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(54) Title: A VEHICLE DRIVELINE SYSTEM

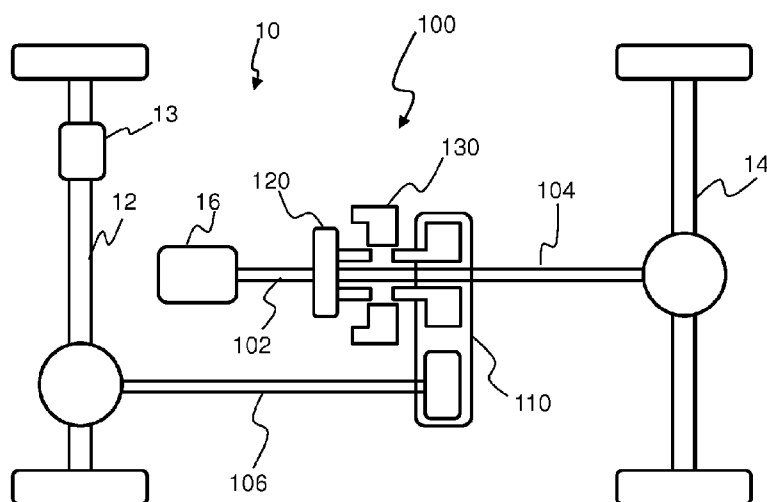


Fig. 1

(57) Abstract: A vehicle driveline system (100) is provided comprising a differential (120) having an input (102), a front output (106) connecting to a front axle (12) and a rear output (104) connecting to a rear axle (14). The vehicle driveline system (100) further comprises an actuator (130) which is configured to control the operation of the differential (120) between a first mode, in which the front output (106) is disconnected from the input (102), and a second mode, in which the front output (106) is connected to the input (102).

A VEHICLE DRIVELINE SYSTEM

Technical Field

The present invention relates to a vehicle driveline system. More particularly,
5 the present invention relates to a vehicle driveline system having a transfer case.

Background

There is an increasing demand to reduce CO₂ emissions from passenger vehicles due to stricter legislation in most parts of the world. These increasing demands for loss
10 reduction in combination with demand for increased functionality and lower cost creates a need for new driveline technology. Today more and more vehicles are equipped with driveline disconnect systems to reduce the losses of the AWD-System. The drawback of these systems are that they tend to come with a high cost and that the loss in the disconnected (2WD)-mode is not fully optimized, mainly because of the high clutch
15 drag.

Also motivated by the CO₂ legislation more and more vehicles are and will be equipped with mild hybridization by for example a small 48 V electrical motor installed as an belt-integrated starter generator (B-ISG) on the engine. Although the B-ISG gives a very good reduction in CO₂ it does not fully utilize the reduction potential of a small
20 electrical motor in the vehicle. For example, while regenerating the engine must be rotating since the B-ISG is directly connected to it, thus resulting in additional losses. Also the used of an electrical motor as B-ISG creates limited additional functionality to the vehicle.

In view of this there is a need for an improved vehicle driveline system.
25

Summary

An object of the present invention is to provide a vehicle driveline system overcoming the drawbacks of prior art system.

According to a specific aspect a vehicle driveline system according to the
30 independent claim is provided. Preferred embodiments are defined by the appended dependent claims.

Brief Description of Drawings

The invention will be described in further detail under reference to the
35 accompanying drawings in which:

Fig. 1 is a schematic view of a vehicle driveline system according to an embodiment;

Fig. 2 is a schematic view of the vehicle driveline system shown in Fig. 1, however operated in a mode in which the front axle is disconnected;

Fig. 3 is a schematic view of a differential according to an embodiment;

Fig. 4 is a cross sectional view of the differential shown in Fig. 3, however
5 operated in a disconnect mode;

Fig. 5 is a cross sectional view of a differential according to an embodiment;

Fig. 6 is a cross sectional view of the differential shown in Fig. 3, however
operated in a disconnect mode;

Fig. 7 is a schematic view of a vehicle driveline system according to a further
10 embodiment; and

Fig. 8 is a schematic view of a vehicle driveline system according to a yet
further embodiment.

Detailed Description

15 In Fig. 1 a vehicle driveline system 100 in the form of a transfer case is shown. The transfer case 100 is arranged in a vehicle 10 having a front axle 12, a rear axle 14, and an engine 16 for driving the transfer case 100 via a transmission (not shown).

The transfer case 100 has an input shaft 102 being connected to the engine 16, a rear output shaft 104, and a front output shaft 106. The front output shaft 106 is
20 arranged non-coaxially relative the rear output shaft 104; the front output shaft 106 is connected to the input shaft 102 via a chain drive 110. Input torque is transmitted to a center differential 120, having a first output being the rear output shaft 104, and a second output being a driving side of the chain drive 110 thus connecting to the front output shaft 106. The front output shaft 106 is driving the front axle 12, while the rear
25 output shaft 104 is driving the rear axle 14.

By using a center differential 120 with a torque distribution of for example 50/50 or 60/40 a good and robust AWD-system can be achieved. Normally the center differential topology cannot be combined with disconnect since disconnecting one shaft 104, 106 from the differential 120 will mean that there will be no torque transfer to any
30 of the output shafts 104, 106. By combining an already existing disconnect 13 of for example the front axle 12 with a mechanical lock of the differential 120 the torque transfer to the other (in this case the rear) axle can be maintained. Since the described system 100 does not have a clutch, the drag losses will be very low in the disconnected mode. An actuator 130 is provided for controlling the operation of the differential 120.
35 The actuator 130 may e.g. be a shifting sleeve, an electro-magnetic actuator, or an electro-magnetic actuator.

The cost of the shifting sleeve 130 providing the connect/disconnect function will be lower than a clutch pack. Also the actuation of the shifting sleeve 130 between connected position and disconnected position can be done by a simpler actuation system and at lower cost than the clutch actuation system. The shifting sleeve 130 can also be designed to lock the differential 120 before disconnecting the front axle 12, thus creating a third state with AWD and locked differential 120 suitable for heavy off-road conditions.

In Fig. 1 the actuator 130, being realized as a shifting sleeve, is arranged in a connect mode connecting the front output of the differential 120 with the front axle 12. Hence, input torque from the engine 16 will be transferred to the front axle 12 as well as to the rear axle 14.

In Fig. 2 the shifting sleeve has moved in order to disconnect the front output of the differential 120 from the front axle 12. Hence, input torque will be transferred to the rear axle 14 only.

Figs. 3-4 show an embodiment of a differential 120 for use with the driveline system 100 of Figs. 1-2. The differential can for example be of bevel gear type as shown or of planetary type.

In Figs. 3 and 4, the differential is embodied as a planetary type differential having an input shaft 102 driving a ring gear 120:1. The ring gear 120:1 meshes with an outer planet carrier 120:2 in fixed rotational connection with an inner planet carrier 120:3. The inner planet carrier 120:3 meshes with a sun gear 120:4 being connected with a rear output 104, while the planet carriers 120:2, 120:3 are in driving connection with the front output 106a. An actuator 130, e.g. in the form of a shifting sleeve, is arranged to mechanically lock the rear output 104, i.e. the planet carriers 120:2, 120:3 to the front output 106a, i.e. the sun gear 120:4. In the normal operation, as is shown in Fig. 3, the actuator 130 is connecting the front output 106a with the planet carriers 120:2, 120:3. In this state, the differential 120 is open such that driving torque is provided to the front and rear axles.

In Fig. 4 a disconnected state is shown, in which the actuator 130 has been actuated to move for locking the differential 120. In this position the planet carriers 120:2, 120:3 are mechanically locked to the sun gear 120:4. At the same time the front output 106a is disconnected from the planet carriers 120:2, 120:3. If the front axle 106a is disconnected, driving torque will still be provided to the rear axle 104.

Upon a desired normal operation of the differential 120, an unlocked state is commanded as shown in Fig. 3. Here the actuator 130 is controlled to unlock the planet carriers 120:2, 120:3 from the ring gear 120:1 and at the same time connect the front

output 106a to the planet carriers 120:2, 120:3. In this state, driving torque is provided to the front output as well as to the rear output.

In Figs. 5 and 6 another embodiment of a differential is shown. The differential 120 has an input 102 for receiving input torque from the engine 16, and two outputs 104, 106a. The rear output 104 connects with the rear axle 14 as shown in Fig. 1, while the front output 106a forms a driving axle for the chain drive 110. Fig. 3 shows an operation mode in which the shifting sleeve 130 is connected to the front output 106a, i.e. the operation mode of Fig. 1. Fig. 4 shows an operation mode in which the shifting sleeve 130 is disconnected from the front output shaft 106a, i.e. the operation mode of Fig. 2.

Now turning to Fig. 7 a further embodiment of a vehicle driveline system 100 in the form of a transfer case is shown. By installing an electrical motor 140 in the transfer case, preferably operating on 48V, and connect it to for example the chain sprocket of the chain drive 110, and thus the front axle output shaft 106, additional functionality can be created and losses can be reduced by using the motor 140 for hybrid functions. In fully disconnected mode the driveline and the electrical motor 140 will be stationary resulting in very low losses. In the need of regeneration the front axle dog clutch 13 can be connected and the electrical motor 140 can be used for regeneration. In the event of driving in disconnected 2WD-mode the electrical motor 140 can be used to accelerate the stationary front driveline 106, 12 and achieve fast AWD by applying torque to the front axle 12 with the electrical motor 140. By connecting the front axle dog clutch 13 the system can also be used for electrical driving at low speeds by applying torque with the electrical motor 140.

Now turning to Fig. 8 another embodiment of a vehicle driveline system 100 is shown. The vehicle driveline system 100 forms a transfer case. An engine/transmission 16 drives an input 102 to the transfer case, and a rear output 104 is connected to a rear axle 14. A front output 106a is connected to the front axle 12 via a chain drive 110 of the transfer case 100. The front axle 12 is provided with a disconnect 13. Fig. 8 differs from the previous embodiments in that the transfer case is provided with a clutch 150, replacing the differential 120 of the previous embodiments. By installing an electrical motor 140 in the front driveline 106 in a disconnect system with a clutch topology, the benefits as described above with reference to Fig. 7 can be achieved, but also the electrical motor 140 can be used to synchronize the speed of the front driveline 106 with the rest of the driveline. Since the torque control of the electrical motor 140 is better than the torque control of a clutch the connection sequence can be made faster and with lower risk for noise vibration and harshness (NVH). Also since the electrical motor 140 will take over the synchronization work for the clutch at a connect sequence, the

requirements on speed and torque accuracy of the clutch actuation system will be lower, resulting in a lower cost. If for example the clutch actuation system has dual piston areas and a solenoid valve to improve speed and accuracy, these can be removed.

5 The electrical motor 140 is preferably arranged between the front axle differential 12:1 and the clutch 150. By such configuration there is no need for additional shafts to pass the oil-filled area formed by the clutch 150 and the chain drive 110. This in turns result in a less number of radial seals and reduced losses. By arranging the electrical motor 140 in this position a greater design freedom is also provided, with less impact on packing and driveline design.

10 Although the present invention has been described above with reference to specific embodiments, it is not intended to be limited to the specific form set forth herein. Rather, the invention is limited only by the accompanying claims.

CLAIMS

1. A vehicle driveline system (100), comprising a differential (120) having an input (102), a front output (104) connecting to a front axle (12) and a rear output (106a) connecting to a rear axle (14), wherein said vehicle driveline system (100) further comprises an actuator (130) which is configured to control the operation of the differential (120) between a first mode, in which the front output (106a) is disconnected from the input (102), and a second mode, in which the front output (106a) is connected to the input (102).
2. The vehicle driveline system according to claim 1, wherein the actuator is further configured to control the operation of the differential in a third mode, in which the differential is locked and in which the front output (106a) is connected to the input (102).
3. The vehicle driveline system according to any one of the preceding claims, wherein said actuator (130) is a shifting sleeve.
4. The vehicle driveline system according to claim 3, wherein the shifting sleeve is arranged coaxially around the rear output (104).
5. The vehicle driveline system according to any one of the preceding claims, further comprising an electrical motor (140) which is in driving connection with the front output (106a).
6. The vehicle driveline system according to any one of the preceding claims, wherein the driveline system (100) forms a transfer case and wherein the front output (106a) is a shaft for driving the front axle (12) via a chain drive (110), and the rear output (104) is a shaft for driving the rear axle (14).
7. The vehicle driveline system according to any one of the preceding claims, wherein the differential (120) is a bevel-gear differential.
8. The vehicle driveline system according to any one of the preceding claims, wherein the differential (120) is a planetary gear differential, wherein a ring gear (120:1), a planet carrier (120:2, 120:3), and a sun gear (120:4) form the differential input (102), the front output (104) and the rear output (106a), respectively.

9. A vehicle driveline system (100) for providing all wheel drive, comprising a clutch (150) having a drive side (102, 104) connected to one of the front axle (12) or the rear axle (14) of the vehicle, and a driven side (106a) connected to the other one of the front or the rear axle (12, 14), whereby driving torque will be transferred to the driven side (106a) upon actuation of the clutch (150), wherein said vehicle driveline system (100) further comprises a disconnect (13) arranged on the driven side of the clutch (150), and an electrical motor (140) arranged between the clutch (150) and a front axle differential (12:1), which is in driving connection with the driven side of the clutch (150).

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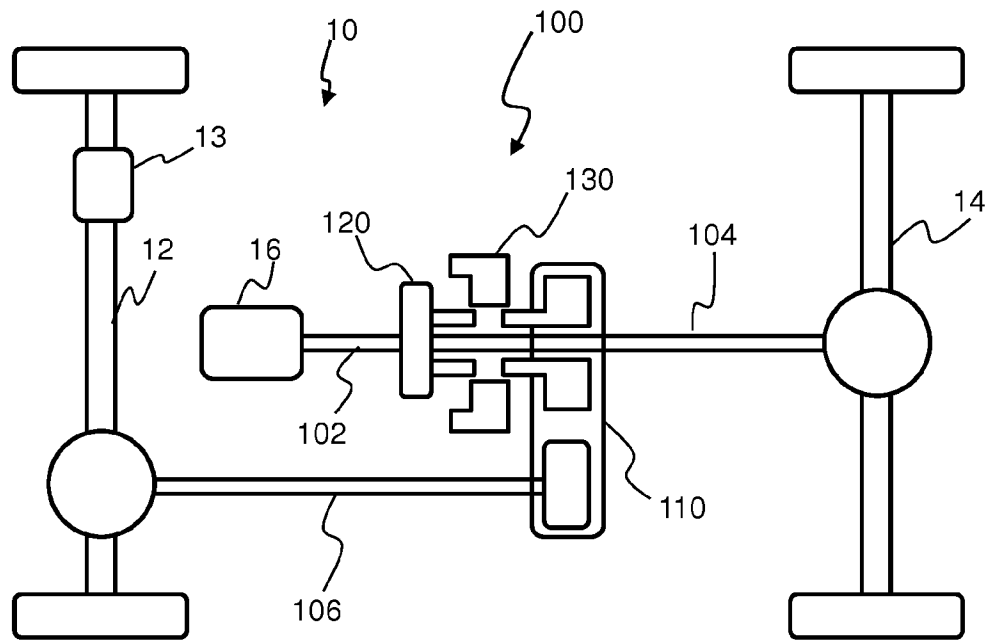


Fig. 1

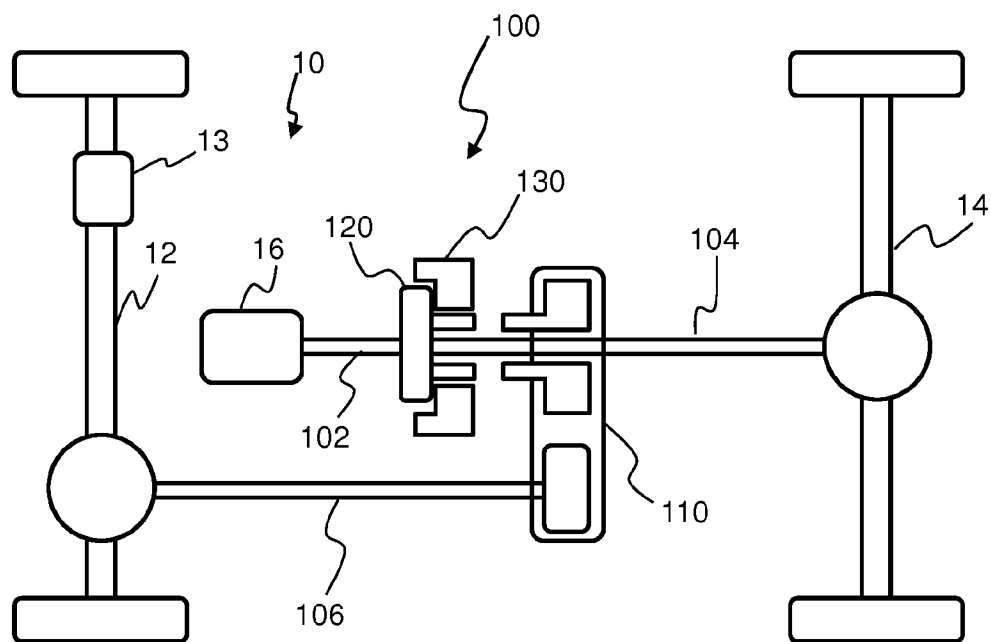
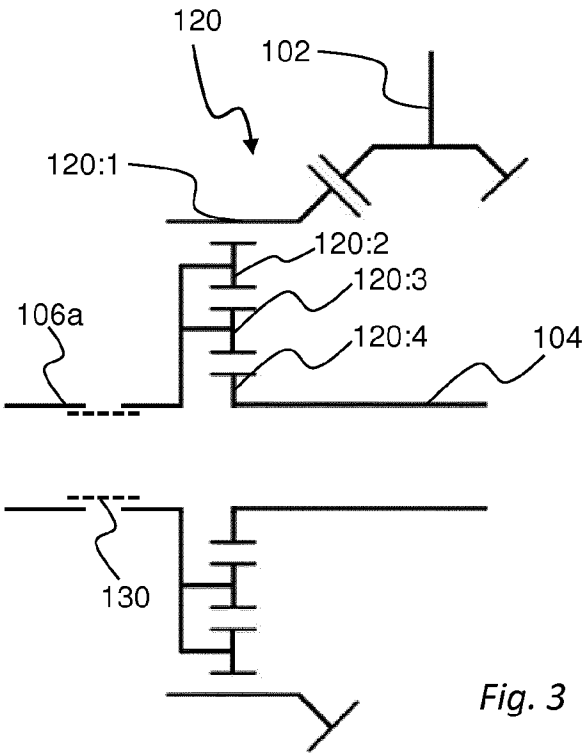
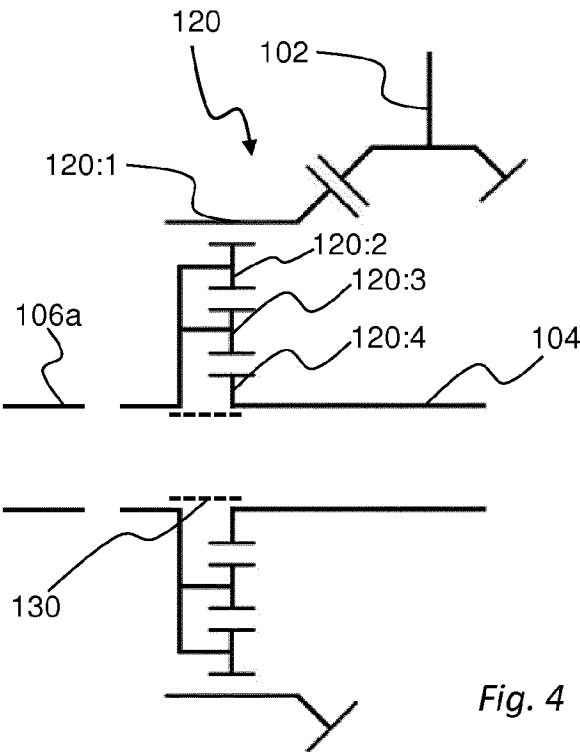
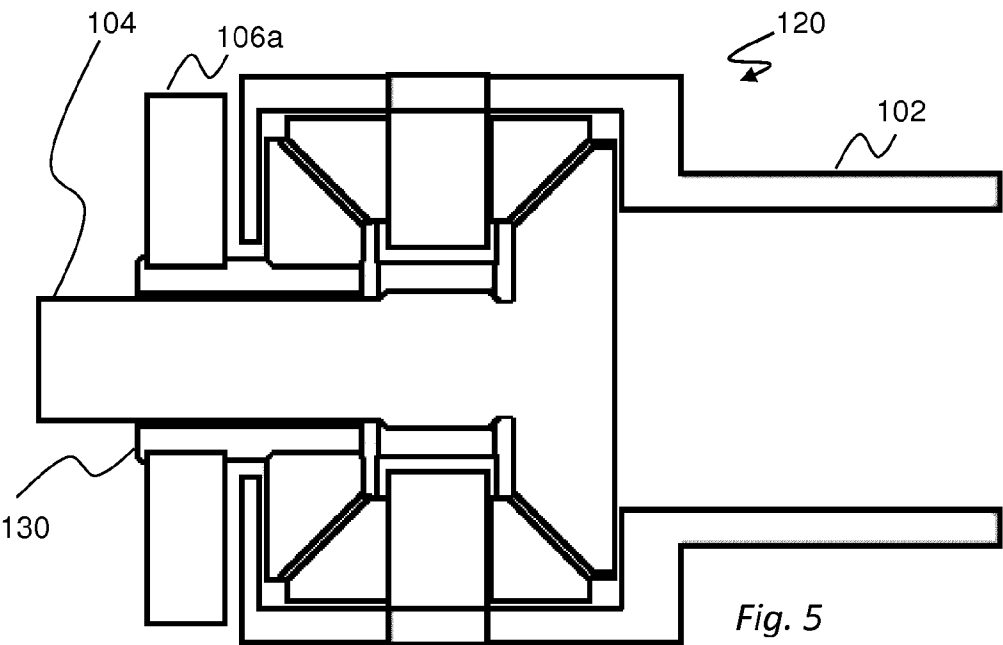
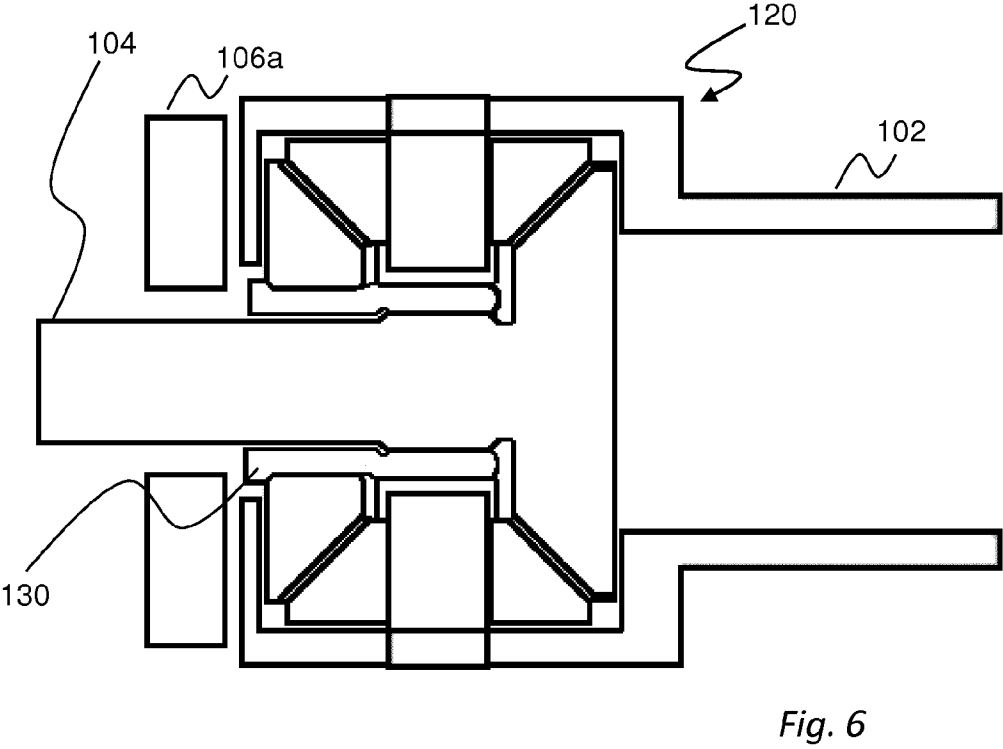


Fig. 2



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4/4

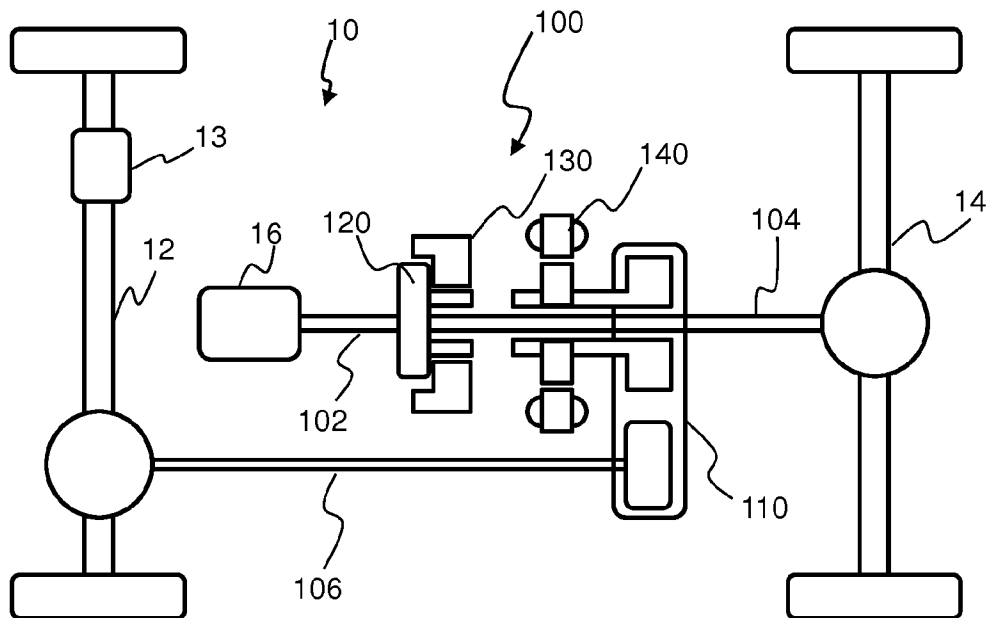


Fig. 7

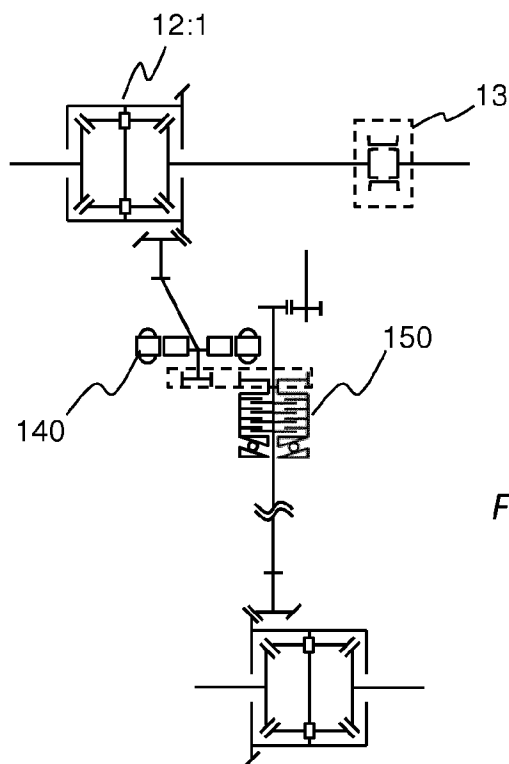


Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2015/065167

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-8

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/065167

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60K17/346 B60K17/35
ADD.

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

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

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

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 7 331 896 B1 (KROPPE WILLIAM J [US]) 19 February 2008 (2008-02-19) figures 2,3 -----	1-8
X	WO 2009/124018 A2 (MAGNA POWERTRAIN USA INC [US]; ZALEWSKI JOHN D [US]) 8 October 2009 (2009-10-08) paragraphs [0033] - [0035]; figures 6-8 -----	1-8
A	GB 2 391 595 A (VISTEON GLOBAL TECH INC [US]) 11 February 2004 (2004-02-11) figure 3 -----	1
A	GB 2 490 427 A (LAND ROVER [GB]) 31 October 2012 (2012-10-31) figure 7 -----	1-8



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

17 September 2015

Date of mailing of the international search report

09/12/2015

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2015/065167

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 7331896	B1	19-02-2008	NONE

WO 2009124018	A2	08-10-2009	NONE

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			JP 2014514987 A 26-06-2014
			WO 2012146785 A1 01-11-2012

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-8

Vehicle driveline comprising a differential with an actuator configured to control the differential

2. claim: 9

Vehicle driveline with a clutch, a disconnect and an electrical motor
