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Other: **WPI; EPODOC; TXTE**

(54) Title of the Invention: **Selected gear determination by multiple thresholds**
Abstract Title: **A predictive gear sensing system for a manual transmission**

(57) A predictive gear sensing system is disclosed in which the axial and rotary position of a gear shift selector member 3A is sensed by axial and rotary sensors formed as a single 2D magnetic selected gear sensor array 7. Signals indicative of the rotary and axial position of the gear shift selector member 3A are provided to an electronic processing unit 5 from the 2C sensor array 7 and the electronic processing unit 5 provides an output of a predicted next to be engaged gear based upon the signals received from the 2D sensor array 7.

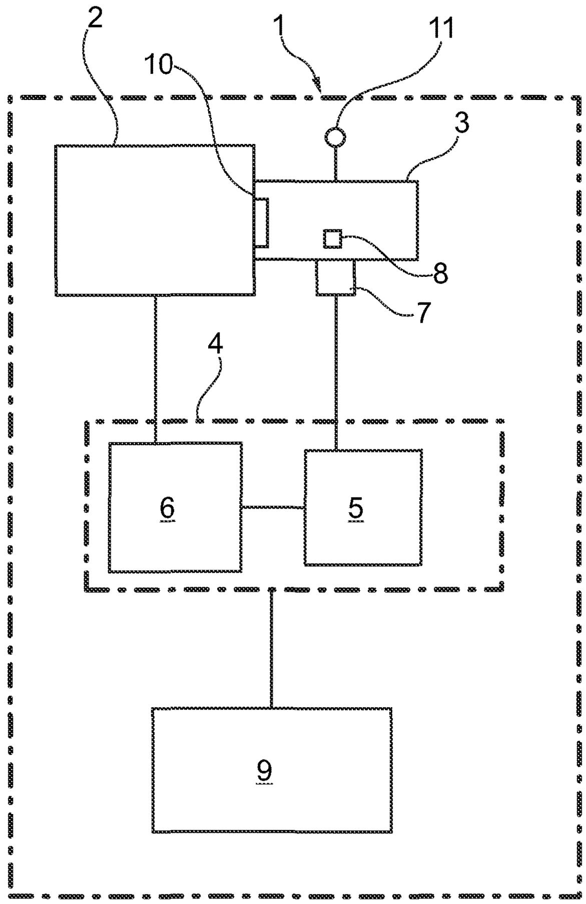

Fig. 1

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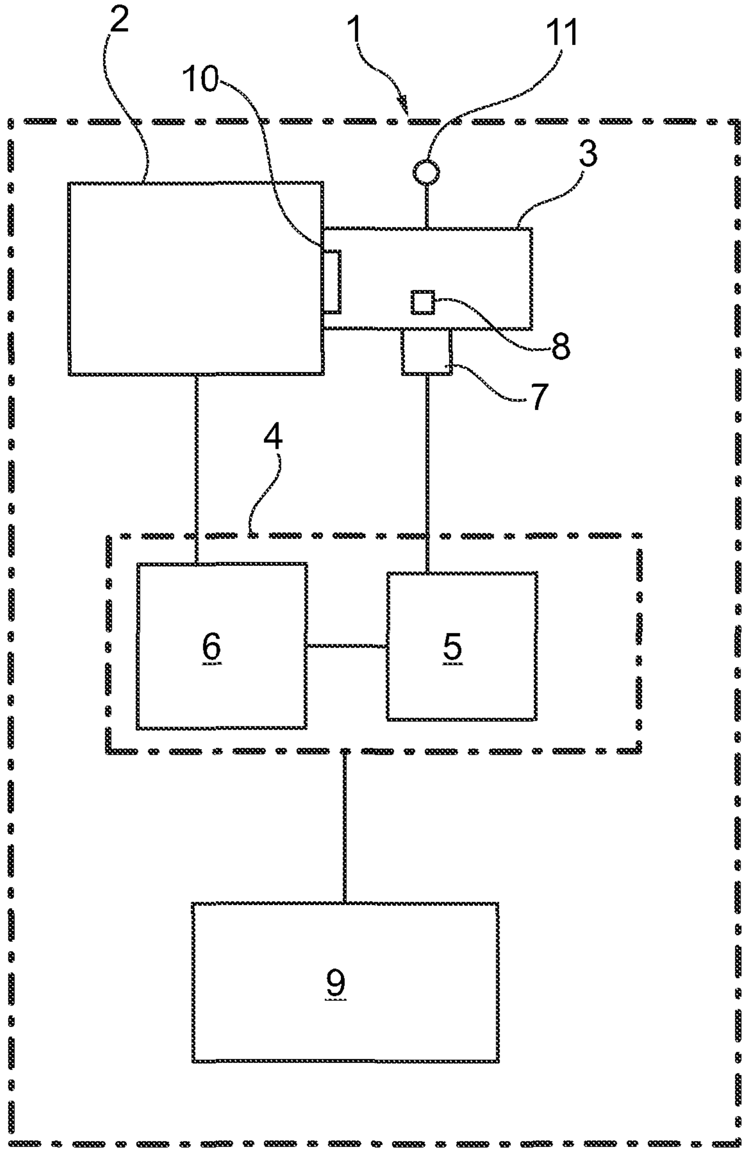

Fig. 1

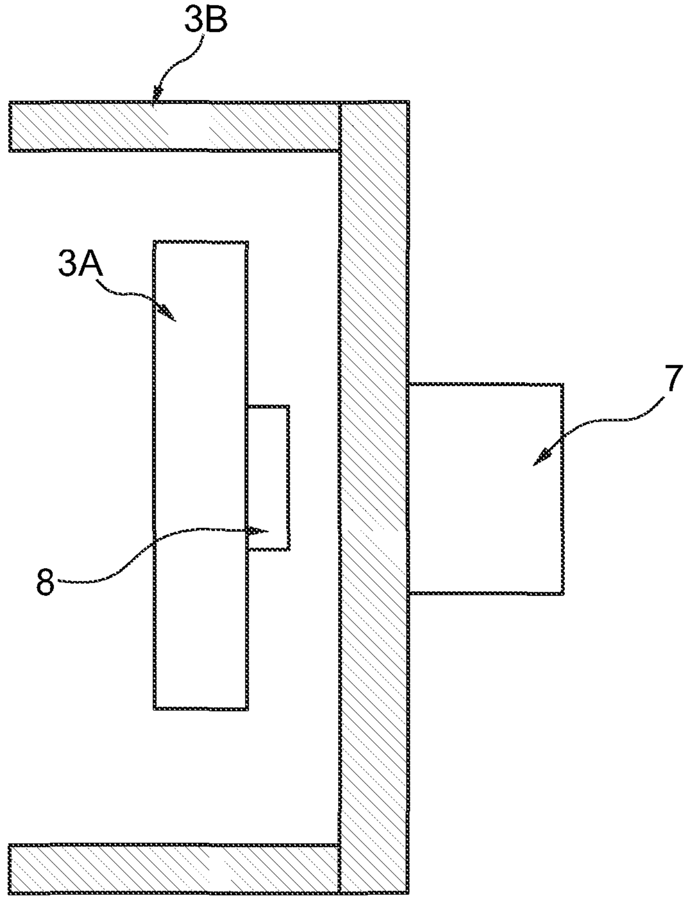

Fig. 2A

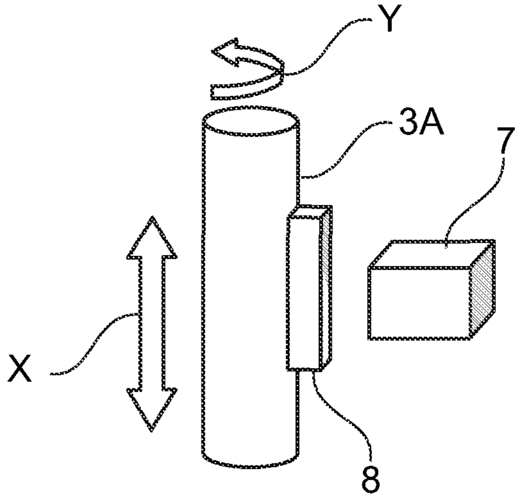

Fig. 2B

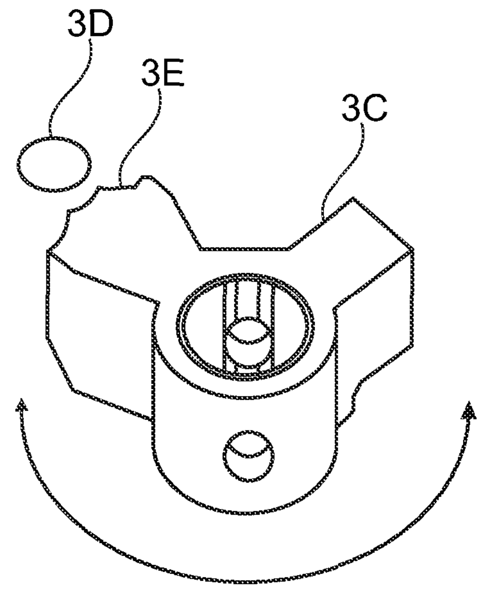

Fig. 3A

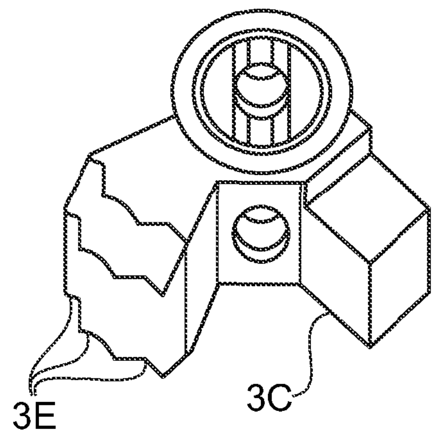

Fig. 3B

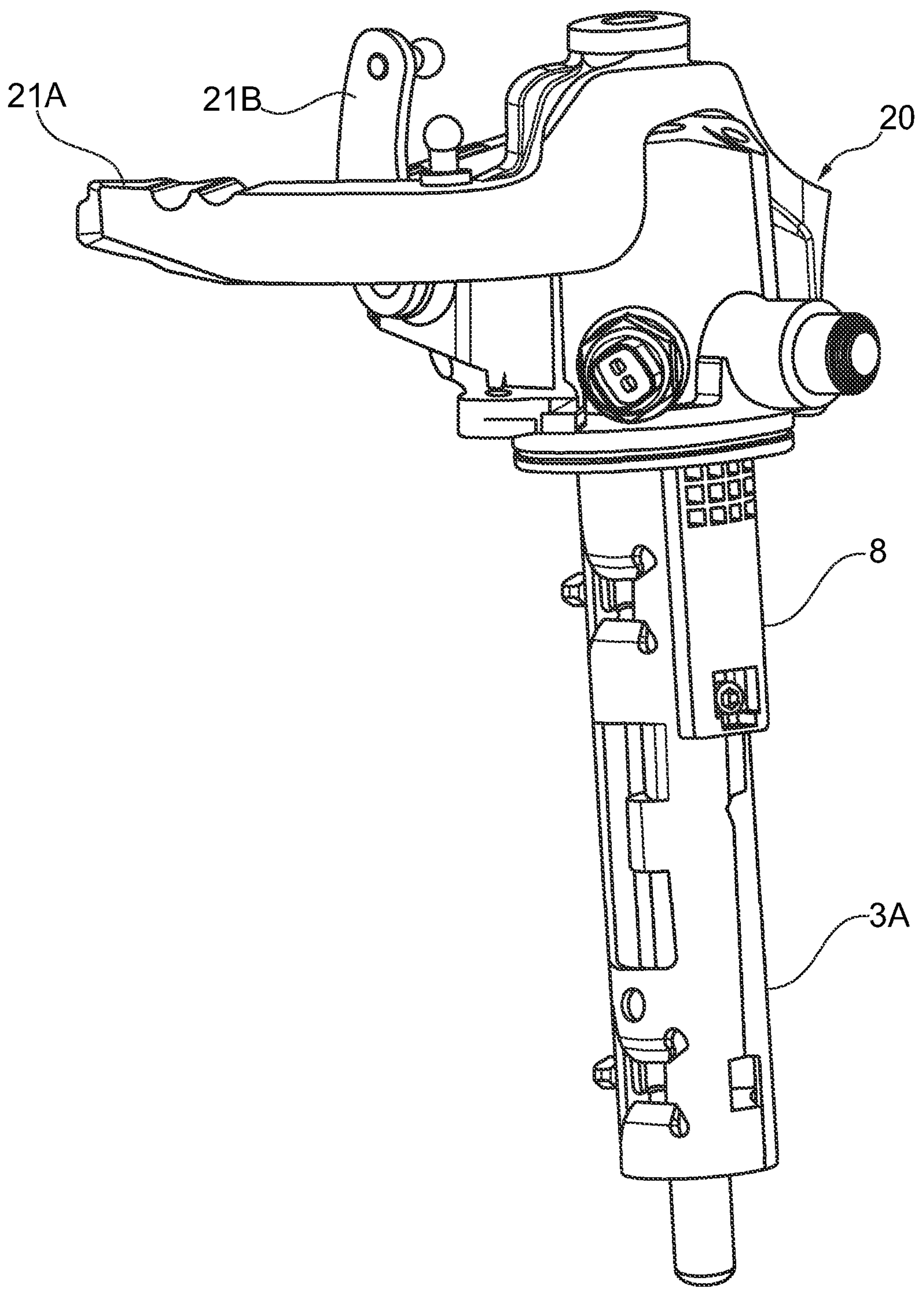

Fig. 4

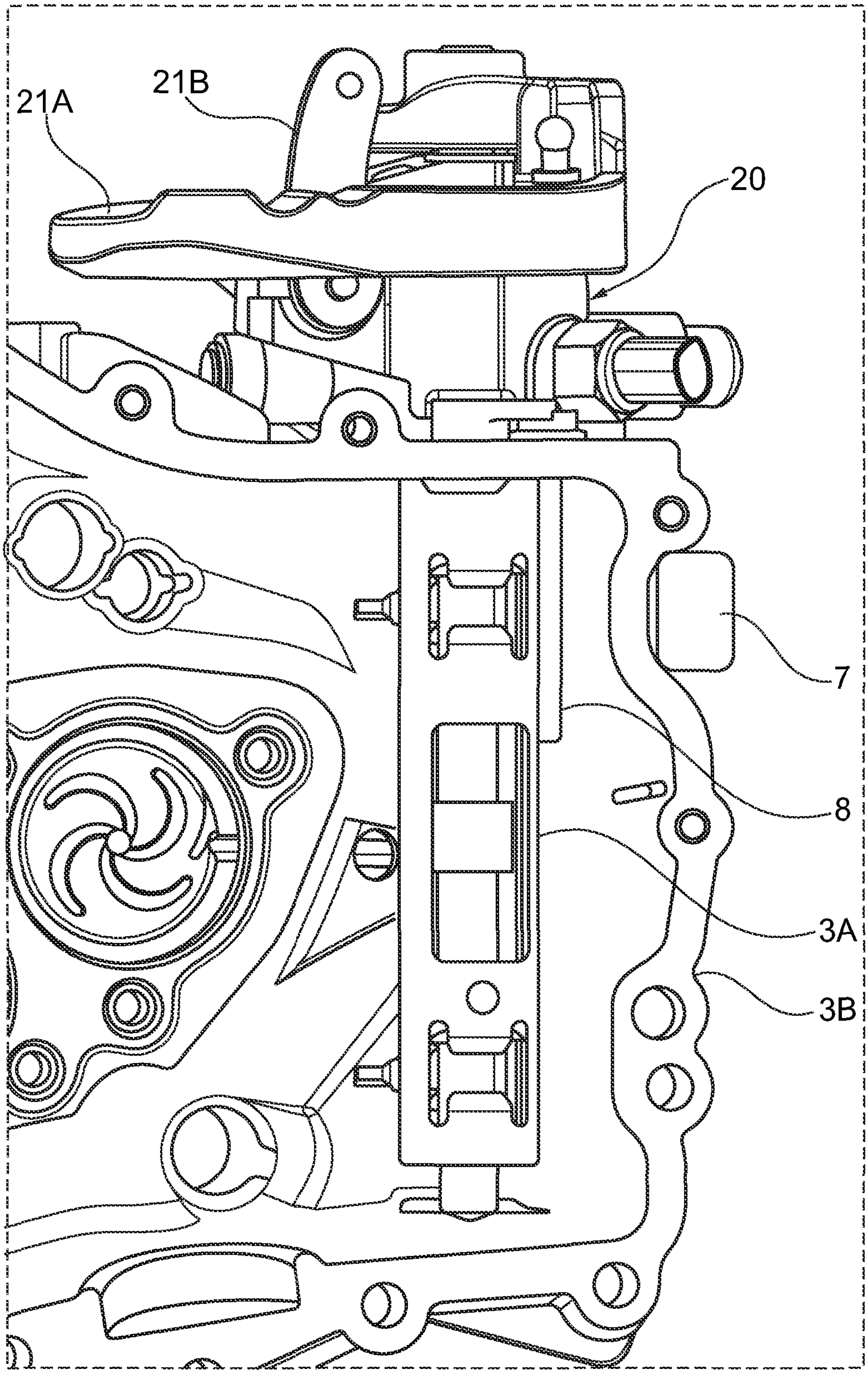

Fig. 5

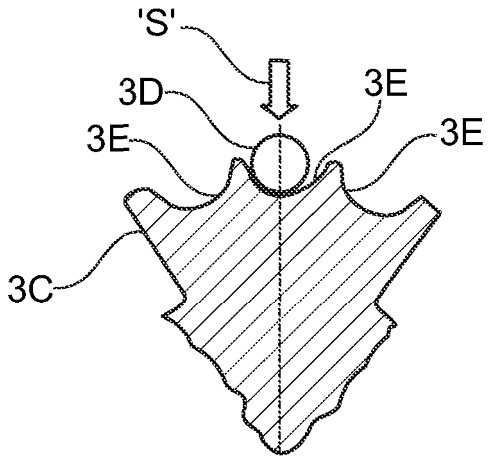

Fig. 6A

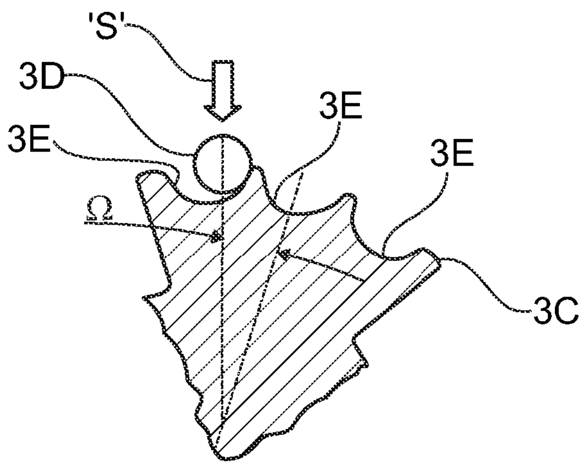

Fig. 6B

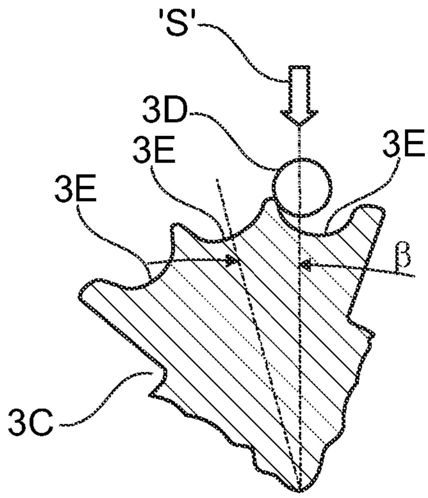

Fig. 6C

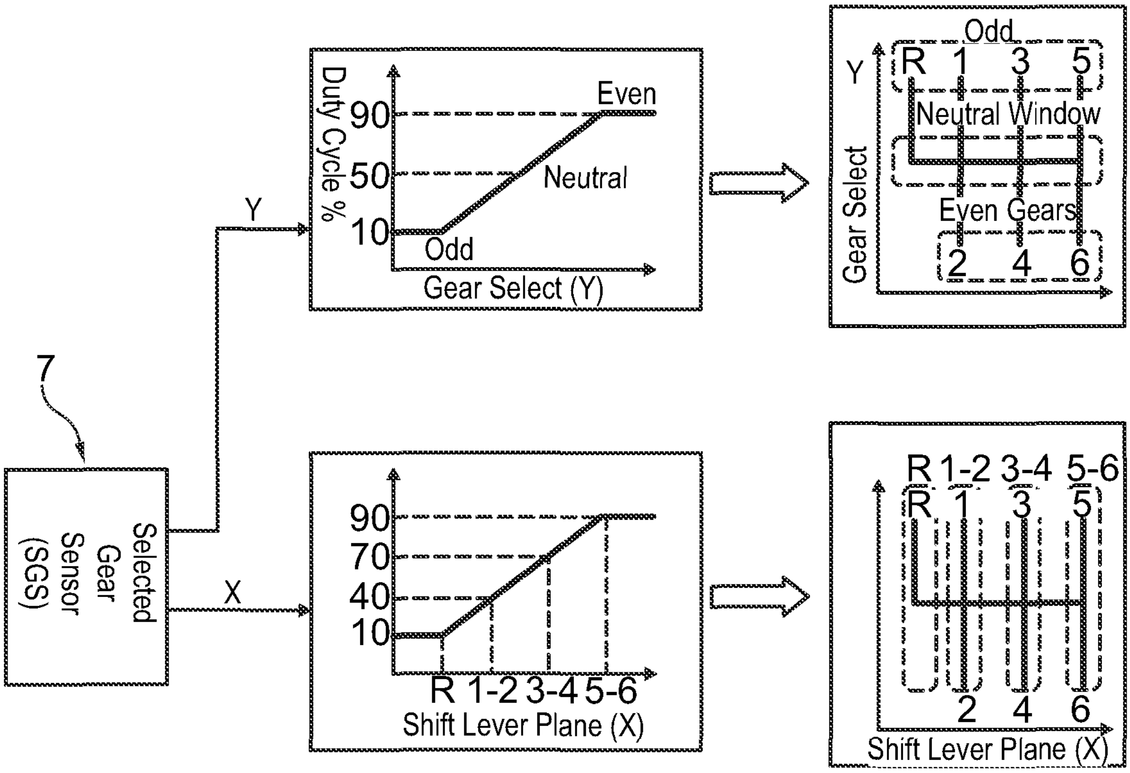
7
Selected Gear Sensor (SGS)
Y
X
Duty Cycle %
90
50
10
Even
Neutral
Odd
Gear Select (Y)
Y
Odd
R 1 3 5
Neutral Window
Gear Select
Even Gears
2 4 6
90
70
40
10
R 1-2 3-4 5-6
Shift Lever Plane (X)
R 1-2 3-4 5-6
R 1 3 5
2 4 6
Shift Lever Plane (X)

Fig. 7A

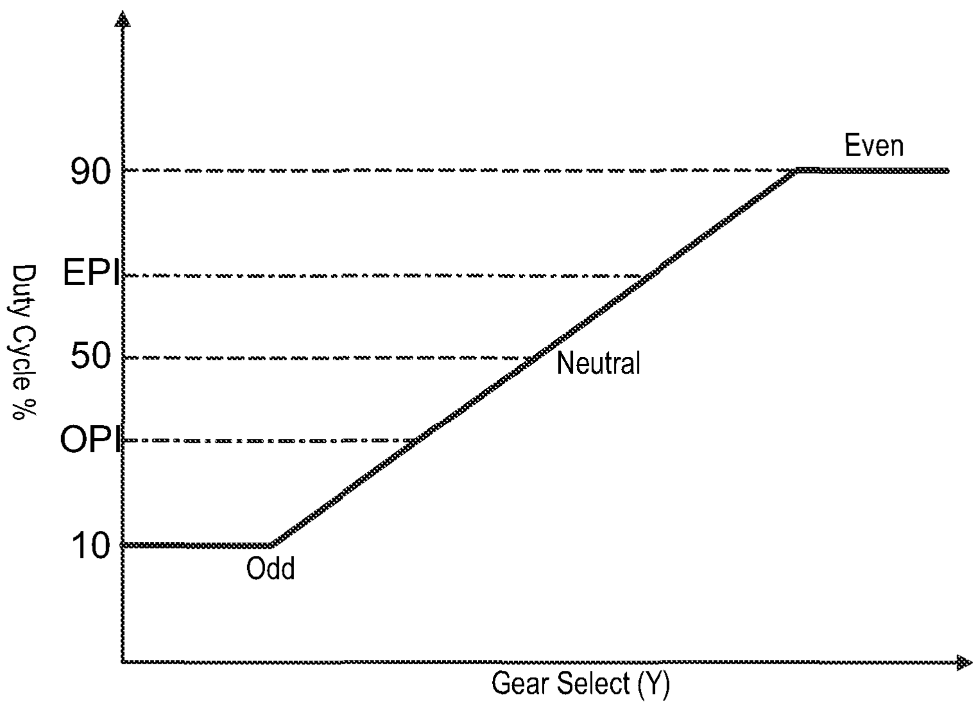
Duty Cycle %
90
EPI
50
OPI
10
Even
Neutral
Odd
Gear Select (Y)

Fig. 7B

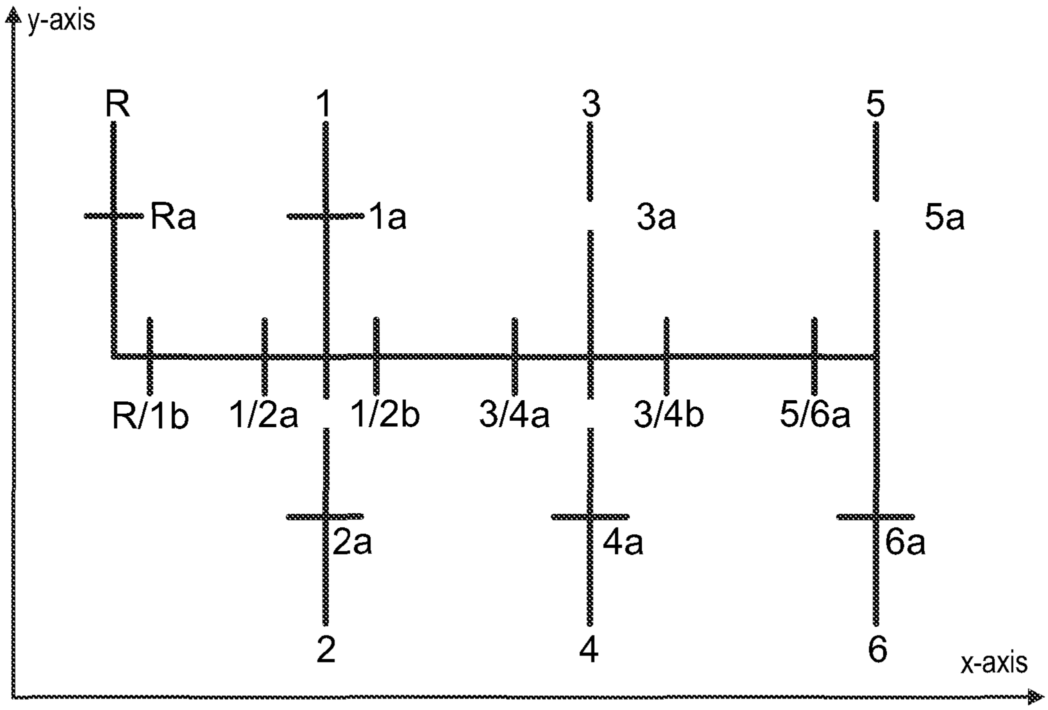

Fig. 8A

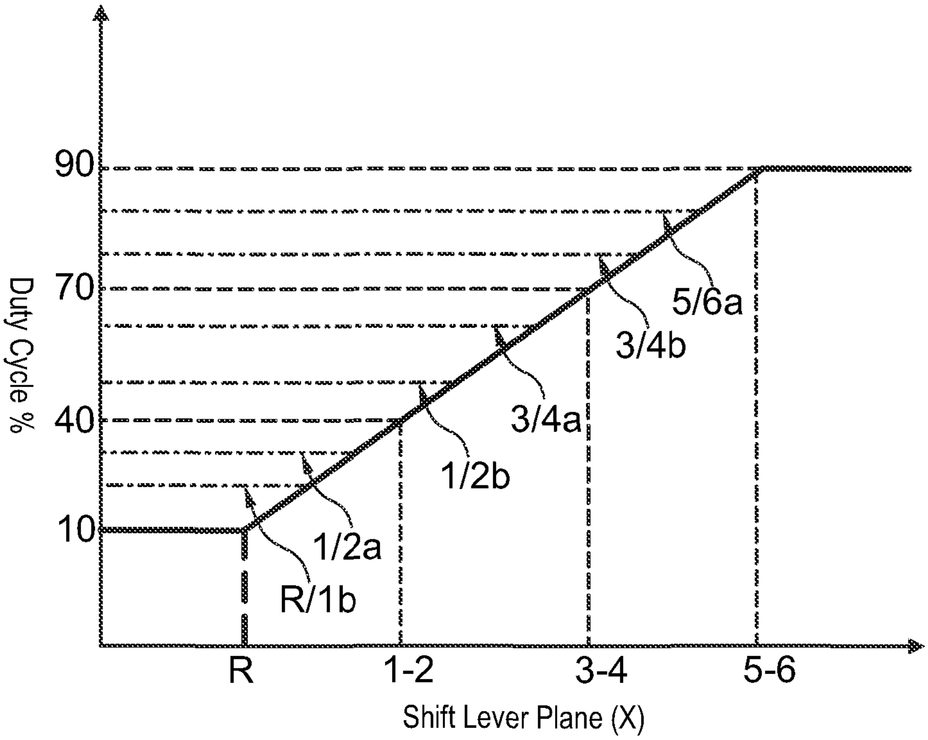
90
70
40
10
Duty Cycle %
5/6a
3/4b
3/4a
1/2b
1/2a
R/1b
R
1-2
3-4
5-6
Shift Lever Plane (X)

Fig. 8B

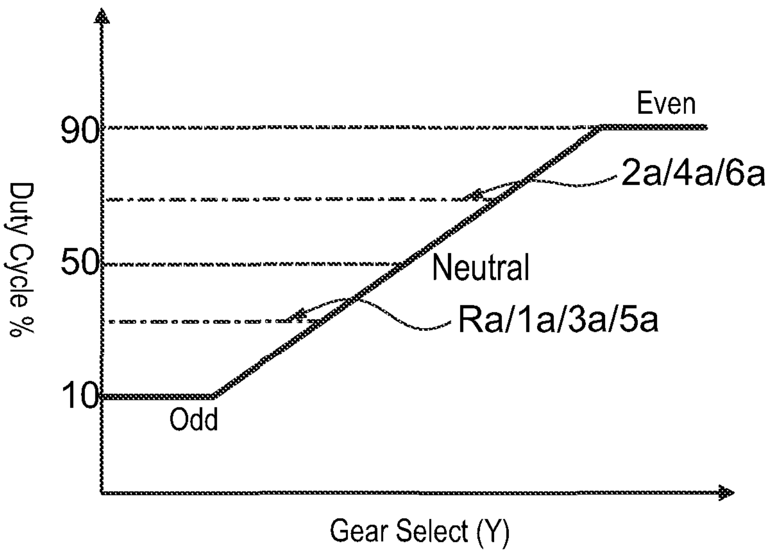
Even
90
2a/4a/6a
50
Neutral
Ra/1a/3a/5a
10
Odd
Duty Cycle %
Gear Select (Y)

Fig. 8C

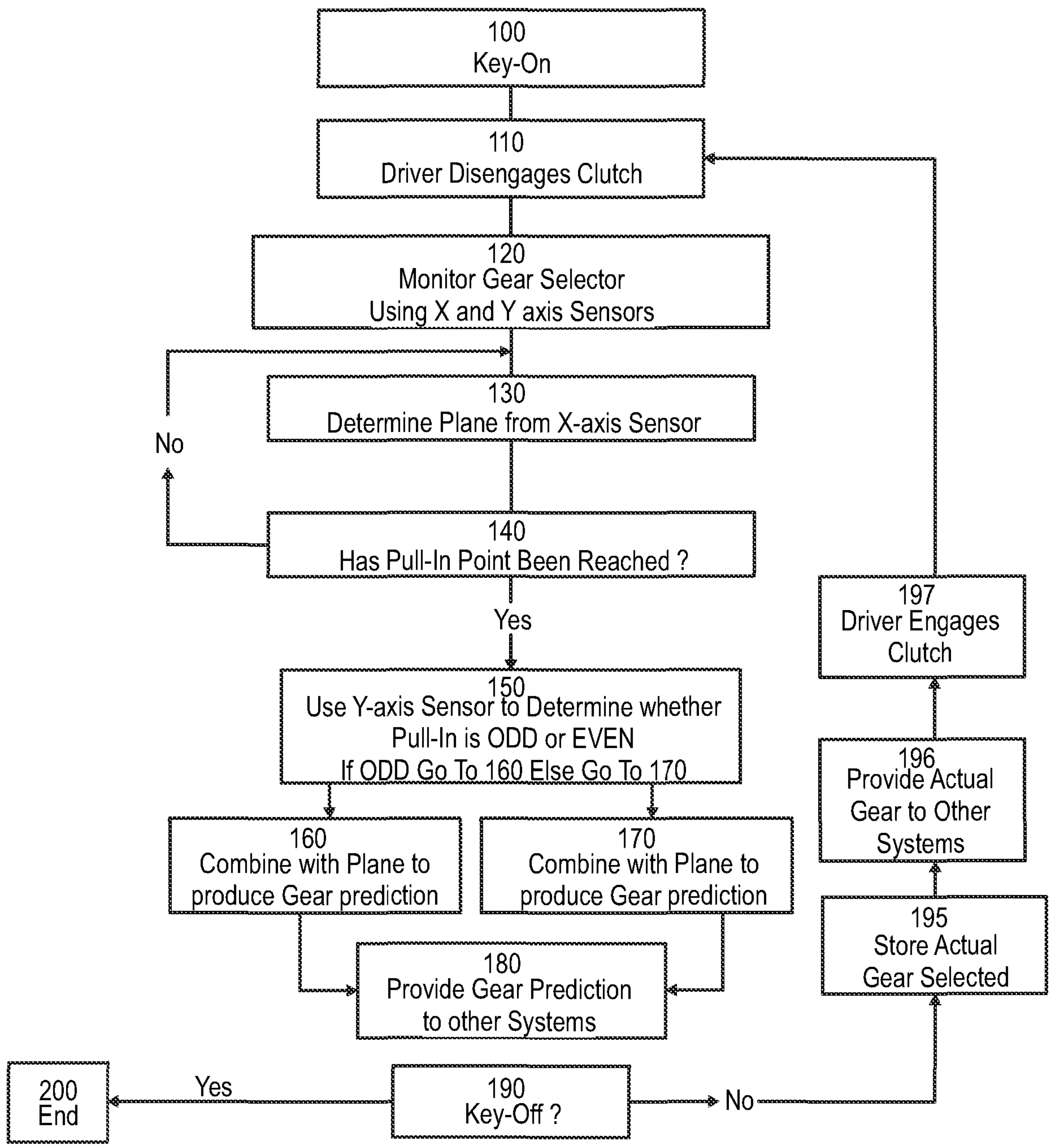
100
Key-On
110
Driver Disengages Clutch
120
Monitor Gear Selector
Using X and Y axis Sensors
130
Determine Plane from X-axis Sensor
No
140
Has Pull-In Point Been Reached ?
Yes
150
Use Y-axis Sensor to Determine whether
Pull-In is ODD or EVEN
If ODD Go To 160 Else Go To 170
160
Combine with Plane to
produce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

Fig. 9

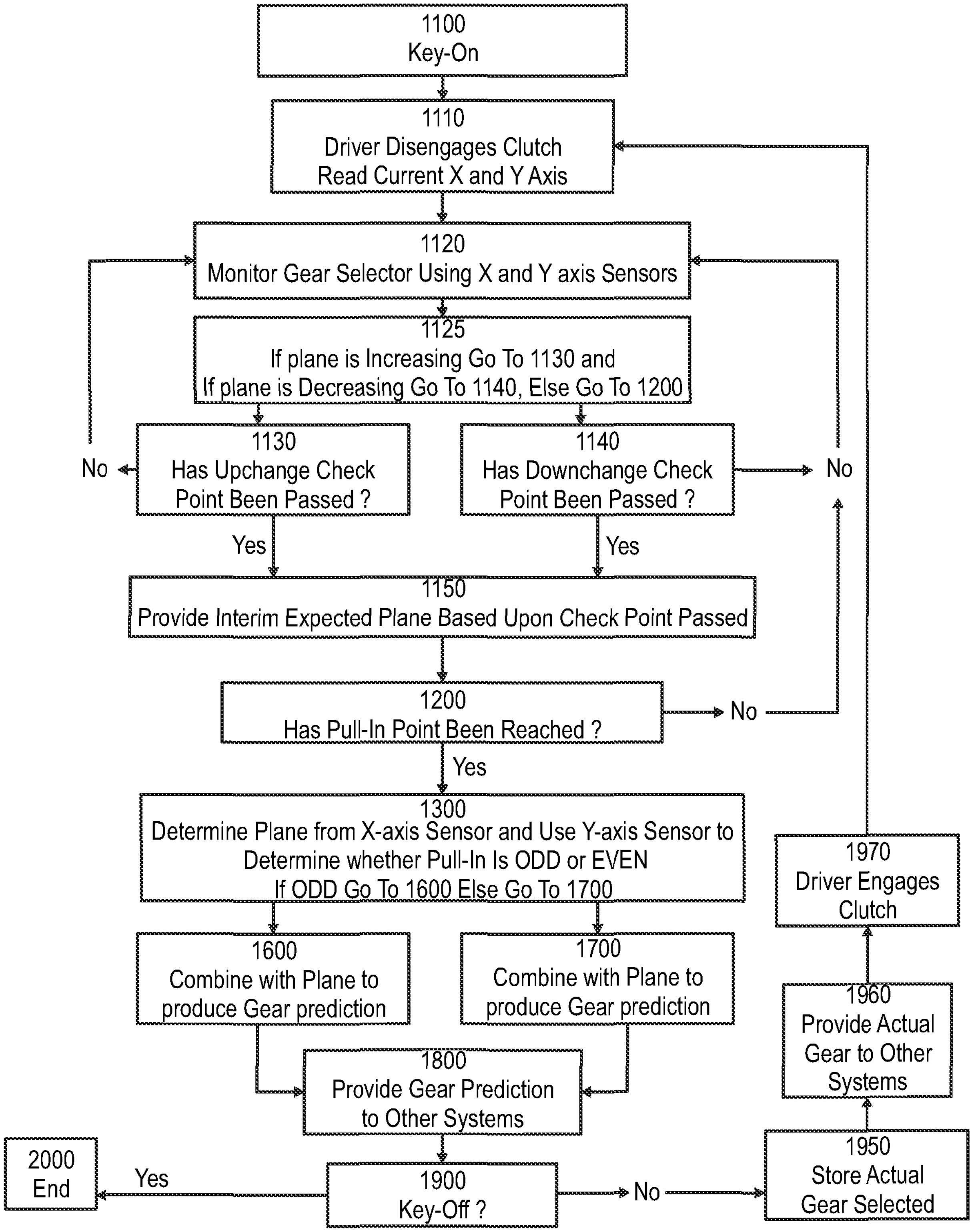
1100
Key-On
1110
Driver Disengages Clutch
Read Current X and Y Axis
1120
Monitor Gear Selector Using X and Y axis Sensors
1125
If plane is Increasing Go To 1130 and
If plane is Decreasing Go To 1140, Else Go To 1200
1130
Has Upchange Check
Point Been Passed ?
No
1140
Has Downchange Check
Point Been Passed ?
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
2000
End
No
1950
Store Actual
Gear Selected
1960
Provide Actual
Gear to Other
Systems
1970
Driver Engages
Clutch

Fig. 10

A Predictive Gear Sensing System for a Manual Transmission

This invention relates to a motor vehicle having a manual transmission and in particular to a system for predicting which gear of the transmission is to be engaged.

It is known to provide a gear sensor that provides a signal which can be used by electronic control apparatus of a motor vehicle to determine which gear is currently engaged. Such in-gear switches including reverse gear switches can be used to indicate instantaneous gear position. However, such switches only measure discrete gear positions after the gear has been engaged and cannot give any information about an intended gear change, e.g., which gear is the driver changing into. This information is very useful and can give a vehicle control system early indication of the gear change intentions of a driver and therefore allow the system to respond to the driver's demand more quickly.

Also, most in-gear switches are installed outside the transmission so as to sense gear lever position, and as such are subject to non-constant inaccuracies due to large tolerances and changes in gear lever position during the life of the vehicle due to wear.

During some operations of a motor vehicle transmission such as a gear change with such known gear sensors there is consequently a period of time in which the gear to be selected is not known and the gear selected is only known when it is finally engaged.

It is also known to use vehicle speed and engine speed comparison to obtain the gear position that the transmission is currently in. However, this method is not usable when the driveline is disengaged such as when the clutch pedal is pressed and so during a gear change operation any new gear position calculations have to be delayed until the change is complete, that is to say, the gear is fully selected and the clutch is re-engaged.

In addition, the use of vehicle speed and engine speed comparison techniques are unreliable when the vehicle is slipping or skidding such as may occur on a low friction road surface.

Any delays in acquiring information regarding the engaged gear can be problematic for those vehicle control systems which need gear information such as Gear Shift Harmonization (GSH). GSH is a technique in which the engine speed is matched to the selected gear during a gear change in order to smooth the transitions between gears.

Delayed or inaccurate gear information can also adversely affect a Human Machine Interface (HMI) where gear information is displayed in an instrument cluster in certain vehicle applications and this can directly affect customer satisfaction.

In some Start-Stop vehicles Gear Neutral Sensors (GNS) are being used. However, these can only measure in-neutral, in-odd or in-even gear positions. They cannot give detailed information about which gear the transmission is currently in or moving towards.

It is an object of the invention to provide a predictive gear sensing system that can predict the gear to be engaged before it is actually engaged.

According to a first aspect of the invention there is provided a predictive gear sensing system of a multi-speed manual transmission having a H-gate shift mechanism including a shift selector member that is moved by a gear shift lever in rotational and axial directions wherein the system comprises a first sensor to sense rotational position of the shift selector member, a second sensor to sense axial position of the shift selector member and an electronic processing unit to receive and process the signals from the first and second sensors, the electronic processing unit being operable to predict a next to be engaged gear based upon the signals received from the first and second sensors.

The electronic processing unit may be operable to predict a next to be engaged gear based upon whether at least one predefined set point has been one of attained and traversed.

The shift selector member may have a 2D magnetic target fixed thereto and the first and second sensors are formed as a single 2D sensor array.

The H-gate mechanism may define a plurality of gear shift lever planes and the signal from the second sensor may be used by the electronic processing unit to determine with which gear shift lever plane the gear shift lever is aligned.

The shift selector member may be rotatable between 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 wherein a first set point may be defined between the first rotational position and the third rotational position at a rotational position at and beyond which the forces acting will cause the shift selector member to be moved into the first rotational position and, when the signal from the first sensor indicates that the rotational position of the shift selector member corresponds to the first set point, the electronic processing unit uses this as an indication that the gear to be engaged is one of the gears in the first row of gears.

The shift selector member may be rotatable between 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 wherein a second set point may be defined between the second rotational position and the third rotational position at a rotational position at and beyond which the forces acting will cause the shift selector member to be moved into the second rotational position and, when the signal from the first sensor indicates that the rotational position of the shift selector member corresponds to the second set point, the electronic processing unit uses this as an indication that the gear to be engaged is one of the gears in the second row of gears.

The electronic control unit may be operable to combine the row prediction from the first sensor signal with the gear shift lever plane information from the second sensor signal to produce the prediction of the next to be engaged gear.

The electronic processing unit may be operable to determine whether the signal from the second sensor is increasing or reducing and use this as a preliminary prediction of which of a higher gear and a lower gear than the previously selected gear will likely be the next to be engaged gear.

At least one inter-plane set point may be provided between adjacent gear shift lever planes and the electronic processing unit is operable to infer that the next to be engaged gear will be one of a higher gear and lower gear than the previously selected gear based upon which of the inter-plane set points has been traversed.

There may be upshift and downshift inter-plane set points between adjacent gear shift lever planes.

The first row of gears may include all of the forward odd numbered gears and the second row of gears may include all of the forward even numbered gears.

According to a second aspect of the invention there is provided motor vehicle having a predictive gear sensing system constructed in accordance with said first aspect of the invention.

According to a third aspect of the invention there is provided a method for predicting a gear to be engaged in a multi-speed manual transmission having an H-gate shift mechanism in which the selectable gears are arranged in two rows and in a plurality of parallel gear shift lever planes and the shift mechanism includes a shift selector member that is moved by the gear shift lever in rotational and axial directions to effect engagement of the selectable gears wherein the method comprises determining the axial and rotational position of the shift selector member and, based upon the determined axial and rotational positions, predicting the next gear to be engaged.

The method may further comprise determining the axial position of the shift selector member, setting predefined rotation set points, comparing the rotational position of the shift selector member with the predefined rotation set points and, when the rotational position of the shift selector reaches one of the predefined rotation set points using this in combination with the known axial position of the shift selector member as an indication that the gear corresponding to the reached set point and axial position is predicted to be the next engaged gear.

The method may further comprise determining the axial direction in which the shift selector member is moving and using the direction of motion of the shift selector member as an early indicator of whether the next to be engaged gear is predicted to be one of a higher gear and a lower gear than the previously engaged gear.

The method may further comprise setting at least one inter-plane set point between adjacent gear shift lever planes, determining whether any of the inter-plane set points have been traversed and, if any of the inter-plane set points have been traversed, using this as an early indication of whether the next to be engaged gear is predicted to be one of a higher gear and a lower gear than the previously engaged gear.

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

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

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 set 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 inter plane set points according to a further 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 inter plane set 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 set points indicated on Fig.8A;

Fig.9 is simplified flow chart of a first embodiment of a method for predicting gear engagement according to the invention; and

Fig.10 is simplified flow chart of a second embodiment of a method for predicting gear engagement according to the invention.

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, vehicle speed from a vehicle speed sensor, clutch pedal position from a pedal sensor, accelerator pedal position from a pedal sensor, brake pedal position from a pedal sensor and may also receive information regarding other components on the motor vehicle

1 such as the state of charge of a battery (not shown) and the operating state of an air conditioning unit (not shown).

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. 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.

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 3A 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. That is to say, the shifter turret selector cylinder 3A is physically moved by the gear shift lever 11 therebeing a mechanical connection therebetween.

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 set points. Each set point is a calibrated value corresponding to the signal value for a specific position. Therefore when one of the signals from the selected gear sensor has a magnitude equal to a set point value the position of the selector cylinder 3A is known to be at a predefined position either rotational or axial.

For example, by carrying out test work the pull-in rotational positions of the selector cylinder 3A can be established and corresponding in-plane set points established which can be used to determine when a pull-in position has been attained. 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 using the predefined set points and 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 to be engaged gear.

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 set 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 to be engaged gear.

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 set 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 invention 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 invention 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 set points related to the pull-in points located in the gear shift planes, a plurality of inter-plane set points located between the gear shift planes are also provided. Each of these inter-plane set points is a calibrated output value corresponding to a specific axial position of the turret selector cylinder 3A.

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

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

The function of the inter-plane set 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 set 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 set 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 set points on Fig.8C (Ra, 1a, 3a and 5a and 2a, 4a and 6a) corresponding respectively to the OPI and EPI set 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 set points are calibrated set-points they are not affected by tolerances in the mechanism and so single values can be used.

For example, the set 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 set points between the various gear shift planes an earlier indication is given when one of the set points is crossed and that hysteresis can be used to prevent flip-flopping.

For example, if there were only one set 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 set points used between all of the adjacent planes.

Table 3 below shows how the traversing of set 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 set points the possible next gear is shown.

Previous Gear	Set Point R/1b	Set Point 1/2b	Set Point 3/4b	Set Point 1/2a	Set Point 3/4a	Set 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 set 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	Set Point R/1b	Set Point 1/2b	Set Point 3/4b	Set Point 1/2a	Set Point 3/4a	Set 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 set points 1a, 2a, 4a, 5a, 6a is traversed but according to this embodiment, as soon as the set 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 set 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.9 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 set points EPI, OPI has been reached. If one of the in-plane set points EPI, OPI has been reached then the method advances to box 150 but if neither of the in-plane set 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 set point EPI, OPI has been reached.

In box 150 it is determined which of the in-plane set points has been reached and based upon this decision the method advances to either box 160 if the odd gear in-plane set point OPI has been reached or to box 170 if the even gear in-plane set 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.10 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 set 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 set 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 set points but it will be appreciated if the same set points are used irrespective of gear change direction the method could advance from box 1120 to a box checking whether any inter plane set 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 set 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 set 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 set point, has been reached. The in-plane set 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 according to this invention 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.

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 predictive gear sensing system of a multi-speed manual transmission having a H-gate shift mechanism including a shift selector member that is moved by a gear shift lever in rotational and axial directions wherein the system comprises a first sensor to sense rotational position of the shift selector member, a second sensor to sense axial position of the shift selector member and an electronic processing unit to receive and process the signals from the first and second sensors, the electronic processing unit being operable to predict a next to be engaged gear based upon the signals received from the first and second sensors.

2. A sensing system as claimed in claim 1 wherein the electronic processing unit is operable to predict a next to be engaged gear based upon whether at least one predefined set point has been one of attained and traversed.

3. A sensing system as claimed in claim 1 or in claim 2 wherein the shift selector member has a 2D magnetic target fixed thereto and the first and second sensors are formed as a single 2D sensor array.

4. A system as claimed in any of claims 1 to 3 wherein the H-gate mechanism defines a plurality of gear shift lever planes and the signal from the second sensor is used by the electronic processing unit to determine with which gear shift lever plane the gear shift lever is aligned.

5. A system as claimed in claim 4 wherein the shift selector member is rotatable between 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 wherein a first set point is defined between the first rotational position and the third rotational position at a rotational position at

and beyond which the forces acting will cause the shift selector member to be moved into the first rotational position and, when the signal from the first sensor indicates that the rotational position of the shift selector member corresponds to the first set point, the electronic processing unit uses this as an indication that the gear to be engaged is one of the gears in the first row of gears.

6. A system as claimed in claim 4 or in claim 5 wherein the shift selector member is rotatable between 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 wherein a second set point is defined between the second rotational position and the third rotational position at a rotational position at and beyond which the forces acting will cause the shift selector member to be moved into the second rotational position and, when the signal from the first sensor indicates that the rotational position of the shift selector member corresponds to the second set point, the electronic processing unit uses this as an indication that the gear to be engaged is one of the gears in the second row of gears.

7. A system as claimed in claim 5 or in claim 6 wherein the electronic control unit is operable to combine the row prediction from the first sensor signal with the gear shift lever plane information from the second sensor signal to produce the prediction of the next to be engaged gear.

8. A system as claimed in any of claims 4 to 7 wherein the electronic processing unit is operable to determine whether the signal from the second sensor is increasing or reducing and use this as a preliminary prediction of which of a higher gear and a lower gear than the previously selected gear will likely be the next to be engaged gear.

9. A system as claimed in any of claims 4 to 8 wherein at least one inter-plane set point is provided between adjacent gear shift lever planes and the electronic processing unit is operable to infer that the next to be engaged gear will be one of a higher gear and lower gear than the previously selected gear based upon which of the inter-plane set points has been traversed.

10. A system as claimed in claim 9 wherein there are upshift and downshift inter-plane set points between adjacent gear shift lever planes.

11. A system as claimed in any of claims 4 to 10 wherein the first row of gears includes all of the forward odd numbered gears and the second row of gears includes all of the forward even numbered gears.

12. *A motor vehicle having a predictive gear sensing system* as claimed in any of claims 1 to 11.

13. A method for predicting a gear to be engaged in a multi-speed manual transmission having an H-gate shift mechanism in which the selectable gears are arranged in two rows and in a plurality of parallel gear shift lever planes and the shift mechanism includes a shift selector member that is moved by the gear shift lever in rotational and axial directions to effect engagement of the selectable gears wherein the method comprises determining the axial and rotational position of the shift selector member and, based upon the determined axial and rotational positions, predicting the next gear to be engaged.

14. A method as claimed in claim 13 wherein the method further comprises determining the axial position of the shift selector member, setting predefined rotation set points, comparing the rotational position of the shift selector member with the predefined rotation set points and,

when the rotational position of the shift selector reaches one of the predefined rotation set points using this in combination with the known axial position of the shift selector member as an indication that the gear corresponding to the reached set point and axial position is predicted to be the next engaged gear.

15. A method as claimed in claim 14 wherein the method further comprises determining the axial direction in which the shift selector member is moving and using the direction of motion of the shift selector member as an early indicator of whether the next to be engaged gear is predicted to be one of a higher gear and a lower gear than the previously engaged gear.

16. A method as claimed in claim 15 wherein the method further comprises setting at least one inter-plane set point between adjacent gear shift lever planes, determining whether any of the inter-plane set points have been traversed and, if any of the inter-plane set points have been traversed, using this as an early indication of whether the next to be engaged gear is predicted to be one of a higher gear and a lower gear than the previously engaged gear.

17. A predictive gear sensing system for a multi-speed manual transmission substantially as described herein with reference to the accompanying drawing.

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

19. A method for predicting a gear to be engaged in a multi-speed manual transmission substantially as described herein with reference to the accompanying drawing.

Application No: GB1208934.8 **Examiner:** Mr Kevin Hewitt
Claims searched: 1 to 19 **Date of search:** 15 September 2012

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
X	1,2,4, 10-13	US 2011/0040461 A1 (WOLTERMAN) See whole document, especially the Abstract.
A	-	DE 4422554 A1 (DAIMLER BENZ) See especially the WPI Abstract Accession Number 1995-337829 [44], and all Figures.
A	-	JP 2004251435 A (AISIN AW) See especially the WPI Abstract Accession Number 2004-490223 [47], and all Figures.
A	-	US 2005/0096180 A1 (WADAS ET AL) See especially the Abstract and all Figures.

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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^X :

Worldwide search of patent documents classified in the following areas of the IPC

B60W; F16H

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

WPI; EPODOC; TXTE

International Classification:

Subclass	Subgroup	Valid From
F16H	0061/02	01/01/2006
B60W	0010/10	01/01/2012
B60W	0010/11	01/01/2012
F16H	0061/28	01/01/2006