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(71) Applicant: **SCANIA CV AB** [SE/SE]; S-151 87 Södertälje (SE).

(72) Inventor: **EVALDSSON, Martin**; Finnboda Parkväg 14A, S-131 31 Nacka (SE).

(74) Agent: **SCANIA CV AB**; Patents, SE-151 87 Södertälje (SE).

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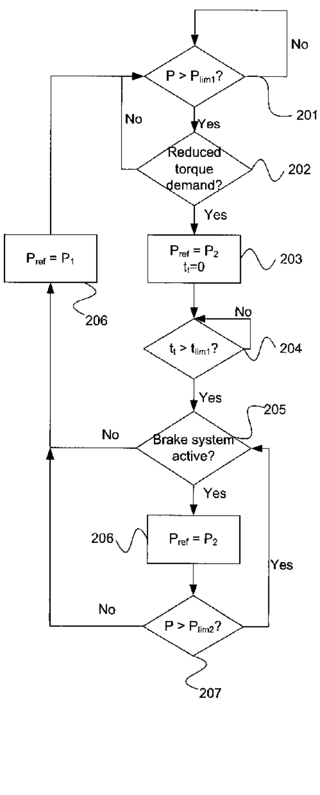
*[Continued on next page]*

# (54) Title: METHOD, SYSTEM AND COMPUTER PROGRAM FOR DELAYING REDUCTION OF CHARGE AIR PRESSURE IF BRAKES ARE ACTIVATED

FIG. 2




**(57) Abstract**: The present invention relates to a method when driving a vehicle (100), wherein said vehicle (100) comprises an internal combustion engine (101) with at least one combustion chamber, wherein said vehicle (100) further comprises means for pressurizing air for supply to said combustion chamber, and wherein said vehicle (100) further comprises at least a first brake system. The method includes: - at a reduction of a torque demand from a second level to a first level being lower than said second level, determining whether said first brake system is activated, and - if said first brake system is activated, maintaining the pressure of said air supplied for said combustion at a second pressure (P2) being higher than a first pressure (Pi) being required at said first level.

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# Method, system and computer program for delaying reduction of charge air pressure if brakes are activated.

## Field of the invention

The present invention relates to a method and a system when driving a vehicle. The invention relates especially to a method and a system when driving a vehicle in which air supply to a combustion chamber of an internal combustion engine can be actively influenced. The present invention also relates to a vehicle, and to a computer program and a computer program product, which implement the method according to the invention.

## Background of the invention

For driving heavy vehicles, such as trucks, buses and the like, vehicle economy has over time had an ever increasing impact on the profitability of the enterprise in which the vehicle is used. In addition to the cost of procurement of the vehicle, it is generally the case that the main items of expenditure for the running of a vehicle are the pay given to the driver of the vehicle, costs of repairs and maintenance, and fuel for propulsion of the vehicle.

Depending on the type of vehicle, different factors can have different levels of impact, but the fuel consumption is generally a substantial item of expenditure, and, since the degree of utilization of heavy vehicles is often high, associated with considerable overall fuel consumption, the fuel costs can have a very great impact on profitability for an owner of the vehicle, for example a haulage company or the like.

Therefore, every possibility of reducing the fuel consumption can have a positive effect on profitability, and, especially in long-distance driving, it is especially important to optimize the fuel consumption. For example, for this purpose, long-distance vehicles are produced which are characterized by a typical cruising speed for the internal combustion engine, where the cruising speed is adapted for a certain operating speed. Typical operating speeds, depending on the region and/or type of road, can be, for example, 80 km/h, 85 km/h or 89 km/h.

In addition to fuel economy, it is becoming more and more important, in heavy vehicles, that the driver of the vehicle finds the driving experience comfortable and intuitive. For example, the use of automatically changing transmissions, where the change of gear is controlled completely or partially by the control system that usually is present in the vehicle, can make driving the vehicle easier.

Automatic gear change also permits further freedom in controlling the progress of the vehicle from the perspective of fuel economy, for example by using the control system of the vehicle to ensure that the vehicle is driven in a gear that is advantageous from the point of view of fuel economy.

However, good comfort for the driver also entails other aspects, for example ensuring good driveability, i.e. that the vehicle from a performance point of view, e.g. torque demand, responds in a manner expected by the driver, and also without undesired delay.

**Summary of the invention**

It is an object of the present invention to provide a method for driving a vehicle that can further reduce the fuel consumption of vehicles driven by an internal combustion engine, which method at the same time permits good driveability when operating the vehicle. This object is achieved by a method according to claim 1.

The present invention relates to a method when driving a vehicle, wherein said vehicle comprises an internal combustion engine, such as a diesel engine, with at least one combustion chamber, wherein said vehicle further comprises means for pressurizing air for supply to said combustion chamber, and wherein said vehicle further comprises at least a first brake system. The method includes:

- at a reduction of a torque demand from a second level to a first level lower than said second level, determining whether said first brake system is activated, and

- if said first brake system is activated, maintaining the pressure of said air supplied for said combustion at a second pressure higher than a first pressure required at said first level.

As has been mentioned above, it is desirable that a vehicle can be driven in a way that is as fuel-efficient as possible, and, as long as the vehicle is being driven at constant speed along a horizontal road, the fuel efficiency of the vehicle among other things, is controlled by how close to optimal efficiency the internal combustion engine is working.

At the same time, it is often important that the vehicle has good driveability and, for example upon torque demand from the driver of the vehicle, is able to quickly respond with an expected increase in the transmitted torque.

Internal combustion engines, for example diesel engines, may be dependent on a compression of the combustion air supplied for combustion in order to provide high torque/high power, and, to ensure that good driveability can be achieved, it is in many situations used a control in which the pressure of the air supplied for combustion is maintained at a pressure higher than what is actually required from the point of view of combustion. With the aid of the higher pressure, an air margin is obtained, which means that a certain increase in an amount of fuel supplied can be effected without the air/fuel ratio in the combustion dropping to too low a value, wherein the power of the internal combustion engine can be made available more quickly. The air margin thus improves vehicle performance, and therefore driveability, from a driver perspective.

A disadvantage of applying such an air margin, i.e. maintaining the air supplied for combustion at a pressure higher than a required pressure, is that greater gas exchange work is performed by the internal combustion engine, with associated losses as a consequence.

By determining, according to the present invention, whether a brake system is activated, i.e. whether a braking force is applied for counteracting the propulsion of the vehicle in the direction of travel, and, if said brake system is activated, maintaining the pressure of the air supplied for combustion at a higher pressure, the combustion air pressure can be maintained without incurring any increased losses.

Since a brake system is activated, losses will still occur in the form of the energy that is converted by the brake system, for example in the form of heat. According to the present invention, by maintaining a high pressure of the air supplied for the combustion, with increased gas exchange work, and therefore engine braking force as a result, it is instead possible for the applied braking force to be reduced to a level corresponding to the losses that are caused by increased gas exchange work.

Since braked away energy is often braked away in a manner in which the energy is not taken care of for later use, the present invention has the advantage that, even if the losses when braking are overall substantially the same, the higher combustion air pressure will mean better driveability, i.e.

the vehicle will be able to be driven with a better response, i.e. will be felt to be more receptive by the driver of the vehicle, since greater force will be directly available when needed, for example if braking is immediately followed by acceleration with a high torque demand. The invention therefore has the result that the vehicle can often be driven with a high available force when needed, without a negative effect on the fuel consumption.

According to one embodiment of the invention, it is determined only whether a brake system is activated as above, while according to another embodiment of the present invention it is also determined whether an applied braking force exceeds some suitable first braking force. This first braking force can be, for example, a braking force corresponding to the braking force that is obtained from increased gas exchange work according to the present invention.

According to one embodiment, it is determined whether a service brake system is activated, while according to another embodiment it is determined whether some other brake system in the vehicle is activated.

The brake system is consequently a selectively activatable brake system, where the brake system can be selectively activated by the driver of the vehicle or by some suitable control system function. As will be appreciated, internal losses of the internal combustion engine for example, or other inevitable losses, do not constitute a selectively activatable brake system.

According to one embodiment of the present invention, it is determined whether any brake system is activated, and, as long as no brake system is activated, the pressure of the air supplied for the combustion is maintained at a pressure higher than a required pressure during a first period for as long as no brake system is activated, whereas, if at least one brake system is activated, the pressure of the air supplied for the combustion is maintained for a second period being longer than said first period. Since the increase in losses caused by higher air pressure are outweighed by losses caused by the brake system, the period of time during which the combustion air pressure is maintained can be allowed to be longer than is normally the case.

According to one embodiment, the combustion air pressure is maintained, provided that a brake system is activated, for as long as possible, i.e. the combustion air pressure is maintained as long as possible as long as a braking force is applied. Since the combustion air pressure is usually obtained with the aid of a turbo unit driven by exhaust gases from the combustion, and since the internal combustion engine during braking is usually driven with little or no supply of fuel, the resulting low exhaust gas flow will have the result that the combustion air pressure drops after a time and therefore cannot be reliably maintained during the entire braking.

When the combustion air pressure can no longer be maintained at the desired pressure, the pressure can be kept as high as possible, where the highest possible pressure can thus decrease with time. Moreover, the combustion air pressure can be arranged such that, when the desired pressure can no longer be maintained, it is at least kept higher than said required pressure for as long as possible.

Further features of the present invention and advantages thereof will become clear from the following detailed description of illustrative embodiments and from the attached drawings.

## Brief description of the drawings

Fig. 1A shows a drive train in a vehicle in which the present invention can be used;

Fig. 1B shows a control unit in a vehicle control system;

Fig. 2 shows an illustrative embodiment according to the present invention;

Fig. 3 shows an example of driving a vehicle with maintained combustion air pressure;

Fig. 4 shows an example of driving a vehicle with maintained combustion air pressure according to an embodiment of the present invention;

Fig. 5 shows another illustrative embodiment according to the present invention;

Fig. 6 shows yet another illustrative embodiment according to the present invention.

## Detailed description of embodiments

Fig. 1A shows schematically a drive train in a vehicle 100 according to one embodiment of the present invention. The vehicle 100 shown schematically in Fig. 1A comprises only one axle 104, 105 with driving wheels 113, 114, but the invention is also applicable to vehicles where more than one axle is provided with driving wheels, and also to vehicles with one or more additional axles, for example one or more support axles. The drive train comprises an internal combustion engine 101, which in a conventional way, via an output shaft on the internal combustion engine 101, usually via a flywheel 102, is connected to a gearbox 103 via a clutch 106. The clutch 106 can be a manually or automatically controlled clutch in a known manner, and the gearbox 103 can be arranged to be changed by the driver of the vehicle 100 or automatically by the control system of the vehicle. According to an alternative embodiment, the vehicle 100 is provided with a clutch-free drive train.

An output shaft 107 of the gearbox 103 then drives the driving wheels 113, 114 via a final gear 108, for example a conventional differential, and drive shafts 104, 105 connected to said final gear 108.

The present invention relates to internal combustion engines, especially diesel engines, where the amount of air supplied to a combustion chamber, for example a cylinder, can be actively regulated.

In a diesel engine without the possibility of actively regulating the air supplied for combustion, the combustion air available in the combustion will consist of the air which is sucked in during downward movement of the piston, where this intake air consists of air that is sucked in from the surroundings of the vehicle. The amount of air in the combustion is thus substantially the same for each combustion cycle (where variations may arise, e.g. because of external factors such as prevailing air pressure, temperature, etc.).

This means that only a certain amount of fuel can be injected before the air/fuel ratio (AFR) of the combustion becomes undesirably low. The relationship between a stoichiometric ratio $AFR_{stoich}$ and the actual ratio between air and fuel supplied for combustion (the quotient between the mass of air (kg) and gasoline (kg) supplied for the combustion) is generally called the lambda value, λ, where the lambda value is defined as $\lambda = \frac{AFR}{AFR_{stoich}}$. As is well known, and as is clear from the equation, a lambda value = 1 signifies a fuel/air ratio where stoichiometric combustion is obtained, i.e. $AFR =$

$AFR_{stoich}$, and where higher or lower lambda values signify excess air or undersupply of air in the combustion. As is known, however, there are methods for increasing the power of diesel engines, for example, by compressing the air supplied for the combustion in order to supply a greater air mass for the combustion, wherein the greater air mass means that a correspondingly larger amount of fuel can be supplied while maintaining the air/fuel ratio, with higher power development as a result.

As is known, the compression of the supplied air can be achieved in different ways. For example, the compression can be achieved with the aid of a turbo unit 119, such as a VGT (variable geometry turbocharger) unit, or a turbo unit with a waste gate.

With the aid of turbo units of these types, or other suitable turbo units such as crankshaft-driven compressors, it is thus possible to compress the air supplied for the combustion, wherein the lambda value $\lambda$ can thus also be regulated since different amounts of air can be supplied for any given amount of fuel supplied.

However, an increase in the lambda value $\lambda$ for a given operating point generally also requires a certain increase in the amount of fuel supplied. This is because supply of a greater amount of air results in greater gas exchange work, with the losses associated therewith, which can mean that an increase in the amount of fuel supplied is required in order to overcome losses caused by increased gas exchange work, such that a desired flywheel moment can continue to be maintained.

As has been mentioned above, however, it is often necessary that a certain compression is maintained such that, from a driver's perspective, the vehicle has good driveability, despite the fact that this means increased fuel consumption.

The present invention relates to a method for utilizing and maintaining compression in situations when this does not entail any increased cost in driving the vehicle.

An illustrative embodiment 200 according to the present invention is shown in Fig. 2, and the invention can be implemented in any suitable control unit, for example the control unit 117 shown in Fig. 1A.

In general, control systems in modern vehicles usually consist of a communications bus system consisting of one or more communications buses for interconnecting a number of electronic control units (ECU), or controllers, and various components arranged on the vehicle. Such a control system can comprise a large number of control units, and the responsibility for a specific function can be divided amongst more than one control unit.

For simplicity, Fig. 1A shows only the control units 116, 117, 118, but vehicles 100 of the type shown often comprise considerably more control units, which is well known to a person skilled in the art.

In the present example, the clutch is an automatically controlled clutch, wherein the control unit 116 controls the clutch 106 via a clutch actuator (not shown), and also the gearbox 103.

The control unit 118 is a brake control unit and is responsible for one or more brake system functions. For example, the vehicle 100 comprises a service brake system, which in a usual manner can comprise brake disks with associated brake linings (not shown) arranged next to each wheel, and the bearing pressure of the brake linings against the brake disks is controlled with the aid of the brake control unit 118, which in a known manner sends signals to the regulators(s) regulating the braking force in the service brake system. The brake control unit 118 can, for example, be arranged to only control the service brake system of the vehicle, but it can also be arranged to control one or more of the other brake systems of the vehicle when these exist. For example, the vehicle can comprise a retarder according to what is described below, and/or other auxiliary brake systems such as exhaust brake and engine brake. Based on suitable commands from the driver, for example, or from other control units, control signals are sent to suitable system modules to request the desired braking force.

The control unit 117, in which the present invention in the embodiment shown is implemented, controls the engine 101 of the vehicle 100. The invention can alternatively be implemented in a control unit dedicated to the present invention or entirely or partially in one or more other control units already present on the vehicle 100.

The control of the gearshift time according to the present invention by the control unit 117 (or the one or more control units in which the present invention is implemented) will probably depend on signals which are received from other control units (also not shown) arranged on the vehicle, and/or information from, for example, various detectors/sensors arranged on the vehicle. It is generally the case that control units of the type shown are normally arranged to receive sensor signals from different parts of the vehicle 100.

Control units of the type shown are also usually arranged to output control signals to different vehicle parts and vehicle components.

The control is often controlled by programmed instructions. These programmed instructions typically consist of a computer program which, when it is executed in a computer or control unit, causes the computer/control unit to perform the desired control, such as method steps according to the present invention. The computer program is usually part of a computer program product, where the computer program product comprises a suitable storage medium 121 (see Fig. 1B) with the computer program 126 stored on said storage medium 121. Said digital storage medium 121 can be, for example, one from the following group: ROM (Read-Only Memory), PROM (Programmable Read-Only Memory), EPROM (Erasable PROM), Flash memory, EEPROM (Electrically Erasable PROM), a hard-disk unit, etc., and can be arranged in or connected to the control unit, wherein the computer program is executed by the control unit. By changing the instructions of the computer program, it is thus possible to adapt the performance of the vehicle in a specific situation.

An example of a control unit (the control unit 117) is shown schematically in Fig. 1B, wherein the control unit in turn can comprise a computing unit 120, which can be in the form, for example, of any suitable type of processor or microcomputer, for example a circuit for digital signal processing (Digital Signal Processor, DSP), or a circuit having a predetermined specific function (Application Specific Integrated Circuit, ASIC). The computing unit 120 is connected to a memory unit 121, which provides the computing unit 120 with, for example, the stored program code 126 and/or the stored data that the computing unit 120 requires in order to be able to perform computations. The computing unit 120 is also arranged to store partial or final results of computations in the memory unit 121.

In addition, the control unit 117 is provided with devices 122, 123, 124, 125 for receiving and transmitting input and output signals. These input and output signals can contain waveforms, impulses, or other attributes which, by the devices

122, 125 for the reception of input signals, can be detected as information for processing by the computing unit 120. The devices 123, 124 for the transmission of output signals are arranged to convert computation results from the computing unit 120 to output signals for transmission to other parts of the control system of the vehicle and/or the one or more components for which the signals are intended. Each of the connections to the devices for receiving and transmitting input and output signals can be in the form of one or more of a cable; a data bus, such as a CAN bus (Controller Area Network bus), a MOST bus (Media Oriented Systems Transport bus), or some other bus configuration; or by a wireless connection.

Returning to the method 200 shown in Fig. 2, this begins at step 201, in which it is determined whether the pressure P for the combustion air exceeds a suitable limit value $P_{lim1}$. The limit value $P_{lim1}$ can, for example, be set at a pressure above which the combustion air pressure represents an overpressure, i.e. a pressure exceeding the prevailing atmospheric pressure. Thus, the limit value $P_{lim1}$ can, for example, be the atmospheric pressure. However, according to a preferred embodiment, the limit value $P_{lim1}$ is a pressure higher than the prevailing atmospheric pressure, such as a suitable pressure exceeding the atmospheric pressure. For example, the limit value $P_{lim1}$ can be a suitable fraction of the maximum pressure to which the combustion air can be pressurized when driving a vehicle. For example, the limit value $P_{lim1}$ can be any suitable fraction in the range of 70-100% of the maximum pressure $P_{max}$ to which the combustion air is pressurized when driving the vehicle 100, typically at maximum load.

As long as the pressure condition is not satisfied, the method remains at step 201, whereas the method transfers to step 202 when the combustion air pressure P exceeds the limit value $P_{lim1}$. In step 202, it is determined whether the torque demanded by the internal combustion engine 101 is reduced. According to one embodiment of the invention, it is determined whether the torque demand is reduced to a suitable extent, for example by a certain percentage or to some suitable level, for example a suitable fraction of the maximum transmissible torque. When the torque demand has been reduced according to step 202, the method continues to step 203.

This is illustrated at $t_1$ in Fig. 3, which shows an example of a function for improving the driveability of the vehicle 100 from the point of view of a driver for example. Fig. 3 shows how the fuel supply Q varies over the time t when driving the vehicle 100 along a road section (not shown). At the time $t_0$ the vehicle 100 is driven with a high transmitted torque from the internal combustion engine 101, and therefore with a relatively high fuel supply Q amounting to a level $Q_2$, and at the time $t_1$ the torque demand is reduced, wherein the fuel supply to the internal combustion engine 101 drops from the level $Q_2$ to the level $Q_1$, with a corresponding reduction of the transmitted torque. At the same time, the combustion air pressure P of the air supplied for combustion changes as shown in the figure.

The fuel requirement Q of the vehicle 100 can decrease from the relatively high level $Q_2$ to the relatively low level $Q_1$, e.g. because the driver of the vehicle 100 releases the accelerator pedal, or because the torque demand is reduced, e.g. by a cruise control function. At the time $t_1$, the driving power requirement thus drops to a relatively low driving power requirement, but instead of at the same time also controlling the combustion air pressure P in such a way that it is reduced to as low a level as possible, with associated fuel saving as a result, the combustion air pressure P is kept at substantially the level $P_2$ right through to the time $t_2$, and only at this time $t_2$ is the combustion air pressure P lowered to a level $P_1$, which from the point of view of fuel consumption is a combustion air pressure P which gives rise to a more economic air/fuel ratio $\lambda$, and which for example results in the lowest air/fuel ratio $\lambda$ that is permitted by, for example, existing regulations and/or, for example, from the point of view of limiting smoke.

This functionality, here called low load function (Low Load Case, LLC), has the purpose of maintaining a high combustion air pressure P, for example by maintaining a high turbo speed for a certain period of time $t_H$, i.e. between $t_1$ and $t_2$ in Fig. 3, for example 1-3 seconds, even after a torque demand has decreased. In this way, the engine response is kept high during this predetermined time $t_H$ in order to ensure that a high power can be made available directly, or at least substantially directly, if the conditions for driving the vehicle during said time $t_H$ are such that a high driving power is once again required, which can be the case, for example, if the torque demand has dropped as a result of changing to another gear, in which case high power is often desirable directly after the gear change, e.g. after changing down gear on an uphill gradient. If the combustion air pressure P is maintained at the pressure $P_2$ during the time period $t_H$, the fuel supply during this time period $t_H$ can be immediately increased again to the level $Q_2$ without any risk of the air/fuel ratio $\lambda$ falling below an inadmissible value, where the entire torque that has been output between the time $t_0$ and $t_1$ in Fig. 3 is directly, or at least substantially directly, available when needed.

According to the method shown in Fig. 2, the vehicle 100 is driven with the low load function illustrated in Fig. 3 activated, i.e. the pressure P of the air supplied for combustion is maintained at a higher pressure during a first period after the torque demand has been reduced. In step 203, therefore, a reference value $P_{ref}$ for the combustion air pressure P is set equal to $P_2$, i.e. the engine control will seek to maintain the combustion air pressure P at the level $P_2$ which existed before the torque demand fell at $t_1$. At the same time, a timer $t_t$ is started after first being set to 0, after which the method continues to step 204. In step 204, it is determined whether the timer $t_t$ has reached the time limit $t_{lim1}$, where the time limit $t_{lim1}$ is the time limit for said low load function which, according to the above, can be 1-3 seconds. As long as the time limit $t_{lim1}$ has not been reached, the method remains at step 204 and, when the time limit $t_{lim1}$ has been reached, it continues to step 205.

In step 205, it is determined whether some suitable brake system is activated. For example, it can be determined whether the service brake system of the vehicle 100 is activated, alternatively whether some other suitable brake system, or indeed any brake system at all, is activated. If it is determined in step 205 that this is not the case, i.e. the service brake system or in the present case the other brake system is not activated, the method continues to step 206 where the pressure reference value $P_{ref}$ for the combustion air pressure P during control of the internal combustion engine 101 is set at the pressure $P_1$ which is presently required. The pressure $P_1$ can, for example, be the atmospheric pressure if the driving power requirement is low, and/or the pressure that is needed so that the lowest air/fuel ratio $\lambda$ which is allowed by e.g. the regulatory authorities and/or e.g. from the point of view of smoke limitation is not undershot. The method then returns to step 201. That is to say, if no brake system is activated, the engine control functions precisely as in the case where the vehicle 100 is driven with activated low load function.

If, on the other hand, it is determined in step 205 that a suitable brake system is activated, the method continues to step 207, where the pressure reference value $P_{ref}$ for the combustion air pressure P is still maintained at the pressure that existed before the reduction of the required driving power, i.e. in the present example the pressure $P_2$. However, the pressure reference value $P_{ref}$ does not have to be set at the pressure $P_2$, and instead it can be another suitable pressure, but one that is still higher than the pressure $P_1$, for example 70-100% of the pressure $P_2$.

The combustion air pressure P is thus still maintained after the time $t_2$ at a high level, with greater internal combustion engine losses because of greater gas exchange work according to the above as a result.

This is illustrated in Fig. 4, where the braking torque L of the engine is illustrated, where $L_2$ represents the combined internal combustion engine losses at a combustion air pressure $P_2$ according to the above, where $L_1$ represents the combined internal combustion engine losses upon reduction of the combustion air pressure according to the above, and where the difference $\Delta L$ in losses between $L_1$ and $L_2$ is caused entirely by losses occasioned by the greater gas exchange work at the combustion air pressure $P_2$. These engine losses on account of the greater gas exchange work can, for example, constitute a braking torque of the order of magnitude of 50-100 Newton meters, i.e. the engine losses increase with this value at a high retained combustion air pressure. The difference in relation to Fig. 3 is illustrated in Fig. 4 by the pressure change according to Fig. 3 being indicated with a dashed line 401, which thus already takes place at the time $t_2$ in Fig. 3. Similarly, the dashed line 402 indicates the corresponding lower losses in gas exchange work that arise at the earlier reduction of the combustion air pressure in Fig. 3.

However, since the combustion air pressure according to the present invention is maintained when a brake system is activated, the increased engine losses can be compensated by a reduction of the applied brake torque, i.e. the brakes can work to a correspondingly lesser degree, wherein the combined losses as regards engine losses and braking force losses can thus be kept at a constant level. According to the present invention, the high combustion air pressure can thus be maintained without any real cost in the form of, for example, increased fuel consumption.

This has the advantage that, if the vehicle 100 has to quickly accelerate again after braking, a large proportion or all of the power (the torque) that the internal combustion engine 101 can generate will be almost immediately available, without the otherwise inevitable delay that occurs when the combustion air pressure first has to be built up before the full torque can be transmitted by the internal combustion engine.

The present invention also has the advantage that, since the brakes can work to a correspondingly lesser degree, there is reduced wear of the brake system, e.g. in respect of brake linings or other components included in the brake system of the vehicle. However, the reduced torque demand will usually mean that the combustion air pressure is not able to be maintained for as long as necessary. For this reason, it is determined in step 208 whether the existing combustion air pressure exceeds some suitable limit value $P_{lim2}$. This limit value $P_{lim2}$ can be set at any suitable limit value, for example a value representing a level where the combustion air pressure has decreased to some suitable pressure on account of the pressure no longer being able to be maintained, which often happens when the reduced work of the internal combustion engine results in a reduced driving power (exhaust gas flow) for driving the turbo unit. The limit value $P_{lim2}$ can, for example, represent the atmospheric pressure, or a pressure level close to this. The limit value $P_{lim2}$ can, for example, also be the pressure which is presently required at the existing driving power demand, or a suitable pressure between the required combustion air pressure at the existing driving power demand and the pressure $P_2$. Moreover, the pressure reference value $P_{ref}$ can be arranged to be changed with time when the brake system is activated and, for example, to be reduced to the pressure $P_1$ or the limit value $P_{lim2}$ in any suitable way.

When the combustion air pressure drops below the limit value $P_{lim2}$, which is shown at the time $t_3$ in Fig. 4, the method returns to step 201 via step 206 according to the above, whereas, as long as the combustion air pressure exceeds said limit $P_{lim2}$, the method returns to step 205 in order to determine whether some brake system is still activated, and, as long as this is the case, the combustion air pressure P is maintained as far as possible. If it is then determined in step 205 that the brake system is no longer activated, the method returns directly to step 201 via step 206 according to the above.

The invention thus allows maximum driveability to be retained for as long as possible, without causing increased losses.

Moreover, the criterion illustrated in step 207, instead of being controlled by the pressure to which the combustion air pressure P has fallen, can instead be controlled by a second timer, where this second timer counts to a time which, compared with the time $t_{lim1}$, means that the combustion air pressure is maintained for a period of time longer than the time $t_{lim1}$. This second timer can be arranged, for example, to be started at the same time as the timer $t_t$, and thus count for a period of time longer than the time $t_{lim1}$.

Said second time can alternatively be counted, for example, from when said brake system is activated, wherein the second timer can count for a time which can be both longer and shorter than the time $t_{lim1}$, but where the total time therefore comes to exceed the time $t_{lim1}$. Thus, according to one embodiment, the transition from step 205 or step 207 to step 206 can be designed to take place when the second timer has reached a defined time, regardless of whether the brake system is still active, and regardless of whether the combustion air pressure P has not yet fallen to the level $P_{lim2}$.

The method shown in Fig. 2 can be designed to be carried out as soon as a reduction in the required torque takes place. Alternatively, the method can be designed to take place only when there is a considerable reduction in the required torque, for example only provided that the reduced torque demand is at most 80% of the torque demand before reduction.

According to the method shown in Fig. 2, the vehicle is driven with a low load function according to Fig. 3 activated. However, there are situations where it can be advantageous to drive the vehicle without a low load function activated. An example of this is shown in the parallel Swedish application 1250775-2, with the title "**METHOD AND SYSTEM FOR DRIVING A VEHICLE II**", from the same applicant as the present invention, where the vehicle can be driven in a first mode or in a second mode, and where, in said second mode, functions such as said low load function are deactivated when this is considered suitable for the purpose of reducing the fuel consumption. However, the present invention is still applicable even in situations such as those described according to the method described in said parallel patent application or generally where a low load function is absent.

An example of a method according to the present invention in such situations is shown in Fig. 5. The method steps 501-502 shown in Fig. 5 correspond in full to the method steps 201-202 in Fig. 2 and are therefore not explained in any more detail. However, according to the method shown in Fig. 5, there is normally no maintaining of the combustion air pressure P, which can be the case, for example, if such a function is completely absent or if the vehicle is driven in said second mode according to said parallel application "**METHOD AND SYSTEM FOR DRIVING A VEHICLE II**".

Consequently it is determined already in step 503 whether any brake system is activated. If this is not the case, the method continues to step 504, which corresponds to step 206 in Fig. 2, i.e. the reference value $P_{ref}$ for the combustion air pressure P is set directly after the reduction of the torque demand in step 502 to the combustion air pressure that is required at the new torque level. According to this embodiment, the driveability of the vehicle is thus affected directly upon reduction in the required torque, as long as a brake system is not activated.

By contrast, if it is determined in step 503 that some brake system is activated, the method continues to step 505, which corresponds to step 207 in Fig. 2, and wherein the combustion air pressure P via the steps 505-506 is then maintained for as long as possible according to what has been described in connection with steps 207-208 in Fig. 2. Since the present invention does not give rise to increased fuel consumption when any brake system is activated, the invention thus allows the driveability of the vehicle to be maintained at a high level in many situations without giving rise to increased fuel consumption, and it is thus able in many situations to permit very good driveability even though the vehicle is actually being driven in a way that prioritizes low fuel consumption over good driveability.

As will be appreciated, the present invention is not limited to the above-described embodiments of the invention and instead it relates to and comprises all embodiments within the scope of protection of the accompanying independent claims.

For example, the method with its method steps can assume other embodiments within the scope of the present invention. For example, the method can be of the type shown in Fig. 6, in which the method steps 601-602 correspond in full to the method steps 201-202 in Fig. 2.

Instead of directly starting the timer $t_t$ as in Fig. 2, it is determined already in step 603 in Fig. 6 whether the brake system is active. If this is the case, the method continues to steps 604-605, which correspond to steps 207-208 in Fig. 2, wherein the combustion air pressure P is maintained for as long as possible. In addition, the above-described embodiment with said second timer can also be applied here.

If it is found in step 603 that the brake system is not active, the method continues to step 606, where said timer $t_t$ is set to zero and is started according to the above. At the same time, precisely as in step 203 above, the reference value $P_{ref}$ for the combustion air pressure P is set equal to $P_2$, after which the method continues to step 607, where it is determined whether the timer $t_t$ has reached the time limit $t_{lim1}$, where the time limit $t_{lim1}$ is the time limit for said low load function according to the above. When the time limit $t_{lim1}$ has been reached, the method continues to step 608, where it is once again determined whether any suitable brake system is activated. If this is not the case, the method returns to step 601 via step 608 where the pressure reference value $P_{ref}$ for the combustion air pressure P is set to the pressure $P_1$ that is presently required. By contrast, if it is established that a suitable brake system is activated, the method continues to step 604 for maintaining of the combustion air pressure according to what has been described above.

## Claims

1. A method when driving a vehicle (100), wherein said vehicle (100) comprises an internal combustion engine (101) with at least one combustion chamber, wherein said vehicle (100) further comprises means for pressurizing air for supply to said combustion chamber, and wherein said vehicle (100) further comprises at least a first brake system, **characterized in that** the method includes:
   - at a reduction of a torque demand from a second level to a first level being lower than said second level, determining whether said first brake system is activated, and

   - if said first brake system is activated, maintaining the pressure of said air supplied for said combustion at a second pressure ($P_2$) being higher than a first pressure ($P_1$) being required at said first level.

2. The method according to claim 1, wherein said method further includes:
   - if said first brake system is activated, maintaining the pressure of said air supplied for said combustion at said second pressure ($P_2$), and

   - if said brake system is not activated, reducing the pressure of said air supplied for said combustion to a first pressure ($P_1$) being lower than said second pressure ($P_2$).

3. The method according to claim 1 or 2, wherein said method further includes:
   - if said first brake system is activated, maintaining the pressure of said air supplied for said combustion at said second pressure ($P_2$), and

- if said brake system is not activated, adjusting the pressure of said air supplied for said combustion to a pressure substantially corresponding to said first pressure ($P_1$).

4. The method according to claim 1, wherein said method includes:
- if said first brake system is activated, maintaining the pressure of said air supplied for said combustion at said second pressure ($P_2$) during a second period, and
- if said brake system is not activated, maintaining the pressure of said air supplied for said combustion at said second pressure ($P_2$) during a first period being shorter than said second period.

5. The method according to claim 4, further including, if said first brake system is activated during said first period, maintaining the pressure of said air supplied for said combustion substantially at said second pressure ($P_2$) during said second period.

6. The method according to claim 5, wherein, if said first brake system is activated during said first period, the pressure of said air supplied for said combustion is maintained substantially at said second pressure ($P_2$) during said second period, wherein said second period is counted from the time said first period is counted or from when said brake system is activated.

7. The method according to any of claims 1-6, further including maintaining a pressure reference value ($P_{ref}$) for the pressure of said air supplied for said combustion at said second pressure ($P_2$) as long as said first brake system is activated.

8. The method according to any of the preceding claims, further including, when said first brake system is activated, maintaining a pressure reference value ($P_{ref}$) for the pressure of said air supplied for said combustion at a pressure being higher than said first pressure ($P_1$) as long as the pressure of said air supplied for said combustion exceeds a limit value ($P_{lim2}$).

9. The method according to any of claims 1-8, further including:
- determining whether the braking force applied by said first brake system exceeds a first braking force, and
- maintaining a pressure reference value ($P_{ref}$) for said air supplied for said combustion at a pressure higher than said first pressure ($P_1$) if the braking force applied by said first brake system exceeds said first braking force.

10. The method according to claim 9, wherein said first braking force at least corresponds to half of the braking force that is obtained from the difference between the gas exchange work at pressurization of said combustion air to said second pressure ($P_2$) and the gas exchange work at pressurization of said combustion air to said first pressure ($P_1$).

11. The method according to any of the preceding claims, wherein said first brake system consists of a service brake system.

12. The method according to any of the preceding claims, wherein transmission of the required torque at said second level requires a second air pressure higher than an air pressure being required at said first level.

13. The method according to any of the preceding claims, wherein said second pressure ($P_2$) is 70-100% of the pressure required for transmission of the required torque at said second level for the air supplied for the combustion.

14. The method according to any of the preceding claims, further including maintaining the pressure of said air supplied for said combustion at said second pressure ($P_2$) if said first brake system is activated, and if the torque demanded at said first level is 0-80% of the torque demanded at said second level.

15. The method according to any of the preceding claims, wherein said first pressure is a pressure which substantially results in an air/fuel ratio constituting a limit value permitted by manufacturers or regulatory authorities when driving said vehicle.

16. The method according to any of the preceding claims, wherein said first brake system consists of a selectively activatable brake system.

17. The method according to any of the preceding claims, further including, when said first brake system is activated, maintaining the pressure of said air supplied for said combustion at said second pressure ($P_2$) for as long as maintaining said air supplied for said combustion at said second pressure ($P_2$) by means of said means for pressurizing air for supply to said combustion chamber is possible when driving said vehicle with the torque demand at said first level.

18. The method according to claim 17, further including, when said second pressure ($P_2$) can no longer be maintained:
- maintaining the pressure of said air supplied for said combustion at as high a pressure as possible.

19. The method according to claim 17 or 18, further including, when said second pressure ($P_2$) can no longer be maintained:
- maintaining the pressure of said air supplied for said combustion at a compared with said first pressure ($P_1$) higher pressure as long as possible.

20. A computer program comprising a program code which, when said program code is executed in a computer, causes said computer to perform the method according to any of claims 1-19.

21. A computer program product comprising a computer-readable medium and a computer program according to claim 20, wherein said computer program is included in said computer-readable medium.

22. A system when driving a vehicle (100), wherein said vehicle (100) comprises an internal combustion engine (101) with at least one combustion chamber, wherein said vehicle (100) further comprises means for pressurizing air for supply to said combustion chamber, and wherein said vehicle (100) further comprises at least a first brake system, **characterized in that** the system comprises:
- means for, at a reduction of a torque demand from a second level to a first level being lower than said second level, determining whether said first brake system is activated, and
- means for, if said first brake system is activated, maintain the pressure of said air supplied for said combustion at a second pressure ($P_2$) being higher than a first pressure ($P_1$) being required at said first level.

23. The system according to claim 22, **characterized in that** said means for pressurizing air for supply to said combustion chamber comprise an assembly being driven by

exhaust gases from the combustion, or an assembly being driven by a crankshaft.

24. A vehicle, **characterized in that** it comprises a system according to claim 22 or 23.

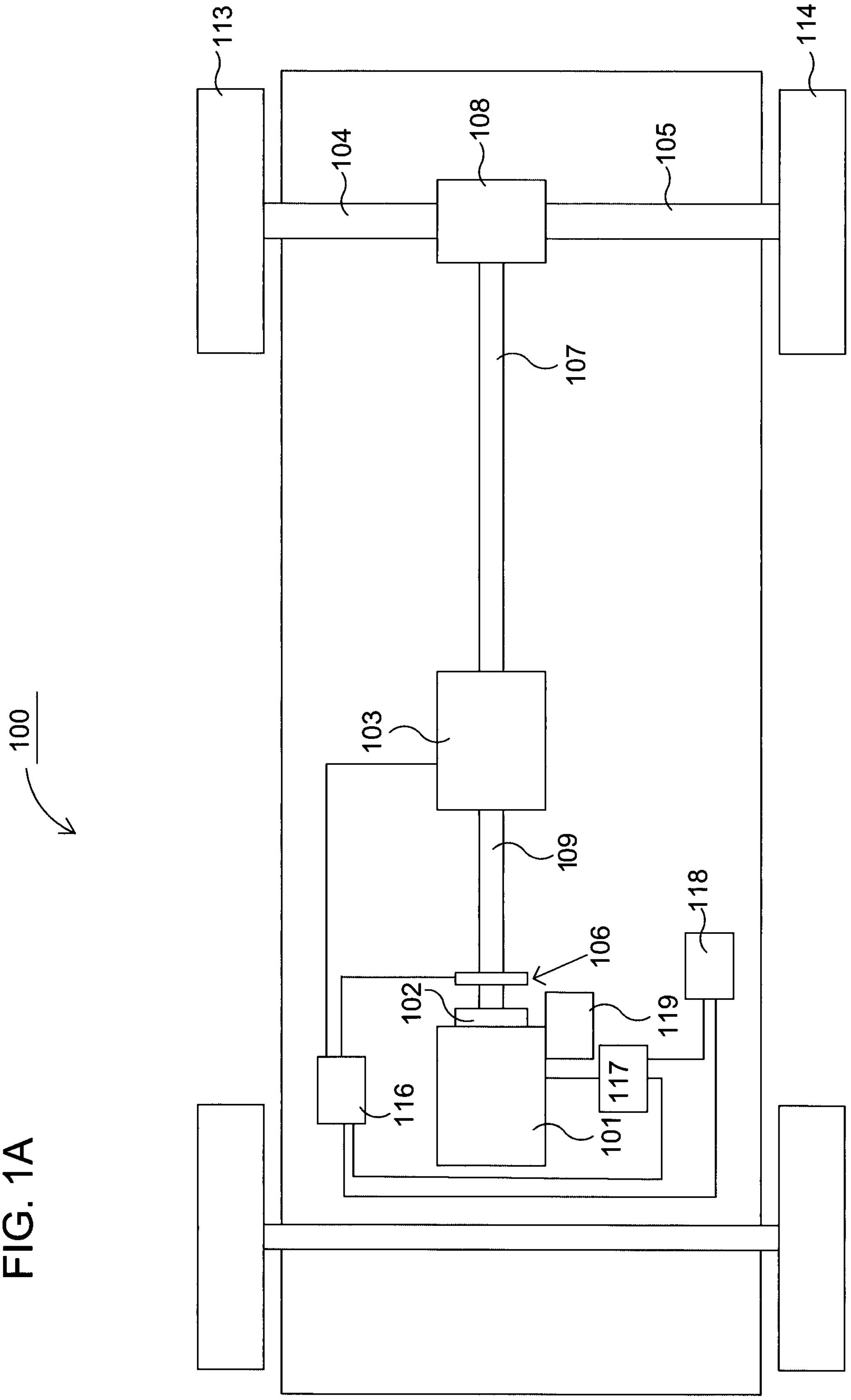



FIG. 1A

FIG. 1B

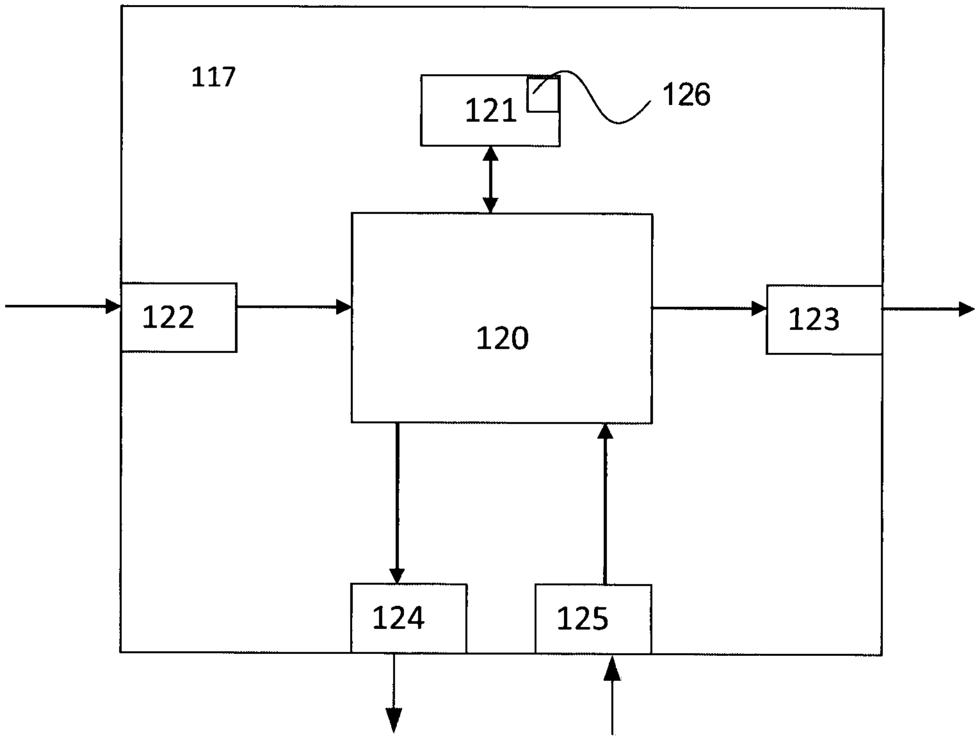
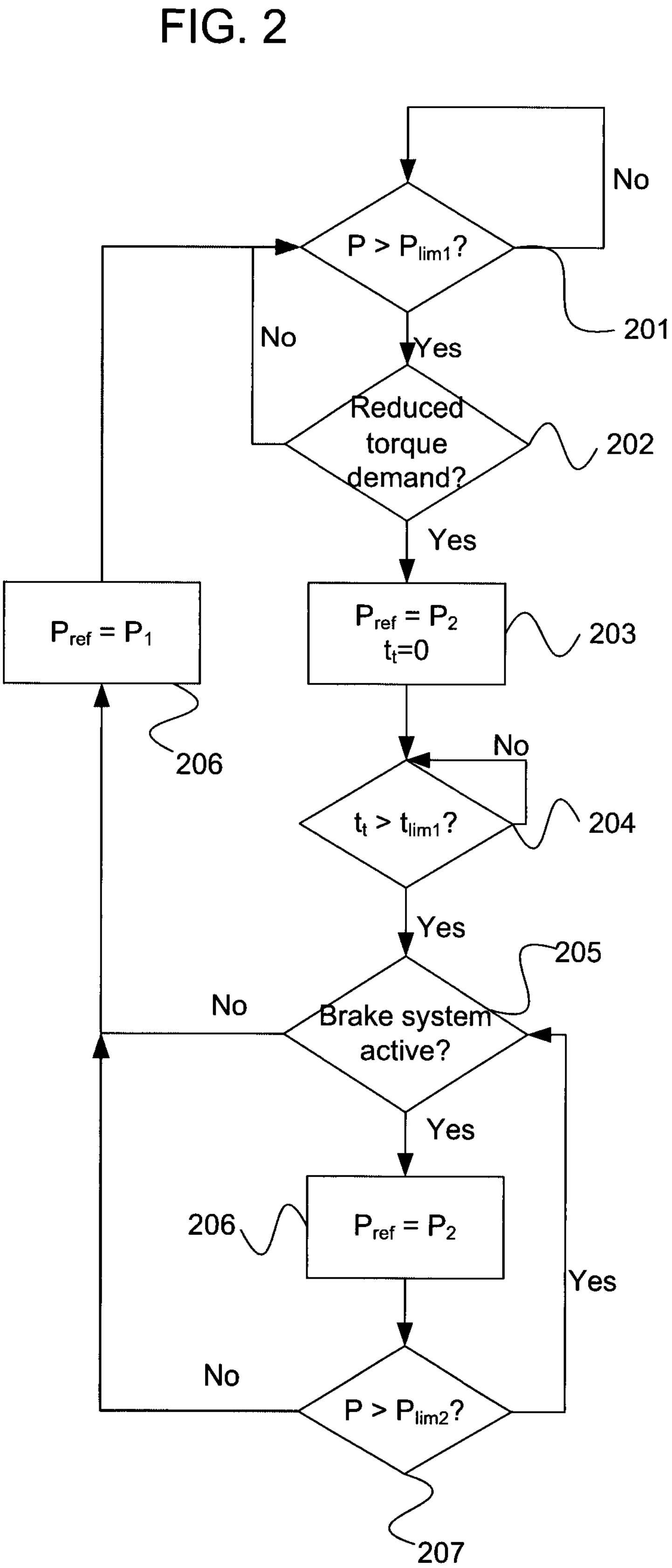


FIG. 2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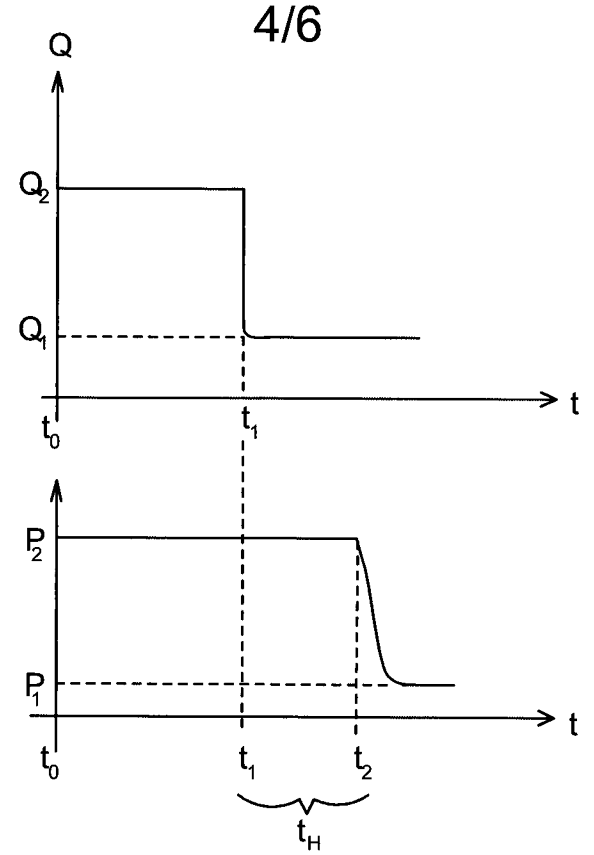
P > Plim1?
No
201
Yes
No
Reduced torque demand?
202
Yes
Pref = P1
Pref = P2
tt=0
203
206
No
tt > tlim1?
204
Yes
205
No
Brake system active?
Yes
206
Pref = P2
Yes
No
P > Plim2?
207

FIG. 3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Q1
t
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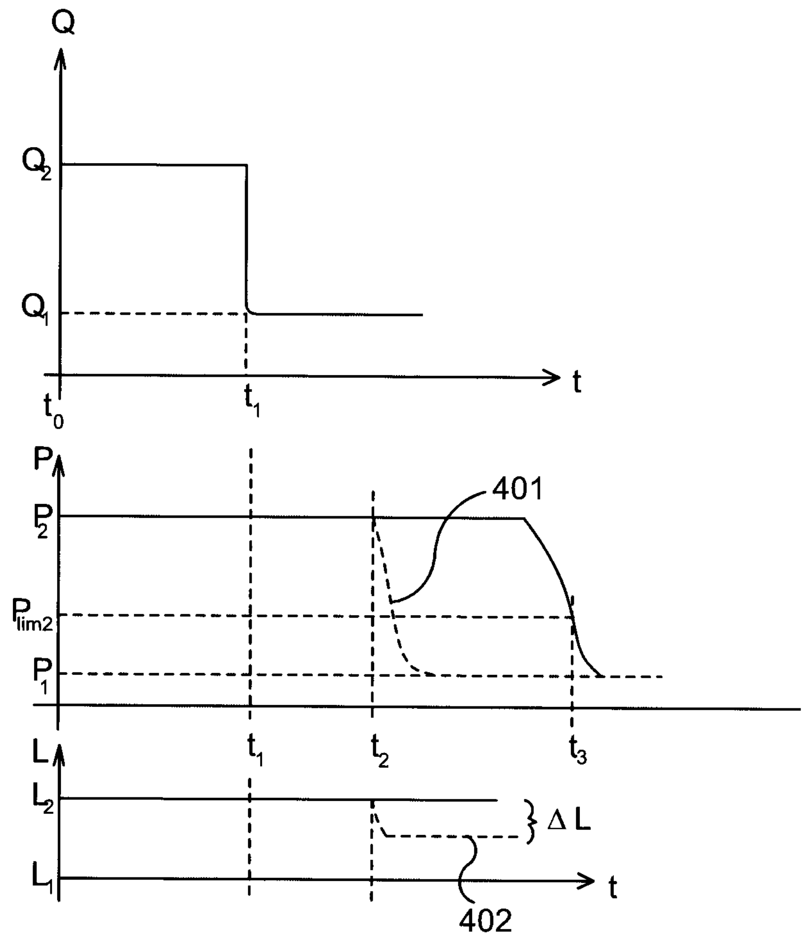
t1
P2
P1
t
t0
t1
t2
tH

FIG. 4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Q2
Q1
t
t0
t1
P
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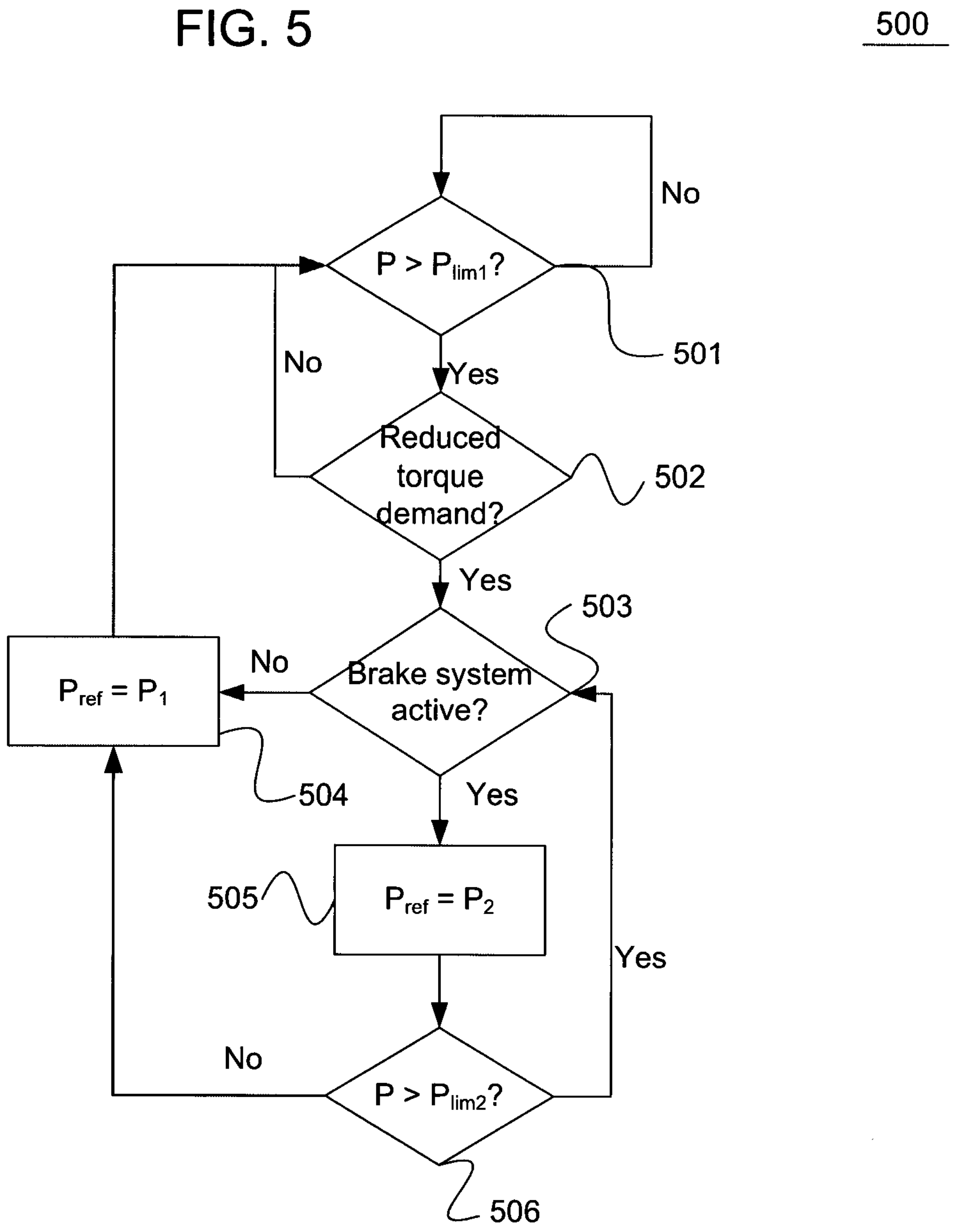
P2
Plim2
P1
t1
t2
t3
L
L2
ΔL
L1
t
402

FIG. 5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501
No
Yes
Reduced torque demand?
502
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503
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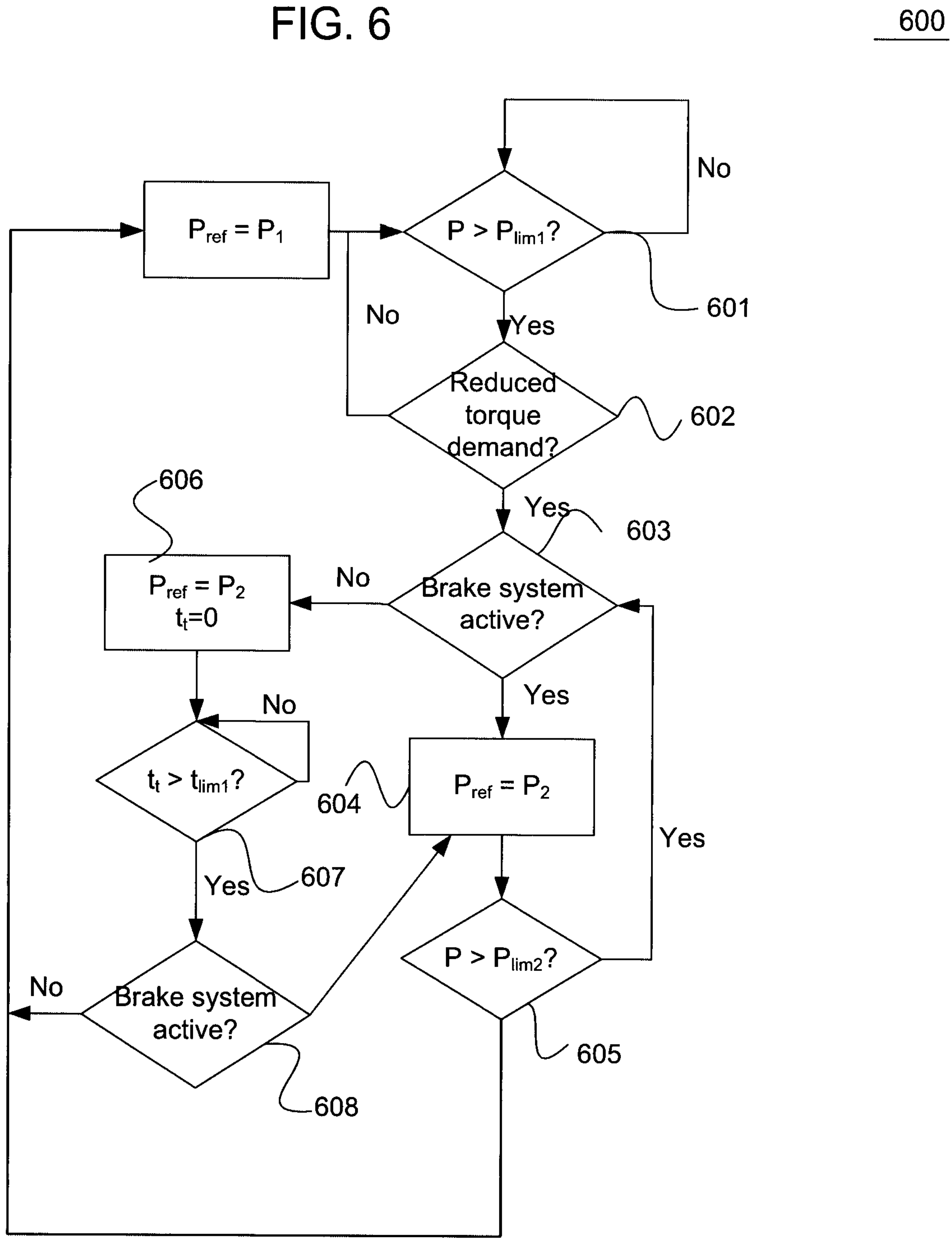
Brake system active?
Pref = P1
504
Yes
505
Pref = P2
Yes
No
P > Plim2?
506

FIG. 6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P > Plim1?
601
No
Yes
Pref = P1
Reduced torque demand?
602
606
Yes
603
No
Pref = P2
tt=0
Brake system active?
No
Yes
tt > tlim1?
Pref = P2
604
Yes
Yes
607
No
P > Plim2?
Brake system active?
605
608

## INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2013/050869

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: B60T, B60W, F02D

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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

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- "A" document defining the general state of the art which is not considered to be of particular relevance
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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 07-11-2013 | 08-11-2013 |

Name and mailing address of the ISA/SE
Patent- och registreringsverket
Box 5055
S-102 42 STOCKHOLM
Facsimile No. + 46 8 666 02 86

Authorized officer
Magnus Thorén
Telephone No. + 46 8 782 25 00

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**Continuation of:** second sheet

**International Patent Classification (IPC)**

***F02D 23/02*** (2006.01)
***B60T 10/00*** (2006.01)
***B60W 10/06*** (2006.01)

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