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(71) Applicant: **PIAGGIO & C. S.P.A.** [IT/IT]; Viale Rinaldo Piaggio, 25, 56025 Pontedera, Pisa (IT).

(72) Inventors: **NESTI, Paolo**; c/o Piaggio & C. S.P.A., Viale Rinaldo Piaggio, 25, 56025 Pontedera, Pisa (IT). **MARIOTTI, Walter**; c/o Piaggio & C. S.P.A., Viale Rinaldo Piaggio, 25, 56025 Pontedera, Pisa (IT). **FRESCHI,**

Giacomo; c/o Piaggio & C. S.P.A., Viale Rinaldo Piaggio, 25, 56025 Pontedera, Pisa (IT).

(74) Agent: **PULIERI, Gianluca Antonio** et al.; c/o Jacobacci & Partners S.P.A., Via Berchet, 9, 35131 Padova (IT).

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(54) Title: CONTINUOUS VARIATION TRANSMISSION DEVICE WITH ADJUSTMENT DEVICE

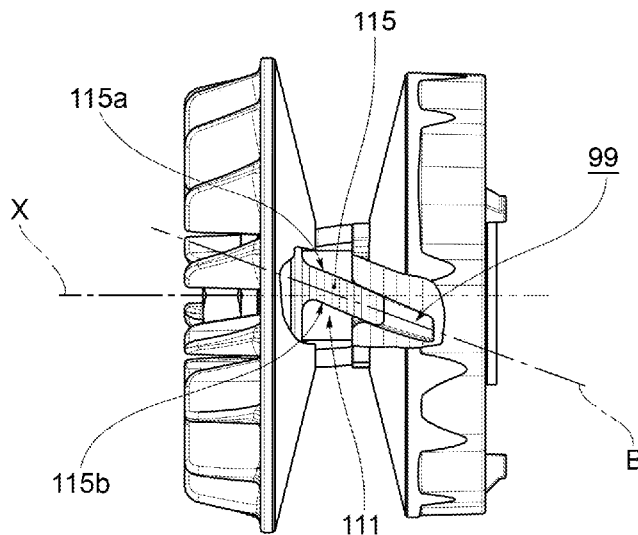


FIG.2

(57) Abstract: A continuous variation transmission device (1) for a motorcycle with two/three/four- wheels comprises a drive pulley (4) provided with a movable bushing (9), a fixed bushing (11) and a cam system (95,111;97,113) between the fixed bushing (11) and the movable bushing (9). The cam system has a driven cam portion (95) of the movable bushing (9) and a drive cam portion (111) of the fixed bushing (11). The driven cam portion (95) comprises at least one recess (99) and the drive cam portion (111) comprises at least one tooth (115) or vice versa. The recess (99) and the tooth (115) have respective sides (99a, 99b; 115a, 115b) which form a shape coupling with each other to guide the relative movement between said movable bushing (9) and said fixed bushing (11).



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MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
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DESCRIPTION**“CONTINUOUS VARIATION TRANSMISSION DEVICE WITH ADJUSTMENT
DEVICE”**

5 The present invention relates to a transmission system, in particular a transmission system for motorcycles of the continuous variation type, provided with a device for varying the change curve.

The term “motorcycles” in this document means a tilting or non-tilting two, three or four-wheel vehicle, such as the vehicle Vespa®, Ape® o MP3® sold by the Applicant.

10 The expandable-pulley and V-belt continuously variable gearbox (or CVT, Continuously Variable Transmission) is a type of automatic gearbox for vehicles in which the gear ratio may continuously vary between two limit values. The continuously variable gearbox is commonly used in vehicles with small and medium-sized cylinder capacity, in particular in motor scooters.

15 The variation of the gear ratio in a traditional CVT occurs by varying the winding diameters of the belt on two pulleys, one of which is motor and the other is driven, and at least one of which has the possibility of juxtaposing or moving away the two parts or semi-pulleys it is formed by.

Typically, the drive pulley comprises a speed controller made with centrifugal masses, generally referred to as “rollers”, aiming at axially juxtaposing the respective
20 semi-pulleys, passing from the low gear condition (distant semi-pulleys) to the high gear condition (juxtaposed semi-pulleys).

Therefore, once the physical and geometrical features of the system are set in a traditional CVT, the gear ratio depends on the number of engine revolutions and on
25 the torque required.

The need exists to provide a CVT transmission system in which the change curve may be significantly modified according to the torque need required by the driver.

In other words, the need exists to provide a CVT transmission system which for example, if the driver suddenly requests more or less torque starting from a given
30 condition, adapts and meets such a request.

International Applications WO-A1-2017/098378, WO-A1-2017/098379, WO-A1-2017/098381 and International Application PCT/IB2017/055668 to the Applicant, already deal with such a need and disclose related solutions.

However, the solutions of the prior art have shown the drawback of a sometimes

significant noisiness. It is the object of the present invention to improve the known solutions by overcoming the drawback mentioned above.

Such an object is achieved by a transmission device manufactured according to claim 1. The dependent claims describe constructional variants.

- 5 The features and advantages of the transmission device according to the invention will become apparent from the following description, given by way of non-limiting example, according to the accompanying drawings, in which:
- figure 1 shows a longitudinal cross-section of a transmission device according to one embodiment of the present invention;
 - 10 - figure 2 depicts a partial sectional view of a pulley of the transmission device in figure 1, in a low gear configuration;
 - figure 3 depicts an assembly in the low gear configuration comprising a fixed bushing and a movable bushing of the device according to the invention, according to one embodiment;
 - 15 - figure 4 depicts a partial sectional view of the pulley in figure 2, in a high gear configuration;
 - figure 5 depicts the fixed bushing-movable bushing assembly in figure 3, in the high gear configuration;
 - figure 6 shows a sectional view of the assembly in figure 5, according to a sectional
20 plane orthogonal to the rotation axis;
 - figure 7 depicts an enlargement of an area of the cross-section in figure 6; and
 - figure 8 is a graph depicting the engine revolutions of a drive pulley and of a driven pulley, for a traditional CVT system and for a CVT system according to the present invention.
- 25 With reference to the accompanying drawings, 1 indicates a continuous variation transmission device as a whole, configured to preferably be applied on a two/three-wheel motorcycle, engaged with a drive shaft 2 which defines a rotation axis X.
- The transmission device 1 comprises a first drive pulley 4, rotationally operated by the drive shaft 2 about said rotation axis X, and a second driven pulley (not depicted),
30 which are connected to each other by a V-belt 6.
- The drive pulley 4 consists of a first half-pulley 8 and a second half-pulley 10 provided with facing active surfaces 8a, 10a, respectively, having the shape of a truncated cone, sliding along said rotation axis X so as to juxtapose and move away the active surfaces 8a, 10a, and rotationally integral with each other.

The first half-pulley 8 in particular comprises

- a movable bushing 9, which carries the active surface 8a and provides a bushing 8b which is coaxial to the drive shaft 2, and

- a speed controller 12 comprising a container 14 supported by the movable bushing 9 and provided with a shaped seat 16 and a plurality of rollers 18 accommodated in seat 16.

The rollers create centrifugal masses which push the first half-pulley 8, and in particular the movable bushing 9, towards the second half-pulley 10 as the number of engine revolutions increases.

10 Thereby, the winding diameter of belt 6 on the drive pulley 4 increases and not being able to extend, such a belt operates to decrease the winding diameter on the driven pulley, thus increasing the gear ratio (high gear).

The drive pulley 4 further comprises a fixed bushing 11 having main extension along the rotation axis X coaxial to the drive shaft 2 and rotationally coupled therewith, for
15 example by means of a grooved profile, so as to keep a secure position thereon.

Preferably, the movable bushing 9 comprises a main wall 91, which is annular with respect to the rotation axis X, the main wall being defined between an inner cylindrical surface 91a and an outer surface 91b.

Preferably, the movable bushing 9 further comprises at least one projection 93
20 projecting radially outwards from the outer surface 91b and provided with a predefined axial extension. For example, there are provided three projections 93 arranged angularly equispaced from one another.

Said projections 93 engage container 14 so as to secure it to the movable bushing 9.

Moreover, the movable bushing 9 comprises at least one driven cam portion 95,
25 which is shaped so as to create surfaces which define a driven cam profile 97.

Preferably, each driven cam portion 95 comprises a respective recess 99, which is lowered with respect to the outer surface 91b of the main wall 91; the fixed bushing 11 slidably penetrates the recesses 99.

The fixed bushing 11 in turn has at least one drive cam portion 111, which is shaped
30 so as to create surfaces which define a drive cam profile 113.

The drive cam portion 111 axially projects and is suitable for interpenetrating the movable bushing 9, namely such as to be inserted into the respective recess 99 of the driven cam portion 95 of the movable bushing 9.

In particular, said drive cam portion 111 comprises a tooth 115 with mainly axial

extension, which is slidably inserted in recess 99 of the driven cam portion 95.

Tooth 115 is delimited by lateral sides 115a, 115b which define the circumferential width thereof (figures 6 and 7).

Particularly, the recess 99 and the tooth 115 have each other a complementary shape. Such complementary shape is kept in any movement of the tooth 115 with respect to the recess 99.

More particularly, recess 99 and tooth 115 have respective sides 99a, 99b; 115a, 115b which form a shape coupling with each other to guide the relative movement between the movable bushing 9 and said fixed bushing 11 so as to limit the noisiness.

Within the scope of the present description, shape coupling means a coupling between tooth and recess, in which the sides of the recess are both substantially in contact with each other. Said tooth and said recess are complementary each other, i.e. provided of shapes which match each other, unless there is a circumferential clearance which allows the mutual axial sliding thereof.

The relative movement between fixed bushing and movable bushing is of the rotary-translating type and therefore comprises an axial component along the axis of the bushings, and a circumferential component about the axis of the bushings.

Dimensionally, the circumferential clearance G defined between the sides of the recess and the sides of the tooth in the coupled configuration is between 0.1 to 0.7 millimeters, preferably between 0.2 to 0.5 millimeters (figure 7).

Thereby, a coupling is obtained which ensures an increased operating reliability and accuracy.

In particular, the active side, which transmits the motion, is substantially in contact with the passive side. In other words, the present invention creates a cam-counter cam solution with a shape coupling between recess and tooth.

Advantageously, this allows lubrication and greasing between tooth and recess to be avoided, with subsequent manufacturing simplicity and affordability due to the absence of grease-oil seals.

Moreover, in the absence of said seals, the axial and radial volume of the device according to the invention advantageously is also particularly reduced, so as to allow the use also in particularly compact transmission systems.

Said lateral sides 115a, 115b each have - on an imaginary plane orthogonal to the main axis X - a cross-section with straight profile for contact with the respective faces

of recess 97a. Correspondingly, said recess 99 has lateral sides 99a, 99b with straight profile.

Tooth 115 axially extends along a substantially straight tooth axis B which is inclined with respect to the main axis X (figures 2 and 4).

5 Said lateral sides 115a, 115b of tooth 115 each have - on a further imaginary plane parallel to the main axis X - a cross-section with straight profile; said profiles are parallel to each other and parallel to the tooth axis B (figures 3 and 5). Correspondingly, said recess 99 has lateral sides 99a, 99b with straight profiles, which are parallel to each other and parallel to the tooth axis B.

10 Such a geometry of the tooth and of the recess allows particularly close circumferential contact surfaces to be made between tooth and recess under all conditions of use of the CVT device, thereby contributing to significantly limiting the noisiness of the device.

Preferably, the lateral sides of the recess and the lateral sides of the tooth are
15 permanently in contact to guide the relative movement between the movable bushing and the fixed bushing so that the noisiness is practically null because no impact occurs in the relative movement between the two bushings.

The transmission device 1 therefore comprises an operating cam system between the fixed bushing 11 and the movable bushing 9, comprising the driven cam portions
20 95 and the respective driven cam profiles 97, and the drive cam portions 111 and the respective drive cam profiles 113, which have a mutual rotary-translating movement. Said cam system is suitable for transmitting the rotation between fixed bushing 11 and movable bushing 9 and is configured to obstruct the juxtaposition between the active surfaces 8a, 10a.

25 In the normal operation of the transmission device 1, in case of active torque transmitted by the drive shaft, in case of request of an increased torque from a low gear, the cam system opposes an advancement of the active surface 8a of the first half-pulley 8 towards the active surface 10a of the second half-pulley 10, whereby the change is delayed and the behavior of the transmission device is more sporty with
30 respect to a standard CVT.

In the case instead of braking torque transmitted by the drive shaft, for example in the case of request of a lower torque by the driver who releases the gas handle or brakes, or with vehicle descending, from a high gear the cam system facilitates the moving away of the active surface 8a of the first half-pulley 8 from the active surface

10a of the second half-pulley 10, whereby the passage to the low gear and therefore a significantly lower gear with respect to a standard CVT, is facilitated.

In particular, the Applicant has noted how the extremely reduced clearance that may be obtained between the sides of recess 99 and tooth 115 significantly contributes to
5 reducing the noisiness of the CVT device.

Innovatively, the above-described transmission device allows the need mentioned to be met because it allows the driver's desire of having more or less torque to be satisfied and simultaneously it is capable of significantly reducing the noisiness of the CVT device.

10 Moreover, by conveniently shaping the profiles of the cam system, a transmission device may advantageously be designed which more or less abruptly meets a request for more or less torque.

For example, figure 8 shows the engine revolutions of the drive pulley and of the driven pulley, for a traditional CVT transmission system and for a CVT transmission
15 system according to the present invention. The latter clearly has increased hysteresis.

According to a further advantageous aspect, the device according to the invention can be mounted with significant ease.

It is apparent that those skilled in the art may make modifications to the above-
20 described transmission device in order to meet contingent needs, without departing from the scope of protection defined by the appended claims.

In another embodiment, a continuous variation transmission device for a motorcycle with two / three / four-wheels, connectable to a drive shaft (2), comprises:

- a drive pulley 4 having an axis of rotation X, provided with active surfaces 8a, 10a
25 for a V-belt 6, provided with a movable bushing 9 bearing one of said active surfaces 8a, said movable bushing 9 sliding axially under the action of rollers 18 of a speed controller 12 to obtain a change between a low gear and high gear;
 - a fixed bushing 11 which can be fixed and is coaxial to the drive shaft 2;
 - a cam system 95,111; 97,113 operating between the fixed bushing 11 and the
30 movable bushing 9 suitable to transmit the rotation between the fixed bushing 11 and the movable bushing 9, configured to obstruct the juxtaposition between the active surfaces 8a, 10a, comprising at least a driven cam portion 95 of the movable bushing 9 and a drive cam portion 111 of the fixed bushing 11;
- wherein said driven cam portion 95 comprises at least one recess 99 and said drive

cam portion 111 comprises at least one tooth 115 or vice versa, said tooth sliding axially in said recess 99, and
wherein said recess 99 and said tooth 115 have respective sides 99a, 99b; 115a, 115b which form a shaped coupling with each other to guide the relative movement
5 between said movable bushing 9 and said fixed bushing 11.

CLAIMS

1. A continuous variation transmission device (1) for a motorcycle with two / three / four-wheels, connectable to a drive shaft (2), comprising

- a drive pulley (4) having an axis of rotation (X), provided with active surfaces (8a, 10a) for a V-belt (6), provided with a movable bushing (9) bearing one of said active surfaces (8a), said movable bushing (9) sliding axially under the action of rollers (18) of a speed controller (12) to obtain a change between a low gear and high gear;

- a fixed bushing (11) which can be fixed and is coaxial to the drive shaft (2);

- a cam system (95,111; 97,113) operating between the fixed bushing (11) and the movable bushing (9) suitable to transmit the rotation between the fixed bushing (11) and the movable bushing (9), configured to obstruct the juxtaposition between the active surfaces (8a, 10a), comprising at least a driven cam portion (95) of the movable bushing (9) and a drive cam portion (111) of the fixed bushing (11);

wherein said driven cam portion (95) comprises at least one recess (99) and said drive cam portion (111) comprises at least one tooth (115) or vice versa, said tooth sliding axially in said recess (99), and

wherein said recess (99) and said tooth (115) are each other so shaped to be complementary in any relative movement for guiding the relative movement between said movable bushing (9) and said fixed bushing (11).

2. A transmission device according to claim 1, wherein between said lateral sides (115a, 115b) of the tooth (115) and said lateral sides (99a, 99b) of the recess (99) there is a circumferential clearance between 0.1 - 0.7 mm, preferably between 0.2 - 0.5 mm.

3. A transmission device according to claim 1 or 2, wherein, having defined an imaginary plane orthogonal to the axis of rotation (X), said lateral sides (115a, 115b) of the tooth (115) and said lateral sides (99a, 99b) of the recess (99) each have a cross-section with a straight profile.

4. A transmission device according to any one of the preceding claims, wherein the tooth (115) and the recess (99) extend along a substantially straight tooth axis (B) inclined with respect to the rotation axis (X).

5. A transmission device according to any one of the preceding claims, in which each point of said lateral sides (115a, 115b) of the tooth (115) and each point of said lateral sides (99a, 99b) of the recess (99) lies on a plane passing through the axis of rotation (X).

6. A transmission device according to any one of the preceding claims, wherein the movable bushing (9) supports a container (14) of the speed controller (12).
7. A transmission device according to any one of the preceding claims, wherein the movable bushing (9) comprises at least one axial projection (93) projecting radially outwards from an outer surface (91b), which engages the container (14) so as to secure it to the movable bushing (9).
- 5

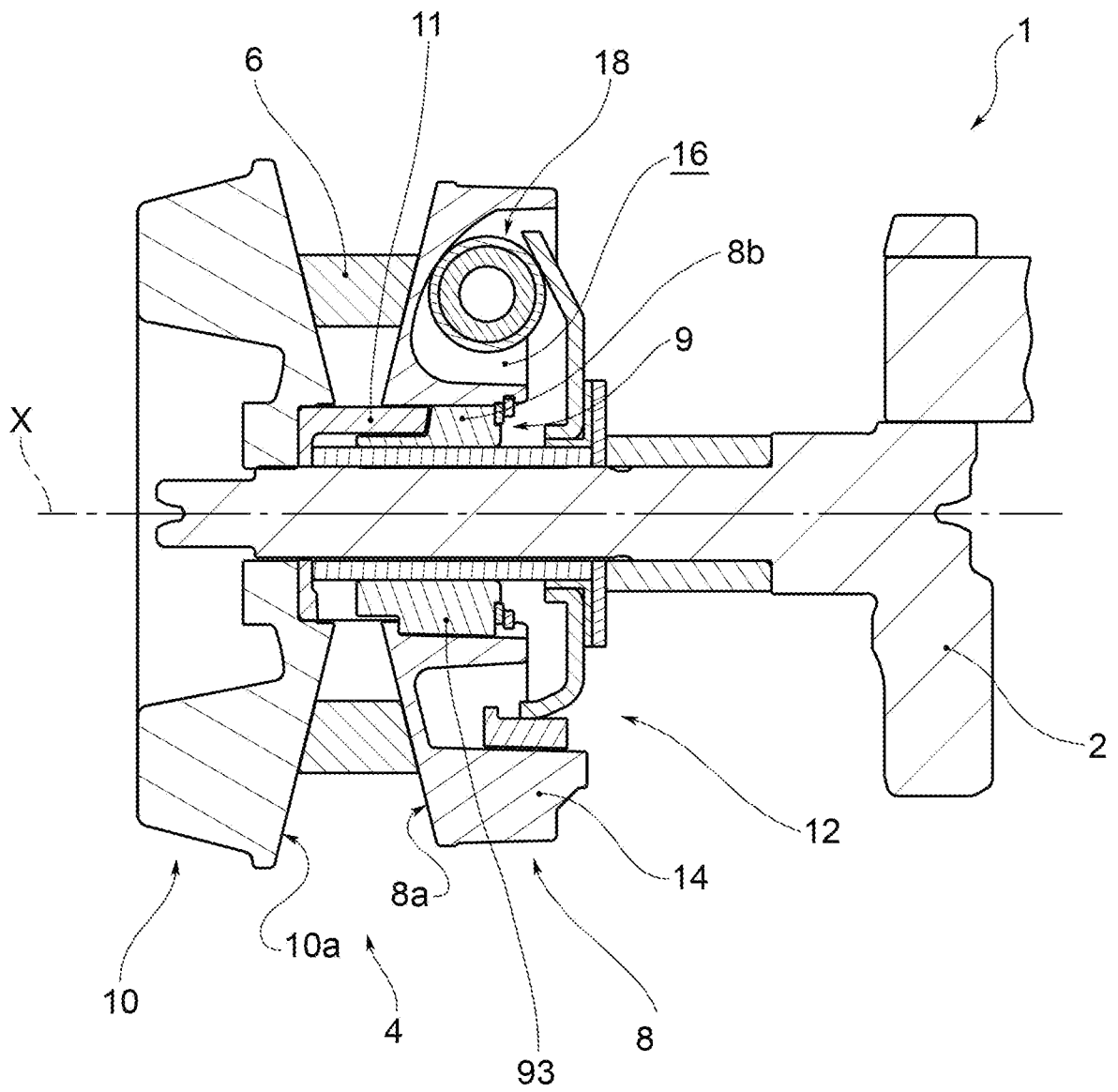


FIG.1

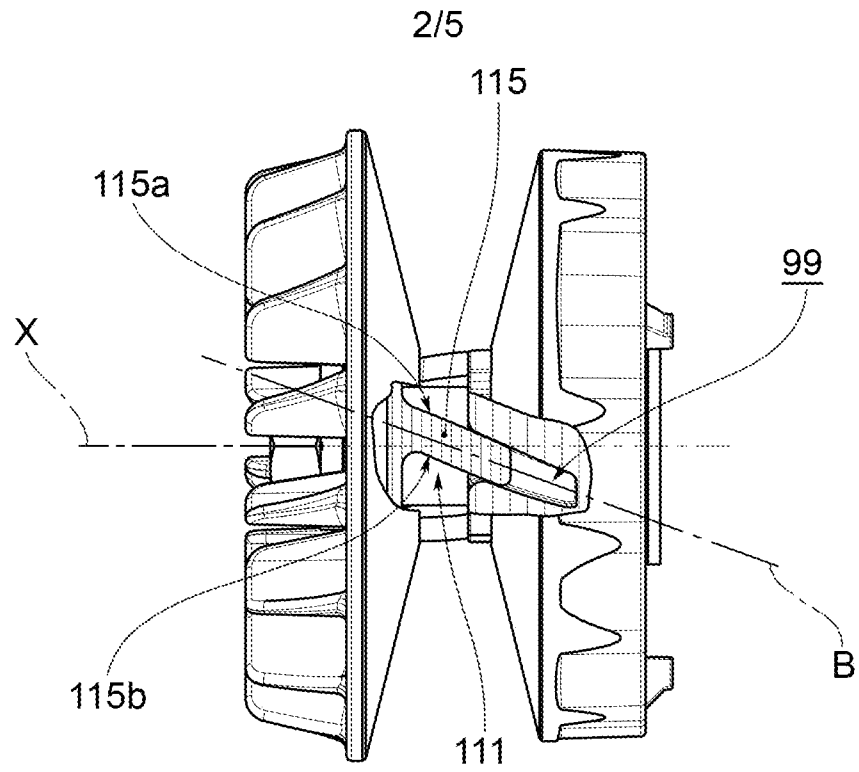


FIG.2

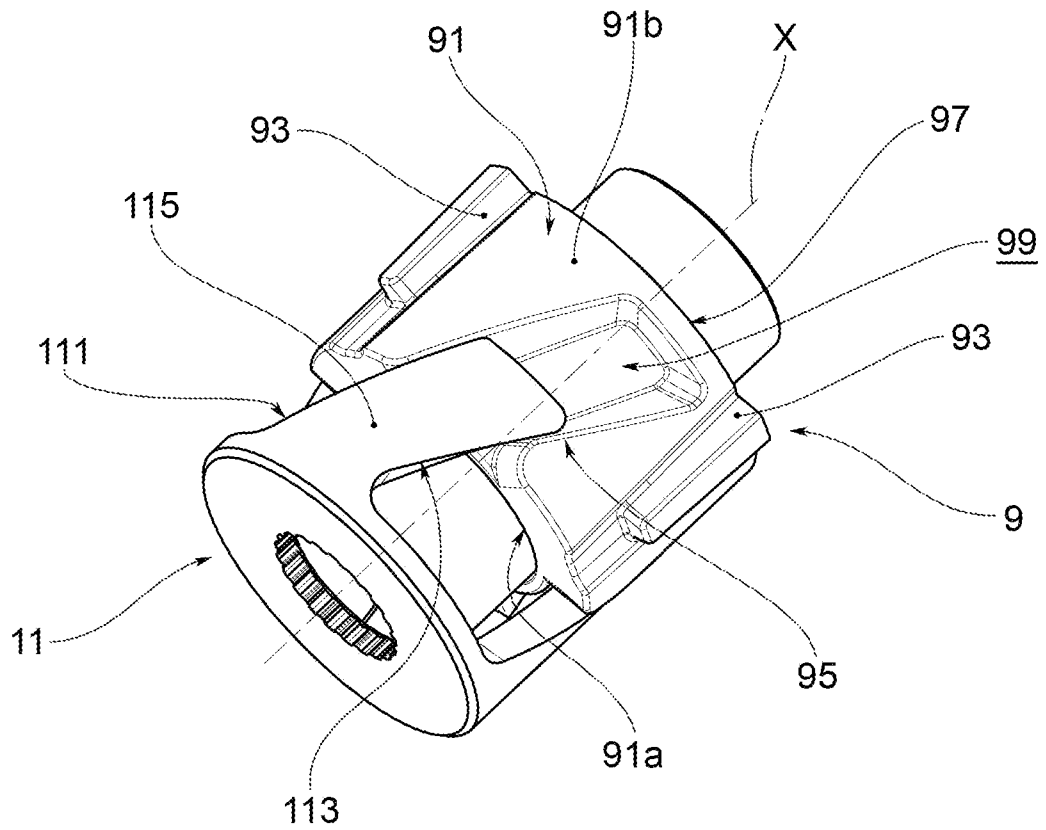


FIG.3

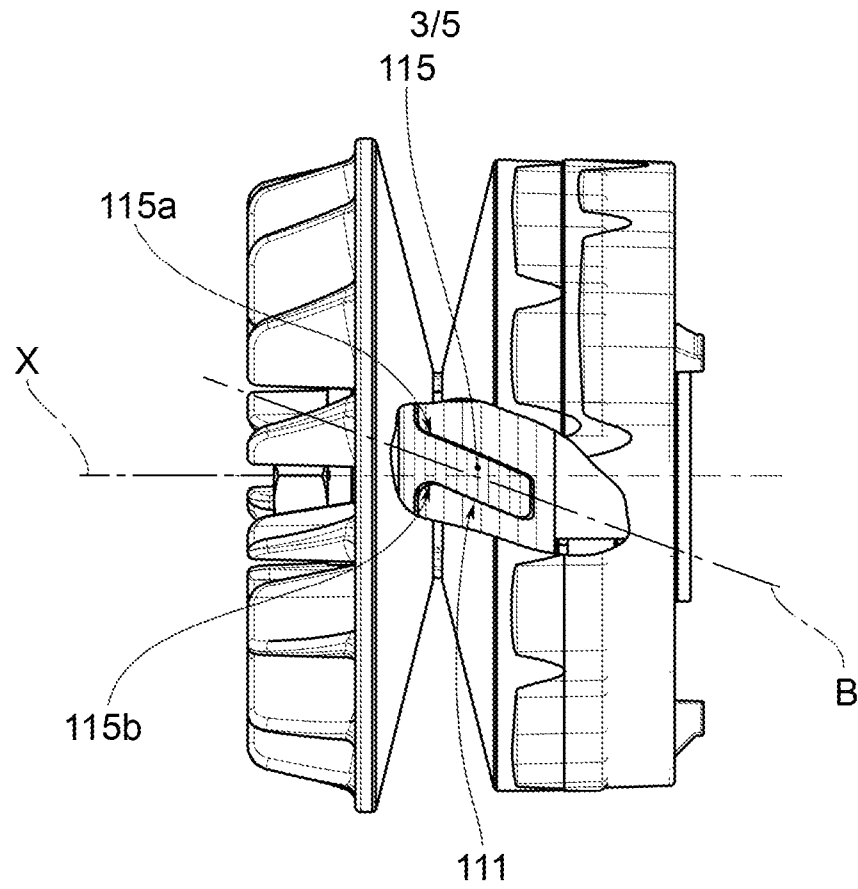


FIG.4

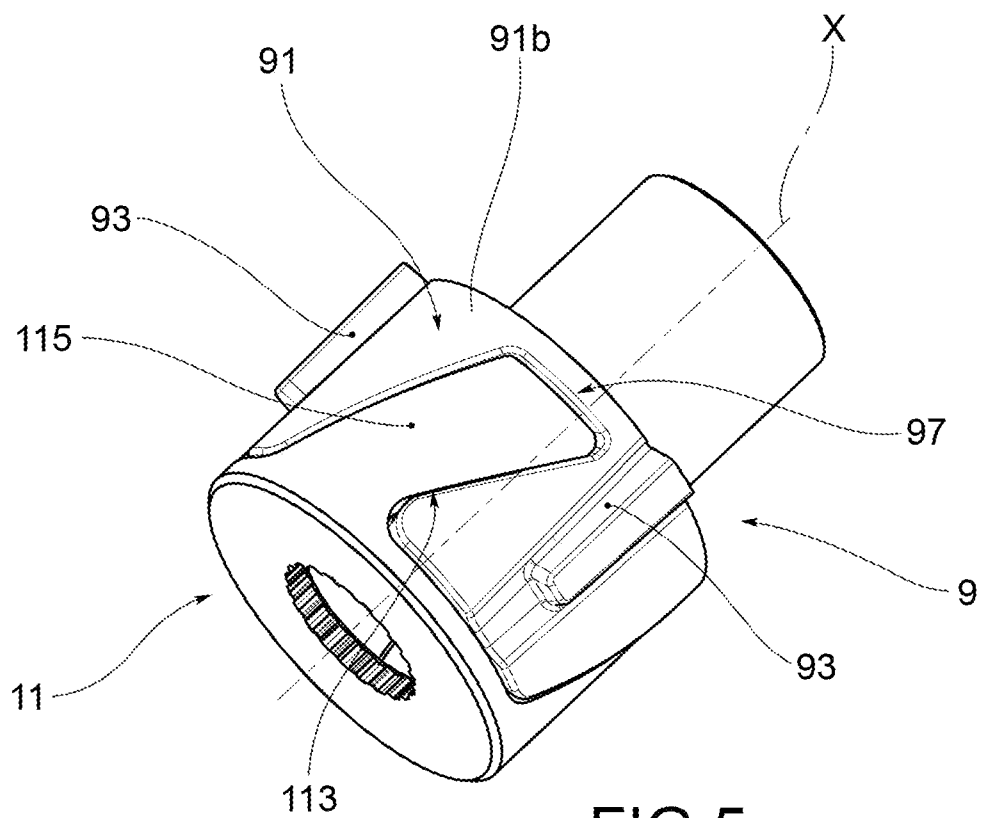


FIG.5

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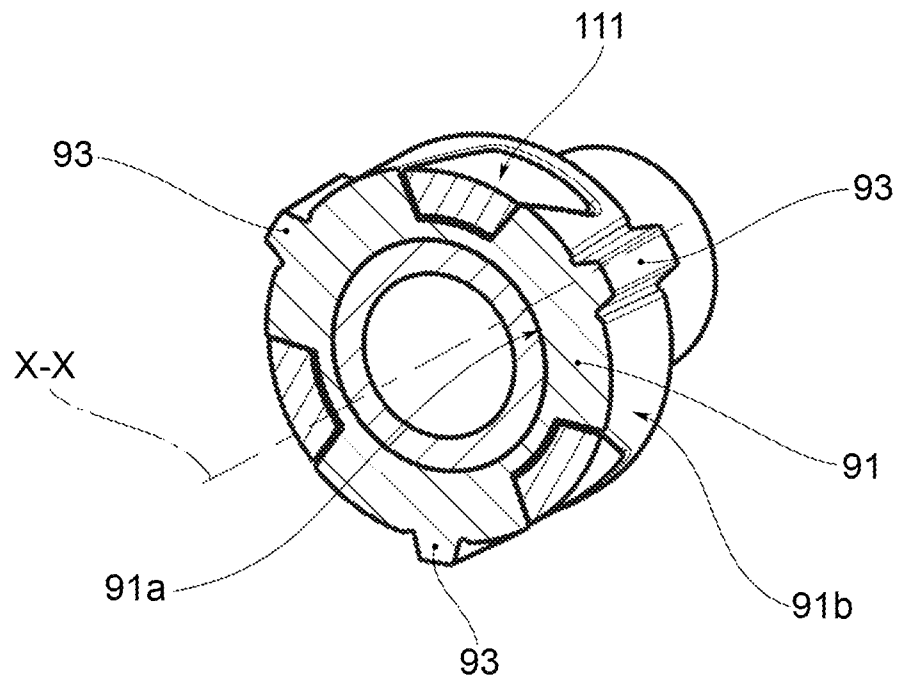


FIG. 6

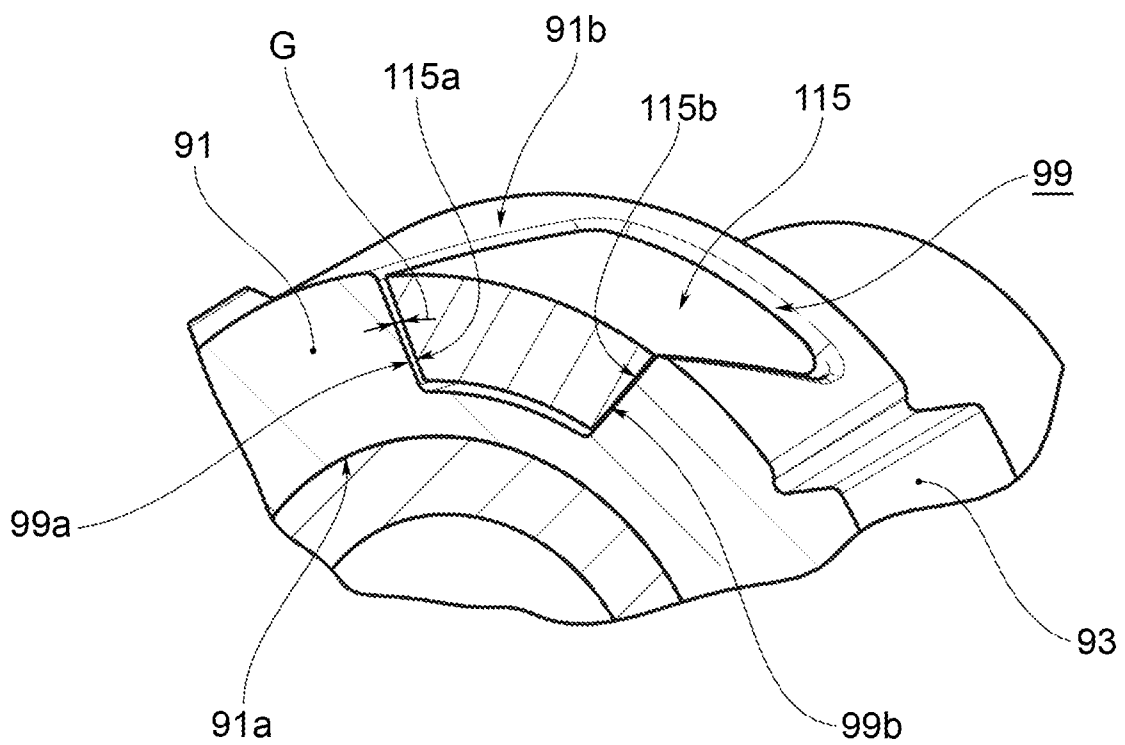


FIG. 7

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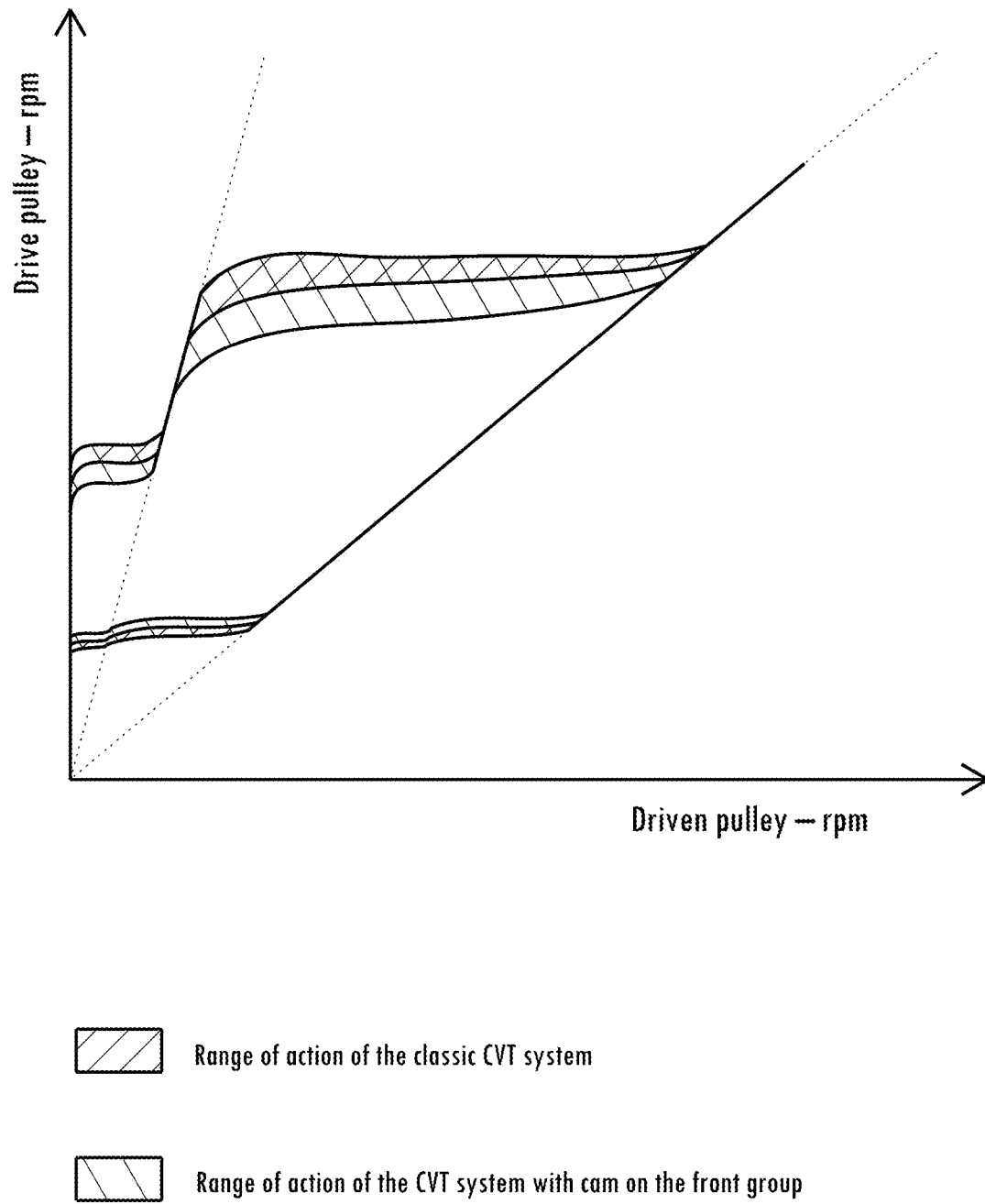


FIG.8

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2018/059576

A. CLASSIFICATION OF SUBJECT MATTER INV. F16H61/662 F16H63/06 F16H9/18 F16H55/56 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) F16H		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2017/098379 A1 (PIAGGIO & C SPA [IT]) 15 June 2017 (2017-06-15) figures 7,8 -----	1,4-7
A	EP 2 767 736 A1 (KANZAKI KOKYUKOKI MFG CO LTD [JP]) 20 August 2014 (2014-08-20) the whole document -----	1-7
A	EP 1 223 366 A2 (YAMAHA MOTOR CO LTD [JP]) 17 July 2002 (2002-07-17) the whole document -----	1-7
A	WO 2009/096385 A1 (HONDA MOTOR CO LTD [JP]; HANAWA KAORU [JP]; IMOTO YUTAKA [JP]) 6 August 2009 (2009-08-06) the whole document -----	1-7
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
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Date of the actual completion of the international search 8 February 2019		Date of mailing of the international search report 18/02/2019
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Hassiotis, Vasilis

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2018/059576

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2017098379 A1	15-06-2017	CN 108603585 A EP 3387295 A1 JP 2018536815 A US 2018355967 A1 WO 2017098379 A1	28-09-2018 17-10-2018 13-12-2018 13-12-2018 15-06-2017
EP 2767736 A1	20-08-2014	EP 2767736 A1 JP 2014156881 A US 2014235382 A1	20-08-2014 28-08-2014 21-08-2014
EP 1223366 A2	17-07-2002	AT 554315 T EP 1223366 A2 ES 2382540 T3 JP 2002206604 A TW 521131 B	15-05-2012 17-07-2002 11-06-2012 26-07-2002 21-02-2003
WO 2009096385 A1	06-08-2009	JP 2009180356 A TW 200949105 A WO 2009096385 A1	13-08-2009 01-12-2009 06-08-2009