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(54) **PLANETARY GEAR TRAIN OF AUTOMATIC TRANSMISSION FOR VEHICLE**

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F16H 3/44 (2006.01)
F16H 37/06 (2006.01)
F16H 3/66 (2006.01)

(52) **U.S. Cl.**

CPC ***F16H 3/66*** (2013.01); *F16H 2200/0069* (2013.01); *F16H 2200/2015* (2013.01); *F16H 2200/2046* (2013.01)

(58) **Field of Classification Search**

CPC F16H 2200/2015; F16H 2200/2046
See application file for complete search history.

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(57) **ABSTRACT**

A planetary gear train apparatus of automatic transmission may include input and output shafts first to fifth planetary gear sets respectively having first to third, fourth to sixth, seventh to ninth, tenth to twelfth, and thirteenth to fifteenth elements, first shaft fixed to the third element and the input shaft, second shaft fixed to the fourteenth element and the output shaft, third shaft fixed to the first and fourth elements, fourth shaft fixed to the second, eighth, and fifteenth elements, fifth shaft fixed to the fifth element, sixth shaft fixed to the sixth, ninth element, and eleventh elements, and shafts, each of which is selectively connectable to housing and fixed to element of the third, fourth, and fifth planetary gear sets which is not fixed to the first to sixth shafts.

18 Claims, 4 Drawing Sheets

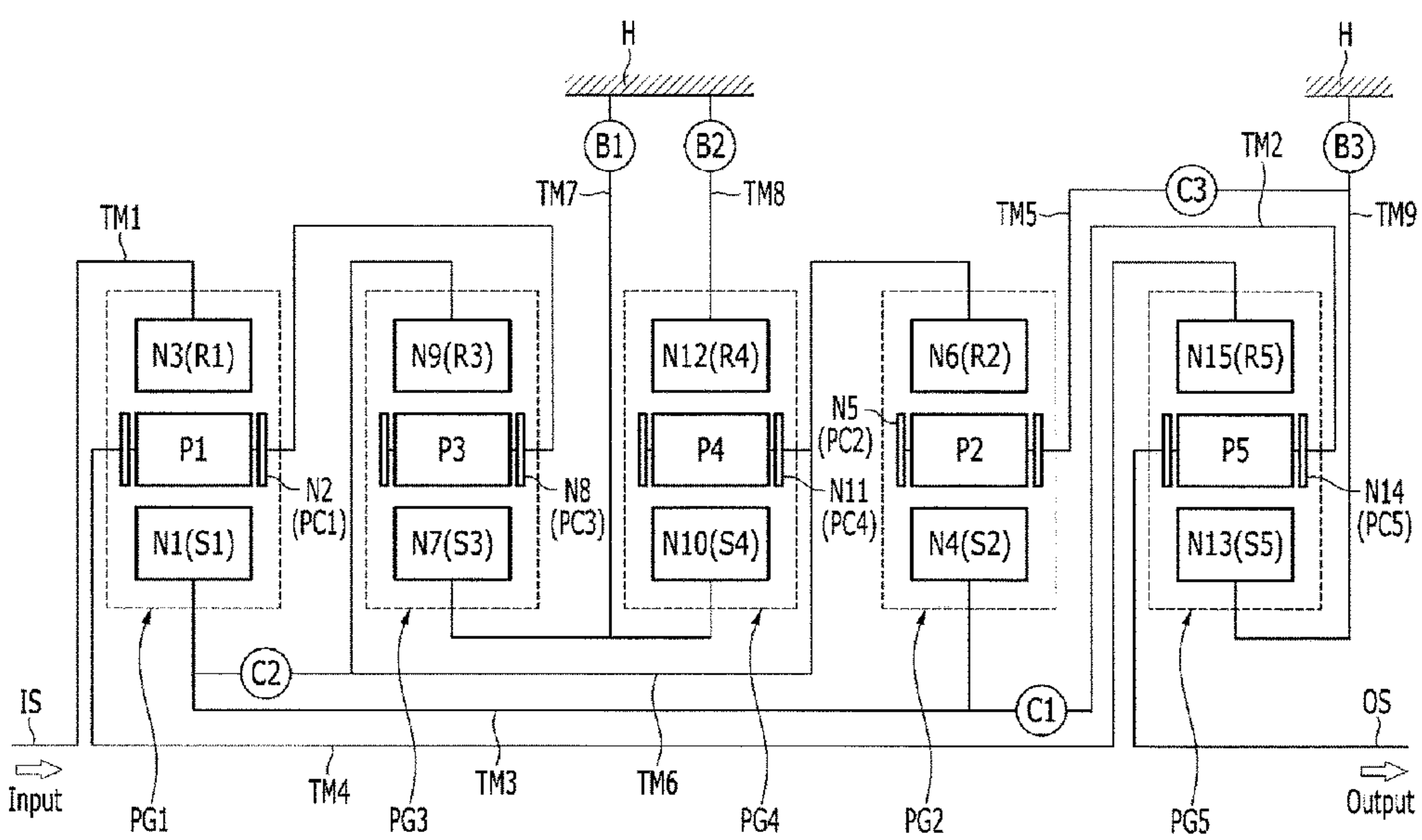


FIG. 1

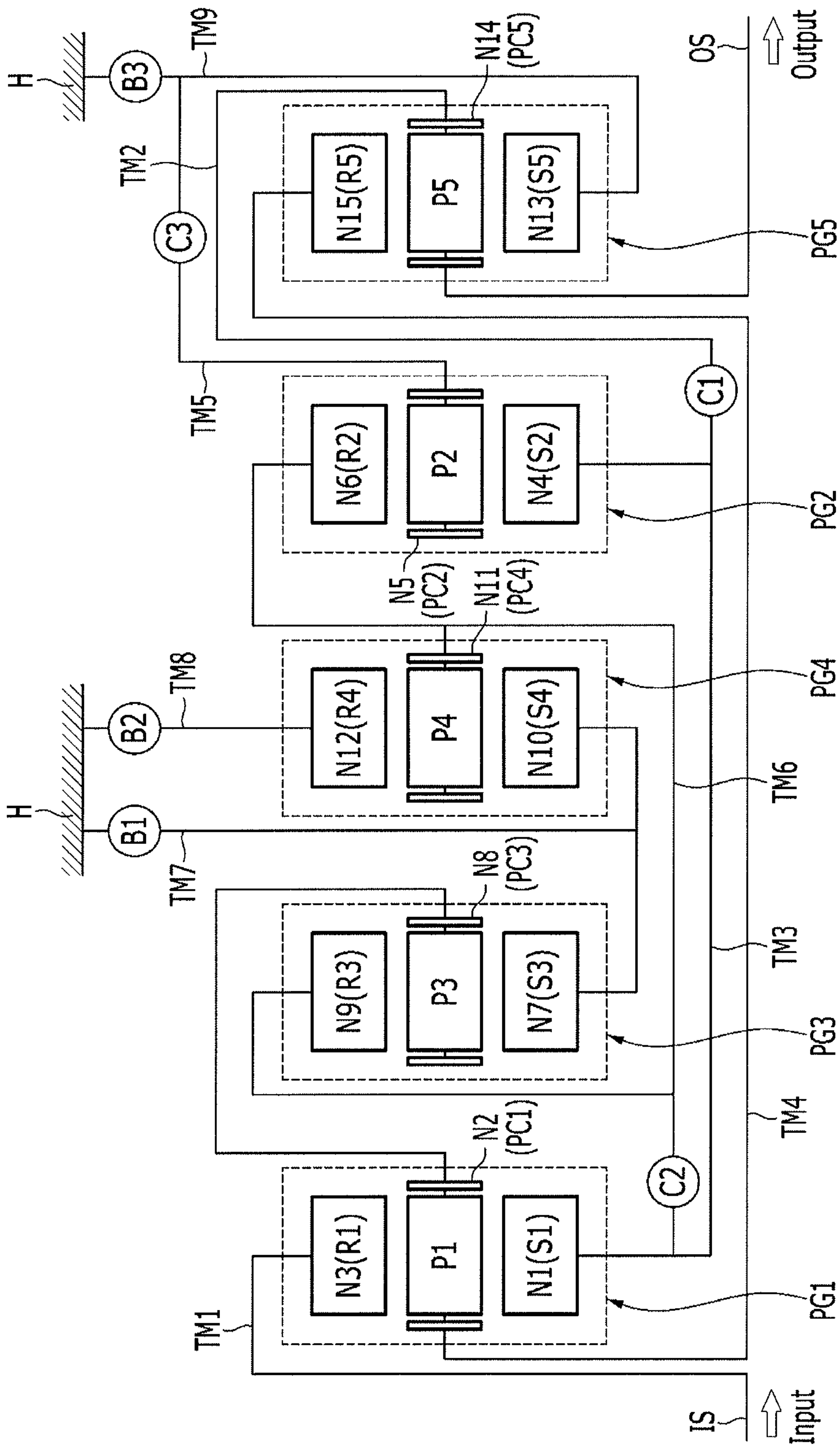
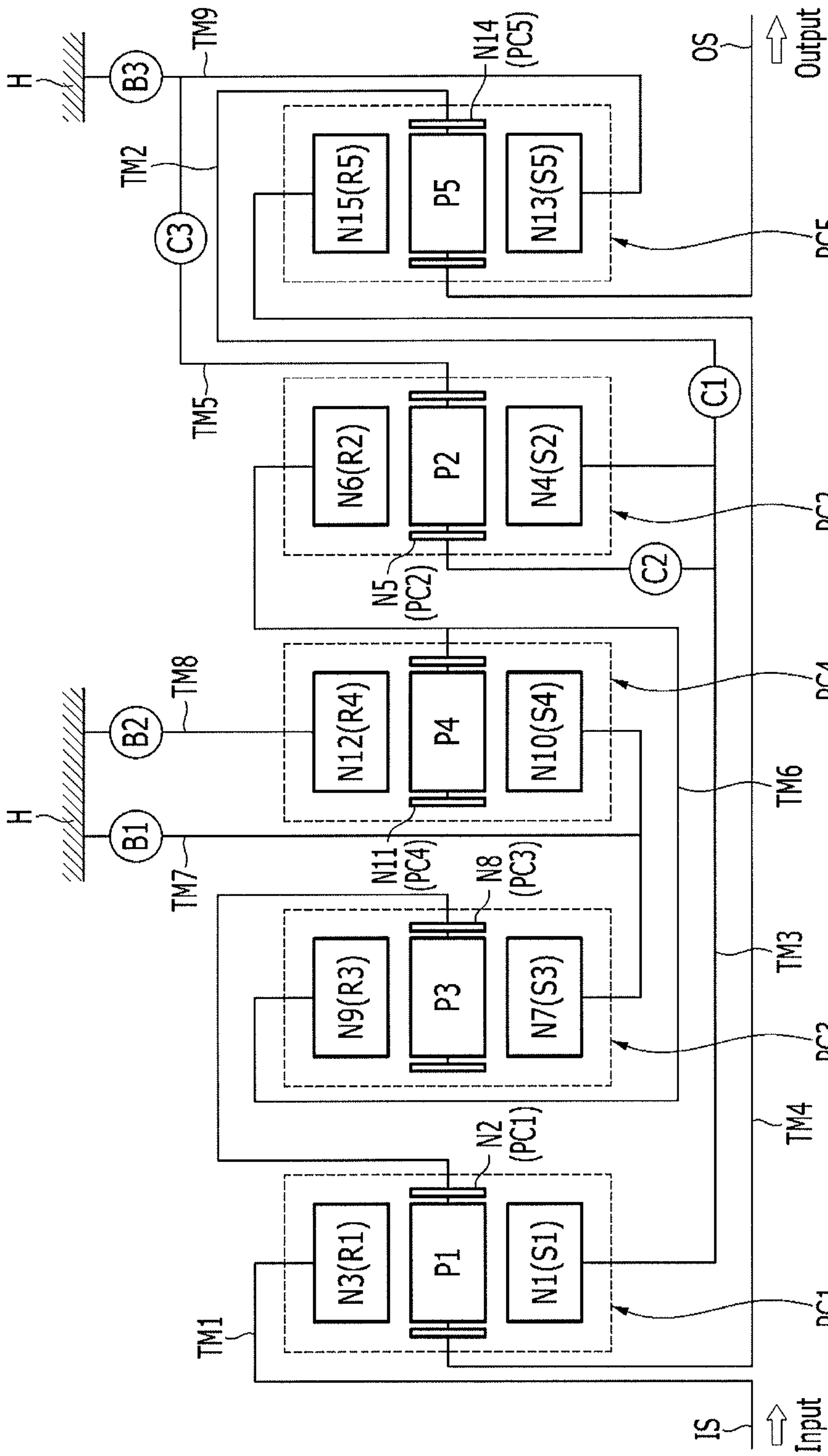

H
B3
TM9
N14
(PC5)
OS
Output
TM2
N15(R5)
P5
N13(S5)
C3
PG5
TM5
C1
N6(R2)
P2
N4(S2)
PG2
N5
(PC2)
N11
(PC4)
PG4
TM8
B2
N12(R4)
P4
N10(S4)
H
B1
TM6
TM7
N8
(PC3)
N9(R3)
P3
N7(S3)
TM3
PG3
N2
(PC1)
TM4
C2
N3(R1)
P1
N1(S1)
PG1
TM1
IS
Input

FIG. 2

Shift-stage	Engagement element						Gear ratio	Step ratio	Remakr
	C1	C2	C3	B1	B2	B3			
D1			●	●		●	4.820	-	Gear ratio span : 8.8 Gear ratio of R/D1 : 1.0
D2			●		●	●	3.375	1.428	
D3		●	●			●	2.356	1.433	
D4		●			●	●	1.872	1.259	
D5		●	●		●		1.430	1.309	
D6	●		●		●		1.190	1.202	
D7	●	●	●				1.000	1.190	
D8	●		●	●			0.848	1.179	
D9		●	●	●			0.679	1.249	
D10	●	●		●			0.550	1.235	
REV			●	●	●		-4.858	-	

FIG. 3


H
B3
TM9
N14
(PC5)
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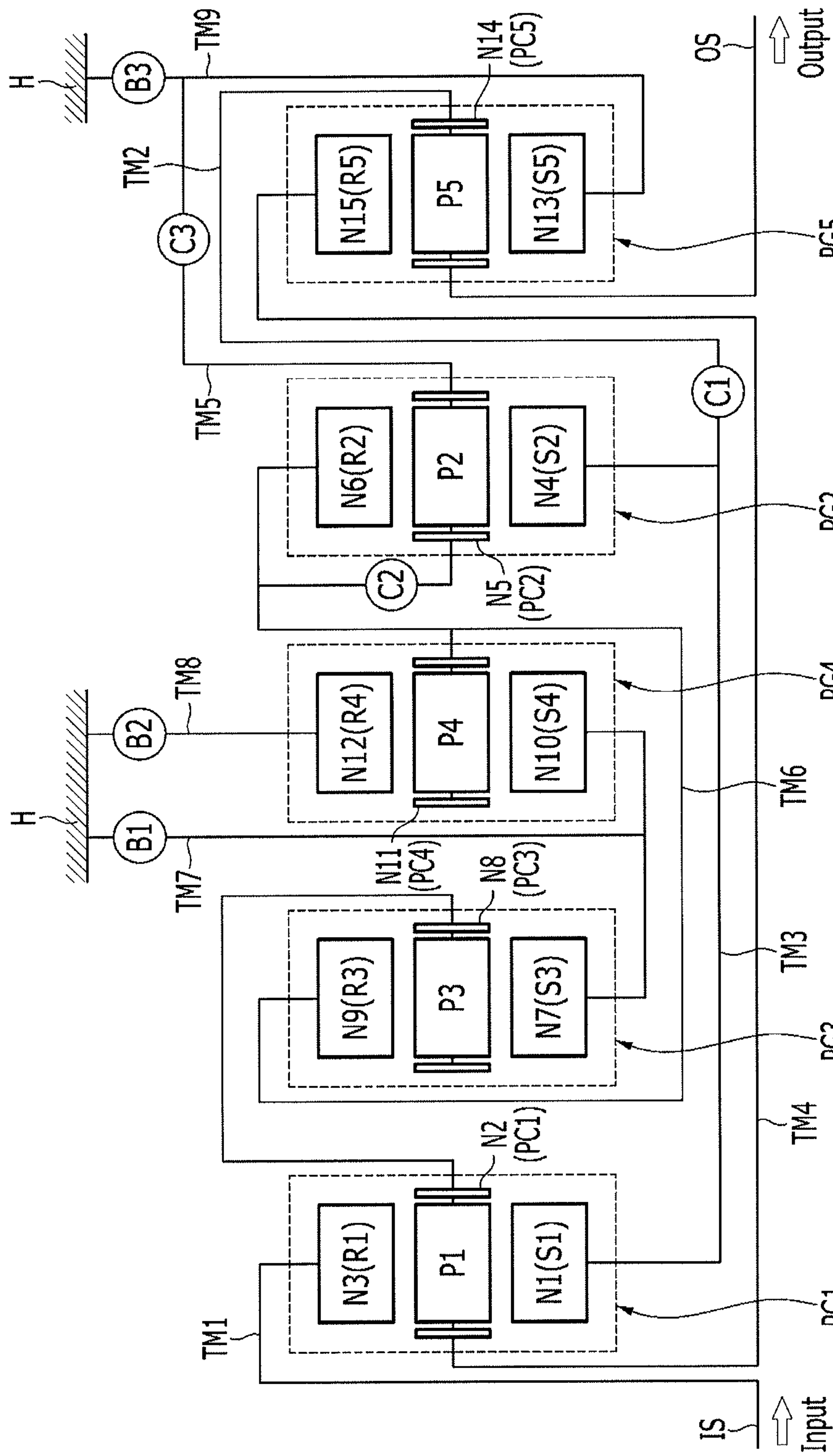
Output
TM2
N15(R5)
P5
N13(S5)
C3
PG5
C1
TM5
N6(R2)
P2
N4(S2)
PG2
N5
(PC2)
C2
TM8
B2
N12(R4)
P4
N10(S4)
PG4
H
B1
TM6
N11
(PC4)
N8
(PC3)
TM7
N9(R3)
P3
N7(S3)
TM3
PG3
N2
(PC1)
TM4
TM1
N3(R1)
P1
N1(S1)
PG1
IS
Input

FIG. 4


H
B3
TM9
N14
(PC5)
OS
Output
TM2
N15(R5)
P5
N13(S5)
C3
PG5
TM5
C1
N6(R2)
P2
N4(S2)
PG2
C2
N5
(PC2)
PG4
H
TM8
B2
N12(R4)
P4
N10(S4)
TM6
B1
TM7
N11
(PC4)
N8
(PC3)
N9(R3)
P3
N7(S3)
TM3
PG3
N2
(PC1)
TM4
TM1
N3(R1)
P1
N1(S1)
PG1
IS
Input

PLANETARY GEAR TRAIN OF AUTOMATIC TRANSMISSION FOR VEHICLE

CROSS-REFERENCE TO RELATED APPLICATION

The present application claims priority to Korean Patent Application No. 10-2017-0165920 filed on Dec. 5, 2017, the entire contents of which is incorporated herein for all purposes by this reference.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an automatic transmission for a vehicle.

Description of Related Art

In the field of an automatic transmission, more multiplicity of shift-stages is useful technology for enhancement of fuel consumption and drivability of a vehicle.

Achieving more shift stages contributes to maximize performance and efficiency of a vehicle in a so-called downsizing trend of an engine, and more linearity in step ratios of the shift-stages enhances drivability of the vehicle by improving uniformity of acceleration before and after a shifting, etc.

To achieve more shift-stages for an automatic transmission, the number of parts is typically increased, which may deteriorate installability, production cost, weight and/or power flow efficiency.

Therefore, to maximally enhance fuel consumption of an automatic transmission having more shift-stages, it is important that better efficiency is derived by less number of parts.

In this background, an eight-speed automatic transmission has been introduced recently and a planetary gear train for an automatic transmission facilitating more shift-stages is under investigation.

A recent eight-speed automatic transmission typically shows a gear ratio span, which is a significant factor for linearity of step ratios, in a level of 6.5 to 7.5, which may require improvement for better fuel consumption.

In addition, an eight-speed automatic transmission may become inferior in respect of linearity of step ratios of shift-stages even if the gear ratio span may become a level of above 9.0. Thus, high efficiency automatic transmission providing at least nine forward speeds may be more appropriate for enhancing driving efficiency and drivability of a vehicle.

The information disclosed in this Background of the Invention section is only for enhancement of understanding of the general background of the invention and may not be taken as an acknowledgement or any form of suggestion that this information forms the prior art already known to a person skilled in the art.

BRIEF SUMMARY

Various aspects of the present invention are directed to providing a planetary gear train of an automatic transmission for a vehicle facilitating at least ten forward speeds, providing better performance and fuel efficiency of a vehicle.

An exemplary planetary gear train of an automatic transmission for a vehicle may include an input shaft receiving an input torque, an output shaft outputting a shifted torque, a first planetary gear set having first, second, and third rotation elements, a second planetary gear set having fourth, fifth, and sixth rotation elements, a third planetary gear set having seventh, eighth, and ninth rotation elements, a fourth planetary gear set having tenth, eleventh, and twelfth rotation elements, a fifth planetary gear set having thirteenth, fourteenth, and fifteenth rotation elements, a first shaft fixedly connected to the third rotation element and the input shaft, a second shaft fixedly connected to the fourteenth rotation element and the output shaft, a third shaft fixedly connected to the first rotation element and the fourth rotation element, a fourth shaft fixedly connected to the second rotation element, the eighth rotation element, and the fifteenth rotation element, a fifth shaft fixedly connected to the fifth rotation element, a sixth shaft fixedly connected to the sixth rotation element, the ninth rotation element, and the eleventh rotation element, and a plurality of shafts, each of which is selectively connectable to the transmission housing and fixedly connected to a rotation element of the third, fourth, and fifth planetary gear sets which is not fixedly connected to any of the first to sixth shafts.

The plurality of shafts may include a seventh shaft fixedly connected to the seventh rotation element and the tenth rotation element and selectively connectable to the transmission housing, an eighth shaft fixedly connected to the twelfth rotation element and selectively connectable to the transmission housing, and a ninth shaft fixedly connected to the thirteenth rotation element and selectively connectable to the transmission housing. The second and third shafts and the fifth and ninth shafts are selectively interconnected, and two shafts among the third, fifth, and sixth shafts are selectively interconnected.

The planetary gear train may further include three clutches each selectively connecting a corresponding pair among the input shaft, the output shaft, and the first to ninth shafts, and three brakes selectively connecting the seventh shaft, the eighth shaft, and the ninth shaft to the transmission housing respectively.

The three clutches may include a first clutch disposed between the second shaft and the third shaft, a second clutch disposed between the third shaft and the sixth shaft, and a third clutch disposed between the fifth shaft and the ninth shaft. The three brakes may include a first brake disposed between the seventh shaft and the transmission housing, a second brake disposed between the eighth shaft and the transmission housing, and a third brake disposed between the ninth shaft and the transmission housing.

The three clutches may include a first clutch disposed between the second shaft and the third shaft, a second clutch disposed between the third shaft and the fifth shaft, and a third clutch disposed between the fifth shaft and the ninth shaft. The three brakes may include a first brake disposed between the seventh shaft and the transmission housing, a second brake disposed between the eighth shaft and the transmission housing, and a third brake disposed between the ninth shaft and the transmission housing.

The three clutches may include a first clutch disposed between the second shaft and the third shaft, a second clutch disposed between the fifth shaft and the sixth shaft, and a third clutch disposed between the fifth shaft and the ninth shaft. The three brakes may include a first brake disposed between the seventh shaft and the transmission housing, a second brake disposed between the eighth shaft and the transmission housing, and a third brake disposed between the ninth shaft and the transmission housing.

The first, second, and third rotation elements may be respectively a first sun gear, a first planet carrier, and a first ring gear. The fourth, fifth, and sixth rotation elements may be respectively a second sun gear, a second planet carrier, and a second ring gear. The seventh, eighth, and ninth rotation elements may be respectively a third sun gear, a third planet carrier, and a third ring gear. The tenth, eleventh, and twelfth rotation elements may be respectively a fourth sun gear, a fourth planet carrier, and a fourth ring gear. The thirteenth, fourteenth, and fifteenth rotation elements may be respectively a fifth sun gear, a fifth planet carrier, and a fifth ring gear.

The first, second, third, fourth, and fifth planetary gear sets may be disposed in the order of the first, third, fourth, second, and fifth planetary gear sets from an input side thereof.

As described above, a planetary gear train according to an exemplary embodiment of the present invention may realize ten forward speeds and one reverse speed by operating five planetary gear sets by six engagement elements.

Furthermore, a gear ratio span may be increased to above 8.8 maximizing engine efficiency, and step ratios of shift-stages may become more linear, improving acceleration and engine drivability before and after a shifting.

Furthermore, the number of engagement elements employed to realize ten forward speeds and one reverse speed is minimized, improving power delivery efficiency and fuel consumption by minimizing drag loss of an automatic transmission.

Furthermore, a torque in parallel scheme is employed in a planetary gear set at an output side, and torque loads applied to engagement elements of respective planetary gear sets become more uniform, improving torque delivery efficiency and durability of an automatic transmission.

Furthermore, a minimal number of engagement elements are controlled to realize shifting between shift-stages of ten forward speeds and one reverse speed, and accordingly, reduction of clutch drag, enhancement of torque transmission efficiency, and enhancement of flexibility of output gear ratios, thereby enhancing linearity of step ratios.

The methods and apparatuses of the present invention have other features and advantages which will be apparent from or are set forth in more detail in the accompanying drawings, which are incorporated herein, and the following Detailed Description, which together serve to explain certain principles of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of a planetary gear train according to various exemplary embodiments of the present invention.

FIG. **2** is an operational chart for respective control elements at respective shift-stages applicable to a planetary gear train according to various exemplary embodiments of the present invention.

FIG. **3** is a schematic diagram of a planetary gear train according to various exemplary embodiments of the present invention.

FIG. **4** is a schematic diagram of a planetary gear train according to various exemplary embodiments of the present invention.

It may be understood that the appended drawings are not necessarily to scale, presenting a somewhat simplified representation of various features illustrative of the basic principles of the invention. The specific design features of the present invention as disclosed herein, including, for example, specific dimensions, orientations, locations, and shapes will be determined in part by the particularly intended application and use environment.

In the figures, reference numbers refer to the same or equivalent parts of the present invention throughout the several figures of the drawing.

DETAILED DESCRIPTION

Reference will now be made more specifically to various embodiments of the present invention(s), examples of which are illustrated in the accompanying drawings and described below. While the invention(s) will be described in conjunction with exemplary embodiments, it will be understood that the present description is not intended to limit the invention (s) to those exemplary embodiments. On the other hand, the invention(s) is/are intended to cover not only the exemplary embodiments, but also various alternatives, modifications, equivalents and other embodiments, which may be included within the spirit and scope of the invention as defined by the appended claims.

Hereinafter, an exemplary embodiment of the present invention will be described more specifically with reference to drawings.

The drawings and description are to be regarded as illustrative in nature and not restrictive, and like reference numerals designate like elements throughout the specification.

In the following description, dividing names of components into first, second, and the like is to divide the names because the names of the components are the same as each other and an order thereof is not particularly limited.

FIG. **1** is a schematic diagram of a planetary gear train according to various exemplary embodiments of the present invention.

Referring to FIG. **1**, a planetary gear train according to various exemplary embodiments of the present invention includes first, second, third, fourth, and fifth planetary gear sets PG**1**, PG**2**, PG**3**, PG**4**, and PG**5** disposed on a same axis, an input shaft IS, an output shaft OS, nine shafts TM**1** to TM**9** interconnecting rotation elements of the first, second, third, fourth, and fifth planetary gear sets PG**1**, PG**2**, PG**3**, PG**4**, and PG**5**, engagement elements of three clutches C**1** to C**3** and three brakes B**1** to B**3**, and a transmission housing H.

A torque of an engine input to the input shaft IS is shifted by cooperative operation of the first, second, third, fourth, and fifth planetary gear sets PG**1**, PG**2**, PG**3**, PG**4**, and PG**5**, and a shifted torque is output through the output shaft OS.

According to various exemplary embodiments of the present invention, the planetary gear sets are disposed in the order of the first, third, fourth, second, and fifth planetary gear sets PG**1**, PG**3**, PG**4**, PG**2**, and PG**5**, from an engine side thereof.

The input shaft IS is an input member and may receive a torque from a crankshaft of an engine through a torque converter.

The output shaft OS is an output element disposed on a same axis with the input shaft IS, and outputs a shifted driving torque to a driveshaft through a differential apparatus.

The first planetary gear set PG**1** is a single pinion planetary gear set, and includes a first sun gear S**1**, a first planet carrier PC**1** rotatably supporting a plurality of first pinion gears P**1** externally gear-meshed with the first sun gear S**1**, and a first ring gear R**1** internally gear-meshed with the plurality of first pinion gears P**1**. The first sun gear S**1** acts as a first rotation element N**1**, the first planet carrier PC**1** acts as a second rotation element N2, and the first ring gear R1 acts as a third rotation element N3.

The second planetary gear set PG2 is a single pinion planetary gear set, and includes a second sun gear S2, a second planet carrier PC2 rotatably supporting a plurality of second pinion gears P2 externally gear-meshed with the second sun gear S2, and a second ring gear R2 internally gear-meshed with the plurality of second pinion gears P2. The second sun gear S2 acts as a fourth rotation element N4, the second planet carrier PC2 acts as a fifth rotation element N5, and the second ring gear R2 acts as a sixth rotation element N6.

The third planetary gear set PG3 is a single pinion planetary gear set, and includes a third sun gear S3, a third planet carrier PC3 rotatably supporting a plurality of third pinion gears P3 externally gear-meshed with the third sun gear S3, and a third ring gear R3 internally gear-meshed with the plurality of third pinion gears P3. The third sun gear S3 acts as a seventh rotation element N7, the third planet carrier PC3 acts as an eighth rotation element N8, and the third ring gear R3 acts as a ninth rotation element N9.

The fourth planetary gear set PG4 is a single pinion planetary gear set, and includes a fourth sun gear S4, a fourth planet carrier PC4 rotatably supporting a plurality of fourth pinion gears P4 externally gear-meshed with the fourth sun gear S4, and a fourth ring gear R4 internally gear-meshed with the plurality of fourth pinion gears P4. The fourth sun gear S4 acts as a tenth rotation element N10, the fourth planet carrier PC4 acts as an eleventh rotation element N11, and the fourth ring gear R4 acts as a twelfth rotation element N12.

The fifth planetary gear set PG5 is a single pinion planetary gear set, and includes a fifth sun gear S5, a fifth planet carrier PC5 rotatably supporting a plurality of fifth pinion gears P5 externally gear-meshed with the fifth sun gear S5, and a fifth ring gear R5 internally gear-meshed with the plurality of fifth pinion gears P5. The fifth sun gear S5 acts as a thirteenth rotation element N13, the fifth planet carrier PC5 acts as a fourteenth rotation element N14, and the fifth ring gear R5 acts as a fifteenth rotation element N15.

In the arrangement of the first, second, third, fourth, and fifth planetary gear sets PG1, PG2, PG3, PG4, and PG5, the first rotation element N1 and the fourth rotation element N4 are fixedly interconnected, the second rotation element N2, the eighth rotation element N8, and the fifteenth rotation element N15 are fixedly interconnected, the sixth rotation element N6, the ninth rotation element N9, and the eleventh rotation element N11 are fixedly interconnected, and the seventh rotation element N7 and the tenth rotation element N10 are fixedly interconnected, forming nine shafts TM1 to TM9.

The nine shafts TM1 to TM9 are hereinafter described more specifically.

The first shaft TM1 is fixedly connected to the third rotation element N3 (first ring gear R1), and fixedly connected to the input shaft IS, always acting as an input element.

The second shaft TM2 is fixedly connected to the fourteenth rotation element N14 (fifth planet carrier PC5), and fixedly connected to the output shaft OS always acting as an output element.

The third shaft TM3 is fixedly connected to first rotation element N1 (first sun gear S1) and fourth rotation element N4 (second sun gear S2).

The fourth shaft TM4 is fixedly connected to the second rotation element N2 (first planet carrier PC1), the eighth rotation element N8 (third planet carrier PC3), and the fifteenth rotation element N15 (fifth ring gear R5).

The fifth shaft TM5 is fixedly connected to the fifth rotation element N5 (second planet carrier PC2).

The sixth shaft TM6 is fixedly connected to the sixth rotation element N6 (second ring gear R2), the ninth rotation element N9 (third ring gear R3), and the eleventh rotation element N11 (fourth planet carrier PC4).

The seventh shaft TM7 is fixedly connected to the seventh rotation element N7 (third sun gear S3) and the tenth rotation element N10 (fourth sun gear S4).

The eighth shaft TM8 is fixedly connected to the twelfth rotation element N12 (fourth ring gear R4).

The ninth shaft TM9 is fixedly connected to the thirteenth rotation element N13 (fifth sun gear S5).

Each of the nine shafts TM1 to TM9 may be a rotation member that fixedly interconnects the input and output shafts and rotation elements of the planetary gear sets PG1, PG2, PG3, and PG4, or may be a rotation member that selectively interconnects a rotation element to the transmission housing H, or may be a fixed member fixed to the transmission housing H.

When two or more members are described to be "selectively connectable" by an engagement element, it means that the selectively connectable members rotates separately when the engagement element is not engaged, and rotates at a same speed when the engagement element is engaged. It may be understood that in the case that a member is "selectively connectable" with a transmission housing by an engagement element, the member may be stationary when the engagement element is engaged.

The second shaft TM2 is selectively connectable to the third shaft TM3, the third shaft TM3 is selectively connectable to the sixth shaft TM6, and the fifth shaft TM5 is selectively connectable to the ninth shaft TM7.

Furthermore, the seventh shaft TM7, the eighth shaft TM8, and ninth shaft TM9 are selectively connectable to the transmission housing H, selectively acting as a fixed element.

The engagement elements of three clutches C1, C2, and C3 are disposed between the nine shafts TM1 to TM9, the input shaft IS, and the output shaft OS, to form selective connections.

The nine shafts TM1 to TM9 may be selectively connectable to the transmission housing H, by control elements of three brakes B1, B2, and B3.

The six engagement elements of the three clutches C1 to C3 and the three brakes B1 to B3 are disposed as follows.

The first clutch C1 is disposed between the second shaft TM2 and the third shaft TM3, and selectively connects the second shaft TM2 and the third shaft TM3, controlling power delivery therebetween.

The second clutch C2 is disposed between the third shaft TM3 and the sixth shaft TM6, and selectively connects the third shaft TM3 and the sixth shaft TM6, controlling power delivery therebetween.

The third clutch C3 is disposed between the fifth shaft TM5 and the ninth shaft TM9, and selectively connects the fifth shaft TM5 and the ninth shaft TM9, controlling power delivery therebetween.

The first brake B1 is disposed between the seventh shaft TM7 and the transmission housing H, and selectively connects the seventh shaft TM7 to the transmission housing H.

The second brake B2 is disposed between the eighth shaft TM8 and the transmission housing H, and selectively connects the eighth shaft TM8 to the transmission housing H.

The third brake B3 is disposed between the ninth shaft TM9 and the transmission housing H, and selectively connects the ninth shaft TM9 to the transmission housing H.

The engagement elements of the first, second, and third clutches C1, C2, and C3 and the first, second, and third brakes B1, B2, and B3 may be realized as multi-plate hydraulic pressure friction devices that are frictionally engaged by hydraulic pressure, however, it may not be understood to be limited thereto, since various other configuration that are electrically controllable may be available.

FIG. 2 is an operational chart for respective control elements at respective shift-stages applicable to a planetary gear train according to various exemplary embodiments of the present invention.

Referring to FIG. 2, a planetary gear train according to various exemplary embodiments of the present invention realizes ten forward speeds and one reverse speed by operating three engagements among the first, second, and third clutches C1, C2, and C3 and first, second, and third brakes B1, B2, and B3.

In the first forward speed D1, the third clutch C3 and the first and second brakes B1 and B2 are simultaneously operated.

As a result, the fifth shaft TM5 and the ninth shaft TM9 are connected by the operation of the third clutch C3. In the present state, the input torque is input to the first shaft TM1.

Furthermore, the seventh and eighth shafts TM7 and TM8 act as fixed elements by the operation of the first and second brakes B1 and B2, realizing the first forward speed and outputting a shifted torque to the output shaft OS connected to the second shaft TM2.

In the second forward speed D2, the third clutch C3 and the second and third brakes B2 and B3 are simultaneously operated.

As a result, the fifth shaft TM5 and the ninth shaft TM9 are connected by the operation of the third clutch C3. In the present state, the input torque is input to the first shaft TM1.

Furthermore, the eighth and ninth shafts TM8 and TM9 act as fixed elements by the operation of the second and third brakes B2 and B3, realizing the second forward speed and outputting a shifted torque to the output shaft OS connected to the second shaft TM2.

In the third forward speed D3, the second and third clutches C2 and C3 and the third brake B3 are simultaneously operated.

As a result, the third shaft TM3 and the sixth shaft TM6 are fixedly interconnected by the operation of the second clutch C2, and the fifth shaft TM5 and the ninth shaft TM9 are connected by the operation of the third clutch C3. In the present state, the input torque is input to the first shaft TM1.

Furthermore, the ninth shaft TM9 acts as a fixed element by the operation of the third brake B3, realizing the third forward speed and outputting a shifted torque to the output shaft OS connected to the second shaft TM2.

In the fourth forward speed D4, the second clutch C2 and the second and third brakes B2 and B3 are simultaneously operated.

As a result, the third shaft TM3 and the sixth shaft TM6 are connected by the operation of the second clutch C2. In the present state, the input torque is input to the first shaft TM1.

Furthermore, the eighth and ninth shafts TM8 and TM9 act as fixed elements by the operation of the second and third brakes B2 and B3, realizing the fourth forward speed and outputting a shifted torque to the output shaft OS connected to the second shaft TM2.

In the fifth forward speed D5, the second and third clutches C2 and C3 and the second brake B2 are simultaneously operated.

As a result, the third shaft TM3 and the sixth shaft TM6 are connected by the operation of the second clutch C2, and the fifth shaft TM5 and the ninth shaft TM9 are connected by the operation of the third clutch C3. In the present state, the input torque is input to the first shaft TM1.

Furthermore, the eighth shaft TM8 acts as a fixed element by the operation of the second brake B2, realizing the fifth forward speed and outputting a shifted torque to the output shaft OS connected to the second shaft TM2.

In the sixth forward speed D6, the first and third clutches C1 and C3 and the second brake B2 are simultaneously operated.

As a result, the second shaft TM2 and the third shaft TM3 are connected by the operation of the first clutch C1, and the fifth shaft TM5 and the ninth shaft TM9 are connected by the operation of the third clutch C3. In the present state, the input torque is input to the first shaft TM1.

Furthermore, the eighth shaft TM8 acts as a fixed element by the operation of the second brake B2, realizing the sixth forward speed and outputting a shifted torque to the output shaft OS connected to the second shaft TM2.

In the seventh forward speed D7, the first, second, and third clutches C1, C2, and C3 are simultaneously operated.

As a result, the second shaft TM2 and the third shaft TM3 are connected by the operation of the first clutch C1, the third shaft TM3 and the sixth shaft TM6 are connected by the operation of the second clutch C2, and the fifth shaft TM5 and the ninth shaft TM9 are connected by the operation of the third clutch C3.

As such, the first, second, third, fourth, and fifth planetary gear sets PG1, PG2, PG3, PG4, and PG5 integrally rotate, realizing the seventh forward speed where a torque is output as inputted, and outputting a shifted torque through the output shaft OS connected to the second shaft TM2.

In the eighth forward speed D8, the first and third clutches C1 and C3 and the first brake B1 are simultaneously operated.

As a result, the second shaft TM2 and the third shaft TM3 are connected by the operation of the first clutch C1, and the fifth shaft TM5 and the ninth shaft TM9 are connected by the operation of the third clutch C3. In the present state, the input torque is input to the first shaft TM1.

Furthermore, the seventh shaft TM7 acts as a fixed element by the operation of the first brake B1, realizing the eighth forward speed and outputting a shifted torque to the output shaft OS connected to the second shaft TM2.

In the ninth forward speed D9, the second and third clutches C2 and C3 and the first brake B1 are simultaneously operated.

As a result, the third shaft TM3 and the sixth shaft TM6 are connected by the operation of the second clutch C2, and the fifth shaft TM5 and the ninth shaft TM9 are connected by the operation of the third clutch C3. In the present state, the input torque is input to the first shaft TM1.

Furthermore, the seventh shaft TM7 acts as a fixed element by the operation of the first brake B1, realizing the ninth forward speed and outputting a shifted torque to the output shaft OS connected to the second shaft TM2.

In the tenth forward speed D10, the first and second clutch C1 and C2 and the first brake B1 are simultaneously operated.

As a result, the second shaft TM2 and the third shaft TM3 are connected by the operation of the first clutch C1, and the third shaft TM3 and the sixth shaft TM6 are connected by the operation of the second clutch C2. In the present state, the input torque is input to the first shaft TM1.

Furthermore, the seventh shaft TM7 acts as a fixed element by the operation of the first brake B1, realizing the tenth forward speed and outputting a shifted torque to the output shaft OS connected to the second shaft TM2.

In the reverse speed REV, the third clutch C3 and the first and second brakes B1 and B2 are simultaneously operated.

As a result, the fifth shaft TM5 and the ninth shaft TM9 are connected by the operation of the third clutch C3. In the present state, the input torque is input to the first shaft TM1.

Furthermore, the seventh and eighth shafts TM7 and TM8 act as fixed elements by the operation of the first and second brakes B1 and B2, realizing the reverse speed and outputting a shifted torque to the output shaft OS connected to the second shaft TM2.

FIG. 3 is a schematic diagram of a planetary gear train according to various exemplary embodiments of the present invention.

According to a planetary gear train according to various exemplary embodiments of the present invention shown in FIG. 1, the second clutch C2 is disposed to selectively connect the third shaft TM3 and the sixth shaft TM6. However, according to a planetary gear train according to various exemplary embodiments of the present invention shown in FIG. 3, the second clutch C2 is disposed to selectively connect the third shaft TM3 and the fifth shaft TM5.

Such various exemplary embodiments only differs from the various exemplary embodiments in the arrangement of the second clutch C2, and shows the same connection relations between the nine shafts TM1 to TM9, remaining two clutches C1 and C3, and three brakes B1 to B3, providing the same operation.

FIG. 4 is a schematic diagram of a planetary gear train according to various exemplary embodiments of the present invention.

According to a planetary gear train according to various exemplary embodiments of the present invention shown in FIG. 1, the second clutch C2 is disposed to selectively connect the third shaft TM3 and the sixth shaft TM6. However, according to a planetary gear train according to various exemplary embodiments of the present invention shown in FIG. 3, the second clutch C2 is disposed to selectively connect the fifth shaft TM5 and the sixth shaft TM6.

Such various exemplary embodiments only differs from the various exemplary embodiments in the arrangement of the second clutch C2, and shows the same connection relations between the nine shafts TM1 to TM9, remaining two clutches C1 and C3, and three brakes B1 to B3, providing the same operation.

As described above, a planetary gear train according to an exemplary embodiment of the present invention may realize ten forward speeds and one reverse speed by operating five planetary gear sets PG1, PG2, PG3, PG4, and PG5 by controlling three clutches C1, C2, and C3 and three brakes B1, B2, and B3.

Furthermore, a gear ratio span may be increased to above 8.8 maximizing engine efficiency, and step ratios of shift-stages may become more linear, improving acceleration and engine drivability before and after a shifting.

Furthermore, the number of engagement elements employed to realize ten forward speeds and one reverse speed is minimized, improving power delivery efficiency and fuel consumption by minimizing drag loss of an automatic transmission.

Furthermore, a torque in parallel scheme is employed in a planetary gear set at an output side, and torque loads applied to engagement elements of respective planetary gear sets become more uniform, improving torque delivery efficiency and durability of an automatic transmission.

Furthermore, a minimal number of engagement elements are controlled to realize shifting between shift-stages of ten forward speeds and one reverse speed, and accordingly, reduction of clutch drag, enhancement of torque transmission efficiency, and enhancement of flexibility of output gear ratios, enhancing linearity of step ratios.

For convenience in explanation and accurate definition in the appended claims, the terms "upper", "lower", "internal", "outer", "up", "down", "upper", "lower", "upwards", "downwards", "front", "rear", "back", "inside", "outside", "inwardly", "outwardly", "internal", "external", "internal", "outer", "forwards", and "backwards" are used to describe features of the exemplary embodiments with reference to the positions of such features as displayed in the figures.

The foregoing descriptions of specific exemplary embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teachings. The exemplary embodiments were chosen and described to explain certain principles of the invention and their practical application, to enable others skilled in the art to make and utilize various exemplary embodiments of the present invention, as well as various alternatives and modifications thereof. It is intended that the scope of the invention be defined by the Claims appended hereto and their equivalents.

What is claimed is:

1. A planetary gear train apparatus of an automatic transmission for a vehicle, the apparatus comprising:

an input shaft receiving an input torque;

an output shaft outputting a shifted torque;

a first planetary gear set having a first rotation element, a second rotation element, and a third rotation element;

a second planetary gear set having a fourth rotation element, a fifth rotation element, and a sixth rotation element;

a third planetary gear set having a seventh rotation element, an eighth rotation element, and a ninth rotation element;

a fourth planetary gear set having a tenth rotation element, an eleventh rotation element, and a twelfth rotation element;

a fifth planetary gear set having a thirteenth rotation element, a fourteenth rotation element, and a fifteenth rotation element;

a first shaft fixedly connected to the third rotation element and the input shaft;

a second shaft fixedly connected to the fourteenth rotation element and the output shaft;

a third shaft fixedly connected to the first rotation element and the fourth rotation element;

a fourth shaft fixedly connected to the second rotation element, the eighth rotation element, and the fifteenth rotation element;

a fifth shaft fixedly connected to the fifth rotation element;

a sixth shaft fixedly connected to the sixth rotation element, the ninth rotation element, and the eleventh rotation element; and

a plurality of shafts, each of which is selectively connectable to a transmission housing and fixedly connected to a rotation element of the third, fourth, and fifth planetary gear sets which is not fixedly connected to the first to sixth shafts,

wherein the plurality of shafts includes:

a seventh shaft fixedly connected to the seventh rotation element and the tenth rotation element and selectively connectable to the transmission housing;

an eighth shaft fixedly connected to the twelfth rotation element and selectively connectable to the transmission housing; and

a ninth shaft fixedly connected to the thirteenth rotation element and selectively connectable to the transmission housing,

wherein the second and third shafts are selectively interconnected, the fifth and ninth shafts are selectively interconnected, and two shafts among the third, fifth, and sixth shafts are selectively interconnected.

2. The planetary gear train apparatus of claim **1**, further including:

three clutches; and

three brakes selectively connecting the seventh shaft, the eighth shaft, and the ninth shaft to the transmission housing, respectively.

3. The planetary gear train apparatus of claim **2**, wherein the three clutches comprise:

a first clutch mounted between the second shaft and the third shaft;

a second clutch mounted between the third shaft and the sixth shaft; and

a third clutch mounted between the fifth shaft and the ninth shaft, and

the three brakes comprise:

a first brake mounted between the seventh shaft and the transmission housing;

a second brake mounted between the eighth shaft and the transmission housing; and

a third brake mounted between the ninth shaft and the transmission housing.

4. The planetary gear train apparatus of claim **2**, wherein the three clutches comprise:

a first clutch mounted between the second shaft and the third shaft;

a second clutch mounted between the third shaft and the fifth shaft; and

a third clutch mounted between the fifth shaft and the ninth shaft, and

the three brakes comprise:

a first brake mounted between the seventh shaft and the transmission housing;

a second brake mounted between the eighth shaft and the transmission housing; and

a third brake mounted between the ninth shaft and the transmission housing.

5. The planetary gear train apparatus of claim **2**, wherein the three clutches comprise:

a first clutch mounted between the second shaft and the third shaft;

a second clutch mounted between the fifth shaft and the sixth shaft; and

a third clutch mounted between the fifth shaft and the ninth shaft, and

the three brakes comprise:

a first brake mounted between the seventh shaft and the transmission housing;

a second brake mounted between the eighth shaft and the transmission housing; and

a third brake mounted between the ninth shaft and the transmission housing.

6. The planetary gear train apparatus of claim **1**,

wherein the first rotation element, the second rotation element, and the third rotation element are a first sun gear, a first planet carrier, and a first ring gear, respectively;

wherein the fourth rotation element, the fifth rotation element, and the sixth rotation element are a second sun gear, a second planet carrier, and a second ring gear, respectively;

wherein the seventh rotation element, the eighth rotation element, and the ninth rotation element are a third sun gear, a third planet carrier, and a third ring gear, respectively;

wherein the tenth rotation element, the eleventh rotation element, and the twelfth rotation element are a fourth sun gear, a fourth planet carrier, and a fourth ring gear, respectively;

wherein the thirteenth rotation element, the fourteenth rotation element, and the fifteenth rotation element are a fifth sun gear, a fifth planet carrier, and a fifth ring gear, respectively.

7. The planetary gear train apparatus of claim **1**, wherein the first, second, third, fourth, and fifth planetary gear sets are disposed in an order of the first, third, fourth, second, and fifth planetary gear sets from an input side thereof.

8. A planetary gear train apparatus of an automatic transmission for a vehicle, including:

an input shaft receiving an input torque;

an output shaft outputting a shifted torque;

a first planetary gear set having a first rotation element, a second rotation element, and a third rotation element;

a second planetary gear set having a fourth rotation element, a fifth rotation element, and a sixth rotation element;

a third planetary gear set having a seventh rotation element, an eighth rotation element, and a ninth rotation element;

a fourth planetary gear set having a tenth rotation element, an eleventh rotation element, and a twelfth rotation element;

a fifth planetary gear set having a thirteenth rotation element, a fourteenth rotation element, and a fifteenth rotation element;

wherein the third rotation element is fixedly connected to the input shaft,

the fourteenth rotation element is fixedly connected to the output shaft,

the first rotation element is fixedly connected to the fourth rotation element, and selectively connectable to the fourteenth rotation element,

the second rotation element is fixedly connected to the eighth rotation element and the fifteenth rotation element,

the fifth rotation element is selectively connectable to the thirteenth rotation element,

the sixth rotation element is fixedly connected to the ninth rotation element and the eleventh rotation element,

the seventh rotation element is fixedly connected to the tenth rotation element, and selectively connectable to a transmission housing,

the twelfth rotation element is selectively connectable to the transmission housing,

the thirteenth rotation element is selectively connectable to the transmission housing.

9. The planetary gear train apparatus of claim 8, wherein two rotation elements among the fourth rotation element, the fifth rotation element, and the sixth rotation element of the second planetary gear set are selectively connectable with each other.

10. The planetary gear train apparatus of claim 9, further including:
three clutches; and
three brakes selectively connecting the tenth rotation element, the twelfth rotation element, and the thirteenth rotation element to the transmission housing, respectively.

11. The planetary gear train apparatus of claim 10, wherein the three clutches comprise:
a first clutch mounted between the fourth rotation element and the fourteenth rotation element;
a second clutch mounted between the fourth rotation element and the sixth rotation element; and
a third clutch mounted between the fifth rotation element and the thirteenth rotation element, and
the three brakes comprise:
a first brake mounted between the tenth rotation element and the transmission housing;
a second brake mounted between the twelfth rotation element and the transmission housing; and
a third brake mounted between the thirteenth rotation element and the transmission housing.

12. The planetary gear train apparatus of claim 11, wherein the first brake is mounted between the seventh rotation element and the transmission housing.

13. The planetary gear train apparatus of claim 10, wherein the three clutches comprise:
a first clutch mounted between the fourth rotation element and the fourteenth rotation element;
a second clutch mounted between the fourth rotation element and the fifth rotation element; and
a third clutch mounted between the fifth rotation element and the thirteenth rotation element, and
the three brakes comprise:
a first brake mounted between the tenth rotation element and the transmission housing;
a second brake mounted between the twelfth rotation element and the transmission housing; and
a third brake mounted between the thirteenth rotation element and the transmission housing.

14. The planetary gear train apparatus of claim 13, wherein the first brake is mounted between the seventh rotation element and the transmission housing.

15. The planetary gear train apparatus of claim 10, wherein the three clutches comprise:
a first clutch mounted between the fourth rotation element and the fourteenth rotation element;
a second clutch mounted between the fifth rotation element and the sixth rotation element; and
a third clutch mounted between the fifth rotation element and the thirteenth rotation element, and
the three brakes comprise:
a first brake mounted between the tenth rotation element and the transmission housing;
a second brake mounted between the twelfth rotation element and the transmission housing; and
a third brake mounted between the thirteenth rotation element and the transmission housing.

16. The planetary gear train apparatus of claim 15, wherein the first brake is mounted between the seventh rotation element and the transmission housing.

17. The planetary gear train apparatus of claim 8,
wherein the first rotation element, the second rotation element, and the third rotation element are a first sun gear, a first planet carrier, and a first ring gear, respectively;
wherein the fourth rotation element, the fifth rotation element, and the sixth rotation element are a second sun gear, a second planet carrier, and a second ring gear, respectively;
wherein the seventh rotation element, the eighth rotation element, and the ninth rotation element are a third sun gear, a third planet carrier, and a third ring gear, respectively;
wherein the tenth rotation element, the eleventh rotation element, and the twelfth rotation element are a fourth sun gear, a fourth planet carrier, and a fourth ring gear, respectively; and
wherein the thirteenth rotation element, the fourteenth rotation element, and the fifteenth rotation element are a fifth sun gear, a fifth planet carrier, and a fifth ring gear, respectively.

18. The planetary gear train apparatus of claim 8, wherein the first, second, third, fourth, and fifth planetary gear sets are disposed in an order of the first, third, fourth, second, and fifth planetary gear sets from an input side thereof.

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