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(54) Title: METHOD AND SYSTEM FOR CONTROLLING A VEHICLE CRUISE CONTROL

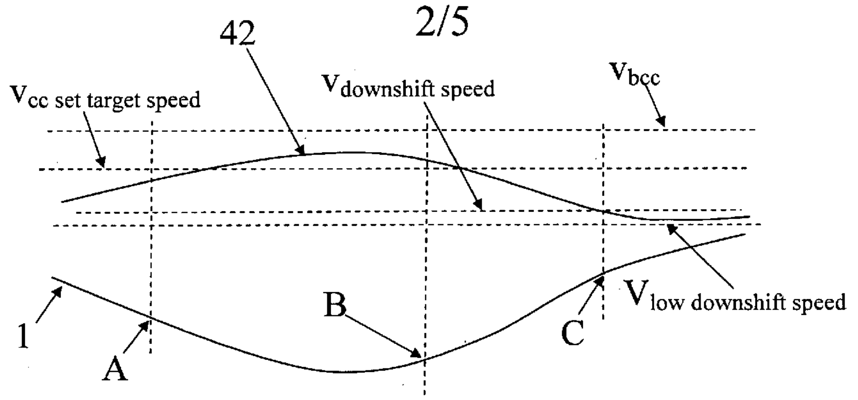

Fig. 4

(57) **Abstract**: Method and cruise control system for controlling a vehicle cruise control comprising the steps of -driving said vehicle with said cruise control active and set to maintain a vehicle set target Speed ($V_{cc\ set\ target\ speed}$); -registering current vehicle condition, which comprises at least a current vehicle position (A), a currently engaged gear ratio, available gear ratios, current vehicle speed, available maximum propulsion torque and road topography of coming travelling road comprising a next coming uphill slope; - based on said current vehicle condition predicting a downshift at a coming vehicle position (C) in said coming uphill slope due to vehicle speed decrease and selecting at least one activity which results in that said downshift can be postponed or avoided; -controlling said cruise control according to said selected activity in order to postpone or avoid, for example a downshift from a direct gear and thereby saving fuel.

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Description

Method and system for controlling a vehicle cruise control

Technical Field

[1] The present invention relates to a method for controlling a cruise control in a vehicle, in accordance with the preamble of the accompanying claim 1. The invention also relates to a vehicle cruise control system intended for such method for controlling said cruise control, in accordance with the preamble of the accompanying claim 8.

[2] The present invention also relates to a computer program, computer program product and a storage medium for a computer all to be used with a computer for executing said method.

Background Art

[3] Motor vehicles, such as cars, lorries, towing vehicles and buses, are often provided with a so-called cruise control system, also denominated speed control system, for automatically controlling the vehicle speed. Such a cruise control system comprises means, such as a speed sensor, for monitoring the actual vehicle speed. The cruise control system compares the actual vehicle speed with a set target speed. The target speed may for instance be entered into the cruise control system as the prevailing actual vehicle speed when a set switch is actuated by the driver. The cruise control system generates an error signal by comparing the actual vehicle speed with the target speed. The error signal is then for instance used to control an actuator coupled to the fuel pump or to the vehicle throttle in order to change the engine speed until the error signal is substantially zero, i.e. until the actual vehicle speed is equal to the target speed.

[4] EP1439976 and US6990401 disclose two examples of prior art where the cruise control system has been further developed. Here the cruise control system is a predictive cruise control system utilizing information about current vehicle position and upcoming road topography, that is for example gradients or elevation values for the coming road, in order to control throttle opening in such a way as to increase fuel efficiency.

[5] A problem with prior art cruise control is that unnecessary downshifts can occur during certain vehicle driving conditions. Three examples of such vehicle driving conditions are disclosed in figures 1 to 3. Each of said figures disclose a typical example of a road section profile 1, 21 and 31 where such unnecessary downshifts can occur. Road section profile 1 in figure 1 disclose a downhill followed by an uphill slope. An upper curve 2 discloses how the vehicle speed varies when driving said road section profile 1 and a cruise control set on target speed $v_{cc\ set\ target\ speed}$. In the disclosed example a maximum allowable overspeed v_{bcc} is set for when a brake cruise will activate auxiliary brakes and/or service brakes of said vehicle in order not to exceed said v_{bcc} when driving in a downhill. With the prevailing vehicle condition a certain

gear in a transmission of said vehicle is engaged and a lower vehicle speed limit for when a downshift ($v_{downshift\ speed}$) to a lower gear (with higher gear ratio) will occur is determined. Said engaged gear can be a direct gear or a gear where torque is transmitted via gear wheel pairs in the transmission(gearbox). In figure 1 when the vehicle is in position A the vehicle is accelerating, and eventually accelerating up to a bit over $v_{cc\ set\ target\ speed}$ after position A. When the vehicle is in position B the uphill slope has started and the vehicle speed is decreasing. In the shown example the inclination is so steep that the available propulsive power of the vehicle is not enough to hold $v_{cc\ set\ target\ speed}$ with the current gear engaged. In position C the vehicle speed has decreased to said $v_{downshift\ speed}$ and a downshift is performed. In the shown example said downshift results in that vehicle speed starts to increase. A drawback is that fuel efficiency is lost due to propulsive power interruption during said downshift. Even more fuel efficiency will be lost if said downshift is a downshift from a direct gear, since driving with a direct gear engaged is more fuel efficient compared to a gear where torque is transmitted via gear wheel pairs.

[6] The examples disclosed in figures 2 and 3 disclose corresponding downshifts C for further two different possible road section profiles 21 and 31. Road section profile 21 starts from a horizontal road followed by an uphill slope. Road section profile 31 starts from a light uphill slope, which is followed by an uphill slope.

[7] The object of the present invention is to further develop such a cruise control system where information about current vehicle position and upcoming road topography is used by the cruise control for controlling vehicle speed.

Summary of invention

[8] Thus, the primary object of the present invention is to present an improved method for cruise control which can avoid unnecessary downshifts in uphill slopes. This is achieved by a method as discussed in the introduction, the characteristics of which are defined by claim 1. The object is also achieved by a system as discussed in the introduction, the characteristics of which are defined by claim 8.

[9] The method according to the invention is a method for controlling a cruise control during driving of a vehicle. Said method comprises (includes, but is not necessarily limited to) the steps of:

[10] -driving said vehicle with said cruise control active and set to maintain a vehicle set target speed;

[11] -registering current vehicle condition, which comprises at least a current vehicle position, a currently engaged gear ratio, available gear ratios, current vehicle speed, available maximum propulsion torque and road topography of coming travelling road comprising a next coming uphill slope;

[12] - based on said current vehicle condition predicting a downshift at a coming vehicle position in said coming uphill slope due to vehicle speed decrease and selecting at least one activity which results in that said downshift can be postponed or avoided;

[13] -controlling said cruise control according to said selected activity.

[14] According to a first alternative embodiment of said invention said activity comprises the step of:

[15] -temporary lowering a downshift limit of said currently engaged gear with a predetermined possible amount to a lowered downshift speed limit.

[16] According to a further embodiment of said invention said method said activity further comprises the steps of:

[17] -predicting if said downshift will be postponed enough or avoided;

[18] -if predicting that said downshift will not be postponed enough or not avoided then performing said temporary lowering of said downshift limit ;

[19] -and additionally based on said current vehicle condition, calculating a lowest vehicle speed for a first vehicle position where the vehicle will start to retard in said uphill slope and which results in that said downshift can be enough postponed or avoided;

[20] -based on said current vehicle condition controlling said cruise control in order to during vehicle driving towards said first vehicle position increase vehicle speed to said lowest vehicle speed when said vehicle eventually has reached said first vehicle position..

[21] In another embodiment of the invention said activity comprises the steps of:

[22] -based on said current vehicle condition calculating a lowest vehicle speed for a first vehicle position where the vehicle will start to retard in said uphill slope which results in that said downshift can be postponed or avoided;

[23] -based on said current vehicle condition controlling said cruise control in order to during vehicle driving towards said first vehicle position increase vehicle speed to said lowest vehicle speed when said vehicle eventually has reached said first vehicle position.

[24] In a further embodiment of the invention said increase of a vehicle speed to said lowest vehicle speed is only allowed if the difference between said vehicle set target speed and said lowest vehicle speed is below a predetermined value.

[25] The invention also relates to a vehicle cruise control system that comprises (includes, but is not necessarily limited to) a control unit, driver input interface, vehicle position identifying device, road topography identifying device. Said system is characterized in that said control unit is arranged to perform the above mentioned method steps of said first embodiment.

[26] Further advantageous embodiments of the invention emerge from the dependent patent claims following patent claim 1.

Description Of Drawings

[27] The present invention will be described in greater detail below with reference to the accompanying drawings which, for the purpose of exemplification, shows further preferred embodiments of the invention and also the technical background, and in

which:

[28] Figure 1 to 3 diagrammatically show vehicle speed diagrams and corresponding driving conditions, and where said speed diagrams discloses cruise control according to known art.

[29] Figure 4 to 9 diagrammatically show vehicle speed diagrams and corresponding driving conditions, and where said speed diagrams disclose cruise control according to different embodiments of the invention.

[30] Figure 10 discloses an embodiment of the invention applied in a computer environment.

Description of the invention

[31] A cruise control system for automatically controlling the vehicle speed can be arranged in a vehicle according to known art. Said cruise control system comprises a control unit for continually processing input signals and deliver output signals to, for example a propulsion unit control for controlling a propulsion unit and if istalled also a brake control unit for controlling braking devices in said vehicle in order to maintain a set vehicle speed. Said braking devices can be a service brake and/or auxiliary brake and/or an electric motor/generator (if for example the vehicle is equipped with a hybrid propulsion system). Said vehicle cruise control system further comprises at least a driver input interface. Said control unit is arranged to perform steps of below described inventive functions with the use of information about current vehicle condition.

[32] Said propulsion unit control can be arranged to control a propulsion unit comprising at least a propulsion unit drivingly connected to driven wheels via an automated mechanical transmission (AMT). When said AMT is in an automatic mode the most suitable gear is automatically selected (among several gears) and engaged during driving of said vehicle.

[33] A cruise control in said vehicle is set to maintain $v_{cc\ set\ target\ speed}$. This can be set by the driver. Thus, said control unit in said cruise control system is arranged to maintain said $v_{cc\ set\ target\ speed}$. A maximum vehicle overspeed v_{bcc} can also be set by the driver in order for the control unit to initiate braking of said vehicle if vehicle speed approaches said v_{bcc}. This functionality is known as such and is also called brake cruise control. Said maximum vehicle overspeed v_{bcc} for said vehicle cruise control can be set to be at least equal to or higher than said $v_{cc\ set\ target\ speed}$. In below described inventive embodiments v_{bcc} is set higher than $v_{cc\ set\ target\ speed}$.

[34] According to an embodiment of the invention said control unit in said cruise control system is programmed to drive said vehicle with said cruise control active and to perform the following steps:

- driving said vehicle with said cruise control active and set to maintain a vehicle set target speed ($v_{cc\ set\ target\ speed}$);
- registering current vehicle condition, which comprises at least a current vehicle position (A), a currently engaged gear ratio, available gear ratios,

current vehicle speed, available maximum propulsion torque and road topography of coming travelling road comprising a next coming uphill slope;

- based on said current vehicle condition predicting a downshift at a coming vehicle position (C) in said coming uphill slope due to vehicle speed decrease and selecting at least one activity which results in that said downshift can be postponed or avoided;
- controlling said cruise control according to said selected activity.

[35] Thus, a coming downshift in a coming uphill slope is predicted when the vehicle is in position A and an activity is selected in order to postpone or avoid said downshift. In this way an uneccessary downshift can be at least postponed or avoided completly during driving said uphill slope. If said currently engaged gear is a direct gear fuel will be saved if driving time with a direct gear engaged can be increased. If said currently engaged gear is a gear where torque is transmitted via gear wheel pairs fuel will be saved if a downshift can be avoided.

[36] Referring to figure 4 the same downhill slope followed by an uphill slope is disclosed as in figure 1. Also the speed of the vehicle is controlled in the same way as in the example of figure 1. According to one embodiment of the invention said activity comprises the step of:

- temporary lowering a downshift limit of said currently engaged gear with a predetermined possible amount to a lowered downshift speed limit ($v_{low\ downshift\ speed}$).

[37] In figure 4 said lowered downshift speed limit is disclosed by the line $v_{low\ downshift\ speed}$. As can be seen the lowered downshift speed limit is in this shown example below the lowest predicted vehicle speed 42 in said uphill slope. Since the lowered downshift speed limit is below the lowest predicted vehicle speed a downshift at position C will not occur. The difference between said lowest predicted vehicle speed and said lowered downshift speed limit can be predetermined. Said difference can depend on for example propulsion unit configuration, on vehicle travel resistance at said uphill slope, and on engine efficiency in the area between the normal downshift speed the lowered downshift speed (if the engine efficiency should decrease dramatically it would make no sense to decrease engine speed since it would cost extra fuel). The amount of lowering of said downshift speed can depend on for example estimated time for the engine to rotate with a rotational speed below said (ordinary) downshift limit $v_{downshift\ speed}$. A typical difference between $v_{downshift\ speed}$ and $v_{low\ downshift\ speed}$ can be 100 rpm. In a corresponding way a lowered down shift speed can be used for the road section profiles 21 and 31. For road profile 21 this is disclosed in figure 6 and for road profile 31 this is disclosed in figure 8. Thus, in the embodiments of figures 6 and 8 the corresponding $v_{low\ downshift\ speed}$ is used as in figure 4.

[38] In a further embodiment of the invention said activity can alternatively comprise the steps of:

- based on said current vehicle condition calculating a lowest vehicle speed for a first vehicle position (B) where the vehicle will start to retard in said uphill slope which results in that said downshift can be postponed or avoided;
- based on said current vehicle condition controlling said cruise control in order to during vehicle driving towards said first vehicle position (B) increase vehicle speed to said lowest vehicle speed when said vehicle eventually has reached said first vehicle position (B).

[39] This embodiment is disclosed in figure 5 where vehicle speed curve 52 is identical to the vehicle speed curves 42 and 2 in figures 4 and 1 respectively. A vehicle speed curve 55 disclose a vehicle speed curve where it is predicted with the knowledge of the present vehicle conditions that if the vehicle passes said position B with a minimum vehicle speed of v_{hill} then it will be possible to drive through said uphill slope without the vehicle speed decreasing to below the $v_{downshift\ speed}$. In this way a downshift at position C can be avoided. As can be seen in figure 5 as soon as it is predicted at, for example, position A that a minimum vehicle speed of v_{hill} is needed in position B for avoiding a downshift the vehicle will be accelerated accordingly between said position A and B in order to reach v_{hill} at position B. Simulation can be used with current vehicle condition as input sata in order to find out the minimum vehicle speed of v_{hill}. If current vehicle condition results in that it is not possible to avoid or postpone enough said downshift and a worse fuel efficiency is reached than if not accelerating to a v_{hill}, then said control unit can be programmed to control vehicle speed according to curve 52, that is, no acceleration to a v_{hill} is performed. In the corresponding way a v_{hill} can be used for the road section profiles 21 and 31. For road profile 21 this is disclosed in figure 7 and for road profile 31 this is disclosed in figure 9. Thus, in the embodiments of figures 7 and 9 the corresponding v_{hill} is used as in figure 5.

[40] In a further embodiment of the invention said control unit can be programmed to combine said activities described in figures 4 and 5 or 6 and 7 or 8 and 9. Thus, said control unit can be programmed to perform the steps of:

- predicting if said downshift will be postponed enough or avoided;
- if predicting that said downshift will not be postponed enough or not avoided then performing said temporary lowering of said downshift limit ;
- and additionally based on said current vehicle condition, calculating a lowest vehicle speed for a first vehicle position where the vehicle will start to retard in said uphill slope and which results in that said downshift can be enough postponed or avoided;
- based on said current vehicle condition controlling said cruise control in order to during vehicle driving towards said first vehicle position increase vehicle speed to said lowest vehicle speed when said vehicle eventually has reached said first vehicle position.

[41] The activity where the downshift speed is temporary lowered is more fuel efficient

compared to the activity where the vehicle speed is increased to said lowest vehicle speed v_{hill}. Therefore it is first predicted if the temporary lowered downshift speed will be enough or not, and if not both activities can be used.

[42] In another embodiment of the invention said increase of a vehicle speed to said lowest vehicle speed v_{hill} is only allowed if the difference between said vehicle set target speed $v_{cc\ set\ target\ speed}$ and said lowest vehicle speed v_{hill} is below a predetermined value. Said control unit can further be programmed to not allow a v_{hill} above a predetermined value such as for example v_{bcc}.

[43] In a further embodiment of said invention said temporary lowering of a downshift limit of said currently engaged gear is active during driving said uphill slope, which means from for example position B and up to a crest (not shown) or up to a position where the vehicle speed has started to accelerate again and engine rotational speed has increased to above $v_{downshift\ speed}$.

[44] In a further embodiment the vehicle can be equipped with an Adaptive Cruise Control (ACC). The ACC will register if another vehicle is relatively close in front of said vehicle when, for example, driving in one of the above mentioned vehicle conditions. Said control unit can be programmed to not initiate said increase of a vehicle speed to said lowest vehicle speed v_{hill} according to one of the above mentioned embodiments as long as said ACC registers said another vehicle relatively close in front of said vehicle.

[45] Figure 10 shows an apparatus 500 according to one embodiment of the invention, comprising a nonvolatile memory 520, a processor 510 and a read and write memory 560. The memory 520 has a first memory part 530, in which a computer program for controlling the apparatus 500 is stored. The computer program in the memory part 530 for controlling the apparatus 500 can be an operating system.

[46] The apparatus 500 can be enclosed in, for example, a control unit, such as said above mentioned control unit in said cruise control system. The data-processing unit 510 can comprise, for example, a microcomputer.

[47] The memory 520 also has a second memory part 540, in which a program for controlling a vehicle cruise control according to the invention is stored. In an alternative embodiment, the program for controlling said vehicle cruise control is stored in a separate nonvolatile data storage medium 550, such as, for example, a CD or an exchangeable semiconductor memory. The program can be stored in an executable form or in a compressed state.

[48] When it is stated below that the data-processing unit 510 runs a specific function, it should be clear that the data-processing unit 510 is running a specific part of the program stored in the memory 540 or a specific part of the program stored in the nonvolatile recording medium 550.

[49] The data-processing unit 510 is tailored for communication with the memory 550 through a data bus 514. The data-processing unit 510 is also tailored for commu-

nication with the memory 520 through a data bus 512. In addition, the data-processing unit 510 is tailored for communication with the memory 560 through a data bus 511. The data-processing unit 510 is also tailored for communication with a data port 590 by the use of a data bus 515.

[50] The method according to the present invention can be executed by the data-processing unit 510, by the data-processing unit 510 running the program stored in the memory 540 or the program stored in the nonvolatile recording medium 550.

[51] The invention should not be deemed to be limited to the embodiments described above, but rather a number of further variants and modifications are conceivable within the scope of the following patent claims.

Claims

[1] Method for controlling a vehicle cruise control comprising the steps of:
-driving said vehicle with said cruise control active and set to maintain a vehicle set target speed ($v_{cc\ set\ target\ speed}$);
-registering current vehicle condition, which comprises at least a current vehicle position (A), a currently engaged gear ratio, available gear ratios, current vehicle speed, available maximum propulsion torque and road topography of coming travelling road comprising a next coming uphill slope;
- based on said current vehicle condition predicting a downshift at a coming vehicle position (C) in said coming uphill slope due to vehicle speed decrease and selecting at least one activity which results in that said downshift can be postponed or avoided;
-controlling said cruise control according to said selected activity.

[2] The method as claimed in the claim 1, where said activity comprising the step of:
-temporary lowering a downshift limit of said currently engaged gear with a pre-determined possible amount to a lowered downshift speed limit ($v_{low\ downshift\ speed}$).

[3] The method as in the preceding claim, where said activity further comprising the steps of:
-predicting if said downshift will be postponed enough or avoided;
-if predicting that said downshift will not be postponed enough or not avoided then performing said temporary lowering of said downshift limit ;
-and additionally based on said current vehicle condition, calculating a lowest vehicle speed (v_{hill}) for a first vehicle position (B) where the vehicle will start to retard in said uphill slope and which results in that said downshift can be enough postponed or avoided;
-based on said current vehicle condition controlling said cruise control in order to during vehicle driving towards said first vehicle position (B) increase vehicle speed to said lowest vehicle speed when said vehicle eventually has reached said first vehicle position (B).

[4] The method as claimed in the claim 1, where said activity comprising the steps of:
-based on said current vehicle condition calculating a lowest vehicle speed for a first vehicle position (B) where the vehicle will start to retard in said uphill slope which results in that said downshift can be postponed or avoided;
-based on said current vehicle condition controlling said cruise control in order to during vehicle driving towards said first vehicle position (B) increase vehicle speed to said lowest vehicle speed when said vehicle eventually has reached said first vehicle position (B).

[5] The method as in one of the claims 3 and 4, where said increase of a vehicle speed to said lowest vehicle speed (v_{hill}) is only allowed if the difference between

said vehicle set target speed ($v_{cc\ set\ target\ speed}$) and said lowest vehicle speed (v_{hill}) is below a predetermined value.

[6] The method as claimed in one of claims 2 or 3, where said temporary lowering of a downshift limit of said currently engaged gear is active during driving said uphill slope.

[7] The method as claimed in one of the preceding claims, where said predicted down shift is a down shift from a direct gear.

[8] A cruise control system comprising a control unit arranged for maintaining a vehicle set target speed ($v_{cc\ set\ target\ speed}$), driver input interface, vehicle position identifying device, road topography identifying device, characterized in that said control unit is programmed to perform the steps of claim 1.

[9] A computer program comprising program code means for performing all the steps of the claim 1 when said program is run on a computer.

[10] A computer program product comprising program code means stored on a computer readable medium for performing all steps of the claim 1 when said program product is run on a computer.

[11] A storage medium, such as a computer memory (520) or a nonvolatile data storage medium (550), for use in a computing environment, the memory comprising a computer readable program code to perform the method of the claim 1.

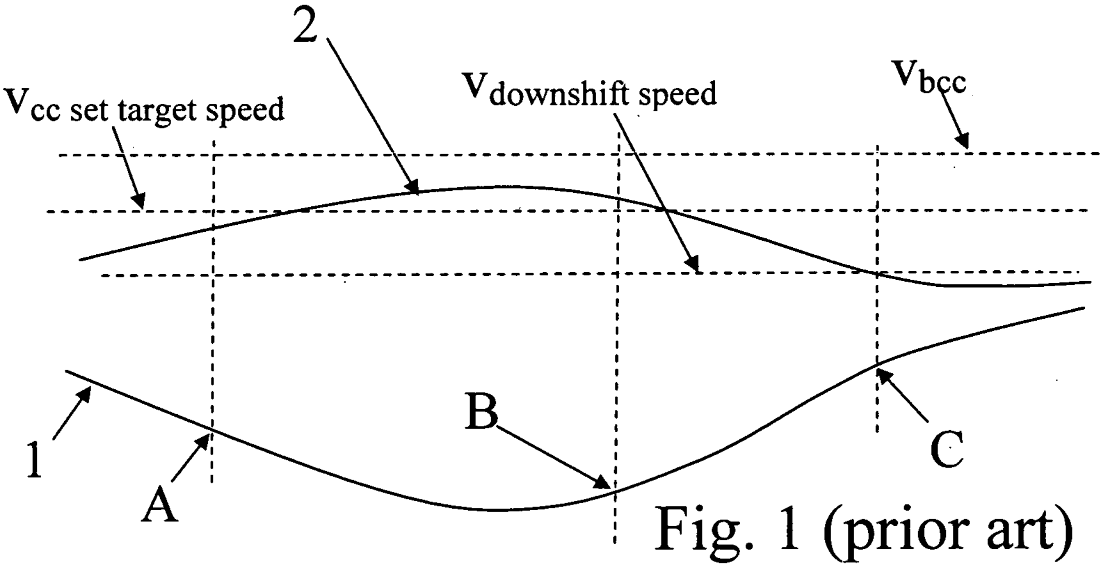


Fig. 1 (prior art)

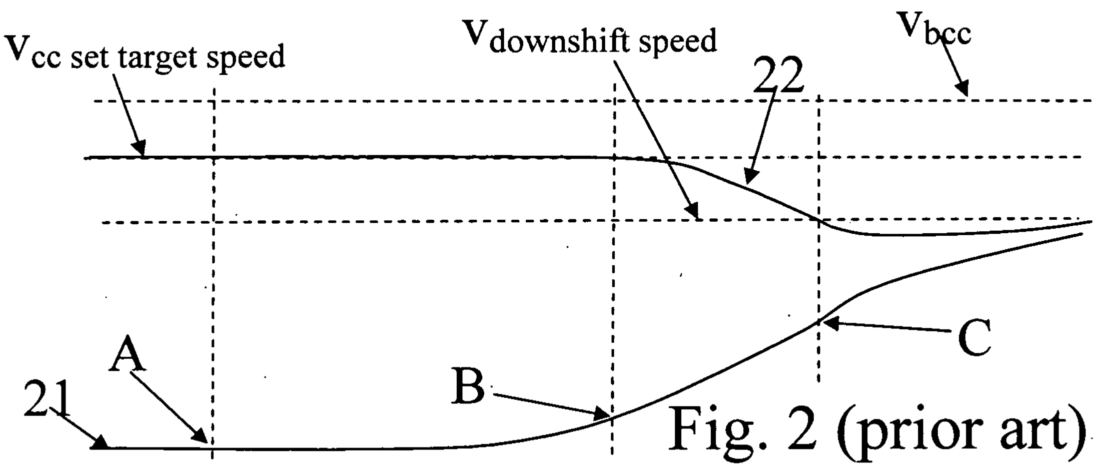


Fig. 2 (prior art)

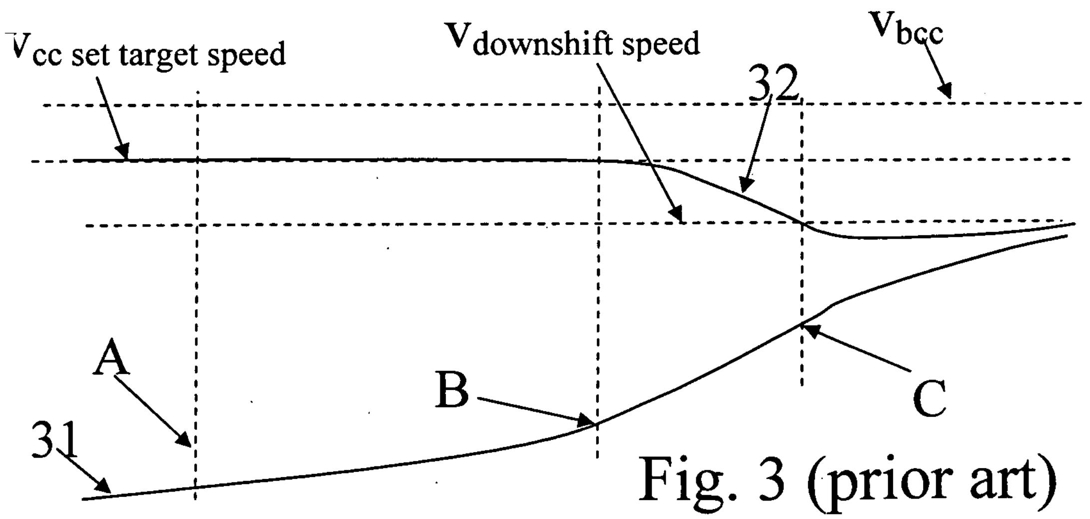


Fig. 3 (prior art)

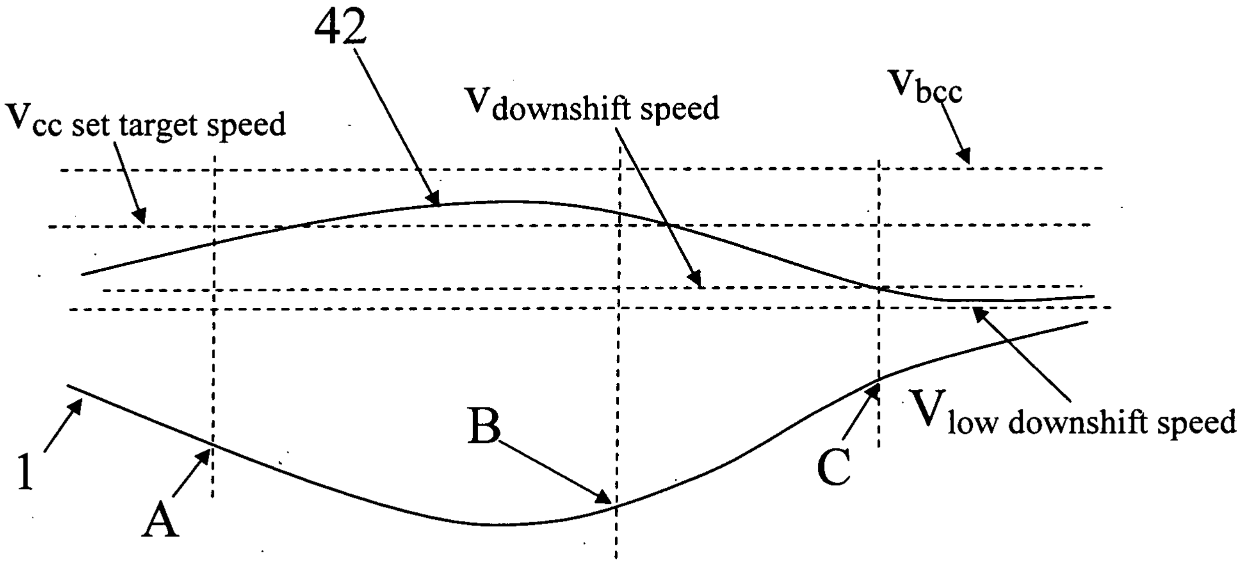

42
Vcc set target speed
Vdownshift speed
Vbcc
Vlow downshift speed
1
A
B
C

Fig. 4

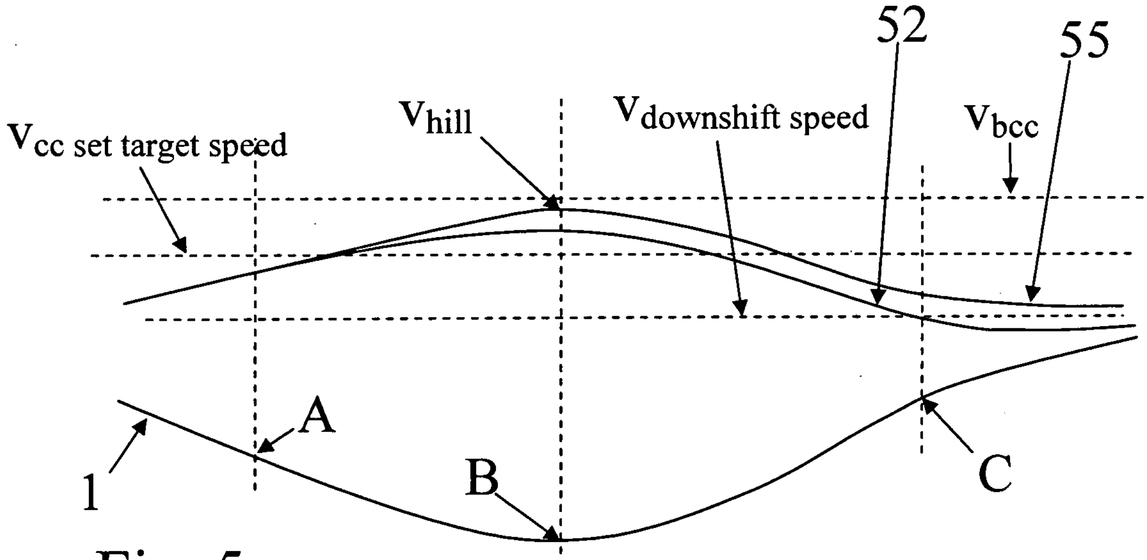
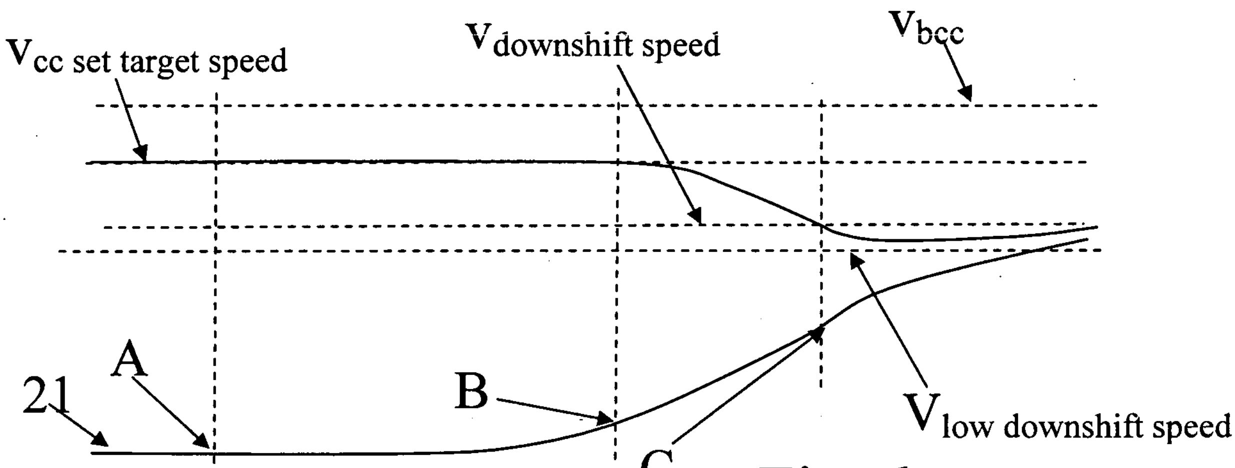
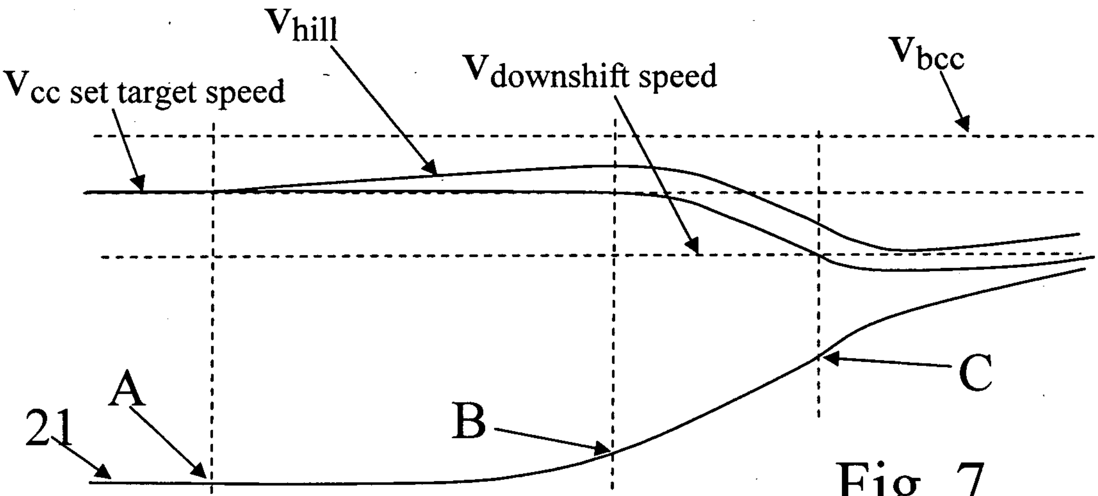

52
55
Vcc set target speed
Vhill
Vdownshift speed
Vbcc
1
A
B
C

Fig. 5



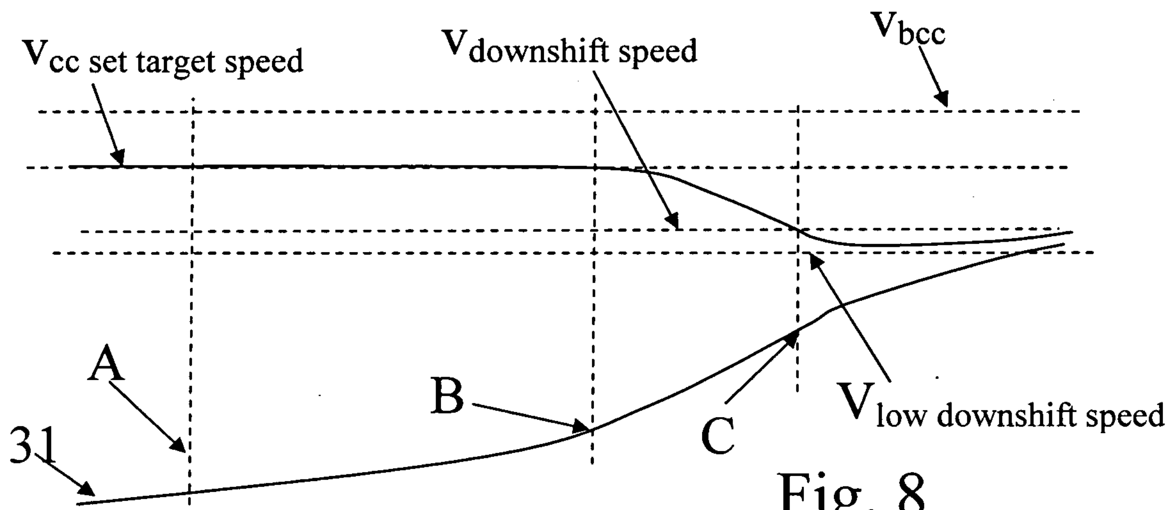
Vcc set target speed
Vdownshift speed
Vbcc
21
A
B
C
Vlow downshift speed

Fig. 6



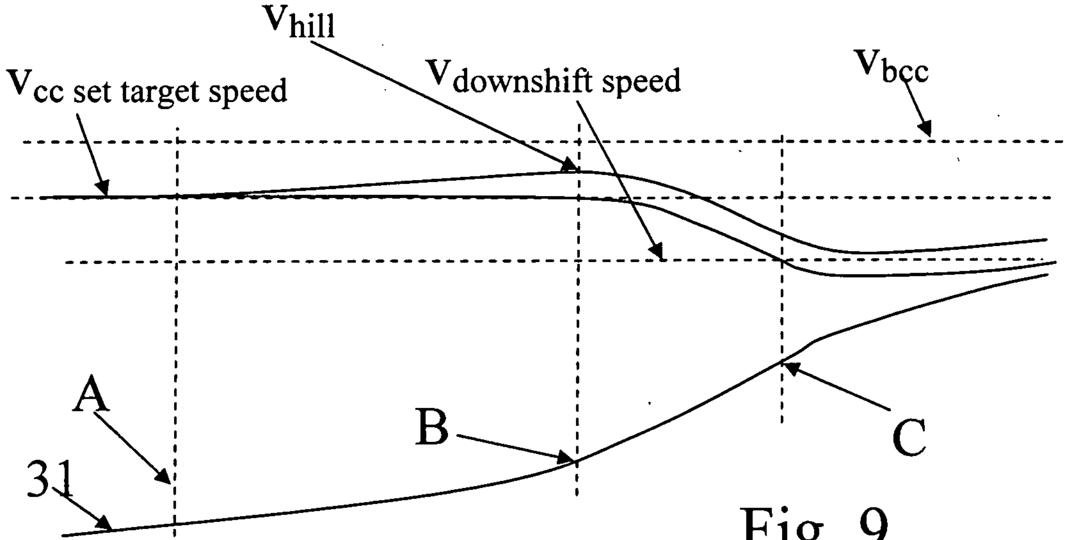
Vhill
Vcc set target speed
Vdownshift speed
Vbcc
21
A
B
C

Fig. 7



$V_{cc\ set\ target\ speed}$
$V_{downshift\ speed}$
V_{bcc}
A
B
C
31
$V_{low\ downshift\ speed}$

Fig. 8



V_{hill}
$V_{cc\ set\ target\ speed}$
$V_{downshift\ speed}$
V_{bcc}
A
B
C
31

Fig. 9

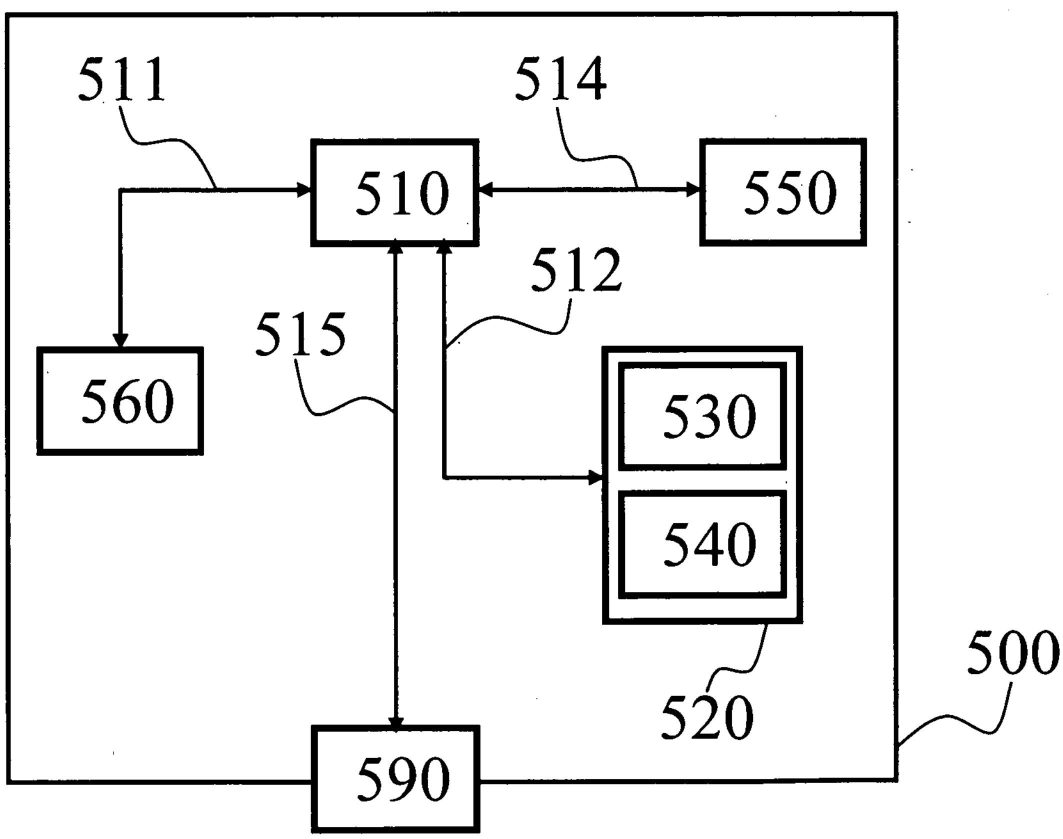


Fig. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/009169

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60K31/00 B60W30/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60K B60W

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6 199 001 B1 (OHTA TAKASHI [JP] ET AL) 6 March 2001 (2001-03-06) column 1, line 5 - column 27, line 9; figures 1-23	1-2,6-11
Y	JP 03 273938 A (MAZDA MOTOR) 5 December 1991 (1991-12-05) abstract; figures 1-4	1-2,6-11
Y	US 5 038 880 A (MATSUOKA TOSHIHIRO [JP] ET AL) 13 August 1991 (1991-08-13) column 2, line 37 - column 8, line 5; figures 1-12	1-2,6-11
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Fax: (+31–70) 340–3016	Baeza Félez, Lluís

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/009169

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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