United States Patent	12392380
Kind Code	B2
Date of Patent	August 19, 2025
Inventor(s)	Uehara; Hiroshi

Damper device

Abstract

A damper device, disposed between an engine and a drive unit, includes an input rotor, an output rotor, an elastic coupling part, and a hysteresis torque generating mechanism. The hysteresis torque generating mechanism generates a hysteresis torque together with the input rotor or the output rotor therebetween. The damper device is in a neutral condition when a torque is not transmitted from both the engine and the drive unit, in a first torsional condition when the torque is transmitted from the engine, and in a second torsional condition when the torque is transmitted from the drive unit. The hysteresis torque generating mechanism is configured not to generate a hysteresis torque when the damper device is in the first torsional condition, and not to generate the hysteresis torque in a first range of torsion angle less than a first angle when the damper device is in the second torsional condition.

Inventors: **Uehara; Hiroshi (Neyagawa, JP)**

Applicant: **EXEDY Corporation** (Neyagawa, JP)

Family ID: **1000008767526**

Assignee: **EXEDY Corporation (Neyagawa, JP)**

Appl. No.: **17/994745**

Filed: **November 28, 2022**

Prior Publication Data

Document Identifier	Publication Date
US 20230204077 A1	Jun. 29, 2023

Foreign Application Priority Data

JP	2021-212616	Dec. 27, 2021

Publication Classification

Int. Cl.: **F16D3/12** (20060101); **F16F15/129** (20060101)

U.S. Cl.:

CPC **F16D3/12** (20130101); **F16F15/129** (20130101); F16D2300/22 (20130101)

Field of Classification Search

CPC: F16D (3/12); F16D (2300/22); F16F (15/129)

USPC: 464/68.41

References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
8998728	12/2014	Komuro	464/68.41	F16D 3/14
11454296	12/2021	Saeki	N/A	F16F 15/1292
12049937	12/2023	Uehara	N/A	F16F 15/13492

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
2014-214819	12/2013	JP	N/A

Primary Examiner: Binda; Greg

Attorney, Agent or Firm: United IP Counselors, LLC

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS
(1) This application claims priority to Japanese Patent Application No. 2021-212616 filed Dec. 27, 2021. The entire contents of that application are incorporated by reference herein in their entirety.
TECHNICAL FIELD
(2) The present invention relates to a damper device.
BACKGROUND ART
(3) A damper device is configured to absorb and attenuate fluctuations of a torque outputted from an engine by one or more coil springs. Specifically, the damper device includes an input rotor, an output rotor, and a plurality of coil springs elastically coupling the input rotor and the output rotor. Besides, another type of damper device has been also proposed that a hysteresis torque is generated by one or more friction materials for further absorbing and attenuating fluctuations of a torque.
(4) For example, a damper device disclosed in Japan Laid-open Patent Application Publication No. 2014-214819 includes a first plate, a second plate, elastic members for elastically coupling the first and second plates, and first and second friction materials. When torsion is caused in the damper device by a torque transmitted thereto from the engine, the first friction material generates a hysteresis torque that is relatively small in magnitude. On the other hand, when torsion is caused to

the opposite side in the damper device in engine starting, the second friction material generates a hysteresis torque that is relatively large in magnitude.
(5) The damper device configured as described above poses a drawback of degradation in attenuation performance in a hybrid vehicle when the hybrid vehicle is on standby, with the engine being activated.
(6) It is an object of the present invention to inhibit degradation in attenuation performance.
BRIEF SUMMARY
(7) A damper device according to an aspect of the present invention is disposed between an engine and a drive unit. The damper device includes an input rotor, an output rotor, an elastic coupling part, and a hysteresis torque generating mechanism. The input rotor is disposed to be rotatable. The output rotor is disposed to be rotatable relative to the input rotor. The elastic coupling part elastically couples the input rotor and the output rotor. The hysteresis torque generating mechanism is configured to generate a hysteresis torque together with at least one of the input rotor and the output rotor therebetween. The damper device is configured to be in a neutral condition, a first torsional condition, and a second torsional condition. The neutral condition is a condition of the damper device made when a torque is not transmitted thereto from both the engine and the drive unit. The first torsional condition is a condition of the damper device made when the torque is transmitted thereto from the engine. The second condition is a condition of the damper device made when the torque is transmitted thereto from the drive unit. The hysteresis torque generating mechanism is configured not to generate the hysteresis torque when the damper device is in the first torsional condition. Besides, the hysteresis torque generating mechanism is configured not to generate the hysteresis torque in a first range of torsion angle set to be less than a first angle when the damper device is in the second torsional condition.
(8) As described above, the hysteresis torque generating mechanism does not generate the hysteresis torque in the first torsional condition. Besides, the hysteresis torque generating mechanism does not generate the hysteresis torque in the second torsional condition when the torsion angle falls in the first range set to be less than the first angle. According to this configuration, acute change in hysteresis torque does not occur in switching between the first torsional condition and the second torsional condition; hence, degradation in attenuation performance can be prevented when the engine is on standby. It should be noted that the term "hysteresis torque" means a torque to be generated by sliding of a friction member against another member. For example, a minute torque to be generated in such a situation as sliding of a coil spring against another member is not regarded as the hysteresis torque in the present invention.
(9) Preferably, the hysteresis torque generating mechanism is configured to generate a first hysteresis torque in a second range of torsion angle, which is set to be greater than or equal to the first angle and be less than a second angle, when the damper device is in the second torsional condition.
(10) Preferably, the hysteresis torque generating mechanism is configured to generate a second hysteresis torque greater in magnitude than the first hysteresis torque in a third range of torsion angle, which is set to be greater than or equal to the second angle and be less than a third angle, when the damper device is in the second torsional condition.
(11) Preferably, the hysteresis torque generating mechanism is configured to generate a third hysteresis torque greater in magnitude than the second hysteresis torque in a fourth range of torsion angle, which is set to be greater than or equal to the third angle and be less than or equal to a maximum angle, when the damper device is in the second torsional condition.
(12) Preferably, the hysteresis torque generating mechanism is configured to generate the second hysteresis torque greater in magnitude than the first hysteresis torque in the third range and not to generate the hysteresis torque in a predetermined minute torsion angular range included in the third range when the damper device is in the second torsional condition.

(13) Overall, according to the present invention, degradation in attenuation performance can be inhibited.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a cross-sectional view of a damper device.
(2) FIG. **2** is a front view of the damper device.
(3) FIG. **3** Ais a schematic diagram showing a relation between an input rotor and ahub flange.
(4) FIG. **3**B is a schematic diagram showing a condition that torsion (relative rotation) of the input rotor with respect to the hub flange is caused to an R**1** side by an angle θ**1**.
(5) FIG. **3**C is a schematic diagram showing a condition that the torsion of the input rotor with respect to the hub flange is caused to the R**1** side by an angle θ**3**.
(6) FIG. **3**D is a schematic diagram showing a condition that the torsion of the input rotor with respect to the hub flange is caused to an R**2** side by the angle θ**1**.
(7) FIG. **4** is a close-up view of a hysteresis torque generating mechanism.
(8) FIG. **5** is a close-up front view for showing a relation between a restriction protrusion and an elongated hole.
(9) FIG. **6** is a partial close-up view of FIG. **2**.
(10) FIG. **7** is a chart showing torsional characteristics.
(11) FIG. **8** is a diagram for explaining actions performed in a neutral condition.
(12) FIG. **9** is a diagram for explaining actions performed in a condition that the torsion is caused from the neutral condition to the R**1** side by 2°.
(13) FIG. **10** is a diagram for explaining actions performed in a condition that the torsion is caused from the neutral condition to the R**1** side by 4°.
(14) FIG. **11** is a diagram for explaining actions performed in a condition that the torsion is caused from the neutral condition to the R**2** side by 2°.
(15) FIG. **12** is a diagram for explaining actions performed in a condition that the torsion is caused from the neutral condition to the R**2** side by 4°.
(16) FIG. **13** is a diagram for explaining actions performed in a condition that the torsion is caused from the neutral condition to the R**2** side by 3°.
(17) FIG. **14** is a diagram for explaining actions performed in a condition that the torsion is caused from the neutral condition to the R**2** side by 2°.
(18) FIG. **15** is a diagram for explaining actions performed in a condition that the torsion is caused from the neutral condition to the R**2** side by 1°.
(19) FIG. **16** is a diagram for explaining actions performed in the neutral condition.
(20) FIG. **17** is a diagram for explaining actions performed in a condition that the torsion is caused from the neutral condition to the R**2** side by 2°.
(21) FIG. **18** is a diagram for explaining actions performed in a condition that the torsion is caused from the neutral condition to the R**2** side by 4°.
(22) FIG. **19** is a diagram for explaining actions performed in a condition that the torsion is caused from the neutral condition to the R**2** side by 7°.
(23) FIG. **20** is a diagram for explaining actions performed in a condition that the torsion is caused from the neutral condition to the R**2** side by 5°.
(24) FIG. **21** is a diagram for explaining actions performed in a condition that the torsion is caused from the neutral condition to the R**2** side by 3°.
DETAILED DESCRIPTION
(25) [Entire Configuration]
(26) FIG. **1** is a cross-sectional view of a torque limiter embedded damper device **1** (hereinafter

simply referred to as “damper device **1**”) according to a preferred embodiment of the present invention. On the other hand, FIG. **2** is a front view of the damper device **1**, from part of which some constituent members are detached. In FIG. **1**, an engine (not shown in the drawing) is disposed on the left side of the damper device **1**, whereas a drive unit (not shown in the drawing), including an electric motor, a transmission, and so forth, is disposed on the right side of the damper device **1**.
(27) It should be noted that in the following explanation, the term “axial direction” refers to an extending direction of a rotational axis O of the damper device **1**. On the other hand, the term “circumferential direction” refers to a circumferential direction of an imaginary circle about the rotational axis O, whereas the term “radial direction” refers to a radial direction of the imaginary circle about the rotational axis O. It should be noted that the circumferential direction is not required to be perfectly matched with that of the imaginary circle about the rotational axis O. Likewise, the radial direction is not required to be perfectly matched with a diameter direction of the imaginary circle about the rotational axis O. Besides, the term “torsion angle” means an angle of torsion (relative rotation) of an input rotor **30** with respect to a hub flange **40**.
(28) As shown in FIG. **1**, the damper device **1** is configured to transmit a torque between a flywheel (not shown in the drawing) and an input shaft (not shown in the drawing) of the drive unit. The damper device **1** is disposed between the engine and the drive unit. The damper device **1** is a device for limiting the torque transmitted between the engine and the drive unit, and simultaneously, for attenuating rotational fluctuations. The damper device **1** includes a torque limiter unit **10** and a damper unit **20**. The damper device **1** is rotated in a first rotational direction when transmitting the torque outputted from the engine toward the drive unit.
(29) [Torque Limiter Unit **10**]
(30) The torque limiter unit **10** is disposed radially outside the damper unit **20**. The torque limiter unit **10** limits the torque transmitted between the flywheel and the damper unit **20**. The torque limiter unit **10** includes a cover plate **11**, a support plate **12**, a friction disc **13**, a pressure plate **14**, and a cone spring **15**.
(31) The cover plate **11** and the support plate **12** are disposed away from each other at a predetermined interval in the axial direction. The outer peripheral part of the cover plate **11** and that of the support plate **12** are fixed to the flywheel by a plurality of bolts **16**.
(32) The friction disc **13**, the pressure plate **14**, and the cone spring **15** are disposed axially between the cover plate **11** and the support plate **12**.
(33) The friction disc **13** includes a core plate and a pair of friction members fixed to both lateral surfaces of the core plate. The friction disc **13** is fixed at an inner peripheral part thereof to the damper unit **20** by a plurality of rivets **17**. The pressure plate **14** and the cone spring **15** are disposed between the friction disc **13** and the support plate **12**.
(34) The pressure plate **14** is made in shape of an annulus. The pressure plate **14** is disposed on the support plate **12** side of the friction disc **13**. It should be noted that the pressure plate **14** is provided with a plurality of pawls **14***a* on the outer peripheral part thereof. The pawls **14***a* are engaged with a plurality of engaging holes **12***a* provided in the support plate **12**, respectively.
(35) The cone spring **15** is disposed between the pressure plate **14** and the support plate **12**. The cone spring **15** presses the friction disc **13** against the cover plate **11** through the pressure plate **14**.
(36) [Damper Unit **20**]
(37) The damper unit **20** includes the input rotor **30**, the hub flange **40** (exemplary output rotor), an elastic coupling part **50**, and a hysteresis torque generating mechanism **60**.
(38) <Input Rotor **30**>
(39) As shown in FIGS. **1** and **2**, the input rotor **30** is disposed to be rotatable. The input rotor includes a first plate **31** and a second plate **32**. Each of the first and second plates **31** and **32** is made in shape of a disc provided with a hole in the center part thereof. The first and second plates **31** and **32** are disposed apart from each other at an interval in the axial direction.

(40) Each of the first and second plates **31** and **32** includes a pair of first support portions **301** and a pair of second support portions **302**. The first support portions **301** of the first plate **31** are provided in identical positions to those of the second plate **32**. Likewise, the second support portions **302** of the first plate **31** are provided in identical positions to those of the second plate **32**. The second plate **32** is provided with assembling holes **32***a* in corresponding positions to the rivets **17**.
(41) The first plate **31** includes a plurality of stopper portions **31***a* and a plurality of fixation portions **31***b*. The stopper portions **31***a* and the fixation portions **31***b* are disposed in the outer peripheral part of the first plate **31**.
(42) The stopper portions **31***a* extend axially toward the second plate **32**. The stopper portions **31***a* are formed by bending the outer peripheral part of the first plate **31** toward the second plate **32**.
(43) The fixation portions **31***b* are formed by bending the distal ends of the stopper portions **31***a* radially outward. The fixation portions **31***b* are fixed to the outer peripheral end of the second plate **32** by a plurality of rivets **33**. Because of this, the first and second plates **31** and **32** are non-rotatable relative to each other and are axially immovable from each other.
(44) The first support portions **301**, provided as a pair in the first plate **31**, are disposed apart from each other at an angular interval of 180° about the rotational axis O. Besides, in the first plate **31**, each second support portion **302** is disposed apart from each first support portion **301** at an angular interval of 90°. In the second plate **32**, the first support portions **301** and the second support portions **302** are also disposed in similar positions to those in the first plate **31**. Each support portion **301**, **302** includes a hole axially penetrating therethrough and an edge part formed by cutting and raising the inner and outer peripheral edges of the hole.
(45) As schematically shown in FIGS. **3**A to **3**D, each support portion **301**, **302** includes an R**1** support surface **301***a*, **302***a* on one end thereof located on the first rotational direction side (hereinafter simply referred to as “R**1** side”) and includes an R**2** support surface **301***b*, **302***b* on the other end thereof located on a second rotational direction side (hereinafter simply referred to as “R**2** side”). In each support portion **301**, **302**, the width of the hole (distance between the R**1** and R**2** support surfaces) is L.
(46) It should be noted that in FIGS. **3**A to **3**D, the first and second support portions **301** and **302** are depicted with solid line, whereas first and second accommodation portions **401** and **402** (to be described) of the hub flange **40** are depicted with dashed-dotted line. It should be also noted that each FIG. **3**A, **3**B, **3**C, **3**D is a schematic diagram; constituent elements therein are different from those shown in actual specific shape in FIG. **2**.
(47) <Hub Flange **40**>
(48) As shown in FIGS. **1** and **2**, the hub flange **40** includes a hub **41** and a flange **42**. The hub **41** and the flange **42** are integrated with each other as a single member. The hub flange **40** is rotatable relative to the input rotor **30** in a predetermined angular range. The hub **41** has a tubular shape and is provided with a spline hole **41***a* in the center part thereof. Besides, the hub **41** penetrates both holes provided in the center parts of the first and second plates **31** and **32**.
(49) The flange **42** has a disc shape and extends radially outward from the outer peripheral surface of the hub **41**. The flange **42** is disposed axially between the first and second plates **31** and **32**.
(50) The flange **42** includes a plurality of stopper protrusions **42***b*, the pair of first accommodation portions **401**, the pair of second accommodation portions **402**, and a plurality of cutouts **403**.
(51) The stopper protrusions **42***b* are shaped to protrude radially outward from the outer peripheral surface of the flange **42**. Each stopper protrusion **42***b* is provided in a position located radially outside the circumferential middle of each accommodation portion **401**, **402**. Now, when the input rotor **30** and the hub flange **40** are rotated relative to each other, the stopper protrusions **42***b* contact with the stopper portions **31***a* of the first plate **31**; accordingly, relative rotation is prevented between the input rotor **30** and the hub flange **40**.
(52) As shown in FIG. **3**A, the pair of first accommodation portions **401** is disposed in corresponding positions to each pair of first support portions **3θ1**. On the other hand, the pair of

second accommodation portions **402** is disposed in corresponding positions to each pair of second support portions **302**. When explained in more detail, in a neutral condition (at a torsion angle of 0°) that the angle of relative rotation between the input rotor **30** and the hub flange **40** is 0°, and in other words, torsion is not caused between the input rotor **30** and the hub flange **40**, as shown in FIG. **3**A, the pair of first accommodation portions **401** is disposed to overlap in part each pair of first support portions **301**, and simultaneously, be offset (or displaced) from each pair of first support portions **301** to the R**1** side by an angle θ**1** (e.g., a torsion angle of 2°) as seen in the axial direction. On the other hand, the pair of second accommodation portions **402** is disposed to overlap in part each pair of second support portions **302**, and simultaneously, be offset (or displaced) from each pair of second support portions **302** to the R**2** side by the identical angle θ**1** to the above as seen in the axial direction.
(53) Each accommodation portion **401**, **402** is a hole made in shape of an approximately rectangle, the outer peripheral part of which is made in shape of a circular arc, as seen in the axial direction. Each accommodation portion **401**,**402** includes an R**1** accommodation surface **401**a, **402**a on one end thereof located on the R**1** side and includes an R**2** accommodation surface **401**b, **402**b on the other end thereof located on the R**2** side. In each accommodation portion **401**, **402**, the width of the hole (distance between the R**1** accommodation surface **401**a, **402**a and the R**2** accommodation surface **401**b, **402**b) is set to be L in similar manner to the width of the hole in each support portion **301**, **302**.
(54) As shown in FIG. **2**, each cutout **403** is disposed between the first and second accommodation portions **401** and **402** circumferentially adjacent to each other. Each cutout **403** is recessed radially inward from the outer peripheral surface of the flange **42** at a predetermined depth. The cutouts **403** are provided in corresponding positions to the rivets **17** by which the first plate **31** and the friction disc **13** of the torque limiter unit **10** are coupled to each other. Therefore, the torque limiter unit **10** and the damper unit **20**, assembled in different steps, can be fixed to each other by the rivets **17** with use of the assembling holes **32**a of the second plate **32** and the cutouts **403** of the flange **42**.
(55) <Elastic Coupling Part **50**>
(56) As shown in FIGS. **1** and **2**, the elastic coupling part **50** elastically couples the input rotor and the hub flange **40**. The elastic coupling part **50** includes a plurality of coil springs **51** and a plurality of resin members **52**. It should be noted that the elastic coupling part **50** may not include the plural resin members **52**.
(57) Each coil spring **51** includes an outer spring and an inner spring. Each coil spring **51** is disposed in each accommodation portion **401**, **402** of the flange **42**. Each coil spring **51** is supported in both radial and axial directions by each axially opposed pair of support portions **301**, **302** of the input rotor **30**. The coil springs **51** are actuated in parallel.
(58) Incidentally, the coil springs **51** are equal in free length to each other. The free length of each coil spring **51** is equal to the width L of each support portion **301**, **302**, i.e., the width L of each accommodation portion **401**, **402**. Besides, the coil springs **51** are equal in stiffness to each other. The resin members **52** are equal in stiffness to each other.
(59) <Accommodation States of Coil Springs **51**>
(60) Now, a layout of the support portions **301** and **302** and the accommodation portions **401** and **402** and an accommodation state of each coil spring **51**, which are made in the neutral condition, will be hereinafter explained in detail. It should be noted that in the following explanation, on an as-needed basis, a combination of each axially opposed pair of first support portions **301** and each first accommodation portion **401** will be referred to as “first window set w**1**”, whereas a combination of each axially opposed pair of second support portions **302** and each second accommodation portion **402** will be referred to as “second window set w**2**”.
(61) As described above, in the neutral condition as shown in FIG. **3**A, each first accommodation portion **401** is offset to the R**1** side by the angle θ**1** from each axially opposed pair of first support portions **301** corresponding thereto. On the other hand, each second accommodation portion **402** is

offset to the R**2** side by the angle θ**1** from each axially opposed pair of second support portions **302** corresponding thereto. Besides, each coil spring **51** is attached in a compressed state to an opening (axially penetrating hole) formed by axial overlap between each axially opposed pair of support portions **301**, **302** and each accommodation portion **401**, **402** corresponding thereto.
(62) Specifically, in the neutral condition as shown in FIG. **3**A, in each of the pair of first window sets w**1**, the coil spring **51** is in contact at the R**1**-side end surface thereof with the R**1** support surfaces **301***a*, while in contact at the R**2**-side end surface thereof with the R**2** accommodation surface **401***b*. In other words, in the neutral condition, in each first window set w**1**, the coil spring **51** is in contact at the R**1**-side end surface thereof with the input rotor **30**, while not in contact thereat with the hub flange **40**. Besides, in the neutral condition, in each first window set w**1**, the coil spring **51** is in contact at the R**2**-side end surface thereof with the hub flange **40**, while not in contact thereat with the input rotor **30**.
(63) In each of the pair of second window sets w**2**, the coil spring **51** is in contact at the R**1**-side end surface thereof with the R**1** accommodation surface **402***a*, while in contact at the R**2**-side end surface thereof with the R**2** support surfaces **302***b*. In other words, in the neutral condition, in each second window set w**2**, the coil spring **51** is in contact at the R**1**-side end surface thereof with the hub flange **40**, while not in contact thereat with the input rotor **30**. Besides, in the neutral condition, in each second window set w**2**, the coil spring **51** is in contact at the R**2**-side end surface thereof with the input rotor **30**, while not in contact thereat with the hub flange **40**.
(64) <Hysteresis Torque Generating Mechanism **60**>
(65) As shown in FIGS. **1** and **4**, the hysteresis torque generating mechanism **60** includes a first bushing **61**, a second bushing **62**, a cone spring **63**, and a friction plate **64**. The hysteresis torque generating mechanism **60**, together with the input rotor **30**, generates a hysteresis torque therebetween.
(66) The hysteresis torque generating mechanism **60** generates the hysteresis torque when rotated relative to the input rotor **30**. Specifically, as explained below, the hysteresis torque generating mechanism **60** generates the hysteresis torque when both the first bushing **61** and the friction plate **64** are rotated relative to the input rotor **30**. It should be noted that FIG. **4** is a partial close-up view of FIG. **1**.
(67) The first bushing **61** is disposed axially between the first plate **31** and the flange **42**. The second bushing **62**, the cone spring **63**, and the friction plate **64** are disposed axially between the second plate **32** and the flange **42**. It should be noted that the friction plate **64** is disposed axially between the flange **42** and the second bushing **62**, whereas the cone spring **63** is disposed axially between the second plate **32** and the second bushing **62**.
(68) The first bushing **61** is rotatable relative to the first plate **31**. Besides, the first bushing **61** is rotatable relative to the flange **42**. The first bushing **61** is provided with a friction member **611** fixed to the first plate **31**-side surface thereof. Because of this, when the first bushing **61** is rotated relative to the first plate **31**, the hysteresis torque is generated.
(69) The first bushing **61** and the friction plate **64** are rotated unitarily with each other. When described in detail, as shown in FIG. **4**, the first bushing **61** includes a plurality of restriction protrusions **61***a* and a plurality of engaging protrusions **61***b*. The engaging protrusions **61***b* are engaged with engaging holes **64***a* provided in the friction plate **64**. Therefore, the first bushing **61** and the friction plate **64** are non-rotatable relative to each other and are rotated unitarily with each other.
(70) The restriction protrusions **61***a* are shaped to axially protrude from the flange **42**-side lateral surface of the first bushing **61**. As shown more close-up in FIG. **5** (partial front view), the restriction protrusions **61***a* penetrate elongated holes **42***c*, respectively. The elongated holes **42***c* are provided in the flange **42** so as to extend in the circumferential direction.
(71) In the neutral condition, gaps are produced on both R**1** and R**2** sides of each restriction protrusion **61***a* in each elongated hole **42***c*, i.e., between each restriction protrusion **61***a* and the

circumferential end surfaces of each elongated hole **42***c*. It should be noted that the R**2**-side gap corresponds to a torsion angle θ**1**. In other words, the R**2**-side gap is equal in magnitude to the amount of offset between each accommodation portion **401**, **402** and each axially opposed pair of support portions **301**, **302**. The R**1**-side gap corresponds to a torsion angle θ**2**. It should be noted that the torsion angle θ**2** is sufficiently greater than the torsion angle θ**1**. Because of this, even when torsion is caused to the R**1** side in use of the damper device **1**, each restriction protrusion **61***a* does not contact with the R**1**-side end surface of each elongated hole **42***c*. It should be noted that the position of the first bushing **61** and the friction plate **64** in the neutral condition will be referred to as "neutral position".
(72) As shown in FIG. **4**, the second bushing **62** is rotatable relative to the friction plate **64**. The second bushing **62** is provided with a friction member **621** fixed to the friction plate **64**-side surface thereof. Because of this, when the second bushing **62** is rotated relative to the friction plate **64**, the hysteresis torque is generated. It should be noted that the cone spring **63** is disposed axially between the second bushing **62** and the second plate **32**, while being compressed therebetween. In other words, the cone spring **63** urges the second bushing **62** toward the friction plate **64**.
(73) The second bushing **62** is rotated unitarily with the second plate **32**. When described in detail, the second bushing **62** is provided with a plurality of engaging protrusions **62***a* (see FIG. **2**) axially protruding from the second plate **32**-side surface thereof. The engaging protrusions **62***a* are engaged with engaging holes **32***b* of the second plate **32**, respectively. Therefore, the second bushing **62** and the second plate **32** are unitarily rotated.
(74) With the configuration described above, the first bushing **61** and the friction plate **64** are rotatable relative to the hub flange **40** by the angle θ**2** to the R**1** side and are also rotatable relative thereto by the angle θ**1** to the R**2** side. Therefore, basically, frictional contact is not caused between the first bushing **61** and the first plate **31** in the torsion angular range described above; a hysteresis torque is not generated therebetween. Besides, in the torsion angular range described above, the friction plate **64** is rotated in synchronization with the first plate **31**. Hence, similarly to the above, frictional contact is not caused between the second bushing **62** and the friction plate **64**; a hysteresis torque is not generated therebetween.
(75) On the other hand, when the torsion angle positively or negatively exceeds the torsion angles described above, the first bushing **61** and the friction plate **64** are prevented from being rotated relative to the flange **42**. Therefore, frictional contact is caused between the first bushing **61** and the first plate **31** and between the second bushing **62** and the friction plate **64**; hysteresis torques are generated therebetween.
(76) As shown in FIG. **2** and FIG. **6** that is a partial close-up view of FIG. **2**, the friction plate **64** herein has a rectangular shape as seen from the front side. Besides, the friction plate **64** includes a pair of protruding portions **641**. The protruding portions **641** protrude radially outward from the outer peripheral surface of the friction plate **64**. The protruding portions **641** are disposed in positions opposite to each other through the rotational axis O.
(77) Each protruding portion **641** is located circumferentially between adjacent first and second window sets w**1** and w**2**. Besides, each protruding portion **641** is in contact at an R**1**-side contact surface **641***a* thereof with the R**2**-side end surface of the coil spring **51** disposed in the compressed state in the second window set w**2**. On the other hand, each protruding portion **641** is in contact at an R**2**-side contact surface **641***b* thereof with the R**1**-side end surface of the coil spring **51** disposed in the compressed state in the first window set w**1**.
(78) As described above, each protruding portion **641** of the friction plate **64** is pressed in opposite directions by the pair of compressed coil springs **51**. Therefore, in the neutral condition, the friction plate **64** and the first bushing **61** rotated in synchronization therewith are configured to be constantly set in the neutral position.
(79) [Torsional Characteristics: without Hysteresis Torque]
(80) First, torsional characteristics, exerted by the four coil springs **51** in a condition without

hysteresis torque, will be herein explained for easy explanation of actions. In FIG. **7**, broken line represents a torsional characteristic (w**1**) of the coil springs **51** in the first window sets w**1**; dashed two-dotted line represents a torsional characteristic (w**2**) of the coil springs **51** in the second window sets w**2**; solid line represents a net torsional characteristic (w**0**) of the torsional characteristic (w**1**) and the torsional characteristic (w**2**).
(81) The damper device **1** is configured to be set to a neutral condition, a first torsional condition, and a second torsional condition. FIG. **3**A is a schematic diagram of the damper device **1** in the neutral condition; FIGS. **3**B and **3**C are schematic diagrams of the damper device **1** in the first torsional condition; FIG. **3**D is a schematic diagram of the damper device **1** in the second torsional condition. It should be noted that the neutral condition means a condition of the damper device **1** made when a torque is not transmitted to the damper device **1** from both the engine and the drive unit. On the other hand, the first torsional condition means a condition of the damper device **1** made when a torque is transmitted to the damper device **1** from the engine, whereby torsion of the input rotor **30** with respect to the hub flange **40** is caused to the R**1** side. By contrast, the second torsional condition means a condition of the damper device **1** made when a torque is transmitted to the damper device **1** from the drive unit, whereby torsion of the input rotor **30** with respect to the hub flange **40** is caused to the R**2** side.
(82) <First Window Sets w**1**>
(83) As shown in FIG. **3**A, in the neutral condition without relative rotation between the input rotor **30** and the hub flange **40**, the coil spring **51** in each first window set w**1** is disposed in the compressed state between the R**1** support surfaces **301***a* and the R**2** accommodation surface **401***b*. The interval between the R**1** support surfaces **301***a* and the R**2** accommodation surface **401***b* is G**0** and is narrower than the width L (equal to the free length of the coil spring **51**) in each of each axially opposed pair of support portions **301**, **302** and each accommodation portion **401**, **402**. Therefore, as depicted with broken line in FIG. **7**, in the first window sets w**1**, a torsional torque −t is generated by the compressed coil springs **51**.
(84) As shown in FIG. **3**B, when the torque is inputted to the damper device **1** from the engine, the damper device **1** is set to the first torsional condition. In other words, torsion of the hub flange **40** with respect to the input rotor **30** is caused from the neutral condition to the R**2** side (corresponding to the positive side in the torsional characteristics) by the angle θ**1**. In this condition, the amount of offset between each axially opposed pair of first support portions **301** and each first accommodation portion **401** becomes “0”.
(85) Here, in each first window set w**1**, the interval between the R**1** support surfaces **301***a* in contact with the R**1**-side end surface of the coil spring **51** and the R**2** accommodation surface **401***b* in contact with the R**2**-side end surface of the coil spring **51** is G**1** and becomes wider than the interval G**0**. The interval G**1** is equal in magnitude to the free length of the coil spring **51**. In other words, when the torsion angle between the input rotor **30** and the hub flange **40** reaches +θ1, the coil spring **51** in each first window set w**1** becomes a free-length state, whereby the torsional torque becomes “0” as shown in FIG. **7**.
(86) Moreover, when torsion of the hub flange **40** with respect to the input rotor **30** is caused at a greater torsion angle than θ1, as shown in FIG. **3**C (in which a condition made at a torsion angle θ**3** (>θ1) is shown), the coil spring **51** in each first window set w**1** is in contact at the R**1**-side end surface thereof with the R**1** accommodation surface **401***a*, while in contact at the R**2**-side end surface thereof with the R**2** support surfaces **301***b*. Here, the interval between the R**1** accommodation surface **401***a* and the R**2** support surfaces **301***b* is G**2** and becomes narrower than the free length of the coil spring **51**. In other words, when the torsion angle between the input rotor **30** and the hub flange **40** becomes greater than θ1, the coil spring **51** is compressed from the free-length state, whereby the torsional torque gradually increases as shown in FIG. **7**.
(87) On the other hand, when the damper device **1** is set to the second torsional condition as shown in FIG. **3**D, in other words, when torsion of the hub flange **40** with respect to the input rotor **30** is

caused from the neutral condition to the R**1** side (corresponding to the negative side in the torsional characteristics), the coil spring **51** in each first window set w**1** is constantly compressed between the R**1** support surfaces **301***a* and the R**2** accommodation surface **401***b*. In other words, in the first window sets w**1**, the torsional torque increases to the negative side with increase in torsion angle to the negative side in a negative-side torsional range as shown in FIG. **7**.
(88) <Second Window Sets w**2**>
(89) As shown in FIG. **3**A, in the neutral condition, the coil spring **51** in each second window set w**2** is disposed in the compressed state between the R**1** accommodation surface **402***a* and the R**2** support surfaces **302***b*. The interval between the R**1** accommodation surface **402***a* and the R**2** support surfaces **302***b* is G**0** and is narrower than the width L (equal to the free length of the coil spring **51**) in each of each axially opposed pair of support portions **301**, **302** and each accommodation portion **401**, **402**. Therefore, as depicted with dashed two-dotted line in FIG. **7**, in the neutral condition, a torsional torque +t is generated by the compressed coil springs **51** in the second window sets w**2**.
(90) As shown in FIGS. **3**B and **3**C, when the damper device **1** is set to the first torsional condition, the coil springs **51** in each second window set w**2** is constantly compressed between the R**1** accommodation surface **402***a* and the R**2** support surfaces **302***b*. In other words, in the second window sets w**2**, the torsional torque increases to the positive side with increase in torsion angle to the positive side in a positive-side torsional range as shown in FIG. **7**.
(91) On the other hand, when the damper device **1** is set to the second torsional condition as shown in FIG. **3**D, in other words, when torsion of the hub flange **40** with respect to the input rotor **30** is caused from the neutral condition to the R**1** side (corresponding to the negative side) by the angle θ**1**, the amount of offset between each axially opposed pair of second support portions **302** and each second accommodation portion **402** becomes “0”.
(92) Here, in each second window set w**2**, the interval between the R**1** accommodation surface **402***a* in contact with the R**1**-side end surface of the coil spring **51** and the R**2** support surfaces **302***b* in contact with the R**2**-side end surface of the coil spring **51** is G**3** and becomes wider than the interval G**0**. The interval G**3** is equal in magnitude to the free length of the coil spring **51**. In other words, when the torsion angle between the input rotor **30** and the hub flange **40** reaches −θ**1**, the coil spring **51** in each second window set w**2** becomes the free-length state, whereby the torsional torque becomes “0” as shown in FIG. **7**.
(93) Moreover, when torsion of the hub flange **40** with respect to the input rotor **30** is caused at a greater torsion angle than θ1 to the R**1** side, the coil spring **51** in each second window set w**2** is in contact at the R**1**-side end surface thereof with the R**1** support surfaces **302***a*, while in contact at the R**2**-side end surface thereof with the R**2** accommodation surface **402***b*. Furthermore, when the torsion angle further increases, the coil spring **51** is compressed from the free-length state, whereby the torsional torque gradually increases to the negative side as shown in FIG. **7**.
(94) <Net Torsional Characteristic>
(95) In FIG. **7**, the torsional characteristic w**0** depicted with solid line is the net torsional characteristic obtained by adding the torsional characteristic w**1** depicted with broken line and the torsional characteristic w**2** depicted with dashed two-dotted line and represents torsional characteristics of the entire damper unit. In other words, the torsional torque is “0” in the neutral condition and increases to both the positive side and the negative side with increase in torsion angle to both the positive side and the negative side.
(96) [Actions: with Hysteresis Torque]
(97) Next, with use of schematic diagrams of FIG. **8** and thereafter, torsional characteristics will be explained in consideration of hysteresis torques. In the schematic diagrams, the first bushing **61** and the friction plate **64** are collectively explained as “friction member FP”. In the following explanation, the angle θ**1** described above will be set as “2°” but this setting is exemplary only. Besides, in the following explanation, the term “torsion angle” means an angle of torsion (relative

rotation) of the input rotor **30** with respect to the hub flange **40**. Furthermore, the torsion angle will be expressed in the form of absolute value.
(98) <Neutral Condition>
(99) FIG. **8** shows the neutral condition. In the neutral condition, the coil spring **51** in each window set w**1**, w**2** is disposed in the compressed state. Besides, as described above, the contact surfaces **641***a* and **641***b*, which are the end surfaces of each protruding portion **641** of the friction plate **64**, are in contact with the end surfaces of the corresponding pair of coil springs **51**. Hence, the friction plate **64** is set in the neutral position. Consequently, gaps are reliably produced between each restriction protrusion **61***a* of the first bushing **61** and the end surfaces of each elongated hole **42***c* of the flange **42**; one is produced on the R**1** side of each restriction protrusion **61***a* and corresponds to θ**2** (of e.g., 20°), whereas the other is produced on the R**2** side of each restriction protrusion **61***a* and corresponds to θ**1** (of e.g., 2°).
(100) First, the torsional characteristics exerted when the damper device **1** is set to the first torsional condition (hereinafter referred to as "positive side torsional characteristics" on an as-needed basis) will be explained.
(101) <Neutral Condition.fwdarw.Torsion Angle of 2°>
(102) FIG. **9** shows a condition that torsion of the input rotor **30** with respect to the hub flange **40** is caused from the neutral condition to the R**1** side by 2°.
(103) During transition from the condition shown in FIG. **8** to that shown in FIG. **9**, in other words, during transition from the neutral condition to torsion caused by the torsion angle of 2°, the coil spring **51** in each first window set w**1** extends from the compressed state and becomes the free-length state, whereas the coil spring **51** in each second window set w**2** is further compressed from the compressed state. On the other hand, the friction member FP and the input rotor **30** are rotated to the R**1** side in synchronization with each other; a hysteresis torque is not generated between the friction member FP and the input rotor **30**. When described in detail, a hysteresis torque is not generated between the first bushing **61** of the friction member FP and the first plate **31**. It should be noted that a hysteresis torque is not generated as well between the second bushing **62** and the friction plate **64**.
(104) <Torsion Angle of 2°.fwdarw.4°>
(105) FIG. **10** shows a condition that torsion of the input rotor **30** with respect to the hub flange is caused to the R**1** side by 4°.
(106) During transition from the condition shown in FIG. **9** to that shown in FIG. **10**, in other words, during transition from the torsion angle of 2° to the torsion angle of 4°, the coil spring **51** in each first window set w**1** is compressed from the free-length state and becomes the compressed state, whereas the coil spring **51** in each second window set w**2** is further compressed from the compressed state. On the other hand, the friction member FP and the input rotor **30** are rotated to the R**1** side in synchronization with each other; a hysteresis torque is not generated between the friction member FP and the input rotor **30**.
(107) <Torsion Angle of 4°.fwdarw.Neutral Condition>
(108) During reverse transition from the torsion caused by the torsion angle of 4° to the neutral condition, the conditions transition from one to another in the reverse order to the above. In other words, the condition shown in FIG. **10** transitions to that shown in FIG. **9**, and finally, the neutral condition shown in FIG. **8** is restored therefrom.
(109) As described above, the hysteresis torque generating mechanism **60** is configured not to generate a hysteresis torque, while the damper device **1** is in the first torsional condition.
(110) Next, torsional characteristics exerted when the damper device **1** is set to the second torsional condition (hereinafter referred to as "negative side torsional characteristics" on an as-needed basis) will be explained.
(111) <Neutral Condition.fwdarw.Torsion Angle of 2°>
(112) FIG. **11** shows a condition that torsion of the input rotor **30** with respect to the hub flange is

caused to the R**2** side by 2° in the course of increase in torsion angle. In this condition, each restriction protrusion **61***a* of the first bushing **61** is in contact with the R**2**-side end surface of each elongated hole **42***c* of the flange **42**.
(113) During transition from the condition shown in FIG. **8** to that shown in FIG. **11**, in other words, during transition from the neutral condition to torsion caused to the R**2** side by 2°, the coil spring **51** in each second window set w**2** extends from the compressed state and becomes the free-length state, whereas the coil spring **51** in each first window set w**1** is further compressed from the compressed state. On the other hand, the friction member FP is rotated to the R**2** side in synchronization with the input rotor **30**. Because of this, a hysteresis torque is not generated between the friction member FP and the input rotor **30**. When described in detail, a hysteresis torque is not generated between the first bushing **61** of the friction member FP and the first plate **31**; likewise, a hysteresis torque is not generated between the second bushing **62** of the friction member FP and the friction plate **64**.
(114) <Torsion Angle of 2°.fwdarw.4°>
(115) FIG. **12** shows a condition that torsion of the input rotor **30** with respect to the hub flange is caused to the R**2** side by 4° in the course of increase in torsion angle.
(116) During transition from the condition shown in FIG. **11** to that shown in FIG. **12**, in other words, during transition from the torsion angle of 2° to the torsion angle of 4°, the coil spring **51** in each first window set w**1** is further compressed from the compressed state, whereas the coil spring **51** in each second window set w**2** is compressed from the free-length state and becomes the compressed state.
(117) Besides, the input rotor **30** is rotated to the R**2** side. On the other hand, each restriction protrusion **61***a* contacts with one end surface of each elongated hole **42***c* of the flange **42**, whereby the friction member FP is prevented from rotating to the R**2** side. As a result, the friction member FP is rotated relative to the input rotor **30**, whereby hysteresis torques are generated therebetween. When described in detail, the first bushing **61** is rotated relative to the first plate **31**, whereby a hysteresis torque is generated therebetween. On the other hand, the second bushing **62** is rotated relative to the friction plate **64**, whereby a hysteresis torque is generated therebetween.
(118) <Torsion Angle of 4°.fwdarw.3°>
(119) FIG. **13** shows a condition that torsion of the input rotor **30** with respect to the hub flange is caused to the R**2** side by 3° in the course of restoration to the neutral condition. During transition from the condition shown in FIG. **12** to that shown in FIG. **13**, in other words, during reverse transition from the torsion angle of 4° to the torsion angle of 3°, the input rotor **30** is rotated to the R**1** side, whereas the friction member FP is not rotated. When described in detail, in the friction member FP, each contact surface **641***a* is in contact with the end surface of the coil spring **51** in each second window set w**2**, whereas each contact surface **641***b* is not in contact with the end surface of the coil spring **51** in each first window set w**1**. In other words, the friction member FP is urged only to the R**2** side by the coil springs **51** in the second window sets w**2**. Because of this, the friction member FP is not rotated to the R**1** side. Therefore, the input rotor **30** is rotated relative to the friction member FP, whereby a hysteresis torque is generated in a torsion angular range of 4° to 3°.
(120) <Torsion Angle of 3°.fwdarw.2°>
(121) FIG. **14** shows a condition that torsion of the input rotor **30** with respect to the hub flange is caused to the R**2** side by 2° in the course of restoration to the neutral condition. During transition from the condition shown in FIG. **13** to that shown in FIG. **14**, in other words, during reverse transition from the torsion angle of 3° to the torsion angle of 2°, the input rotor **30** and the friction member FP are rotated in synchronization with each other. In other words, the input rotor **30** and the friction member FP are not rotated relative to each other.
(122) When described in detail, in the course of restoration to the neutral condition, the torsion angle reaches 3° (exemplary only) and torques generated by the coil springs **51** in the second

window sets w**2** are made small; accordingly, the torques generated by the coil springs **51** in the second window sets w**2** and the hysteresis torque generated between the input rotor **30** and the friction member FP are balanced. Because of this, the coil spring **51** in each second window set w**2** is prevented from further extending from the state thereof made at this moment by the hysteresis torque. In other words, until the torsion angle reaches 2° from 3°, the coil spring **51** in each second window set w**2** is not actuated. Because of this, only the coil spring **51** in each first window set w**1** contributes to the torsional stiffness of the entirety of the damper device **1** (specifically, with one-half of the stiffness in the net characteristic).
(123) Besides, during reverse transition from the torsion angle 3° to the torsion angle of 2°, the friction member FP and the input rotor **30** are rotated to the R**1** side in synchronization with each other; hence, a hysteresis torque is not generated therebetween.
(124) <Torsion Angle of 2°.fwdarw.1°>
(125) FIG. **15** shows a condition that torsion of the input rotor **30** with respect to the hub flange is caused to the R**2** side by 1° in the course of restoration to the neutral condition. During transition from the condition shown in FIG. **14** to that shown in FIG. **15**, in other words, during reverse transition from the torsion angle of 2° to the torsion angle of 1°, the input rotor **30** is rotated relative to the friction member FP.
(126) Speaking in detail, when the torsion angle reaches 2°, the coil spring **51** in each second window set w**2** is in contact at the R**1**-side end surface thereof with the corresponding end surface of the hub flange **40**. Because of this, until the torsion angle reaches 1° from 2°, the friction member FP receives repulsion from the coil spring **51** in each second window set w**2** and is disabled to be rotated in conjunction with the input rotor **30**. Consequently, the input rotor **30** is rotated relative to the friction member FP, whereby a hysteresis torque is generated in accordance with a force (torque) by which the coil spring **51** in each second window set w**2** is compressed.
(127) Besides, until the torsion angle reaches 10 from 2°, the coil spring **51** in each second window set w**2** is not actuated. Because of this, only the coil spring **51** in each first window set w**1** contributes to the torsional stiffness of the entirety of the damper device **1** (specifically, with one-half of the stiffness in the net characteristic).
(128) <Torsion Angle of 1°.fwdarw.Neutral Condition>
(129) As shown in FIG. **15**, when the torsion angle reaches 10, the coil spring **51** in each second window set w**2** contacts at the R**2**-side end surface thereof with the corresponding end surfaces of the input rotor **30**. Because of this, during transition from the condition shown in FIG. **15** to that shown in FIG. **8**, in other words, during reverse transition from torsion caused by the torsion angle of 1° to the neutral condition, the input rotor **30** is rotated in synchronization with the friction member FP; hence, a hysteresis torque is not generated therebetween.
(130) Besides, during reverse transition from torsion caused by the torsion angle of 1° to the neutral condition, the coil spring **51** in each first window set w**1** and that in each second window set w**2** are actuated, whereby a net stiffness is obtained, as the torsional stiffness of the entire device, by adding the stiffness of the coil springs **51** in the first window sets w**1** and that of the coil springs **51** in the second window sets w**2**. Besides, at this moment, the friction member FP is set in the neutral position.
(131) As described above, while the damper device **1** is in the second torsional condition, the hysteresis torque generating mechanism **60** is configured not to generate a hysteresis torque in a first range of torsion angle (of 0° to 1°) set to be less than a first angle. Specifically, the hysteresis torque generating mechanism **60** does not generate a hysteresis torque both in the course of transition from the torsion angle of 0° to the torsion angle of 1° and in the course of reverse transition from the torsion angle of 1° to the torsion angle of 0°.
(132) Besides, the hysteresis torque generating mechanism **60** generates a first hysteresis torque in a second range of torsion angle (of 1° to 2°) set to be greater than or equal to the first angle and be less than a second angle. Specifically, the hysteresis torque generating mechanism **60** does not

generate a hysteresis torque in the course of transition from the torsion angle of 1° to the torsion angle of 2° but generates a hysteresis torque in the course of reverse transition from the torsion angle of 2° to the torsion angle of 1°.

(133) Moreover, the hysteresis torque generating mechanism **60** generates a second hysteresis torque in a third range of torsion angle (of 2° to 3°) set to be greater than or equal to the second angle and be less than a third angle. Specifically, the hysteresis torque generating mechanism **60** generates a hysteresis torque in the course of transition from the torsion angle of 2° to the torsion angle of 3° but does not generate a hysteresis torque in the course of reverse transition from the torsion angle of 3° to the torsion angle of 2°. It should be noted that the second hysteresis torque is greater in magnitude than the first hysteresis torque.

(134) Furthermore, the hysteresis torque generating mechanism **60** generates a third hysteresis torque in a fourth range of torsion angle (of 3° to MAX) set to be greater than or equal to the third angle and be less than or equal to the maximum angle. Specifically, the hysteresis torque generating mechanism **60** generates a hysteresis torque both in the course of transition from the torsion angle of 3° to the torsion angle of MAX and in the course of reverse transition from the torsion angle of MAX to the torsion angle of 3°. It should be noted that the third hysteresis torque is greater in magnitude than the second hysteresis torque.

Other Preferred Embodiments

(135) The present invention is not limited to the preferred embodiment described above, and a variety of changes or modifications can be made without departing from the scope of the present invention. (a) In the preferred embodiment described above, the torsion angle θ**1**, corresponding to the gap between each restriction protrusion **61***a* and the circumferentially R**2**-side end surface of each elongated hole **42***c*, is equal in magnitude to the R**2**-side offset amount θ**1** between each axially opposed pair of first support portions **301** and each first accommodation portion **4θ1**. However, the configuration of the damper device **1** is not limited to this. For example, the torsion angle, corresponding to the gap between each restriction protrusion **61***a* and the circumferentially R**2**-side end surface of each elongated hole **42***c*, can be set to be greater in magnitude than the offset amount θ**1**.

(136) For example, the torsion angle, corresponding to the gap between each restriction protrusion **61***a* and the circumferentially R**2**-side end surface of each elongated hole **42***c*, can be set to be 2 θ1.

(137) The torsional characteristics to be exerted in this setting will be hereinafter explained with schematic diagrams. It should be noted that the torsional characteristics, exerted when the damper device **1** is in the first torsional condition, are similar to those in the preferred embodiment described above; hence, the torsional characteristics, exerted when the damper device **1** is in the second torsional condition, will be explained.

(138) FIG. **16** shows the neutral condition. The neutral condition in this setting is identical to that in the preferred embodiment described above except for the gap between each restriction protrusion **61***a* and the R**2**-side end surface of each elongated hole **42***c*. It should be noted that the torsion angle 2θ**1**, corresponding to the gap between each restriction protrusion **61***a* and the R**2**-side end surface of each elongated hole **42***c*, is set to be, for instance, 4°.

(139) <Neutral Condition.fwdarw.Torsion Angle of 2°>

(140) FIG. **17** shows a condition that torsion of the input rotor **30** with respect to the hub flange is caused to the R**2** side by 2° in the course of increase in torsion angle.

(141) During transition from the condition shown in FIG. **16** to that shown in FIG. **17**, in other words, during transition from the neutral condition to torsion caused to the R**2** side by 2°, the coil spring **51** in each first window set w**1** is further compressed from the compressed state. On the other hand, the coil spring **51** in each second window set w**2** extends from the compressed state and becomes the free-length state.

(142) Besides, the friction member FP is rotated in synchronization with the input rotor **30**. Because of this, a hysteresis torque is not generated between the friction member FP and the input

rotor **30**. When described in detail, a hysteresis torque is not generated between the first bushing **61** of the friction member FP and the first plate **31**; likewise, a hysteresis torque is not generated between the second bushing **62** of the friction member FP and the friction plate **64**.
(143) <Torsion Angle of 2°.fwdarw.4°>
(144) FIG. **18** shows a condition that torsion of the input rotor **30** with respect to the hub flange is caused to the R**2** side by 4° in the course of increase in torsion angle.
(145) During transition from the condition shown in FIG. **17** to that shown in FIG. **18**, in other words, during transition from the torsion angle of 2° to the torsion angle of 4°, the coil spring **51** in each first window set w**1** is further compressed from the compressed state. On the other hand, the coil spring **51** in each second window set w**2** is compressed from the free-length state and becomes the compressed state.
(146) The friction member FP is still kept rotated in synchronization with the input rotor **30**; hence, a hysteresis torque is not generated between the friction member FP and the input rotor **30**.
(147) Each contact surface **641***a* of the friction member FP is gradually separated away from the corresponding end surface of the coil spring **51** in each second window set w**2**; then, when the torsion angle reaches 4°, the angle, corresponding to the gap between each contact surface **641***a* and the corresponding end surface of the coil spring **51** in each second window set w**2**, becomes 2°.
(148) <Torsion Angle of 4°.fwdarw.7°>
(149) FIG. **19** shows a condition that torsion of the input rotor **30** with respect to the hub flange is caused to the R**2** side by 7° in the course of increase in torsion angle.
(150) During transition from the condition shown in FIG. **18** to that shown in FIG. **19**, in other words, during transition from the torsion angle of 4° to the torsion angle of 7°, the coil spring **51** in each first window set w**1** and that in each second window set w**2** are further compressed from the compressed state.
(151) Besides, the input rotor **30** is rotated to the R**2** side. On the other hand, each restriction protrusion **61***a* contacts with one end surface of each elongated hole **42***c* of the flange **42**, whereby the friction member FP is prevented from rotating to the R**2** side. As a result, the friction member FP is rotated relative to the input rotor **30**, whereby hysteresis torques are generated therebetween. When described in detail, the first bushing **61** is rotated relative to the first plate **31**, whereby a hysteresis torque is generated therebetween. On the other hand, the second bushing **62** is rotated relative to the friction plate **64**, whereby a hysteresis torque is generated therebetween.
(152) Besides, when the torsion angle is greater than or equal to 4°, the torsion angle, corresponding to the gap between each contact surface **641***a* and the corresponding end surface of the coil spring **51** in each second window set w**2**, is constantly maintained at 2°. The angle of this gap (i.e., 2°) is obtained by subtracting the torsion angle corresponding to the amount of offset (i.e., 2°) from the angle corresponding to the gap produced on the R**2** side of each restriction protrusion **61***a* in each hole **42***c* (i.e., 4°). Therefore, the friction member FP can be actuated together with the input rotor **30** in the angular range of 2° described above (relative torsion angle) included in a high torsion angular range that the torsion angle is greater than or equal to 4°. In other words, a hysteresis torque is not generated when the relative torsion angle falls in the angular range of 2° (exemplary minute torsion angular range).
(153) Therefore, a relatively large hysteresis torque can be obtained in the high torsion angular range that the torsion angle (absolute angle) is greater than or equal to 4°. Besides, even when the absolute torsion angle is greater than or equal to 4°, a hysteresis torque is not generated if the relative torsion angle between the input rotor **30** and the hub flange **40** falls in the minute torsion angular range of 2°. Therefore, minute torque fluctuations can be effectively attenuated in a traveling range corresponding to the high torsion angular range in the torsional characteristics.
(154) <Torsion Angle of 7°.fwdarw.5°>
(155) FIG. **20** shows a condition that torsion of the input rotor **30** with respect to the hub flange is caused to the R**2** side by 5° in the course of restoration to the neutral condition. During transition

from the condition shown in FIG. **19** to that shown in FIG. **20**, in other words, during reverse transition from the torsion angle of 7° to the torsion angle of 5°, the input rotor **30** is rotated to the R**1** side in synchronization with the friction member FP Therefore, a hysteresis torque is not generated until the torsion angle reaches 5° from 7°.
(156) <Torsion Angle of 5°.fwdarw.3°>
(157) FIG. **21** shows a condition that torsion of the input rotor **30** with respect to the hub flange is caused to the R**2** side by 3° in the course of restoration to the neutral condition. During transition from the condition shown in FIG. **20** to that shown in FIG. **21**, in other words, during reverse transition from the torsion angle of 5° to the torsion angle of 3°, the input rotor **30** is rotated to the R**1** side, whereas the friction member FP is not rotated. When described in detail, in the friction member FP, each contact surface **641***a* is in contact with the corresponding end surface of the coil spring **51** in each second window set w**2**, whereas each contact surface **641***b* is not in contact with the corresponding end surface of the coil spring **51** in each first window set w**1**. In other words, the friction member FP is urged only to the R**2** side by the coil springs **51** in the second window sets w**2**. Because of this, the friction member FP is not rotated to the R**1** side. Therefore, the input rotor **30** is rotated relative to the friction member FP, whereby a hysteresis torque is generated until the torsion angle reaches 3° from 50.
(158) <Torsion Angle of 3°.fwdarw.Neutral Condition>
(159) The torsional characteristics, exerted during reverse transition from the torsion caused by the torsion angle of 3° to the neutral condition, are identical to those in the preferred embodiment described above; hence, the detailed explanation thereof will be hereinafter omitted.
(160) As described above, the hysteresis torque generating mechanism **60** is configured not to generate a hysteresis torque in the first range of torsion angle (of 0° to 1°) set to be less than the first angle, while the damper device **1** is in the second torsional condition. Specifically, the hysteresis torque generating mechanism **60** does not generate a hysteresis torque both in the course of transition from the torsion angle of 0° to the torsion angle of 1° and in the course of reverse transition from the torsion angle of 1° to the torsion angle of 0°.
(161) Besides, the hysteresis torque generating mechanism **60** generates the first hysteresis torque in the second range of torsion angle (of 1° to 4°) set to be greater than or equal to the first angle and be less than the second angle. Specifically, the hysteresis torque generating mechanism **60** does not generate a hysteresis torque in the course of transition from the torsion angle of 1° to the torsion angle of 4° but generates a hysteresis torque both in the course of reverse transition from the torsion angle of 4° to the torsion angle of 3° and in the course of reverse transition from the torsion angle of 2° to the torsion angle of 1°.
(162) Moreover, the hysteresis torque generating mechanism **60** generates the second hysteresis torque in the third range of torsion angle (of 4° to 5°) set to be greater than or equal to the second angle and be less than the third angle. Specifically, the hysteresis torque generating mechanism **60** generates a hysteresis torque both in the course of transition from the torsion angle of 4° to the torsion angle of 5° and in the course of reverse transition from the torsion angle of 5° to the torsion angle of 4°. It should be noted that the second hysteresis torque is greater in magnitude than the first hysteresis torque.
(163) Furthermore, the hysteresis torque generating mechanism **60** generates the third hysteresis torque in the fourth range of torsion angle (of 5° to 7°) set to be greater than or equal to the third angle and be less than or equal to the maximum angle. Specifically, the hysteresis torque generating mechanism **60** generates a hysteresis torque in the course of transition from the torsion angle of 5° to the torsion angle of 7° but does not generate a hysteresis torque in the course of reverse transition from the torsion angle of 7° to the torsion angle of 5°. It should be noted that the third hysteresis torque is lesser in magnitude than the second hysteresis torque. (b) The width of each support portion **301**, **302**, the width of each accommodation portion **401**, **402**, the length of each coil spring **51**, or numeric values specifically set for the torsion angle are exemplary only and are

not limited to the settings. (c) In the preferred embodiment described above, all the coil springs are set to be equal in stiffness. However, coil springs herein used can be different in stiffness from each other. (d) The number of accommodation portions, that of support portions, and that of coil springs are exemplary only and are not limited to those in the preferred embodiment described above. (e) In the preferred embodiment described above, the hysteresis torque generating mechanism **60** includes the first bushing **61**, the second bushing **62**, the cone spring **63**, and the friction plate **64**. However, the configuration of the hysteresis torque generating mechanism **60** is not limited to this. For example, the hysteresis torque generating mechanism **60** may not include the second bushing **62** and the cone spring **63**.

(164) Furthermore or alternatively, the hysteresis torque generating mechanism **60** may not include the friction plate **64**. In this case, what is only required is that, instead of the friction plate **64**, the first bushing **61** is provided with the pair of protruding portions **641**.

REFERENCE SIGNS LIST

(165) **1** Damper device **30** Input rotor **40** Hub flange **50** Elastic coupling part **60** Hysteresis torque generating mechanism

Claims

1. A damper device disposed between an engine and a drive unit, the damper device comprising: an input rotor disposed to be rotatable; an output rotor disposed to be rotatable relative to the input rotor; an elastic coupling part configured to elastically couple the input rotor and the output rotor; and a hysteresis torque generating mechanism configured to generate a hysteresis torque together with at least one of the input rotor or the output rotor therebetween, wherein the damper device is configured to be in a neutral condition when a torque is not transmitted thereto from both the engine and the drive unit, the damper device configured to be in a first torsional condition when the torque is transmitted thereto from the engine, the damper device configured to be in a second torsional condition when the torque is transmitted thereto from the drive unit, and the hysteresis torque generating mechanism is configured not to generate the hysteresis torque when the damper device is in the first torsional condition, the hysteresis torque generating mechanism configured not to generate the hysteresis torque in a first range of torsion angle when the damper device is in the second torsional condition, the first range of torsion angle set to be less than a first angle, wherein the hysteresis torque generating mechanism is configured to generate a first hysteresis torque in a second range of torsion angle when the damper device is in the second torsional condition, the second range of torsion angle set to be greater than or equal to the first angle and be less than a second angle, the hysteresis torque generating mechanism is configured to generate a second hysteresis torque in a third range of torsion angle when the damper device is in the second torsional condition, the second hysteresis torque greater in magnitude than the first hysteresis torque, the third range of torsion angle set to be greater than or equal to the second angle and be less than a third angle and the hysteresis torque generating mechanism is configured to generate the second hysteresis torque greater in magnitude than the first hysteresis torque in the third range and not to generate the hysteresis torque in a predetermined minute torsion angular range included in the third range when the damper device is in the second torsional condition.

2. The damper device according to claim 1, wherein the hysteresis torque generating mechanism is configured to generate a third hysteresis torque in a fourth range of torsion angle when the damper device is in the second torsional condition, the third hysteresis torque greater in magnitude than the second hysteresis torque, the fourth range of torsion angle set to be greater than or equal to the third angle and be less than or equal to a maximum angle.