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(58) Field of Search:
INT CL **B60W, F16H**
Other: **Online WPI and EPODOC**

(54) Title of the Invention: **A method and system for improving gear change quality**
Abstract Title: **A method and system for improving gear change quality**

(57) A method and system for improving shift quality for a manual transmission 3 of a motor vehicle 1. During a gear shift, information from a predictive gear sensing system predicting the next to be engaged gear before it is actually selected along with the speed of the vehicle 1 are used to determine the required speed of an engine 2 at the end of the gear shift and the engine speed is adjusted towards this synchronisation speed for the predicted gear. The quality of the gear shift is improved because more time is available to adjust the engine speed than is the case when the engine speed adjusting is delayed until a gear is actually engaged. Optionally the system determines upon engaging the gear if the gear engaged is the same as the predicted next to be engaged gear and may update a desired engine speed based on the current vehicle speed.

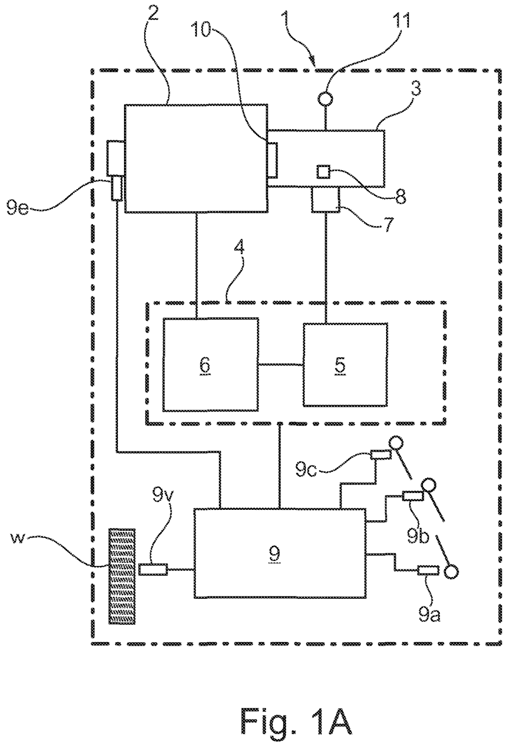


Fig. 1A

GB 2491885 A

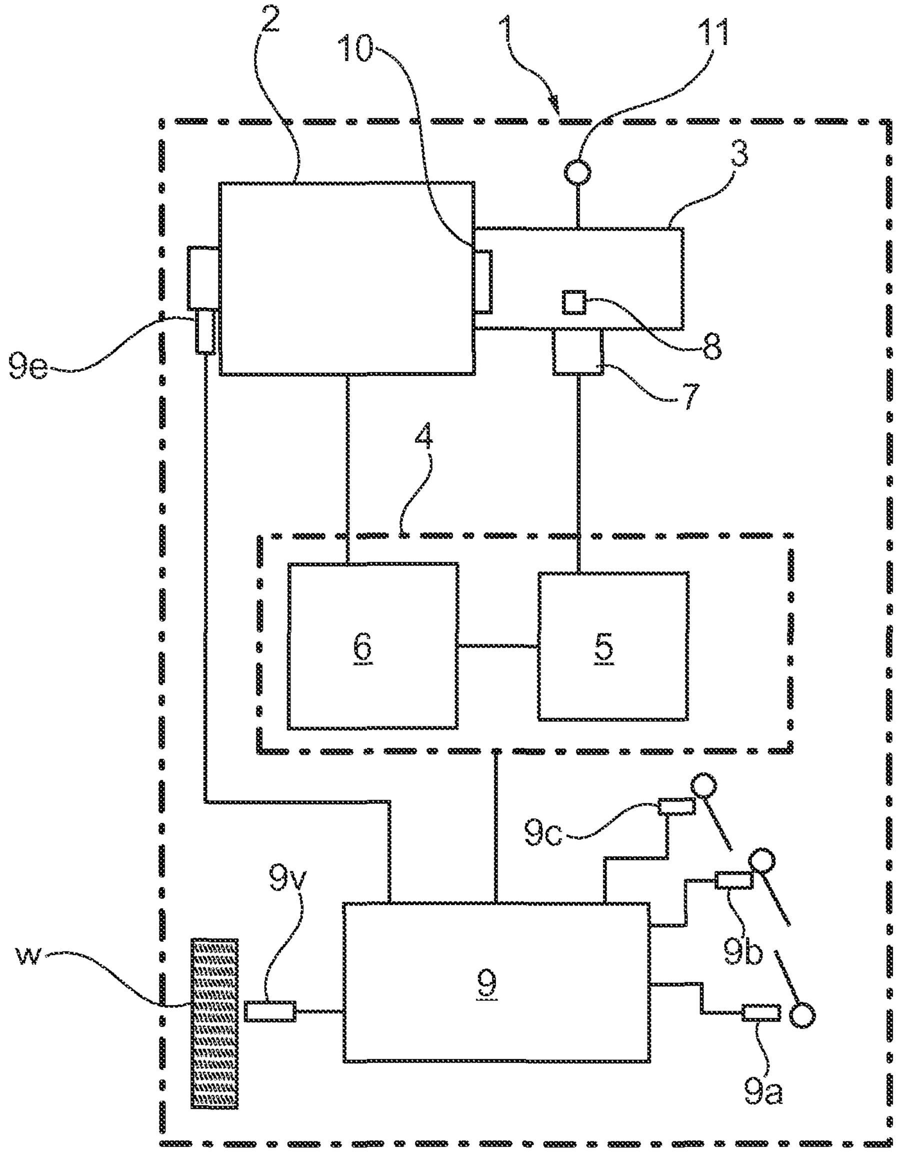


Fig. 1A

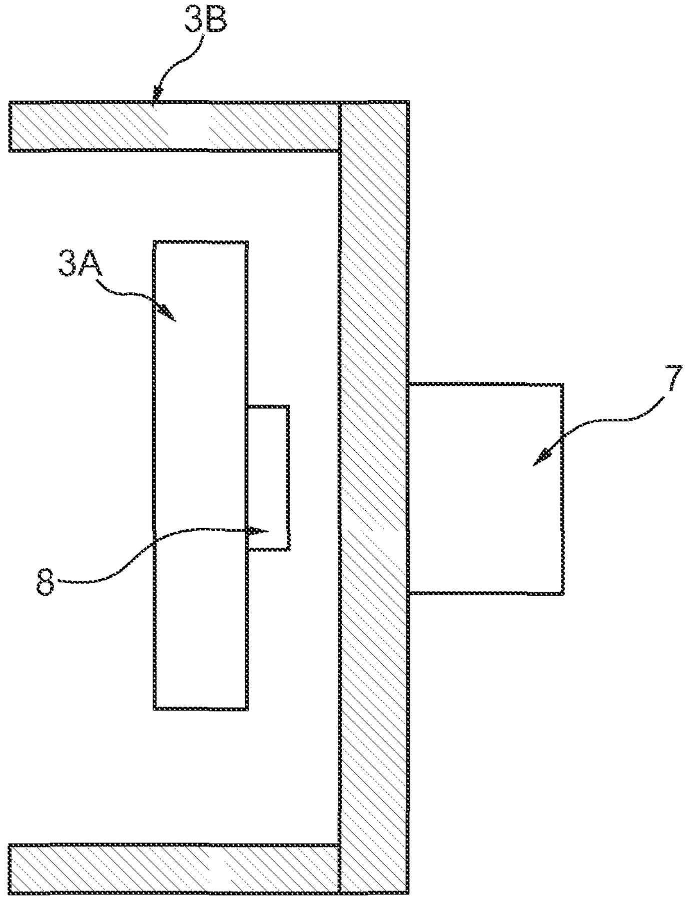


Fig. 2A

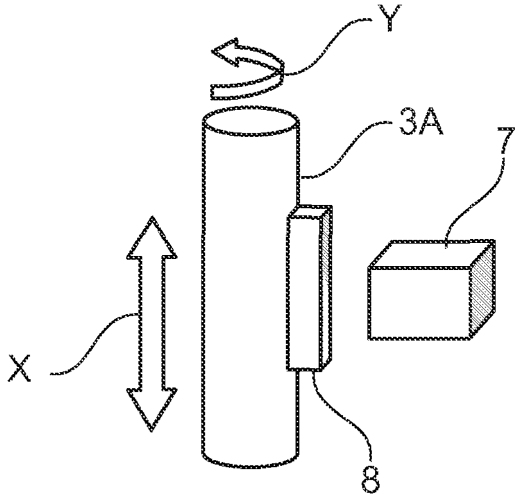


Fig. 2B

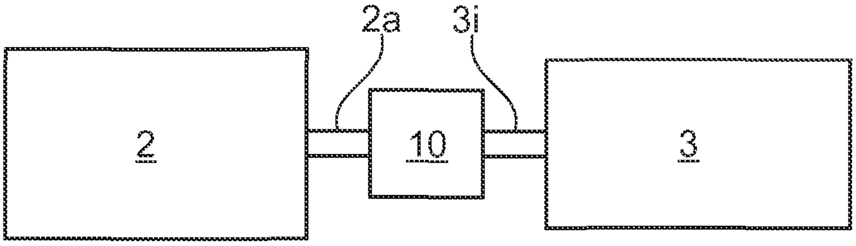


Fig. 1B

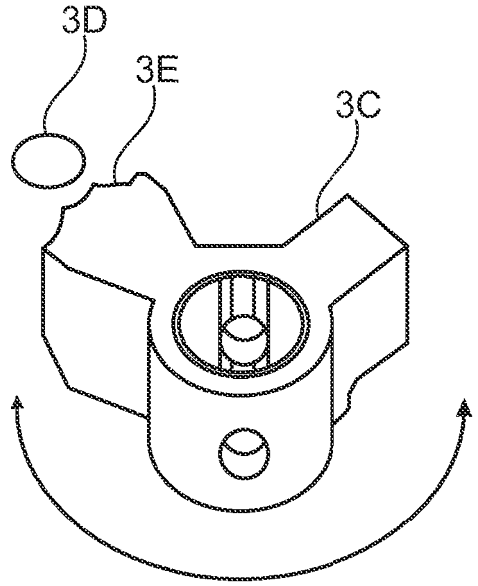


Fig. 3A

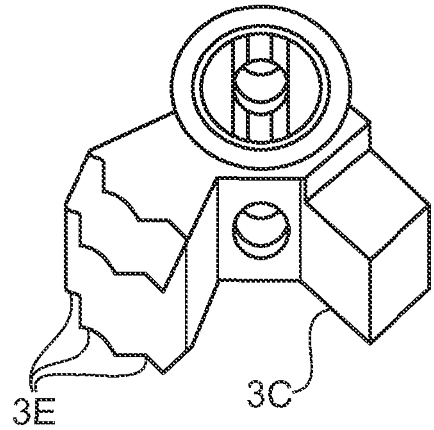


Fig. 3B

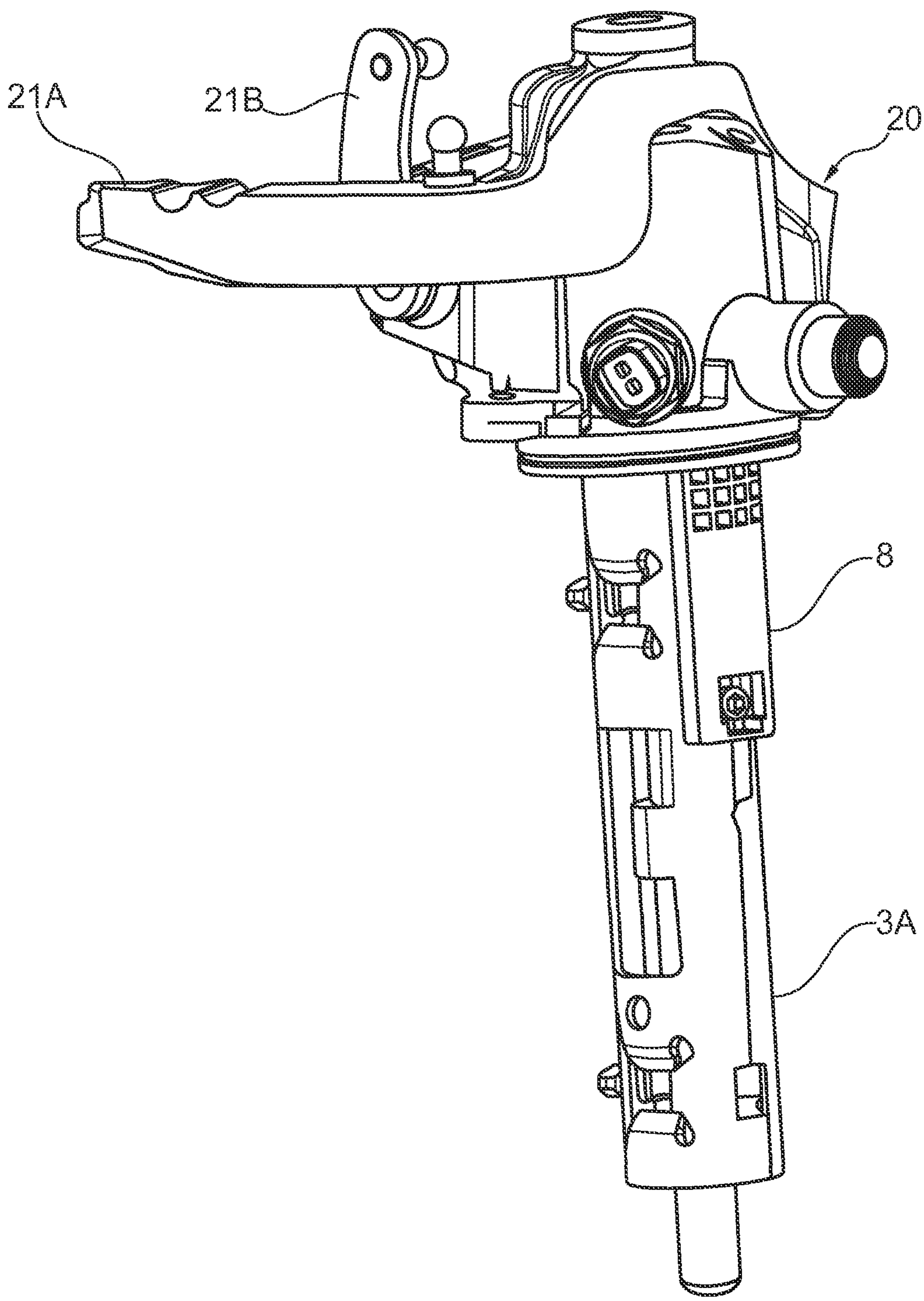


Fig. 4

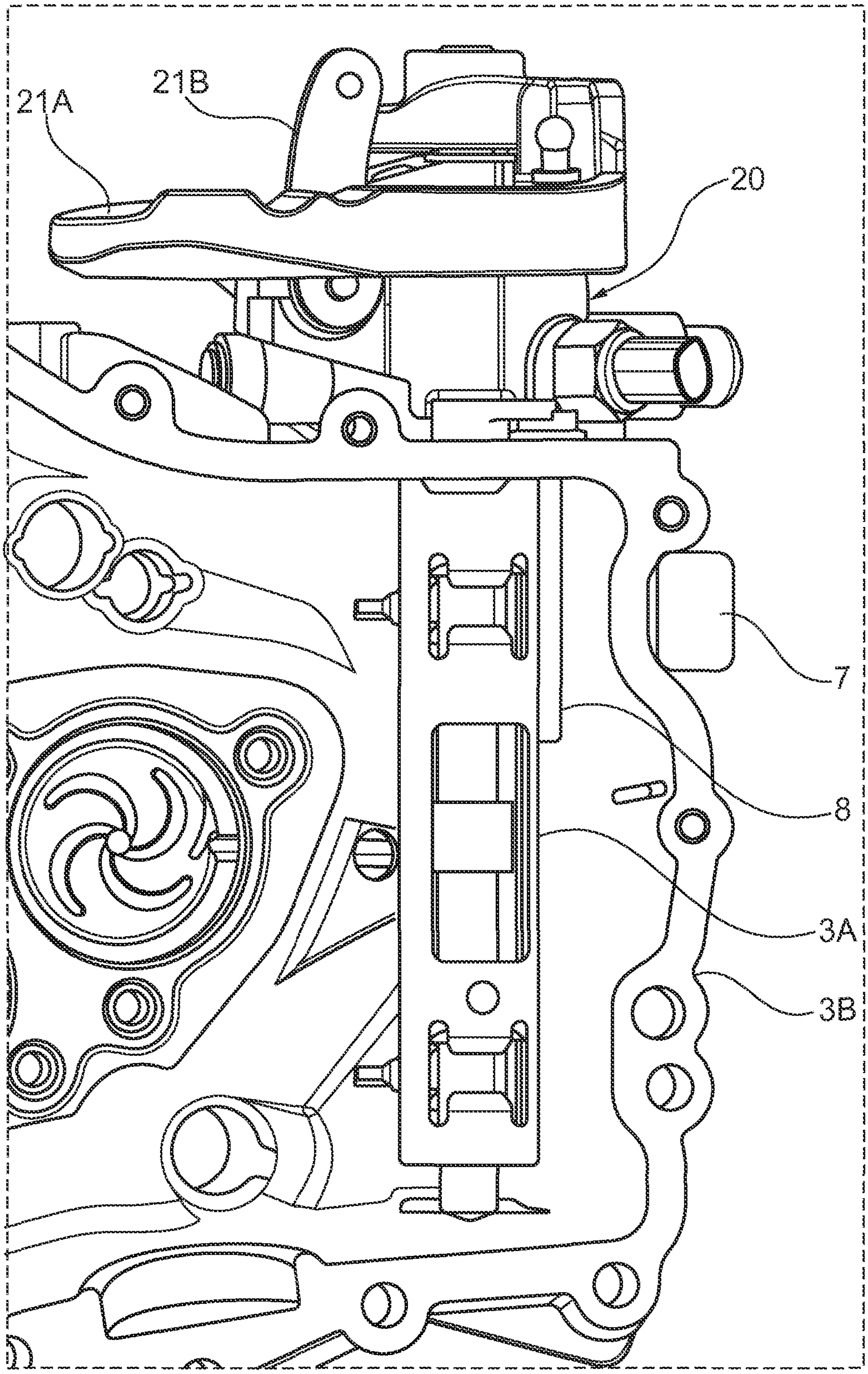


Fig. 5

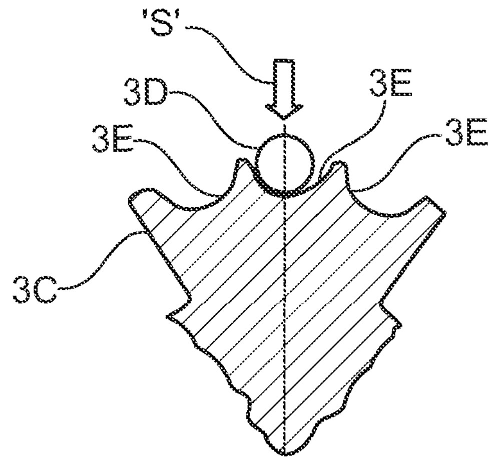


Fig. 6A

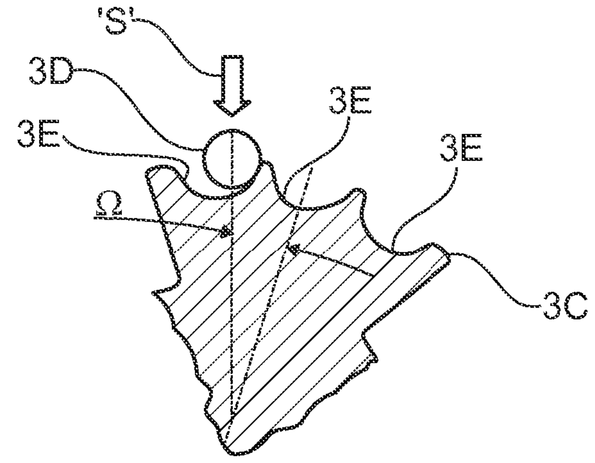


Fig. 6B

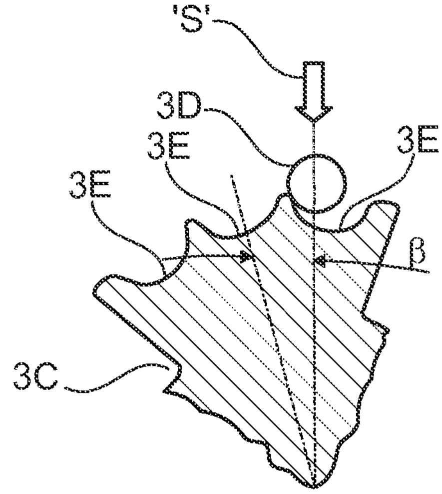
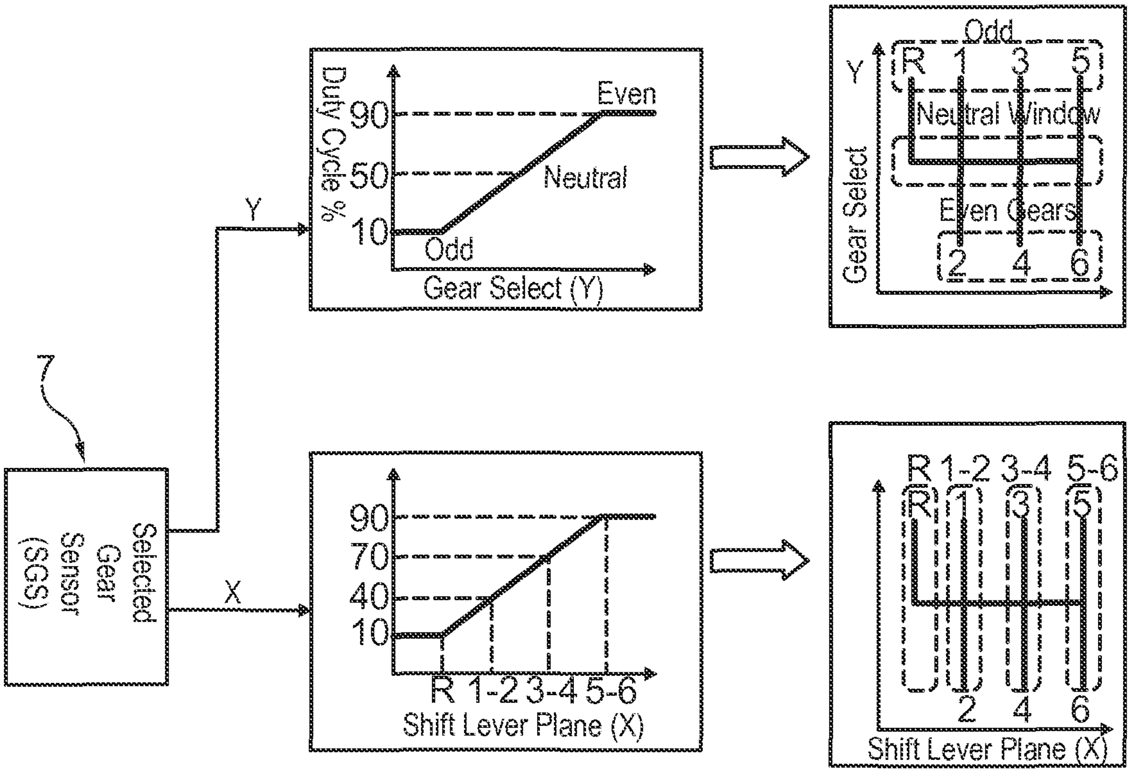
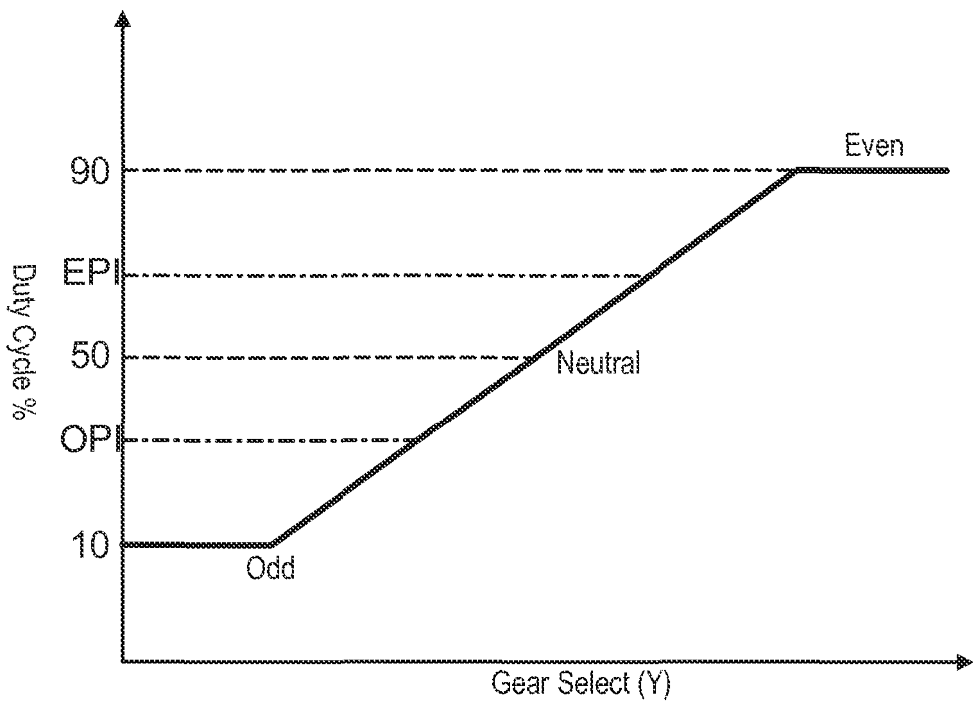


Fig. 6C



7
Selected Gear Sensor (SGS)
Y
X
Duty Cycle %
90
50
10
Even
Neutral
Odd
Gear Select (Y)
Odd
R 1 3 5
Y
Neutral Window
Gear Select
Even Gears
2 4 6
90
70
40
10
R 1-2 3-4 5-6
Shift Lever Plane (X)
R 1-2 3-4 5-6
R 1 3 5
2 4 6
Shift Lever Plane (X)

Fig. 7A



Duty Cycle %
90
EPI
50
OPI
10
Even
Neutral
Odd
Gear Select (Y)

Fig. 7B

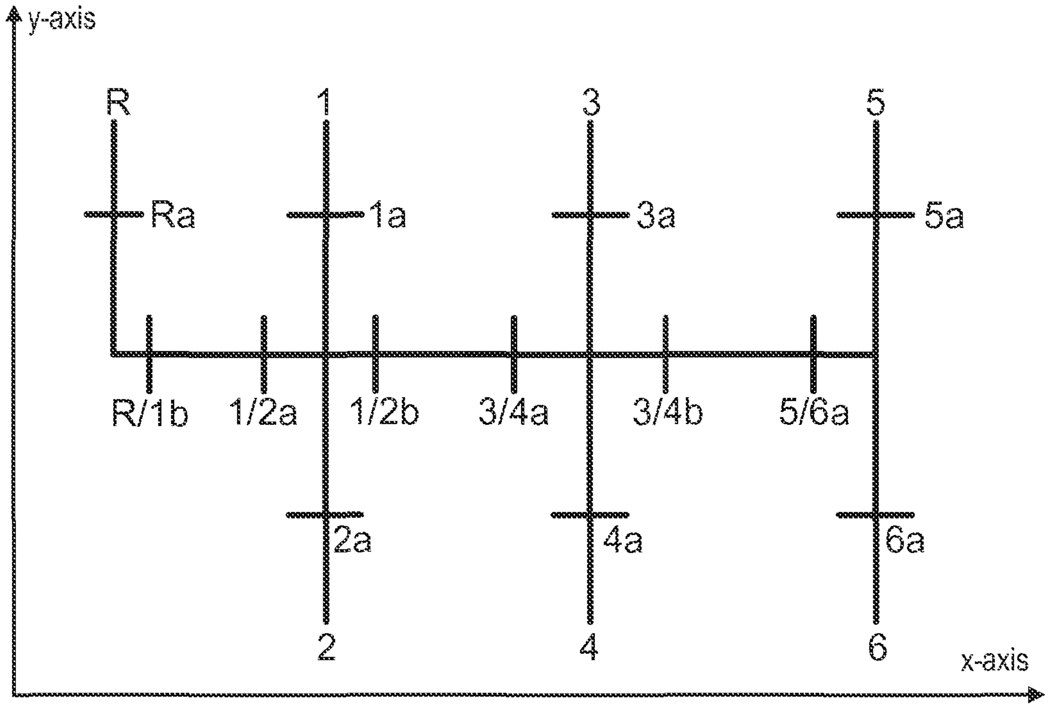

y-axis
R
1
3
5
Ra
1a
3a
5a
R/1b
1/2a
1/2b
3/4a
3/4b
5/6a
2a
4a
6a
2
4
6
x-axis

Fig. 8A

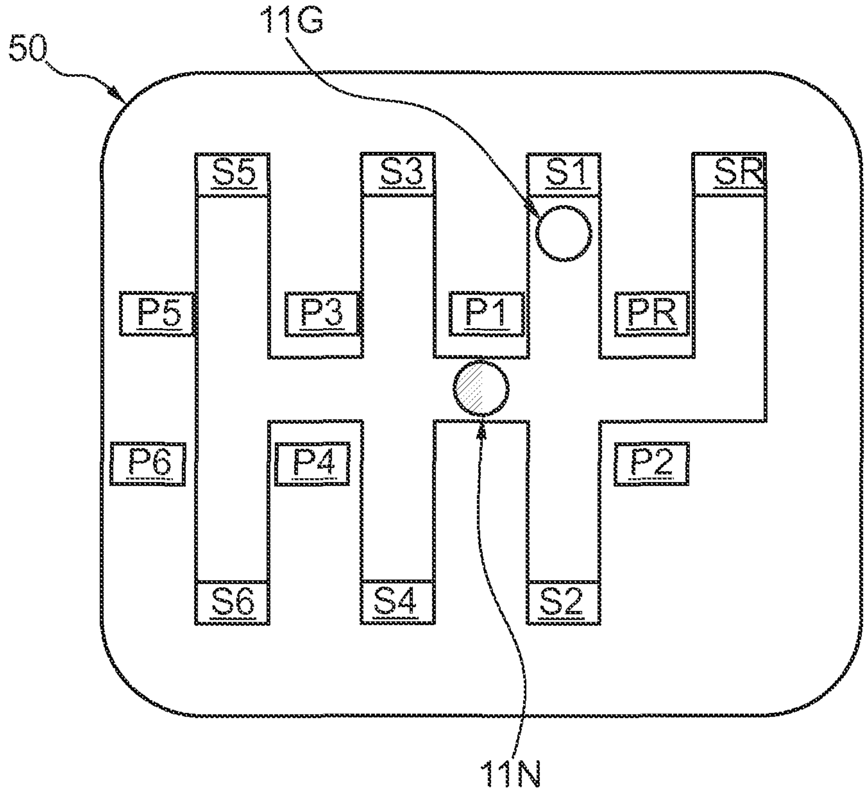

50
11G
S5
S3
S1
SR
P5
P3
P1
PR
P6
P4
P2
S6
S4
S2
11N

Fig. 8D

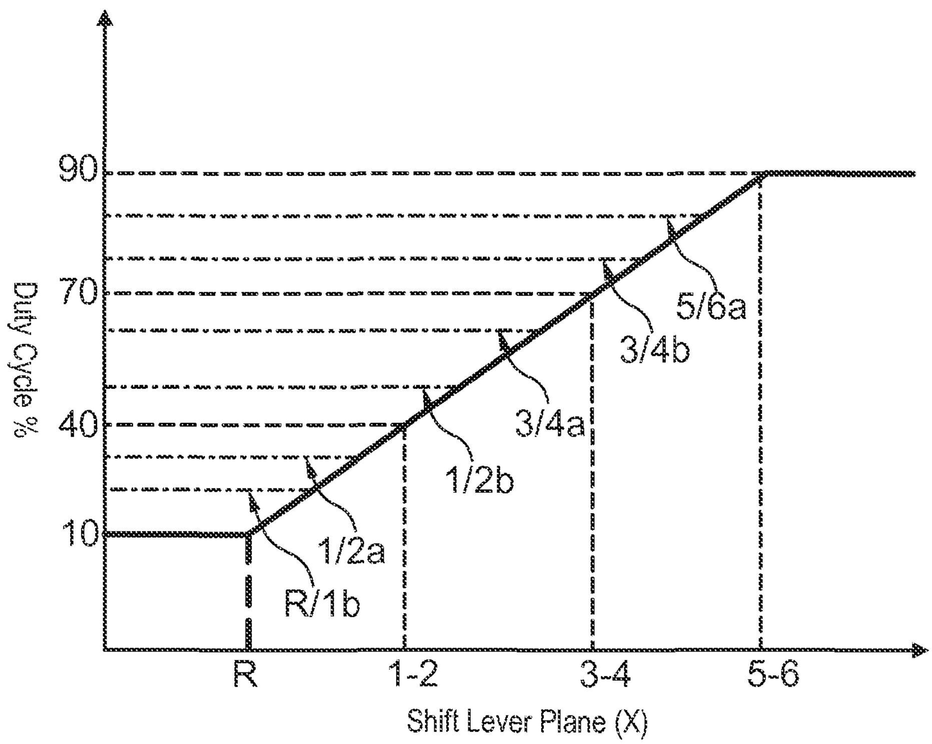

90
70
40
10
Duty Cycle %
5/6a
3/4b
3/4a
1/2b
1/2a
R/1b
R
1-2
3-4
5-6
Shift Lever Plane (X)

Fig. 8B

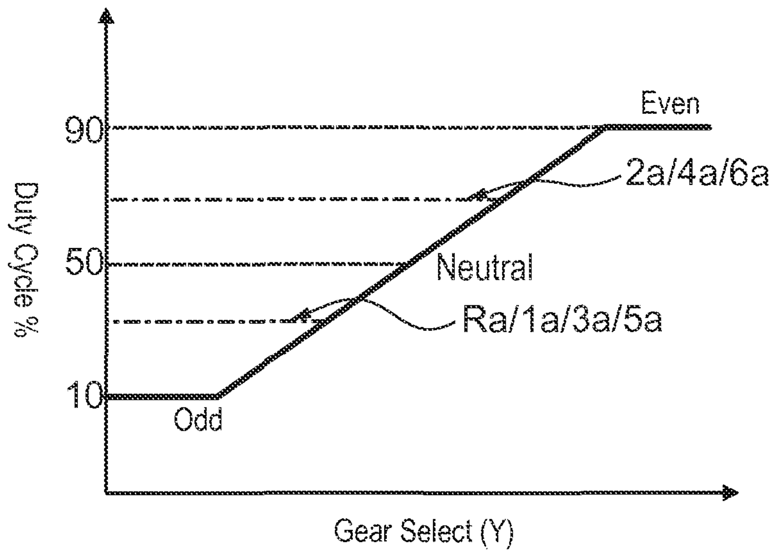

Even
90
2a/4a/6a
50
Neutral
Ra/1a/3a/5a
10
Odd
Duty Cycle %
Gear Select (Y)

Fig. 8C

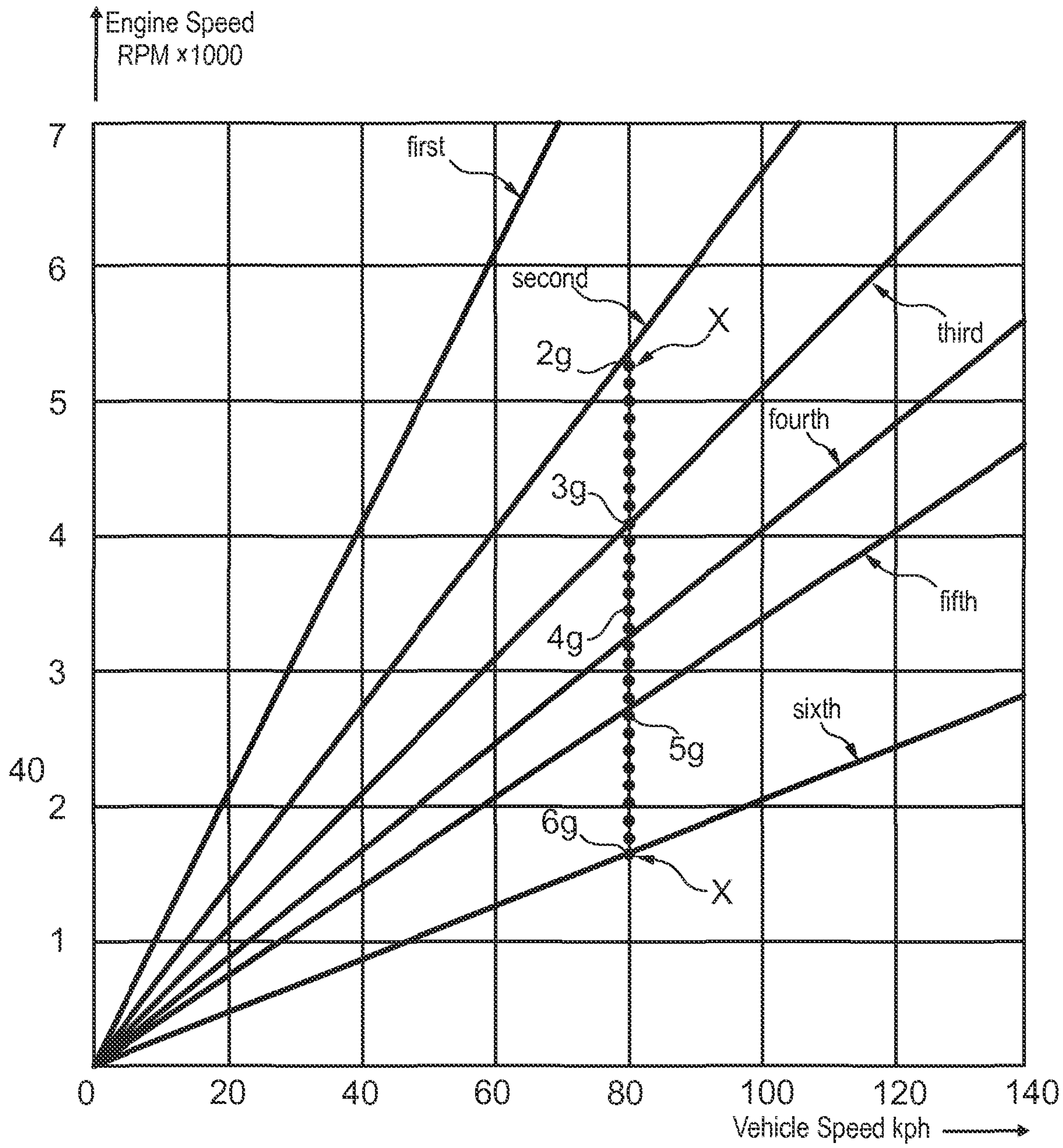

Engine Speed
RPM ×1000
7
6
5
4
3
2
1
40
0
20
40
60
80
100
120
140
Vehicle Speed kph
first
second
third
fourth
fifth
sixth
2g
3g
4g
5g
6g
X
X

Fig. 9

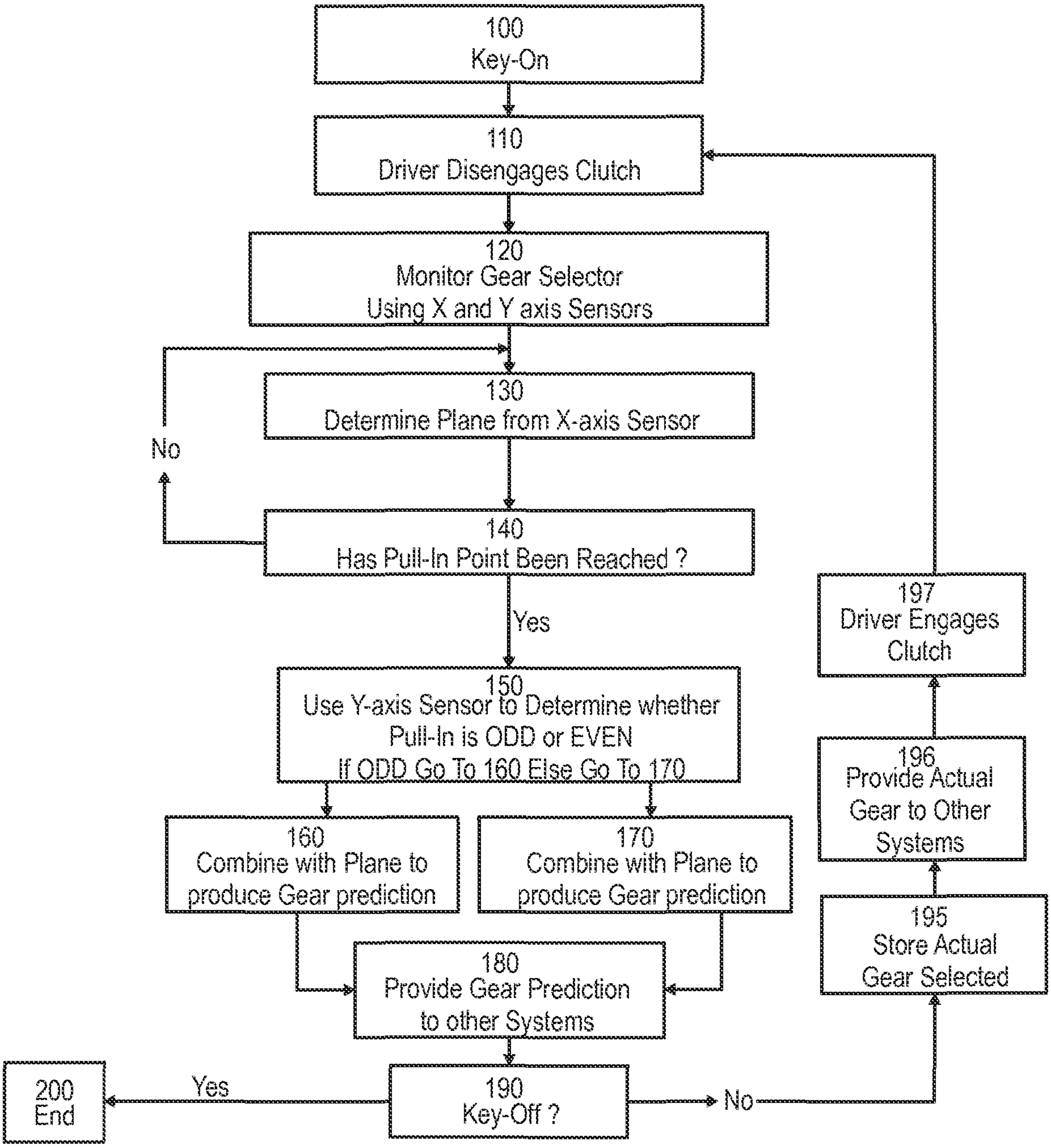
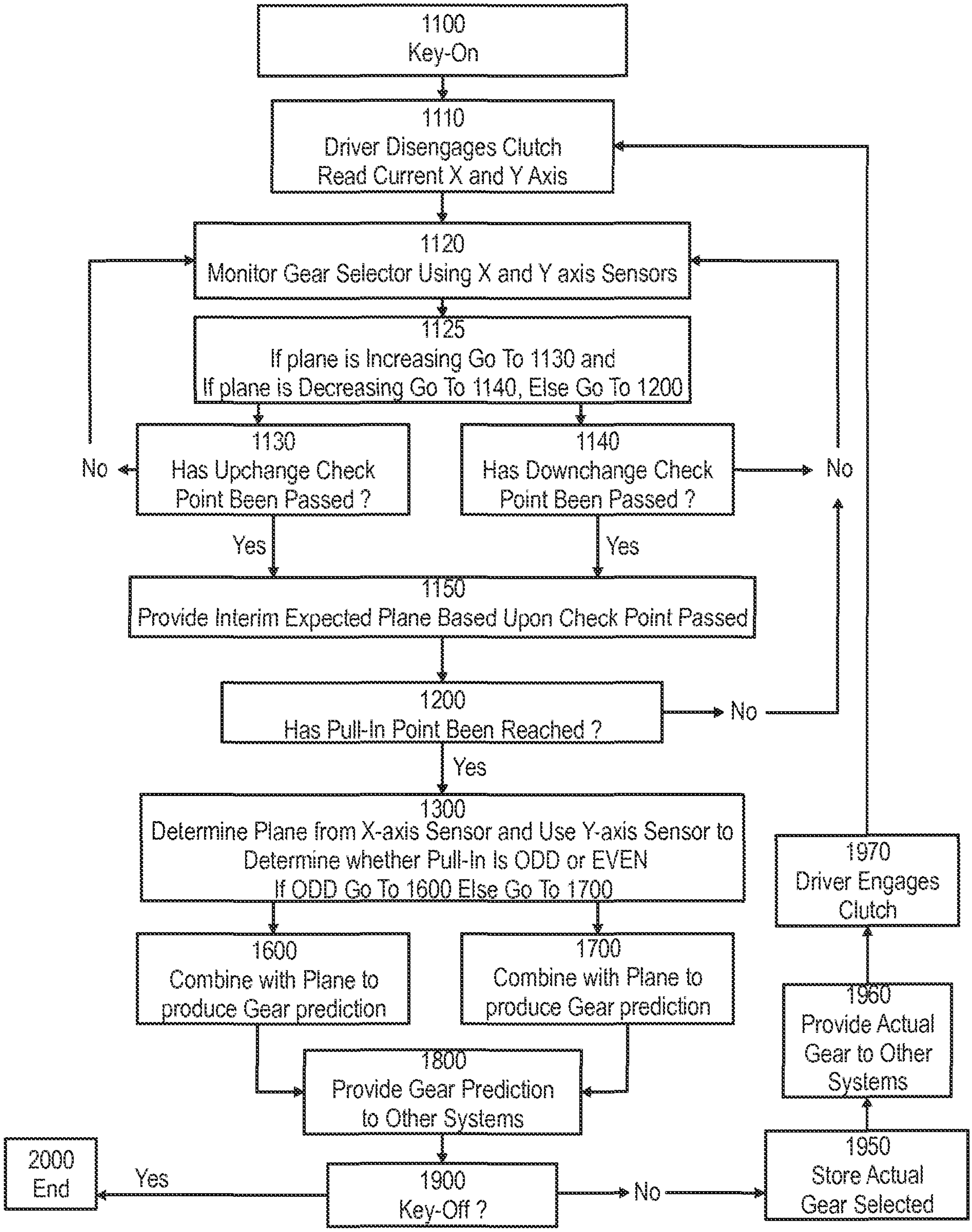

100
Key-On
110
Driver Disengages Clutch
120
Monitor Gear Selector
Using X and Y axis Sensors
130
Determine Plane from X-axis Sensor
No
140
Has Pull-In Point Been Reached ?
Yes
150
Use Y-axis Sensor to Determine whether
Pull-In is ODD or EVEN
If ODD Go To 160 Else Go To 170
160
Combine with Plane to
produce Gear prediction
170
Combine with Plane to
produce Gear prediction
180
Provide Gear Prediction
to other Systems
190
Key-Off ?
Yes
200
End
No
195
Store Actual
Gear Selected
196
Provide Actual
Gear to Other
Systems
197
Driver Engages
Clutch

Fig. 10



1100
Key-On
1110
Driver Disengages Clutch
Read Current X and Y Axis
1120
Monitor Gear Selector Using X and Y axis Sensors
1125
If plane is Increasing Go To 1130 and
If plane is Decreasing Go To 1140, Else Go To 1200
1130
Has Upchange Check
Point Been Passed ?
No
1140
Has Downchange Check
Point Been Passed ?
No
Yes
Yes
1150
Provide Interim Expected Plane Based Upon Check Point Passed
1200
Has Pull-In Point Been Reached ?
No
Yes
1300
Determine Plane from X-axis Sensor and Use Y-axis Sensor to
Determine whether Pull-In Is ODD or EVEN
If ODD Go To 1600 Else Go To 1700
1600
Combine with Plane to
produce Gear prediction
1700
Combine with Plane to
produce Gear prediction
1800
Provide Gear Prediction
to Other Systems
1900
Key-Off ?
Yes
No
2000
End
1950
Store Actual
Gear Selected
1960
Provide Actual
Gear to Other
Systems
1970
Driver Engages
Clutch

Fig. 11

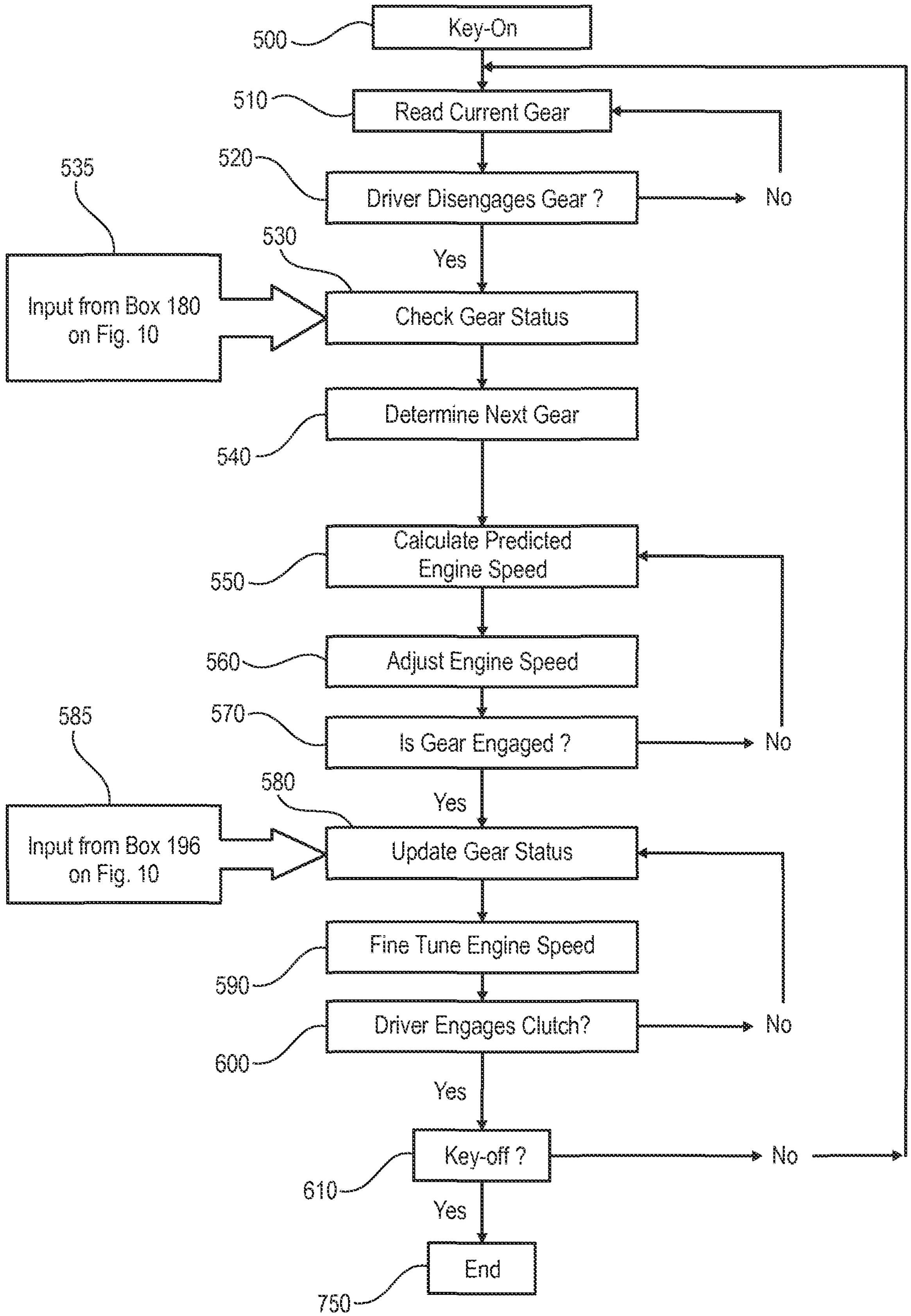

Key-On
500
Read Current Gear
510
Driver Disengages Gear ?
520
No
535
Input from Box 180 on Fig. 10
530
Yes
Check Gear Status
Determine Next Gear
540
Calculate Predicted Engine Speed
550
Adjust Engine Speed
560
Is Gear Engaged ?
570
No
585
Input from Box 196 on Fig. 10
580
Yes
Update Gear Status
Fine Tune Engine Speed
590
Driver Engages Clutch?
600
No
Yes
Key-off ?
610
No
Yes
End
750

Fig. 12

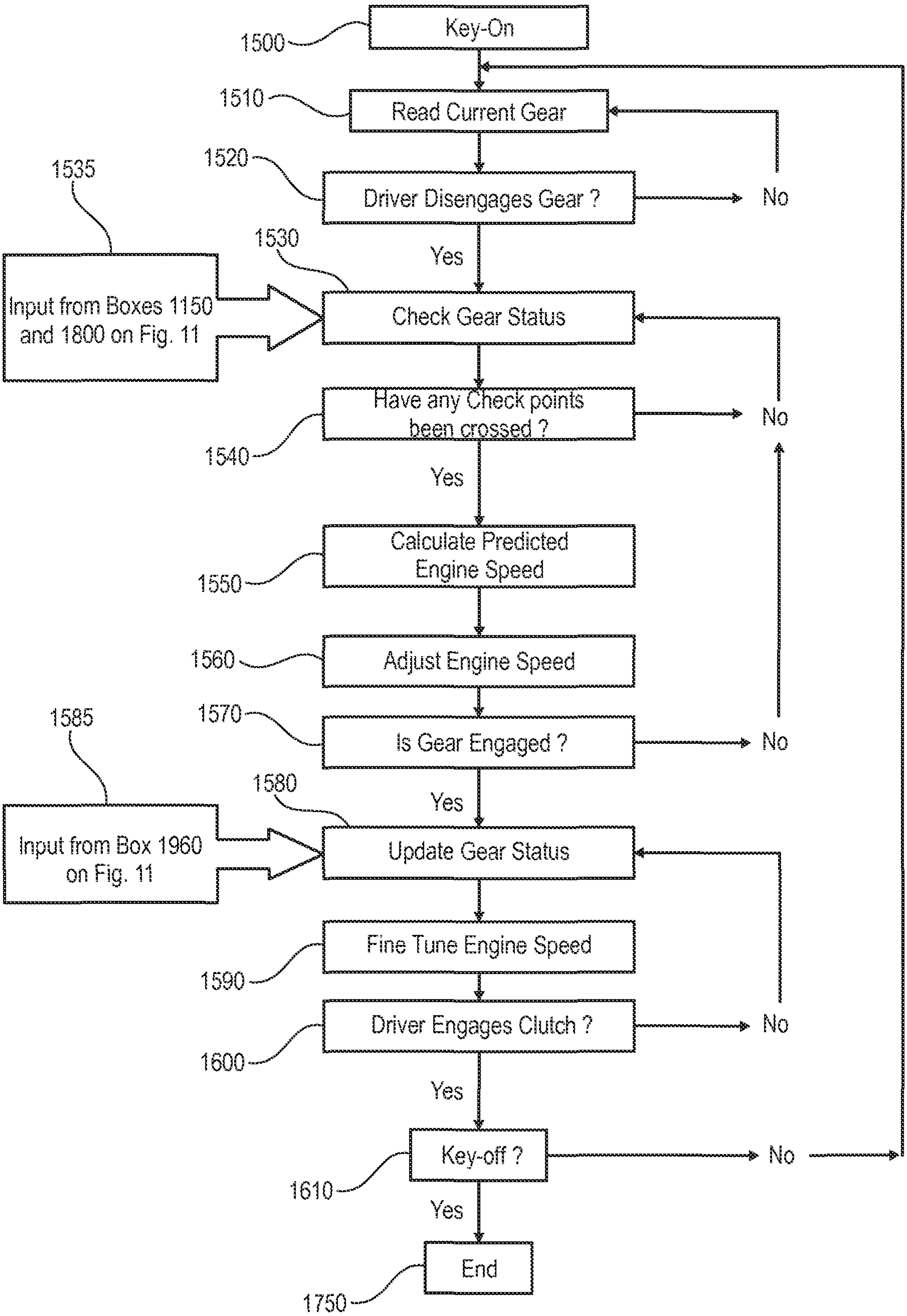

Key-On
1500
1510
Read Current Gear
1520
Driver Disengages Gear ?
No
1535
1530
Yes
Input from Boxes 1150 and 1800 on Fig. 11
Check Gear Status
Have any Check points been crossed ?
No
1540
Yes
Calculate Predicted Engine Speed
1550
1560
Adjust Engine Speed
1585
1570
Is Gear Engaged ?
No
1580
Yes
Input from Box 1960 on Fig. 11
Update Gear Status
Fine Tune Engine Speed
1590
Driver Engages Clutch ?
No
1600
Yes
Key-off ?
No
1610
Yes
End
1750

Fig. 13

A Method and System for Improving Gear Change Quality

This invention relates to a motor vehicle and in particular to an improved method and system for synchronising engine speed with an input speed of a manual transmission driven by the engine via a clutch during a gear shift.

Poor drivability during gear changes in manual transmission vehicles is a significant contributor to customer complaints. Poor drivability or a poor quality shift can be experienced as vehicle jerk during gear shifts which can be attributed to torque disturbances due to engine and transmission speed mismatches as the clutch is engaged following a gear change.

Gear Shift Harmonisation (GSH) strategies (otherwise known as 'speed-matching' or 'speed-targeting') exist which strive to match engine and transmission speeds across the clutch plates following a gear shift, just prior to clutch engagement.

Prior art GSH strategies rely on guessing the next gear that a driver is about to select or measuring the gear that has been selected. Successful speed matching depends on the ability to modify the engine speed quickly whilst the clutch is disengaged to the optimum target speed for the next gear that the driver is about to select.

Using a ‘best guess’ method, the system assumes that the driver is going to select a gear that is one higher or one lower than the previous and, as soon as the clutch is depressed, the system operates to adjust the engine speed to the optimal speed for the guessed next gear. The disengagement of the clutch is used as the trigger in order to maximise the time available to adjust the engine speed.

However such methods often result in the wrong gear being guessed and as a consequence the speed differential across the clutch will not be optimal. In addition, the use of clutch disengagement or a measure of clutch disengagement such as clutch pedal position as the trigger event will result in erroneous results if the driver temporarily disengages the clutch but does not perform a gear shift.

Using a ‘sensed gear’ method in which the gear actually selected is sensed and then used to set the target engine speed is more accurate and reliable than a best guess method but, by the time the driver has actually selected a gear, the time remaining for speed adjustment prior to clutch engagement has been considerably reduced. In some cases the time remaining in which to adjust the engine speed is so short that it is not possible to achieve the desired speed for synchronisation in the available time.

Therefore in summary, both of the known methods have problems associated with them which potentially compromise drivability.

It is an object of the invention to provide a method and apparatus for improving the shift quality of a manual transmission.

According to a first aspect of the invention there is provided a method for improving the shift quality of a manual transmission of a motor vehicle having an engine driving the transmission via a clutch wherein the method comprises, predicting during a gear shift using a predictive gear sensing system a next to be engaged gear, determining, based upon the predicted next to be engaged gear and vehicle speed, an engine speed required at the end of the gear shift and adjusting the speed of the engine to the required engine speed.

The method may further comprise determining when a gear is engaged whether the gear engaged is the same as the predicted next to be engaged gear and, if the gear engaged is different to the predicted next to be engaged gear, adjusting the engine speed based upon the gear engaged and the current vehicle speed.

If the gear engaged is the same as the predicted next to be engaged gear, the method may further comprise determining an updated engine speed based upon the current vehicle speed and adjusting the engine speed to achieve the updated engine speed.

The next predicted to be engaged gear may be based upon the sensing by a gear sensor that one or more check points associated with a gear shift mechanism of the transmission have been traversed.

A gear shift may commence when one gear is disengaged and ends when another gear and the clutch are engaged.

According to a second aspect of the invention there is provided a system for improving the shift quality of a manual transmission of a motor vehicle wherein the system comprises an engine to provide drive to the transmission via a clutch, a predictive gear sensing system to provide information indicative of the engagement state of the transmission, a controller to control the speed of the engine and an input to the electronic controller to provide information indicative of the speed of the motor vehicle wherein, the electronic controller is operable during a gear shift in response to predicted next to be engaged gear information received from the predictive gear sensing system and the vehicle speed information to adjust the speed of the engine to an engine speed required at the end of the gear shift.

The electronic controller may be further operable to determine when a gear is engaged whether the gear engaged is the same as the predicted next to be engaged gear and, if the gear engaged is different to the predicted to be engaged gear, adjust the engine speed based upon the gear engaged and the current vehicle speed.

If the gear engaged is the same as the predicted next to be engaged gear, the electronic controller may be operable to determine an updated engine speed based upon the current vehicle speed and adjust the engine speed to achieve the updated engine speed.

The next predicted to be engaged gear information may comprise the sensing by the gear sensor that one or more check points associated with a gear shift mechanism of the transmission have been traversed.

A gear shift may commence when one gear is disengaged and end when another gear and the clutch are engaged.

The electronic controller may comprises a transmission state module to receive and process one or more signals from the gear sensor and an engine control unit operatively connected to the transmission state module and arranged to adjust the speed of the engine during a gear change.

The vehicle speed input may be from a vehicle speed sensor.

According to a third aspect of the invention there is provided a motor vehicle having a manual transmission and a system for improving gear shift quality of the manual transmission constructed in accordance with said second aspect of the invention.

The invention will now be described by way of example with reference to the accompanying drawing of which:-

Fig.1A is a diagrammatic representation of a motor vehicle according to one aspect of the invention;

Fig.1B is a diagrammatic representation of part of the driveline of the motor vehicle shown in Fig.1A;

Fig.2A is a diagrammatic view of part of a transmission of the motor vehicle shown in Fig.1 showing the location of a 2D selected gear sensor and a 2D magnetic target;

Fig.2B is a pictorial view showing the motion of a transmission turret shift selector cylinder, the axial (X axis) and rotational (Y axis) positions of which are sensed by the 2D selected gear sensor;

Fig.3A is a first pictorial view of a turret selector cylinder follower;

Fig.3B is a second pictorial view of the turret selector cylinder follower shown in Fig.3A;

Fig.4 is a pictorial view of a transmission turret shift mechanism showing in more detail the turret selector cylinder shown in Fig.2B;

Fig.5 is a more detailed view of the part of the transmission shown in Fig.2A showing the location of the 2D target and the 2D magnetic sensor array;

Fig.6A is an enlarged cross-section through part of the turret selector cylinder follower shown in Figs.3A and 3B showing the turret selector follower in a Neutral gear position;

Fig.6B is an enlarged cross-section through part of the turret selector cylinder follower shown in Figs.3A and 3B showing the turret selector follower in an Even gear pull-in position;

Fig.6C is an enlarged cross-section through part of the turret selector cylinder follower shown in Figs.3A and 3B showing the turret selector follower in an Odd gear pull-in position;

Fig.7A is diagram showing the relationship between transmission turret selector cylinder rotational and axial positions and the respective signal outputs from the 2D selected gear sensor;

Fig.7B is an enlarged view of the relationship between transmission turret selector cylinder rotational position and signal output showing two in-plane or rotational check points according to one embodiment of a predictive gear sensing system according to the invention;

Fig.8A is a schematic drawing of an H-gate selector mechanism showing a number of in-plane and between plane check points according to a second embodiment of a predictive gear sensing system according to the invention;

Fig.8B is chart showing the relationship between transmission turret selector cylinder axial position and signal output showing the between plane check points indicated on Fig.8A;

Fig.8C is chart showing the relationship between transmission turret selector cylinder rotational position and signal output showing the in-plane check points indicated on Fig.8A;

Fig.8D is an underside view of an H-gate shift lever guide showing the location of a number of shift lever sensors forming part of a third embodiment of a predictive gear sensing system;

Fig.9 is a chart showing the relationship between vehicle speed and engine speed for various transmission ratios;

Fig.10 is simplified flow chart of a first embodiment of a method for predicting gear engagement;

Fig.11 is simplified flow chart of a second embodiment of a method for predicting gear engagement;

Fig.12 is a simplified flow chart of a first embodiment of a method for improving the shift quality of a manual transmission of a motor vehicle; and

Fig.13 is a simplified flow chart of a second embodiment of a method for improving the shift quality of a manual transmission of a motor vehicle.

Referring firstly to Figs 1 to 6C there is shown a motor vehicle 1 having an engine 2 drivingly connected to a manual gearbox/ transmission 3 via a clutch 10. The transmission 3 includes a gear shift lever 11 by which the driver may select using an H-gate selector mechanism the various gears of the transmission 3.

An electronic processing unit in the form of a Powertrain Control Module (PCM) 4 is provided to control the powertrain of the motor vehicle 1. The PCM 4 includes an engine control unit 6 to control the operation of the engine 2 and a transmission state module 5 to determine the operating state of the transmission 3.

The PCM 4 is arranged to receive a number of inputs or signals from sensors 9 including one or more of engine speed from an engine speed sensor 9e, vehicle speed from a vehicle speed sensor 9v associated with a wheel 'W', clutch pedal position from a clutch pedal sensor 9c, throttle position from an accelerator pedal position sensor 9a, brake pedal position from a brake pedal sensor 9b and may also receive information regarding other components on the motor vehicle 1.

Some or all of the inputs from the sensors 9 may be used by engine control unit 6 to control the operation of the engine 2 and in particular the speed of the engine 2. It will be appreciated that the engine control unit 6 and the transmission state module 5 could be separate processing units or be formed as part of a single electronic processor such as the PCM 4 as shown.

Referring to Fig.1B the engine has an output 2a which drives the clutch 10 and which rotates at the same speed as a crankshaft of the engine 2. In practice the output 2a is formed by a flywheel of the engine 2. The clutch 10 is used to releasably couple the output 2a to an input 3i of the transmission 3 which in most cases is formed by an input shaft of the transmission 3.

It will be appreciated that when the clutch 10 is engaged with no slip the speed of the engine output 2a is the same as the speed of the transmission input 3i. When the clutch 10 is disengaged there is no direct relationship between engine output speed and transmission input speed but the transmission input speed is related to the speed of the vehicle and the gear ratio of the transmission 3 plus any other factors that affect the relationship between transmission input speed and vehicle velocity such as final drive ratio and rolling radius of the wheel 'W' of the motor vehicle 1.

It will be appreciated that the term 'manual transmission' as meant herein is a transmission in which the various gear ratios are manually selected by a driver of the motor vehicle 1 by the movement of the shift lever 11.

It will be further appreciated that engagement and disengagement of the clutch 10 is manually controlled by the driver of the motor vehicle 1 or electronically controlled in response to driver actions as in the case of an e-clutch. An e-clutch is an electronically controlled clutch in which clutch pedal position is monitored using a sensor and the actual clutch engagement/disengagement is performed via an electronically controlled actuator.

The motor vehicle 1 includes a first embodiment of a predictive gear sensing system comprised of the transmission state module 5, a 2D magnetic target 8 and a 2D selected gear sensor 7 forming in combination a 2D selected gear sensor pair. The transmission state module 5 is arranged to receive signals from the selected gear sensor 7 attached to a casing 3B of the transmission 3. The selected gear sensor 7 is a 2D magnetic PWM sensor array that provides signals based upon variations in flux between the selected gear sensor 7 and the 2D magnetic target 8 associated with a shift selector member in the form of a turret selector cylinder 3A. The selected gear sensor 7 combines a rotary position sensor and an axial displacement sensor in a single 2D sensor array.

Figs.2A, 4 and 5 shows a typical 'H-gate' transmission configuration consisting of a shifter turret selector cylinder 3A located inside the main transmission casing 3B. The shifter turret selector cylinder 3A rotates when the gear lever 11 is moved forwards and backwards to select respectively odd and even gears and it moves axially when the gear lever 11 is moved left and right to change the gear shift lever plane in which the gear lever moves. Reverse gear can be configured as an odd gear or an even gear depending upon the configuration of the transmission 3. It will be appreciated that the shifter turret selector cylinder could be arranged such that forward and backward movement results in axial movement of the selector cylinder and left right movement results in rotation of the selector cylinder and the output from the 2D sensor array would be interpreted accordingly.

The gear shift lever 11 is connected by a cable drive to a pair of levers 21A, 21B formed as part of the shifter turret assembly 20 which actuate the shifter turret selector cylinder 3A.

The 2D magnetic target 8 is attached to the shifter turret selector cylinder 3A and, in the example shown, the selected gear sensor 7 is located on the outside of the transmission housing 3B and detects axial and rotational movement of the magnetic target 8. However, it will be appreciated that the selected gear sensor 7 could be mounted inside the transmission casing 3B.

Figure 2B shows the movement of the magnetic target 8 when different gears are selected.

Figs.3A, 3B, 6A, 6B and 6C show a follower 3C which is attached to and rotates with the selector cylinder 3A, the follower 3C has three detents 3E, a central detent corresponding to a neutral gear position, an odd gear detent to one side of the neutral detent and an even gear detent to the other side of the neutral detent. A ball 3D is biased by a spring (indicated diagrammatically by the arrow ‘S’ on Figs. 6a, 6B and 6C) for engagement with one of the detents 3E. The ball 3D is slidingly supported by the transmission casing 3B either directly or via a bracket. It will be appreciated that the ball 3D could be replaced by a spring biased pin having a hemi-spherical end. The detents 3E define first, second and third rotational positions corresponding to a selection position for a first row of gears, a selection position for a second row of gears and a neutral position for the transmission 3 and in particular the peaks located between the neutral detent and the in-gear detents determine whether upon releasing the gear lever 11 the transmission 3 will move into gear (pull-in) or into neutral (no pull-in) as will be described in greater detail hereinafter.

Starting with the transmission 3 it can be seen that there is a physical link to the magnetic target 8 in the form of the mechanical connection of the magnetic target 8 to the selector cylinder 3A and a physical connection to the selected gear sensor 7 in the form of the mechanical connection of the selected gear sensor 7 to the transmission housing 3B.

There is a flux connection between the selected gear sensor 7 and the magnetic target 8 such that variations in flux can be sensed by the selected gear sensor 7 to provide a signal indicative of the axial and rotational positions of the selector cylinder 3A and hence whether the transmission 3 is in an odd gear, an even gear or neutral and which one of the odd and even gears is engaged.

The selected gear sensor 7 continuously outputs signals indicative of the rotational and axial positions of the selector cylinder 3A and these are used to predict the next gear to be engaged by comparing the output signals with various check points.

For example, by carrying out test work the pull-in rotational positions of the selector cylinder 3A can be established. The even and odd gear pull-in positions are shown in Figs. 6B and 6C respectively.

In Fig.6A the selector cylinder 3A is shown in the neutral position and in Figs. 6B and 6C the selector cylinder 3A is shown in positions corresponding to an even pull-in point (EPI) and an odd pull-in point (OPI). The even pull-in point in this case is reached when the selector cylinder 3A is rotated Ω degrees from the neutral position and the odd pull-in point is reached when the selector rotation cylinder 3A is rotated -β degrees from the neutral position. Clockwise rotation of the selector cylinder 3A is represented on Figs. 6A to 6C as a positive angle and counter clockwise rotation as a negative angle.

If the rotational position at which these pull-in positions (EPI and OPI) are reached is known and the selected gear sensor 7 is calibrated such that the transmission state module 5 is able to determine from the signals received from the selected gear sensor 7 when these rotational positions are reached then this can be used to predict, before a gear is actually engaged, whether the engaged gear will be an odd gear or an even gear. By combining this information with the axial position of the selector cylinder 3A determined from the axial position signal generated by the selected gear sensor 7 the transmission state module 5 is able to predict the next gear to be engaged.

It will be appreciated by those skilled in the art that the respective odd and even pull-in points are the rotational positions of the shift cylinder 3A where, the various forces acting will rotate the shift cylinder 3A so that the ball 3D fully engages with the respective detent 3E and the corresponding gear will be engaged. That is to say, at and beyond the pull-in point the transmission will automatically be pulled into gear and before the pull-in point is reached the transmission will revert to a neutral gear position.

Referring now to Figs 7A and 7B the two inputs to the transmission state module 5, a sensed rotational position signal (Y axis) and a sensed axial displacement signal (X-axis). To be more precise, the selected gear sensor 7 outputs a PWM signal which is either in range (between 10% and 90% in this case) or out of range (>90% or < 10% in this case). Input driver software in the transmission state module 5 interprets the PWM and, if the PWM is out of range (>90% or < 10%) the input driver software sets a quality signal to FAULT. It will be appreciated that the 10 to 90% range is provided by way of example and that the invention is not limited to the use of such a range.

If the PWM signal is in range (between 10% and 90%) the input driver software sets the quality signal to OK. The transmission state module 5 then compares the PWM signal to thresholds to determine whether neutral is or is not selected, an odd gear is or is not selected, an even gear is or is not selected the odd gear pull-in point (OPI) has been reached and the even gear pull-in point (EPI) has been reached.

It can be seen on Fig.7A that the six speed transmission has a conventional H-gate arrangement with the odd gears and reverse arranged in one row and the even gears arranged in another row and that the gears are arranged in a number of gear shift lever planes in which there are arranged reverse gear, and then in the remaining planes two forward gears namely first and second gear (1/ 2 plane), third and fourth gears (3/ 4 plane) and fifth and sixth gears (5/ 6 plane).

Referring now to Fig.7B if the PWM signal is substantially 90% then the transmission state module 5 interprets this as an indication that one of the even gears has been selected, if the PWM signal is substantially 10%

then the transmission state module 5 interprets this as an indication that one of the odd gears has been selected, if the PWM signal is substantially 50% then the transmission state module 5 interprets this as an indication that neutral has been selected.

It will be appreciated that there may in practice be tolerance bands on all of these figures and, for example, the transmission state module 5 may well operate for the rotational direction with logic tests as follows:-

If 85%< PWM < 90% Then engaged gear equals even; (1)
If 10%< PWM < 15% Then engaged gear equals odd; (2)
If 45%< PWM < 55% Then gear equals neutral. (3)

In addition to these in-gear evaluations the transmission state module 5 also compares the rotary position signal from the selected gear sensor 7 with two rotational check points for the even gear pull-in point (EPI) and for the odd gear pull-in point (OPI) which are used to predict the next gear to be engaged.

For example, as shown on Fig.7B, the transmission state module 5 performs for the rotational direction the following logic tests:-

If PWM< 30% Then predicted next gear equals odd; (4)
If PWM> 70% Then predicted next gear equals even. (5)

Where, the predefined rotational check points EPI and OPI are 70% and 30% respectively.

Using this logic the transmission state sensor 5 is able to predict by combining it with the axial position of the shift cylinder 3A the next to be engaged gear before it is actually engaged. This information can then be sent several milliseconds earlier (20-40ms) to other control systems requiring knowledge of gear selection such as a HMI gear indicator or the engine control unit 6 before the gear is actually engaged.

It will be appreciated that the selected gear sensor 7 could also be arranged such that when the transmission 3 is in neutral the corresponding nominal sensor signal is 50%, when the gear lever is moved forwards into one of the odd gears the sensor signal increases above 50% and when one of the even gears is selected the sensor signal decreases below 50% and so the logic tests given above would be reversed in sense e.g.

If 85%< PWM < 90% Then engaged gear equals odd; (1')
If 10%< PWM < 15% Then engaged gear equals even; (2')
If 45%< PWM < 55% Then gear equals neutral. (3')
If PWM< 30% Then predicted next gear equals even; (4')
If PWM> 70% Then predicted next gear equals odd. (5')

Referring back to Fig.7A the output signal from the selected gear sensor 7 for the axial or X axis direction is shown and it can be seen that for the six speed transmission shown by way of example:

If PWM = 10% Reverse gear plane is selected;

If PWM = 40% first/ second gear plane is selected;

If PWM = 70% third/ fourth gear plane is selected;

If PWM = 90% fifth/ sixth gear plane is selected;

As before tolerance bands can be applied to these figures to allow for wear or inaccuracies of construction and so in practice the transmission state module may perform for the axial direction the logic tests:

If 10% < PWM < 15% Reverse gear plane is selected; (6)

If 37.5% < PWM < 42.5% first/ second gear plane is selected; (7)

If 67.5% < PWM < 72.5% third/ fourth gear plane is selected; (8)

If 85% < PWM < 90% fifth/ sixth gear plane is selected; (9)

The transmission state module 5 can use the logic tests (4) and (5) above in combination with one of the tests (6) to (9) to predict the next to be engaged gear (N2G) as set out below in Table 1.

Test Passed	Test (4) Passed	Test (5) Passed
6	N2G = Reverse	/
7	N2G = First	N2G = Second
8	N2G = Third	N2G = Fourth
9	N2G = Fifth	N2G = Sixth

Table 1

The transmission state module 5 can then confirm, when the gear is actually engaged, the engaged gear (EG) after confirmation is received from the selected gear sensor 7 using the logic tests (1) and (2) above in combination with one of the tests (6) to (9) as set out below in Table 2.

Test Passed	Test (2) Passed	Test (1) Passed
6	EG = Reverse	/
7	EG = First	EG = Second
8	EG = Third	EG = Fourth
9	EG = Fifth	EG = Sixth

Table 2

It will be appreciated that as referred to in respect of the rotational calibration the axial position calibration could be the opposite of that described above with 10% =

sixth gear and 90% = Reverse in which case the logic tests for the plane would be different to those given above.

Although the predictive gear sensing system has been described with respect to the use of a PWM magnetic selected sensor which uses a 2D magnet and generates PWM outputs, the invention is not limited to the use of sensors producing a PWM output it is equally applicable for use with a displacement sensor which generates variable voltage outputs instead of PWM outputs.

It will also be appreciated that the predictive gear sensing system is not limited to the use of a single 2D magnetic sensor array 7 for the selected gear sensor it may also be put into effect using a 3D sensor and magnet arrangement or two separate sensors one for sensing rotary motion and one for sensing axial motion.

It will also be appreciated that the invention is not limited to a six forward speed transmission or to the positioning of reverse gear as shown in Fig. 7A and that the invention could be applied to transmissions having a different number of forward speeds or a different reverse gear position with equal benefit.

Referring now to Figs. 8A to 8C there is shown part of a second embodiment of a predictive gear sensing system which in most respects is identical to that previously described and so will not be described again in detail.

The primary difference between this second embodiment and the first embodiment described above is that, in addition to the in-plane check points related to the pull-in points located in the gear shift planes, a plurality of inter-plane check points located between the gear shift planes are also provided.

Referring firstly to Fig. 8A there are shown a number of in-plane check points Ra, 1a, 2a, 3a, 4a, 5a and 6a. The check points Ra, 1a, 3a and 5a correspond to the odd gear pull-in point (OPI) referred to above and the check points 2a, 4a, and 6a correspond to the even gear pull-in point (EPI) referred to above. The predictive gear system operates as above with respect to these check points and as described above is able to predict the next to be engaged gear.

In addition to theses in-plane check points Ra, 1a, 2a, 3a, 4a, 5a and 6a, there are also a number of inter-plane check points R/1b, 1/2b, 3/4b and 1/2a, 3/4a, 5/6a. The inter-plane check points R/1b, 1/2b and 3/4b are upshift check points and the inter-plane check points 1/2a, 3/4a and 5/6a are downshift check points.

The function of the inter-plane check points is to provide an early indication of whether the gear changing taking place is an upchange or a downchange. This information is useful if the predictive gear sensing system is being used for example to supply information to a Gear Shift Harmonization (GSH) system where the engine speed has to be adjusted in a very short period of time during a gear change between the point in time when the clutch 10 is disengaged and the point in time when the clutch 10 is re-engaged.

The inter-plane check points are therefore used by the transmission state module 5 to determine whether the current gear change is an upchange or a downchange that is to say whether the next gear is a higher gear or a lower gear than the previously engaged gear.

Fig.8B shows the inter-plane check points R/1b, 1/2b, 3/4b, 1/2a, 3/4a and 5/6a as %PWM outputs from the axial displacement sensor output of the selected gear sensor 7 and

Fig.8C replicates Fig.7B with the in-plane check points on Fig.8C (Ra, 1a, 3a and 5a and 2a, 4a and 6a) corresponding respectively to the OPI and EPI check points on Fig.7B.

In each case the gear previously engaged, that is to say, the gear that was engaged before the gear change commenced is known and this is used to provide an early indication of the next to be engaged gear.

Because the inter-plane check points are set-points they are not affected by tolerances in the mechanism and so single values can be used.

For example, the check points shown on Figs. 8a and 8B have the assigned %PWM values of:

R/1b = 17.5%
1/2a = 32.5%
1/2b = 45%
3/4a = 65%
3/4b = 75%
5/6a = 85%

These are used to determine early in the gear change cycle whether an upchange or a downchange is taking place using the knowledge of the %PWM for the currently engaged gear.

For example, if the currently engaged gear is fourth gear then the following tests can be used:-

If %PWM < 65% Assume Downchange; and
If %PWM > 75% Assume Upchange.

Similarly, if the currently selected gear is second gear the following tests can be used:-

If %PWM < 32.5% Assume Downchange; and
If %PWM > 45% Assume Upchange.

Note that by having separate up and down check points between the various gear shift planes an earlier indication is given when one of the check points is crossed and that hysteresis can be used to prevent flip-flopping.

For example, if there were only one check point of say, 55%, the notification of a downchange from the 3/ 4 plane to the 1/ 2 plane or an upshift from the 1/ 2 plane to the 3/ 4 plane would be delayed. 65% versus 55% and 45% versus 55% respectively.

It will be appreciated that the same is true for the use of dual check points used between all of the adjacent planes.

Table 3 below shows how the traversing of check points is used by the transmission state module 5 to provide an early indication of whether the next gear is likely to be higher or lower than the previously selected gear. For each of the inter gear plane check points the possible next gear is shown.

Previous Gear	Check Point R/1b	Check Point 1/2b	Check Point 3/4b	Check Point 1/2a	Check Point 3/4a	Check Point 5/6a
R	1,2,3,4,5,6	3,4,5,6	5,6	-	-	-
1	-	3,4,5,6	5,6	R	-	-
2	-	3,4,5,6	5,6	R	-	-
3	-	-	5,6	R	R,1,2	-
4	-	-	5,6	R	R,1,2	-
5	-	-	-	R	R,1,2	R,1,2,3,4
6	-		-	R	R,1,2	R,1,2,3,4

Table 3

This output is modified based upon expected result which is the normal gear change pattern expected from the driver. This can be predefined or can be adaptively learned for example if the driver regularly changes from fifth gear down to third gear then if the check point 5/6a is traversed this can be used to indicate that the next expected gear is third.

In Table 4 below the results from Table 3 are shown corrected based upon a predefined logical shift change pattern.

Previous Gear	Check Point R/1b	Check Point 1/2b	Check Point 3/4b	Check Point 1/2a	Check Point 3/4a	Check Point 5/6a
R	1 or 2	3 or 4	5 or 6	-	-	-
1	-	3 or 4	5 or 6	R	-	-
2	-	3 or 4	5 or 6	R	-	-
3	-	-	5 or6	R	1 or 2	-
4	-	-	5 or6	R	1 or 2	-
5	-	-	-	R	1 or 2	3 or 4
6	-		-	R	1 or 2	3 or 4

Table 4

Therefore a predictive gear sensing system according to this second embodiment is able to provide further time in which to take any other action such as GSH by providing an early indication of the action required.

For example, assuming the currently selected gear is third and a downshift to second is made, with a system according to the first embodiment of a predictive gear sensing system it cannot be predicted whether the gear to be selected is higher or lower than third gear until one of the in-gear plane check points 1a, 2a, 4a, 5a, 6a is traversed but according to this embodiment, as soon as the check point 3/4A is traversed it is known that a downshift is occurring and so this information can be provided to any system requiring it and then when the relevant in-plane check point 2a is traversed this information can be used as a further prediction of the next gear and finally confirmed when the gear is actually engaged.

It will be appreciated that the time taken for a driver to move a gear shift lever 11 from the third gear position to a second gear position is relatively short and so any additional information provided early in a gear change is potentially very useful to a system requiring knowledge of the selected gear.

For example, with a GSH system knowing early in the gear change that the gear change is an upshift allows the GSH system to begin reducing the engine speed and conversely knowing early in the gear change that the gear change is a downshift allows the GSH system to begin increasing the engine speed.

Referring now to Fig.10 there is shown the basic steps required to perform a first embodiment of a method for predicting a gear to be engaged in a multi-speed manual transmission of the type previously described.

The method commences at box 100 with a Key-on event and then in box 110 the driver disengages the clutch in preparation for a gear change or the selection of a gear.

The method then advances to box 120 where the selected gear sensor 7 is used to monitor the movement of a gear shift member such as the shift cylinder 3A and in box 130 the gear shift lever plane is determined. That is to say, in box 130 it is determined in which of the gear shift planes the gear lever 11 currently resides.

Then in box 140 it is determined whether one of the pull in points or in-plane check points EPI, OPI has been reached. If one of the in-plane check points EPI, OPI has been reached then the method advances to box 150 but if neither of the in-plane check points EPI, OPI has been reached the method loops back to box 130 and will continue to loop around the boxes 130, 140 until an in-plane check point EPI, OPI has been reached.

In box 150 it is determined which of the in-plane check points has been reached and based upon this decision the method advances to either box 160 if the odd gear in-plane check point OPI has been reached or to box 170 if the even gear in-plane check point EPI has been reached.

In boxes 160 and 170 the plane information from box 130 is combined with the information regarding whether the gear to be selected is odd or even to provide a prediction of the next gear to be selected and in box 180 this is provided to any systems requiring this information.

The method then advances to box 190 where it is determined whether a Key-off event has occurred, if it has the method ends at box 200 and if it has not the method continues to box 195 where the gear actually selected is stored for future use and then this information is provided in box 196 to the systems requiring the gear state knowledge as a confirmation of the prediction supplied in box 180.

The method then continues to box 197 where the driver re-engages the clutch 10 and then pauses at box 197 until the driver next disengages the clutch 10 at which point in time it moves back to box 110 to start the method again.

Referring now to Fig.11 there is shown the basic steps required to perform a second embodiment of a method for predicting a gear to be engaged in a multi-speed manual transmission of the type previously described.

The method commences at box 1100 with a Key-on event and then in box 1110 the driver disengages the clutch 10 in preparation for a gear change or the selection of a gear and currently stored values for axial and rotational position are read or a currently selected gear state is read.

The method then advances to box 1120 where the selected gear sensor 7 is used to monitor the movement of a gear shift member such as the shift cylinder 3A and in box 1125 it is determined whether the gear shift lever is being moved in the same plane (the %PWM signal is substantially constant), in an up gear direction corresponding to an upshift (the %PWM signal is increasing) or in a down gear direction corresponding to a downshift (the %PWM signal is decreasing). Based upon this determination the method advances to box 1200 if there is no change in-plane, to box 1130 if it is an upchange and to box 1140 if it is a downchange.

In box 1130 it is checked whether an upchange inter-plane check point has been passed and, if so, the method advances to box 1150 but, if not, loops back to 1120. Similarly in box 1140 it is checked whether a downchange inter-plane check point has been passed and, if so, the method advances to box 1150 but, if not, loops back to 1120.

Boxes 1130 and 1140 allow for the use of different upchange and downchange inter plane check points but it will be appreciated if the same check points are used irrespective of gear change direction the method could advance from box 1120 to a box checking whether any inter plane check points have been passed and then, if they have, onto box 1150 but, if they have not, back to 1120.

In box 1150 an interim future gear shift lever plane based upon the check point passed is provided to any systems requiring knowledge of whether the next gear is likely to be higher or lower than the previously engaged gear. This may be a multi-stage step with the information being updated as various inter-plane check points are passed until in box 1200 a pull-in point is passed. That is to say, if the test in box 1200 is failed, the method could alternatively loop back to step 1150 and not as shown to box 1120.

Continuing now with box 1200 it is determined whether a pull-in point that is to say, an in-plane check point, has been reached. The in-plane check points EPI, OPI are used as before to determine whether the gear to be selected is an odd one or an even one. If a pull-in point has not been reached the method loops back to 1120 and, if a pull-in point has been reached, the method advances to box 1300 where the gear shift lever plane is determined and it is determined whether the pull-in point reached is for an odd gear or an even gear.

Then in boxes 1600 and 1700 the determined gear shift plane from box 1300 that the gear lever 11 currently resides in is combined with the pull-in direction knowledge to produce a prediction of the next selected gear.

Then in box 1800 this prediction is provided to any systems requiring this information.

The method then advances to box 1900 where it is determined whether a Key-off event has occurred, if it has the method ends at box 2000 and if it has not the method continues to box 1950 where the gear actually selected is stored for future use and then this information is provided in box 1960 to the systems requiring the gear state knowledge as a confirmation of the prediction supplied in box 1800.

The method then continues to box 1970 where the driver re-engages the clutch 10 and then pauses at box 1970 until the driver next disengages the clutch 10 at which point in time it moves back to box 1110 to start the method again.

It will be appreciated that the two embodiments of a method for predicting a next to be engaged gear described above are provided by way of example and that the invention is not limited to the specific steps disclosed or the order in which the steps are performed.

Referring now to Fig.8D there is shown a predictive gear sensor forming part of a third embodiment of a predictive gear sensing system that could be used to replace the two preferred embodiments described above.

In this case the motion of the shift lever 11 is monitored using a large number of separate sensors SR, S1, S2, S3, S4, S5, S6; PR, P1, P2, P3, P4, P5 and P6. The gear lever has a magnetic target (not shown) attached to it and when it passes by or is in close proximity to one of the sensors SR, S1, S2, S3, S4, S5, S6; PR, P1, P2, P3, P4, P5 and P6 magnetic coupling occurs which is monitored by the transmission state module 5 so as to form a predictive gear sensing system.

There are two types of sensor shown, the first type SR, S1, S2, S3, S4, S5 and S6 each provide a signal that can be used to indicate when the transmission 3 is fully in the respective gear with which they are associated and the second type PR, P1, P2, P3, P4, P5 and P6 are check point sensors that provide a signal that can be used to indicate when the transmission 3 is almost in-gear. That is to say, the second type of sensor are used to indicate when the pull-in points referred to above have been reached but not only provide an indication of whether the gear to be engaged is odd or even also provide the plane information so that they are definitive of the gear to be engaged. In Fig.8D the shift lever 11 is shown in a first gear selected position 11G and in a neutral position 11N.

If a gear shift from first gear to second gear were to take place then the signal from the sensor S1 would first indicate that the shift lever 11 has been moved from an in-gear position, the sensor P1 would then indicate that the shift lever 11 is continuing to move towards neutral, then the sensor P2 would indicate that it is second gear that is to be engaged and finally the sensor S2 would confirm that second gear has been engaged. The second type of sensor therefore provides a prediction of the gear to be engaged before it is actually engaged.

It will be appreciated that further sensors (not shown) could be located between the planes of the H-gate to provide feedback of between plane movement thereby providing information similar to that provided by the check points R/1b, 1/2b, 3/4b and 1/2a, 3/4a, 5/6a shown on Fig.8A.

As referred to briefly above one of the uses of a predictive gear sensing system is for gear shift harmonisation (GSH) which is used to improve the shift quality of a transmission.

The use of such a predictive gear sensing system provides more time in which to harmonise or synchronise the engine speed with the speed of the input 3i to the transmission 3.

In a manual transmission arrangement as soon as the clutch 10 is disengaged there is no relationship between the speed of the engine 2 and the input speed of the transmission 3 and even if a speed sensor is fitted to the input 3i of the transmission 3 it will not provide specific information until a gear is actually engaged that is to say, to change gear neutral has to be traversed and during this period of time the final speed of the input 3i to the transmission 3 is not known. Therefore the only time available for adjusting engine speed is the time after the gear is actually engaged while the driver is engaging the clutch 10.

However, in accordance with this invention the next to be engaged gear is predicted using a predictive gear sensing system so that more time is provided in order to synchronise the speed of the engine output 2a with the input 3i to the transmission thereby improving the quality of the gear shift.

In accordance with this invention the required synchronising speed is known before the gear is actually engaged either when a pull-in check point is passed or when an inter plane or between plane check point is traversed thereby providing more time to adjust the engine speed to the required speed.

Referring now to Fig.9 there is shown a chart referencing engine speed against vehicle speed for the motor vehicle 1 shown in Fig.1.

The line X-X shows for a vehicle speed of 80 kph the various engine speeds 2g-6g for second through sixth gear. The engine speed for first gear at this vehicle speed is above the maximum permitted engine speed of 7000RPM for the engine 2 and so is not shown.

From Fig.9 it can be seen that the corresponding engine speeds are:-

Second gear	(2g)	= 5333RPM	(15kph/1000RPM)
Third gear	(3g)	= 4000RPM	(20kph/1000RPM)
Fourth gear	(4g)	= 3200RPM	(25kph/1000RPM)
Fifth gear	(5g)	= 2667RPM	(30kph/1000RPM)
Sixth gear	(6g)	= 1600RPM	(50kph/1000RPM)

Therefore if a change from fourth gear to fifth gear is required the engine speed will need to be adjusted down from 3200 to 2667RPM and if the change is from fourth gear to third gear the engine speed will need to be adjusted up from 3200 to 4000RPM.

Operation of system for improving the shift quality of a manual transmission in accordance with this invention therefore operates in the following manner.

The powertrain control module 4 receives inputs from the various sensors and in particular from the vehicle speed sensor 9v, the engine speed sensor 9e and the selected gear sensor 7 which forms with the transmission state module 5 a predictive gear sensing system.

The speed of the motor vehicle 1 is used to provide an estimate of the required engine speed and is continually monitored and updated. It will be appreciated that other means for providing vehicle speed information could be used as an input of vehicle speed such as, for example, global positioning system (GPS) information and that the invention is not restricted to the use of a vehicle speed sensor.

The transmission state module 5 is operable to provide to the engine control unit 6 information concerning the predicted next to be engaged gear in the manner described above and the engine control unit 6 uses this information to adjust the engine speed to the required engine speed based upon information regarding the current vehicle speed. It will be appreciated that the vehicle speed may vary slightly during a gear shift and that the engine control unit 6 may be operable to fine tune or update the required engine speed during the gear shift from the time the first prediction of next to be engaged gear is received until the gear is fully engaged and the clutch 10 is being engaged. In this way errors in the synchronisation speed are reduced to a minimum and a smooth take up of the drive can be assured.

Although for shift quality and clutch durability purposes the speed of the engine 2 should be synchronised to the input speed of the transmission 3 such that the required engine speed equals the transmission input speed at the end of the gear shift when the clutch 10 is fully engaged, the required engine speed may, if required, be set to other values. For example, in the case of an upchange, the required engine speed may be set slightly higher than the transmission input speed if the vehicle is accelerating so as to continue the momentum of the motor vehicle 1 and if the motor vehicle 1 is sensed to be slowing the required engine speed may be set slightly lower.

It will also be appreciated that in other embodiments the information supplied to the engine control unit 6 could be the required engine speed and that, in such a case, the engine control unit 6 simply provides the control functionality to drive the engine speed to the required speed.

Therefore in summary, a system for improving the shift quality of the manual transmission 3 of the motor vehicle 1 comprises the engine 2 to provide drive to the transmission 3 via the clutch 10, a gear sensor 7 to provide information indicative of the engagement state of the transmission 3 to the powertrain control module 4 and in particular to the transmission state module 5, an engine control unit 6 to control and adjust the speed of the engine 2 and a source of information indicative of the speed of the motor vehicle 1 for use by the powertrain control module 4.

The powertrain control module 4 is operable to determine that a gear shift has commenced based upon a signal received from the gear sensor 7 or one of the gear sensors PR and P1 to P6 indicating that a gear has been disengaged. That is to say, the pull-in check points can be used in this case to indicate that a gear change is occurring. This is achieved by noting when a pull-in check point for the same gear or same row as the gear previously engaged is traversed. For example, if the transmission is in second gear and depending upon the construction of the gear sensor either the second gear pull-in check point or the even gear pull-in check point is traversed then it is known that a gear change is occurring.

The powertrain control module 4 is further operable during the gear shift in response to predicted next to be engaged gear information received from the predictive gear sensor system and vehicle speed information received, in this case, from the speed sensor 9v to adjust the speed of the engine 2 to an engine speed required at the end of the gear shift to match the speed of the input 3i of the transmission 3.

A predictive gear sensing system as meant herein is a system having a gear sensor for sensing operation of part of a gear selection apparatus and providing information in the form of one or more signals that can be interpreted by an electronic processor to provide a prediction of a next to be engaged gear during a gear shift before a gear is actually engaged.

With reference to Fig.12 there is shown a first embodiment of a method for improving the shift quality of the manual transmission 3 of the motor vehicle 1.

The method starts at box 500 with a key-on event and then advances to box 510 where a currently engaged gear is read from a memory device. The method then advances to box 520 where the method proper starts with a check as to whether a gear has been disengaged. When the motor vehicle 1 is first started the transmission 3 will normally be in neutral and the method will continue to cycle around the loop 510 to 520 until eventually a gear has been engaged and is subsequently disengaged.

If it is determined from the transmission state module 5 that a gear has been disengaged then in box 530 the gear status is checked by, for example, receiving an input from box 180 shown on Fig.10. That is to say, box 530 comprises reading information received from the transmission state module 5 and then in box 540 it is determined which is the predicted next to be engaged gear which is supplied to the engine control unit 6 for use in calculating the required engine speed in box 550.

The method then advances to box 550 where the required engine speed is calculated based upon the prediction of the next to be engaged gear and the current speed of the motor vehicle 1 and in box 560 the speed of the engine 2 is adjusted by the engine control unit 6 to match the required engine speed.

The method then advances to box 570 where it is determined whether a gear has actually been engaged. If a gear has not been engaged the method loops back to box 550 but, if a gear has been engaged, the engaged gear status is updated by in this case reading an input from box 196 on Fig.10 confirming which gear has actually been engaged and storing this information so that it can be read in box 510.

Knowledge of the current gear can be used in some embodiments to determine the factor that needs to be applied to vehicle speed to obtain the required engine speed. That is to say, when the clutch is fully engaged the engine speed can be obtained from the engine speed sensor 9e and the vehicle speed can be obtained from vehicle speed sensor 9v and so the overall ratio of engine speed to vehicle speed for that gear can be calculated. Such a technique also provides an opportunity to confirm the integrity of the signals from the two sensors 9e, 9v by comparing the result with a value achieved by knowledge of the gear ratios of the transmission 3 and the final drive ratio of the motor vehicle 1 including the rolling radius of the wheel 'W'.

Then in box 590 the method comprises in most cases fine tuning the engine speed by repetitively recalculating the required engine speed to account for any slight changes in vehicle speed and making small adjustments via the engine control unit 6.

If for some reason the gear finally engaged is not the same as the predicted gear then the fine tuning will actually be the adjusting of the engine speed to the required speed based upon the gear actually engaged as per the prior art 'sensed gear' method.

If the speed of the motor vehicle 1 is constant during this period of time then no fine tuning adjustments will be required. This process continues until the driver engages the clutch 10 as indicated in box 600. Note that the time available for fine tuning is approximately the same as the time available for the prior art 'sensed gear' GSH method where the harmonisation is done in the time span between gear engagement and clutch engagement.

In the case of a method according to this invention, the required speed is already known based upon the predicted next to be engaged gear by the time gear engagement occurs and adjustments have commenced to attain this required speed, the engine speed adjustment therefore required during fine tuning is normally relatively small thereby ensuring that the required speed can be more reliably and accurately achieved.

After the clutch is engaged the method advances to box 610 where it is checked whether a Key-off event has occurred and, if it has, the method ends at box 750 but, if it has not, the method returns to box 510 ready for the next gear shift.

With reference to Fig.13 there is shown a second embodiment of a method for improving the shift quality of the manual transmission 3 of the motor vehicle 1. The difference between this method and the method previously described is that this method uses both in-plane check points such as pull-in points and between or inter-plane check points that is to say it uses a predictive gear sensing system that operates in a manner similar to that shown in Fig.11.

The method starts at box 1500 with a key-on event and then advances to box 1510 where a currently engaged gear is read from a memory device. The method then advances to box 1520 where the method proper starts with a check as to whether a gear has been disengaged. When the motor vehicle 1 is first started the transmission 3 will normally be in neutral and the method will continue to cycle around the loop 1510 to 1520 until eventually a gear has been engaged and is subsequently disengaged.

If it is determined from the transmission state module 5 that a gear has been disengaged then in box 1530 the gear status is checked by for example receiving an input from box 1150 shown on Fig.11. This prediction is based upon the use of a between gear sensor and so does not provide information about the exact next gear to be engaged only whether it is likely to be a higher gear or a lower gear. In such a case it is assumed that in the case of an upshift the next to be engaged gear will be one gear higher than that previously engaged and in the case of a downshift that the next to be engaged gear will be one gear lower than the previously engaged gear.

For example, if the previously engaged gear was third gear then for a down shift it will be assumed the next to be engaged gear is second gear even though it could be first gear. Similarly, in the case of an upchange from second gear it will be assumed that the next to be engaged gear will be third gear even though it could be any one of the higher gears.

Box 1530 also receives an input such as that from box 1800 on Fig.11 so that if the gear shift is a same plane shift the check point will be an in-plane check point such as a pull-in point.

That is to say, box 1530 comprises reading information received from the transmission state module 5 and then using this in box 1540 to determine which is the predicted next to be engaged gear.

Then in box 1550 the required engine speed is calculated based upon the prediction of the next to be engaged gear and the current speed of the motor vehicle 1 and then in box 1560 the speed of the engine 2 is adjusted by the engine control unit 6 to match the required engine speed.

The method then advances to box 1570 where it is determined whether a gear has actually been engaged and if not the method loops back to box 1530 but if a gear has been engaged, the engaged gear status is updated by in this case reading an input from box 1960 on Fig.11 confirming which gear has actually been engaged and storing this information so that it can be read in box 1510.

If a gear has been engaged the method advances to box 1590 where fine tuning the engine speed by repetitively recalculating the required engine speed to account for any slight changes in vehicle speed and making small adjustments via the engine control unit 6. This process continues until the driver engages the clutch 10 as indicated in box 1600.

As discussed above, the time available for fine tuning is approximately the same as the time available for the prior art 'sensed gear' GSH method where the harmonisation is done in the time span between gear engagement and clutch engagement.

One advantage of a method according to this invention is that the required speed is already known based upon the predicted next to be engaged gear and adjustments have commenced to attain this required speed prior to gear engagement and only fine tuning is required during the time period between gear engagement and clutch engagement thereby ensuring that the required speed can more reliably and accurately be achieved.

After the clutch 10 is engaged the method advances to box 1610 where it is checked whether a Key-off event has occurred and, if it has, the method ends at box 1750 but, if it has not, the method returns to box 1510.

If in box 1570 the gear has not been engaged, that is to say, only a between plane check point has been traversed then the method loops back to box 1530 to check whether any of the in-plane check points such as the pull-in point check points have been traversed.

It is only when such an in-plane check point is traversed that the predicted next to be engaged gear is known, prior to this the prediction is based upon the one gear higher or one gear lower assumption referred to above. The predicted next to be engaged gear is then used in box 1550 to calculate the required engine speed and in box 1560 the engine speed is adjusted to the required engine speed returning to box 1570 to retest whether confirmation that a gear has been engaged has been received.

For example, assuming that the motor vehicle is travelling at 80kph as shown on Fig. 9, that the transmission is in fifth gear and that the driver actually makes a down shift to third gear then the method will operate in the following manner. The first time the method executes the steps 1530 through 1570 only a between plane check point such as check point 5/6a on Fig.8A will have been traversed. As discussed above it will be assumed that the down shift is to fourth gear and so the engine speed will be adjusted in box 1570 to 3200RPM. Then in box 1570 no gear will have been engaged and so the method will re-execute the steps 1530 through 1570 until at some time an in-plane check point, such as the check point 3a on Fig.8A, is traversed at which time the engine speed will be adjusted to an engine speed required for third gear namely 4000RPM. This change in engine speed from 3200 to 4000 is small compared to the change in engine speed between the original engine speed of 2667RPM for fifth gear and that for third gear of 4000RPM which would be required if the between plane estimation had not been used.

Following the traversing of an in-plane check point the engagement of gear will follow and so at that time the method will then continue from box 1570 to box 1580 and the method will proceed as described above.

It will be appreciated that the two embodiments of a shift quality improvement method described above are provided by way of example and that the invention is not limited to the specific steps disclosed or the order in which the steps are performed

In summary, both of the described shift quality improvement methods have the advantage that a prediction of the next to be engaged gear is used to start the engine speed harmonisation process before a gear is actually engaged thereby providing more time in which to achieve the required engine speed for harmonisation.

It will be appreciated by those skilled in the art that although the invention has been described by way of example with reference to one or more embodiments it is not limited to the disclosed embodiments and that one or more modifications to the disclosed embodiments or alternative embodiments could be constructed without departing from the scope of the invention as set out in the appended claims.

Claims

1. A method for improving the shift quality of a manual transmission of a motor vehicle having an engine driving the transmission via a clutch wherein the method comprises, predicting during a gear shift using a predictive gear sensing system a next to be engaged gear, determining, based upon the predicted next to be engaged gear and vehicle speed, an engine speed required at the end of the gear shift and adjusting the speed of the engine to the required engine speed.

2. A method as claimed in claim 1 wherein the method further comprises determining when a gear is engaged whether the gear engaged is the same as the predicted next to be engaged gear and, if the gear engaged is different to the predicted next to be engaged gear, adjusting the engine speed based upon the gear engaged and the current vehicle speed.

3. A method as claimed in claim 2 wherein, if the gear engaged is the same as the predicted next to be engaged gear, the method further comprises determining an updated engine speed based upon the current vehicle speed and adjusting the engine speed to achieve the updated engine speed.

4. A method as claimed in any of claims 1 to 3 wherein the next predicted to be engaged gear is based upon the sensing by a gear sensor that one or more check points associated with a gear shift mechanism of the transmission have been traversed.

5. A method as claimed in any of claims 1 to 4 wherein a gear shift commences when one gear is disengaged and ends when another gear and the clutch are engaged.

6. A system for improving the shift quality of a manual transmission of a motor vehicle wherein the system comprises an engine to provide drive to the transmission via a clutch, a predictive gear sensing system to provide information indicative of the engagement state of the transmission, a controller to control the speed of the engine and an input to the electronic controller to provide information indicative of the speed of the motor vehicle wherein, the electronic controller is operable during a gear shift in response to predicted next to be engaged gear information received from the predictive gear sensing system and the vehicle speed information to adjust the speed of the engine to an engine speed required at the end of the gear shift.

7. A system as claimed in claim 6 wherein the electronic controller is further operable to determine when a gear is engaged whether the gear engaged is the same as the predicted next to be engaged gear and, if the gear engaged is different to the predicted to be engaged gear, adjust the engine speed based upon the gear engaged and the current vehicle speed.

8. A system as claimed in claim 7 wherein, if the gear engaged is the same as the predicted next to be engaged gear, the electronic controller is operable to determine an updated engine speed based upon the current vehicle speed and adjust the engine speed to achieve the updated engine speed.

9. A system as claimed in any of claims 6 to 8 wherein the next predicted to be engaged gear information comprises the sensing by the gear sensor that one or more check points associated with a gear shift mechanism of the transmission have been traversed.

10. A system as claimed in any of claims 6 to 9 wherein a gear shift commences when one gear is disengaged and ends when another gear and the clutch are engaged.

11. A system as claimed in any of claims 6 to 10 wherein the electronic controller comprises a transmission state module to receive and process one or more signals from the gear sensor and an engine control unit operatively connected to the transmission state module and arranged to adjust the speed of the engine during a gear change.

12. A system as claimed in any of claims 6 to 11 wherein the vehicle speed input is from a vehicle speed sensor.

13. A motor vehicle having a manual transmission and a system for improving gear shift quality of the manual transmission as claimed in any of claims 6 to 12.

14. A method for improving the shift quality of a manual transmission of a motor vehicle substantially as described herein with reference to the accompanying drawing.

15. A system for improving the shift quality of a manual transmission of a motor vehicle substantially as described herein with reference to the accompanying drawing.

16. A motor vehicle substantially as described herein with reference to the accompanying drawing.

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Application No: GB1110203.5 **Examiner:** Mr Patrick Phillips

Claims searched: 1 - 13 **Date of search:** 13 October 2011

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
Y	1, 5, 6, 10, 12, 13	US 5830104 A (DESAUTELS) WPI Abstract (a/n 1997-145505 [13]).
Y	1, 5, 6, 10, 12, 13	JP 63270253 A (KOMATSU) EPODOC Abstract.

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X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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Field of Search:

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B60W; F16H

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC

International Classification:

Subclass	Subgroup	Valid From
F16H	0063/50	01/01/2006
B60W	0010/06	01/01/2006
F16H	0059/44	01/01/2006
F16H	0061/02	01/01/2006