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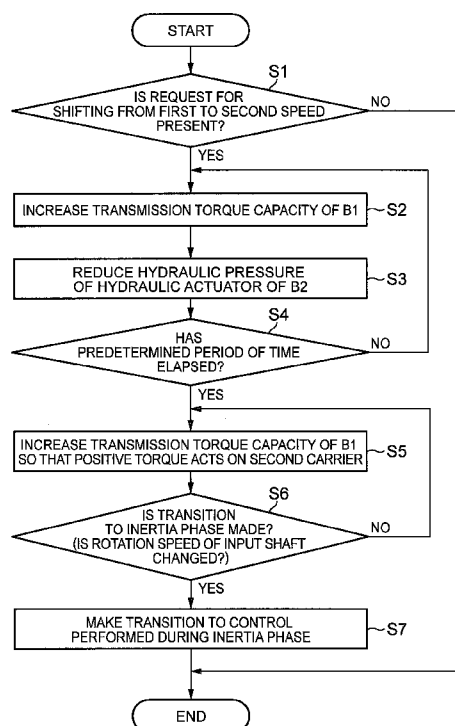
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[Continued on next page]

(54) Title: CONTROL DEVICE FOR TRANSMISSION

FIG. 1



(57) Abstract: A control device for a transmission is provided. The transmission has multiple transmission stages and includes a first engagement mechanism B2 and a second engagement mechanism B1. The first engagement mechanism includes a first member 16 and a second member 19. The first member is provided with first dog teeth where inclined surfaces are formed. The second member is provided with second dog teeth where inclined surfaces are formed. The control device includes an electronic control unit. The electronic control unit is configured to control the second engagement mechanism when a second transmission stage is set such that the capacity of the torque transmission of the second engagement mechanism is increased and the thrust for separating the first member and the second member of the first engagement mechanism from each other in an axial direction is generated.

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CONTROL DEVICE FOR TRANSMISSION

BACKGROUND OF THE INVENTION

5 1. Field of the Invention

[0001] The invention relates to a control device for a transmission that is provided with a first engagement device transmitting a torque by meshing and a second engagement device capable of changing a transmission torque capacity and, more particularly, to a control device for a transmission that is configured to perform shifting by releasing a first
10 engagement device and engaging a second engagement device.

2. Description of Related Art

[0002] Japanese Patent Application Publication No. 2002-174335 (JP 2002-174335 A) discloses a control device for a transmission that is configured to change a
15 torque which is output from an engine and transmit the changed torque to a drive wheel. The transmission is provided with a power transmission path through which the torque is transmitted from an input shaft to an output shaft via a dog clutch and a power transmission path through which the torque is transmitted from the input shaft to the output shaft via a friction clutch. Accordingly, the torque that acts on the dog clutch is gradually
20 reduced as a result of an increase in the transmission torque capacity of the friction clutch, and thus the release of the dog clutch is initiated after the transmission torque capacity of the friction clutch rises to some extent in a case where the dog clutch is released.

[0003] The timing of the initiation of the dog clutch can be determined by using the length of time elapsed after the transmission torque capacity of the friction clutch
25 begins to be increased. However, the friction clutch, the dog clutch, or a device that controls these members has inevitable irregularities. Accordingly, the length of time taken to reach a state where the dog clutch can be released after the transmission torque capacity of the friction clutch begins to be increased has inevitable irregularities. Accordingly, the torque continues to act on the dog clutch and the release of the dog clutch

cannot be ensured in some cases when the timing of the beginning of the release of the dog clutch is determined based on the length of time after the transmission torque capacity of the friction clutch begins to be increased. Accordingly, the control device for a transmission that is disclosed in JP 2002-174335 A is configured to detect the transmission
5 torque capacity of the friction clutch and determine whether or not to release the dog clutch based on the detected transmission torque capacity.

[0004] In addition, International Publication No. 2013/076827 discloses a transmission that is provided with a planetary gear mechanism. A mesh-type brake is disposed in this transmission so that one rotating element of the planetary gear mechanism
10 can be selectively engaged with a fixed portion such as a housing. In addition, a normally-closed dog clutch is adopted so that hydraulic pressure supply to a hydraulic actuator that controls the engagement and release of the brake can be stopped during the engagement of the brake.

[0005] Japanese Utility Model Application Publication No. 2-21336 (JP 2-21336
15 U) discloses the shape of a dog clutch that is used in a machine tool. In this dog clutch, one side surfaces of dog teeth are formed to be inclined so that backlash is suppressed and poor meshing attributable to contact between tooth tips is suppressed when the dog teeth mesh. More specifically, this dog clutch is used at a part that rotates in only one direction and is shaped so that meshing is completed based on the relative rotation of the dog teeth
20 along inclined surfaces even in a case where the tooth tips are brought into contact with each other during a meshing operation.

SUMMARY OF THE INVENTION

[0006] The shift control that is described in JP 2002-174335 A can be applied to
25 control for releasing the dog clutches described in International Publication No. 2013/076827 and JP 2-21336 U. This release control is performed through a plurality of control steps as follows. After the establishment of a shift determination, control for gradually increasing the transmission torque capacity of the friction clutch is initiated (Step 1). The transmission torque capacity is detected (Step 2). The detected transmission

torque capacity is compared to a reference value determined in advance and the dog clutch is released based on the result of the comparison (Step 3). Since the release control is performed through the plurality of control steps described above, the complexity of the control process as well as the control device may increase.

5 **[0007]** The invention provides a control device for a transmission that is capable of simplifying control which is performed during shifting based on the release of a mesh-type engagement mechanism.

[0008] According to an aspect of the invention, a control device for a transmission is provided. The transmission has multiple transmission stages and includes
10 a first engagement mechanism and a second engagement mechanism. The first engagement mechanism includes a first member and a second member. The first member is provided with first dog teeth. The first dog teeth include first tooth surfaces directed to one side in a circumferential direction and second tooth surfaces directed to the other side in the circumferential direction. The second member is provided with second dog teeth.
15 The second dog teeth include third tooth surfaces facing the first tooth surfaces and fourth tooth surfaces facing the second tooth surfaces. The second member is configured to be moved in an axial direction such that the second dog teeth mesh with the first dog teeth. The first engagement mechanism is configured to transmit a torque between the first member and the second member when the second dog teeth mesh with the first dog teeth.
20 The second engagement mechanism includes a third member and a fourth member. The second engagement mechanism is configured to perform switching between a state where the third member and the fourth member rotate relative to each other and a state where the third member and the fourth member are connected to each other for torque transmission. The second engagement mechanism is configured to change a capacity of the torque
25 transmission between the third member and the fourth member during the connection. The transmission is configured to select a first transmission stage among the multiple transmission stages by engaging the first engagement mechanism and releasing the second engagement mechanism. The transmission is configured to select a second transmission stage having a transmission ratio lower than the transmission ratio of the first transmission

stage by releasing the first engagement mechanism and engaging the second engagement mechanism. The transmission is configured to reverse the direction of a torque acting on the first member or the second member as a result of an increase in the capacity of the torque transmission of the second engagement mechanism when the second engagement mechanism is engaged. The first tooth surfaces and the third tooth surfaces are inclined surfaces such that a thrust for separating the first member and the second member from each other in the axial direction is generated in accordance with a torque in a direction in which the first tooth surfaces and the third tooth surfaces are brought into contact with each other when the second transmission stage is set. The control device includes an electronic control unit (ECU). The ECU is configured to control the second engagement mechanism when the second transmission stage is set such that the capacity of the torque transmission of the second engagement mechanism is increased and the thrust for separating the first member and the second member from each other in the axial direction is generated.

[0009] In the control device according to the aspect described above, the ECU may be configured to calculate a length of time required for separating the second member from the first member when the second transmission stage is set. The ECU may be configured to control the capacity of the torque transmission of the second engagement mechanism based on the calculated length of time.

[0010] In the control device according to the aspect described above, the first engagement mechanism may include a brake mechanism.

[0011] In the control device according to the aspect described above, the first member and the second member may be configured to rotate relative to each other. The first engagement mechanism may be configured to connect the first member and the second member to each other for integral rotation with the first dog teeth and the second dog teeth meshing with each other.

[0012] In the control device according to the aspect described above, the first engagement mechanism may include a thrust generation mechanism configured to control a load for pressing the second member to the first member side. The thrust generation

mechanism may be configured to reduce the load by which the second member is pressed to the first member side when the second transmission stage is set.

[0013] In the control device according to the aspect described above, the transmission may include a third engagement mechanism engaged when the first
5 transmission stage is set and when the second transmission stage is set.

[0014] In the control device according to the aspect described above, the transmission may include a first planetary gear mechanism and a second planetary gear mechanism. Each of the first planetary gear mechanism and the second planetary gear mechanism may include at least three rotating elements. The first engagement
10 mechanism and the second engagement mechanism may be configured to connect the rotating elements of any one of the first planetary gear mechanism and the second planetary gear mechanism to each other or fix the rotating elements of any one of the first planetary gear mechanism and the second planetary gear mechanism.

[0015] According to the aspect described above, the transmission is provided with
15 the first engagement mechanism that connects the first member and the second member to each other to be capable of torque transmission by allowing the meshing of the respective dog teeth formed in the first member and the second member and the second engagement mechanism that is capable of connecting the third member and the fourth member, which rotate relative to each other, to each other to be capable of torque transmission and
20 changing the capacity of the transmitted torque. In addition, the first transmission stage is set when the first engagement mechanism is engaged and the second engagement mechanism is released and the second transmission stage, which has a transmission ratio lower than the transmission ratio of the first transmission stage, is set when the first engagement mechanism is released and the second engagement mechanism is engaged.
25 In addition, the direction of the torque that acts on the first member or the second member is gradually reversed as a result of an increase in the transmission torque capacity of the second engagement mechanism. Accordingly, the torque that acts on the first member or the second member is gradually reduced with the increase in the transmission torque capacity of the second engagement mechanism when the first transmission stage is set, and

then the direction of the torque that acts on the first member or the second member is reversed. In addition, the first tooth surfaces of the first dog teeth and the second tooth surfaces of the second dog teeth face each other and these tooth surfaces are inclined surfaces generating the thrust for separating the first member and the second member from each other in the axial direction in accordance with the torque in the direction in which these tooth surfaces are brought into contact with each other. When the second transmission stage is set, the transmission torque capacity of the second engagement mechanism is increased so that the torque which acts between the first member and the second member becomes the torque generating the thrust for separating the first member and the second member from each other by pressing the first member and the second member in the axial direction. Accordingly, the first engagement mechanism can be released and the second transmission stage can be set when the transmission torque capacity of the second engagement mechanism is controlled. Accordingly, the control that is performed during the selection of the second transmission stage described above can be simplified.

[0016] In addition, the length of time required for separating the second member from the first member when the second transmission stage is set is obtained and the transmission torque capacity of the second engagement mechanism is determined based on the obtained length of time. Accordingly, shifting in accordance with a required shift response can be performed based on the control of the transmission torque capacity of the second engagement mechanism.

[0017] If the thrust generation mechanism that presses the second member to the first member side is provided, the separation of the respective dog teeth can be suppressed by pressing the second member to the first member side by using the thrust generation mechanism even in a case where the torque is applied to the first tooth surfaces and the third tooth surfaces as the first tooth surfaces and the third tooth surfaces are brought into contact with each other under a condition in which the shifting from the first transmission stage to the second transmission stage is not performed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Features, advantages, and technical and industrial significance of exemplary embodiments of the invention will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

5 FIG. 1 is a flowchart for showing an example of control by a control device according to the invention;

FIG. 2 is a map for determining the transmission torque capacity of a first brake during the application of a torque for releasing a piston to a second brake;

10 FIG. 3A is a time chart illustrating how the transmission torque of each brake and the torque of an input shaft 10 change during the execution of the control illustrated in FIG. 1;

FIG. 3B is a time chart illustrating how the rotation speed of the input shaft 10 and the torque that is output from a transmission change during the execution of the control illustrated in FIG. 1;

15 FIG. 4 is a skeleton diagram illustrating an example of the configuration of the transmission that is provided with each engagement mechanism according to the invention;

FIG. 5 is an engagement table illustrating which engagement mechanism is engaged when each transmission stage is set;

FIG. 6 is a nomogram illustrating the operation state of each rotating element of the transmission; and

20 FIG. 7 is a sectional view for showing an example of the configuration of the second brake.

DETAILED DESCRIPTION OF EMBODIMENTS

[0019] The invention relates to a control device for a transmission provided with
25 a first engagement mechanism that connects two members to each other to be capable of torque transmission with dog teeth meshing and a second engagement mechanism that is capable of engaging two members, which are disposed to be capable of relative rotation, with each other to be capable of torque transmission and changing the capacity of the transmitted torque. FIG. 4 illustrates an example of the configuration of the transmission

that has each of the engagement mechanisms which have the above-described configuration. The transmission that is illustrated in FIG. 4, which is mounted on a vehicle, has a known double pinion-type planetary gear mechanism (hereinafter, referred to as a first planetary gear mechanism 1) and a Ravigneaux-type planetary gear mechanism (hereinafter, referred to as a second planetary gear mechanism 2). This transmission is connected to an output shaft 4 of an engine 3, which is a driving force source, via a torque converter (not illustrated) and is configured to output a torque after changing an input torque and a rotation speed. More specifically, this transmission is configured to be capable of setting transmission stages of a forward first speed to a forward eighth speed and transmission stages of a reverse first speed and a reverse second speed and is configured to set any of the transmission stages in accordance with a target rotation speed of the engine 3, a required driving force, and the like. These planetary gear mechanisms correspond to the first planetary gear mechanism and the second planetary gear mechanism pertaining to the case of the implementation of the invention.

[0020] The configuration of the transmission that is illustrated in FIG. 4 will be described in detail. A first sun gear 6 that is connected to a fixed portion 5 such as a housing, a first inner pinion gear 7 that meshes with the first sun gear 6, a first outer pinion gear 8 that meshes with the first inner pinion gear 7, a first ring gear 9 that meshes with the first outer pinion gear 8, and a first carrier 11 that holds the first inner pinion gear 7 and the first outer pinion gear 8 to be capable of rotation and revolution and is connected to an input shaft 10 constitute the first planetary gear mechanism 1. In other words, the first planetary gear mechanism 1 is a differential mechanism that has three rotating elements and is configured for the first carrier 11 to function as an input element, for the first sun gear 6 to function as a reaction force element, and for the first ring gear 9 to function as an output element when the engine 3 outputs a driving force. In addition, the first planetary gear mechanism 1 functions as a decelerator.

[0021] A second sun gear 12 and a third sun gear 13 that are concentrically arranged with the input shaft 10, a second inner pinion gear 14 that meshes with the third sun gear 13, a second outer pinion gear 15 that meshes with the second inner pinion gear

14 and the second sun gear 12, a second carrier 16 that holds the second inner pinion gear 14 and the second outer pinion gear 15 to be capable of rotation and revolution, and a second ring gear 17 that meshes with the second outer pinion gear 15 constitute the second planetary gear mechanism 2 that is illustrated in FIG. 4. In other words, the second planetary gear mechanism 2 is configured to have both the second carrier 16 and the second ring gear 17 of a single pinion-type planetary gear mechanism and a double pinion-type planetary gear mechanism and is configured as a differential mechanism that has the four rotating elements of the second sun gear 12, the third sun gear 13, the second carrier 16, and the second ring gear 17.

10 **[0022]** A plurality of clutches for selective engagement between the respective rotating elements of the first planetary gear mechanism 1 described above and the respective rotating elements of the second planetary gear mechanism 2 and a brake for stopping any of the rotating elements are additionally disposed. Specifically, a first clutch C1 is disposed to connect the first ring gear 9 and the third sun gear 13 to each other, a second clutch C2 is disposed to connect the input shaft 10 or the first carrier 11 and the second carrier 16 to each other, a third clutch C3 is disposed to connect the first ring gear 9 and the second sun gear 12 to each other, and a fourth clutch C4 is disposed to connect the first carrier 11 and the second sun gear 12 to each other. Each of the clutches C1, C2, C3, C4 is configured to be capable of changing the transmission torque capacity based on the amount of the control of a hydraulic actuator, an electromagnetic actuator, or the like. In the following description, a friction clutch that is configured to be capable of transmitting the torque by using a frictional force and changing the transmission torque capacity in accordance with the hydraulic pressure which is supplied to the hydraulic actuator will be described as an example.

25 **[0023]** In addition, a first brake B1 is disposed to stop the second sun gear 12 by connecting the fixed portion 5 such as the housing and the second sun gear 12 to each other. Likewise, a second brake B2 is disposed to stop the second carrier 16 by connecting the fixed portion 5 and the second carrier 16 to each other. In the example that is illustrated in FIG. 4, a friction brake that is capable of controlling a braking force which acts on the

second sun gear 12 by changing the frictional force, that is, by changing the transmission torque capacity, constitutes the first brake B1 and the second brake B2 is configured to stop the second carrier 16 when the second carrier 16 and the fixed portion 5 mesh with each other. The second brake B2 corresponds to the first engagement mechanism pertaining to
5 the case of the implementation of the invention.

[0024] An electronic control unit (hereinafter, referred to as an ECU 18) is also disposed so as to control the engine 3, each engagement device, and the like. The ECU 18 is configured to have a microcomputer as a main component as is known, and is configured to determine a signal to be output to the engine 3 or the respective engagement
10 devices based on a signal that is input from a sensor (not illustrated), a pre-stored map, a pre-stored arithmetic expression, and the like and output the determined signal to the engine 3 and the respective engagement devices. As an example thereof, signals of a vehicle speed that is detected by a vehicle speed sensor and an accelerator opening that is detected by an accelerator opening sensor are input into the ECU 18. As is known, a shift
15 map that is prepared in advance by using the vehicle speed and the accelerator opening as parameters is stored in the ECU 18, and the transmission stage is determined by using the input signals and the shift map. Then, the signal is output to the respective clutches and the respective brakes described above so that the transmission stage which is determined is attained. In this case, the transmission torque capacity of the friction clutch, the friction
20 brake, or the like may be controlled in accordance with various conditions so as to, for example, suppress a shock that is caused when the transmission stage is changed.

[0025] The engagement table in FIG. 5 illustrates which engagement mechanism is engaged when each transmission stage is set. "o" in FIG. 5 represents a state where the clutch or the brake is engaged, and "-" represents a state where the clutch or the brake is
25 released. As illustrated in FIG. 5, the forward first speed is set when the first clutch C1 and the second brake B2 are engaged, the forward second speed is set when the first clutch C1 and the first brake B1 are engaged, the forward third speed is set when the first clutch C1 and the third clutch C3 are engaged, the forward fourth speed is set when the first clutch C1 and the fourth clutch C4 are engaged, the forward fifth speed is set when the first

clutch C1 and the second clutch C2 are engaged, the forward sixth speed is set when the second clutch C2 and the fourth clutch C4 are engaged, the forward seventh speed is set when the second clutch C2 and the third clutch C3 are engaged, and the forward eighth speed is set when the second clutch C2 and the first brake B1 are engaged. In addition, the reverse first speed is set when the second brake B2 and the third clutch C3 are engaged and the reverse second speed is set when the second brake B2 and the fourth clutch C4 are engaged. The transmission ratio is "1" when the forward sixth speed is set, the transmission ratio exceeds "1" when any one of the transmission stages of the forward first speed to the forward fifth speed is set, and the transmission ratio is less than "1" when the forward seventh speed or the forward eighth speed is set. The forward first speed corresponds to the first transmission stage pertaining to the case of the implementation of the invention, the forward second speed corresponds to the second transmission stage pertaining to the case of the implementation of the invention, the first brake B1 corresponds to the second engagement mechanism pertaining to the case of the implementation of the invention, and the first clutch C1 corresponds to the third engagement mechanism pertaining to the case of the implementation of the invention.

[0026] FIG. 6 is a nomogram illustrating the operation state of each rotating element in the respective transmission stages. The vertical axis in FIG. 6 represents the rotation speed of each rotating element, and the rotation speed input into the transmission is illustrated as being constant. In the following description, a case where the direction of rotation of each rotating element is the same as the direction of rotation of the engine 3 will be referred to as positive rotation and a case where the direction of rotation of each rotating element is opposite to the direction of rotation of the engine 3 will be referred to as negative rotation. In addition, a torque that acts to reduce the rotation speed during the negative rotation or a torque that acts to increase the rotation speed during the positive rotation will be referred to as a positive torque and a torque that acts to reduce the rotation speed during the positive rotation or a torque that acts to increase the rotation speed during the negative rotation will be referred to as a negative torque. Accordingly, in FIG. 6, the positive rotation is the side above "0", the negative rotation is the side below "0", the

torque that acts in the upward direction with respect to each rotating element is the positive torque, and the torque that acts in the downward direction with respect to each rotating element is the negative torque.

[0027] As described above, the first planetary gear mechanism 1 is configured to function as the decelerator and is configured to amplify the torque that is transmitted from the engine 3 and then output the amplified torque from the first ring gear 9. In addition, the first clutch C1 is engaged at the forward first speed. In other words, the first ring gear 9 and the third sun gear 13 are connected to each other via the first clutch C1 as described above. Accordingly, the positive torque is input from the engine 3 to the third sun gear 13 via the first ring gear 9, and thus the third sun gear 13 functions as the input element of the second planetary gear mechanism 2. At the forward first speed, in addition, the second brake B2 is engaged to connect the second carrier 16 and the fixed portion 5 to each other, and thus the rotation speed of the second carrier 16 is maintained at "0". Accordingly, the second carrier 16 functions as the reaction force element of the second planetary gear mechanism 2. As a result, the torque that is input into the transmission is amplified in accordance with the gear ratio of the transmission and then is output from the second ring gear 17. The negative torque is transmitted to the second carrier 16 while the driving force is output from the engine 3.

[0028] The first clutch C1 is engaged not only at the forward first speed but also at the forward second speed. Accordingly, the positive torque is input from the engine 3 to the third sun gear 13 via the first ring gear 9, and thus the third sun gear 13 functions as the input element of the second planetary gear mechanism 2. At the forward second speed, the first brake B1 is engaged to connect the second sun gear 12 and the fixed portion 5 to each other, and thus the rotation speed of the second sun gear 12 is maintained at "0". Accordingly, the second carrier 16 functions as the reaction force element of the second planetary gear mechanism 2. As a result, the torque that is input into the transmission is amplified in accordance with the gear ratio of the transmission and then is output from the second ring gear 17.

[0029] During the upshift to the forward second speed from the forward first

speed set as described above, the second brake B2 is released and the first brake B1 is engaged. As described above, the second brake B2 is configured to transmit the torque by meshing. The brake that transmits the torque by meshing as described above cannot control the transmission torque capacity. Accordingly, a large amount of torque is applied to the second brake B2 and a large amount of frictional force acts on the meshing surface while the second carrier 16 is functioning as the reaction force element, and thus the second brake B2 becomes less likely to be released in some cases. Accordingly, this control device for a transmission is configured for the second brake B2 to be released in a state where the transmission torque capacity of the first brake B1 is increased to be allowed to function as a reaction force at the forward first speed. In other words, this control device for a transmission is configured for the negative torque that is applied to the second brake B2 to be reduced when the traveling is performed with the forward first speed set.

[0030] It is necessary to determine whether the second brake B2 is completely released in the case of performing a transition to the forward second speed by increasing the transmission torque capacity of the first brake B1 so as to suppress the application of the torque to the second brake B2, releasing the second brake B2 thereafter, and then increasing the transmission torque capacity of the first brake B1. When a sensor or the like is disposed so as to detect a complete release of the second brake B2, the device may become larger in size, or the shift response may be reduced due to a factor such as the waiting for the release of the second brake B2. In addition, the shift control may become complicated because cooperation control has to be performed between control for releasing the second brake B2 and control for changing the transmission torque capacity of the first brake B1.

[0031] Accordingly, the invention is configured to allow the second brake B2 to be released by increasing the transmission torque capacity of the first brake B1 so that the positive torque is transmitted to the second carrier 16. FIG. 7 is a schematic diagram for showing the configuration of the second brake B2. The second brake B2 that is illustrated in FIG. 7 is configured for a piston 19, which is spline-engaged with the fixed portion 5, and the second carrier 16 to mesh with each other. Specifically, a side surface of the

second carrier 16 and the piston 19 are disposed to face each other in an axial direction, a plurality of first dog teeth 20 that protrude in the axial direction are formed at predetermined intervals in a circumferential direction on the surface of the second carrier 16 facing the piston 19, and a plurality of second dog teeth 21 that protrude in the axial direction and mesh with the first dog teeth 20 are formed at predetermined intervals in the circumferential direction on the surface of the piston 19 facing the second carrier 16. The piston 19, which is an annularly formed member, has an outer circumferential surface that is spline-engaged with an inner circumferential surface of the fixed portion 5. In other words, the piston 19 is engaged with the fixed portion 5 to be capable of moving in the axial direction and not to be capable of rotating. The piston 19 corresponds to the second member pertaining to the case of the implementation of the invention.

[0032] A thrust generation mechanism 22 is disposed so as to move the piston 19. In the example that is illustrated in FIG. 7, a return spring 23 that exerts a load on the piston 19 so that the piston 19 is separated from the second carrier 16 and a hydraulic actuator 24 that is disposed on a back surface (surface on the side opposite to the surface facing the second carrier 16) side of the piston 19 so as to exert a thrust against the spring force of the return spring 23 constitute the thrust generation mechanism 22. Accordingly, the piston 19 that is illustrated in FIG. 7 is configured to approach the second carrier 16 when the hydraulic pressure supplied to the hydraulic actuator 24 increases and, on the contrary, to be separated from the second carrier 16 by the spring force of the return spring 23 when the hydraulic pressure supplied to the hydraulic actuator 24 decreases.

[0033] The respective dog teeth 20, 21 that are illustrated in FIG. 7 have tooth surfaces formed so that the hydraulic pressure supplied to the hydraulic actuator 24 can be reduced when the driving force is transmitted from the engine 3 with the forward first speed set, that is, the thrust for separation from the second carrier 16 is less likely to be generated in the piston 19 when the first dog teeth 20 and the second dog teeth 21 are in contact with each other. Specifically, the side surfaces of the dog teeth 20, 21 that are in contact with each other while the vehicle is traveling with the forward first speed set, that is, tooth surfaces 25, 26 where the first dog teeth 20 and the second dog teeth 21 face each

other, are formed to be substantially orthogonal to the direction of rotation. The tooth surfaces 25 of the first dog teeth 20 that are in contact when the vehicle travels with the forward first speed set correspond to the second tooth surfaces pertaining to the case of the implementation of the invention and the tooth surfaces 26 of the second dog teeth 21 correspond to the fourth tooth surfaces pertaining to the case of the implementation of the invention. Although the respective tooth surfaces 25, 26 are formed to be orthogonal to the direction of rotation in the example that is illustrated in FIG. 7, the respective tooth surfaces 25, 26 may also be formed at a predetermined angle to the direction of rotation as illustrated by the dashed line.

10 **[0034]** The negative torque that is transmitted to the second carrier 16 is reduced first when the transmission torque capacity of the first brake B1 begins to be increased during the setting of the forward first speed. When the transmission torque capacity of the first brake B1 is further increased thereafter, the torque that is transmitted to the second carrier 16 is reversed in direction to become the positive torque. In other words, an increase in the transmission torque capacity of the first brake B1 causes the direction of the torque that is transmitted to the second carrier 16 to be gradually reversed. When the direction of the torque that is transmitted to the second carrier 16 is reversed as described above, the meshing between the dog teeth 20, 21 is reversed. Accordingly, this control device for a transmission is configured for the meshing between the dog teeth 20, 21 to be reversed and the thrust for separating the piston 19 from the second carrier 16 to be generated in accordance with the torque in the direction in which tooth surfaces 27, 28 are brought into contact with each other. Specifically, the surfaces 27, 28 are inclined which are brought into contact with each other with the reversal of the meshing between the respective dog teeth 20, 21. In other words, the tooth surfaces 27, 28 that are directed to be opposite to the respective tooth surfaces 25, 26 in the circumferential direction are formed to be inclined. These tooth surfaces 27, 28 correspond to the first tooth surface and the third tooth surface pertaining to the case of the implementation of the invention, respectively.

25 **[0035]** The shapes of the respective tooth surfaces 27, 28 will be described in

detail. The respective dog teeth 20, 21 are formed for the angle θ that is formed by the axial direction and the respective tooth surfaces 27, 28 to be equal to or larger than a predetermined value, that is, configured for a load to act on the piston 19 in the direction in which the piston 19 is separated from the second carrier 16 in accordance with the torque
 5 which is applied to the respective tooth surfaces 27, 28 as a result of the contact between the respective tooth surfaces 27, 28. It is preferable that this inclination angle θ is set to an angle which satisfies the following expression.

$$B - C - \mu_1 \times F > 0 \dots (1)$$

[0036] The B in the Expression (1) represents the load that acts on the piston 19
 10 so as to separate the piston 19 from the second carrier 16 when a load acts on the tooth surfaces 28. In other words, the B in the Expression (1) can be calculated based on a normal force A that is applied to the tooth surfaces 28 and the inclination angle θ . Specifically, the B in the Expression (1) can be calculated as follows. The F in the following equation represents the load in the direction of rotation acting on the piston 19.

$$15 \quad B = A \times \sin \theta \dots (2)$$

$$A = F / \cos \theta \dots (3)$$

[0037] Since the frictional force is generated when the piston 19 is moved in the axial direction, the axial component of the frictional force acts on the piston 19. The C in the Expression (1) represents the axial component of the frictional force. Accordingly,
 20 the C can be obtained by the following equation. The μ_2 in the following equation represents the coefficient of friction in the contact surfaces of the respective dog teeth 20, 21.

$$C = \mu_2 \times A \times \cos \theta \dots (4)$$

[0038] In addition, the " $\mu_1 \times F$ " in the Expression (1) represents the frictional force
 25 that is caused by the piston 19 and the fixed portion 5, and the μ_1 represents the coefficient of friction in the contact surfaces of the piston 19 and the fixed portion 5.

[0039] Accordingly, the Expression (1) shows a condition in which the piston 19 can be moved in a case where the torque is applied to the respective tooth surfaces 27, 28 in a state where the thrust generation mechanism 22 does not press the piston 19.

Because the return spring 23 always presses the piston 19, the spring force of the return spring 23 may be added to the left-hand side of the Expression (1).

[0040] When the second brake B2 has the above-described configuration, it is possible to allow the load to act on the piston 19 and release the second brake B2 by controlling the torque that is transmitted by the first brake B1. Specifically, when the transmission torque capacity of the first brake B1 is increased with the forward first speed set, the first brake B1 is in charge of a reaction force torque corresponding to the transmission torque capacity. Accordingly, the torque that is applied to the second brake B2 is gradually reduced. In other words, the first brake B1 and the second brake B2 are in charge of the reaction force torque. When the transmission torque capacity of the first brake B1 is further increased, the positive torque is transmitted to the second carrier 16 and the direction of the meshing of the second brake B2 is reversed. When the direction of the meshing of the second brake B2 is reversed as described above, the tooth surfaces 27, 28 are brought into contact with each other and the second brake B2 is released. Even when the meshing of the second brake B2 is reversed, the rotation speed of each rotating element does not change until the second brake B2 is released. Accordingly, the first brake B1 is in a slip state. In addition, the separation of the piston 19 from the second carrier 16 can be suppressed, because the thrust generation mechanism 22 is provided, although the load acts on the second brake B2 to release the piston 19 during reverse traveling or an engine brake operation. In other words, another friction brake or the like does not have to be disposed.

[0041] Next, an example of the control that is performed by the ECU 18 in the control device for a transmission having the above-described configuration will be described with reference to the flowchart illustrated in FIG. 1. The flowchart illustrated in FIG. 1 is repeatedly executed at predetermined time intervals. According to the example illustrated in FIG. 1, it is determined first whether or not a request for the shifting from the forward first speed to the forward second speed is present (Step S1). Specifically, it is determined whether or not the request for the shifting from the forward first speed to the forward second speed is present in accordance with the vehicle speed and the accelerator

opening as described above or it is determined whether or not the request for the shifting is present in accordance with a shift lever position, various switch operations, or the like. When the upshift is requested in a state where an accelerator pedal is depressed, it is preferable to improve the shift response. Accordingly, this control may be initiated in a case where the request for the shifting from the forward first speed to the forward second speed is present with the vehicle speed becoming equal to or greater than a predetermined vehicle speed in a state where the accelerator pedal is depressed. In a case where the request for the shifting from the forward first speed to the forward second speed is absent and a negative determination is made in Step S1, this routine is temporarily terminated as it is.

[0042] In a case where the request for the shifting from the forward first speed to the forward second speed is present and a positive determination is made in Step S1, in contrast, the transmission torque capacity of the first brake B1 is increased (Step S2) so as to reduce the torque that is applied to the second brake B2. In Step S2, the transmission torque capacity of the first brake B1 is increased so that the forward first speed can be set with the reaction force torque caused by the first brake B1 alone. Accordingly, in this case, a target value of the transmission torque capacity for the first brake B1 is a value that is determined based on the torque transmitted to the input shaft 10 and the rotation speed thereof, the vehicle speed, and the gear ratio at the forward first speed.

[0043] In addition, the hydraulic pressure of the hydraulic actuator 24 that controls the second brake B2 is reduced (Step S3). In other words, the thrust that acts on the piston 19 is reduced. Specifically, oil is discharged from a hydraulic pressure chamber of the hydraulic actuator 24. In Step S3, the hydraulic pressure may be controlled and reduced at the same time or, simply, the oil may be drained. In addition, Step S3 may be initiated prior to Step S2 or Step S2 and Step S3 may be initiated at the same time.

[0044] The hydraulic actuator 24 has irregularities in hydraulic pressure reduction speed due to a factor such as processing precision and temperature. Accordingly, the length of time taken for the complete separation of the piston 19 may vary when the piston

19 is separated by the spring force of the return spring 23 alone. Accordingly, this control device for a transmission is configured to press the piston 19 to the release side by transmitting the positive torque to the second carrier 16 and applying the torque to the respective tooth surfaces 27, 28 a predetermined period of time after the torque applied to the second brake B2 is reduced to the extent that the piston 19 can be moved by the spring force of the return spring 23. Accordingly, it is determined whether or not a predetermined period of time determined in advance has elapsed since the initiation of Step S2 and Step S3 (Step S4) with regard to Step S2 and Step S3 described above. The predetermined period of time pertaining to Step S4 is determined to be a period of time that is shorter than the minimum period of time in which the piston 19 is likely to be completely separated from the second carrier 16 without contact between the tooth surfaces 27, 28. In other words, the predetermined period of time is determined so that the determination of Step S4 is established before the release of the respective dog teeth 20, 21 by the pressing of the piston 19 with the spring force of the return spring 23 alone.

[0045] In a case where a negative determination is made in Step S4 as the predetermined period of time has not elapsed since the initiation of the shift control, Step S2 and Step S3 are repeatedly executed until the elapse of the predetermined period of time. In contrast, in a case where a positive determination is made in Step S4 as the predetermined period of time has elapsed since the initiation of the shift control, the transmission torque capacity of the first brake B1 is increased (Step S5) so that the positive torque acts on the second carrier 16. In other words, the transmission torque capacity of the first brake B1 is increased so that a torque for releasing the second brake B2 is applied to the second brake B2. Specifically, the length of time required for the complete separation after the second carrier 16 begins to press the piston 19 is obtained, and the transmission torque capacity of the first brake B1 is calculated so that the piston 19 can be separated during the predetermined period of time. The length of time required for the complete separation after the second carrier 16 begins to press the piston 19 can be determined based on the accelerator opening, an engine load, an engine rotation speed, a turbine rotation speed, or the like. In addition, the axial load acts on the piston 19, in

accordance with the torque transmitted to the second carrier 16, as described above. Accordingly, it is possible to obtain the load that acts on the piston 19 based on the predetermined period of time determined as described above and the amounts of meshing of the respective dog teeth 20, 21 calculated by design or computation when the
5 predetermined period of time elapses and calculate the transmission torque capacity of the first brake B1 based on the load. As illustrated in FIG. 2, a map using the length of time required for the complete separation after the piston 19 begins to be pressed and the transmission torque capacity of the first brake B1 as parameters may be prepared in advance.

10 **[0046]** When the transmission torque capacity of the first brake B1 is increased with the shifting from the forward first speed to the forward second speed initiated as described above, the torque that is applied to the second brake B2 is gradually reduced, and the torque is applied to the second brake B2 for the release of the second brake B2 as the transmission torque capacity of the first brake B1 is further increased after the reduction of
15 the amounts of meshing of the respective dog teeth 20, 21. In other words, the torque is applied to the tooth surfaces 27, 28. When the torque is applied to the second brake B2 as described above, the second brake B2 is released for a transition to an inertia phase. Accordingly, it is determined whether or not the transition to the inertia phase has been performed in Step S5 (Step S6). Specifically, it is determined whether or not the rotation
20 speed of the input shaft 10 has begun to change because the rotation speed of the second sun gear 12 begins to be reduced to become close to "0" and the rotation speed of the input shaft 10 begins to be reduced when the second brake B2 is released. This determination is to promptly initiate inertia phase control by determining that the second brake B2 is released.

25 **[0047]** In a case where the transition to the inertia phase has yet to be made, for example, in a case where only a short period of time has passed since the initiation of the shift control, and a negative determination is made in Step S6, Step S6 is repeatedly executed until the transition to the inertia phase. In the case of the transition to the inertia phase and a positive determination in Step S6, in contrast, the control of the inertia phase is

initiated (Step S7) and this routine is temporarily terminated. In the inertia phase, the rotation speeds of both the second sun gear 12 and the input shaft 10 change and no torque is transmitted to a drive wheel. Accordingly, the output of the engine 3 is reduced because the engine 3 is blown when the output of the engine 3 is high. In addition, in a case where the transmission torque capacity of the first brake B1 is small, the torque does not act to reduce the rotation speed of the engine 3 and the length of time taken until the transmission torque capacity of the first brake B1 is increased to a transmission torque capacity required after the shifting increases. Accordingly, the transmission torque capacity of the first brake B1 is set to be almost as high as the transmission torque capacity required after the shifting. Then, after the engine rotation speed (rotation speed of the input shaft 10) is reduced to a rotation speed based on the transmission ratio of the forward second speed and the vehicle speed, the output of the engine 3 is increased to a value corresponding to the required driving force and the first brake B1 is completely engaged not to slip.

[0048] FIG. 3A is a time chart illustrating how the transmission torque of each of the brakes B1, B2 and the torque of the input shaft 10 change during the execution of the control illustrated in FIG. 1. FIG. 3B is a time chart illustrating how the rotation speed of the input shaft 10 and the torque (torque of the second ring gear 17) that is output from the automatic transmission change during the execution of the control illustrated in FIG. 1. In FIG. 3A, the solid line represents the transmission torque (T_{b1}) of the first brake B1, the dashed line represents the transmission torque (T_{b2}) of the second brake B2, and the one-dot chain line represents the torque (T_t) of the input shaft 10. In FIG. 3B, the solid line represents the rotation speed (N_t) of the input shaft 10 and the dashed line represents the torque (T_o) of the second ring gear 17. In FIG. 3A, in addition, the direction in which each of the brakes B1, B2 functions as the reaction force while increasing the driving force is illustrated as having a positive value. In other words, at the forward first speed, the second brake B2 functions as the reaction force as described above, and thus has a value exceeding "0".

[0049] As illustrated in FIG. 3A, the transmission torque of the second brake B2

begins to be reduced by the same amount when the shifting from the forward first speed to the forward second speed is initiated and the transmission torque of the first brake B1 begins to increase. According to FIG. 3A, the transmission torque of the first brake B1 is proportionally changed. However, the manner of the change is not particularly limited thereto. In addition, when the first brake B1 begins to transmit the torque as described above, a transition to a torque phase is made, and thus the torque transmitted to the second ring gear 17 is reduced as a result of the increase in the transmission torque of the first brake B1.

[0050] When the transmission torque of the first brake B1 reaches a predetermined magnitude (time t1), the transmission torque of the second brake B2 becomes "0". When the piston 19 is moved by at least a predetermined amount in the direction of the separation from the second carrier 16 in this case, the transmission torque of the first brake B1 is further increased (time t2) because of the positive determination in Step S4 described above. As a result, the meshing of the second brake B2 is changed as described above and the piston 19 is released. In a case where a torque acts to release the second brake B2, the torque of the second brake B2 acts to reduce the torque of the second ring gear 17, and thus the torque of the second ring gear 17 is temporarily reduced during the release of the second brake B2.

[0051] When the second brake B2 is released as described above, the first brake B1 slips and the transmission torque capacity of the first brake B1 is set for the torque for releasing the second brake B2 to be applied. Accordingly, the rotation speed of the input shaft 10 begins to be reduced (time t3) promptly after the release of the second brake B2. In other words, the transition to the inertia phase is made. Accordingly, the control of the inertia phase is initiated and the transmission torque capacity of the first brake B1 is changed in accordance with the torque of the input shaft 10 while the torque of the input shaft 10 is reduced so as to suppress the blowing of the engine 3. Also, the torque of the input shaft 10 can be changed by changing the degree of throttle opening in the engine 3. According to FIG. 3A, the transmission torque of the first brake B1 is reduced after the time t2. Point is, however, suppressing the blowing of the engine 3 may be performed by

keeping a balance between the torque of the input shaft 10 and the transmission torque of the first brake B1, and thus the transmission torque of the first brake B1 can be maintained at the same value as at the time t2 when the torque of the input shaft 10 is increased to exceed that in FIG. 3A.

5 **[0052]** When the rotation speed of the input shaft 10 is reduced to the rotation speed that is calculated based on the vehicle speed and the gear ratio at the forward second speed, the torque of the input shaft 10 is controlled to a torque corresponding to the required driving force and the first brake B1 is completely engaged. According to FIG. 3A, which illustrates the transmission torque of the first brake B1, the transmission torque
10 of the first brake B1 does not change even when the transmission torque capacity of the first brake B1 is increased to the maximum value after the shifting to the forward second speed.

[0053] When the transmission torque capacity of the first brake B1 that sets the transmission stage after the shifting is increased by forming the inclined surface in the
15 piston 19 in the second brake B2 as described above, the torque is applied to the second brake B2 so that the piston 19 is released and the second brake B2 can be released. In addition, the transition to the inertia phase can be made promptly after the release of the second brake B2. Accordingly, time is not required for determining that the torque applied to the second brake B2 is reduced and determining that the second brake B2 is
20 released, and thus the shift response can be improved. In addition, the second brake B2 can be released by controlling the transmission torque capacity of the first brake B1, and thus an increase in the complexity of the control, such as the cooperation between the control for releasing the second brake B2 and the control for changing the transmission torque capacity of the first brake B1, can be suppressed. Moreover, the speed at which
25 the piston 19 is moved can be improved since the second brake B2 is released by the second carrier 16 pressing the piston 19. As a result, the length of time taken until the completion of the release of the second brake B2 after the second brake B2 begins to be released can be shortened. Accordingly, the shift response can be further improved. In addition, an increase in the size of the control device for a transmission can be suppressed

since no other device for releasing the second brake B2 has to be disposed. In addition, the length of time taken for the release of the second brake B2 can be inhibited from varying, that is, the length of time taken for the transition to the inertia phase after the initiation of the shift control can be inhibited from varying, since the second brake B2 is released through the application of the torque to the second brake B2, even in the presence of, for example, a structural irregularity of the thrust generation mechanism 22 pressing the second brake B2 or irregularity in the amount of the oil discharged from the hydraulic actuator 24.

[0054] The first engagement mechanism according to the invention is not limited to being engaged during the setting of the transmission stage (forward first speed) having the maximum transmission ratio. Instead, for example, the first engagement mechanism according to the invention may be an engagement mechanism that is engaged during the setting of the forward second speed. In other words, the first brake B1 in FIG. 4 may be a mesh-type brake in which inclined surfaces are formed in the dog teeth as illustrated in FIG. 7. In this case, the shifting can be performed by increasing the transmission torque capacity of the third clutch C3 to release the first brake B1 during the shifting from the forward second speed to the forward third speed.

[0055] In addition, the first engagement mechanism according to the invention is not limited to functioning to stop the rotating member. Instead, the first engagement mechanism according to the invention may be configured to function as a so-called clutch for connection between members rotating relative to each other. Specifically, a mesh-type clutch in which the inclined surfaces are formed in the dog teeth as illustrated in FIG. 7 may take the place of the first clutch C1 in FIG. 4. In a case where the mesh-type clutch takes the place of the first clutch C1 as described above, the torque can be exerted to release the first clutch C1 by increasing the transmission torque capacity of the fourth clutch C4 during a transition from the forward fifth speed to the forward sixth speed.

[0056] In the example that has been described above, the upshift from the forward first speed to the forward second speed has been described as an example. However, the invention can also be applied to the case of shifting to a transmission stage higher than the

forward second speed such as upshift from the forward first speed to the forward third speed and upshift from the forward first speed to the forward fourth speed. In a case where the so-called “jump shift” is performed as described above, the transmission torque capacity of the third clutch C3 may be increased during the upshift to the forward third speed and the transmission torque capacity of the fourth clutch C4 may be increased during the upshift to the forward fourth speed.

[0057] In FIG. 7, a configuration in which the dog teeth are formed on the surfaces of the second carrier 16 and the piston 19 that face each other is illustrated as an example. However, as in known dog clutches, the fixed portion 5 and the rotating member may be configured to be engaged with each other by forming dog teeth on the outer circumferential surface of the rotating member and moving a sleeve which meshes with the dog teeth in the axial direction.

[0058] Moreover, the transmission according to the invention is not limited to setting the transmission stage by engaging the rotating elements of the planetary gear mechanisms with each other as illustrated in FIG. 4 or fixing any one of the rotating elements. Instead, the transmission may be a transmission having the configuration described in JP 2002-174335 A, that is, a configuration in which a plurality of gears are connected to an input shaft to be capable of relative rotation, any one of the gears and the input shaft are engaged with each other by a dog clutch for the setting of a predetermined transmission stage, and the other gear and the input shaft are engaged with each other by a friction clutch for shifting to a desired transmission stage which has a lower transmission ratio than the predetermined transmission stage.

CLAIMS:

1. A control device for a transmission, the transmission having multiple transmission stages and including a first engagement mechanism and a second engagement mechanism, the first engagement mechanism including a first member and a second member, the first member being provided with first dog teeth, the first dog teeth including first tooth surfaces directed to one side in a circumferential direction and second tooth surfaces directed to the other side in the circumferential direction, the second member being provided with second dog teeth, the second dog teeth including third tooth surfaces facing the first tooth surfaces and fourth tooth surfaces facing the second tooth surfaces, the second member being configured to be moved in an axial direction such that the second dog teeth mesh with the first dog teeth, the first engagement mechanism being configured to transmit a torque between the first member and the second member when the second dog teeth mesh with the first dog teeth, the second engagement mechanism including a third member and a fourth member, the second engagement mechanism being configured to perform switching between a state where the third member and the fourth member rotate relative to each other and a state where the third member and the fourth member are connected to each other for torque transmission, the second engagement mechanism being configured to change a capacity of the torque transmission between the third member and the fourth member during the connection, the transmission being configured to set a first transmission stage among the multiple transmission stages by engaging the first engagement mechanism and releasing the second engagement mechanism, the transmission being configured to set a second transmission stage having a transmission ratio lower than the transmission ratio of the first transmission stage by releasing the first engagement mechanism and engaging the second engagement mechanism, the transmission being configured to reverse the direction of a torque acting on the first member or the second member as a result of an increase in the capacity of the torque transmission of the second engagement mechanism when the second engagement mechanism is engaged, and the first tooth surfaces and the third tooth surfaces being inclined surfaces such that a thrust for

separating the first member and the second member from each other in the axial direction is generated in accordance with a torque in a direction in which the first tooth surfaces and the third tooth surfaces are brought into contact with each other when the second transmission stage is set, the control device comprising:

an electronic control unit configured to control the second engagement mechanism when the second transmission stage is set such that the capacity of the torque transmission of the second engagement mechanism is increased and the thrust for separating the first member and the second member from each other in the axial direction is generated.

2. The control device according to claim 1, wherein

the electronic control unit is configured to calculate a length of time required for separating the second member from the first member when the second transmission stage is set, and

the electronic control unit is configured to control the capacity of the torque transmission of the second engagement mechanism based on the calculated length of time.

3. The control device according to claim 1 or 2, wherein the first engagement mechanism includes a brake mechanism.

4. The control device according to any one of claims 1 to 3, wherein

the first member and the second member are configured to rotate relative to each other, and

the first engagement mechanism is configured to connect the first member and the second member to each other for integral rotation with the first dog teeth and the second dog teeth meshing with each other.

5. The control device according to any one of claims 1 to 4, wherein

the first engagement mechanism includes a thrust generation mechanism configured to control a load for pressing the second member to the first member side, and

the thrust generation mechanism is configured to reduce the load by which the second member is pressed to the first member side when the second transmission stage is set.

6. The control device according to any one of claims 1 to 5, wherein the transmission includes a third engagement mechanism engaged when the first transmission stage is set and when the second transmission stage is set.

7. The control device according to any one of claims 1 to 6, wherein
the transmission includes a first planetary gear mechanism and a second planetary gear mechanism,

each of the first planetary gear mechanism and the second planetary gear mechanism includes at least three rotating elements, and

the first engagement mechanism and the second engagement mechanism are configured to connect the rotating elements of any one of the first planetary gear mechanism and the second planetary gear mechanism to each other or fix the rotating elements of any one of the first planetary gear mechanism and the second planetary gear mechanism.

FIG. 1

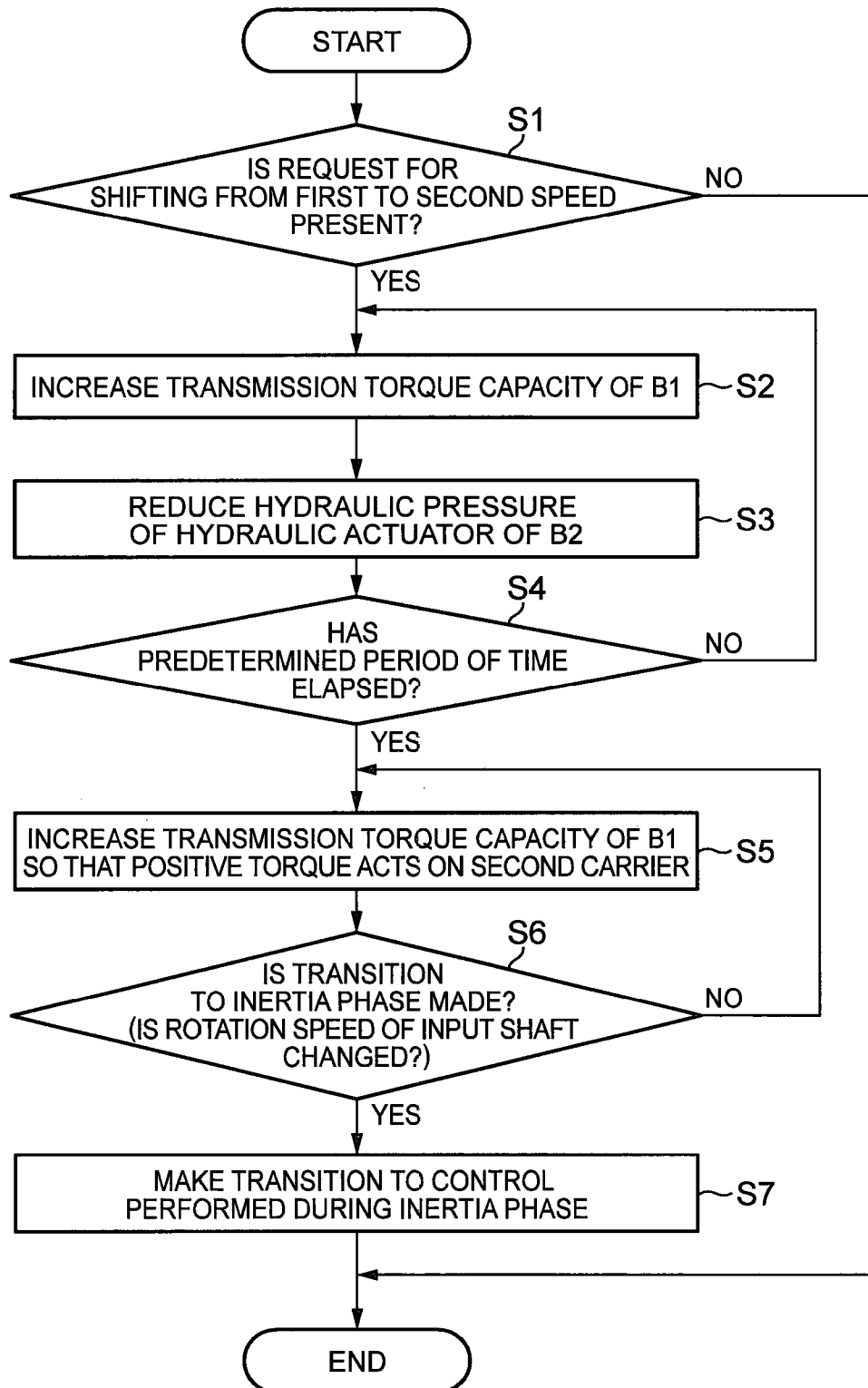


FIG. 2

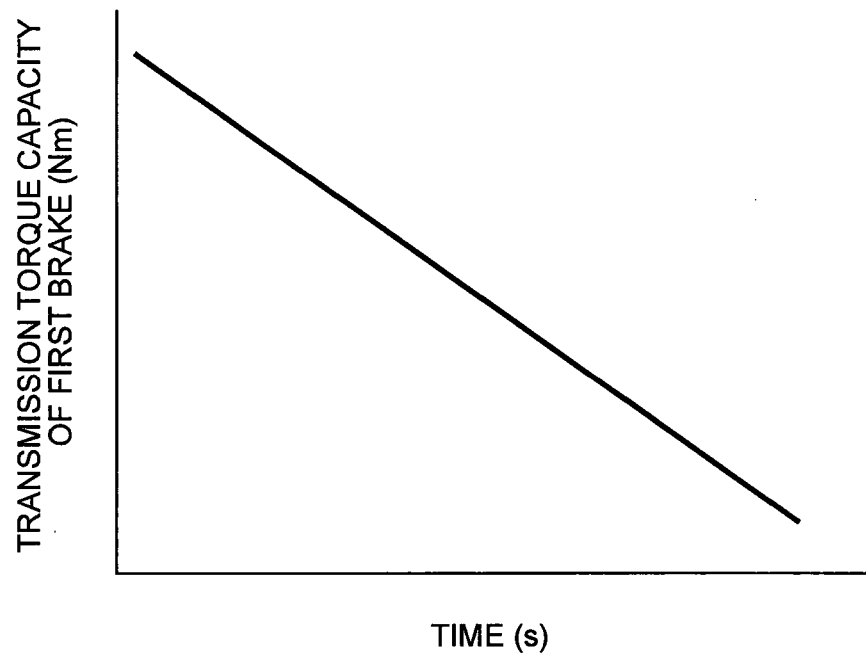


FIG. 3A

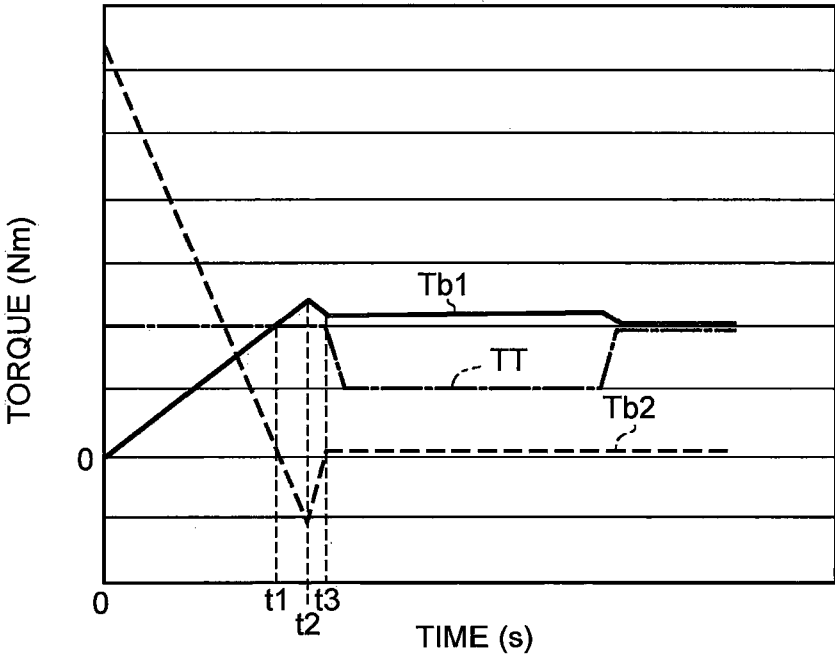


FIG. 3B

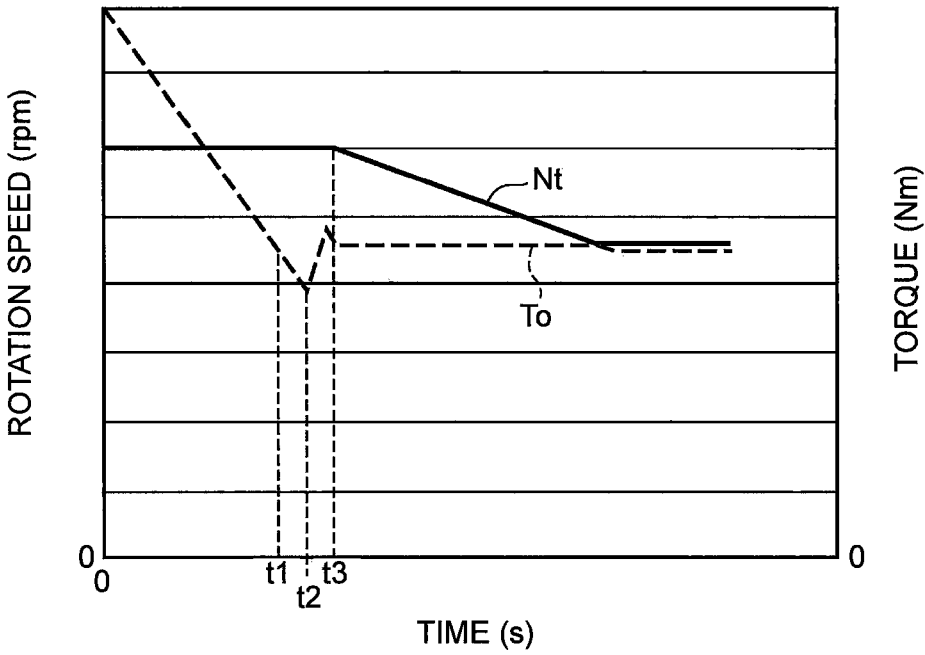


FIG. 4

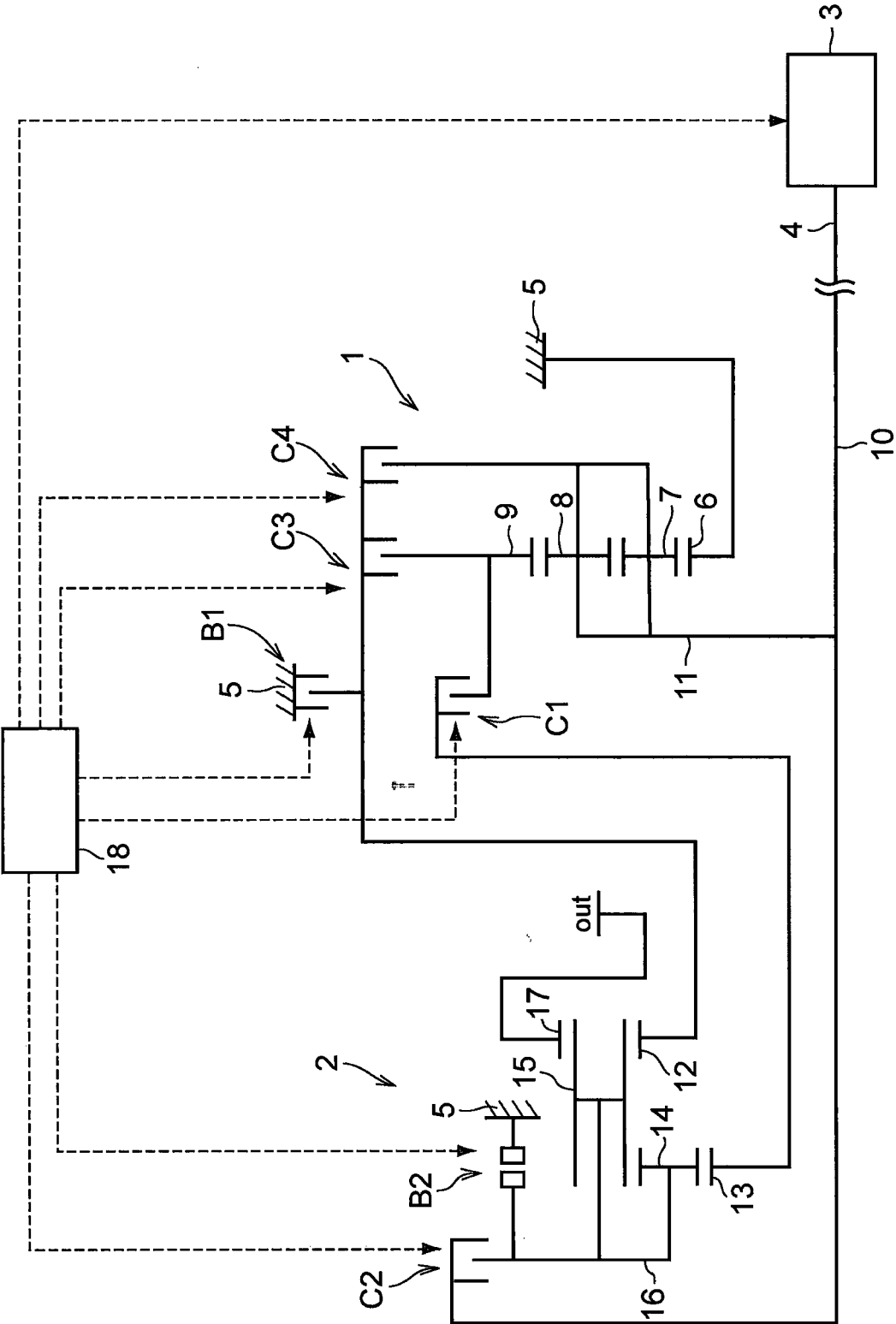


FIG. 5

TRANSMISSION STAGE	C1	C2	C3	C4	B1	B2
1st	○	—	—	—	—	○
2nd	○	—	—	—	○	—
3rd	○	—	○	—	—	—
4th	○	—	—	○	—	—
5th	○	○	—	—	—	—
6th	—	○	—	○	—	—
7th	—	○	○	—	—	—
8th	—	○	—	—	○	—
Revs1	—	—	○	—	—	○
Revs2	—	—	—	○	—	○

○ : ENGAGED
 — : RELEASED

FIG. 6

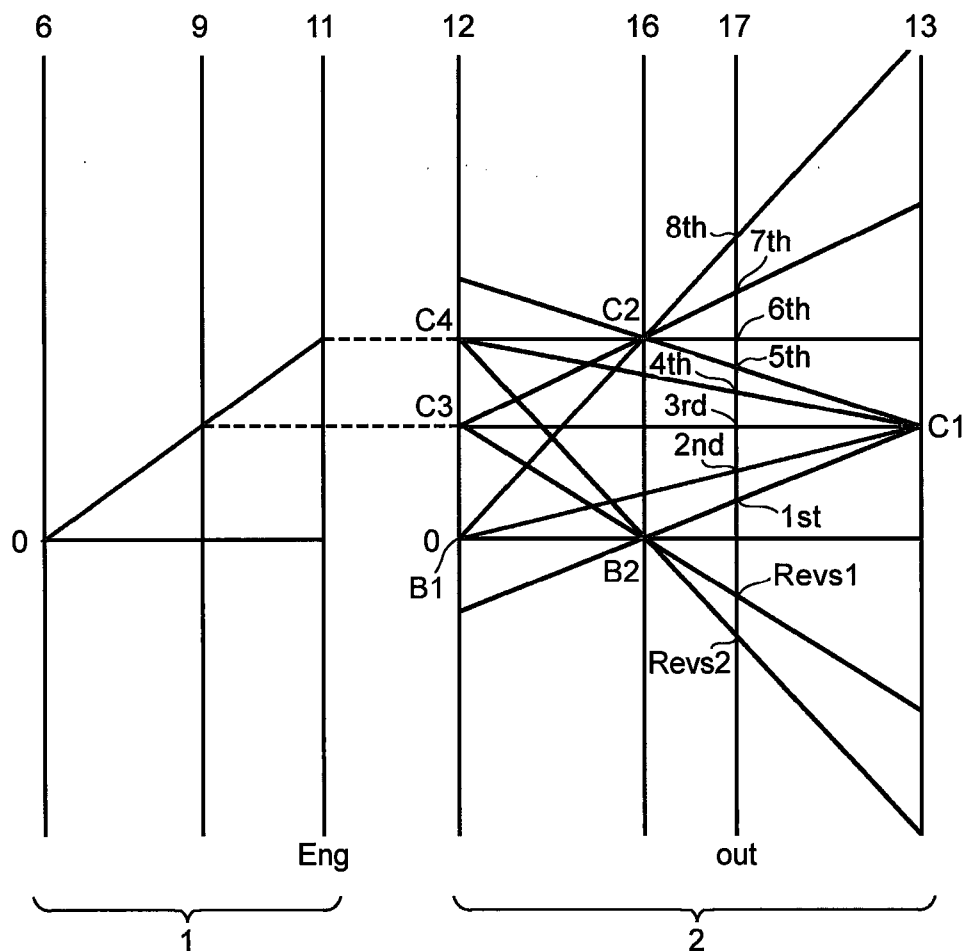
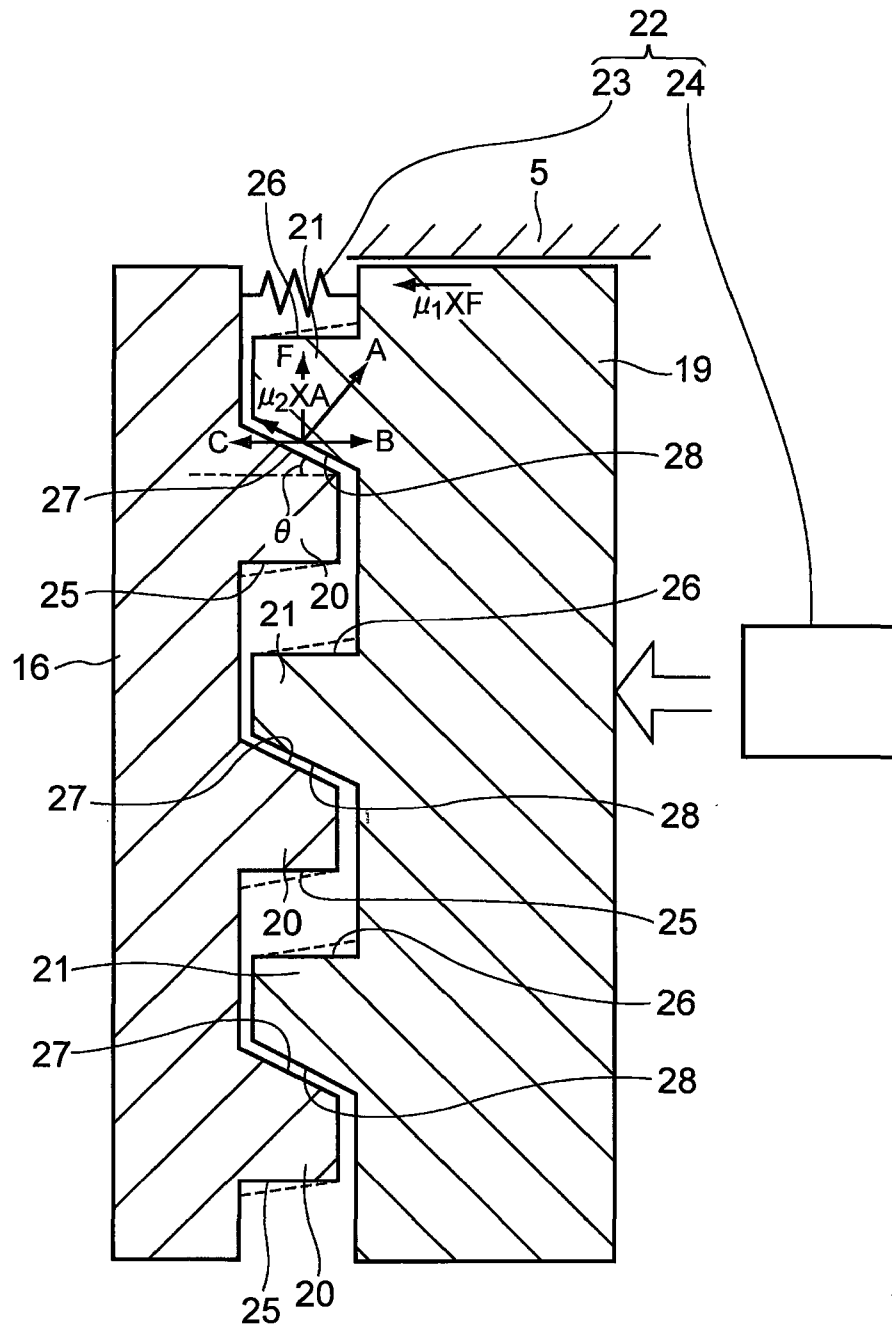


FIG. 7



INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2015/001170

A. CLASSIFICATION OF SUBJECT MATTER

INV. F16H61/04 F16H61/686
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 F16D

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	US 2004/152563 A1 (DREIBHOLZ RALF [DE] ET AL) 5 August 2004 (2004-08-05)	1,3-6
A	abstract paragraphs [0039] - [0041] -----	2
X	US 2012/283064 A1 (HERBETH VALENTINE [DE] ET AL) 8 November 2012 (2012-11-08)	1,3-7
A	the whole document -----	2
A	US 2012/024652 A1 (ISHII DAISUKE [JP] ET AL) 2 February 2012 (2012-02-02)	1-7
	paragraphs [0123] - [0128]; figures -----	
A	US 5 699 871 A (HARA TOMOYUKI [JP] ET AL) 23 December 1997 (1997-12-23)	1-7
	column 32, line 50 - column 36, line 43; figures 29-35 -----	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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"P" document published prior to the international filing date but later than the priority date claimed

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

24 September 2015

Date of mailing of the international search report

06/10/2015

Name and mailing address of the ISA/

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Authorized officer

Meritano, Luciano

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2015/001170

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