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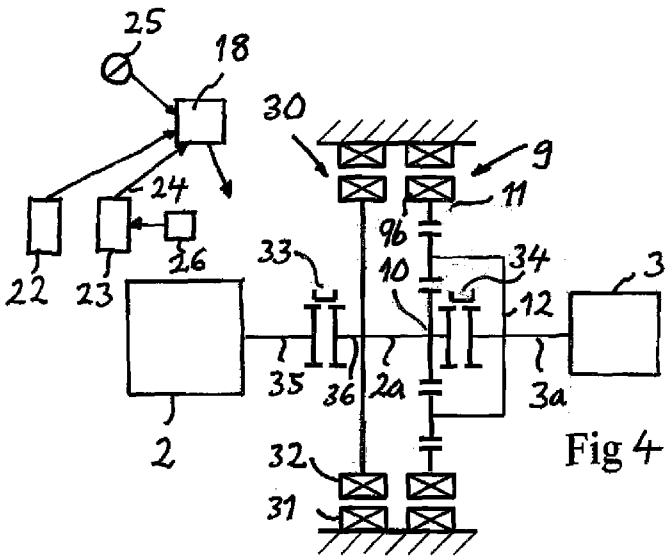

Fig 4

(57) Abstract: A drive system for a vehicle comprises a combustion engine (2), an electric machine (9) and a planetary geering with a sun gear (10), a ring gear (11) and a planetary gears carrier (12). The drive system further comprises an arrangement (30) for exchange of electric energy with the electric machine, a control unit (18) configured to control fuel supplied to the combustion engine (2) and exchange of electric energy of said electric machine with said arrangement and an accelerator pedal (22) to be controlled by a driver of the vehicle so as to control supply of fuel to the combustion engine and by that the rotation speed of the output shaft of the combustion engine. The drive system also comprises a further pedal (23) controllable by a said driver so as to request a torque to be applied to the output shaft (3a) of the planetary geering for the propulsion of the vehicle depending upon the position of said further pedal and means (24) configured to send information about the position of the further pedal (23) to a control unit (18) configured to control the electric machine (9) to obtain said requested torque on the output shaft of the planetary geering.

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A DRIVE SYSTEM FOR A VEHICLE COMPRISING A SHUNT PEDAL

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a drive system for a vehicle according to the preamble of appended claim 1.

The invention is especially but not exclusively directed to such a drive system for motor vehicles in the form of wheeled utility motor vehicles, especially heavy such vehicles, such as trucks and buses.

Thus, the invention relates to a drive system for the propulsion of a hybrid vehicle, which is generally speaking a vehicle which may be driven by a primary engine, here a combustion engine, and a secondary engine, here an electric machine. The vehicle is for that sake provided with a said arrangement for exchange of electric energy with said electric machine, and this arrangement may for example suitably comprise means for storing energy, such as electric batteries or a capacitor for storing electric energy, but it may instead or additionally for example comprise a further electric machine. The electric machine may through exchange of electric energy with said arrangement alternatively operate as motor and generator depending upon the state of operation of the vehicle. When braking the vehicle the electric machine generates electric energy which may be stored, and the electric energy stored may later be utilized for for example the propulsion of the vehicle.

The output shaft of the planetary geering in a drive system according to the introduction may form the input shaft of a gearbox of the

drive system, and by connecting the output shaft of the combustion engine, the rotor of the electric machine and the input shaft of the gearbox in such a drive system by a planetary geering a conventional clutch mechanism and a number of disadvantages thereof may be avoided. The use of a conventional clutch mechanism to disconnect the input shaft of a gearbox from the combustion engine during a gear shifting process in the gearbox involves disadvantages, such as heating of the discs of the clutch mechanism, which results in an increased fuel consumption and wear of the clutch discs. Great fuel losses result particularly when starting the vehicle. Other disadvantages of a conventional clutch mechanism are the weight and cost thereof. It is also comparatively space demanding. Furthermore, friction losses are caused when using a hydraulic converter/torque converter usually used in automatic transmission gearboxes.

BACKGROUND ART

A drive system of the type defined in the introduction is known through for example EP 1 319 546 and SE 1051384-4. Although especially the drive system disclosed in SE 1051384-4 is well functioning and has a number of advantageous features there is of course an ongoing attempt to improve such a drive system with respect to the behavior and function in certain situations.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a drive system of the type defined in the introduction being improved in at least some aspect with respect to such drive systems already known.

This object is according to the invention obtained by providing such a drive system with the features listed in the characterizing part of appended claim 1.

A vehicle drive system having such a further pedal may be considered to have a clutch pedal, so that the drive system has three pedals as a conventional drive system with a clutch mechanism but without any clutch function. The operation of said further pedal will be the same as that of a Clutch By Wire (CBW) but with a quite different function. US 2010/0298094 A1 discloses such a Clutch By Wire in a motor vehicle having a drive system of another type than the one defined in the introduction and being there for really functioning as a clutch during gear shifting procedures. Said further pedal in the drive system according to the present invention relying on the control by wire principle offers the driver of the vehicle a possibility to take over the control of the torque to be applied to the output shaft of the planetary geering for the propulsion of the vehicle. This possibility will be interesting in difficult situations when the vehicle through the normal control of the combustion engine and the electric machine by the vehicle control unit will get a too low torque applied on said output shaft of the planetary geering resulting in a risk of getting stuck, such as when driving on roads with a poor quality or in dirt and/or snow and ice. The behavior of the vehicle when shunting during loading and unloading may also be improved by the possibility to control said torque by controlling said electric machine by the actuation of said further pedal. Thus, the position of said further pedal will send information, such as an electric signal, to a control unit controlling the electric machine to obtain a corresponding torque on the output

shaft of the planetary geering. This control unit function may be included in the control unit configured to control fuel supply to the combustion engine and exchange of electric energy of the electric machine with said arrangement when it is not acted upon said further pedal or be provided through a separate control unit.

According to an embodiment of the invention the drive system comprises means to switch the drive system to a shunting mode in which a mid position of said further pedal corresponds to a requested zero torque to be applied to said output shaft of the planetary geering and the value of said requested torque increases, but with different signs, when said further pedal is moved in opposite directions away from said mid position for enabling driving of the vehicle forwards and backwards by control of said further pedal. To switch the drive system into such a mode when shunting of the vehicle is to take place will improve and facilitate the control of the drive system by said further pedal during shunting, such as when loading and unloading a truck.

According to another embodiment of the invention said control unit configured to control said electric machine is configured to consider said requested torque to be a zero torque if said accelerator pedal is within a certain distance from the position assumed when not actuated by a driver, such as moved less than 40% or less than 20% of the range of possible movement thereof from the position last mentioned. It is by this ensured that a torque not requested is not applied to the output shaft of the planetary geering for the propulsion of the vehicle when the driver removes the feet from the

pedals. However, when the accelerator pedal is moved to be outside said certain distance it may function as normally to control supply of fuel to the combustion engine.

According to another embodiment of the invention the accelerator pedal is in said shunting mode configured to have no influence upon the control of the combustion engine and said requested torque when moved by a said driver. This means that the accelerator pedal will control neither the number of revolutions of the output shaft of the combustion engine nor the torque applied to the planetary geering for the propulsion of the vehicle, but the control will merely be carried out by moving said further pedal.

According to another embodiment of the invention the drive system comprises means controllable for disconnecting and connecting said further pedal with respect to the influence of a control thereof upon the operation of the drive system. This means that the vehicle may be operated in two pedal mode when desired by such a disconnection of said further pedal.

According to another embodiment of the invention the planetary gears carrier is said second component and according to a further embodiment the sun gear of the planetary geering is said first component and the ring gear said third component. A compact structure easy to fit into spaces already existing for drive trains with clutch mechanisms instead of planetary geering may be obtained by connecting the rotor of the electric machine with the ring gear and the output shaft of the combustion engine with the sun gear. A gearbox for a hybrid vehicle may by this be made compact and not substantially more space demanding than a standard gearbox.

This means that the weight increase normally caused by a hybrid construction may be considerably reduced. Another advantage is that a connection of the rotor of the electric machine with the ring gear results in a higher possible braking torque through this than if it instead would be connected to the sun gear.

According to another embodiment of the invention the drive system comprises a first locking means transferable between a locking position in which two of said components are interlocked so that the three components rotate with the same number of revolutions and a releasing position in which the components are allowed to rotate with different numbers of revolutions.

According to another embodiment of the invention the drive system comprises a second locking means transferable between a locking position in which the output shaft of the combustion engine is locked to said first component and a releasing position in which the output shaft of the combustion is released from said first component and allowed to rotate independently thereof. The presence of such a second locking means results in a number of advantages, such as a possibility to start the combustion engine when torque is transferred from the output shaft of the planetary geering for the propulsion of the vehicle.

According to another embodiment of the invention said output shaft of the planetary geering forms an input shaft of a gearbox of the vehicle.

According to another embodiment of the invention said arrangement for exchange of electric energy with said electric machine

comprises an additional electric machine with a stator and a rotor connected to the output shaft of the combustion engine between the combustion engine and said first component. The arrangement of such an additional electric machine makes it possible to obtain exchange of electric energy with the electric machine interacting with the third component of the planetary geering without any need of means for storing electric energy, such as electric batteries, contained in said arrangement. It will for instance be possible to start driving a vehicle standing still while maintaining power balance, i.e. while providing means for storing electric energy when present, such as electric batteries, and other electric loads of the vehicle with a controlled current/power at the same time as a desired torque is maintained in the drive train of the vehicle.

According to another embodiment of the invention the arrangement for exchange of electric energy with said electric machine comprises means for storing electric energy, such as at least one electric battery.

The present invention also relates to a motor vehicle, especially a wheeled vehicle, such as a truck or a bus, which comprises a drive system according to the invention.

Further advantages as well as advantageous features of the present invention appear from description following below.

BRIEF DESCRIPTION OF THE DRAWINGS

With reference to the appended drawings, below follows a specific description of embodiments of the invention cited as examples.

In the drawings:

Fig 1 illustrates very schematically a drive train of a vehicle which may be provided with a drive system according to the invention,

Fig 2 is a more detailed but still simplified view of a part of said drive system,

Fig 3 is a simplified view illustrating the general construction of a drive system according to a first embodiment of the invention, and

Fig 4 is a simplified view illustrating the general construction of a drive system according to a second embodiment of the invention.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Fig 1 shows a drive train for a heavy vehicle 1. The drive train comprises a combustion engine 2, a gearbox 3 and a number of drive shafts 4 and drive wheels 5. The drive train has an intermediate portion 6 located between the combustion engine 2 and the gearbox 3. Fig 2 shows a part of the components in said intermediate portion 6 more in detail, namely those which are also present in drive systems of the type defined in the introduction already known, such as through SE 1051384-4. The combustion engine 2 is provided with an output shaft 2a and the gearbox 3 with an input

shaft 3a in the intermediate portion 6. The output shaft 2a of the combustion engine is arranged coaxially with respect to the input shaft 3a of the gearbox. The output shaft 2a of the combustion engine and the input shaft 3a of the gearbox rotate around a rotation axis 7 in common. The intermediate portion 6 comprises a housing 8 enclosing an electric machine 9 and a planetary geering. The electric machine 9 comprises a stator 9a and a rotor 9b. The stator 9a comprises a stator core secured to the inner wall of the housing 8. The stator core comprises the windings of the stator. The first electric machine 9 is configured to under certain operation states utilize electric energy stored so as to supply driving force to the input shaft 3a of the gearbox and during other operation states utilize kinetic energy of the input shaft 3a of the gearbox to produce and store electric energy.

The planetary geering is arranged substantially radially internally of the stator 9a and the rotor 9b of the electric machine. The planetary geering comprises a sun gear 10, a ring gear 11 and a planetary gears carrier 12. The planetary gears carrier 12 carries a number of geers 13 arranged to rotate in a radial space between the sun gear 10 and the teeth of the ring gear 11. The sun gear 10 is here secured to a peripheral surface of the output shaft 2a of the combustion engine. The sun gear 10 and the output shaft 2a of the combustion engine rotate as a unit with a first number of revolutions n_1. The planetary gears carrier 12 comprises a securing portion 12a secured to a peripheral surface of the input shaft 3a of the gearbox by means of a splines joint 14. The planetary gears carrier 12 and the input shaft 3a of the gearbox may by means of this joint rotate as a unit with a second number of revo-

lutions n_2. The ring gear 11 comprises an external peripheral surface onto which the rotor 9b is secured. The rotor 9b and the ring gear 11 form a rotatable unit rotating with a third number of revolutions n_3.

The drive system comprises further a first locking means by the fact that the output shaft 2a of the combustion engine is provided with a displaceable coupling member 15. The coupling member 15 is secured to the output shaft 2a of the combustion engine by means of a splines joint 16. The coupling member 15 is in this case secured against rotation on the output shaft 2a of the combustion engine and displaceable in an axial direction on this output shaft 2a. The coupling member 15 comprises a coupling portion 15a which is connected to a coupling portion 12b of the planetary gears carrier 12. A displacing member 17 schematically shown is arranged to displace the coupling member 15 between a first position in which the coupling portions 15a, 12b are not in mutual engagement corresponding a releasing position of the first locking means and a second position in which the coupling portions 15a, 12b are in mutual engagement corresponding to a locking position of the first locking means. The output shaft 2a of the combustion engine and the input shaft 3a of the gearbox will in this locking position be interlocked and they and by that also the rotor of the electric machine will rotate with the same number of revolutions. This state may be called locked planet. The locking mechanism may also have any other construction, such as the one disclosed in the Swedish patent application 1250696-0. The locking means may also be formed by any suitable type of friction coupling or clutch.

An electric control unit 18 is configured to control the displacing member 17. The control unit 18 is also configured to decide on which occasions the electric machine shall function as a motor and on which occasions it shall function as a generator. The control unit 18 may receive information about suitable operation parameters for deciding which function is to be chosen. The control unit 18 may be a computer with software for this task. The control unit 18 controls a regulating equipment 19 schematically indicated which regulates the flow of electric energy between a hybrid battery 20 and the stator windings 9a of the electric machine. When the electric machine 9 operates as motor electric energy stored in the hybrid battery 20 is supplied to the stator 9a. When the electric machine operates as generator electric energy is supplied to the hybrid battery 20 from the stator 9a. The hybrid battery 20 delivers and stores electric energy having a voltage in the order of 300 – 900 V. It is important that the electric machine 9 and the planetary geering constitute a compact unit, since the intermediate portion 6 between the combustion engine 2 and the gearbox 3 in a vehicle is restricted. The components 10, 11, 12 of the planetary geering are arranged substantially radially internally of the stator 9a of the electric machine. The rotor 9b of the electric machine, the ring gear 11 of the planetary geering, the output shaft 2a of the combustion engine and the input shaft 3a of the gearbox are here arranged to rotate around a rotation axis 7 in common. Such a design means that the electric machine 9 and the planetary geering require comparatively little space. The vehicle 1 is provided with an engine control function 21 through which the number of revolutions n_1 of the combustion engine 2 is controlled. The control unit 18 has by that the possibility to activate the engine control function 21 and create a zero torque state in the gearbox 3 during gear

shifting in the gearbox 3. The drive system may of course instead of being controlled by one single control unit 18 be controlled by several different control units.

The drive system is also provided with an accelerator pedal 22 to be controlled by the driver through a connection therewith to the engine control function 21. The part of a drive system according to the present invention described so far and shown in Fig 2 is also present in a drive system according to SE 1051384-4. The drive system disclosed there has a two pedal design by also having a brake pedal not shown. The part of a drive system according to a first embodiment of the invention added to the part described so far will now be described while making reference to Fig 3.

The drive system shown in Fig 3 differs from that shown in Fig 2 by having no gearbox downstream the output shaft 3a of the planetary geering transmitting a torque for the propulsion of the vehicle from the planetary geering. This drive system comprises besides the accelerator pedal 22 a further pedal 23 controllable by a driver of the vehicle so as to request a torque to be applied to the output shaft 3a of the planetary geering for the propulsion of the vehicle depending upon the position of this further pedal. Means 24 is configured to send information about the position of this further pedal 23 to a control unit 18 configured to control the electric machine 9 to obtain said requested torque on the output shaft of the planetary geering. This enables the driver to choose to control the number of revolutions of the combustion engine by acting upon the accelerator pedal 22 and control the torque delivered by the electric machine by acting upon said further pedal 23. During normal driving, such as cruising, of the vehicle the driver will only act upon

the accelerator pedal for controlling the torque to be applied on the output shaft 3a of the planetary geering by the combustion engine 2 and the electric machine 9. However, in some special situations, such as when driving on roads of a poor quality or on snow and ice or when shunting during loading and unloading of the vehicle, the driver may wish to be able to actively carry out control of the torque applied on said output shaft 3a of the planetary geering, and this may then be done by acting upon said further pedal 23.

The drive system further comprises means 25 to switch the drive system to a shunting mode in which a mid position of the further pedal 23 corresponds to a requested zero torque to be applied to the output shaft 3a of the planetary geering and the value of said requested torque increases, but with different signs, when the further pedal 23 is moved in opposite directions away from the mid position for enabling driving of the vehicle forwards and backwards by control of the further pedal 23. Accordingly, the accelerator pedal 22 will not be involved in the driving of the vehicle when the drive system is switched to the shunting mode by actuating said means 25. However, it would also be possible to let the accelerator pedal participate in the driving of the vehicle also in the shunting mode. The drive system has also means 26 controllable for disconnecting and connecting said further pedal 23 with respect to the influence of a control thereof upon the operation of the drive system, so that the drive system may be switched between a three pedal design and a two pedal design.

A driving system according to a second embodiment of the invention is shown in Fig 4. This drive system differs from that shown in

Fig 3 among others by having a gearbox 3 and having no means for storing electric energy, but the arrangement for exchange of electric energy with the electric machine 9 does here instead include a second electric machine 30 making it possible to omit means for storing electric energy when desired. The second electric machine has a stator 31 with stator windings and a rotor 32 connected to the output shaft 2a of the combustion engine. A second locking means 33, which may have a similar design as the first locking means 34, which is more in detail shown in Fig 2, is configured to in a releasing position separate a first part 35 of the output shaft of the combustion engine closest to the combustion engine from a second part 36 thereof connected to the sun gear 10 of the planetary geering, so that the rotor 32 of the second electric machine and the sun gear 10 are allowed to rotate independently of the first part 35 of the output shaft of the combustion engine. The second locking means is transferable to a locking position in which both parts 35, 36 of the output shaft of the combustion engine are interlocked and by that said first part 35 is locked to the rotor of the second electric machine. The control unit 18 is configured to control supply of fuel to the combustion engine 2 and exchange of electric energy between the first electric machine 9 and the second electric machine 30. This drive system has a further pedal 23 with the same function as the one present in the embodiment shown in Fig 3. Accordingly, the torque applied on the input shaft 3a of the gearbox 3 may be controlled by adjusting the position of said further pedal 23.

The invention is of course in no way restricted to the embodiments described above, since many possibilities for modifications thereof are likely to be obvious to one skilled in the art without having to

deviate from the scope of invention defined in the appended claims.

It is pointed out that also in the case of a driving system with two electric machines of the type shown in Fig. 4 means for storing electric energy, such as electric batteries, are mostly present.

Claims

1. A drive system for a vehicle, said drive system comprising an output shaft (2a) of a combustion engine (2), an electric machine (9) comprising a stator (9a) and a rotor (9b) and a planetary geering comprising three components in the form of a sun gear (10), a ring gear (11) and a planetary gears carrier (12), said output shaft (2a) of the combustion engine being connected to a first of said components of the planetary geering so that a rotation of this shaft results in a rotation of this component, an output shaft (3a) of the planetary geering for transmitting a torque for the propulsion of the vehicle being connected to a second of said components of the planetary geering so that a rotation of this shaft results in a rotation of this component and the rotor (9b) of the electric machine being connected to a third of said components of the planetary geering so that a rotation of the rotor results in a rotation of this component, said drive system further comprising an arrangement (20, 30) for exchange of electric energy with said electric machine (9), a control unit (18) configured to control fuel supply to the combustion engine and exchange of electric energy of said electric machine with said arrangement and an accelerator pedal (22) to be controlled by a driver of the vehicle so as to control supply of fuel to the combustion engine and by that the rotation speed of said output shaft of the combustion engine (2),

characterized in that the drive system comprises a further pedal (23) controllable by a said driver so as to request a torque to be applied to said output shaft (3a) of the planetary

geering for the propulsion of the vehicle depending upon the position of said further pedal and means (24) configured to send information about the position of said further pedal to a control unit (18) configured to control said electric machine (9) to obtain said requested torque on said output shaft (3a) on the planetary geering.

2. A drive system according to claim 1, ***characterized*** in that it comprises means (25) to switch the drive system to a shunting mode in which a mid position of said further pedal (23) corresponds to a requested zero torque to be applied to said output shaft (3a) of the planetary geering and the value of said requested torque increases, but with different signs, when said further pedal is moved in opposite directions away from said mid position for enabling driving of the vehicle forwards and backwards by control of said further pedal.

3. A drive system according to claim 1 or 2, ***characterized*** in that said control unit (18) configured to control said electric machine (9) is configured to consider said requested torque to be a zero torque if said accelerator pedal (22) is within a certain distance from the position assumed when not actuated by a driver, such as moved less than 40% or less than 20% of the range of possible movement thereof from the position last mentioned.

4. A drive system according to claim 2 or 2 and 3, ***characterized*** in that the accelerator pedal (22) is in said shunting mode

configured to have no influence upon the control of the combustion engine (2) and said requested torque when moved by a said driver.

5. A drive system according to any of the preceding claims, ***characterized*** in that it comprises means (26) controllable for disconnecting and connecting said further pedal (23) with respect to the influence of a control thereof upon the operation of the drive system.

6. A drive system according to any of the preceding claims, ***characterized*** in that the planetary gears carrier (12) is said second component.

7. A drive system according to claim 6, ***characterized*** in that the sun gear (10) of the planetary geering is said first component and the ring gear (11) said third component.

8. A drive system according to any of the preceding claims, ***characterized*** in that it comprises a first locking means (34) transferable between a locking position in which two of said components are interlocked so that the three components rotate with the same number or revolutions and a releasing position in which the components are allowed to rotate with different numbers of revolutions.

9. A drive system according to any of the preceding claims, ***characterized*** in that it comprises a second locking means (33) transferable between a locking position in which the output shaft (2a) of the combustion engine (2) is locked to said first

component (10) and a releasing position in which the output shaft of the combustion engine is released from said first component and allowed to rotate independently thereof.

10. A drive system according to any of the preceding claims, ***characterized*** in that said output shaft of the planetary geering forms an input shaft (3a) of a gearbox (3) of the vehicle.

11. A drive system according to any of the preceding claims, ***characterized*** in that said arrangement for exchange of electric energy with said electric machine (9) comprises an additional electric machine (30) with a stator (31) and a rotor (32) connected to the output shaft (2a) of the combustion engine (2) between the combustion engine and said first component (10).

12. A drive system according to any of the preceding claims, ***characterized*** in that arrangement for exchange of electric energy with said electric machine comprises means (20) for storing electric energy, such as at least one electric battery.

13. A motor vehicle (1), especially a wheeled vehicle, such as a truck or a bus, ***characterized*** in that it comprises a drive system according to any of claims 1-12.

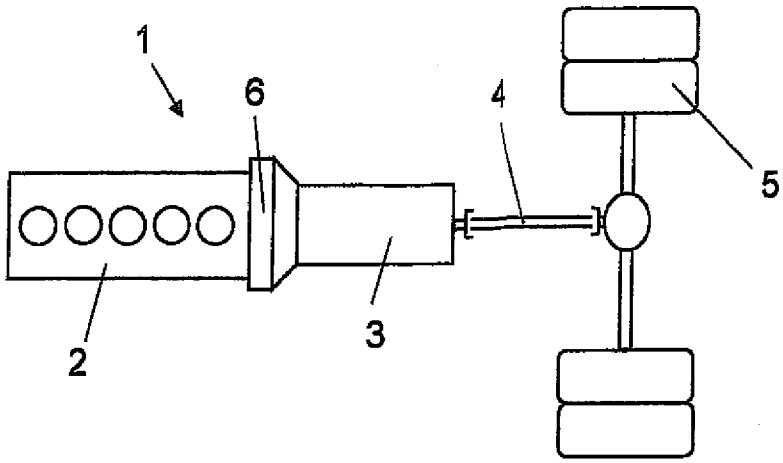
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Fig 1

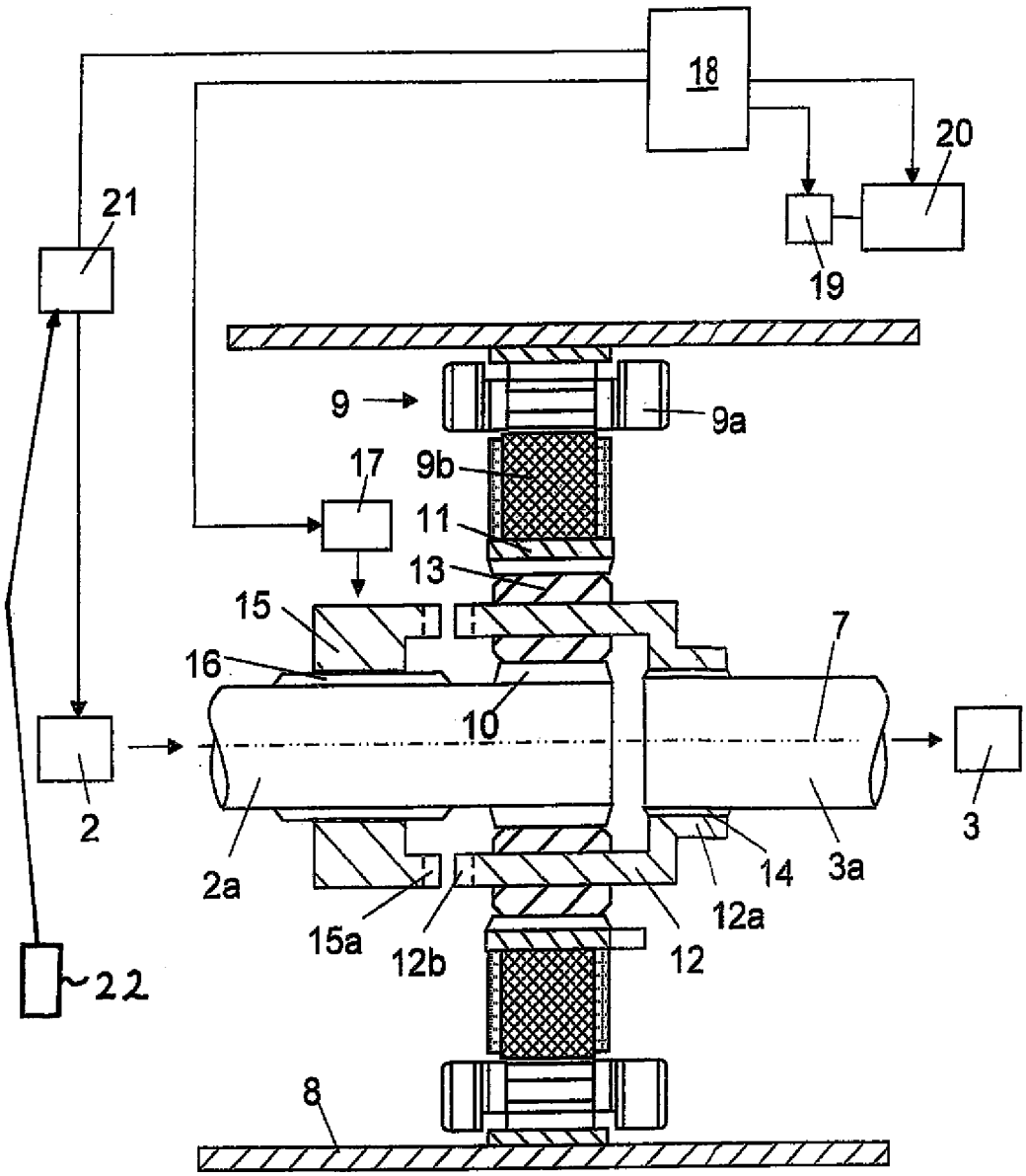
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Fig 2

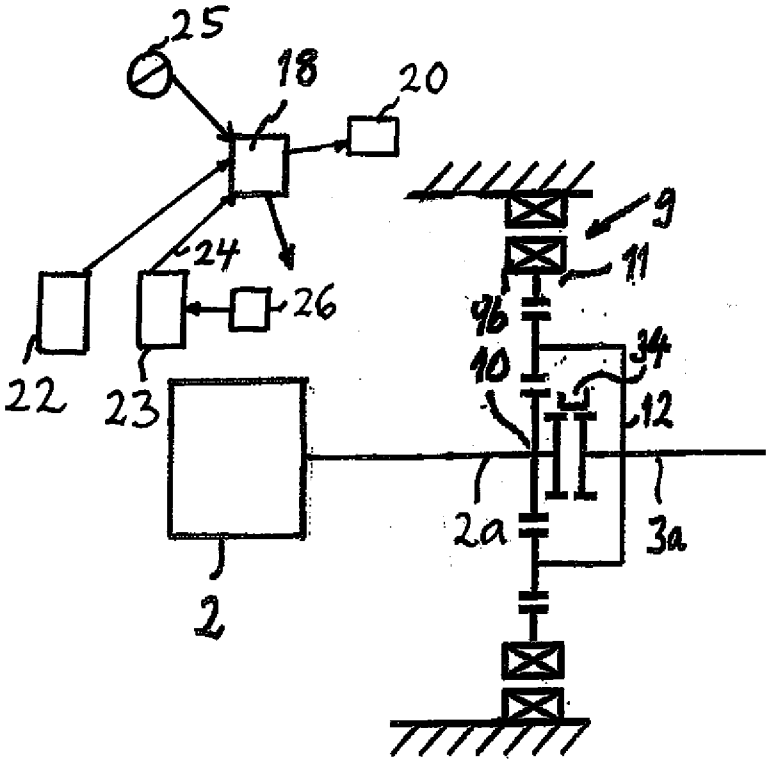

Fig 3

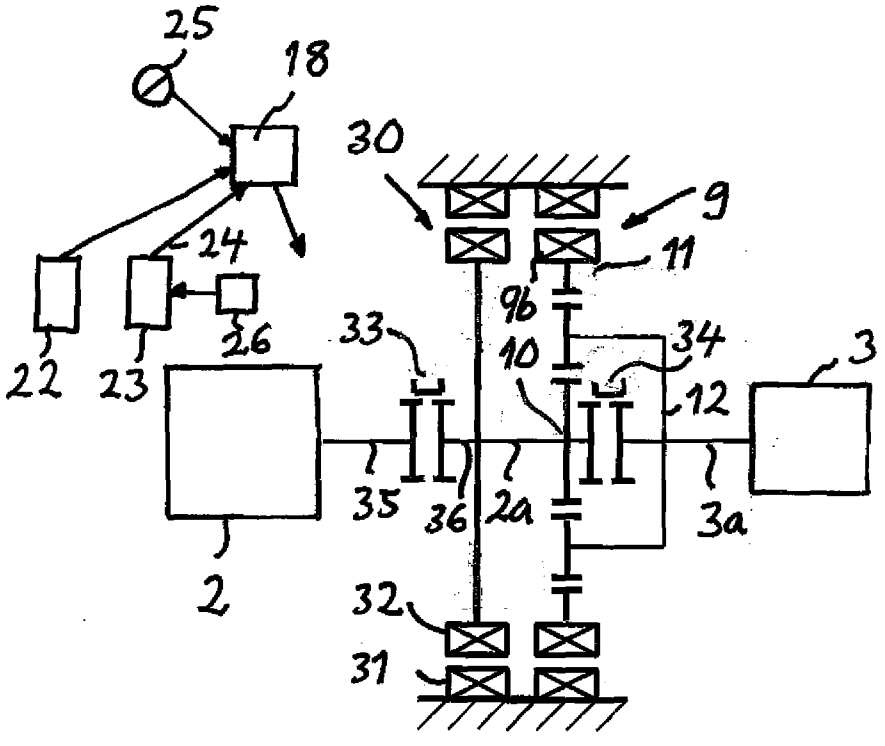

Fig 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2016/050538

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: B60K, B60W, B66F, E02F, F02D, G05G

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 8800698 B1 (MEHR NASSER FRED ET AL), 12 August 2014 (2014-08-12); figures 1-4; column 2, line 36 - column 3, line 18 --	1-13
A	US 20130316865 A1 (ENGSTROEM JOERGEN ET AL), 28 November 2013 (2013-11-28); figure 1; paragraphs [0021]-[0032] -- --------	1-13

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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