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(54) Title: ONE WAY CLUTCH ARRANGEMENT FOR A PUMP WITH POWER SPLIT DRIVE AND ELECTRIC MOTOR

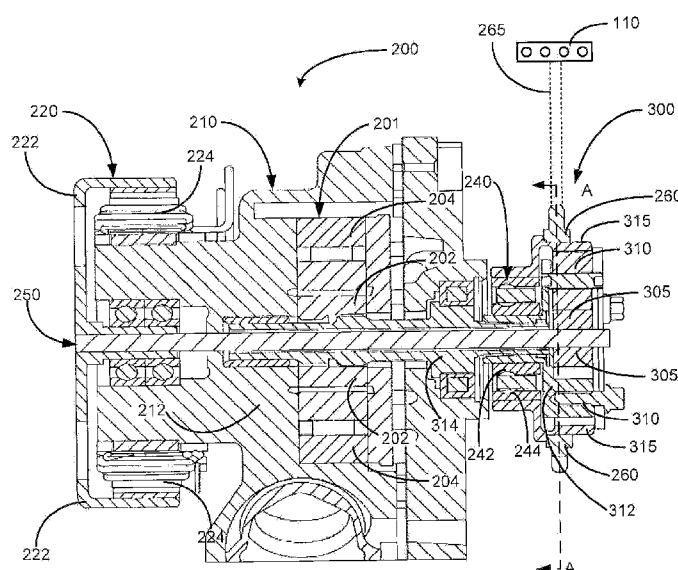


FIG. 2

(57) Abstract: A system for providing rotational torque to a pump (201) associated with a transmission (112) of a vehicle includes an engine (110), an electrical motor (220), a shaft (250) configured to receive rotational torque input, and a planetary gear set (300). The planetary gear set (300) provides output rotational torque to the pump (201) based on one of a plurality of pump operating modes, the plurality of modes including an electric drive mode, a direct engine drive mode, and a hybrid drive mode. The system includes a one-way clutch (240) disposed within a path of rotational torque transfer internal to the planetary gear set (300) and, when activated, causing the planetary gear set (300) to operate at a gear ratio of 1:1, the one-way clutch (240) being activated when the pump operating mode is the direct drive mode.

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One Way Clutch Arrangement for a Pump With Power Split Drive and Electric Motor**Technical Field**

[0001] The present disclosure generally relates to transmissions within a motor vehicle
5 drive train and, more particularly, to pump and electric motor combinations for use within a
transmission of a motor vehicle drive train.

Background

[0002] Many automobiles implement a vehicle transmission, which receives rotational
input from a power source, such as a mechanical engine and/or an electric motor, and
10 increases torque output by using gear-based reduction in rotational speed. Such torque output
power may then be transferred to axles of the vehicle, which may then drive wheels of the
vehicle.

[0003] Some example transmissions are hydraulically-controlled and use pressurized
fluid to change gear ratios, of the transmission, by utilizing planetary gear sets, in a
15 conventional manner. Pressure for such fluid may be provided by a pump, which may be a
fixed-displacement pump, having output linearly tied to engine speed. Such fixed-
displacement pumps should be designed to provide sufficient hydraulic control of the
transmission at low speeds and, thus, are often oversized for other vehicle operating
conditions.

20 [0004] In some prior transmission designs, the fixed-displacement pump is supplemented
with an auxiliary pump, which delivers fluid during vehicle operating conditions that are
underserved by the fixed-displacement pump, such as engine idle conditions, low speed
conditions, and/or high pressure demand conditions. However, implementing two pumps in a

transmission may add unwanted cost and/or unwanted complexity to the hydraulic control system.

[0005] To that end, it is desired to implement a transmission in an automobile, wherein a single pump can be used and operational efficiency of all transmission components can be maintained, while operating under a plurality of conditions. Accordingly, new clutch and gear arrangements, utilized to preserve such operational efficiency, are desired.

Summary

[0006] In accordance with one aspect of the disclosure, a power split pump device for a transmission of a vehicle is disclosed. The power split pump device may provide rotational torque to a pump associated with the transmission. The power split pump device may include a shaft configured to receive rotational torque input from an electrical motor. The power split pump device may further include a planetary gear set providing output rotational torque to the pump. The planetary gear set may include a set of pinion gears, a sun gear operatively coupled with the shaft and configured to receive rotational torque input from one or more of the electrical motor, the set of pinion gears, and any combinations thereof, and a ring gear disposed radially outward of the sun gear and configured to receive rotational torque input from an engine. The set of pinion gears may be disposed radially outward of the sun gear and radially inward of the ring gear and each of the set of pinion gears may be configured to rotate based on input from one or both of the sun gear and the ring gear. The power split pump device may further include a one-way clutch operatively associated with the planetary gear set, selectively activated, and configured to halt rotation of the set of pinion gears when activated.

[0007] In accordance with another aspect of the disclosure, a system for providing rotational torque to a pump associated with a transmission of a vehicle is disclosed. The system may include an engine, an electrical motor, a shaft configured to receive rotational torque input and a planetary gear set. The planetary gear set may provide output rotational torque to the pump based on one of a plurality of pump operating modes, the plurality of modes including an electric drive mode, a direct drive mode, and a hybrid drive mode. The system may further include a one-way clutch disposed within a path of rotational torque transfer internal to the planetary gear set and, when activated, causing the planetary gear set to operate at a gear ratio of 1:1, the one-way clutch being activated when the pump operating mode is in the direct drive mode.

[0008] In accordance with yet another aspect of the disclosure, a drivetrain for a vehicle is disclosed. The drivetrain may include an engine, and a transmission operatively coupled with the engine. The transmission may include a pump, an electrical motor, and a power split pump device. The power split pump device may provide rotational torque to the pump. The power split pump device may include a shaft configured to receive rotational torque input. The power split pump device may further include a planetary gear set providing output rotational torque to the pump. The planetary gear set may include a set of pinion gears, a sun gear operatively coupled with the shaft and configured to receive rotational torque input from one or more of the electrical motor, the set of pinion gears, and any combinations thereof, and a ring gear disposed radially outward of the sun gear and configured to receive rotational torque input from an engine. The set of pinion gears may be disposed radially outward of the sun gear and radially inward of the ring gear and each of the set of pinion gears may be configured to rotate based on input from one or both of the sun gear and the ring gear. The

power split device may further include a one-way clutch operatively associated with the planetary gear set, selectively activated, and configured to halt rotation of the set of pinion gears when activated. The drivetrain may further include a transfer case operatively associated with the transmission and receiving power transmission from the transmission and
5 at least one drive shaft, wherein power is transferred to the driveshaft from the transfer case.

[0009] These and other aspects and features of the present disclosure will be better understood when read in conjunction with the accompanying drawings.

Brief Description of the Drawings

10 [0010] FIG. 1 is a schematic diagram of a vehicle drivetrain, the drivetrain including a transmission, in accordance with and embodiment of the present disclosure.

[0011] FIG. 2 is a cross-sectional illustration of a power split device of the transmission of FIG. 1, including, at least, a one-way clutch and a planetary gear set, in accordance with an embodiment of the present disclosure.

15 [0012] FIG. 3 is radial, cross-sectional illustration of the planetary gear set of FIG. 2, taken about a cutaway line A-A, in accordance with FIG. 2 and the present disclosure.

[0013] FIG. 3A is the radial, cross sectional illustration of the planetary gear set of FIG. 3, illustrating rotational motion of gears of the planetary gear set when operating in an electric drive mode, in accordance with FIG. 3 and the present disclosure;

20 [0014] FIG. 3B is the radial, cross sectional illustration of the planetary gear set of FIG. 3, illustrating rotational motion of gears of the planetary gear set when operating in a direct drive mode, in accordance with FIG. 3 and the present disclosure;

[0015] FIG. 3C is the radial, cross sectional illustration of the planetary gear set of FIG. 3, illustrating rotational motion of gears of the planetary gear set when operating in a hybrid drive mode, in accordance with FIG. 3 and the present disclosure;

[0016] FIG. 4 is a schematic diagram illustrating arrangement of rotational torque transfer between an electric motor, an engine, a pump, the planetary gear set of FIGS. 2-3, and the one-way clutch of FIG. 2, in accordance with FIGS. 1-3 and the present disclosure.

[0017] FIG. 5 is another schematic diagram illustrating an alternative arrangement of rotational torque transfer between the electric motor, the engine, a pump, the planetary gear set of FIGS. 2-3, and the one-way clutch of FIG. 2, in accordance with FIGS. 1-3 and the present disclosure.

[0018] FIG. 6 is yet another schematic diagram illustrating another alternative arrangement of rotational torque transfer between the electric motor, the engine, a pump, the planetary gear set of FIGS. 2-3, and the one-way clutch of FIG. 2, in accordance with FIGS. 1-3 and the present disclosure.

[0019] FIG. 7 is a graph showing flow rate versus input shaft speed for the pump of FIGS. 1-3, as compared to fixed displacement pumps under a variety of operating modes for the transmission of FIG. 1, in accordance with the present disclosure.

[0020] While the following detailed description will be given with respect to certain illustrative embodiments, it should be understood that the drawings are not necessarily to scale and the disclosed embodiments are sometimes illustrated diagrammatically and in partial views. In addition, in certain instances, details which are not necessary for an

understanding of the disclosed subject matter or which render other details too difficult to perceive may have been omitted. It should therefore be understood that this disclosure is not

limited to the particular embodiments disclosed and illustrated herein, but rather to a fair reading of the entire disclosure and claims, as well as any equivalents thereto.

Detailed Description

5 [0021] Referring now to the drawings and with specific reference to FIG. 1, a schematic view of a plan for a drivetrain 100 for a vehicle is disclosed. The drivetrain 100 may include an engine 110 that is coupled to a transmission 112. In some examples, the engine 110 may be a prime mover of the drivetrain 100 and may include one or more of an internal combustion engine, an electric motor, an electric generator, and any combinations thereof.

10 The engine 110 may provide driving power (e.g., via a rotating output shaft, generating rotational torque output) to the transmission 112, wherein the transmission 112 includes components operable to convert the speed and torque of the driving power provided by the engine 110. Such components may include, for example, a gear train that provides multiple gear ratios. The transmission 112 may be a manual transmission, an automatic transmission,

15 a hydraulically-controlled automatic transmission, a semi-automatic transmission, a continuously variable transmission, a dual clutch transmission or any other suitable transmission, known in the art, for use with a drivetrain of a vehicle.

[0022] The transmission may provide driving power to a front driveshaft 140, which may be operatively associated with a front axle 160 and/or front wheels 164. The front driveshaft

20 140 may provide driving power to the front axle 160 via a front differential 162.

Accordingly, the front axle 160 may be a solid axle or a pair of independent half axles, which are configured to provide driving power to the pair of front wheels 164, each of which may be fitted with tires. Further, in some examples, the drivetrain 100 may include, or otherwise

be associated with, a rear axle 150, which may be, for example, a solid axle or a pair of independent half axles, which is configured to connect a pair of rear wheels 154, each of which may be fitted with tires. While the drivetrain 100 is depicted as a front wheel drive (FWD) drivetrain 100 which drives the front axle 160, it is certainly not limited to being a

5 FWD drivetrain 100. Alternatively, the transmission 112 can be utilized in powering any rear wheel drive (RWD) drivetrains, by providing driving power to the rear axle 150, and/or the transmission 112 can be utilized in all-wheel drive (AWD) drivetrains, which provide driving power to both the rear axle 150 and the front axle 160.

[0023] Turning now to FIG. 2, a power split pump device 200 of the transmission 112 is
10 illustrated, which may be used to power a pump 201 of a hydraulic control system and be operatively associated with a housing 210, includes an electric motor 220, a one way clutch 240, and a planetary gear set 300. As depicted, the pump 201 may be housed within the housing 210, the housing 210 laterally extending, at least, from the pump 201 to the electric motor 220. Accordingly, the pump 201 may be substantially disposed within a bore 212 of
15 the housing 210. In contrast to fixed-displacement pumps driven only by a prime mover through a transmission, the pump 201 may be electrically driven by one or more of the electric motor 220, the engine, and any combinations thereof, to more efficiently match the flow rate of a fluid to the demands of the vehicle.

[0024] The pump 201 may be a gerotor pump, a vane pump, a crescent pump, or any
20 other type of shaft-driven pump, known in the art, which may be configured for containment within the housing 210. The pump 201 may include a pump rotor 202 and a pump stator 204. In operation, the pump rotor 202 may be driven by a shaft 250, which, in some examples, may be driven by the electric motor 220. As configured to drive the shaft 250, the electric

motor 220 may include a motor rotor 222, which surrounds or encircles a motor stator 224. As shown, the electric motor may be disposed on the housing 210 and, in some examples, radially outward of a portion of the housing 210. Of course, the electric motor 210 is not limited to being positioned in this manner and it may be, in whole or in part, disposed within
5 the bore 212 of the housing 210. Further, the electric motor may be connected to the shaft 250 through use of a spline, a press joint, or any other type of mechanical connection, known in the art, allowing the electric motor 220 to drive the shaft 250 and supply power to the pump 201.

[0025] The one-way clutch 240 may include an inner race 242, which is coupled with a
10 carrier shaft 314, which is operatively associated with a carrier 312 of the planetary gear set 300. The one way-clutch 240 may further include an outer race 244, which is coupled with a sprocket 260, the sprocket being operatively associated with a ring gear 315 of the planetary gear set 300, as discussed in more detail below. In some examples, the sprocket 260 may be connected to the engine 110 via, for example, a chain 262, while, of course, other devices or
15 connections to the engine 10 are certainly possible. The one-way clutch 240 allows for a plurality of operation modes for the power split device 200, as discussed in more detail below.

[0026] As shown, the one-way clutch 240 may be arranged between members of the planetary gear set 300. The planetary gear set 300, as shown in FIG. 2 and further illustrated
20 in the radial, cross-sectional view of FIG. 3, may include, but is not limited to including, a sun gear 305, a set of pinion gears 310, and a ring gear 315. The sun gear 305 may be directly coupled with the shaft 250 and, thus, rotates with the shaft and, in turn, the electric motor 220. Further, the ring gear may be operatively coupled with the sprocket 260 and,

thusly, operatively coupled with the engine 110 via the chain 265. The sun gear 305 is disposed radially inward from the ring gear 315 and, conversely, the ring gear 315 is disposed radially outward of the sun gear 305. Located there between, the set of pinion gears 310 are disposed radially outward of the sun gear 305 and radially inward of the ring gear 315. The set of pinion gears 310 may each be configured to rotate based on input from one or both of the sun gear 305, the ring gear 315, and any combinations thereof and, therefore, may transfer rotational torque between the sun gear 305 and the ring gear 315, based on a configured gear ratio for the planetary gear set 300. For transferring such torque, the pinion gears 310 are operatively associated with the pinion carrier 312, which engages with the ring gear 315 and rotates in opposite direction of the pinion gears 310, based on input from the pinion gears 310.

[0027] Operation of the planetary gear set 300 and rotation of any gears thereof may be influenced by the one-way clutch 240 and such operation may be based on one of a plurality of power modes for utilizing the power split pump device 200 to provide power to the pump 201. The choice of such modes may be based on fluid flow demands for the pump 201, such fluid flow demands having a direct relationship with the rotational speed transferred to the rotor 202 of the pump 201, via the carrier shaft 314, from one or both of the engine 110 and the electrical motor 210. The carrier shaft 314 rotates with the carrier 312 of the planetary gear set 300. To that end, the power split pump device 200 may operate to provide power, as rotational torque and speed, to the pump 201 in an electric drive mode, a direct engine drive mode, and a hybrid electric drive mode.

[0028] The one way clutch 240 may be integrated with the planetary gear set 300, such that the one way clutch is positioned between two members of the planetary gear set 300.

Therefore, when the one-way clutch 240 is locked, which occurs based on engine conditions (e.g., engine speed), the carrier shaft 314 will rotate at a 1:1 gear ratio provided by the planetary gear set 300, with the ring gear 315, and, thus, the entire planetary gear set 300 will rotate as a singular unit. In other words, when activated, the one-way clutch 240 is

5 configured to halt rotation of the set of pinion gears 310 and, by association, the pinion carrier 312, thus causing the planetary gear set 300 to have a 1:1 gear ratio, as the ring gear 315 and sun gear 305 rotate at the same angular velocity.

[0029] An example mechanical schematic illustrating the paths of rotational torque transfer to the pump 201 is shown in FIG. 4, which correlates to the configuration of the one-

10 way clutch 240, as it interacts with the planetary gear set 300, of FIG. 2. The schematic of FIG. 4 shows rotational torque flowing from the engine 110 and/or the electric motor 210 and illustrates how such rotational torque may be influenced by the planetary gear set 300 and the one-way clutch 240. Specifically, the one-way clutch 240 is positioned, in the flow of rotational torque, between the ring gear 315 and the carrier 312. Therefore, when the one-

15 way clutch 240 is selectively activated, it will halt rotation of the set of pinion gears 310 and, thus, cause the planetary gear set 300 to rotate at a 1:1 gear ratio.

[0030] FIGS. 5 and 6 illustrate alternative paths of rotational torque transfer to the pump 201, which similarly cause rotation of the set of pinion gears 310 to halt when the one-way clutch 240 is selectively activated. In the example of FIG. 5, the one-way clutch 240 is

20 situated in between the ring gear 305 and the pinion gear set 310 and, thus, when the one-way clutch 240 is activated the carrier gear 312 rotates with the sun gear 305 and the planetary gear set 300 then rotates as a single unit, resulting in a 1:1 gear ratio for the planetary gear set 300.

[0031] By utilizing any of the aforementioned arrangements between the one-way clutch 240 and the planetary gear set 300, unnecessary meshing of the pinion gear set 310 may be avoided. If the pinion gear set 310 were not to be halted, the pinion gear set 310 may be subject to excess operation at high engine speed, when it is not necessary for the pinion gear set 310 to be operating. Such unnecessary operation may produce noise and drag of elements within the planetary gear set 300, which may cause operational inefficiency or component damage. Therefore, the arrangements disclosed herein are useful in avoiding these problems as the arrangement of the one-way clutch 240 as integrated with the planetary gear set 300 produces the 1:1 gear ratio, when the clutch 240 is engaged, thus rotating as a rigid body and eliminating unnecessary rotation of the set of pinion gears 310.

[0032] As discussed above, such an arrangement may be useful in configuring and/or transitioning power input to the pump 201 in electric drive, direct engine drive, and/or hybrid drive operation modes. It may be advantageous to operate the pump 201 in the electric drive mode in scenarios wherein there is no power from the engine 110 and, thus, the pump 201 is to be driven at an under drive level. In the electric drive mode, the shaft 250 is driven by the electric motor 210, but there is no input to the ring gear 315 from the engine 110. In such scenarios, the one-way clutch 240 will not be engaged and, thus, the sun gear 305 will transfer rotational torque to the carrier gear 312, via the pinion gear set 310, resulting in a gear ratio less than one for the planetary gear set 300. An illustration of the radial, cross-sectional view of the planetary gear set 300 of FIG.3, showing which elements of the planetary gear set are in rotation during the electric drive mode, is depicted in FIG. 3A.

[0033] Further, in the direct engine drive mode, ring gear 315 is driven by the engine 110, but there is no input to the sun gear 305 from the electric motor 210. In such scenarios, the

one-way clutch 240 will be engaged and, thus, the planetary gear set 300 will bypass the pinion gear set 310 and rotate, as a rigid body, in a 1:1 gear ratio. An illustration of the radial, cross-sectional view of the planetary gear set 300 of FIG.3, showing which elements of the planetary gear set are in rotation during the direct drive mode, is depicted in FIG. 3B.

5 [0034] In the hybrid drive mode, the ring gear 315 is driven by the engine 110 and there is input to the sun gear 305 from the electric motor 210. In such scenarios, the one-way clutch 240 will not be engaged and, thus, all gears will be active, resulting in a gear ratio greater than one. An illustration of radial, cross-sectional view of the planetary gear set 300 of FIG.3, showing which elements of the planetary gear set are in rotation during the direct
10 engine drive mode, is depicted in FIG. 3C.

[0035] FIG. 7 depicts a graph showing flow rate versus engine speed for the pump 201 of FIGS. 2, and 4-6 as compared to traditional fixed displacement pumps under a variety of operating modes for the transmission 112 of FIG. 1. An example of flow rate required according to vehicle operating mode is shown by a flow demand 400. The flow demand 400
15 represents the flow rate requirement to provide sufficient line pressure in the hydraulic control system over a variety of vehicle operating modes. An example of flow rate versus input shaft speed for a traditional fixed displacement pump is shown by flow curve 402. An example of flow rate versus engine speed for a down-sized fixed displacement pump is shown by flow curve 404. Finally, an example of flow rate versus engine speed for an integrated
20 and electrical pump, such as the pump 201 of FIGS. 2 and 4-6, is shown by flow curve 406.

[0036] In a first vehicle operating mode, namely, a vehicle stop/start mode represented by mode region 408, the flow demand 400 is at a minimum level required to maintain sufficient line pressure in the hydraulic control system to allow the transmission 112 to shift upon a

restart of the engine 112. The flow curve 402 indicates that the traditional fixed displacement pump is unable to meet the flow demand 400 in this vehicle stop/start mode, as the traditional fixed displacement pump does not operate when the vehicle is stopped. The flow curve 404 indicates that the down-sized, fixed-displacement, mechanical pump is similarly unable to provide sufficient flow rate to meet the flow demand 400 since the down-sized fixed displacement pump does not operate when the vehicle is stopped. Operating the pump 201 of FIGS. 2 and 4-6 in the previously described electric drive mode within the mode region 408 results in the flow curve 406, providing a sufficient flow rate to meet the flow demand 400.

[0037] In a second vehicle operating mode, namely, an overdrive mode represented by

mode region 410, the flow demand 400 reaches a peak and levels off, remaining constant.

The flow curve 402 indicates the traditional fixed displacement pump supplies excess flow rate well above the flow demand 400 for much of the mode region 410, while the flow curve 404 indicates that the down-sized fixed displacement pump is not able to provide sufficient flow rate to meet the flow demand 400. The flow curve 406, representative of the pump 201 operating in a hybrid drive mode and being driven both by the electric motor 210 and by the engine 110, indicates that the flow demand 400 is being substantially met in mode region 410.

[0038] Further, in a third vehicle operating mode, namely, a drive mode represented by mode region 412, the flow demand 400 remains at a constant level. The flow curves 402, 404

indicate that both the traditional fixed displacement pump and the down-sized fixed displacement pump supply excessive flow rate to meet the flow demand 400 over the entire mode region 412. The flow curve 406, representative of the pump 201 operating in a direct drive mode and being driven only by the engine 110, indicates the pump 201 is now

supplying a slight excess flow above the flow demand 400 in the mode region 712. The excess flow generated by the pump 201 can be exploited in the final vehicle operating mode as described below.

[0039] In a fourth vehicle operating mode, namely, an underdrive mode represented by mode region 414, the flow demand 400 again remains at a constant level. The flow curves 402, 404 indicate that both the traditional fixed displacement pump and the down-sized fixed displacement pump supply flow in excess of the flow demand 400 over the entire mode region 414. The flow curve 406, representative of the pump 201 operating in the hybrid drive mode and being driven by the engine 110 while the electric motor 210 may operate as a generator, indicates that the pump 201 can be used both to provide a fluid flow, and at the same time, convert energy for storage. Generating energy with the electric motor 210 is possible when the pump 201 is mechanically driven at high engine speeds to provide a flow rate in excess of the flow demand 400.

[0040] In general, the present disclosure may find applicability in many industries, for example the automotive industry and, more particularly to drive systems for electric and/or hybrid-electric vehicles. In that regard, the present disclosure generally relates to gear drive components for use with an electric or hybrid-electric vehicle and, more particularly, to oil distribution systems associated with such gear drive components.

Industrial Applicability

[0041] In general, the present disclosure may find applicability in many industries, for example the automotive industry and, more particularly to transmission systems for vehicles, which utilize hydraulic pumps. In that regard, generally relates to transmissions within a

motor vehicle drive train and, more particularly, to pump and electric motor combinations for use within a transmission of a motor vehicle drive train.

[0042] As discussed above, utilizing the one-way clutch and planetary gear set arrangement may lead to greater operational efficiency for the transmission, may protect components of a planetary gear set utilized, particularly a pinion gear set, and/or may result in greater fluid flow efficiency by a hydraulic pump. Particularly, by utilizing any of the aforementioned arrangements between a one-way clutch and a planetary gear set, unnecessary meshing of a pinion gear set, of such planetary gear set, may be avoided. If the carrier gear and/or pinion gear set were not to be halted by the one-way clutch, in the manners discussed above, the pinion gear set may be subject to excess operation at high engine speed, when it is not necessary for the pinion gear set to be operating. Such unnecessary operation may produce noise and drag of elements within the planetary gear set, which may cause operational inefficiency or component damage. Therefore, the arrangements disclosed herein are useful in avoiding these problems as the arrangement of the one-way clutch, as integrated with the planetary gear set, produces a 1:1 gear ratio, when the clutch is engaged, thus rotating as a rigid body and eliminating unnecessary rotation of the set of pinion gears.

[0043] It will be appreciated that the present disclosure power split devices, systems for providing rotational torque to a pump, and drivetrains. While only certain embodiments have been set forth, alternatives and modifications will be apparent from the above description to those skilled in the art. These and other alternatives are considered equivalents and within the spirit and scope of this disclosure and the appended claims.

Claims

What is claimed is:

1. A power split pump device (200) for a transmission (112) of a vehicle, the power split device (200) providing rotational torque to a pump (201) associated with the transmission
5 (112), the power split device (200) comprising:
 - a shaft (250) configured to receive rotational torque input;
 - a planetary gear set (300) providing output rotational torque to the pump (210), the planetary gear set (300) including
 - a set of pinion gears (310),
 - 10 a sun gear (305) operatively coupled with the shaft (250) and configured to receive rotational torque input from one or more of an electrical motor (220), the set of pinion gears (310), and any combinations thereof, and
 - a ring gear (315) disposed radially outward of the sun gear (305) and configured to receive rotational torque input from an engine (110),
 - 15 the set of pinion gears (310) disposed radially outward of the sun gear (305) and radially inward of the ring gear (315), each of the set of pinion gears (310) configured to rotate based on input from one or both of the sun gear (305) and the ring gear 315); and
 - a one-way clutch (240) operatively associated with the planetary gear set (300),
 - 20 selectively activated, and configured to halt rotation of the set of pinion gears (310) when activated.

2. The power split device (200) of claim 1, wherein the one way clutch (240) is disposed, in a path of rotational torque transfer, between the set of pinion gears (310) and the ring gear (315).
- 5 3. The power split device (200) of claim 1, wherein the one way clutch (240) is disposed, in a path of rotational torque transfer, between the sun gear (305) and the set of pinion gears (310).
4. The power split device (200) of claim 1, wherein the one way clutch (240) is
10 disposed, in a path of rotational torque transfer, between the sun gear (305) and the ring gear (315).
5. The power split device (200) of claim 1, further comprising a sprocket (260), the sprocket (260) rotationally coupled with both the ring gear (315) and an output of the engine
15 (110), the sprocket (260) being integrated with the planetary gear set (300).
6. The power split device (200) of claim 1, wherein, when the one-way clutch (240) is activated, the planetary gear set (300) operates at a gear ratio of 1:1.
- 20 7. A system for providing rotational torque to a pump (201) associated with a transmission (112) of a vehicle, the system comprising:
an engine (110);
an electrical motor (220);

a shaft (250) configured to receive rotational torque input;

a planetary gear set (300) providing output rotational torque to the pump (201) based on one of a plurality of pump operating modes, the plurality of modes including an electric drive mode, a direct engine engine drive mode, and a hybrid drive mode; and

5 a one-way clutch (240) disposed within a path of rotational torque transfer internal to the planetary gear set (300) and, when activated, the one-way clutch (240) causing the planetary gear set (300) to operate at a gear ratio of 1:1, the one-way clutch (240) being activated when the pump operating mode is in the direct engine drive mode.

10 8. The system of claim 7, wherein, when the pump operating mode is the electric drive mode, the planetary gear set (300) is driven by only the electrical motor (220) and the gear ratio is less than 1.

9. The system of claim 7, wherein, when the pump operating mode is the hybrid drive
15 mode, the planetary gear set (300) is driven by both the electrical motor (220) and the engine (110).

10. The system of claim 7, wherein the planetary gear (300) set includes

a set of pinion gears (310),

20 a sun gear (305) operatively coupled with the shaft (250) and configured to receive rotational torque input from one or more of the electrical motor (220), the set of pinion gears (310), and any combinations thereof, and

a ring gear (315) disposed radially outward of the sun gear (305) and configured to receive rotational torque input from an engine (110),

the set of pinion gears (310) disposed radially outward of the sun gear (305) and radially inward of the ring gear (315), each of the set of pinion gears (310) configured to
5 rotate based on input from one or both of the sun gear (305) and the ring gear (315).

11. The system of claim 10, wherein, when the pump (201) is operating in the direct engine drive mode, the one-way clutch (240) is configured to halt rotation of the set of pinion
gears (310).

10

12. The system of claim 11, wherein the one way clutch (240) is disposed, in a path of rotational torque transfer, between the set of pinion gears (310) and the ring gear (315).

13. The system of claim 11, wherein the one way clutch (240) is disposed, in a path of
15 rotational torque transfer, between the sun gear (305) and the set of pinion gears (310).

14. The system of claim 11, wherein the one way clutch (240) is disposed, in a path of rotational torque transfer, between the sun gear (305) and the ring gear (315).

20 15. A drivetrain (100) for a vehicle, the drivetrain (100) comprising:
an engine (110);
a transmission (112) operatively coupled with the engine (110) and including
a pump (201),

an electrical motor (220), and

a power split pump device (200) providing rotational torque to the pump (201), the power split device (201) including

a shaft (250) configured to receive rotational torque input,

5 a planetary gear set (300) providing output rotational torque to the pump (201), the planetary gear set (300) including

a set of pinion gears (310),

a sun gear (305) operatively coupled with the shaft (250) and configured to receive rotational torque input from one or more of the

10 electrical motor (220), the set of pinion gears (310), and any combinations thereof, and

a ring gear (315) disposed radially outward of the sun gear (305) and configured to receive rotational torque input from an engine (110),

15 the set of pinion gears (310) disposed radially outward of the sun gear (305) and radially inward of the ring gear (315), each of the set of pinion gears (310) configured to rotate based on input from one or both of the sun gear (305) and the ring gear (315); and

a one-way clutch (240) operatively associated with the planetary gear set (300), selectively activated, and configured to halt rotation of the set of pinion gears (310) when activated;

20 at least one drive shaft (140), power transferred to the drive shaft from transmission (112).

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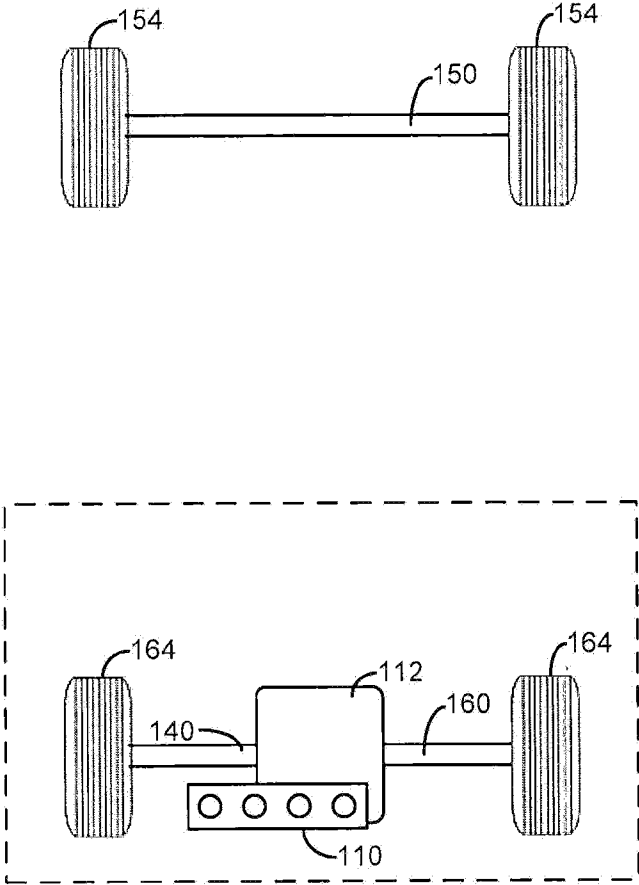


FIG. 1

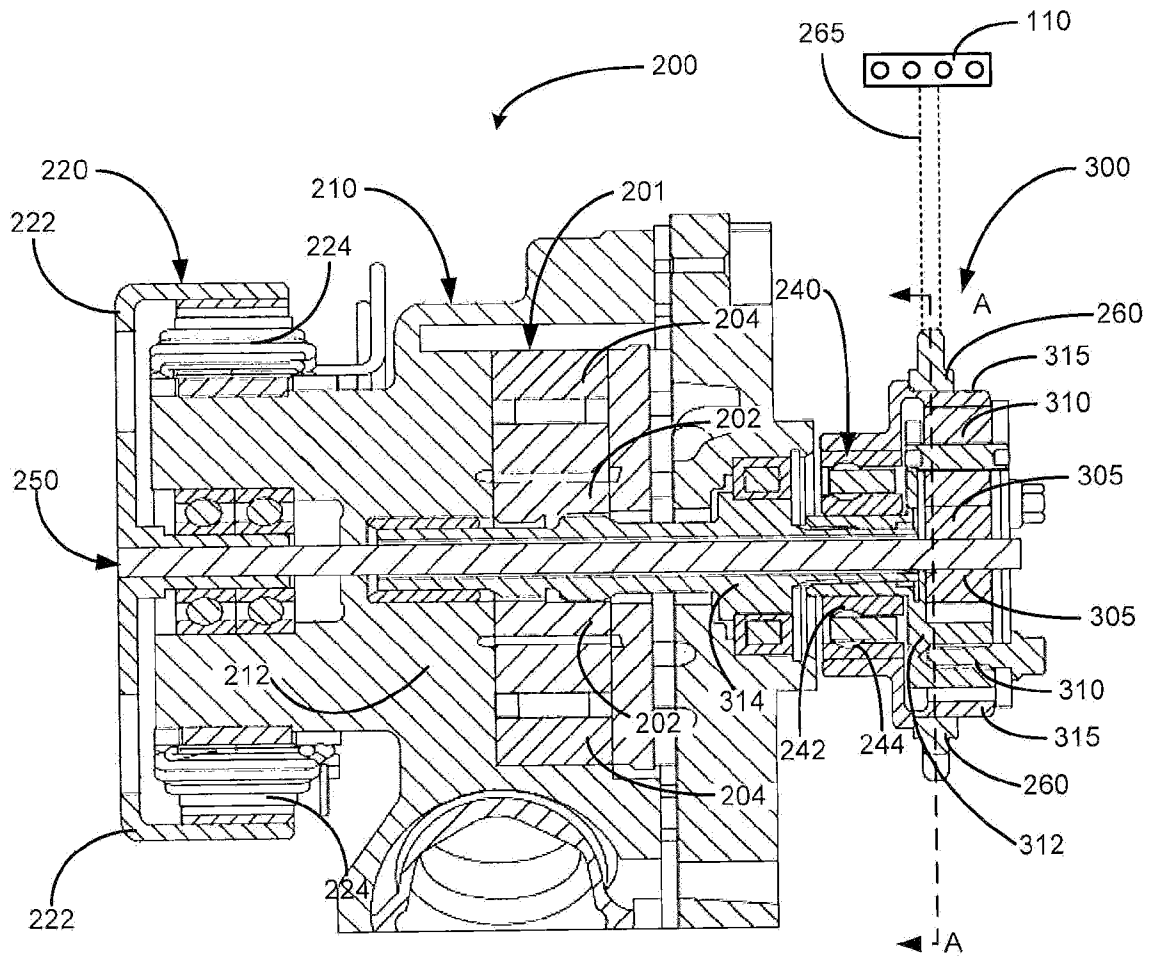


FIG. 2

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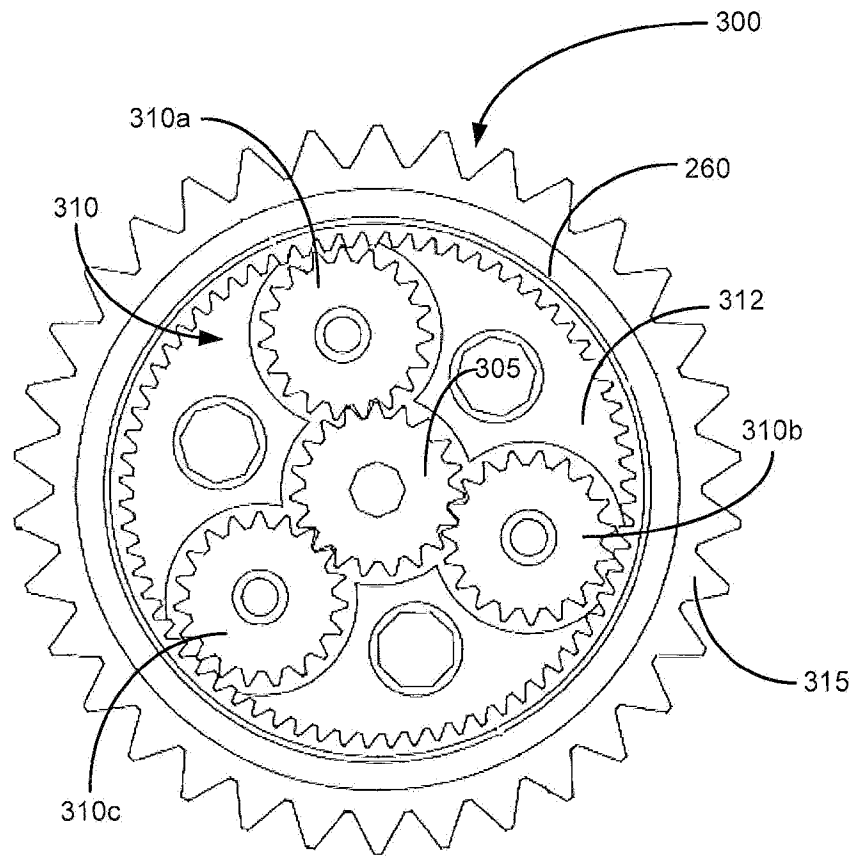


FIG. 3

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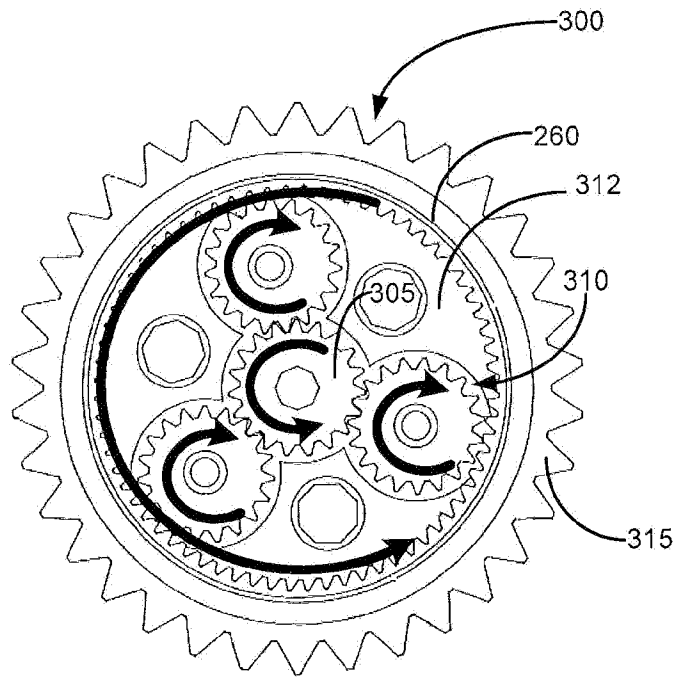


FIG. 3A

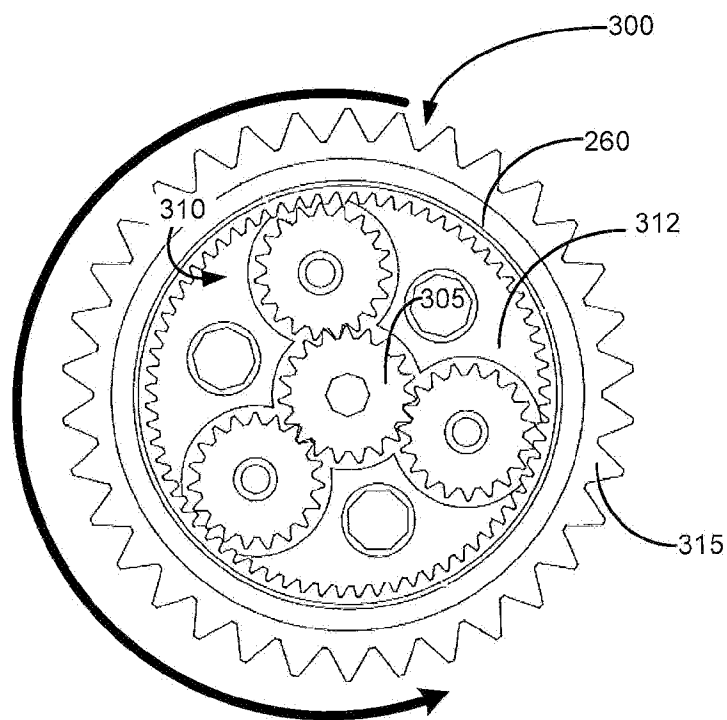


FIG. 3B

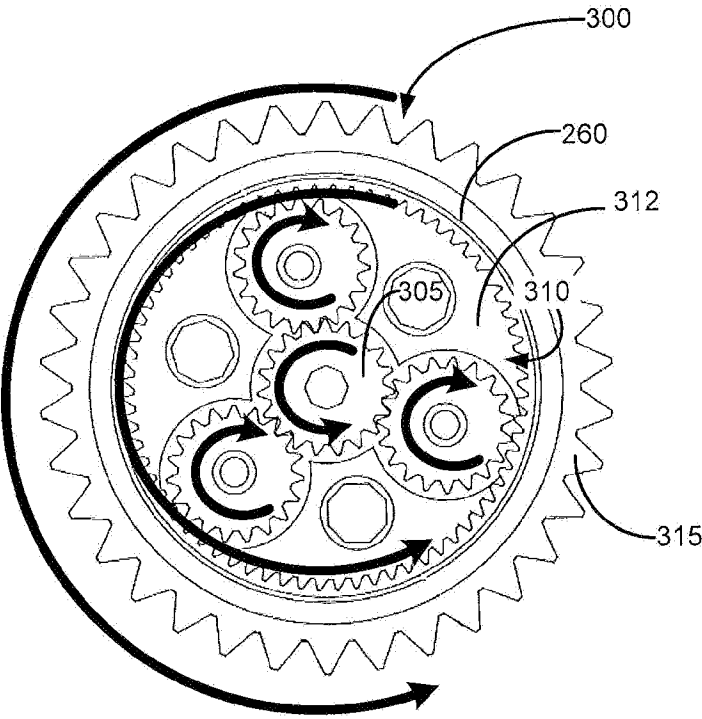


FIG. 3C

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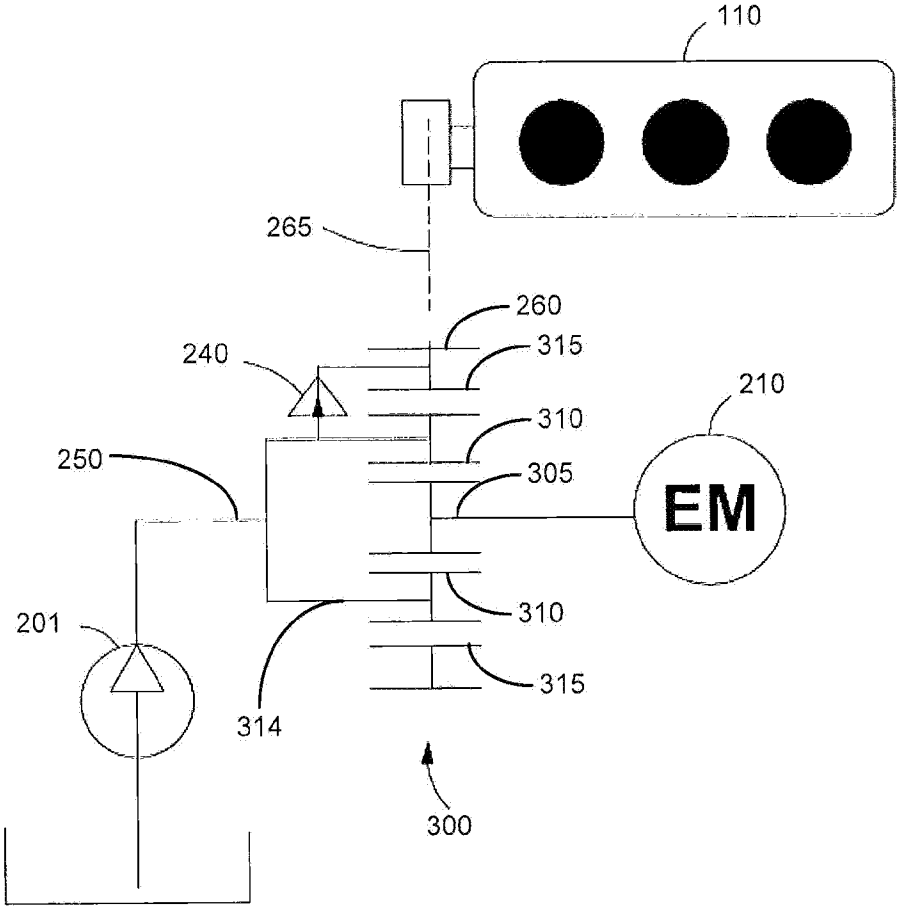


FIG. 4

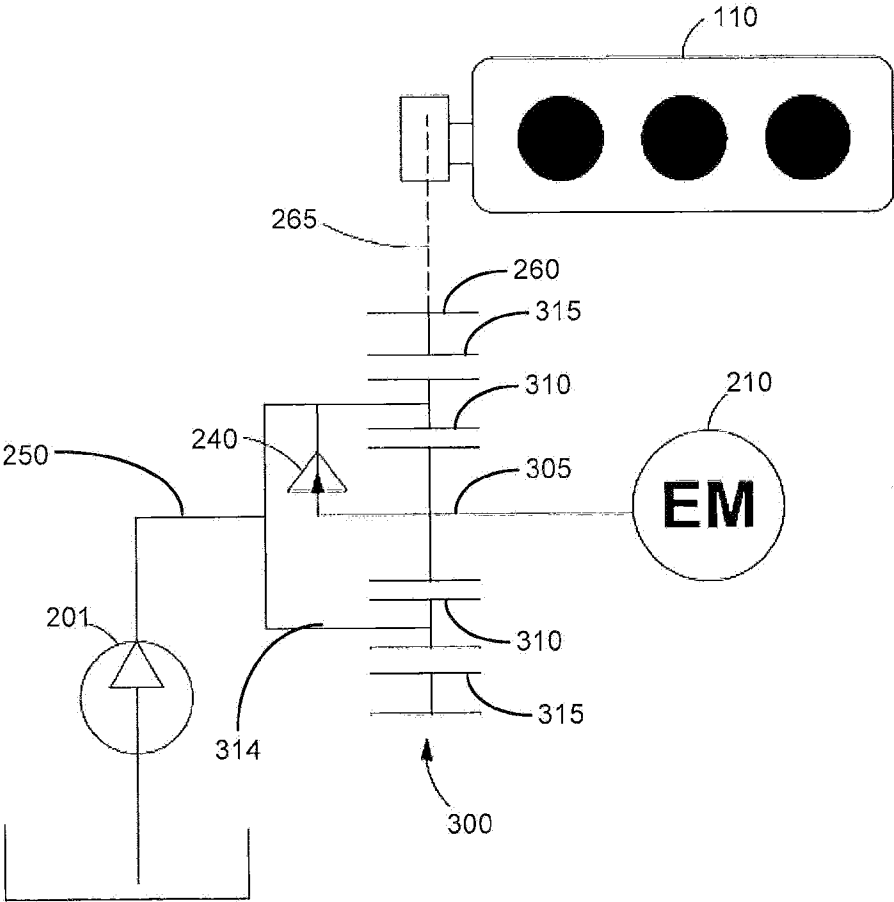


FIG. 5

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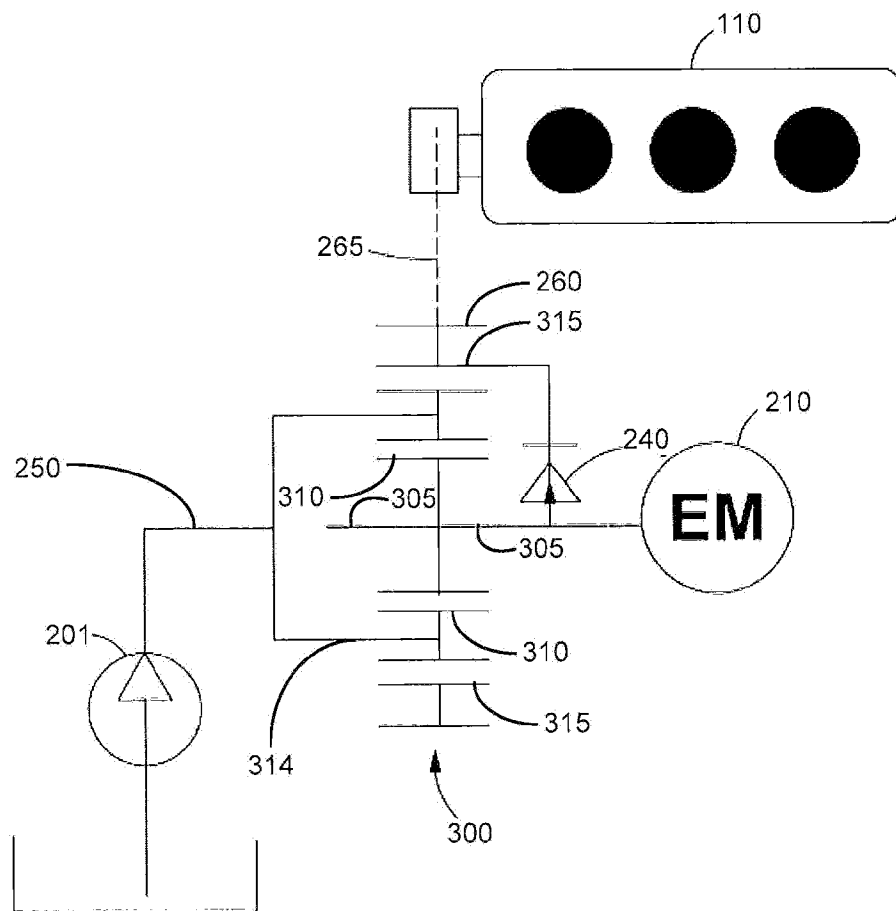


FIG. 6

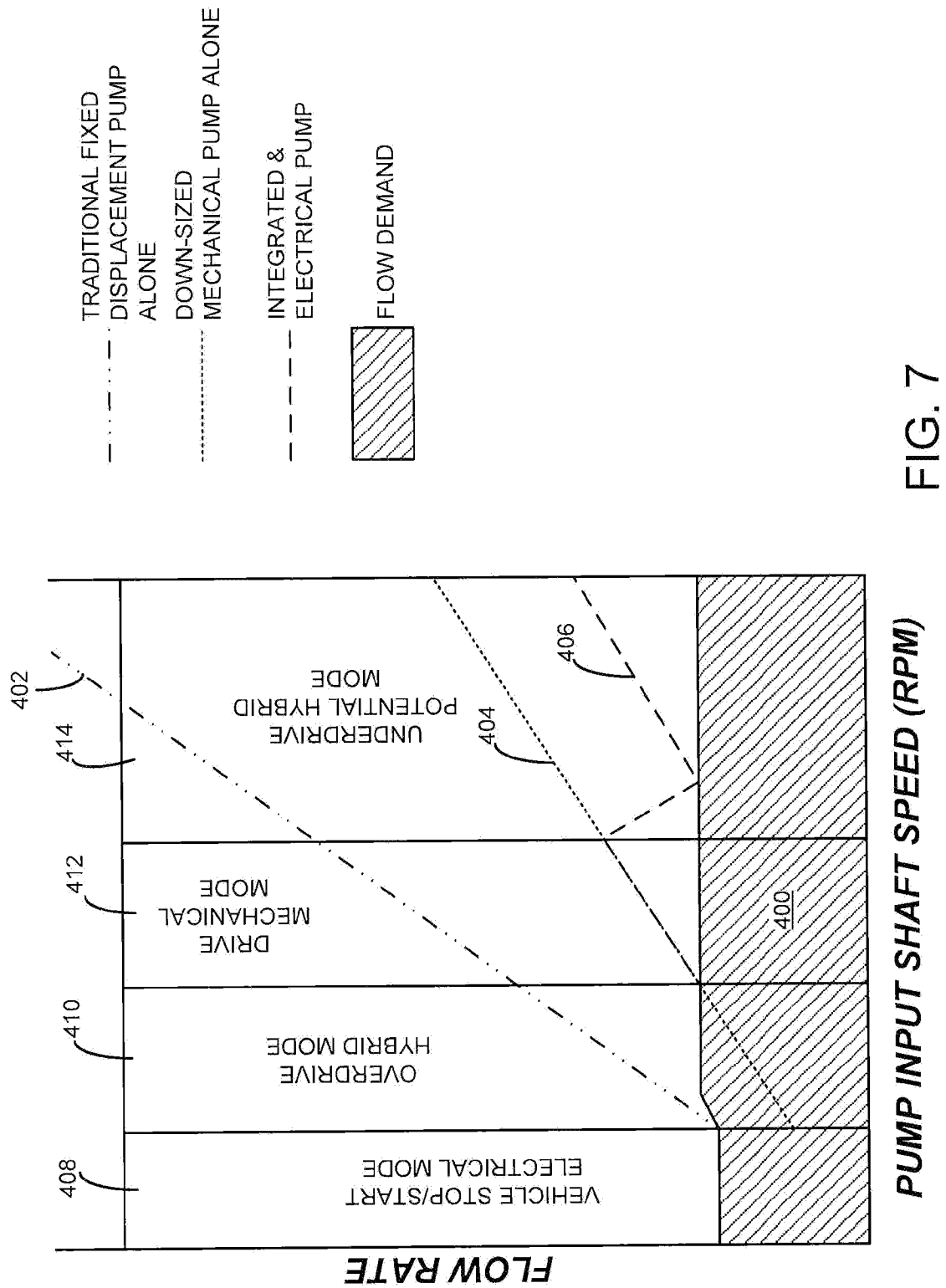


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2018/021470**A. CLASSIFICATION OF SUBJECT MATTER****B60K 6/365(2007.10)i, B60K 6/383(2007.10)i, B60K 6/24(2007.10)i, B60K 6/26(2007.10)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)

B60K 6/365; F16H 37/08; B60W 20/00; B60W 10/08; F16H 3/72; F04D 13/06; F16H 57/04; B60K 6/383; B60K 6/24; B60K 6/26

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: planetary, sun, ring, pinion, gear, hybrid, electric, motor, pump, one-way, clutch, shaft, rotate, activate, halt, torque, input and output

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2012-0269653 A1 (LUTOSLAWSKI et al.) 25 October 2012 See paragraphs [0025]–[0037] and figures 1–9.	1–15
Y	US 2016-0375754 A1 (TOYOTA JIDOSHA KABUSHIKI KAISHA) 29 December 2016 See paragraphs [0054]–[0059] and figures 6–8.	1–15
A	US 2015-0011359 A1 (MARUYAMA et al.) 08 January 2015 See paragraphs [0057]–[0058] and figure 8.	1–15
A	US 2010-0203995 A1 (ZHANG et al.) 12 August 2010 See paragraphs [0037]–[0040] and figure 1.	1–15
A	US 2017-0059033 A1 (TOYOTA JIDOSHA KABUSHIKI KAISHA) 02 March 2017 See paragraphs [0031]–[0035] and figure 1.	1–15



Further documents are listed in the continuation of Box C.



See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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

"&" document member of the same patent family

Date of the actual completion of the international search

28 June 2018 (28.06.2018)

Date of mailing of the international search report

28 June 2018 (28.06.2018)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea



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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2018/021470

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