is pushing the engagement elements radially outward and the torque must overcome this bias.

In some aspects (not shown), clutch **200** is located in a fluid-filled device and the fluid is disposed between the interlocking features in the free-wheel mode. As torque transmitted by element **204** in the locking mode causes the interlocking features to move together (matingly engage), the protrusions displace fluid from the recesses. The displacement action absorbs a portion of torque from element **204**. In some aspects (not shown), clutch **200** is disposed in a device, such as a stator, with side plates disposed on opposite radial sides of said clutch. That is, the plates axially sandwich the clutch. The plates at least partially contain the fluid between the interlocking features. The plates restrict the passage of fluid out of the recesses, increasing the amount of energy (torque from element **204**) needed to displace the fluid.

In some aspects (not shown), clutch **200** includes more than two engagement, elements or a single engagement element.

The following should be viewed in light of FIGS. **8** through **17**. Clutch **100** is used as an example in the following discussion, however, it should be understood that the discussion applies to present invention one-way clutches in general. As noted supra, roller and sprag one-way clutches require significant axial widths to handle the forces associated with locking mode, since the force-bearing components have nominal circumferential extent and the force is applied in a radial direction. In contrast, clutch **100** applies the force in a substantially circumferential direction. For example, the torque transmitted by element **104** through the engagement element to element **102** is applied primarily in a rotational, or circumferential, direction from surfaces **146** of interlocking features **132** to surfaces **148** of interlocking features **130**.

In addition, clutch **100** advantageously maximizes the circumferential extent of the area of elements **102** and **108** handling the torque transmitted by element **104**. As noted supra, an intermediary element(s) in a one-way clutch must sustain the torque delivered by the torque transmitting element of the clutch. That is, the intermediary element(s) must have a certain amount of contact surface area. Advantageously, a present invention clutch is able to gain the necessary surface area primarily in a substantially circumferential orientation, with a minimal axial extent. Thus, the axial width of a present invention clutch can be advantageously minimized.

In some aspects, element **102** is arranged for rotational connection to a torque transmitting assembly or component and element **104** is not rotatable or may rotate at a lesser rate than element **102**. In this case, clutch **100** operates as expected for a one-way clutch. For this configuration, the radial displacement of element **106** and rotational connection of elements **102** and **108** remain as described for FIGS. **8** and **9**. However, the directions for free-wheel and locking modes are reversed if elements **102** and **108** remain as shown in FIGS. **8** and **9**. For example, direction **120** is the direction for the locking mode. To maintain the same directions shown in FIGS. **8** and **9**, the configuration of elements **102** and **108** can be flipped or mirrored. That is, element **108** runs counterclockwise from notch **112** and protrusions **134** are circumferentially reversed.

Regarding FIGS. **15** through **17**, if element **202** is arranged for rotational connection to a torque transmitting assembly or component and element **204** is rotatable or may rotate at a lesser rate, clutch **200** also operates as expected for a one-way clutch and the operation of elements **202**, **204**, **206**, and **208** with respect to rotational engagement remain as described in FIGS. **15** through **17**. However, the directions for free-wheel and locking modes are reversed if elements **204** and **208** remain as shown in FIGS. **15** through **17**. To maintain the same directions shown in FIGS. **15** through **17**, the configuration of elements **204** and **208** can be flipped or mirrored. That is, element **208** is tapered in a counterclockwise direction and ramps **212** taper radially outward in direction **216**.

In some aspects (not shown), the configuration of interlocking elements shown in FIGS. **8** and **9** is reversed. Element **108** is rotationally connected to element **102** and interlocking features are located on surface **140** of element **108** and on surface **124** of element **104**. The outer circumference of element **102** and circumference **116** are smooth. In this configuration, the free-wheel and locking mode directions are reversed. In direction **120** (now locking mode), the frictional contact urges element **108** to displace radially outward, matingly engaging the interlocking feature. In direction **128**, the frictional contact urges element **108** to displace radially inward, so that elements **102** and **104** are rotationally independent. The preceding discussion also is applicable to aspects in which element **102** is arranged for rotational connection to a torque transmitting assembly or component.

In some aspects (not shown), the configuration of interlocking elements shown in FIGS. **15** through **17** is reversed. For example, surface **214** is at a uniform radial distance from axis **218** and has interlocking features and surface **236** has complimentary interlocking features. The ramps are formed on outer circumference **238** of element. **202** and inner edges **240** of elements **208** are smoothed to engage with the ramps. In this configuration, the free-wheel and locking mode directions are reversed. The preceding discussion also is applicable to aspects in which element **202** is arranged for rotational connection to a torque transmitting assembly or component.

The components in a present invention clutch can be formed by stamping. For example, elements **202**, **204**, **206**, **208**, and **210** in clutch **200** can be stamped. It should be understood that a present invention clutch can include any combination of stamped and non-stamped components.

FIG. **18** is a front cross-sectional view of present invention radial one-way clutch **300** in stator **301** for a torque converter.

FIG. **19** is a partial cross-sectional view of clutch **300** as shown in FIG. **18** along line **19-19** in FIG. **18**.

FIG. **20** is a partial cross-sectional view of clutch **300** shown in FIG. **18** along line **20-20** in FIG. **18**. The following should be viewed in light of FIGS. **18** through **20**. In general, the discussions for FIGS. **15** through **17** regarding clutch **200** are applicable to clutch **300**. Clutch **300** includes elements **302**, **304**, **306**, and **308**, and **310** substantially similar to elements **202**, **204**, **206**, **208**, and **210**, respectively, in FIGS. **8** and **9**. FIGS. **18** through **20** give an example of a present invention clutch in a particular automotive device, in this case, stator **302**. Element **304** is rotationally connected to blades **312** in the stator and transmits torque from the blades. Element **314** is a hub for the stator and is arranged for rotational connection to a stator shaft (not shown), which is typically not rotatable. It should be understood that a present invention clutch is not limited to use with a stator having the configuration shown in the figures. Further, it should be understood that a present invention clutch is not limited to use with only a stator and that the use of a present invention clutch in any automotive device, or component, such as a transmission, is within the spirit and scope of the claimed invention.

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. A radial one-way clutch for an automotive device, comprising:

- a first annular element;
- a second annular element arranged for rotational connection to a torque transmitting element in said automotive device;
- at least one engagement element radially disposed between said first and second annular elements and having at least one first interlocking feature; and,
- an annular frictional element frictionally engaged with said at least one engagement element, wherein a first one of said first and second annular elements further comprises at least one second interlocking feature and is rotationally locked with said annular frictional element, wherein in a first rotational direction, said frictional engagement is arranged to urge said at least one engagement element to radially displace to engage said at least one first and second interlocking features to rotationally connect said first and second annular elements, wherein in a second rotational direction, said frictional engagement is arranged to urge said at least one engagement element to radially displace such that said first and second annular elements are rotationally independent.

2. The clutch of claim **1** wherein in said first direction, said frictional contact is arranged to urge said at least one engagement element radially inward and wherein in said second direction, said frictional contact is arranged to urge said at least one engagement element radially outward.

3. The clutch of claim **1** wherein in said first direction, said frictional contact is arranged to urge said at least one engagement element radially outward and wherein in said second direction, said frictional contact is arranged to urge said at least one engagement element radially inward.

4. The clutch of claim **1** wherein said second element is arranged to transmit a force in said first direction, and said frictional contact is arranged to absorb at least a portion of said force.

5. The clutch of claim **1** wherein said at least one engagement element comprises an area, having a circumferential extent and an axial extent, arranged to engage said one of said first and second annular elements and wherein said circumferential extent is greater than said axial extent.

6. The clutch of claim **1** wherein said second interlocking feature is formed complimentarily with respect to said first interlocking feature and wherein in said first rotational direction, said at least one first and second interlocking features are arranged to matingly engage to rotationally lock said first one of said first and second annular elements and said at least one engagement element.

7. The clutch of claim **6** wherein in said second direction, said at least one first and second interlocking feature are free of contact.

8. The clutch of claim **6** wherein said first interlocking feature further comprises one of a radial protrusion or radial recess and said second interlocking feature further comprises the other of said radial protrusion or said radial recess.

9. The clutch of claim **6** wherein said device further comprises fluid disposed between said at least one first and second interlocking features and one of said at least one first and second interlocking features is arranged to displace said fluid.

10. The clutch of claim **9** wherein said second annular element is arranged to transmit a force in said first direction, and said displacement of said fluid is arranged to absorb at least a portion of said force.

11. The clutch of claim **9** further comprising first and second side plates disposed on opposite radial sides of engagement element and arranged to at least partially contain said fluid between said at least one first and second interlocking features.

12. The clutch of claim **1** wherein a second one of said first and second annular elements further comprises at least one circumferential surface tapering radially inward in said second direction, wherein in said first direction, said frictional engagement causes said at least one engagement element to slide along said circumferential surface, and said circumferential surface is arranged to urge said at least one engagement element radially toward said at least one first interlocking feature.

13. The clutch of claim **12** wherein said circumferential surface is arranged to urge said at least one engagement element to rotationally connect with said first one of said first and second annular elements to rotationally connect said first and second annular elements.

14. The clutch of claim **12** further comprising at least one first biasing element connected to said at least one engagement element and urging said at least one engagement element radially away from said first interlocking feature.

15. The clutch of claim **12** wherein in said second direction, said at least one engagement element is arranged to slide along said circumferential surface to disengage from said one of said first and second annular elements.

16. The clutch of claim **1** wherein said second annular element is arranged to transmit a force in said first direction and said at least one engagement element is elastically deformable to absorb at least a portion of said force.

17. The clutch of claim **1** wherein said second annular element is arranged to transmit a force in said first direction, said at least one engagement element further comprises first and second engagement elements connected by at least one elastically deformable element, and said at least one elastically deformable element is arranged to absorb at least a portion of said force.

18. The clutch of claim **17** further comprising an annular elastically deformable element in contact with said first and second engagement elements and applying axial pressure to said first and second engagement elements.

19. The clutch of claim **1** wherein said second element is arranged to transmit a force in said first rotational direction and said second element is arranged to apply said force to said at least one engagement element in a substantially circumferential direction.

20. The clutch of claim **1** wherein said at least one engagement element is rotationally connected to said second annular element.

21. The clutch of claim **1** wherein said first annular element is non-rotatable.

22. The clutch of claim **1** wherein said first annular element is rotatable.

23. A radial one-way clutch in a stator for a torque converter, comprising:

a hub for said stator, said hub including at least one radial protrusion;

an annular element rotationally connected to blades for said stator;

an annular frictional element rotationally locked with said hub; and,

at least one elastically deformable engagement element radially disposed between said hub and said annular element, rotationally connected to said annular element, and frictionally engaged with said frictional element, having at least one radial recess, wherein in said first rotational direction, said frictional engagement urges said at least one engagement element radially inward so that said at least one radial protrusion and recess lockingly engage to rotationally lock said hub and said annular element, wherein in a second rotational direction, said frictional engagement urges said at least one engagement element radially outward so that said hub and said annular element are rotationally independent.

24. A radial one-way clutch in a stator for a torque converter, comprising:

a hub for said stator, said hub with at least one radial recess;

an annular element, rotationally connected to blades for said stator and having at least one circumferential surface tapering radially outward in a first rotational direction;

an annular frictional element rotationally fixed with said hub;

at least one engagement element with at least one radial protrusion, said at least one engagement element radially disposed between said hub and said annular element and frictionally engaged with said frictional element; and,

at least one biasing element urging said at least one engagement element radially outward, wherein in said first direction, said frictional engagement urges said at least one engagement element along said circumferential surface, and said circumferential surface is arranged to urge said at least one engagement element radially inward to engage said at least one radial protrusion and recess to rotationally lock said hub and said annular element, and wherein in a second rotational direction, said frictional engagement urges said at least one engagement element along said circumferential surface so that said at least one engagement element displaces radially outward and said hub and said annular element are rotationally independent.

25. A radial one-way clutch for an automotive device, comprising:

a first annular element;

a second annular element arranged for rotational connection to a torque transmitting element in said automotive device;

at least one engagement element radially disposed between said first and second annular elements and having at least one first interlocking feature;

an annular frictional element frictionally engaged with said at least one engagement element, wherein a first one of said first and second annular elements further comprises at least one second interlocking feature and is rotationally locked with said annular frictional element, wherein in a first rotational direction, said frictional engagement is arranged to urge said at least one engagement element to radially displace to rotationally connect with said first and second annular elements to apply torque from said second element to said at least one engagement element in a substantially circumferential direction and wherein in a second rotational direction, said frictional engagement is arranged to urge said at least one engagement element to radially displace such that said first and second annular elements are rotationally independent.

* * * * *