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(54) Title: DUAL-PASS CONTINUOUSLY VARIABLE AUTOMATIC TRANSMISSION

(57) Abstract: A dual-pass continuously variable transmission (14) includes a first drive assembly (36) including a planetary gear set (34), a first friction clutch (36), and a second friction clutch (37) for engaging an input shaft (26) with the first intermediate shaft (30), a second drive assembly (44) including a third friction clutch (42) for engaging the input shaft (26) with the second intermediate shaft (32), a third drive assembly (50) including a first multi-mode clutch module (MMCM) (48) for engaging the first intermediate shaft (30) with the output shaft (28), a fourth drive assembly (56) including a second MMCM (54) for engaging the second intermediate shaft (32) with the output shaft (28), and a variator (58) engaging the first (30) and second (32) intermediate shafts.

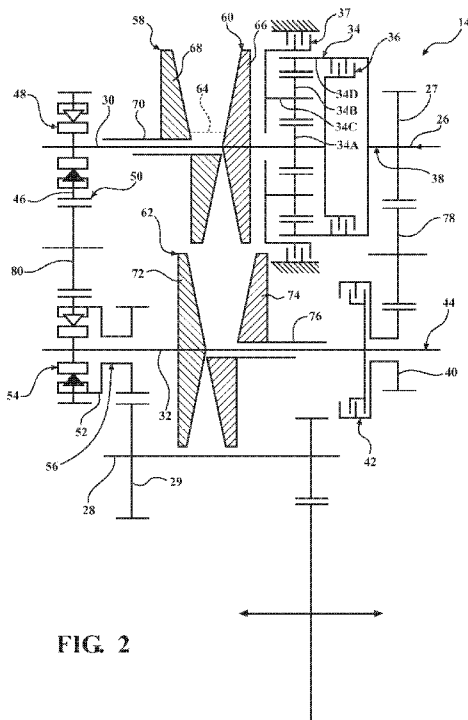


FIG. 2

**Declarations under Rule 4.17:**

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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— *with international search report (Art. 21(3))*

DUAL-PASS CONTINUOUSLY VARIABLE AUTOMATIC TRANSMISSION**CROSS-REFERENCE TO RELATED APPLICATION(S)**

5 [0001] The present application claims priority to and all the benefits of U.S. Provisional Patent Application No. 62/148,841, filed on April 17, 2015, which is hereby expressly incorporated herein by reference in its entirety.

BACKGROUND OF INVENTION

10 1. *Field of Invention*

 [0002] The present invention relates generally to powertrain systems and, more specifically, to a dual-pass continuously variable automatic transmission.

15 2. *Description of the Related Art*

 [0003] Conventional vehicle powertrain systems known in the art typically include an engine in rotational communication with a transmission. The engine generates rotational torque which is selectively translated to the transmission which, in turn, translates rotational torque to one or more wheels. The typical automotive transmission is shifted in discrete steps between a
20 high-torque, low-speed mode for starting a vehicle and a high-speed, low-torque mode for vehicle operation at highway speeds. In a manual transmission shifting is accomplished by the engagement of gear sets. In an automatic transmission shifting is accomplished by the controlled engagement of friction elements. Because such shifting is in step functions, the most efficient vehicle operation can only be approximated. Automotive engineers have long recognized that
25 efficiency would be improved if the transmission could be adjusted continuously to compensate

for changing loads, speeds, etc. This would allow the engine to be operated at maximum efficiency under changing conditions.

[0004] Continuously variable automatic transmissions or CVTs have been known for some time. The typical CVT employs a variator including a variable pulley with a pair of flanges mounted on a primary shaft such that one of the flanges is movable axially with respect to the other. Another similar variable pulley is mounted on a secondary shaft. A flexible belt couples the pulleys for transferring torque therebetween when the primary shaft is driven. When the pitch radius of one pulley is changed, the pitch radius of the other pulley is changed simultaneously in the opposite direction. As a result, the drive ratio between the shafts is variable in a continuous, smooth manner within the ratio range of the variator. Typically, the limits of this range are an underdrive or reduction ratio and an overdrive ratio.

[0005] A dual-pass CVT includes input and output shafts, first and second intermediate shafts, and a variator engaging the intermediate shafts. A first drive mechanism includes a first one-way clutch engaging the input shaft with the first intermediate shaft and allowing the first intermediate shaft to overrun. A second drive mechanism includes a clutching mechanism for engaging the input shaft with the second intermediate shaft, and also includes a second one-way clutch engaging the second intermediate shaft with the input shaft and allowing the input shaft to overrun. A third drive mechanism includes another clutching mechanism for engaging the first intermediate shaft with the output shaft, and also includes a third one-way clutch engaging the output shaft with the first intermediate shaft and allowing the first intermediate shaft to overrun. A fourth drive mechanism includes a fourth one-way clutch engaging the second intermediate shaft with the output shaft and allowing the output shaft to overrun.

[0006] As described above, the dual-pass CVT uses four one-way clutches and two dog (or jaw) clutches to selectively engage and disengage the second pass through the variator. Such a dual-pass CVT is disclosed in U.S. Patent No. 4,630,504 to Smirl, the disclosure of which is hereby incorporated by reference in its entirety. However there is a need in the art to provide a new dual-pass continuously variable automatic transmission with a powerflow that combines a two-pass variator assembly with a planetary gearset and clutches to provide forward/reverse capability and with a combination of friction clutches, one-way clutches and multi-mode clutches to manage shifting from a first pass to a second pass through the variator.

SUMMARY OF THE INVENTION

[0007] The present invention provides a dual-pass continuously variable automatic transmission of a vehicle powertrain system including rotatable input and output shafts, rotatable first and second intermediate shafts, a first drive assembly including a planetary gear set, a first friction clutch, and a second friction clutch for engaging the input shaft with the first intermediate shaft, a second drive assembly including a third friction clutch for engaging the input shaft with the second intermediate shaft, a third drive assembly including a first multi-mode clutch module (MMCM) for engaging the first intermediate shaft with the output shaft, a fourth drive assembly including a second MMCM for engaging the second intermediate shaft with the output shaft, and a variator for engaging the first and second intermediate shafts, wherein a first drive path is established from the input shaft through the first drive assembly, first intermediate shaft, variator, second intermediate shaft and fourth drive assembly to the output shaft, and a second drive path is established from the input shaft through the third drive

assembly, second intermediate shaft, variator, first intermediate shaft and second drive assembly to the output shaft.

[0008] In addition, the present invention provides a method for controlling a dual-pass continuously variable automatic transmission of a vehicle powertrain system including the steps of providing rotatable input and output shafts and providing rotatable first and second intermediate shafts. The method also includes the steps of providing a planetary gear set, a first friction clutch, and a second friction clutch of a first drive assembly for engagement with an input shaft and a first intermediate shaft, a third friction clutch of a second drive assembly for engagement with the input shaft and a second intermediate shaft, a first multi-mode clutch module (MMCM) of a third drive assembly for engagement with the first intermediate shaft and an output shaft, and a second MMCM of a fourth drive assembly for engagement with the second intermediate shaft and the output shaft. The method further includes the steps of engaging the intermediate shafts with a variator, establishing a first drive path from the input shaft through the first drive assembly, first intermediate shaft, variator, second intermediate shaft and fourth drive assembly to the output shaft, and establishing a second drive path from the input shaft through the third drive assembly, second intermediate shaft, variator, first intermediate shaft and second drive assembly to the output shaft.

[0009] One advantage of the present invention is that a new dual-pass continuously variable (automatic) transmission (CVT) is provided. Another advantage of the present invention is that the dual-pass CVT provides a powerflow that combines a two-pass variator assembly with a planetary gear set and clutches to provide forward/reverse capability and with a combination of friction clutches, one-way clutches and multi-mode clutches to manage shifting from a first pass to a second pass through the variator. Yet another advantage of the present

invention is that the dual-pass CVT provides a front-wheel drive powerflow where the transmission is mounted transversely between the front wheels of the vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

5 [0010] Other objects, features, and advantages of the present invention will be readily appreciated as the same becomes better understood after reading the subsequent description taken in connection with the accompanying drawings wherein:

 [0011] Figure 1 is a schematic view of a vehicle powertrain system including a dual-pass continuously variable automatic transmission, according to the present invention;

10 [0012] Figure 2 is a schematic view of a first embodiment, according to the present invention, of the dual-pass continuously variable automatic transmission of Figure 1; and

 [0013] Figure 3 is a schematic view of a second embodiment, according to the present invention, of the dual-pass continuously automatic transmission of Figure 1.

DETAILED DESCRIPTION OF THE INVENTION

15 [0014] Referring now to the figures, where like numerals are used to designate like structure unless otherwise indicated, a vehicle powertrain system is schematically illustrated at 10 in Figure 1. The powertrain system 10 includes an engine 12 in rotational communication with a dual-pass continuously variable (automatic) transmission (CVT) 14. The engine 12
20 generates rotational torque which is selectively translated to the CVT 14 which, in turn, translates rotational torque to one or more wheels, generally indicated at 16. To that end, a pair of continuously-variable joints 18 translates rotational torque from the CVT 14 to the wheels 16. The CVT 14 may be cooled, lubricated, actuated, and modulates torque using hydraulic fluid.

The powertrain system 10 typically includes a control system 20 that controls the CVT 14. In one embodiment, the control system 20 may include a power controller 22 in electrical communication with one or more actuators 24 used to control the CVT 14. It should be appreciated that the engine 12 and the CVT 14 of Figure 1 are of the type employed in a conventional “transverse front wheel drive” powertrain system 10. It should also be appreciated that the engine 12 and/or the CVT 14 could be configured in any suitable way such as with a rear mounted engine to generate and translate rotational torque so as to drive the vehicle, without departing from the scope of the present invention.

[0015] Referring to Figure 2, the CVT 14 includes a rotatable input shaft 26 adapted to receive torque from a power source, for example the engine 12, and an input drive gear 27 secured to the input shaft 26. The CVT 14 also includes a rotatable output shaft 28 adapted to direct torque to, for example, the joints 18 and an output driven gear 29 secured to the output shaft 28.

[0016] The CVT 14 also includes rotatable first and second intermediate shafts 30 and 32 respectively, and a planetary gear set, generally indicated at 34, secured to a first friction clutch, generally indicated at 36, secured to the intermediate shaft 30. The planetary gearset 34 provides both a forward gear and a reverse gear. The planetary gearset 34 includes a sun gear 34A, one or more pinion gears 34B, a pinion carrier 34C, and a ring gear 34D. The CVT 14 includes a second friction clutch, generally indicated at 37, between a housing or ground and the planetary gearset 34. The second friction clutch 37 allows the intermediate shaft 30 to be selectively connected to the input shaft 26 (when a variator 58 to be described is in the low ratio range) or not connected (when the variator 58 is in the high ratio range). It should be appreciated that the gear 27, gearset 34 and friction clutches 36 and 37 together constitute a first drive assembly,

generally indicated at 38, for transferring torque from the input shaft 26. When the first friction clutch 36 is applied, the planetary gearset 34 will spin 1:1 with the input shaft 26 and forward driving direction is engaged. The first friction clutch 36 connects the input shaft 26 to the sun gear 34A of the planetary gearset 34 and then to the intermediate shaft 30. When the second
5 friction clutch 37 is engaged (and the first friction clutch 36 is open), the input shaft 26 is connected to the ring gear 34D of the planetary gearset 34 and the friction clutch grounds the carrier 34C of the planetary gearset 34. The planetary gearset 34 then takes the input from the ring gear 34D and the pinions 34B and transfers it to the sun gear 34A and to the intermediate shaft 32. It should be appreciated that this gear transfer then reverses the direction of the rotation
10 and reverse gear direction is available. It should also be appreciated that, if the clutches 36 and 37 are both engaged, then the planetary gearset 34 cannot spin. It should further be appreciated that either one or both of these friction clutches 36 and 37 may be replaced with MMCMS to be described. It should still further be appreciated that the first drive assembly 38 can transfer torque/speed in either direction – either from the input shaft 26 into the CVT 14 or from the CVT
15 14 back to the input shaft 26 for engine braking.

[0017] The CVT 14 further includes a second driven gear 40 and a friction clutch, generally indicated at 42, that may be engaged to lock the driven gear 40 and input shaft 26 to the intermediate shaft 32 and torque/speed transfer occurs in both directions. The friction clutch 42 allows the intermediate shaft 32 to be selectively driven. It should be appreciated that the
20 gear 27, driven gear 40, and friction clutch 42 together constitute a second drive assembly, generally indicated at 44, for transferring torque/speed in either direction between the input shaft 26 and the second intermediate shaft 32 when the friction clutch 42 is engaged, and there is no transfer of torque/speed in either direction between the intermediate shaft 32 and the input shaft

26 when the friction clutch 42 is not engaged. It should also be appreciated that the intermediate shaft 32 will be driven by the input shaft 26 when the variator 58 is in the high ratio range. It should further be appreciated that the friction clutch 42 is open when the variator 58 is in the low ratio range. It should still further be appreciated that the friction clutch 42 could be replaced
5 with a multi-mode clutch module (MMCM) or one-way clutch. It should yet further be appreciated that the first drive assembly 38 and second drive assembly 44 serve as inputs to the CVT 14.

[0018] The CVT 14 also includes a third drive gear 46 and a first multi-mode clutch module (MMCM), generally indicated at 48, that may be engaged to lock the first intermediate
10 shaft 30 to the third drive gear 46 and torque/speed transfer occurs in both directions. An example of the MMCM is disclosed in PCT Patent Application Publication No. WO 2014/120595, the disclosure of which is hereby incorporated by reference in its entirety. It should be appreciated that the drive gear 46 and MMCM 48 together constitute a third drive assembly, generally indicated at 50, for transferring torque/speed in either direction between the
15 first intermediate shaft 30 and the output shaft 28 when the MMCM 48 is engaged, and there is no transfer of torque/speed in either direction between the first intermediate shaft 30 and the output shaft 28 when the MMCM 48 is not engaged.

[0019] The CVT 14 further includes a fourth drive gear 52 and a second multi-mode clutch module (MMCM), generally indicated at 54, that that may be engaged to lock the second
20 intermediate shaft 32 to the fourth drive gear 52 and torque/speed transfer occurs in both directions. The fourth drive gear 52 is at the same time connected to gear 80 and 50. The MMCM 54 is used to connect the second intermediate shaft 32 to the output gear 29 and final drive. It should be appreciated that the second intermediate shaft 32, MMCM 54, and output

gear 29 together constitute a fourth drive assembly, generally indicated at 56, for transferring torque/speed from the second intermediate shaft 32 to the output shaft 28 when the MMCM 54 is engaged, and there is no transfer of torque/speed in either direction between the second intermediate shaft 32 and the output shaft 28 when the second MMCM 54 is not engaged. It should also be appreciated that the third drive assembly 50 and fourth drive assembly 56 are outputs from the CVT 14.

[0020] The particular application of CVT 14 will determine whether these four drive assemblies 38, 44, 50, and 56 provide underdrive or overdrive. Powerflow for the first (underdrive) pass is from the input shaft 26 through the first drive assembly 38, into the first intermediate shaft 30, through the belt and pulley into the second intermediate shaft 32 then out through the second MMCM 54, gears 56, 29 and into the output shaft 28 then to final drive and out to the wheels 16 of the vehicle. Powerflow for the second (overdrive) pass is from the input shaft 26 through the gears 27/78/40 (or the chain 82 in Figure 3), through the friction clutch 42, into the second intermediate shaft 32, through the belt 64 and pulley up to the first intermediate shaft 30, out through the first MMCM 48 then gears 80, 56, 29, the output shaft 28, the final drive, and out to the wheels 16 of the vehicle.

[0021] The CVT 14 further includes a variator, generally indicated at 58, that engages the first and second intermediate shafts 30 and 32. The variator 58 includes a variable pulley, generally indicated at 60, on the first intermediate shaft 30 and another variable pulley, generally indicated at 62, on the second intermediate shaft 32. The pulleys 60 and 62 are continuously variable respectively between minimum and maximum pitch radii. The CVT 14 also includes a suitable belt 64, chain, or the like to couple the pulleys 60 and 62.

[0022] As is well known in the art, the pitch radii of the pulleys 60 and 62 may be varied such that the ratio of the variator 58 is continuously variable within a range having predetermined limits. These limits should provide a fifth, underdrive ratio and a sixth, overdrive ratio substantially equal to the overdrive ratio through the gear trains 34,27,40 and 46,29,52.

5 [0023] The pulley 60 includes a fixed flange 66 rotatable with the first intermediate shaft 30 and a slidable flange 68 having a hub 70 rotatable with and slidable relative to the first intermediate shaft 30. As shown in solid lines above the intermediate shaft 30, the flange 68 is in its distal position relative to the flange 66. In this position, the pulley 60 develops its minimum pitch radius. As shown in solid lines below the first intermediate shaft 30, the flange 68 is in its
10 proximal position, with the hub 70 abutting the flange 66. It should be appreciated that, in this position, the pulley 60 develops its maximum pitch radius.

[0024] The pulley 62 is similar to the pulley 60 and includes a fixed flange 72 rotatable with the second intermediate shaft 32 and a slidable flange 74 having a hub 76 rotatable with and slidable relative to the second intermediate shaft 32. As shown in solid lines below the second
15 intermediate shaft 32, the flange 74 is in its proximal position relative to the flange 72, with the hub 76 abutting the flange 72. This determines the maximum pitch radius of the pulley 62. As shown in solid lines above the second intermediate shaft 32, the flange 74 is in its distal position, which determines the minimum pitch radius of the pulley 62. It should be appreciated that when the pulley 62 is in the low range, this is the driven side and when the pulley 62 is in the high
20 range, this is the drive side.

[0025] The CVT 14 may include a first transfer gear 78 that connects the input shaft 26 via the input gear 27 to the gear 40 of the second intermediate shaft 32 in the embodiment illustrated in Figure 2. The CVT 14 may include a second transfer gear 80 that connects the first

intermediate shaft 30 via the gear 46 to the second intermediate shaft 32 via the gear 52. The CVT 14 may include a chain 82 instead of the first transfer gear 78 that connects the input shaft 26 via the gear 27 to the gear 40 of the second intermediate shaft 32 in the second embodiment illustrated in Figure 3. It should be appreciated that a similar chain could be used instead of the second transfer gear 80. It should also be appreciated that like reference numerals indicated like parts between the embodiments of Figures 2 and 3. It should also be appreciated that second embodiment of the CVT 14 of Figure 3 is similar to the first embodiment of the CVT 14 of Figure 2 but uses a chain drive via the chain 82 instead of a gear drive via the transfer gear 78.

[0026] The sequence of events for a vehicle acceleration from stop. A first drive path is established from the input shaft 26 through the first drive assembly 38, first intermediate shaft 30, variator 58, second intermediate shaft 32, MMCM 54, and fourth drive assembly 56 to the output shaft 28. At this point, the CVT 14 is in the low-range mode and provides underdrive from the input shaft 26 to the output shaft 28.

[0027] The variator 58 now is shifted continuously through its ratio range from underdrive to overdrive. This results in a continuous, smooth increase in the output speed at the output shaft 28.

[0028] At the end of the first pass through the variator 58, the CVT 14 provides direct drive from the input shaft 26 to the output shaft 28. The second intermediate shaft 32 is in substantial synchronism with the gear 40, and the first intermediate shaft 30 is in substantial synchronism with the gear 46. If desired, suitable sensors may be provided for transmitting appropriate torque and/or speed signals. In response to these signals, if provided, the control system 20 releases the friction clutch 36, applies the friction clutch 42, releases the MMCM 54,

and applies the MMCM 48 to switch from the first pass to the second pass through the variator 58.

[0029] When the friction clutch 42 and MMCM 54 are engaged, a second drive path is established from the input shaft 26 through the input gears 27,78,40 and to the friction clutch 42 then into the second intermediate shaft 32, then into the variator 58 and fourth drive assembly 56, output gear 29, and out via the output shaft 28. The CVT 14 is in the high-range mode, but still provides direct drive from the input shaft 26 to the output shaft 28.

[0030] The variator 58 now is shifted in the opposite direction continuously through its ratio range from underdrive to overdrive. This results in an additional continuous, smooth increase in the output speed at the output shaft 28.

[0031] At the end of the second pass through the variator 58, the CVT 14 provides overdrive from the input shaft 26 to the output shaft 28. One operating cycle (two passes through the variator 58) has been completed. The belt 64 is in its initial, starting position, with the pulleys 60 and 62 rotating at correspondingly higher speeds.

[0032] It should be appreciated that the MMCM 48 is engaged when the CVT 14 is in the high-range mode; that is, when it is configured for the second drive path. The MMCM 48 establishes a positive connection for the transfer of torque between the shafts 26 and 28. Thus, the CVT 14 provides engine braking in this mode.

[0033] The present invention has been described in an illustrative manner. It is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation.

[0034] Many modifications and variations of the present invention are possible in light of the above teachings. Therefore, within the scope of the appended claims, the invention may be practiced other than as specifically described.

What is claimed is:

1. A dual-pass continuously variable transmission (14) comprising:

rotatable input (26) and output (28) shafts;

rotatable first (30) and second (32) intermediate shafts;

5 a first drive assembly (38) including a planetary gear set (34), a first friction clutch (36), and a second friction clutch (37) for engaging said input shaft (26) with said first intermediate shaft (30);

a second drive assembly (44) including a third friction clutch (42) for engaging said input shaft (26) with said second intermediate shaft (32);

10 a third drive assembly (50) including a first multi-mode clutch module (MMCM) (48) for engaging said first intermediate shaft (30) with said output shaft (28);

a fourth drive assembly (56) including a second MMCM (54) for engaging said second intermediate shaft (32) with said output shaft (28); and

a variator (58) for engaging said first (30) and second (32) intermediate shafts, wherein a
15 first drive path is established from the input shaft (26) through the first drive assembly (38), first intermediate shaft (30), variator (58), second intermediate shaft (32) and fourth drive assembly (56) to the output shaft (28), and a second drive path is established from the input shaft (26) through the third drive assembly (50), second intermediate shaft (32), variator (58), first intermediate shaft (30) and second drive assembly (44) to the output shaft (28).

20

2. A dual-pass continuously variable transmission (14) as set forth in claim 1 wherein said first (38) and second (44) drive assembly respectively includes first (27, 34) and second (27, 40) gear sets driven by said input shaft (36).

3. A dual-pass continuously variable transmission (14) as set forth in claims 1 or 2 wherein said third and fourth drive assembly respectively including third (46) and fourth (29) gear sets driving said output shaft (28).

5

4. A dual-pass continuously variable transmission (14) of claim 3 wherein said variator (58) includes a variable pulley (60) rotatable with said first intermediate shaft (30), another variable pulley (32) rotatable with said second intermediate shaft (32), and a belt (64) coupling said pulleys (60, 62), each of said pulleys (60, 62) including a fixed flange (66, 72) rotatable with its associated intermediate shaft (30, 32), and another flange (68, 74) rotatable with and slidable relative to its associated intermediate shaft (30, 32) between proximal and distal positions relative to its associated fixed flange (66, 72), the distal position of the slidable flange (68) of said pulley (60) and the proximal position of the slidable flange (74) of said other pulley (62) determining one of said limits, and the proximal position of the slidable flange (68) of said pulley (60) and the distal position of the slidable flange (74) of said other pulley (62) determining the other of said limits.

5. A dual-pass continuously variable transmission (14) as set forth in any one of claims 1-4 including a first transfer gear (78) interconnecting the input gear (27) on the input shaft (26) and the gear (40) on said second intermediate shaft (32).

6. A dual-pass continuously variable transmission (14) as set forth in any one of claims 1-5 including a second transfer gear interconnecting the gear on said first intermediate shaft and the gear on said second intermediate shaft.

5 7. A dual-pass continuously variable transmission (14) as set forth in claims 1-4 including a chain (82) interconnecting the input gear (27) on the input shaft (26) and the gear (40) on said second intermediate shaft (32).

8. A method for controlling a multi-mode clutch system for use with a continuously
10 variable automatic transmission (14) of a vehicle powertrain system (10), said method comprising the steps of:

providing rotatable input (26) and output (28) shafts;

providing rotatable first (30) and second (32) intermediate shafts;

providing a planetary gear set (34), a first friction clutch (36), and a second friction clutch
15 (37) of a first drive assembly (38) for engagement with the input shaft (26) and the first intermediate shaft (30);

providing a third friction clutch (42) of a second drive assembly (44) with the input shaft (26) and the second intermediate shaft (32);

providing a first multi-mode clutch module (MMCM) (48) of a third drive assembly (50)
20 for engagement with the first intermediate shaft (30) and the output shaft (28);

providing a second MMCM (54) of a fourth drive assembly (56) for engagement with the second intermediate shaft (32) and the output shaft (28); and

engaging the intermediate shafts with a variator (58), establishing a first drive path from the input shaft (26) through the first drive assembly (36), first intermediate shaft (30), variator (58), second intermediate shaft (32) and fourth drive assembly (56) to the output shaft (28), and establishing a second drive path from the input shaft (26) through the third drive assembly (50),
5 second intermediate shaft (32), variator (58), first intermediate shaft (30) and second drive assembly (44) to the output shaft.

9. A method as set forth in claim 8 including the step of providing the first (38) and second (44) drive assembly with first (34) and second (40) gear sets driven by the input shaft
10 (26).

10. A method as set forth in claims 8 or 9 including the step of providing the third (50) and fourth (56) drive assembly with third (46) and fourth (29) gear sets driving the output shaft (28).
15

11. A method as set forth in any one of claims 8-10 including the step of interconnecting the input gear (27) on the input shaft (26) and the gear (40) on the second intermediate shaft (32) with a first transfer gear (78).

20 12. A method as set forth in any one of claims 8-10 including the step of interconnecting the gear (46) on the first intermediate shaft (30) and the gear (40) on the second intermediate shaft (32) with a second transfer gear (80).

13. A method as set forth in any one of claims 8-10 including the step of interconnecting the input gear (27) on the input shaft (26) and the gear (40) on the second intermediate shaft (32) with a chain (82).

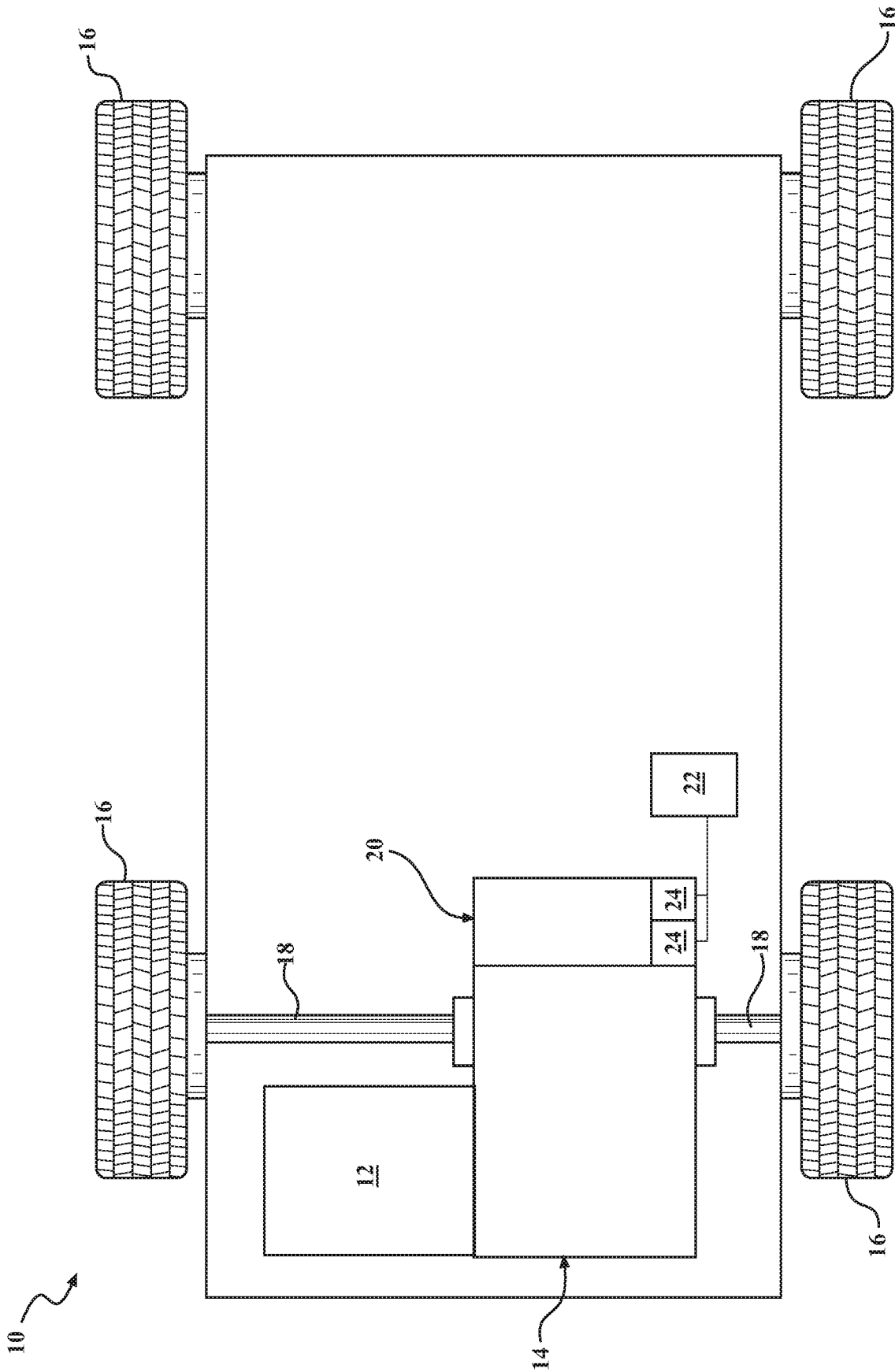
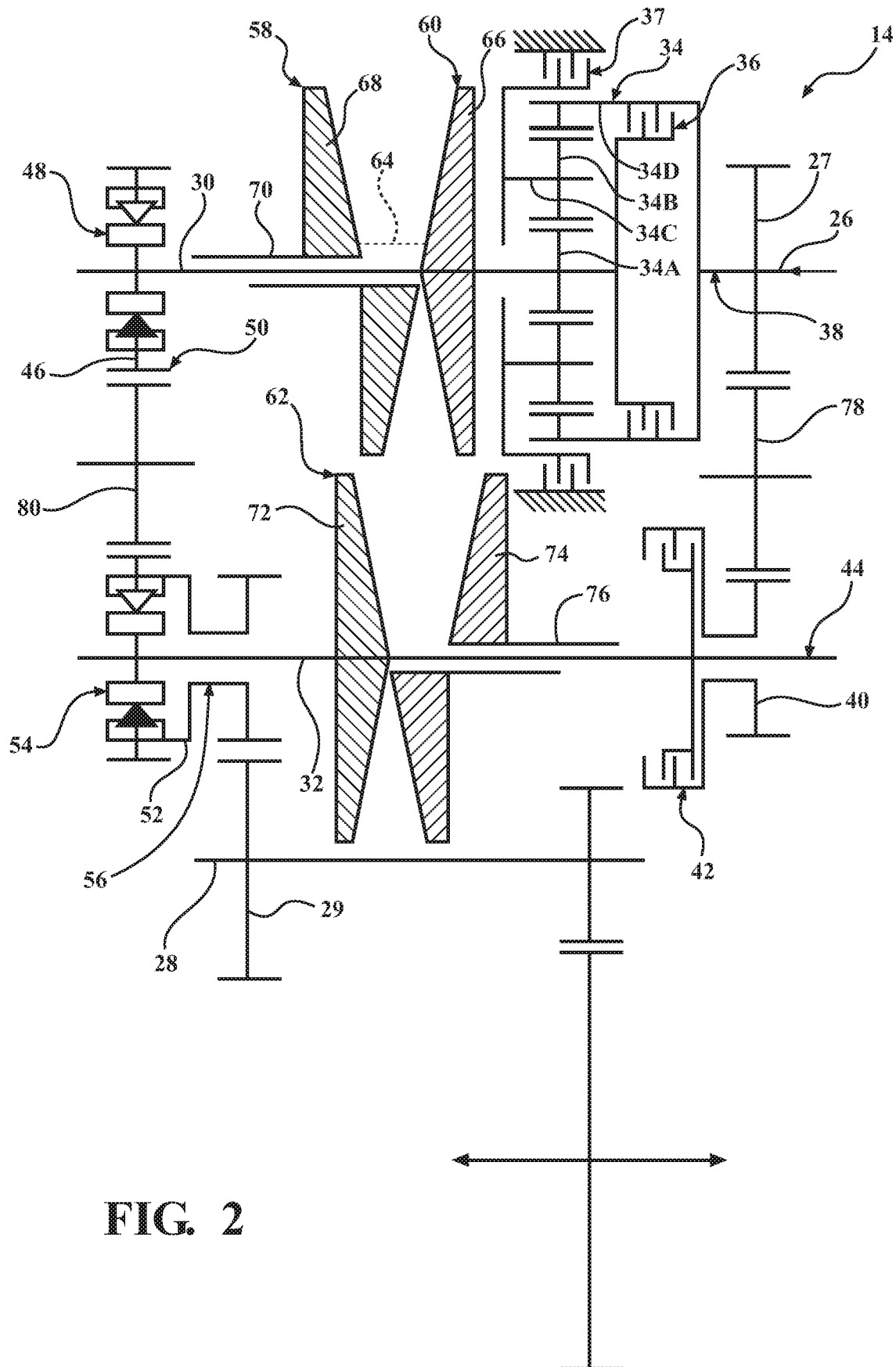


FIG. 1



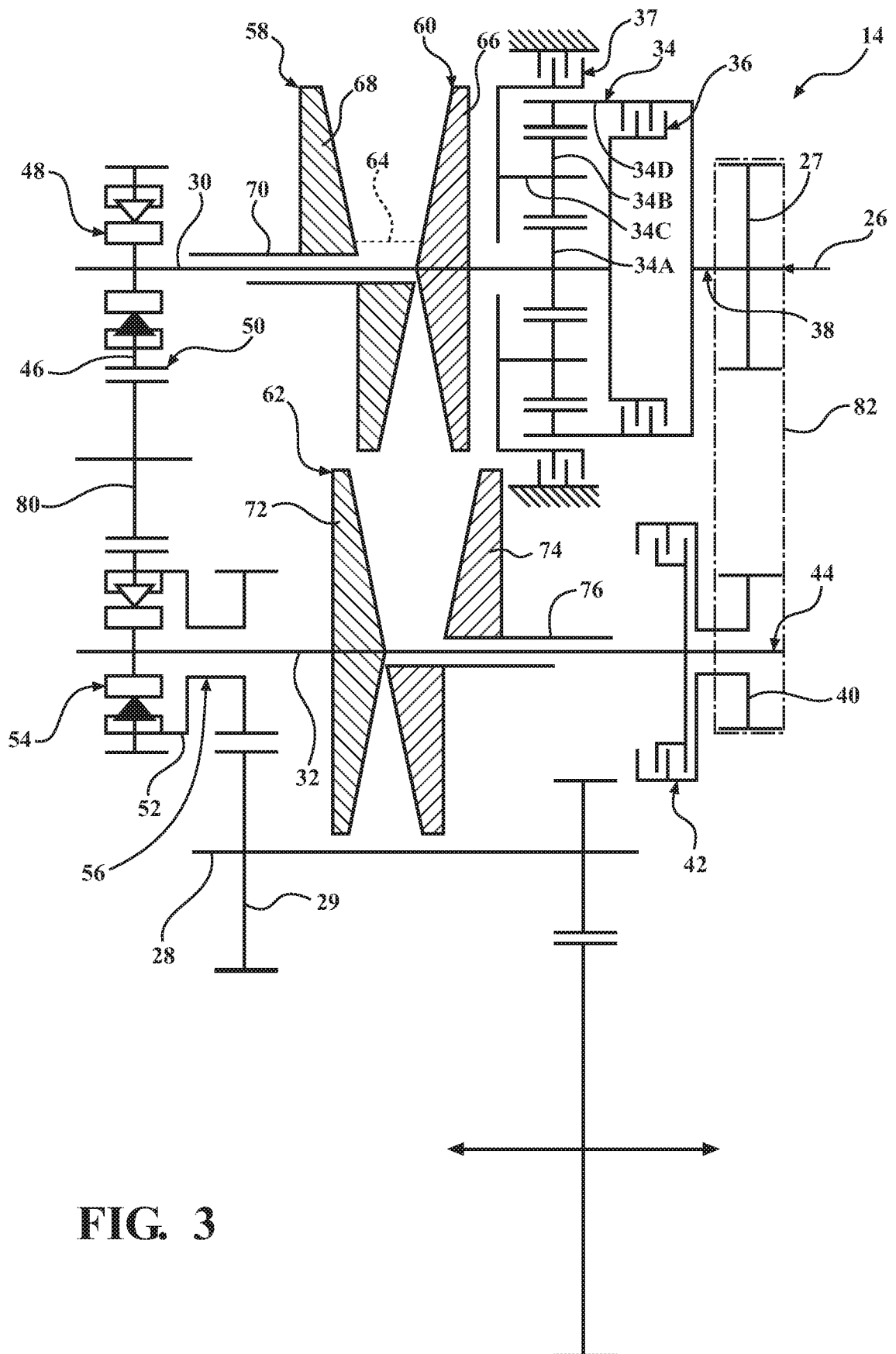


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/027020**A. CLASSIFICATION OF SUBJECT MATTER****F16H 61/662(2006.01)i, F16H 61/664(2006.01)i, F16D 41/08(2006.01)i**

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 61/662; B60K 41/10; F16H 59/00; F16H 59/38; F16D 41/04; F16H 11/02; F16H 37/02; F16H 61/16; F16H 3/08; F16H 61/664; F16D 41/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: dual-pass, transmission, shaft, clutch, friction, gear, variator, pulley, multi-mode clutch

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2010-053939 A (NISSAN MOTOR CO., LTD.) 11 March 2010 See paragraphs [0009]–[0020] and figure 1.	1–13
A	KR 10-2014-0148386 A (TOYOTA JIDOSHA KABUSHIKI KAISHA) 31 December 2014 See paragraphs [0030]–[0042] and figure 1.	1–13
A	US 4630504 A (SMIRL, RICHARD L.) 23 December 1986 See column 3, line 4 – column 4, line 26 and figures 1a–1f.	1–13
A	US 4495838 A (GOOCH, DOUGLAS C.) 29 January 1985 See abstract, column 2, line 67 – column 4, line 56, and figure 1.	1–13
A	US 2004-0185973 A1 (SATO et al.) 23 September 2004 See paragraphs [0043]–[0050] and figure 3.	1–13



Further documents are listed in the continuation of Box C.



See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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