Title: METHOD FOR STARTING A COMBUSTION ENGINE IN A HYBRID VEHICLE

Abstract: A method for starting a combustion engine (2) in a propulsion system (1) of a hybrid vehicle, the propulsion system comprising a planetary gear having three components in the form of a sun gear (10), a ring gear (11) and a planet wheel carrier (12), the output shaft (2a) of the combustion engine being connected to a first of said components of the planetary gear, an input shaft (3a) of a gearbox (3) being connected to a second of said components of the planetary gear and a rotor (9b) of an electric machine (9) being connected to a third of said components of the gearbox. According to the method, the vehicle is set in an initial position with a suitable gear engaged in the gearbox and with a brake acting on the input shaft of the gearbox, where after the electric machine is controlled so that the ring gear is brought into rotation with a negative rotation speed (n3) and the output shaft (2a) of the combustion engine is thereby, via the sun gear of the planetary gear, brought to rotate with a positive rotation speed (ni) so that the combustion engine may be started.
Published:

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

— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))
METHOD FOR STARTING A COMBUSTION ENGINE IN A HYBRID VEHICLE

FIELD OF THE INVENTION AND PRIOR ART

The present invention relates to a method for starting a combustion engine in a propulsion system of a vehicle according to the preamble of appended claim 1.

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

The inventive method relates to starting of a combustion engine in a propulsion system of a so-called hybrid vehicle, which generally is a vehicle which may be driven by a primary engine, here a combustion engine, and a secondary engine, here an electric machine. The electric machine is suitably provided with at least one hybrid energy storing means, for example a battery or a capacitor, for storing electric energy and regulating equipment for regulating the flow of electric energy between the energy storing means and the electric machine. The electric machine may thereby alternately operate as motor and generator depending on the state of operation of the vehicle. When a brake is applied to the vehicle, the electric machine generates electric energy which may be stored and/or utilised directly. The stored electric energy may later be utilized for example for driving the vehicle.

The utilization of a conventional clutch mechanism connecting the input shaft of the gearbox with the combustion engine upon
take-off of the vehicle and disconnecting it during a gear changing process in the gearbox involves disadvantages, such as heating of the discs of the clutch mechanism, which results in an increased fuel consumption and a wear of the clutch discs. This is particularly relevant upon connection of the shafts. Furthermore, a conventional clutch mechanism is relatively heavy and costly. It also occupies a relatively large space in the vehicle. Friction losses also occur upon use of a hydraulic converter/torque transformer commonly used in automatic gearboxes.

The conventional clutch mechanism as well as the hydraulic converter and said disadvantages associated therewith may be avoided by providing for that the vehicle has a propulsion system in which the output shaft of the combustion engine, the rotor of the electric machine and the input shaft of the gearbox are interconnected by a planetary gear. A vehicle having a propulsion system of this type is known through EP 1319 546. There is of course an ongoing attempt to improve the way to drive a vehicle having such a propulsion system with respect to energy efficiency and the way that the electric machine and the combustion engine interact.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a method of the sort initially defined considering the attempt mentioned above. This object is according to the invention achieved by providing a method according to the appended claim 1.
In order to start the combustion engine according to the inventive  
method, a vehicle with a propulsion system of the above-  
mentioned type is set in an initial position with a brake applied  
and a suitable gear engaged in the gearbox. The electric ma-  
chine cranks the combustion engine via the planetary gear  
whereafter the vehicle, on a given signal, may take off directly  
without additional gear changing. The vehicle may therefore be  
brought to take-off quickly after starting the combustion engine  
by easing off the engaged brake and demand a propelling torque  
using the accelerator. This method is particularly advantageous  
for short breaks when the combustion engine keeps warm during  
the break, for example in urban transport or for a bus at a bus  
stop. The combustion engine is thereby started when the vehicle  
is still standing, whereafter take-off takes place. The method is  
also suitable for starting the combustion engine when the vehicle  
is moving and is propelled solely by the electric machine, for ex-  
ample at the end of a downhill slope before a climb.

According to an embodiment of the invention, the method is car-  
rried out for a propulsion system in which said first component is  
the sun gear, said second component is the planetary gear carrier  
and said third component is the ring gear. Such a propulsion  
system is described in the still unpublished SE 1051384-4. By  
connecting the electric machine to the ring gear and the output  
shaft of the combustion engine to the sun gear, a compact con-  
struction is achieved, which is easy to fit into already existing  
spaces for propulsion systems having clutch mechanisms instead  
of planetary gears. Thereby, a hybridized gearbox may be made  
size and weight compatible with a standard gear box and stand-  
ardized interfaces may be maintained. This means that the
weight increase normally associated with hybridization may be reduced considerably. Another advantage is that a connection of the electric machine to the ring gear gives a higher possible brake torque associated with the electric machine than had it instead been connected to the sun gear.

According to an embodiment of the invention, the electric machine is in step b) controlled so that the combustion engine reaches its idle rotation speed. This results in lower noise level and the combustion engine reaches its idle rotation speed faster than by producing torque by itself for accelerating up to the idle rotation speed.

According to an embodiment of the invention, a brake is in step (a) applied to the input shaft of the gearbox by means of the service brake of the vehicle. According to another embodiment of the invention, a brake is in step (a) applied to the input shaft of the gearbox by means of the parking brake of the vehicle. Also some other braking mechanism such as a mechanic lock or a countershaft brake may be used.

According to an embodiment of the invention, the method is carried out for a propulsion system wherein the output shaft of the combustion engine is connected to said first component of the planetary gear at a fixed transmission ratio, and/or wherein the input shaft of the gearbox is connected to said second component of the planetary gear at a fixed transmission ratio.

According to an embodiment of the invention, the method is carried out for a propulsion system wherein the output shaft of the
combustion engine is connected to said first component of the planetary gear so that these rotate as a unit with the same rotation speed and/or wherein the input shaft of the gearbox is connected to said second component of the planetary gear so that these rotate as a unit with the same rotation speed.

The invention also relates to a computer program having the features listed in claim 10, a computer program product having the features listed in claim 11, an electronic control unit having the features listed in claim 12 and a vehicle having the features listed in claim 13.

Other advantageous features and advantages of the invention will appear from the description following below.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will in the following be further described by means of example with reference to the appended drawings, wherein

Fig 1 is a schematic drawing of a propulsion system of a vehicle for which a method according to the invention may be carried out,

Fig 2 is a simplified view of a part of a propulsion system,

Fig 3 shows how the torque of the different components in the propulsion system can vary over time when carrying out the method,
Fig 4 shows how the rotation speed of the components in fig. 3 may vary over time when carrying out the method.

Fig 5 is a schematic drawing of a control unit for implementing a method according to the invention, and

Fig 6 is a flow chart illustrating a method according to the invention.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Fig. 1 shows a propulsion system 1 for a heavy vehicle. The propulsion system comprises a combustion engine 2, a gearbox 3, a number of drive shafts 4 and drive wheels 5. Between the combustion engine 2 and the gearbox 3 the propulsion system 1 comprises an intermediate portion 6.

Fig. 2 shows a more detailed view of the components in the intermediate portion 6. The combustion engine 2 is provided with an output shaft 2a and the gear box 3 with an input shaft 3a in the intermediate portion 6. The output shaft 2a of the combustion engine is coaxially arranged with respect to the input shaft 3a of the gear box. The output shaft 2a of the combustion engine and the input shaft 3a of the gear box are arranged to rotate around a common rotation axis 7. The intermediate portion 6 comprises a housing 8 enclosing an electric machine 9 and a planetary gear. The electric machine 9 comprises as usual a stator 9a and a rotor 9b. The stator 9a comprises a stator core secured in a suita-
ble way on the inside of the housing 8. The stator core comprises the windings of the stator. The electric machine 9 is adapted to, in certain operation situations, utilize stored electric energy for supplying propelling force to the input shaft 3a of the gearbox and, in other operation situations, utilize kinetic energy of the input shaft 3a of the gearbox to extract and store electric energy.

The planetary gear is arranged essentially radially internally of the stator 9a and rotor 9b of the electric machine. The planetary gear comprises as usual a sun gear 10, a ring gear 11 and a planet wheel carrier 12. The planet wheel carrier 12 carries a number of gear wheels 13 being rotatably arranged in a radial space between the teeth of the sun gear 10 and the ring gear 11. The sun gear 10 is secured to a circumferential surface of the output shaft 2a of the combustion engine. The sun gear 10 and the output shaft 2a of the combustion engine are here arranged to rotate as a unit with a first rotation speed \( n_1 \). The planet wheel carrier 12 comprises a fastening portion 12a being fastened to a circumferential surface of the input shaft 3a of the gearbox by means of a splined connection 14. By means of this connection, the planet wheel carrier and the input shaft 3a of the gearbox may rotate as a unit with a second rotation speed \( n_2 \). The ring gear 11 comprises an external circumferential surface onto which the rotor 9b is secured. The rotor 9b and the ring gear 11 form a rotatable unit arranged to rotate with a third rotation speed \( n_3 \).

The propulsion system 1 comprises in this embodiment also locking means for interlocking two of the components of the planetary gear. The locking means are here arranged on the output shaft 2a of the combustion engine and on the planet wheel carrier 12
by means of a displaceable coupling member 15 provided on the output shaft 2a of the combustion engine, which coupling member 15 via a coupling portion 15a is connectable to a coupling portion 12b of the planet wheel carrier 12. The coupling member 15 is fastened to the output shaft 2a of the combustion engine by means of a splined connection 16. The coupling member 15 is in this case fixed against rotation to the output shaft 2a of the combustion engine and displaceable in an axial direction on the output shaft 2a of the combustion engine. A schematically illustrated displacing member 17 is adapted to displace the coupling member 15 between a first position in which the coupling portions 15a, 12b are not mutually engaged, corresponding to a releasing position of the locking means, and a second position in which the coupling portions 15a, 12b are mutually engaged, corresponding to a locking position of the locking means. When the coupling portions 15a, 12b are mutually engaged, the output shaft 2a of the combustion engine and the input shaft 3a of the gearbox will be interlocked. These two axes 2a, 3a and the rotor 9b of the electric machine will thereby rotate with the same rotation speed.

In the illustrated embodiment, an electric control unit 18 is adapted to control the displacing member 17. The control unit 18 is also adapted to determine the occasions on which the electric machine 9 shall operate as a motor and on which occasions it shall operate as a generator. In order to make this decision, the control unit 18 may receive current information about suitable operating parameters. The control unit 18 may be a computer with suitable software for this task. The control unit 18 also controls a schematically shown regulating equipment 19 regulating the flow of electric energy between an energy storing means 20,
such as a hybrid battery, and the stator 9a of the electric machine. On occasions upon which the electric machine operates as a motor, stored electric energy is supplied from the energy storing means 20 to the stator 9a and/or to other consumers. On occasions upon which the electric machine operates as a generator, electric energy is supplied from the stator 9a to the energy storing means 20. The energy storing means 20 delivers and stores electric energy with a voltage in order of 200-800 Volt. Since the intermediate portion 6 between the combustion engine 2 and the gearbox 3 in a vehicle is restricted, it is required that the electric machine 9 and the planetary gear constitute a compact unit. The components 10-12 of the planetary gear are here 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 gear, the output shaft 2a of the combustion engine and the input shaft 3a of the gearbox are here arranged to rotate around a common axes of rotation 5. Through such a design, the electric machine 9 and the planetary gear occupies a comparatively small space. The vehicle is provided with a motor control function 21 through which the rotation speed \( n_1 \) of the combustion engine may be regulated. The control unit 18 thereby has a possibility to activate the motor control function 21 upon engagement and disengagement of gears in the gearbox 3 in order to create a state of zero torque in the gearbox 3. The propulsion system may of course, instead of being controlled by one single control unit 18, be controlled by several different control units.

Fig. 3 and 4 show how the torques \( T_1, T_2 \) and \( T_3 \) and the rotation speeds \( n_1, n_2 \) and \( n_3 \) for the output shaft 2a of the combustion
engine (dashed line), the input shaft 3a of the gearbox (dotted line) and the rotor 9b of the electric machine (solid line), respectively, may vary over time while carrying out an embodiment of the method according to the invention. By definition, the combustion engine 2, which only rotates one way, rotates with a positive rotation speed. Components rotating in the same direction as the combustion engine thereby by definition rotate with a positive rotation speed and components rotating in an opposite direction by definition rotate with a negative rotation speed. In this embodiment of the inventive method, a propulsion system 1 in which the rotor 9b of the electric machine is arranged to rotate as a unit with the ring gear 11, the output shaft 2a of the combustion engine is arranged to rotate as a unit with the sun gear 10 and the input shaft 3a of the gearbox is arranged to rotate as a unit with the planet wheel carrier 12 is used. Fig. 6 shows a flow chart illustrating the method.

Upon starting the combustion engine 2 according to the present invention, the vehicle is first put in a suitable initial position 610, which may be either a standing position, which is the case in the course shown in Fig. 3 and 4, or a position in which a brake is applied to the vehicle. In the initial position, a brake is applied to the input shaft 3a of the gearbox and slows down the rotation thereof, while simultaneously a suitable gear is engaged in the gearbox 3. The locking means are in the releasing position. Which gear is appropriate to engage depends on many factors, such as the weight of the vehicle, the slope of the ground, the velocity of the vehicle, the type of gearbox, the driving direction, etc. In a standing initial position a gear suitable for take-off should be engaged. If the combustion engine is to be started
while driving forward, a suitable initial position is obtained by braking through a brake mechanism (not shown) acting on the input shaft 3a of the gearbox. In this embodiment, applying a brake to the input shaft 3a of the gearbox directly results in a braking of the planet wheel carrier 12 connected to the shaft 3a.

When the combustion engine 2 in step 611 is to be started at the time $t_0$, the electric machine 9 receives a signal from the control unit 18. The electric machine 9 in a step 612 applies a negative torque $\tau_3$ acting on the ring gear 11, so that the ring gear via the rotor 9b is brought into rotation with a negative rotation speed $n_3$. The electric machine 9 now functions as a motor which can crank the combustion engine 2, since the rotation of the ring gear 11 in combination with the braking of the planet wheel carrier 12 via the input shaft 3a of the gearbox gives a reaction torque $T_i$ acting on the sun gear 10. This reaction torque is in a step 613 transmitted via the sun gear 10 to the combustion engine 2. The output shaft 2a of the combustion engine thereby starts to rotate with an accelerating positive rotation speed $n_1$.

The electric machine 9 suitably accelerates the combustion engine 2 until the latter at the time $t_i$ in a step 614 has reached its idle rotation speed. The ring gear 11 continues to rotate with a rotation speed $n_3$, but the torque $\tau_3$ is now zero. The combustion engine 2 is kept going by the idle speed control system until the driver at the time $t=t_i$ in a step 615 presses the accelerator. The brake acting on the input shaft 3a of the gearbox is then eased off in a step 616.

The electric machine 9 is now controlled towards a positive torque $\tau_3$, which is determined by the position of the accelerator.
At the same time, the rotation speed of the combustion engine 2 is controlled such that the rotation speed is kept essentially constant. The electric machine 9 now functions as a generator and electric energy from the stator 9a is transferred to the energy storing means 20. Since the positive torque $\tau_3$ of the electric machine 9 acts to reduce the rotation speed $n_i$ of the combustion engine 2, the result thereof is that the motor control function 21, in order to keep the rotation speed of the combustion engine, controls the combustion engine so that it applies a positive torque $\tau_1$ acting on the sun gear 10. The result is that a resulting positive torque $\tau_2$ acts on the input shaft 3a of the gearbox. Since the brake is no longer acting on the planet wheel carrier 12, the input shaft 3a of the gearbox is accelerated and the vehicle takes off, simultaneously as the rotation speed $n_3$ of the electric machine is reduced towards zero. The inventive method has thereby come to an end and the combustion engine and the electric machine are hereafter controlled depending on the desired driving mode.

The torque of the electric machine is preferably controlled so that the electric machine cranks the combustion engine to its idle rotation speed during the starting procedure, but it is also possible to interrupt the control somewhat earlier and let the combustion engine accelerate by itself up to the idle rotation speed.

The brake which is applied to the input shaft of the gearbox during the starting procedure is preferably the service brake of the vehicle, but it may also be the parking brake or another braking mechanism which acts directly or indirectly on the input shaft of the gearbox or on the planet wheel carrier connected to this
shaft. In this context, the braking mechanism acting indirectly on the input shaft of the gearbox means that the braking mechanism acts directly on a component connected to the input shaft of the gearbox, for example on the drive wheels of the vehicle. The parking brake and the service brake both act indirectly on the input shaft of the gearbox.

Computer program code for implementing a method according to the invention is suitably included in a computer program which is readable into an internal memory of a computer, such as the internal memory of an electronic control unit of a motor vehicle. Such a computer program is suitably provided through a computer program product comprising a data storing medium readable by an electronic control unit, which data storing medium has the computer program stored thereon. Said data storing medium is for example an optical data storing medium in the form of a CD-ROM-disc, a DVD-disc, etc., a magnetic data storing medium in the form of a hard disc, a diskette, a tape etc., or a Flash memory or a memory of the type ROM, PROM, EPROM or EEPROM.

Fig 5 illustrates very schematically an electronic control unit 40 comprising an execution means 41, such as a central processor unit (CPU), for executing a computer program. The execution means 41 communicates with a memory 42, for example of the type RAM, through a data bus 43. The control unit 40 comprises also a data storing medium 44, for example in the form of a Flash memory or a memory of the type ROM, PROM, EPROM or EEPROM. The execution means 41 communicates with the data storing medium 44 through the data bus 43. A computer program
comprising computer program code for implementing a method according to the invention is stored on the data storing medium 44.

The invention is of course not in any way restricted to the embodiments described above, but many possibilities to modifications thereof would be apparent to a person with skill in the art without departing from the scope of the invention as defined in the appended claims.
Claims

1. A method for starting a combustion engine (2) in a propulsion system (1) of a vehicle, the propulsion system comprising a combustion engine (2) with an output shaft (2a), an electric machine (9) comprising a stator (9a) and a rotor (9b), a gearbox (3) with an input shaft (3a), and a planetary gear comprising three components in the form of a sun gear (10), a ring gear (11) and a planet wheel carrier (12), the output shaft (2a) of the combustion engine being connected to a first of said components (10) of the planetary gear so that a rotation of the output shaft (2a) of the combustion engine results in a rotation of said first component (10), the input shaft (3a) of the gearbox being connected to a second of said components (12) of the planetary gear so that a rotation of the input shaft (3a) of the gearbox results in a rotation of said second component (12) and the rotor (9b) of the electric machine being connected to a third of said components (11) of the planetary gear, so that a rotation of the rotor (9b) results in a rotation of said third component (11), characterised in that the method comprises the following steps:

   a) setting the vehicle in an initial position with a suitable gear engaged in the gearbox (3) and with a brake acting indirectly on the input shaft (3a) of the gearbox,

   b) controlling the electric machine (9a) so that said third component (11) is brought into rotation with negative rotation speed (n3) and the output shaft (2a) of the combustion engine is thereby, via the said first component (10) of the planetary gear, brought to rotate with a positive rotation
speed (n-i), so that the combustion engine (2) may be started.

2. The method according to claim 1, characterised in that it is carried out for a propulsion system (1) wherein the output shaft (2a) of the combustion engine is connected to the sun gear (10), the input shaft (3a) of the gearbox is connected to the planet wheel carrier (12) and the rotor (9b) of the electric machine is connected to the ring gear (11).

3. The method according to claim 1 or 2, characterised in that the electric machine (9) in step b) is controlled so that the combustion engine (2) reaches its idle rotation speed.

4. The method according to any of the preceding claims, characterised in that a brake is indirectly applied to the input shaft (3a) of the gearbox by means of the service brake of the vehicle.

5. The method according to any of claims 1-3, characterised in that a brake is indirectly applied to the input shaft (3a) of the gearbox by means of the parking brake of the vehicle.

6. The method according to any of the preceding claims, characterised in that it is carried out for a propulsion system wherein in the output shaft (2a) of the combustion engine is connected to said first component (10) of the planetary gear at a fixed transmission ratio.
7. The method according to any of claims 1-5, characterised in that it is carried out for a propulsion system wherein the output shaft (2a) of the combustion engine is connected to said first component (10) of the planetary gear such that these rotate as a unit with the same rotation speed.

8. The method according to any of the preceding claims, characterised in that it is carried out for a propulsion system wherein the input shaft (3a) of the gearbox is connected to said second component (12) of the planetary gear at a fixed transmission ratio.

9. The method according to any of claims 1-7, characterised in that it is carried out for a propulsion system wherein the input shaft (3a) of the gearbox is connected to said second component (12) of the planetary gear such that these rotate as a unit with the same rotation speed.

10. A computer program comprising computer program code for bringing a computer to implement a method according to any of claims 1-9 when the computer program code is executed in the computer.

11. A computer program product comprising a data storing medium readable by a computer, in which the computer program code of a computer program according to claim 10 is stored on the data storing medium.

12. An electronic control unit (40) comprising an execution means (41), a memory (42) connected to the execution means and a
18

data storing medium (44) connected to the execution means, the computer program code of a computer program according to claim 10 being stored on said data storing medium (44).

13. A vehicle comprising an electronic control unit according to claim 12.
Initial position with a gear engaged and a brake applied to the input shaft of the gearbox

Signal to start the combustion engine

Controlling the electric machine in order to bring the ring gear into rotation with a negative rotational speed

The combustion engine is brought into rotation by the reaction torque

The combustion engine is idle

Pressing the accelerator

The vehicle takes off when easing off the brake

Fig 6
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, F02N

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 database consulted during the international search (name of database and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>EP 13 19546 A1 (SIEMENS AG), 18 June 2003 (2003-06-1 8); paragraphs [0007], [001 0], [001 1]; figures 1, 2</td>
<td>1-13</td>
</tr>
<tr>
<td>Y</td>
<td>US 5433282 A (MOROTO SHUZO ET AL), 18 July 1995 (1995-07-1 8); column 6, line 12 - line 27; figure 8</td>
<td>1-13</td>
</tr>
<tr>
<td>Y</td>
<td>DE 102007042949 A1 (HIENZ GEORG), 2 April 2009 (2009-04-02); figure 1; claim 7</td>
<td>1-13</td>
</tr>
<tr>
<td>Y</td>
<td>US 6805648 B1 (EHRLINGER FRIEDRICH J), 19 October 2004 (2004-1-0-1 9); column 1, line 22 - line 47; figures; claim 1</td>
<td>1-13</td>
</tr>
</tbody>
</table>

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

* Special categories of cited documents:
  "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
18-1-0-201 3

Date of mailing of the international search report
21-10-201 3

Name and mailing address of the ISA/SE
Patent- och registreringssverket
Box 5055
S-1 02 42, STOCKHOLM
Facsimile No. +46 8 666 02 86

Authorized officer
Tomas Lund
Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 2009)
<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>DE 102007004464 A1 (ZAHNRADFABRIK FRIEDRICHSHAFEN), 31 July 2008 (2008-07-31); paragraph [0012]; figures 1.5 --</td>
<td>1-13</td>
</tr>
<tr>
<td>Y</td>
<td>DE 19903936 A1 (BOSCH GMBH ROBERT), 4 May 2000 (2000-05-04); column 2, line 61 - column 3, line 24; figure 1 --</td>
<td>1-13</td>
</tr>
</tbody>
</table>

Form PCT/ISA/210 (continuation of second sheet) (July 2009)
Continuation of: second sheet

International Patent Classification (IPC)

*B60*W 70/06 (2006.01)
*B60K* 6/365 (2007.10)
*B60W* 10/08 (2006.01)
*B60W* 10/11 (2012.01)
*B60W* 10/18 (2012.01)
*B60W* 20/00 (2006.01)
*B60W* 30/18 (2012.01)
*F02N* 11/00 (2006.01)
*B60K* 6/48 (2007.10)
<table>
<thead>
<tr>
<th>Country</th>
<th>Application Number</th>
<th>Date</th>
<th>Type</th>
<th>Patent Number</th>
<th>Date</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>JP</td>
<td>5319110 A</td>
<td>03/11/1993</td>
<td>NONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>JP</td>
<td>2857535 B2</td>
<td>17/02/1999</td>
<td>NONE</td>
</tr>
<tr>
<td>DE</td>
<td>102007042949 A1</td>
<td>02/04/2009</td>
<td>NONE</td>
<td></td>
<td></td>
<td>NONE</td>
</tr>
<tr>
<td>US</td>
<td>6805648 B1</td>
<td>19/01/2004</td>
<td>DE</td>
<td>19934696 A1</td>
<td>17/05/2001</td>
<td>NONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DE</td>
<td>50015024 D1</td>
<td>17/04/2008</td>
<td>NONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>EP</td>
<td>1196302 A1</td>
<td>17/04/2002</td>
<td>NONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>JP</td>
<td>2003505289 A1</td>
<td>12/02/2003</td>
<td>NONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>WO</td>
<td>0107278 A1</td>
<td>01/02/2001</td>
<td>NONE</td>
</tr>
<tr>
<td>DE</td>
<td>102007004464 A1</td>
<td>31/07/2008</td>
<td>NONE</td>
<td></td>
<td></td>
<td>NONE</td>
</tr>
<tr>
<td>DE</td>
<td>19903936 A1</td>
<td>04/05/2000</td>
<td>NONE</td>
<td></td>
<td></td>
<td>NONE</td>
</tr>
</tbody>
</table>