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**Yanagawa et al.**

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(54) **WEBBING TAKE-UP DEVICE**

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*B60R 22/28* (2006.01)

(52) **U.S. Cl.**
CPC ........... ***B60R 22/38*** (2013.01); *B60R 2022/287* (2013.01)

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USPC ........ 242/374, 379.1, 383, 383.2, 383.5, 384, 242/394, 396.1, 396.4; 280/805–807; 297/471, 472, 476–478
See application file for complete search history.

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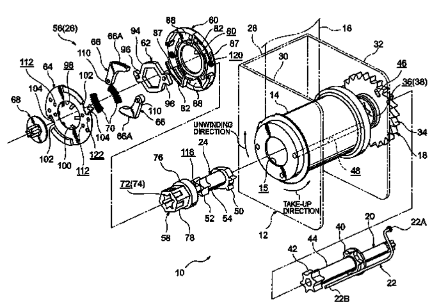
(57) **ABSTRACT**

A webbing take-up device that is both capable of promoting reductions in size and weight and capable of excellently maintaining coupling strength between a pawl member and a ring portion. A clutch plate and a lock ring of this webbing take-up device are coupled by plural teeth provided at the clutch plate meshing with plural teeth provided at the lock ring. This lock ring is specified to have a lower material strength than the clutch plate. A tooth height H**2** of the plural teeth of the lock ring is specified to be lower than a tooth height of the plural teeth of the clutch plate. Thus, when the lock ring and the clutch plate mesh, tooth tips of the plural teeth of the clutch plate come into contact with tooth bottoms of the plural teeth of the lock ring.

**6 Claims, 6 Drawing Sheets**



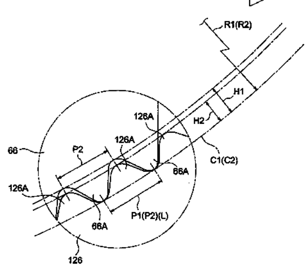



FIG. 1

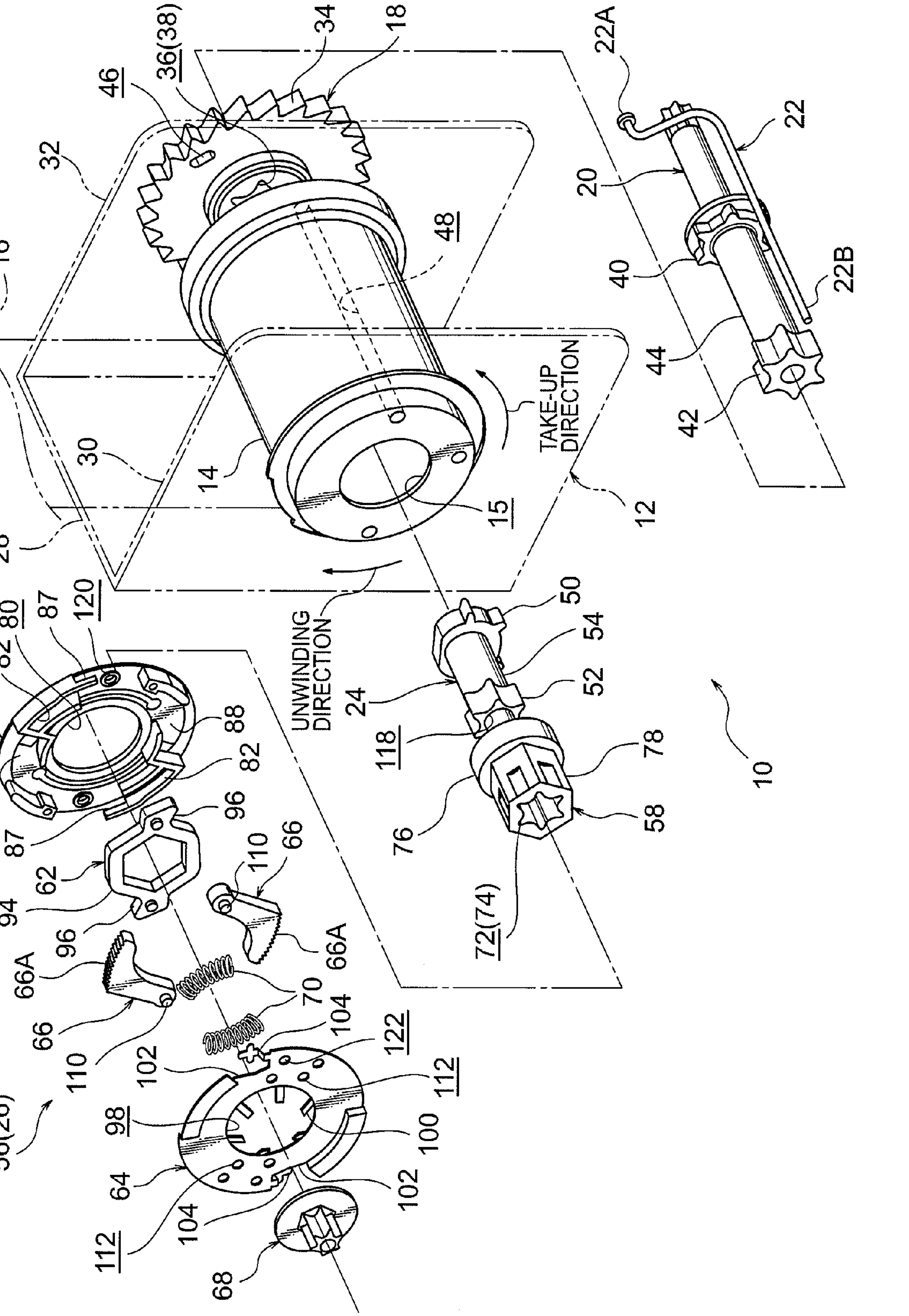

TAKE-UP DIRECTION
UNWINDING DIRECTION
10
12
14
15
16
18
20
22
22A
22B
24
28
30
32
34
36(38)
40
42
44
46
48
50
52
54
56(26)
58
60
62
64
66
66A
68
70
72(74)
76
78
80
82
87
88
94
96
98
100
102
104
110
112
118
120
122

FIG. 2

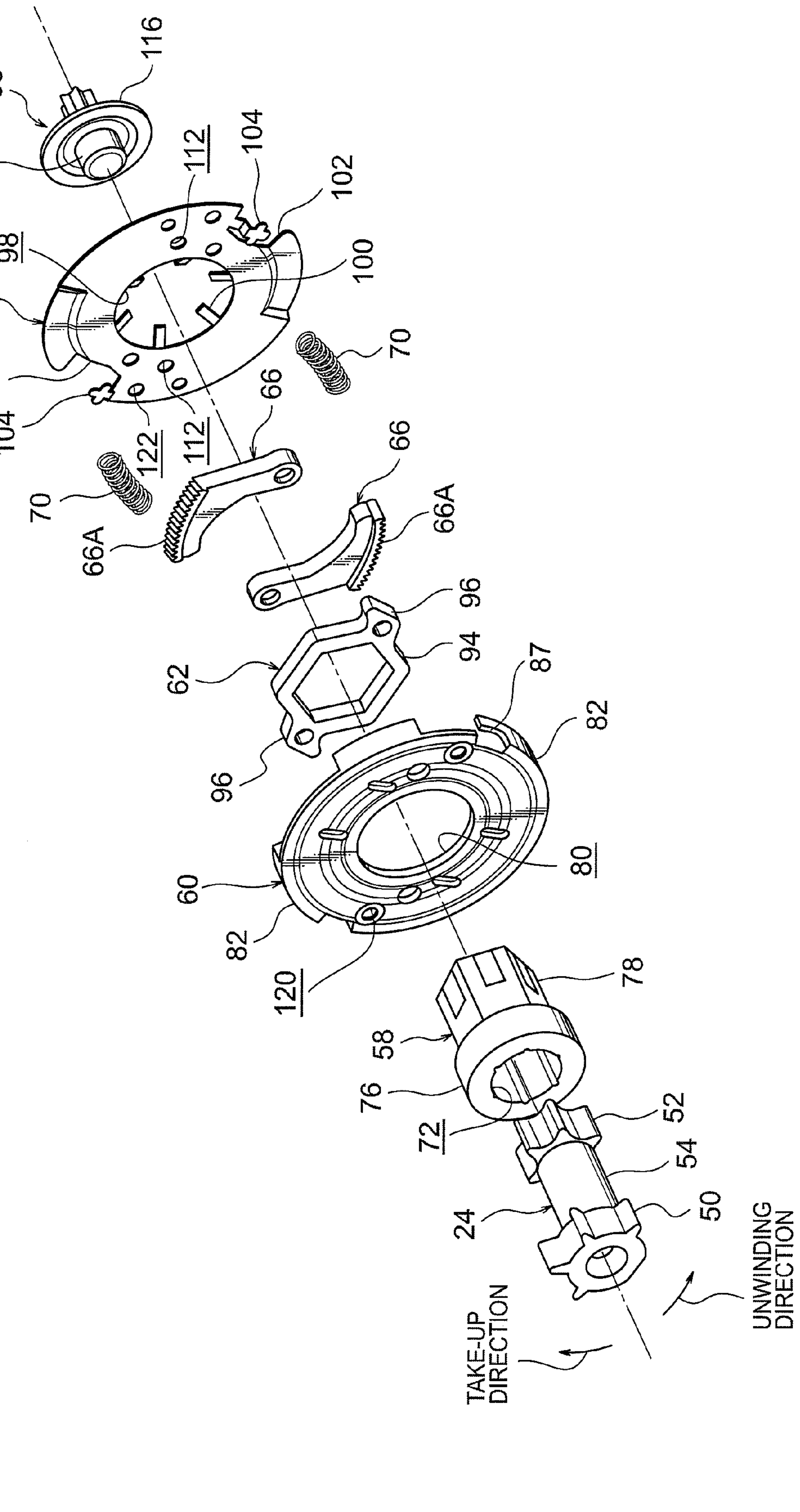

116
68
114
112
104
102
98
64
100
70
102
104
122
112
66
70
66A
66
66A
96
94
62
87
82
96
60
80
82
120
78
58
76
72
52
54
24
50
TAKE-UP DIRECTION
UNWINDING DIRECTION

FIG. 3

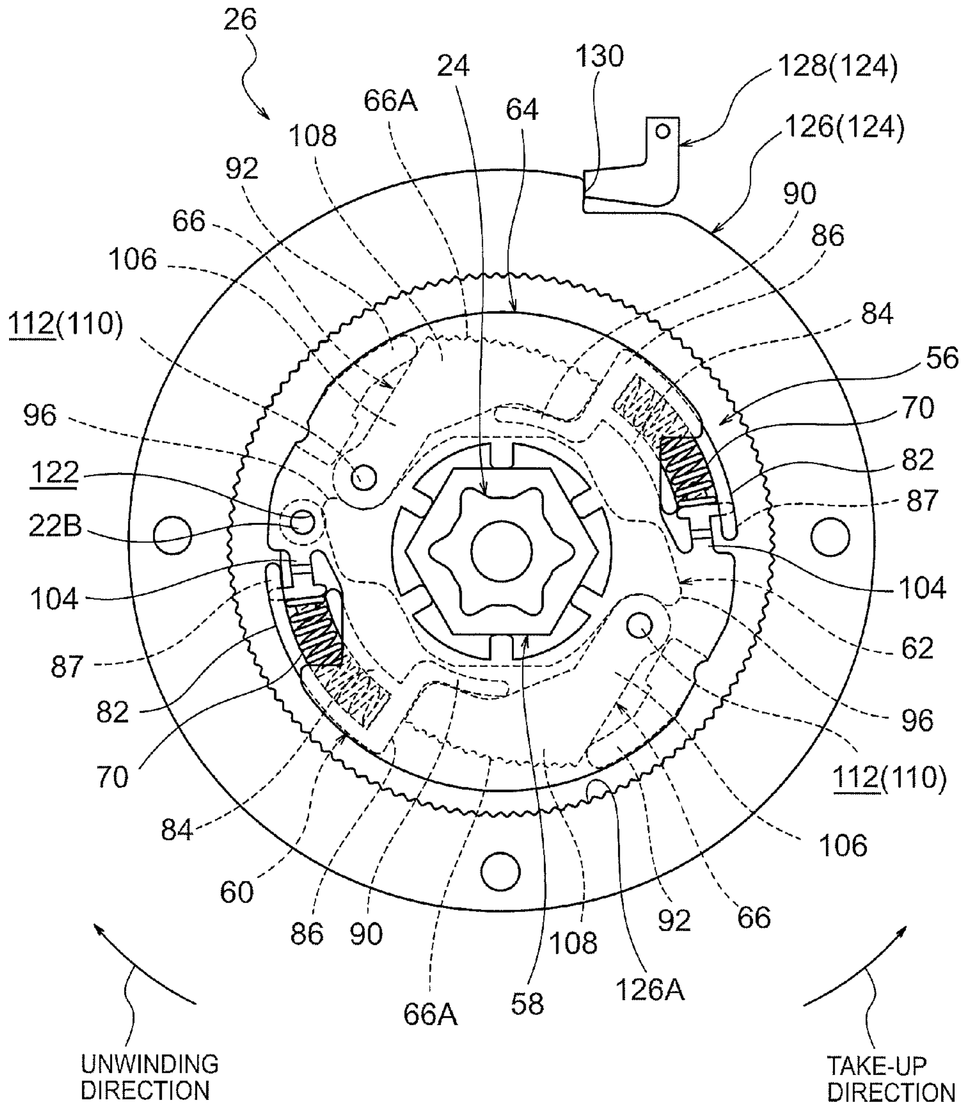

26
24
130
128(124)
66A
64
126(124)
108
92
90
66
86
106
84
112(110)
56
70
96
82
122
87
22B
104
62
96
112(110)
106
60
86
90
108
92
66
66A
58
126A
UNWINDING DIRECTION
TAKE-UP DIRECTION

FIG. 4

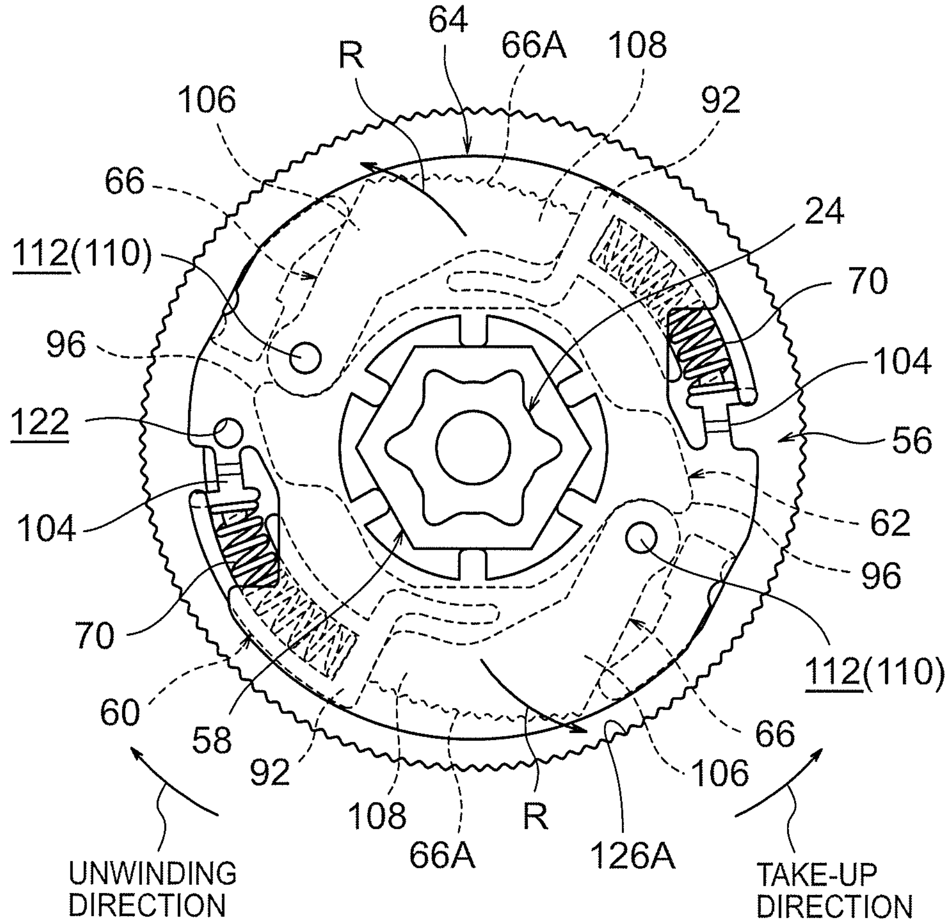

64
66A
108
R
106
92
66
24
112(110)
70
96
104
122
56
104
62
96
70
112(110)
60
58
92
66
106
108
R
66A
126A
UNWINDING DIRECTION
TAKE-UP DIRECTION

FIG. 5

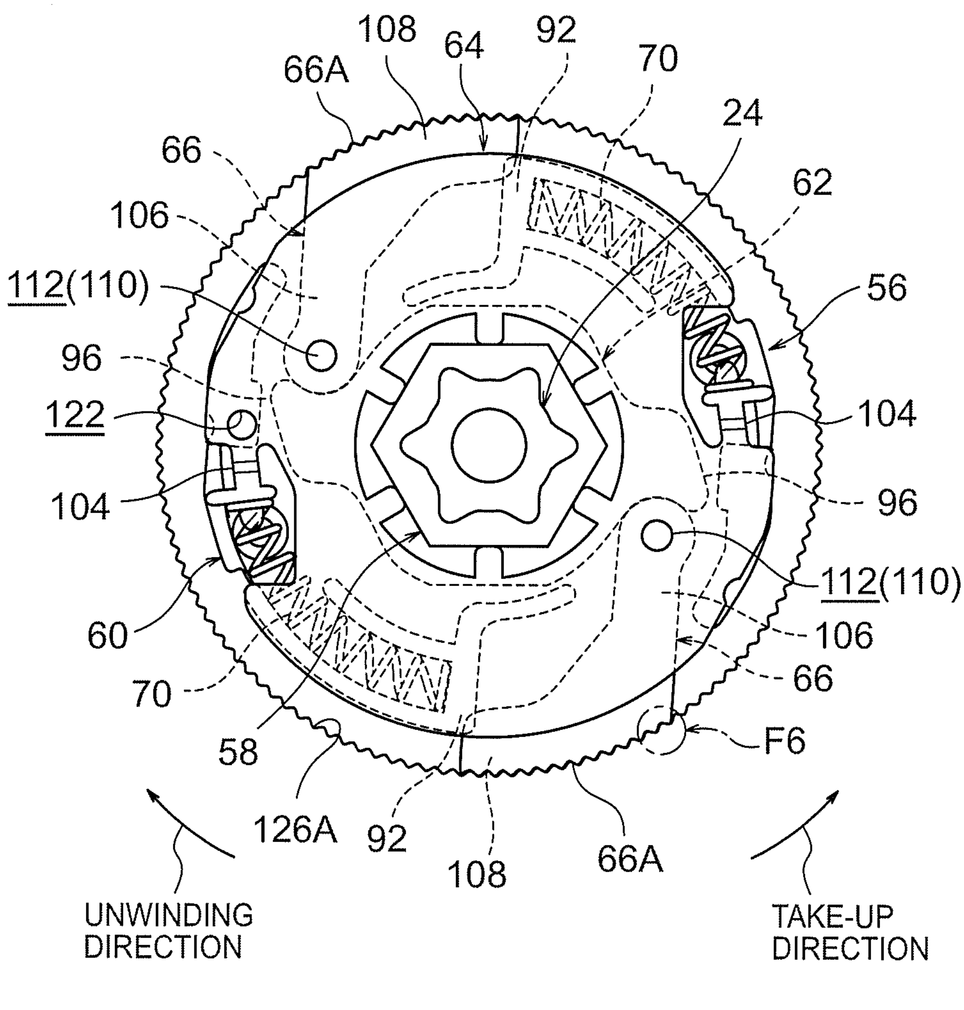
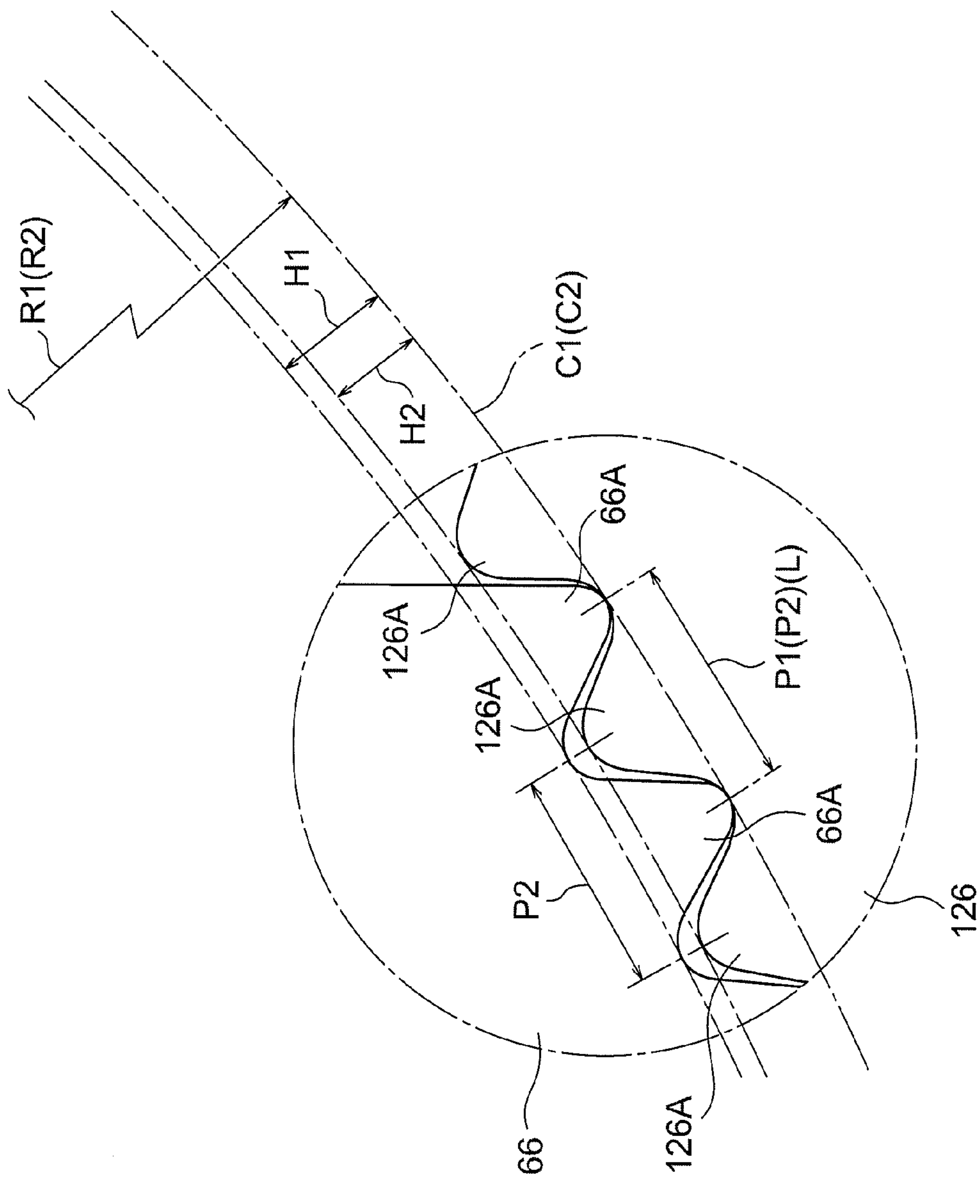

108
64
92
66A
70
24
66
62
106
112(110)
56
96
122
104
104
96
112(110)
60
106
70
66
58
F6
126A
92
108
66A
UNWINDING
DIRECTION
TAKE-UP
DIRECTION

FIG. 6



# WEBBING TAKE-UP DEVICE

## CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority under 35 USC 119 from Japanese Patent Application No. 2010-142883 filed on Jun. 23, 2010, the disclosure of which is incorporated by reference herein.

## BACKGROUND

1. Technical Field

The present invention relates to a webbing take-up device.

2. Related Art

Heretofore, a webbing take-up device has been known that is provided with: a torsion shaft that rotates integrally with a spool; and a load transmission mechanism that transmits a load to a frame that rotatably supports the spool (for example, see Japanese Patent Application Laid-Open (JP-A) No. 2007-84042).

In the webbing take-up device disclosed in JP-A No. 2007-84042, a second lock base is integrally joined to the torsion shaft, and a second lock pawl is turnably attached to this second lock base. A lock ring, which is supported at the frame, is disposed at the radial direction outer side of the second lock base, and a ratchet is formed at an inner periphery portion of the lock ring. When the second lock pawl turns toward the lock ring, a ratchet formed at a distal end of the second lock pawl meshes with the ratchet of the lock ring. Thus, the torsion shaft and the lock ring are coupled via the second lock pawl and suchlike, and a load inputted at the spool side is transmitted to the frame side.

In recent years, with more numerous functions and reduced weight in vehicles, reductions in size and weight of webbing take-up devices have been called for. Accordingly, it is necessary to achieve further reductions in size and weight of structural members of a load transmission mechanism as described above. However, it is also necessary to maintain excellent coupling strength between the second lock pawl (a pawl member) and the lock ring (a ring portion).

## SUMMARY

The present invention has been made in consideration of the problem described above, and an object of the present invention is to provide a webbing take-up device that is both capable of promoting reductions in size and weight and capable of excellently maintaining coupling strength between a pawl member and a ring portion.

In order to solve the problem described above, a first aspect of the present invention provides a webbing take-up device including:

a rotary member that rotates integrally with a spool; and

a load transmission mechanism that transmits a load between the spool and a frame that rotatably supports the spool,

wherein the load transmission mechanism comprises:

a ring portion provided at the frame side thereof, a plurality of teeth being provided at an inner periphery portion of the ring portion, which inner periphery portion is concentric with the rotary member; and

a pawl member disposed at the inner side of the ring portion, the pawl member being supported at the rotary member to be movable to a meshing position, at which a plurality of teeth provided at a distal end portion of the pawl member mesh with the plurality of teeth provided at the ring portion, and

wherein one of the ring portion or the pawl member has a material strength specified to be lower than the other, and a tooth height of the teeth provided at the one is specified to be lower than a tooth height of the teeth provided at the other.



In the webbing take-up device according to the first aspect, the plural teeth are provided at the inner periphery portion of the ring portion provided at the frame. The pawl member, which is supported at the rotary member that rotates integrally with the spool, is movable toward the meshing position at which the plural teeth provided at the distal end portion of the pawl member mesh with the plural teeth of the ring portion, and the ring portion and the pawl member are coupled by this meshing. Hence, loads (torques) may be transmitted between the spool and the frame.

In this webbing take-up device, one of the ring portion and the pawl member is specified to have a material strength lower than the other. In addition, the height of the teeth provided at the one (the member with the lower material strength) is specified to be lower than the height of the teeth provided at the other (the member with the higher material strength). Therefore, when meshed as described above, the tips of the teeth provided at the member with the higher material strength may be engaged with the bottoms of the teeth provided at the member with the lower material strength, and thus the material with the lower material strength receives a load from the member with the higher material strength at the tooth bottom side thereof, at which the cross-sectional areas of the teeth are larger. Therefore, a shear area of the member with the lower material strength is specified to be larger, and thus a coupling strength between the pawl member and the ring portion may be excellently maintained.

Therefore, a required coupling strength may be maintained with minimal sizes of the teeth of the pawl member and the ring portion. Therefore, reductions in size and weight of the pawl member and the ring portion may be promoted, and hence reductions in size and weight of the device may be promoted. Herein, the material strengths relating to the first aspect may be compared according to, for example, tensile strengths of the materials.

A webbing take-up device relating to a second aspect of the invention is the webbing take-up device according to the first aspect, in which, when the teeth mesh, tooth tips of the teeth provided at the other of the ring portion or the pawl member come into contact with tooth bottoms of the teeth provided at the one member.

In the webbing take-up device according to the second aspect, when the pawl member and the ring portion mesh, the tips of the teeth provided at the member with the higher material strength abut against the bottoms of the teeth provided at the member with the lower material strength. Therefore, the member with the lower material strength receives a load from the member with the higher material strength at the tooth bottoms, where the cross-sectional areas of the teeth are largest. Therefore, the shear area of the member with the lower material strength may be set to a maximum, and the coupling strength between the pawl member and the ring portion may be even more excellently maintained.

A webbing take-up device relating to a third aspect of the invention is the webbing take-up device according to the first aspect or the second aspect, in which the distal end portion of the pawl member is curved so as to match a curve of the inner periphery portion of the ring portion in a state in which the pawl member is disposed at the meshing position.

In the webbing take-up device according to the third aspect, the distal end portion of the pawl member is curved so as to match the curve of the inner periphery portion of the ring portion. Therefore, the plural teeth provided at the distal end portion of the pawl member may be simultaneously or substantially simultaneously meshed with the plural teeth provided at the ring portion. Thus, the tips of the plural teeth provided at the other of the pawl member and the ring portion (the member with the higher material strength) may come into contact with the bottoms of the plural teeth provided at the one (the member with the lower material strength) simultaneously or substantially simultaneously, and the coupling strength between the pawl member and the ring portion may be even more excellently maintained.

A webbing take-up device relating to a fourth aspect of the invention is the webbing take-up device according to the third aspect, in which a radius of curvature of a circular arc joining the tooth bottoms of the plurality of teeth provided at the one of the ring portion or the pawl member is specified to be equal to a radius of curvature of a circular arc joining the tooth tips of the plurality of teeth provided at the other of the ring portion or the pawl member.

In the webbing take-up device according to the fourth aspect, the radius of curvature of the circular arc joining the bottoms of the plural teeth provided at the one of the pawl member and the ring portion (the member with the lower material strength) is specified to be equal to the radius of curvature of the circular arc joining the tips of the plural teeth provided at the other (the member with the higher material strength). Therefore, when the pawl member and the ring portion are meshed (are coupled), the tips of the plural teeth provided at the member with the higher material strength may come into contact with the bottoms of the plural teeth provided at the member with the lower material strength simultaneously or substantially simultaneously. Therefore, the coupling strength between the pawl member and the ring portion may be realized at a maximum.

Herein, the term "equal" relating to the fourth aspect does not necessarily mean identical; operation and effect the same as the operation and effect described above may be obtained even if a dimensional error of the order of, for example, several hundredths of a millimeter arises in fabrication. In other words, it is sufficient if, in accordance with deformation of one or both of the pawl member and the ring portion during transmission of a load, most of the tips of the plural teeth provided at the member with the higher material strength come into contact with the bottoms of the plural teeth provided at the member with the lower material strength.

As described hereabove, a webbing take-up device relating to the present invention may both promote reductions in size and weight and excellently maintain coupling strength between a pawl member and a ring portion.

## BRIEF DESCRIPTION OF THE DRAWINGS

An exemplary embodiment of the present invention will be described in detail based on the following figures, wherein:

FIG. **1** is an exploded perspective diagram illustrating structure of principal portions of a webbing take-up device relating to an exemplary embodiment of the present invention;

FIG. **2** is an exploded perspective diagram illustrating partial structure of a load transmission mechanism, which is a structural member of the webbing take-up device illustrated in FIG. **1**;

FIG. **3** is a diagram of the load transmission member that is a structural member of the webbing take-up device illustrated in FIG. **1**, viewed from the opposite side thereof from a side at which a spool is disposed;

FIG. **4** is a diagram of the load transmission member illustrated in FIG. **3**, illustrating a state in which clutch plates thereof have started to turn toward a lock ring;

FIG. **5** is a diagram of the load transmission member illustrated in FIG. **3**, illustrating a state in which the clutch plates are meshed with the lock ring; and

FIG. **6** is a magnified diagram in which the portion marked with the symbol F**6** in FIG. **5** is magnified.

## DETAILED DESCRIPTION

Herebelow, an exemplary embodiment of the present invention is described on the basis of the attached drawings.

As illustrated in FIG. **1** and FIG. **2**, a webbing take-up device **10** relating to the exemplary embodiment of the present invention includes a frame **12**, a spool **14**, a webbing belt **16**, a lock gear **18**, a main torsion shaft **20**, a trigger wire **22**, a sub torsion shaft **24** that serves as a rotary member, and a load transmission mechanism **26**.

The frame **12** includes a plate-form back plate **28** fixed to a vehicle body. Leg pieces **30** and **32** extend substantially orthogonally from each of two width direction end portions of the back plate **28**. Thus, the frame **12** forms a substantial three-sided rectangular shape in plan view.

The spool **14** is formed in a circular tube shape with a penetrating hole **15** that penetrates therethrough in the axial direction. The spool **14** is disposed between the leg piece **30** and the leg piece **32** of the frame **12**. The spool **14** is disposed in a state in which the axial direction thereof is along the direction of opposition of the leg piece **30** and leg piece **32**. The spool **14** is rotatably supported at the frame **12** via the main torsion shaft **20**, the sub torsion shaft **24** and the like, which are described below.

The webbing belt **16** is applied to the body of a vehicle occupant, and a base end portion of the webbing belt **16**, which is one length direction end portion thereof, is anchored at the spool **14**. The spool **14** takes up the webbing belt **16** from the base end thereof by rotating in a winding direction, which is one direction of rotation, and accommodates the webbing belt **16**.

The lock gear **18** is disposed coaxially with the spool **14** at one axial direction end of the spool **14**. A gear portion **34** is formed at an outer periphery portion of the lock gear **18**. A penetrating hole **36** is formed at an axial center portion of the lock gear **18** and penetrates through the lock gear **18** in the axial direction thereof. A spline-form engaging object portion **38** is formed at an inner periphery portion of this penetrating hole.

The main torsion shaft **20** is disposed coaxially with the spool **14** and the lock gear **18**, and is inserted into both the penetrating hole **15** of the spool **14** and the penetrating hole **36** of the lock gear **18**. A spline-form first engaging portion **40** is formed at a length direction central portion of the main torsion shaft **20**, and a spline-form second engaging portion **42** is formed at a distal end portion of the main torsion shaft **20**.

The main torsion shaft **20** is integrally rotatably fixed to the lock gear **18** by the first engaging portion **40** being engaged with the engaging object portion **38** of the lock gear **18**. The main torsion shaft **20** is integrally rotatably fixed to the spool **14** by the first engaging portion **40** being engaged with an unillustrated engaging object portion that is formed at an axial direction central portion of an inner periphery portion of the spool **14**.

A portion of the main torsion shaft **20** between the first engaging portion **40** and the second engaging portion **42** is constituted to serve as a first energy-absorbing portion **44**, for absorbing energy introduced by tensing of the webbing belt **16**, as described below.

The trigger wire **22** extends along the main torsion shaft **20**. As illustrated in FIG. **1**, a base end portion **22**A of the trigger wire **22** is inserted into a hole portion **46**, which is formed at a position of the lock gear **18** at the radial direction outer side relative to the penetrating hole **36**, and is anchored at the lock gear **18**. A distal end from the base end portion of the trigger wire **22** is inserted into a hole portion **48**, which is formed in the spool **14** in parallel with the penetrating hole **15**, and a distal end portion **22**B of the trigger wire **22** protrudes from the spool **14** at the other axial direction end of the spool **14**.

The sub torsion shaft **24** is disposed to be coaxial with the main torsion shaft **20**. A base end side relative to a length direction central portion of the sub torsion shaft **24** is inserted into the penetrating hole **15** of the spool **14**. A distal end side relative to the length direction central portion of the sub torsion shaft **24** protrudes from the axial direction other end of the spool **14**.

A spline-form first engaging portion **50** is formed at a base end portion of the sub torsion shaft **24**, and a spline-form second engaging portion **52** is similarly formed at a distal end portion of the sub torsion shaft **24**. The first engaging portion **50** is engaged with an unillustrated engaging object portion formed at an axial direction central portion of the inner periphery portion of the spool **14**. Thus, the sub torsion shaft **24** is integrally rotatably fixed to the spool **14**.

A portion of the sub torsion shaft **24** between the first engaging portion **50** and the second engaging portion **52** is constituted to serve as a second energy-absorbing portion **54**, for absorbing energy introduced by tensing of the webbing belt **16** as described below.

The load transmission mechanism **26** includes a clutch mechanism **56**. The clutch mechanism **56** is provided with a sleeve **58**, a clutch guide **60**, a clutch base **62**, a clutch cover **64**, a pair of clutch plates **66** that serve as pawl members, a screw **68** and a pair of coil springs **70**.

The sleeve **58** is disposed coaxially with the sub torsion shaft **24**. A penetrating hole **72** is formed at an axial center portion of the sleeve **58**, and penetrates through the sleeve **58** in the axial direction. The sub torsion shaft **24** described above is inserted with play into this penetrating hole **72**. A spline-form engaging object portion **74** is formed at a distal end side of an inner periphery portion of this sleeve **58**. The sleeve **58** is integrally rotatably fixed to the sub torsion shaft **24** by the second engaging portion **52** being engaged with the engaging object portion **74**.

A base end side of the sleeve **58** is constituted as a support portion **76** with a circular profile. A distal end side of the sleeve **58** from the support portion **76** is constituted as a fitting portion **78** with a hexagonal profile.

The clutch guide **60** is a resin molded component, and is formed in an annular shape including a penetrating hole **80** that penetrates therethrough in the axial direction. The above-mentioned support portion **76** is fitted into this penetrating hole **80**. Thus, the clutch guide **60** is relatively rotatably supported at the sleeve **58**, and hence at the sub torsion shaft **24**.

As illustrated in FIG. **3**, a pair of coil spring accommodation portions **82**, which accommodate the coil springs **70**, are formed at two circumferential direction locations of the clutch guide **60**. The coil spring accommodation portions **82** are formed with point symmetry about the central portion of the clutch guide **60**. Each coil spring accommodation portion **82** is formed in a substantial three-sided rectangular shape including an outer wall portion **82**, an inner wall portion **84** and a connecting wall portion **86**. The outer wall portion **82** and inner wall portion **84** extend in the circumferential direction of the clutch guide **60**. The connecting wall portion **86** extends in the radial direction of the clutch guide **60** and connects end portions of the outer wall portion **82** and the inner wall portion **84**. An incision portion **87** is formed in an end portion of the outer wall portion **82** at the opposite end thereof from the end at which the connecting wall portion **86** is disposed. The incision portions **87** correspond with cross-shaped pawls **104** of the clutch cover **64**, which are described below.

A pair of clutch plate accommodation portions **88** are formed in the clutch guide **60**, adjacent to the coil spring accommodation portions **82**. The clutch plate accommodation portions **88** accommodate the clutch plates **66**. At each clutch plate accommodation portion **88**, a first support wall portion **90** and a second support wall portion **92** are formed. The first support wall portion **90** extends from the connecting wall portion **86** to the opposite side thereof from the side at which the inner wall portion **84** is disposed. The second support wall portion **92** is distant from the connecting wall portion **86** at the opposite side thereof from the side at which the outer wall portion **82** is disposed.

The clutch base **62** includes an annular fitting object portion **94** with a hexagonal shape. The fitting portion **78** is fitted (pushed into) the inner side of the fitting object portion **94**. Thus, the clutch base **62** is integrally rotatably fixed to the sleeve **58**. A pair of anchoring portions **96** is also formed at the clutch base **62**. The anchoring portions **96** protrude to the outer side from the fitting object portion **94**. These anchoring portions **96** are anchored with base end portions of arm portions **106** formed at the clutch plates **66**, which are described below.

The clutch cover **64** is disposed coaxially with the sleeve **58**, and is disposed to oppose the clutch guide **60** at the opposite side of the clutch guide **60** from the side thereof at which the spool **14** is disposed. The clutch cover **64** is formed in an annular shape with a penetrating hole **98** that penetrates therethrough in the axial direction. Fitting pawls **100** are plurally formed at an inner periphery portion of the clutch cover **64**. The fitting pawls **100** protrude to the radial direction inner side. The fitting portion **78** mentioned above is inserted into the penetrating hole **98**, and the plural fitting pawls **100** fit into the fitting portion **78**. Thus, the clutch cover **64** is integrally rotatably fixed to the sleeve **58**, and hence to the sub torsion shaft **24**.

Incision portions **102** are formed at two circumferential direction locations of the clutch cover **64**. Viewed in the axial direction, the incision portions **102** are formed in three-sided rectangular shapes that open to the radial direction outer side. A pair of the cross-shaped pawls **104** is also formed at the clutch cover **64**. The cross-shaped pawls **104** are formed so as to be disposed in the incision portions **102**, and the cross-shaped pawls **104** are formed with point symmetry about the central portion of the clutch cover **64**. By the cross-shaped pawls **104** being caught in the above-mentioned incision portions **87**, the clutch cover **64** and the clutch guide **60** are prevented from moving apart in the axial direction.

Each clutch plate **66** is disposed between the clutch cover **64** and the clutch guide **60**. The clutch plate **66** includes the arm portion **106** and a circular arc portion **108** that is formed at a distal end portion of the arm portion **106**.

A turning axle **110** is formed at a base end portion of each arm portion **106**. The turning axle **110** protrudes toward the clutch cover **64** and extends along the axial direction of the sub torsion shaft **24**. By this turning axle **110** being inserted into a hole portion **112** formed in the clutch cover **64**, the clutch plate **66** is turnably supported at the clutch cover **64**. At an outer periphery portion of the circular arc portion **108** (a distal end portion of the clutch plate **66**), a plural number of spur gear teeth **66**A are formed. These teeth **66**A are formed by, for example, linear knurling with a roller, pressing or the like, and are arranged side by side in the circumferential direction of the circular arc portion **108**.

The screw **68** includes a threaded portion **114** and a push portion **116** with a larger diameter than the threaded portion **114**. The threaded portion **114** engages by threading with a threaded hole **118** formed in a distal end portion of the sub torsion shaft **24**. Thus, the screw **68** is fixed to the distal end portion of the sub torsion shaft **24**. When the screw **68** has thus been fixed to the distal end portion of the sub torsion shaft **24**, the push portion **116** abuts against a distal end portion of the sleeve **58**. Hence, movement of the sleeve **58** in the direction of disengaging from the sub torsion shaft **24** is restricted.

Hole portions **120** and **122** are formed in the clutch guide **60** and the clutch cover **64**, respectively. The distal end portion **22**B of the trigger wire **22** is inserted into each of the hole portions **120** and **122**. Thus, relative rotation of the clutch guide **60** with respect to the spool **14** and the clutch cover **64** is restricted.

In the state in which relative rotation of the clutch guide **60** with respect to the spool **14** and the clutch cover **64** is restricted, each cross-shaped pawl **104** is disposed in the vicinity of the opening portion of the coil spring accommodation portion **82** that is formed substantially in a three-sided rectangular shape. One axial direction end portion of the coil spring **70** accommodated in the coil spring accommodation portion **82** is anchored at the cross-shaped pawl **104**, and the other axial direction end portion of the coil spring **70** is anchored at the connecting wall portion **86**.

In this state, the distance between the cross-shaped pawl **104** and the connecting wall portion **86** is shorter than the total length of the coil spring **70** in a relaxed state. Thus, each coil spring **70** is in a compressed state. Therefore, urging force is acting on the clutch guide **60** in the take-up direction.

Meanwhile, in this state, a distance between each hole portion **112** of the clutch cover **64** (the turning axle **110** of each clutch plate **66**) and the connecting wall portion **86** is maintained at a sufficient distance, and each clutch plate **66** is accommodated in the clutch plate accommodation portion **88** such that the plural teeth **66**A are kept to the inner side relative to an outer periphery portion of the clutch guide **60**. Furthermore, in this state each connecting wall portion **86** abuts against a distal end of the circular arc portion **108**.

As illustrated in FIG. **3**, this load transmission mechanism **26** includes a switching mechanism **124** in addition to the clutch mechanism **56** described above. The switching mechanism **124** includes a lock ring **126** that serves as a ring portion, an engaging member **128**, and an unillustrated gas generator. The lock ring **126** is formed in a ring shape and is disposed to be coaxial with the clutch mechanism **56** at the radial direction outer side of the clutch mechanism **56**. The lock ring **126** is attached to the leg piece **30** of the frame **12** to be relatively rotatable with respect thereto. A plural number of spur gear teeth **126**A are formed at an inner periphery portion of the lock ring **126**. The teeth **126**A are formed by, for example, linear knurling with a roller, pressing or the like, and are arranged side by side in the circumferential direction of the lock ring **126**. The teeth **126**A are formed to be engageable (meshable) with the plural teeth **66**A of the clutch plates **66**.

The engaging member **128** engages with a recess portion **130** formed in an outer periphery portion of the lock ring **126**. Thus, relative rotation of the lock ring **126** with respect to the frame **12** is restricted. When the unillustrated gas generator provided at the switching mechanism **124** receives an operation signal from an unillustrated electronic control unit (ECU) and operates, the engaging member **128** is rotated, and the state of engagement of the recess portion **130** of the lock ring **126** with the engaging member **128** is released. Therefore, the restriction on relative rotation of the lock ring **126** with respect to the frame **12** is released.

The webbing take-up device **10** relating to the present exemplary embodiment is configured to operate as follows.

In a state in which the webbing belt **16** has been unwound from the spool **14** and applied to the body of an occupant of the vehicle, if, for example, the vehicle goes into a state of rapid deceleration and an unillustrated lock mechanism operates, an unillustrated lock member provided at this lock mechanism is engaged with the gear portion **34** of the lock gear **18**, and rotation of the lock gear **18** is restricted.

As a result, rotation of the spool **14**, which is joined to the lock gear **18** via the main torsion shaft **20**, in the unwinding direction is restricted, and unwinding of the webbing belt **16** from the spool **14** is restricted. Therefore, the body of the occupant, which is acting to move forward, is restrained by the webbing belt **16**.

In the state in which rotation of the lock gear **18** is restricted, if the body of the occupant tenses the webbing belt **16** with a larger force, and a rotary force on the spool **14** in the unwinding direction due to the tension force exceeds a mechanical strength of the first energy-absorbing portion **44**, the first energy-absorbing portion **44** twists and the spool **14** rotates in the unwinding direction by an amount corresponding to the twisting.

Accordingly, the webbing belt **16** unwinds from the spool **14** by the amount of rotation of the spool **14** in the unwinding direction. Thus, a load (burden) from the webbing belt **16** on a chest area of the occupant is moderated, and the energy introduced by the tensing of the webbing belt **16** is absorbed in an amount corresponding to the twisting.

The spool **14** rotating in the unwinding direction with respect to the lock gear **18** as described above conversely means that the lock gear **18** is relatively rotating in the take-up direction with respect to the spool **14**. Thus, when the lock gear **18** relatively rotates in the take-up direction with respect to the spool **14**, the base end portion of the trigger wire **22** is moved in the circumferential direction of the main torsion shaft **20** while the distal end of the trigger wire **22** from the base end portion stays inserted in the spool **14**. Therefore, the distal end of the trigger wire **22** from the base end portion is pulled toward the lock gear **18** relative to the hole portion **48**.

As a result, the distal end portion **22**B of the trigger wire **22** is disengaged from the hole portion **120** of the clutch guide **60** and the hole portion **122** of the clutch cover **64**, and the restriction on relative rotation of the clutch guide **60** with respect to the spool **14** and the clutch cover **64** is released.

The clutch guide **60** relatively rotates in the take-up direction with respect to the clutch cover **64**, due to the urging force of the coil springs **70**, the distance between each hole portion **112** of the clutch cover **64** (the turning axle **110** of each clutch plate **66**) and the connecting wall portion **86** is reduced, and the distal end of the circular arc portion **108** is pushed (guided) in a tangential direction of the clutch guide **60**. Accordingly, the clutch plate **66** is turned toward the lock ring **126** (the direction of arrow R in FIG. **4**), and the plural teeth **66**A of the clutch plate **66** mesh with the plural teeth **126**A of the lock ring **126** (the state illustrated in FIG. **5**). Thus, the clutch plates **66** and the lock ring **126** are coupled. At this time, the clutch plates **66** are pressed against the lock ring **126** by the anchoring portions **96** formed at the clutch base **62** pressing the base end portions of the arm portions **106** in the unwinding direction, and the state of coupling between the clutch plates **66** and the lock ring **126** is sustained. Therefore, rotation of the clutch base **62**, and hence rotation of the sleeve **58**, with respect to the lock ring **126** is restricted. In this state, a rotary force in the unwinding direction that is inputted to the spool **14** is transmitted to the frame **12** via the sub torsion shaft **24**, the sleeve **58**, the clutch base **62**, the clutch plates **66**, the lock ring **126** and the engaging member **128**.

Then, in the state in which rotation of the sleeve **58** is restricted, if the body of the occupant tenses the webbing belt **16** with an even larger force, and a rotary force of the spool **14** in the unwinding direction due to this tension force exceeds a mechanical strength of the second energy-absorbing portion **54**, the second energy-absorbing portion **54** twists and the spool **14** rotates in the unwinding direction by an amount corresponding to this twisting.

Accordingly, the webbing belt **16** unwinds from the spool **14** by the amount of rotation of the spool **14** in the unwinding direction. Thus, the load (burden) from the webbing belt **16** on the chest area of the occupant is moderated, and the energy introduced by the tensing of the webbing belt **16** is absorbed in an amount corresponding to the twisting.

Alternatively, if, before operation of the unillustrated lock mechanism described above, the ECU determines that a body size of the occupant is less than a pre-specified reference value on the basis of a signal from an unillustrated body size detector, the unillustrated gas generator is operated by the ECU.

When the gas generator operates, the engaging member **128** is turned and the state of coupling between the engaging member **128** and the recess portion **130** of the lock ring **126** is cancelled. Therefore, when the clutch mechanism **56** operates in this case, rotary force of the spool **14** is transmitted to the lock ring **126** via the clutch mechanism **56**, and the lock ring **126** is turned in the unwinding direction together with the spool **14**. Therefore, in this state, there is twisting of the first energy-absorbing portion **44** but there is no twisting of the second energy-absorbing portion **54**, and there is no absorption of energy by the second energy-absorbing portion **54**.

That is, this webbing take-up device **10** may, in accordance with the size of an occupant, selectively switch between a mode in which energy is absorbed by the second energy-absorbing portion **54** and a mode in which energy is not absorbed by the second energy-absorbing portion **54**.

Next, principal portions of the present exemplary embodiment are described.

In FIG. **6**, the state in which each clutch plate **66** described above is disposed at the position of meshing with the lock ring **126** is illustrated in a magnified diagram in which a portion of FIG. **5** (the portion denoted with the indication F**6**) is magnified. As illustrated in FIG. **6**, the plural teeth **66**A provided at the clutch plate **66** and the plural teeth **126**A provided at the lock ring **126** form substantially triangular shapes as viewed in the axial direction of the lock ring **126**, and the tooth tips and tooth bottoms are smoothly connected by curves. These teeth **66**A and **126**A are formed such that cross sectional areas thereof increase from the tooth tip sides to the tooth bottom sides.

In the present exemplary embodiment, a pitch P**1** of the plural teeth **66**A provided at the clutch plate **66** and a pitch P**2** of the plural teeth **126**A provided at the lock ring **126** are specified to be equal (P**1**=P**2**). Further in the present exemplary embodiment, as illustrated in FIG. **5**, tooth tip portions of the clutch plate **66** (an outer periphery portion of the circular arc portion **108**) are curvedly formed so as to match



the inner periphery portion of the lock ring **126** in the state in which the clutch plate **66** is meshed with the lock ring **126**. More specifically, in the present exemplary embodiment, as illustrated in FIG. **6**, a radius of curvature R**1** of a circular arc C**1** that joins the tooth tips of the plural teeth **66**A provided at the clutch plate **66** and a radius of curvature R**2** of a circular arc C**2** that joins the tooth bottoms of the plural teeth **126**A provided at the lock ring **126** are specified to be equal (R**1**=R**2**).

In the present exemplary embodiment, a tooth height H**2** of the teeth **126**A of the lock ring **126** is specified to be lower than a tooth height H**1** of the teeth **66**A of the clutch plate **66**. Therefore, in the state in which the plural teeth **66**A provided at the clutch plates **66** are meshed with the plural teeth **126**A provided at the lock ring **126**, gaps are maintained between the tooth tips of the plural teeth **126**A and the tooth bottoms of the plural teeth **66**A, whereas the tooth tips of the plural teeth **66**A abut against (touch) the tooth bottoms of the plural teeth **126**A.

Furthermore, in the present exemplary embodiment, the clutch plates **66** are formed of, for example, a steel-based material, while the lock ring **126** is formed of for example, an aluminium-based material. Thus, a material strength of the lock ring **126** is specified to be lower than a material strength of the clutch plates **66**.

Next, operation and effects of the present exemplary embodiment are described.

According to the webbing take-up device **10** with the above structure, as described above, in the mode in which energy is absorbed by the second energy-absorbing portion **54** of the sub torsion shaft **24**, the teeth **66**A of the clutch plates **66** mesh with the teeth **126**A of the lock ring **126** (see FIG. **5**) in the state in which relative rotation of the lock ring **126** with respect to the frame **12** is restricted. Therefore, the clutch plates **66** and the lock ring **126** are coupled and rotation of the clutch base **62** with respect to the lock ring **126** is restricted.

In this state, when the webbing belt **16** is tensed by an excessive load, rotary force in the unwinding direction acts on the spool **14**, the sub torsion shaft **24**, the sleeve **58** and the clutch base **62**, and the arm portion **106** of each clutch plate **66** is pushed in the unwinding direction by the anchoring portion **96** of the clutch base **62**. Thus, the clutch plates **66** are pushed against the lock ring **126**, and a coupling strength between the clutch plates **66** and the lock ring **126** is sustained. At this time, the rotary force in the unwinding direction that is inputted to the clutch plates **66** from the clutch base **62** is supported by shear strength of the plural teeth **66**A of the clutch plates **66** and the plural teeth **126**A of the lock ring **126**. Therefore, rotation of the sleeve **58** in the unwinding direction is firmly restricted. In this state, if the webbing belt **16** is tensed by an even larger force, the second energy-absorbing portion **54** of the sub torsion shaft **24** is twisted by the rotary force of the spool **14** in the unwinding direction due to this tension force, and the spool **14** rotates in the unwinding direction by an amount corresponding to this twisting. Thus, energy introduced by the tensing of the webbing belt **16** is absorbed.

Now, in this exemplary embodiment, the lock ring **126** described above is specified to have a lower material strength than the clutch plates **66**. Further, in this exemplary embodiment, the tooth height H**2** of the teeth **126**A provided at the lock ring **126** (the member with the lower material strength) is specified to be lower than the tooth height H**1** of the teeth **66**A provided at each clutch plate **66** (the member with the higher material strength). Therefore, when the clutch plates **66** and the lock ring **126** mesh, the tooth tips of the teeth **66**A provided at the clutch plates **66** come into contact with the tooth bottoms of the teeth **126**A provided at the lock ring **126**.

Therefore, the lock ring **126** receives a load in the unwinding direction from the clutch plates **66** at the tooth bottoms of the teeth **126**A, at which the cross-sectional areas thereof are larger. In other words, because shearing forces are applied along the circular arc C**2** joining the tooth bottoms of the plural teeth **126**A of the lock ring **126**, a length L of shearing portions of the teeth **126**A may be kept at a maximum (L≈P**1**=P**2**). Thus, a shearing area of the lock ring **126** may be set to a maximum, and therefore coupling strength (torque transmission strength) between the clutch plates **66** and the lock ring **126** may be excellently maintained.

Therefore, a required coupling strength between the clutch plates **66** and the lock ring **126** may be maintained with minimal sizes of the teeth **66**A and **126**A. Therefore, reductions in size and weight of the clutch plates **66** and the lock ring **126** may be promoted, and hence reductions in size and weight of the device may be promoted.

Further, in this exemplary embodiment the radius of curvature R**1** of the circular arc C**1** joining the tooth tips of the plural teeth **66**A provided at the clutch plate **66** and the radius of curvature R**2** of the circular arc C**2** joining the tooth bottoms of the plural teeth **126**A provided at the lock ring **126** are specified to be equal. Therefore, when the clutch plates **66** and the lock ring **126** mesh (when the same couple), the tooth tips of the plural teeth **66**A provided at each clutch plate **66** (the member with the higher material strength) may simultaneously come into contact with the tooth bottoms of the plural teeth **126**A provided at the lock ring **126** (the member with the lower material strength). Thus, the coupling strength between the clutch plates **66** and the lock ring **126** may be realized at a maximum.

As described in detail hereabove, according to the exemplary embodiment of the present invention, reductions in size and weight may be promoted and coupling strength between the clutch plates **66** and the lock ring **126** may be excellently maintained.

The exemplary embodiment described above has a configuration in which the lock ring **126** that serves as the ring portion is formed separately from the frame **12** and is rotatably attached to (supported at) the leg piece **30** of the frame **12**. However, the inventions relating to the first to fourth aspects are not limited this; configurations are possible in which the ring portion is provided integrally with the frame.

Further, the above exemplary embodiment has a configuration in which the plural teeth **66**A of the clutch plate **66** and the plural teeth **126**A of the lock ring **126** are formed by knurling or the like. However, the inventions relating to the first to fourth aspects are not limited this; methods of machining the plural teeth may be suitably amended.

The above exemplary embodiment has a configuration in which the material strength of the lock ring **126** that serves as the ring portion is specified to be lower than the material strength of the clutch plates **66** that serve as the pawl member. However, the inventions relating to the first to fourth aspects are not limited thus; configurations are possible in which the material strength of the pawl member is specified to be lower than the material strength of the ring portion.

The above exemplary embodiment has a configuration in which the radius of curvature R**1** of the circular arc C**1** joining the tooth tips of the plural teeth **66**A provided at the clutch plate **66** and the radius of curvature R**2** of the circular arc C**2** joining the tooth bottoms of the plural teeth **126**A provided at the lock ring **126** are specified to be equal. However, the inventions relating to the first to third aspects are not limited thus; configurations are possible in which the radiuses of curvature R**1** and R**2** are different.

The above exemplary embodiment has a configuration in which, when each clutch plate **66** (the pawl member) meshes with the lock ring **126** (the ring portion), the tooth tips of the teeth **66**A provided at the clutch plate **66** come into contact with the tooth bottoms of the teeth **126**A provided at the lock ring **126**. However, the invention relating to the first aspect is not limited this. It is sufficient that the height of the teeth provided at the member with the lower material strength, of the pawl member and the ring portion, is specified to be lower than the height of the teeth provided at the member with the higher material strength. In such a case, the tooth tips of the teeth provided at the member with the higher material strength may be engaged with the tooth bottoms of the teeth provided at the member with the lower material strength when the pawl member and the ring portion mesh. Therefore, the member with the lower material strength receives a load from the member with the higher material strength at the tooth bottoms, at which the cross-sectional areas of the teeth are larger. Thus, a shear area of the member with the lower material strength may be specified to be larger, and coupling strength between the pawl member and the ring portion may be excellently maintained.

The above exemplary embodiment has been described for a case in which the present invention is applied to the load transmission mechanism **26** that transmits a load between the sub torsion shaft **24** and the frame **12**. However, the present invention may be applied to a load transmission mechanism that transmits a load between a rotary member that rotates integrally with a spool and a frame.

In other respects, the present invention may be embodied with various modifications in a technical scope not departing from the spirit of the invention. It will be clear that the scope of rights of the present invention is not to be limited to the above exemplary embodiment.

What is claimed is:

**1**. A webbing take-up device comprising:

a rotary member that rotates integrally with a spool; and

a load transmission mechanism that transmits a load between the spool and a frame that rotatably supports the spool,

wherein the load transmission mechanism comprises:

a ring portion provided at the frame side thereof, a plurality of teeth being provided at an inner periphery portion of the ring portion, which inner periphery portion is concentric with the rotary member; and

a pawl member disposed at the inner side of the ring portion, the pawl member being supported at the rotary member to be movable to a meshing position, at which a plurality of teeth provided at a distal end portion of the pawl member mesh with the plurality of teeth provided at the ring portion, and

wherein the pawl member teeth have a material strength specified to be higher than the material strength of the ring portion teeth, and a tooth height of the teeth provided at the one is specified to be lower than a tooth height of the teeth provided at the other, and all of the ring portion teeth have a same shape, and all of the pawl member teeth have a same shape.

**2**. The webbing take-up device according to claim **1**, wherein a tooth height of the teeth provided at the ring portion is specified to be lower than a tooth height of the teeth provided at the pawl member, so that when the teeth mesh, tooth tips of the higher strength, higher teeth provided at the pawl member come into contact with tooth bottoms of the lower strength, lower teeth provided at the ring portion.

**3**. The webbing take-up device according to claim **2**, wherein the distal end portion of the pawl member is curved so as to match a curve of the inner periphery portion of the ring portion in a state in which the pawl member is disposed at the meshing position.

**4**. The webbing take-up device according to claim **3**, wherein a radius of curvature of a circular arc joining the tooth bottoms of the plurality of teeth provided at the one of the ring portion or the pawl member is specified to be equal to a radius of curvature of a circular arc joining the tooth tips of the plurality of teeth provided at the other of the ring portion or the pawl member.

**5**. The webbing take-up device according to claim **1**, wherein the distal end portion of the pawl member is curved so as to match a curve of the inner periphery portion of the ring portion in a state in which the pawl member is disposed at the meshing position.

**6**. The webbing take-up device according to claim **5**, wherein a radius of curvature of a circular arc joining the tooth bottoms of the plurality of teeth provided at the one of the ring portion or the pawl member is specified to be equal to a radius of curvature of a circular arc joining the tooth tips of the plurality of teeth provided at the other of the ring portion or the pawl member.

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