



- (51) International Patent Classification:
B60K 17/34 (2006.01) **B60K 17/346** (2006.01)
B60K 17/28 (2006.01)
- (21) International Application Number:
PCT/US2016/043084
- (22) International Filing Date:
20 July 2016 (20.07.2016)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
14/804,447 21 July 2015 (21.07.2015) US
- (71) Applicant: **AMERICAN AXLE & MANUFACTURING, INC.** [US/US]; One Dauch Drive, Detroit, Michigan 48211-1198 (US).
- (72) Inventors: **ZINK, Frederick E.**; One Dauch Drive, Detroit, Michigan 48211 (US). **STUART, Charles G.**; One Dauch Drive, Detroit, Michigan 48211 (US).
- (74) Agents: **ZALOBSKY, Michael D.** et al.; Harness, Dickey & Pierce, P.L.C., P.O. Box 828, Bloomfield Hills, Michigan 48303 (US).

- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

[Continued on next page]

- (54) Title: **DRIVELINE ACTUATOR POWERED BY SYNCHRONIZATION EVENT**

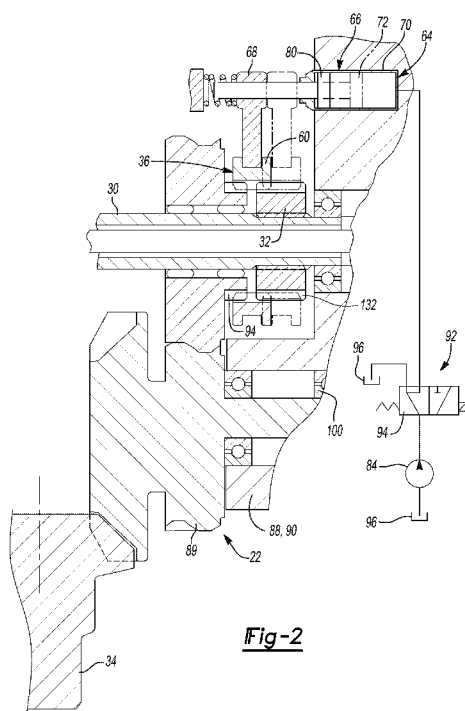


Fig-2

- (57) Abstract: A disconnectable all-wheel drive vehicle driveline having a primary driveline, a power take-off unit (PTU), a secondary driveline, a hydraulic pump and a driveline actuator. The PTU has a PTU input member, which is driven by the primary driveline, a PTU output member and a first coupling that selectively couples the PTU input and output members. The secondary driveline includes a second coupling that selectively inhibits power transmission through the secondary driveline. The hydraulic pump is configured to operate the first coupling but is powered by a synchronization event in which the second coupling is engaged so as to back drive the PTU output member.



— *as to the applicant's entitlement to claim the priority of
the earlier application (Rule 4.17(iii))*

Published:

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

DRIVELINE ACTUATOR POWERED BY SYNCHRONIZATION EVENT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Utility Application No. 14/804,447, filed on July 21, 2015, the disclosure of which is incorporated by reference as if fully set forth in detail herein.

FIELD

[0002] The present disclosure relates to a disconnectable all-wheel drive vehicle driveline having a primary driveline, a secondary driveline, a torque transmitting device and a driveline actuator that is powered by a synchronization event to cause the torque transmitting device to transmit rotary power from the primary driveline to the secondary driveline.

BACKGROUND

[0003] This section provides background information related to the present disclosure which is not necessarily prior art.

[0004] U.S. Patent No. 8,047,323 discloses a disconnecting all-wheel drive drivetrain having a primary driveline, which is operated on a full-time basis, and a secondary driveline that is operated on an as-needed basis so as to maximize fuel economy. More specifically, the '323 patent discloses a configuration in which a power take-off unit (PTU) has a PTU input member, which is driven by the primary driveline, a PTU output member, and a synchronizer having a collar that is selectively movable via an actuator to control transmission of rotary power through the PTU. The actuator in the PTU is described as being electrically, mechanically, hydraulically and/or pneumatically operated.

SUMMARY

[0005] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[0006] In one form, the present teachings provide a vehicle drivetrain that includes a primary driveline, a power take-off unit (PTU), a secondary driveline, an actuator and a hydraulic pump. The primary driveline has a first driveline input member, a first differential assembly and a pair of first driveline output members. The first driveline input member is configured to receive rotary power directly from a vehicle powertrain. The first differential assembly is driven on a full-time basis by the first driveline input member and transmits rotary power to the first and second driveline output members. The PTU has a PTU input member, a PTU output member and a first coupling. The PTU input member is driven by the first driveline input member. The first coupling has an axially slidable coupling member that is movable between a first position and a second position. When the coupling member is in the first position, the first coupling is operable in a first coupling mode in which the PTU output member is decoupled from the PTU input member to inhibit transmission of rotary power therebetween. When the coupling member is in the second position, the first coupling is operable in a second coupling mode in which the PTU input member and the PTU output member are drivingly coupled to one another. The secondary driveline has a second driveline input member, a second differential assembly, a pair of second driveline output members and a second coupling. The second driveline input member is coupled for rotation with the PTU output member. The second coupling is a multi-plate friction coupling that is operable in a third coupling mode, in which the second input member is decoupled from at least one of the pair of second driveline output members to inhibit transmission of rotary power therebetween, and a fourth coupling mode in which the second driveline input member and the pair of second driveline output members are drivingly coupled to one another through the second differential assembly. The actuator is coupled to the PTU and has a hydraulic cylinder and an actuator output member that is driven by the hydraulic cylinder and engaged to the coupling member. The actuator output member is movable to cause corresponding movement of the coupling member between the first and second positions. The hydraulic pump has a pump stator and a pump rotor that is rotatable relative to the pump stator and coupled for rotation with the PTU output member.

[0007] In another form, the present teachings provide a method for operating a vehicle driveline having a primary driveline, a power take-off unit (PTU) and a secondary driveline. The primary driveline has a first driveline input member that is drivingly coupled to a pair of first driveline output members. The PTU has a PTU input member, which is driven by the first driveline input member, a PTU output member and a first coupling. The secondary driveline has a second driveline input member, a pair of driveline output members and a second coupling. The method includes: operating the vehicle driveline in a two-wheel drive mode in which rotary power is not transmitted through the first and second couplings; operating the second coupling when the vehicle driveline is operating in the two-wheel drive mode to back drive the PTU output member and to provide rotary power to a hydraulic pump; and transmitting pressurized hydraulic fluid from the hydraulic pump to a hydraulic actuator to operate the first coupling in a mode in which rotary power is transmitted between the PTU input member and the PTU output member to thereby cause the vehicle driveline to be operated in an all-wheel drive mode.

[0008] Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

[0009] The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

[0010] Figure 1 is a schematic illustration of an exemplary vehicle having a drivetrain that is constructed in accordance with the teachings of the present disclosure;

[0011] Figure 2 is a sectional view of a portion of the drivetrain that is illustrated in Figure 1, the view depicting a portion of a power take-off unit and schematically illustrating a hydraulic system that is configured to operate a first coupling; and

[0012] Figure 3 is a section view depicting a part of the hydraulic system;

[0013] Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

5 **[0014]** With reference to Figure 1 of the drawings, an exemplary vehicle 10 is illustrated to have a power train 12 and a drivetrain 14 that constructed in accordance with the teachings of the present disclosure. The power train 12 can be conventionally constructed and can comprise a power source 16 and a transmission 18. The power source 16 can be configured to provide propulsive
10 power and can comprise an internal combustion engine and/or an electric motor, for example. The transmission 18 can receive propulsive power from the power source 16 and can output power to the drivetrain 14. The transmission 18 can have a plurality of automatically or manually-selected gear ratios. The drivetrain 14 in the particular example provided is of a disconnectable all-wheel drive
15 configuration in which the front vehicle wheels are driven on a full-time basis and the rear vehicle wheels are selectively driven on an on-demand basis.

[0015] The drivetrain 14 can include a primary driveline (e.g., a front axle assembly 20 in the example provided), a power take-off unit (PTU) 22, a prop shaft 24 and a secondary driveline (e.g., a rear axle assembly 26 in the example
20 provided). An output of the transmission 18 can be coupled to an input of the front axle assembly 20 to drive an input member 30 of the front axle assembly 20. The PTU 22 can have a PTU input member 32, which can receive rotary power from the input member 30 of the front axle assembly 20, a PTU output member 34 that can transmit rotary power to the prop shaft 24, and a first or
25 PTU coupling 36 that can be configured to selectively interrupt power transmission between the PTU input member 32 and the PTU output member 34. An exemplary configuration of the PTU 22 is disclosed in U.S. Patent No. 8,047,323, but it will be appreciated that other configurations could be employed for the PTU 22, including without limitation those disclosed in U.S. Patent Nos.
30 8,469,854; 8,795,126; 8,961,353; and 8,986,148.

[0016] The prop shaft 24 can couple the PTU output member 34 to the rear axle assembly 26 such that rotary power output by the PTU 22 is received by the rear axle assembly 26 to drive a pair of rear vehicle wheels 40. The rear axle assembly 26 can include a second coupling 46 that can be configured to selectively interrupt power transmission between the prop shaft 24 and at least one of the rear vehicle wheels 40. An exemplary configuration of the rear axle assembly 26 is shown in U.S. Patent No. 8,047,323, but it will be appreciated that other configurations could be employed for the rear axle assembly 26, including without limitation those disclosed in U.S. Patent Nos. 8,469,854; 8,795,126; 8,961,353; and 8,986,148; and 9,028,358. The first and second couplings 36 and 46 can be employed to halt power transmission through the PTU 22, the prop shaft 24 and portions of the rear axle assembly 26, such as an input pinion 48 and a ring gear 50, so that the vehicle drivetrain 14 operates in a front-wheel drive mode.

[0017] The second coupling 46 can be a multi-plate friction clutch, the engagement of which can be controlled in a ramped or staggered manner so as to permit portions of the vehicle driveline 14 between the first and second couplings 36 and 46 to be ramped up in speed when the driveline 14 is to be switched from the front-wheel drive mode to an all-wheel drive mode. As is known in the art, one or more of the rear vehicle wheels 40 can provide rotary power to an output section 54 of the second coupling 46, which can be employed to drive the portions of the rear axle assembly 26 (e.g., the ring gear 50 and the input pinion 48), the prop shaft 24 and the portion of the PTU 22 between the first coupling 36 and the PTU output member 34. Accordingly, the second coupling 46 can be selectively operated to accelerate elements or components of the vehicle drivetrain 14 between the first and second couplings 36 and 46 so that their rotary speeds are matched (i.e., synchronized) in a corresponding manner to the rotational speeds of these components if the vehicle drivetrain 14 were to be operating in the all-wheel drive mode.

[0018] With additional reference to Figure 2, the first coupling 36 can be operated to permit rotary power to be transmitted from the PTU input member 32 to the PTU output member 34 once the portion of the vehicle driveline 14 between the first and second couplings 36 and 46 has been accelerated so that

its speed is synchronized for engagement of the first coupling 36. The first coupling 36 can comprise a clutch, a synchronizer, a sliding collar or can be configured as a dog clutch so as to have an axially movable coupling member 60 that can be moved via a hydraulic actuator 64 between a first position, in which the transmission of rotary power between the PTU input member 32 and the PTU output member 34 is interrupted, and a second position in which the transmission of rotary power between the PTU input member 32 and the PTU output member 34 is enabled. The hydraulic actuator 64 can include a cylinder assembly 66 and an actuator output member 68. The cylinder assembly 66 can include a cylinder structure 70 and a piston 72 that can be slidably received in the cylinder structure 70. The actuator output member 68 can be configured to transmit motion of the piston 72 to the axially movable coupling member 60. In the particular example provided, the hydraulic actuator 64 is constructed in a manner that is described in co-pending International Patent Application Serial No. PCT/US2015/016111 entitled "Actuator For A Driveline Component", the disclosure of which is incorporated by reference as if fully set forth in detail herein. Briefly, the hydraulic actuator 64 is configured with a latching mechanism 80 that permits the piston 72 to be locked in an extended or retracted position in response to a predetermined drop in hydraulic pressure acting on the piston 72 so that it is not necessary to constantly apply hydraulic pressure to the hydraulic actuator 64.

[0019] A hydraulic pump 84 can be driven by a portion of the drivetrain 14 that is rotatable when the drivetrain 14 is operated in an all-wheel drive mode (in which rotary power is transmitted from the PTU 22 to the rear axle assembly 26) but which halts rotation when the drivetrain 14 is operated in a front-wheel drive mode (in which rotary power is not transmitted between the PTU 22 and the rear axle assembly 26). The hydraulic pump 84 can have a rotor 86 (Fig. 3) and a pump stator or housing 88 (Fig. 3) that can be fixedly mounted to a non-rotating portion of the vehicle drivetrain 14, such as a housing of the PTU 22 or the rear axle assembly 26. The rotor 86 (Fig. 3) can be coupled for rotation with any rotatable element between an output of the first coupling 36 and an output of the second coupling 46, such as the PTU output member 34, the prop shaft 24 or the input pinion 48. In the particular example provided, the rotor 86 (Fig. 3) is

driven by an intermediate gear 89 that is disposed in a power transmission path between the PTU input member 32 and the PTU output member 34.

[0020] During operation of the drivetrain 14 in a front-wheel drive mode, the first and second couplings 36 and 46 are operated so that rotary power is not transmitted between the PTU 22 and the rear axle assembly 26 and as such, the PTU output member 34 does not rotate relative to the housing 90 of the PTU 22. Consequently, the rotor 86 (Fig. 3) does not rotate relative to the pump stator 88 when the drivetrain 14 is operated in the front-wheel drive mode so that the hydraulic pump 84 is not capable of producing pressurized hydraulic fluid to operate the hydraulic actuator 64.

[0021] The second coupling 46 can be engaged to initiate the process for transitioning the drivetrain 14 from the front-wheel drive mode to the all-wheel drive mode. As described above, the second coupling 46 can be operated in a desired manner to rotationally accelerate the elements/components of the drivetrain 14 between the first and second couplings 36 and 46 that do not rotate when the drivetrain 14 is operated in the front-wheel drive mode. It will be appreciated that rotational acceleration of this portion of the drivetrain 14 will cause rotation of the PTU output member 34 relative to the housing 88 of the PTU 22, and as such, rotation of the rotor 86 (Fig. 3) relative to the pump stator 88 so that the hydraulic pump 84 can operate to provide pressurized hydraulic fluid.

[0022] A control valve 92 can be employed to selectively couple the hydraulic pump 84 to the hydraulic actuator 64. In the example provided, the control valve 92 is an electric solenoid-controlled two-position, three-way directional valve having a valve element 94 that is movable between a first position, in which the control valve 92 couples the output of the hydraulic pump 84 in fluid connection to a hydraulic reservoir 96 that provides a source of hydraulic fluid to the input of the hydraulic pump 84, and a second position in which the control valve 92 couples the output of the hydraulic pump 84 in fluid connection to the hydraulic actuator 64. Accordingly, it will be appreciated that after the second coupling 46 has been operated to cause transmission of rotary power to the PTU output member 34 (and the rotor 86 of the hydraulic pump 84), the control valve 92 can be operated briefly to permit sufficient pressurized

hydraulic fluid to be transmitted to the hydraulic actuator 64 to cause the movement of the piston 72 and the actuator output member 68 that engages the first coupling 36. Due to the presence of the latching mechanism 80 in the hydraulic actuator 64, the valve element 94 of the control valve 92 can thereafter
5 be moved (e.g., via a return spring 100 not shown) so that hydraulic fluid exiting the hydraulic pump 84 is returned directly to the hydraulic reservoir 96. It will be appreciated, however, that the hydraulic actuator 64 need not have a latching mechanism and that in such situation, the valve element 94 could be maintained (e.g., electronically via the electric solenoid) in the second position to permit the
10 hydraulic pump 84 to output pressurized hydraulic fluid to the hydraulic actuator 64 to selectively change the operational mode of the drivetrain 14 between the front-wheel drive mode and the all-wheel drive mode.

[0023] The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or
15 to limit the disclosure. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and
20 all such modifications are intended to be included within the scope of the disclosure.

CLAIMS

What is claimed is:

1. A vehicle drivetrain comprising:

5 a primary driveline having a first driveline input member, a first differential assembly and a pair of first driveline output members, the first driveline input member being adapted to receive rotary power directly from a vehicle powertrain, the first differential assembly being driven on a full-time basis by the first driveline input member and transmitting rotary power to the first and second driveline output members;

10 a power take-off unit (PTU) having a PTU input member, a PTU output member and a first coupling, the PTU input member being driven by the first driveline input member, the first coupling having an axially slidable coupling member that is movable between a first position and a second position, wherein when the coupling member is in the first position, the first coupling is operable in
15 a first coupling mode in which the PTU output member is decoupled from the PTU input member to inhibit transmission of rotary power therebetween, and wherein when the coupling member is in the second position, the first coupling is operable in a second coupling mode in which the PTU input member and the PTU output member are drivingly coupled to one another;

20 a secondary driveline having a second driveline input member, a second differential assembly, a pair of second driveline output members and a second coupling, the second driveline input member being coupled for rotation with the PTU output member, the second coupling being a multi-plate friction clutch that is operable in a third coupling mode, in which the second input member is
25 decoupled from at least one of the pair of second driveline output members to inhibit transmission of rotary power therebetween, and a fourth coupling mode in which the second driveline input member and the pair of second driveline output members are drivingly coupled to one another through the second differential assembly;

30 an actuator coupled to the PTU, the actuator having a hydraulic cylinder and an actuator output member that is driven by the hydraulic cylinder and

engaged to the coupling member, the actuator output member being movable to cause corresponding movement of the coupling member between the first and second positions; and

5 a hydraulic pump having a pump stator and a pump rotor, the pump rotor being rotatable relative to the pump stator and being coupled for rotation with the PTU output member.

2. The vehicle driveline of Claim 1, wherein the actuator is configured to latch the actuator output member to maintain the coupling member in at least
10 one of the first and second positions.

3. The vehicle driveline of Claim 2, wherein the actuator is configured to latch the actuator output member to maintain the coupling member in both of the first and second positions in response to a drop in hydraulic pressure that is
15 applied to the hydraulic cylinder.

4. The vehicle driveline of Claim 3, further comprising a two-position, three-way valve coupled to the hydraulic pump, the hydraulic cylinder and a hydraulic fluid reservoir.

20 5. The vehicle driveline of Claim 4, two-position, three-way valve has a valve element that is movable between a first valve element position, in which the hydraulic pump is coupled in fluid communication to the hydraulic fluid reservoir and the hydraulic cylinder is coupled in fluid communication to the hydraulic fluid reservoir, and a second valve element position in which the
25 hydraulic pump is coupled in fluid communication to the hydraulic cylinder.

6. The vehicle driveline of Claim 5, wherein the two-position, three-way valve is a solenoid controlled valve.

30 7. The vehicle driveline of Claim 1, wherein the pump stator is mounted to a housing of the PTU.

8. A method for operating a vehicle driveline having a primary driveline, a power take-off unit (PTU) and a secondary driveline, the primary driveline having a first driveline input member that is drivingly coupled to a pair of first driveline output members, the PTU having a PTU input member, which is
5 driven by the first driveline input member, a PTU output member and a first coupling, the secondary driveline having a second driveline input member, a pair of driveline output members and a second coupling, the method comprising:
- operating the vehicle driveline in a two-wheel drive mode in which rotary power is not transmitted through the first and second couplings;
- 10 operating the second coupling when the vehicle driveline is operating in the two-wheel drive mode to back drive the PTU output member and to provide rotary power to a hydraulic pump; and
- transmitting pressurized hydraulic fluid from the hydraulic pump to a hydraulic actuator to operate the first coupling in a mode in which rotary power is
15 transmitted between the PTU input member and the PTU output member to thereby cause the vehicle driveline to be operated in an all-wheel drive mode.

9. The method of Claim 8, wherein prior to transmitting pressurized hydraulic fluid from the hydraulic pump to the hydraulic actuator, the method
20 comprises operating a valve to couple the hydraulic pump in fluid communication with the hydraulic actuator.

10. The method of Claim 9, wherein after transmitting pressurized fluid from the hydraulic pump to the hydraulic actuator, the method further comprises:
- 25 latching the hydraulic actuator to maintain a movable coupling member of the first coupling in a desired position; and
- coupling an output of the hydraulic pump in fluid communication a hydraulic reservoir.

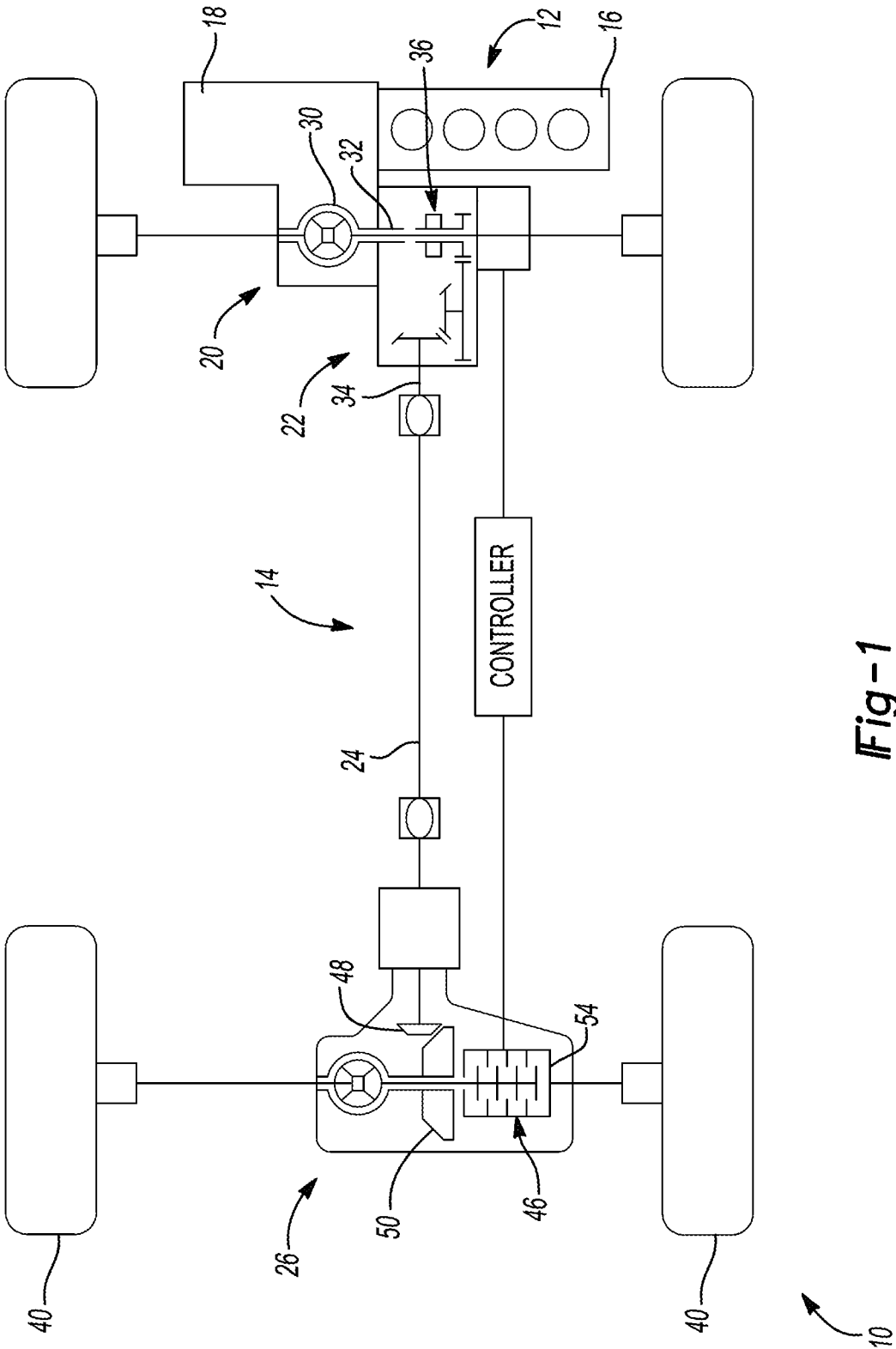
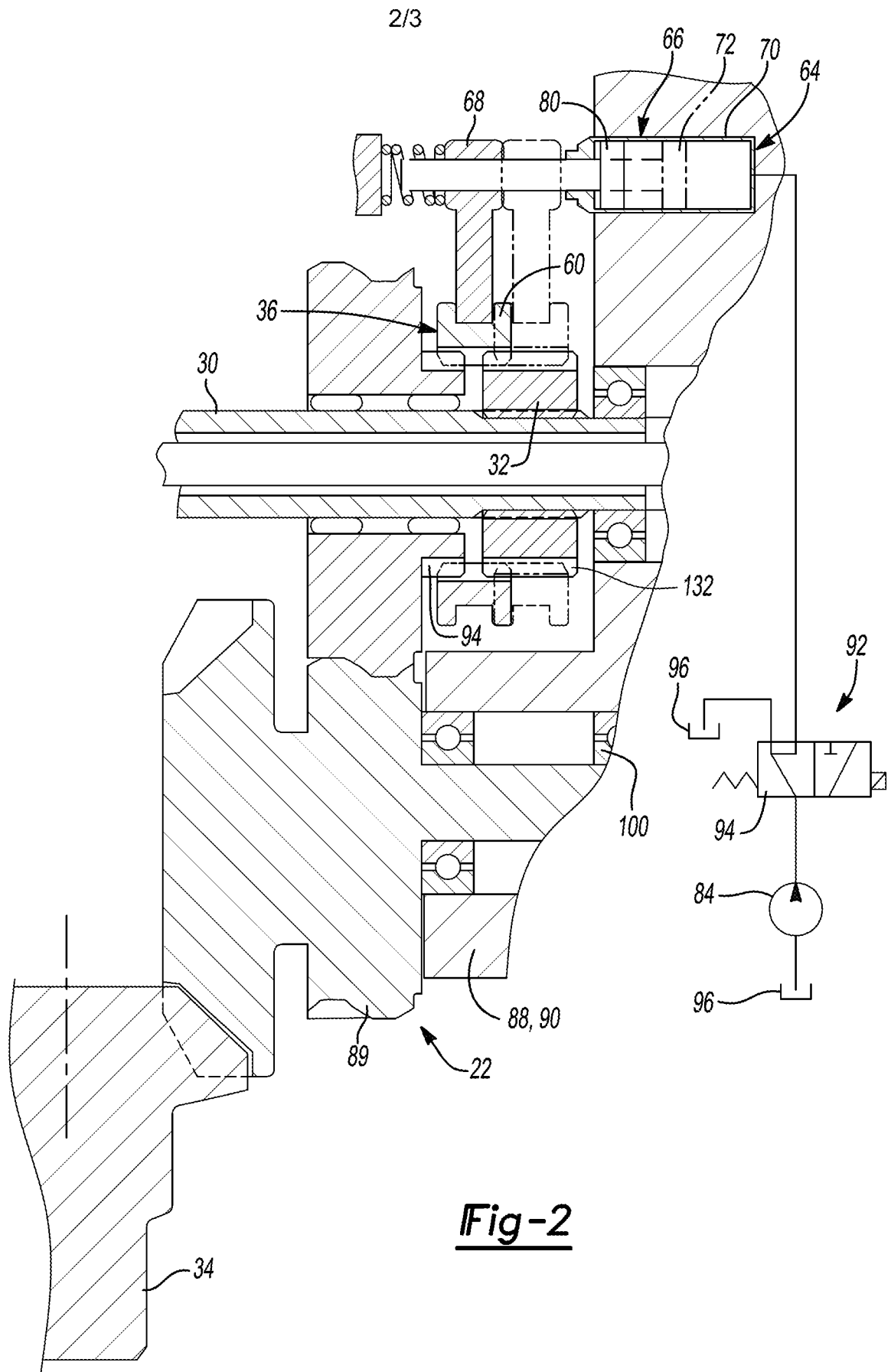


Fig-1



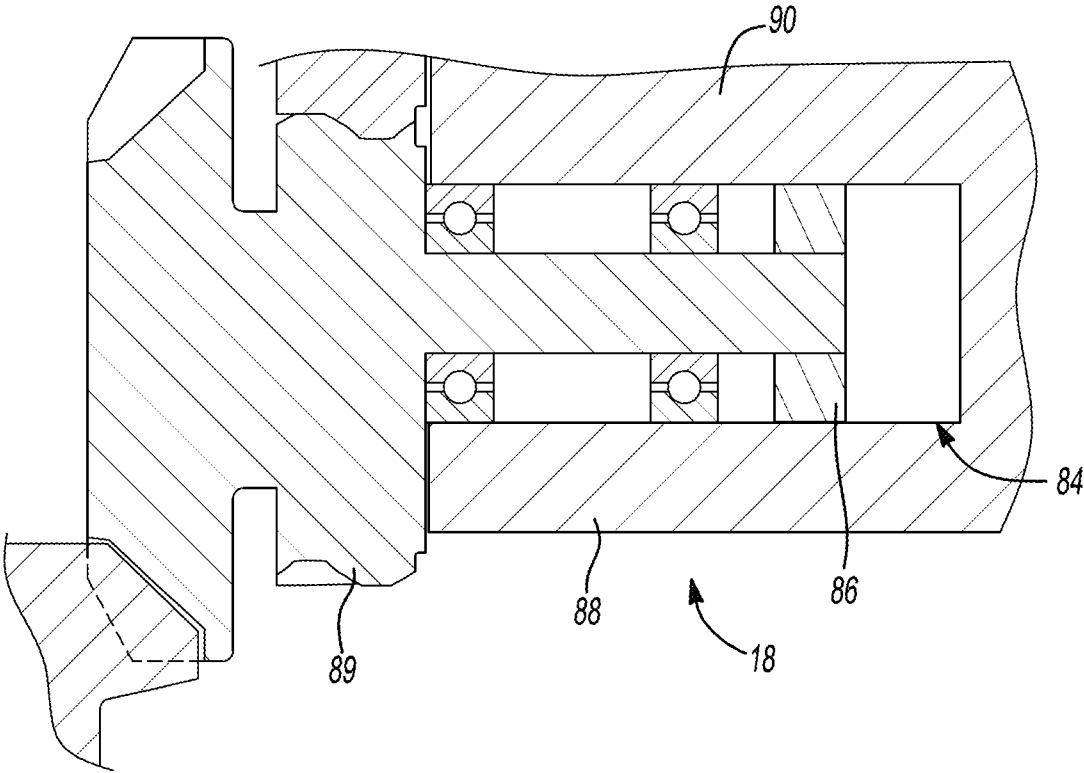


Fig-3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/043084**A. CLASSIFICATION OF SUBJECT MATTER****B60K 17/34(2006.01)i, B60K 17/28(2006.01)i, B60K 17/346(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)

B60K 17/34; F16D 31/06; B60K 17/35; B60K 17/346; F16D 25/00; B60K 17/348; B60K 17/28

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: power-take-off, transmission, drivetrain, four-wheel, all-wheel, hydraulic actuator, pump, vane, rotor, stator

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2012-0024614 A1 (SIGMUND et al.) 02 February 2012 See paragraphs [0016]-[0040] and figures 1, 2.	1-10
Y	US 4676336 A (HIRAMATSU et al.) 30 June 1987 See column 12, line 53 - column 13, line 30 and figure 11.	1-10
A	EP 0283821 B1 (TOYODA KOKI KABUSHIKI KAISHA) 24 July 1991 See column 4, line 42 - column 6, line 52 and figures 1-3.	1-10
A	US 2010-0038164 A1 (DOWNS et al.) 18 February 2010 See paragraphs [0013]-[0025] and figures 1, 2.	1-10
A	US 4850447 A (HIRAKUSHI et al.) 25 July 1989 See column 4, line 29 - column 14, line 7 and figures 1-5.	1-10



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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

"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

24 October 2016 (24.10.2016)

Date of mailing of the international search report

24 October 2016 (24.10.2016)

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

Facsimile No. +82-42-481-8578

Authorized officer

LEE, Dal Kyong

Telephone No. +82-42-481-8440



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/043084

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2012-0024614 A1	02/02/2012	US 8534409 B2	17/09/2013
US 4676336 A	30/06/1987	JP 60-104426 A	08/06/1985
		JP 60-110533 A	17/06/1985
		JP 60-116529 A	24/06/1985
		JP 61-089125 A	07/05/1986
		JP 61-102326 A	21/05/1986
		KR 10-1989-0001335 B1	29/04/1989
EP 0283821 B1	24/07/1991	AU 605568 B2	17/01/1991
		EP 0283821 A1	28/09/1988
		JP 01-093631 A	12/04/1989
		JP 01-126441 A	18/05/1989
		JP 01-141240 A	02/06/1989
		JP 01-141241 A	02/06/1989
		JP 01-169132 A	04/07/1989
		JP 01-172643 A	07/07/1989
		JP 06-100236 B2	12/12/1994
		JP 07-017162 B2	01/03/1995
		JP 07-036187 B2	19/04/1995
		JP 2518321 B2	24/07/1996
		JP 2522810 B2	07/08/1996
		JP 63-240429 A	06/10/1988
		KR 10-1995-0003839 B1	20/04/1995
		US 4905808 A	06/03/1990
		US 5056640 A	15/10/1991
US 2010-0038164 A1	18/02/2010	GB 2474608 A	20/04/2011
		KR 10-1546994 B1	30/10/2015
		US 2010-0044138 A1	25/02/2010
		US 8042642 B2	25/10/2011
		US 8047323 B2	01/11/2011
		WO 2010-019641 A2	18/02/2010
		WO 2010-019641 A3	14/05/2010
		WO 2011-016950 A2	10/02/2011
		WO 2011-016950 A3	28/04/2011
US 4850447 A	25/07/1989	JP 08-011494 B2	07/02/1996
		JP 63-284028 A	21/11/1988
		JP 63-315326 A	23/12/1988