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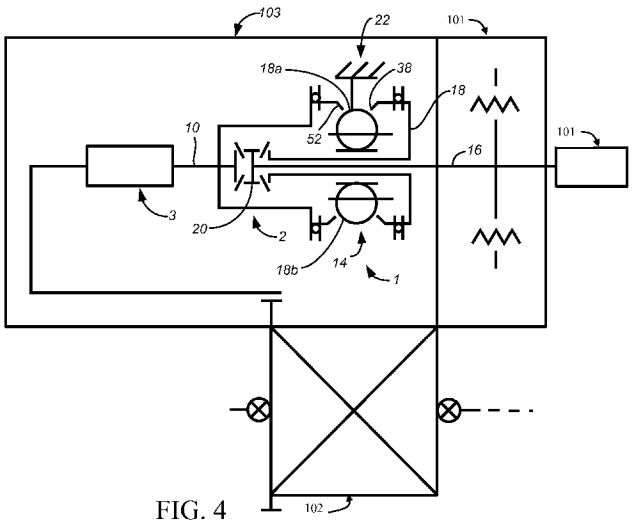

FIG. 4

(57) Abstract: A variable transmission includes an input shaft; a bevel gear power divider drivingly engaged with the input shaft, and comprising a first bevel gear drivingly engaged with a variator input shaft, and a second bevel gear drivingly engaged with an output shaft; and a variator comprising, a variator carrier assembly, a first ring assembly, and a second ring assembly; and the output shaft. The bevel gear power divider unit splits ingoing torque between the variator and the output shaft that drivingly engages the vehicle output.

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CVT BASED ON A BALL TYPE CVP INCLUDING POWERSPLIT PATHS THROUGH A BEVEL GEAR

CROSS-REFERENCE

[0001] This application claims the benefit of U.S. Provisional Application No. 61/697,953, filed September 7, 2012 and U.S. Provisional Application No. 61/778,200, filed March 12, 2013, which are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

[0002] Automatic and manual transmissions are commonly used on automobile vehicles. Those transmissions are becoming more and more complicated since the engine speed has to be more precisely controlled to limit the fuel consumption and the emissions of cars. This finer control of the engine speed in usual transmissions can only be done by adding more discrete step ratio gears and increasing the overall complexity and cost. Consequently, 6-speed manual transmissions then become more frequently used as are 8 or 9 speed automatic transmissions.

[0003] Besides these transmissions, Continuously Variable Transmissions or CVTs have been developed. Those CVTs are of many types: belts with variable pulleys, toroidal, and conical, for non-limiting example. The principle of a CVT is that it enables the engine to run at its most efficient rotation speed by changing steplessly the transmission ratio in function of the speed of the car and the torque demand (throttle position) of the driver. If needed for example when accelerating, the CVT can also shift to the most optimum ratio providing more power. A CVT can change the ratio from the minimum to the maximum ratio without any interruption of the power transmission, as opposed to the opposite of usual transmissions which require an interruption of the power transmission by disengaging to shift from one discrete ratio to engage the next ratio.

SUMMARY OF THE INVENTION

[0004] Provided herein is a variable transmission comprising: an input shaft; a bevel gear power divider drivingly engaged with the input shaft, and comprising a first bevel gear drivingly engaged with a variator input shaft, and a second bevel gear drivingly engaged with an output shaft; and a variator comprising, a variator carrier assembly, a first ring assembly, and a second ring assembly; and the output shaft. The variable transmissions described herein may be used in any vehicle type requiring such functions provided by these variable transmission.

[0005] In some embodiments, the bevel gear power divider unit splits ingoing torque 50/50 between the variator and the output shaft. In some embodiments, the bevel gear power divider unit splits ingoing torque 10/90 (variator/output), 20/80, 25/75, 30/70, 40/60, 60/40, 70/30, 75/25, 80/20, or 90/10 between the variator and the output shaft.

[0006] In some embodiments, the variator comprises a continuously variable variator, an infinitely variable variator, or a combination thereof.

[0007] In some embodiments, the input shaft has a gear at an end thereof that engages with a plurality of bevels of the bevel gear power divider unit.

[0008] In some embodiments, variator balls of the variator carrier assembly, the first ring assembly, and the second ring assembly are rotatably disposed in the housing.

[0009] In some embodiments, the variable transmission further comprises a gearbox drivingly engaged with the output shaft. In some embodiments, the gearbox is a two speed gearbox. In some embodiments, the gearbox is configured to compensate for spread loss caused by the bevel gear power divider unit. In some embodiments, the gearbox is configured to allow for a reverse drive mode. In some embodiments, the variable transmission configured to change continuously its ratio to provide the best ratio achievable for an engine engaged thereto in function of the objectives of consumption or power.

[0010] In some embodiments, the input shaft and the output shaft are at least partially disposed in the housing.

[0011] In some embodiments, the variable transmission comprises an axial force generator configured to generate sufficient axial force to properly operate the vehicle transmission. In some embodiments, the axial force generator comprises one or more clamping mechanisms. In some embodiments, the axial force generator comprises a ball ramp. In some embodiments, the axial force generator comprises a ball ramp thrust ring. In some embodiments, the axial force generator comprises a load applied during assembly of the variable transmission.

[0012] In some embodiments, the input shaft is drivingly engaged with a torsional dampener disposed between an engine and the variable transmission.

[0013] In some embodiments, the first ring assembly is rotatably disposed in the housing drivingly engaged with the bevel gear power divider unit, the first ring assembly comprising a first variator ball engagement surface that is in driving engagement with a plurality of variator balls of the carrier assembly. In some embodiments, the first ring assembly is

rotatably disposed in the housing drivingly engaged with the bevel gear power divider unit using the variator input shaft.

[0014] In some embodiments, a first variator ball engagement surface is formed in an input ring of the first ring assembly. In some embodiments, a first variator ball engagement surface is formed in a distal end of the first ring assembly. In some embodiments, the first variator ball engagement surface is a conical surface or a concave or convex toroidal surface in contact with or slightly spaced apart from each of the variator balls. In some embodiments, the first variator ball engagement surface is in driving engagement with each of the variator balls of the carrier assembly through one of a boundary layer type friction and an elastohydrodynamic film.

[0015] In some embodiments, a carrier assembly is rotatably disposed in the housing and is drivingly engaged first ring assembly, the carrier assembly comprising an annular arrangement of the plurality of tiltable variator balls each having ball axle shafts, and configured to be prevented from rotating relative to the housing by a grounding device. In some embodiments, each of the ball axle shafts is adjusted using a cam style tilting mechanism. In some embodiments, each of the ball axle shafts is adjusted using a split carrier axle skewing mechanism.

[0016] In some embodiments, the second ring assembly is rotatably disposed in the housing, and wherein the second ring assembly comprises and a second variator ball engagement surface that is in driving engagement with variator balls of the carrier assembly. In some embodiments, the second variator ball engagement surface is formed in a distal end of the second ring assembly. In some embodiments, a second variator ball engagement surface is formed in an input ring of the first ring assembly. In some embodiments, the second variator ball engagement surface is a conical surface or a concave or convex toroidal surface in contact with or slightly spaced apart from each of the variator balls. In some embodiments, the second variator ball engagement surface is in driving engagement with each of the variator balls of the first carrier assembly through one of a boundary layer type friction and an elastohydrodynamic film.

[0017] In some embodiments, the output shaft is drivingly engaged with a vehicle output.

[0018] Provided herein is a vehicle driveline comprising: an engine; a dampener in driving engagement with the engine; a variable transmission as described herein or obvious to one of skill in the art upon reading the disclosure herein, and a vehicle output. The vehicle driveline may comprise a starting device.

[0019] In some embodiments, the vehicle output comprises a wheel differential and one or more wheels of a vehicle. In some embodiments, the vehicle output comprises a wheel differential and a drive axle. In some embodiments, the dampener is disposed between the engine and the variable transmission. In some embodiments, the dampener comprises at least one torsional spring. In some embodiments, the dampener is coupled with a clutch. In some embodiments, the starting device is a wet or dry clutch.

[0020] In some embodiments, the vehicle driveline comprises a starting device. In some embodiments, the starting device comprises a torque converter. In some embodiments, the starting device is in locked mode after startup.

[0021] Provided herein is a method comprising providing a variable transmission as described herein or obvious to one of skill in the art upon reading the disclosure herein.

INCORPORATION BY REFERENCE

[0022] All publications, patents, and patent applications mentioned in this specification are herein incorporated by reference to the same extent as if each individual publication, patent, or patent application was specifically and individually indicated to be incorporated by reference.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The novel features of the invention are set forth with particularity in the appended claims. A better understanding of the features and advantages of the present invention will be obtained by reference to the following detailed description that sets forth illustrative embodiments, in which the principles of the invention are utilized, and the accompanying drawings of which:

Figure 1 depicts certain elements of an embodiment CVP.

Figure 2 depicts a ratio change mechanism in an embodiment CVP.

Figure 3 depicts a basic driveline configuration including an embodiment CVT.

Figure 4 depicts an embodiment CVP variator coupled to a bevel gear power divider unit and an additional gearbox.

DETAILED DESCRIPTION OF THE INVENTION

[0024] A specific use of CVTs is the Infinite Variable Transmission or IVT. Where the CVT is limited to positive speed ratios, the IVT configuration can perform a neutral gear and even reverse ratios steplessly. A CVT can be used as an IVT in some driveline configurations.

[0025] Provided herein are configurations based on a ball type CVT, also known as CVP, for constant variable planetary. Aspects of the CVTs are describes in US20040616399 or AU2011224083A1, incorporated herein by reference in their entirety. This CVT comprises of a certain number of balls 997 (for example, 3-15 balls), depending on the application, two discs 995, 996 or annular rings each having an engagement portion that engages the variator balls as input and output as shown on FIG. 1. The engagement portions may be in a conical or toroidal convex or concave surface contact with the variator balls, as input and output. The CVT may include an idler 999 contacting the balls as well as shown on FIG. 1. The variator balls are mounted on axes 998, themselves held in a cage or carrier allowing changing the ratio by tilting the variator balls' axes. Other types of ball CVTs also exist, like the one produced by Milner but are slightly different. These alternative ball CVTs are additionally contemplated herein.

[0026] The working principle is shown on FIG. 2. The CVP itself works with a traction fluid. The lubricant between the ball and the conical rings acts as a solid at high pressure, transferring the power from the input ring, through the variator balls, to the output ring. By tilting the variator balls' axes, the ratio can be changed between input and output. When the axis of each of the variator balls is horizontal the ratio is one, when the axis is tilted the distance between the axis and the contact point change, modifying the overall ratio. When the axis is horizontal the ratio is one (1:1), when the axis is tilted the distance between the axis and the contact point change, modifying the overall ratio (input radius > output radius = underdrive; input radius < output radius = overdrive). All the variator balls' axles are tilted at the same time with a mechanism included in the cage.

[0027] In a car, the CVT 103 includes a CVP (continuously variable planetary) and is used to replace traditional transmission and is located between the engine 100 and the differential 102 as shown on FIG. 3. A torsional damper 101 has to be introduced between the engine and the CVT 103 to avoid transferring torque peaks and vibrations that could seriously damage the CVT 103. In some configurations, this damper 101 can be coupled with a clutch for the starting function.

Example 1

[0028] An embodiment CVP is depicted in FIG. 4. This configuration uses a starting device ((like a torque converter or a wet or dry clutch) and a bevel gear power divider unit 2, with which the CVP is connected to. An output shaft 10 is then coupled to the bevel gear power divider unit 2 and goes to an additional gearbox 3 (such as a two speed or forward/reverse

gearbox), then to a wheel differential. The bevel gear power divider unit 2 splits the ingoing torque 50/50. One path goes through the variator 1 and the other path is linked with the output (output shaft 10) of the variator 1. The power splitting causes this configuration to have a higher native efficiency and the variator size can be chosen smaller. The central part of that configuration is an embodiment variator.

[0029] The variator may be of multiple configurations, including a continuously variable variator, or an infinitely variable variator, or a combination thereof in coordination with any combination of planetary gearsets or portions thereof, or in coordination with combinations of one or more clutches (grounding devicees, brakes, or other types of clutches).

[0030] Thus, a first configuration of a vehicle driveline includes a variable transmission 103 as shown in FIG. 4. The variable transmission (CVP) 103 includes a variator 1 that includes a variator carrier assembly 14, a first ring assembly, and a second ring assembly. The variable transmission 103 comprises an input shaft 16 drivingly engaged to a bevel gear power divider unit 2 having a variator input 18 and an output shaft 10 drivingly engaged thereto. The input shaft 16 has a gear 20 formed at an end thereof that engages with a plurality of bevels of the bevel gear power divider unit 2. The input shaft 16 and an output shaft 10 of the variable transmission are at least partially disposed in a housing. Variator balls 18a, 18b of the variator carrier assembly, the first ring assembly, and the second ring assembly are rotatably disposed in the housing. As previously noted the variable transmission further includes a bevel gear power divider unit 2 and/or a gearbox 3.

[0031] Ball ramps, indicated in FIG. 4 by a circle between a pair of vertical lines, making up a first thrust ring on the first ring assembly and a second thrust ring on the second ring assembly are disposed between components of the variable transmission 103 as shown to generate an amount of axial force necessary for proper operation of the variable transmission 103 (i.e. transfer of torque); however, it is understood that the amount of axial force necessary for proper operation may be generated by a clamping mechanism (not shown) or as a load applied during assembling of the variable transmission 103. As depicted in FIG. 4, a ball ramp on each side of the variator 1 provides the clamping force necessary to transfer the torque in this embodiment.

[0032] The input shaft 16 has a first end drivingly engaged with the engine, second end drivingly engaged with a bevel gear of the bevel gear power divider unit 2. The bevel gear power divider unit is drivingly engaged with the first ring assembly (of the variator 1). The bevel gear power divider unit 2 is additionally drivingly engages and couples to the output

shaft 10 of the CVP. The bevel gear power divider unit 2 splits the torque from the ICE (engine) between the output shaft 10 and the variator first ring assembly. The split is described as being 50/50, in this embodiment, however other torque splits such as 10/90 (Variator/Output), 20/80, 25/75, 30/70, 40/60, 60/40, 70/30, 75/25, 80/20, or 90/10 is contemplated herein.

[0033] The variator carrier assembly is rotatably disposed in the housing and includes a plurality of ball axle shafts tiltably disposed therein in an annular arrangement. Each of the ball axle shafts includes a variator ball 18a, 18b rotatably disposed thereon. Each of the ball axle shafts may be adjusted using one of a cam style tilting mechanism and a split carrier axle skewing mechanism. The variator carrier assembly is drivingly engaged with first ring assembly. The variator carrier assembly comprises an annular arrangement of the plurality of tiltable variator balls 18a. 18b each having ball axle shafts. The variator carrier assembly is configured to be prevented from rotating relative to the housing by a grounding device 22, in the embodiment of FIG. 4.

[0034] The first ring assembly is an annular member rotatably disposed in the housing. As mentioned hereinabove, the first ring assembly is drivingly engaged with the input shaft 16 using the bevel gear power divider unit 2. A first variator ball engagement surface 38 is formed in a distal end of the first ring assembly. The first variator ball engagement surface 38 may be a conical surface or a concave or convex toroidal surface in contact with or slightly spaced apart from each of the variator balls 18a, 18b. The first variator ball engagement surface 38 is in driving engagement with each of the variator balls 18a, 18b through one of a boundary layer type friction and an elastohydrodynamic film.

[0035] The second ring assembly is an annular member rotatably disposed in the housing. The second ring assembly is drivingly engaged with the output shaft 10. The output shaft 10 is additionally coupled to the bevel gear power divider unit 2 which couples to an additional gearbox 3 (such as a two speed gearbox or a forward/reverse gearbox), which then couples to a differential. As previously noted, the bevel gear power divider unit 2 thereby splits the torque from the ICE between the output shaft 10 and the variator first ring assembly. The split is described as being 50/50, in this embodiment, however other torque splits such as 10/90 (Variator/Output), 20/80, 25/75, 30/70, 40/60, 60/40, 70/30, 75/25, 80/20, or 90/10 is contemplated herein.

[0036] A second variator ball engagement surface 52 is formed in a distal end of the second ring assembly. The second variator ball engagement surface 52 may be a conical surface or a

concave or convex toroidal surface in contact with or slightly spaced apart from each of the variator balls 18a, 18b. The second variator ball engagement surface 52 is in driving engagement with each of the variator balls 18a, 18b through one of a boundary layer type friction and an elastohydrodynamic film.

[0037] The variator is also used in CVP mode by blocking the carrier of the variator. This may be achieved by the grounding device 22 as shown in FIG. 4. The grounding device 22 may be a mechanism that grounds the variator carrier. In this embodiment, cam axle tilt reaches into the variator along the central axis of the variator and allows the ratio shifting while the carrier is held stationary from rotation. The skew shifting is accomplished by indexing at a variable angle the two halves of the variator carrier relative to one another through a pair of control levers that are located at the grounding mechanism at the outside of the carrier.

[0038] This configuration comprises a starting device to provide standstill and very low vehicle speeds, for example up to 10 kph. A torque converter may be used, for non-limiting example, giving damping and torque multiplication. For higher speeds, for example above 10 kph, the torque converter may be in lock-up mode to improve efficiency.

[0039] The bevel gear power divider unit 2 causes the transmission configuration to lose ratio spread. This may be compensated for by adding an additional two speed gearbox 3. Also, driving in reverse is provided by the additional gearbox 3. By adding the additional two speed gearbox 3, spread is similar to a traditional gearbox.

[0040] This device is able to change continuously its ratio to provide an optimized or optimum ratio achievable for the engine in function of the objectives of fuel consumption or power. In a manual or automatic transmission, only some predetermined and discrete ratios are available and an interruption of the power transmission is needed to shift from one ratio to another ratio. According to the embodiment of FIG.4, the only interruptions of power in this device are the ratios shifting of the additional gearbox. Other advantages of this configuration are that a relatively small variator can be chosen; spread is similar to a traditional gearbox and the native efficiency of the transmission is increased by using the CVP in a powersplit device, therefore letting a part of the power passing through a more efficient mechanical path.

[0041] While preferred embodiments of the present invention have been shown and described herein, it will be obvious to those skilled in the art that such embodiments are provided by way of example only. Numerous variations, changes, and substitutions will now

occur to those skilled in the art without departing from the invention. It should be understood that various alternatives to the embodiments of the invention described herein may be employed in practicing the invention. It is intended that the following claims define the scope of the invention and that methods and structures within the scope of these claims and their equivalents be covered thereby.

CLAIMS

WHAT IS CLAIMED IS:

1. A variable transmission comprising:

an input shaft;

a bevel gear power divider drivingly engaged with the input shaft, and comprising a first bevel gear drivingly engaged with a variator input shaft, and a second bevel gear drivingly engaged with an output shaft; and

a variator comprising, a variator carrier assembly, a first ring assembly, and a second ring assembly; and

the output shaft.

2. The variable transmission of claim 1, wherein the bevel gear power divider unit splits ingoing torque 50/50 between the variator and the output shaft.

3. The variable transmission of claim 1, wherein the bevel gear power divider unit splits ingoing torque 10/90 (variator/output), 20/80, 25/75, 30/70, 40/60, 60/40, 70/30, 75/25, 80/20, or 90/10 between the variator and the output shaft.

4. The variable transmission of claim 1, wherein the variator comprises a continuously variable variator, an infinitely variable variator, or a combination thereof.

5. The variable transmission of claim 1, wherein the input shaft has a gear at an end thereof that engages with a plurality of bevels of the bevel gear power divider unit.

6. The variable transmission of claim 1, wherein variator balls of the variator carrier assembly, the first ring assembly, and the second ring assembly are rotatably disposed in the housing.

7. The variable transmission of claim 1, further comprising a gearbox drivingly engaged with the output shaft.

8. The variable transmission of claim 7, wherein the gearbox is a two speed gearbox.

9. The variable transmission of claim 7, wherein the gearbox is configured to compensate for spread loss caused by the bevel gear power divider unit.

10. The variable transmission of claim 7, wherein the gearbox is configured to allow for a reverse drive mode.

11. The variable transmission of claim 7 configured to change continuously its ratio to provide the best ratio achievable for an engine engaged thereto in function of the objectives of fuel consumption or power.

12. The variable transmission of claim 1, wherein the input shaft and the output shaft are at least partially disposed in the housing.

13. The vehicle transmission of claim 1, comprising an axial force generator configured to generate sufficient axial force to properly operate the vehicle transmission.

14. The vehicle transmission of claim 13, wherein the axial force generator comprises one or more clamping mechanisms.

15. The vehicle transmission of claim 13, wherein the axial force generator comprises a ball ramp.

16. The vehicle transmission of claim 13, wherein the axial force generator comprises a ball ramp thrust ring.

17. The vehicle transmission of claim 13, wherein the axial force generator comprises a load applied during assembly of the variable transmission.

18. The variable transmission of claim 1, wherein the input shaft is drivingly engaged with a torsional dampener disposed between an engine and the variable transmission.

19. The variable transmission of claim 1, wherein the first ring assembly is rotatably disposed in the housing drivingly engaged with the bevel gear power divider unit, the first ring assembly comprising a first variator ball engagement surface that is in driving engagement with a plurality of variator balls of the carrier assembly.

20. The variable transmission of claim 19, wherein the first ring assembly is rotatably disposed in the housing drivingly engaged with the bevel gear power divider unit using the variator input shaft.

21. The variable transmission of claim 19, wherein a first variator ball engagement surface is formed in an input ring of the first ring assembly.

22. The variable transmission of claim 19, wherein a first variator ball engagement surface is formed in a distal end of the first ring assembly.

23. The variable transmission of claim 19, wherein the first variator ball engagement surface is a conical surface or a concave or convex toroidal surface in contact with or slightly spaced apart from each of the variator balls.

24. The variable transmission of claim 19, wherein the first variator ball engagement surface is in driving engagement with each of the variator balls of the carrier assembly through one of a boundary layer type friction and an elastohydrodynamic film.

25. The variable transmission of claim 1, wherein the carrier assembly is rotatably disposed in the housing and is drivingly engaged first ring assembly, the carrier assembly

comprising an annular arrangement of the plurality of tiltable variator balls each having ball axle shafts, and configured to be prevented from rotating relative to the housing by a grounding device.

26. The variable transmission of claim 25, wherein each of the ball axle shafts is adjusted using a cam style tilting mechanism.

27. The variable transmission of claim 25, wherein each of the ball axle shafts is adjusted using a split carrier axle skewing mechanism.

28. The variable transmission of claim 1, wherein the second ring assembly is rotatably disposed in the housing, and wherein the second ring assembly comprises and a second variator ball engagement surface that is in driving engagement with variator balls of the carrier assembly.

29. The variable transmission of claim 28, wherein the second variator ball engagement surface is formed in a distal end of the second ring assembly.

30. The variable transmission of claim 28, wherein a second variator ball engagement surface is formed in an input ring of the first ring assembly.

31. The variable transmission of claim 28, wherein the second variator ball engagement surface is a conical surface or a concave or convex toroidal surface in contact with or slightly spaced apart from each of the variator balls.

32. The variable transmission of claim 28, wherein the second variator ball engagement surface is in driving engagement with each of the variator balls of the first carrier assembly through one of a boundary layer type friction and an elastohydrodynamic film.

33. The variable transmission of claim 28, wherein the output shaft is drivingly engaged with a vehicle output.

34. A vehicle driveline comprising:

an engine;

a dampener in driving engagement with the engine;

a variable transmission of any claims 1-33;

a vehicle output.

35. The vehicle driveline of claim 34, wherein the vehicle output comprises a wheel differential and one or more wheels of a vehicle.

36. The vehicle driveline of claim 34, wherein the vehicle output comprises a wheel differential and a drive axle.

37. The vehicle driveline of claim 34, wherein the dampener is disposed between the engine and the variable transmission.

38. The vehicle driveline of claim 34, wherein the dampener comprises at least one torsional spring.

39. The vehicle driveline of claim 34, wherein the dampener is coupled with a clutch.

40. The vehicle driveline of claim 34, wherein the clutch is a wet clutch or a dry clutch.

41. The vehicle driveline of claim 34, comprising a starting device.

42. The vehicle driveline of claim 41, wherein the starting device comprises a torque converter.

43. The vehicle driveline of claim 41, wherein the starting device is in locked mode after startup.

44. A method comprising providing a variable transmission of any of claims 1-33.

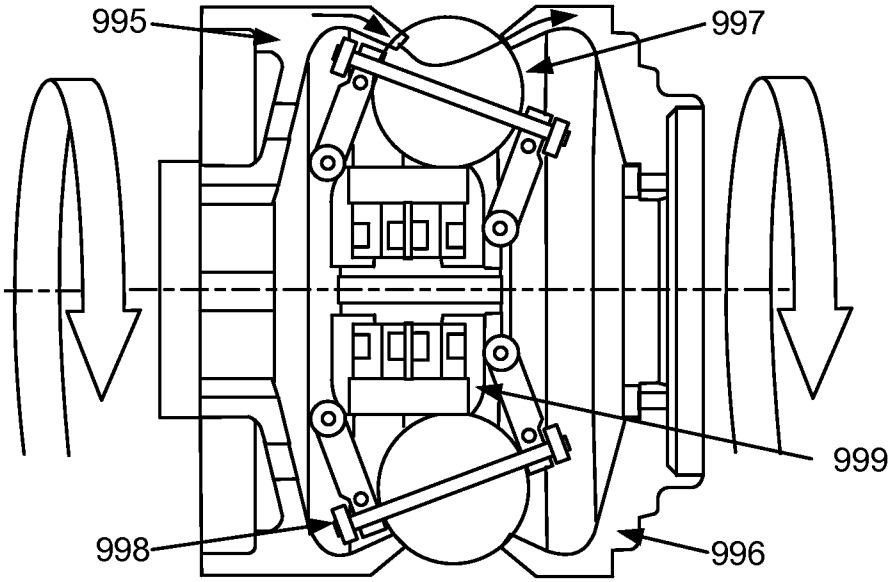

FIG. 1

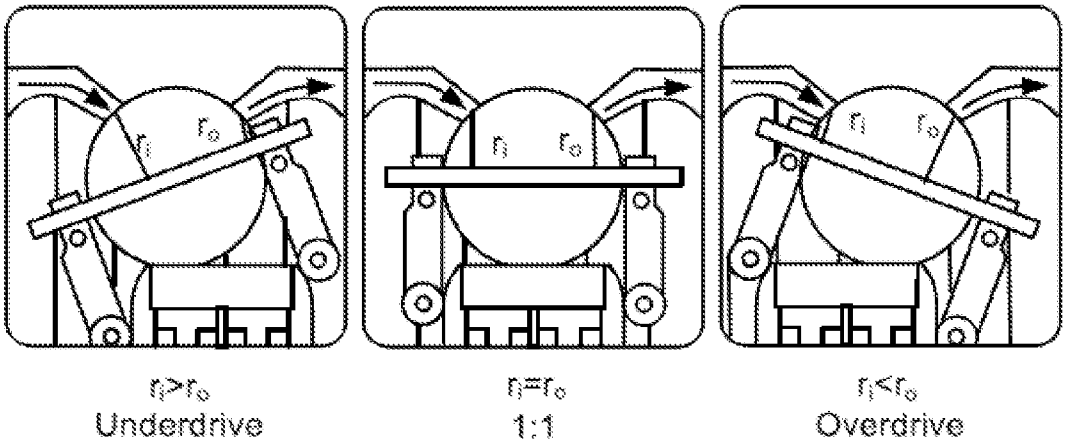

FIG. 2

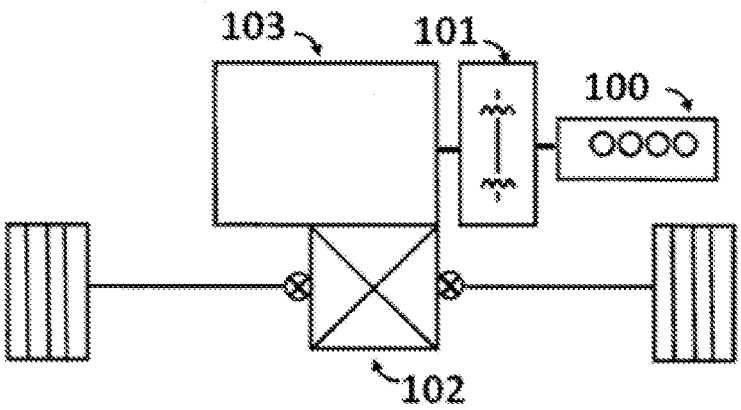

FIG. 3

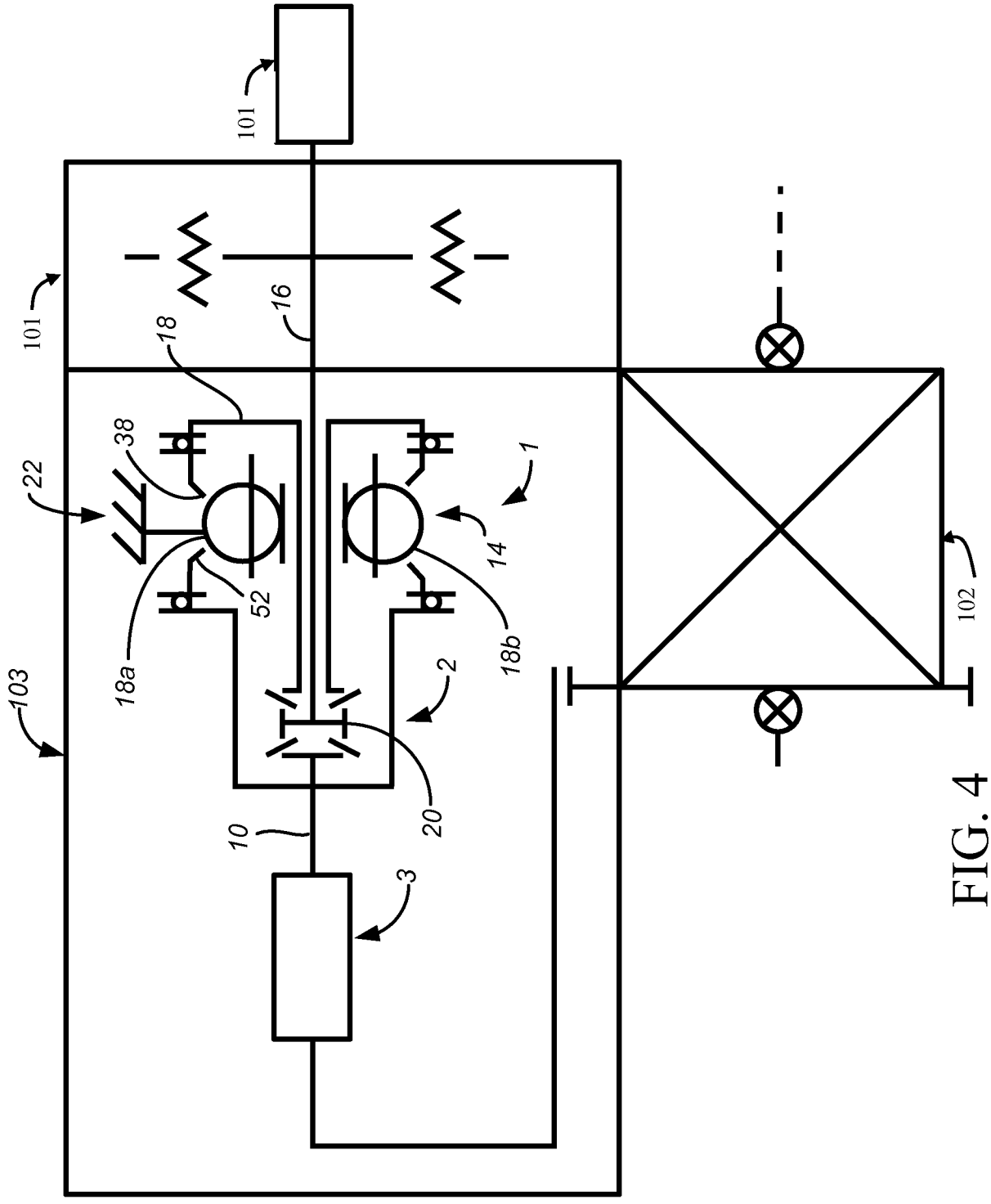

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US13/57839

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B60K 17/00, 17/344, 17/346; F16H 37/02, 37/08 (2014.01)
USPC - 475/5, 6, 215
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)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
IPC(8): B60W 10/06; B60K 17/00, 17/344, 17/346; F16H 37/02, 37/08 (2014.01)
USPC - 475/5, 6, 215

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
MicroPatent (US Granted, US Applications, EP-A, EP-B, WO, JP, DE-G, DE-A, DE-T, DE-U, GB-A, FR-A); Google/Scholar; ProQuest; KEYWORDS: cvt, variator, ball*, bevel, gear, output, drive*, shaft, torque, power, divid*, differential, ramp, bearing, brak*, clutch, torsional , dampener, engine, converter, lock, starter, continuously variable trasmission

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 7,717,815 B2 (TENBERGE, P) 18 May 2010; figures 1, 2, 4; column 1, lines 15-20, column 5, lines 5-10, column 6, lines 50-65	1-18, 28-33, 34/1-34/18, 34/28-34/33, 35/34/1-35/34/18, 35/34/28-35/34/33, 36/1-36/18, 36/28-36/33, 37/34/1-37/34/18, 37/34/28-37/34/33, 38/1-38/18, 38/28-38/33, 39/34/1-39/34/18, 39/34/28-39/34/33, 40/34/1-40/34/18, 40/34/28-40/34/33, 41/34/1-41/34/18, 41/34/28-41/34/33, 42/41/34/1-42/41/34/18, 42/41/34/28-42/41/34/33, 43/41/34/1-43/41/34/18, 43/41/34/28-43/41/34/33, 44/1-44/18 and 44/28-44/33

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Date of the actual completion of the international search	Date of mailing of the international search report
28 January 2014 (28.01.2014)	06 FEB 2014
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US13/57839

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	US 2004/0171452 A1 (MILLER, DC et al.) 02 September 2004; figures 1-4, 10, 15, 32, 35, 39a; paragraphs [0007], [0010], [0014], [0017], [0038], [0062], [0071], [0073], [0076], [0104], [0107], [0111]	1-18, 28-33, 34/1-34/18, 34/28-34/33, 35/34/1-35/34/18, 35/34/28-35/34/33, 36/1-36/18, 36/28-36/33, 37/34/1-37/34/18, 37/34/28-37/34/33, 38/1-38/18, 38/28-38/33, 39/34/1-39/34/18, 39/34/28-39/34/33, 40/34/1-40/34/18, 40/34/28-40/34/33, 41/34/1-41/34/18, 41/34/28-41/34/33, 42/41/34/1-42/41/34/18, 42/41/34/28-42/41/34/33, 43/41/34/1-43/41/34/18, 43/41/34/28-43/41/34/33, 44/1-44/18 and 44/28-44/33
Y	US 2008/0185201 A1 (BISHOP T) 07 August 2008; abstract; paragraph [0002]	36/1-36/18, 36/28-36/33, 38/1-38/18, and 38/28-38/33