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(54) **Method and apparatus for controlling the rotation speed of a fan of the engine cooling circuit in a vehicle**

(57) Method for controlling the rotation speed of a fan of an engine cooling circuit in a vehicle, comprising the steps of: evaluating the contributions to the fan rotating speed deriving from the presence of the retarder and of the engine unit, according to the difference between a reference temperature value (2) of the fluid of the engine cooling system and a current measured temperature (3) of the fluid in the engine cooling system, and according to a percentage value (4) of the braking torque required by the retarder or according to a measured value (5) of current speed of the fan; obtainment of the fan rotation speed by adding up the contributions given by the retarder and the engine system.

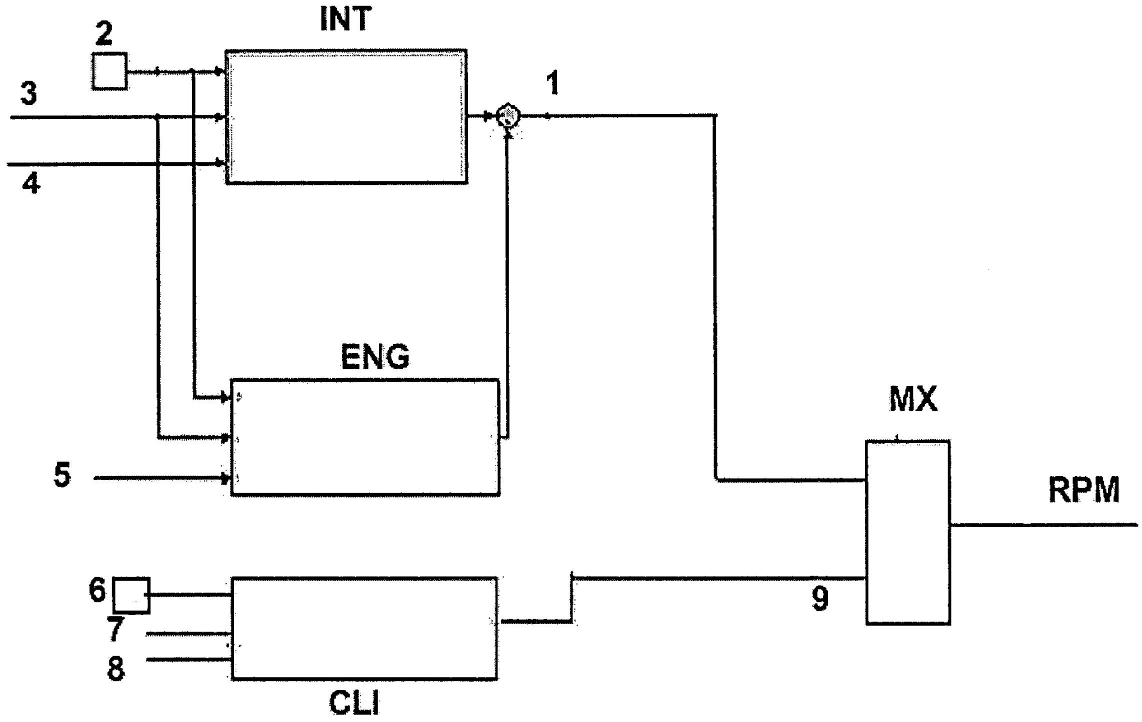

FIG. 1

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Description

Application field of the invention

[0001] The present invention refers to a method and apparatus for controlling the rotation speed of a fan of the engine cooling circuit in a vehicle.

Description of the prior art

[0002] The propulsion systems using thermal engines are usually equipped with a fluid cooling circuit, with different levels of complexity, which uses a fan.

[0003] There are various vehicle systems that may require the activation of the fan: for example, in addition to the circulation system of the engine cooling fluid, which may include various additional elements such as the turbosupercharger circuit and its respective interrefrigeration steps, also the deceleration systems of the dissipative type, such as for example hydraulic decelerators, known as "retarder", the air-conditioning unit, the power takeoffs, and others.

[0004] Usually there is one single fan placed between the engine and the radiator cores, such as the condenser of the air-conditioning circuit, the interrefrigeration heat-exchanger ("aftercooler") of the turbosupercharger circuit, and the engine cooling radiator.

[0005] It is known in the art to make the fan rotate at different discrete speeds, according to the different conditions detected by specially provided control circuits.

[0006] There are several travel conditions wherein the fan rotation speed would be too high, if the fan was able to rotate only at the maximum speed. This would cause an excessive cooling of the circulating fluids: for example an excessive cooling of the engine oil would increase its viscosity, which increases its friction and the fuel consumption.

[0007] Therefore the cooling fan absorbs a remarkable percentage of the power delivered by the engine, thus stopping it, or decreasing its rotation speed in particular operating conditions, makes it possible to spare a lot of energy.

[0008] The fan is usually activated, for certain vehicular applications, such as for example the commercial and industrial ones, by means of a mechanical connection to the drive shaft, using appropriate devices which, for example, are suitable to control the speed variation, instead of using a direct connection to the drive shaft.

[0009] Devices such as the viscous joint, or the electromagnetic coupling, which generate a friction coupling between fan and engine, are known in the art, and, according to the vehicular conditions, they can vary the gear ratio between drive shaft and fan. The viscous joint has the advantage to provide a continuous gear ratio control, but it has the disadvantage to continually drive the fan which, moreover, has a delayed response to the temperature changes. On the other hand, the electromagnetic coupling provides a reasonable number of levels of engine/fan speed ratio, which results in the advantage of a quicker response and a reduced fan driving when the coupling is disconnected, but it has the disadvantage to provide a less gradual variation of the fan speed. Such different levels determine different power absorption and therefore different fuel consumption levels. Said modalities for varying the fan speed, however, are not optimal, since the simplified decision mode, according to which the fan has two or three discrete progressive speeds, still determines a too high fan rotation speed, which does not optimize the fuel consumption.

Summary of the invention

[0010] Therefore the aim of the present invention is to overcome all the drawbacks mentioned above related to an activation according to discrete speed levels, and to provide a method and apparatus for controlling the rotation speed of a fan of the engine cooling circuit in a vehicle, which is able to optimize the fan speed variation, and consequently to optimize the fuel consumption, by keeping a satisfactory performance in terms of engine cooling.

[0011] In particular, a continuous control of the fan rotation speed is actuated, which means that a complete decoupling from the rotation of the drive shaft is possible, according to appropriate control strategies, in order to optimize functioning, efficiency and fuel consumption.

[0012] Advantageously, the continuous control of the fan rotation speed is actuated on the coupling joint between fan and engine.

[0013] In case of an electromagnetic joint coupling, a mechanical coupling is actuated by means of a pulse control.

[0014] The subject of the present invention is a method for controlling the rotation speed of a fan of the engine cooling circuit in a vehicle, comprising the steps of: evaluating the contribution to the fan rotation speed deriving from the presence of a retarder in the engine unit, according to the difference between a reference temperature value of the fluid of the engine cooling system and a measured current temperature of the fluid of the engine cooling system, and according to the percentage of braking torque required by the retarder; evaluating the contribution to the fan rotation speed deriving from the engine system, according to the difference between a reference temperature value of the fluid of the engine cooling system and a measured current temperature of the fluid of the engine cooling system, and according to the measured value of the current fan speed; obtaining said fan rotation speed by adding up the contributions from said retarder and engine system.

[0015] The subject of the present invention is also a method for controlling the rotation speed of a fan of the engine cooling circuit in a vehicle, when said fan is coupled to said engine by means of an electromagnetic joint coupling, the method comprising the steps of: evaluating the contribution to the fan rotation speed deriving from the presence of a retarder in the engine unit, according to the difference between a reference temperature value of the fluid of the engine cooling system and a measured current temperature of the fluid of the engine cooling system, and according to the percentage of braking torque required by the retarder; evaluating the contribution to the fan rotation speed deriving from the engine system, according to the difference between a reference temperature value of the fluid of the engine cooling system and a measured current temperature of the fluid of the engine cooling system, and according to the measured value of the current fan speed; obtaining said fan rotation speed by adding up the contributions from said retarder and engine system; comparison of said first speed value with respect to discrete predetermined fan speed values, and providing a second fan rotation speed value, such as one among a null value, an intermediate value and a maximum value of direct coupling between said coupling and said fan; evaluation of a measurement of the current fuel consumption with respect to a threshold, choosing said fan rotation speed as first speed value if said measurement of the current fuel consumption is higher than the threshold, otherwise as second speed value.

[0016] The subject of the present invention is in particular a method and apparatus for controlling the rotation speed of a fan of the engine cooling circuit in a vehicle, as described more fully in the claims which are an integral part of the present description.

Brief description of the Figures

[0017] Further purposes and advantages of the present invention will become clear from the following detailed description of a preferred embodiment (and respective alternative embodiments) and the drawings that are attached hereto, which are merely illustrative and non-limitative, in which:

figure 1 shows a block diagram of a first alternative embodiment of the method for controlling the fan rotation speed according to the present invention;
figures 2, 3, 4 show block diagrams of embodiments of the INT, ENG, CLI blocks of the method of fig. 1.
figure 5 shows a block diagram of a second alternative embodiment of the method for controlling the fan rotation speed according to the present invention;
figure 6 shows a functional block diagram of an embodiment of the block 53 of fig. 5.

[0018] In the drawings the same reference numbers and letters are used to identify the same elements or components.

Detailed description of preferred embodiments of the invention

[0019] In the following there is the description of the method that is object of the invention, which allows to perform a continuous control of the fan rotation speed, allowing the decoupling from the rotation of the drive shaft.

[0020] The method is described with reference to the functional block diagrams of the attached figures, wherein each block corresponds to the logic functions performed by the apparatus which realizes them.

[0021] Different systems of the vehicle may require the activation of the fan, as they generate heat which is transferred in the respective cooling systems. In the non-limitative example described below, the involved systems are the engine unit, the deceleration system (henceforth called retarder), and the air-conditioning unit.

[0022] Said vehicular systems provide, in a way known in the art, for example on the CAN internal data line, signals or magnitudes which, together with others, are used as input of the continuous control system that is object of the invention, which is suitable to provide in output a magnitude expressing the fan rotation speed.

[0023] With reference to figure 1, the continuous control method comprises a block INT which evaluates the contribution of the retarder, when it is present in the engine system, to the fan speed value; moreover a block ENG evaluates the contribution of the engine system, which may comprise several additional elements, such as the turbo-charger circuit, to said value The two values are added up in output in order to obtain an overall value 1. In case the retarder is not present, its contribution is null.

[0024] The retarder and the engine cooling system are managed together, since in the overall engine system there is the interaction between the two effects generated by the water heating cycle and by the functioning of the retarder, which brakes the kinematic chain of the vehicle, dissipating the kinetic energy into the heat in the hydraulic cooling circuit.

[0025] The retarder generates heat in a rapid way, thus according to the percentage of braking torque required by the retarder, the block performs a predictive control of which fan speed is necessary in order to cool the water. Considering only the contribution of the engine system (block ENG) would excessively delay the optimal intervention of the fan. Therefore the block INT estimates the amount of thermal power that the retarder will introduce in the cooling system: as a matter of fact the required fan rotation speed will be higher if the retarder is activated.

[0026] The block INT receives at the input data relating to: a reference temperature parameter 2 of the fluid in the engine cooling system (for example 102 °C) which ideally should be maintained; the percentage 4 of braking torque required by the retarder 4; the current temperature 3 of the fluid in the engine cooling system.

[0027] The block ENG receives at the input data relating to: the reference temperature parameter 2; the current temperature 3 of the fluid in the engine cooling system; the measured value 5 of the current fan speed.

[0028] An embodiment of the blocks INT and ENG will be described below with reference respectively to figures

2 and 3.

[0029] Preferably it is also present a further block CLI suitable to determine and provide as output 9 a fan speed value given by the contribution of the behaviour of the air-conditioning unit. As a matter of fact, it is necessary to provide a control of the pressure of the gas (freon) in the circuit of the air-conditioning unit, which should not exceed a certain value. Given that the increase of the gas pressure is correlated to the temperature increase of the respective cooling circuit, the control of the gas pressure may be performed by controlling the fan rotation speed.

[0030] The block CLI receives at the input data relating to: a constant reference pressure value 6 of the gas (freon) of the cooling circuit, for example 16bar; a current measured pressure value 7 of the freon; a fan speed value 8, for example 850 rpm.

[0031] An embodiment of the block CLI will be described below with reference to figure 4.

[0032] If the block CLI is not present, the fan speed control value RPM is given by the contribution in the output 1. Otherwise, if the block CLI is present, the fan speed control value RPM is determined in a block MX as the highest value between the two values present in the outputs 1 and 9.

[0033] In a non limitative example the blocks INT, ENG, CLI comprise parallel branches which process the input data according to criteria of integration, derivation and multiplication, which are added up and limited in order to obtain the output value. The input data are available by means of the internal CAN line.

[0034] In fig. 2 the block INT evaluates the difference between the temperature constant 2 and the measured value 3 defined above. The difference is provided to three multiplier inputs by the appropriate constants M1, M2, M3, belonging to three parallel branches: the output of M1 is directly provided to an adder S2; the output of M2 feeds an integrator I2 whose second input receives the percentage value 4 of braking torque required by the retarder, and whose output is provided to a second input of the adder S2; the output of M3 is, on the contrary, provided to a third input of the adder S2. The latter provides in output the sum of the three received contributions to a saturator, whose output provides the value of the block INT contribution to the fan speed value.

[0035] In fig. 3 the block ENG evaluates the difference between the temperature constant 2 and the measured value 3 defined above. The difference is provided to three multiplier inputs by the appropriate constants M4, M5, M6, belonging to three parallel branches: the output of M4 is directly provided to an adder S3; the output of M5 feeds an integrator I3 whose second input receives the measured value 5 of the current fan speed, and whose output is provided to a second input of the adder S3; the output of M6 is, on the contrary, provided to a derivator D3, whose output is provided to a third input of the adder S2. The latter provides in output the sum of the three received contributions to a saturator, whose output provides the value of the block INT contribution to the fan speed value.

[0036] In fig. 4 the block CLI evaluates the difference between the pressure constant 6 of the freon and the measured value 7 defined above. The difference is provided to three multiplier inputs by the appropriate constants M7, M8, M9, belonging to three parallel branches: the output of M7 is directly provided to an adder S4; the output of M8 feeds an integrator I4 whose second input receives the fan speed value 8, and whose output is provided to a second input of the adder S4; the output of M6 is, on the contrary, provided to a derivator D4, whose output is provided to a third input of the adder S4. The latter provides in output the sum of the three received contributions to a saturator, whose output provides the value of the block CLI contribution to the fan speed value.

[0037] In the following a description is given of an alternative embodiment of the control method of the fan rotation speed, in case of electromagnetic joint coupling to the drive shaft. It is known in the art to impose the coupling a condition which makes the fan rotate according to discrete speeds, for example two speeds, an intermediate speed and a maximum speed (in addition to the condition of fan stopped), with direct coupling. As said above, this type of speed control may be improved in terms of fuel consumption. On the other hand, the direct coupling guarantees the less possible wear of the material of the coupling.

[0038] The fan speed control of the continuous type according to the invention may be applied to the electromagnetic coupling by means of a pulse control, using the PWM technique (Pulse Width Modulation). The fan speed control of the continuous type, as said, optimizes the fuel consumption. But on the other hand, the pulse control of the type PWM may cause the wearing of the material of the coupling. In order to solve this potential drawback, the system as described above (fig. 1) is completed by decisional blocks, which are able to decide what kind of fan speed control has to be instantly actuated, whether of the continuous or discrete type, according to its evaluations of the driving or travelling conditions.

[0039] In this case the method comprises the block of fig. 1, and also a block 51 which receives the speed value 1 given by adding up the value calculated by the blocks INT and ENG described above, and evaluates its positioning with respect to two discrete fan speed values, an intermediate value and a maximum value of direct coupling, or the null value, which it chooses at its outputs.

[0040] A decision circuit D5 is foreseen to actuate the decision on the type of fan speed control, enabling the outputs of the block MX described above or of the block 51 according to the signals received at its inputs.

[0041] A block 52 receives a measurement 10 of the current fuel consumption. If said measurement is lower than a threshold 11, for example it is null while braking or when the accelerator pedal is released, the decision circuit D5 provides to the block 51 a choice signal of the original discrete control, since there is no problem of fuel consumption.

[0042] A block 53 may also be present which is able to evaluate the degree of instant and progressive wear of the electromagnetic coupling according to available tabular values.

[0043] A possible embodiment of the block 53 is illustrated in figure 6.

[0044] Measured values of speed engine (angular speed of the drive shaft), of instant fan speed and of the overall distance covered are available, for example by means of the CAN data line. Moreover, the temperature data of the electromagnetic coupling may also be available.

[0045] The fan speed 61 and the drive shaft speed 62 are provided to a block 65 which verifies the difference between the two speed values, and uses such difference in order to find in a pre-stored table, of the type known, the incremental value of the instant wear (in mm/s) which is currently occurring. This wear value is integrated in an integrator 66. Each time the engine is started, the integrator starts from a predetermined value, for example zero; each time the engine is stopped, the obtained value is stored and is then added to the trend obtained in the following functioning of the engine.

[0046] The output of the integrator is provided to a comparator 67 which compares it with a tabular value provided by the block 68, which gives in output a value of expected wear, or tolerable wear, as a function of the overall covered kilometres which are available at the input 63. The table is preloaded. If the calculated wear is higher than the expected and tolerable value, then the output of the comparator 67 will provide to the system, as output of the block 53, the indication to choose the speed control of the original discrete type, which minimizes the wear of the coupling. Moreover if the data on the coupling temperature is available, it is provided to the input 64 of a block 69 which evaluates if the coupling temperature is higher than a threshold: then also the output of the block 69 gives to the system the indication to choose the speed control of the discrete type, which minimizes the wear of the coupling.

[0047] An optional block 70 may also be available, suitable for identifying the type of vehicular usage, which, as a matter of fact, evaluates if it is used on motorways or not, according to the available vehicular parameters. This block may be realized in a way known in the art.

[0048] A motorway usage would be suitable for a continuous pulse control of the fan speed, in order to minimize fuel consumption. On the contrary, a usage for which the dispersion of the thermal flow of the vehicle systems is more difficult, such as for example a hilly or mountainous road, with numerous upward slopes, where the fuel consumption increases a lot, the advantage of a continuous control would be less evident, while the risk to wear the coupling may prevail. Then also the output of the block 70 gives to the system the indication to choose the speed control of the original discrete type, which minimizes the wear of the coupling.

[0049] The outputs of the blocks 67, 69 and 70 are provided to a logic OR which provides the indication signal about the control type to be actuated by the decision circuit D5 (fig. 5).

[0050] The apparatus suitable for the realization of the method may comprise an electronic control unit, which comprises a software which performs the operations described above, appropriately programmed using the programming techniques available to the person skilled in the art. Moreover the apparatus comprises an interface which converts the fan speed data provided in output by the control unit into an electric signal or similar, whose characteristics depend on the type of coupling device between the fan and the drive shaft. In the example of the electromagnetic coupling described above, the signal is a pulse electric signal.

[0051] At least a portion of the control method according to the present invention may advantageously be realized by means of a computer program, which comprises program code means performing one or more steps of said method, when said program is run on a computer. For this reason the scope of the present patent is meant to cover also said computer program and the computer-readable means that comprises a recorded message, such computer-readable means comprising the program code means for performing one or more steps of such method, when such program is run on a computer.

[0052] It will be apparent to the person skilled in the art that further alternative and equivalent embodiments of the invention can be conceived and reduced to practice without departing from the scope of the invention.

[0053] The advantages deriving from the use of this invention are evident.

[0054] Using this solution it is possible to keep an optimal and precise temperature control of the fluid of the different cooling circuits, and therefore it is possible to keep the temperature higher, thus increasing the efficiency of the engine, and reducing the fuel consumption.

[0055] While with the existing systems, given their imprecision and delay of activation, the temperature should be kept lower, in order to avoid problems of overheating.

[0056] From the description set forth above it will be possible for the person skilled in the art to embody the invention with no need of describing further details.

Claims

1. Method for controlling the rotation speed of a fan of the engine cooling circuit in a vehicle, comprising the steps of:

    - evaluating the contribution to the fan rotating speed deriving from the presence of a retarder in the engine unit, according to the difference between a reference temperature value (2) of the fluid of the engine cooling system and a measured current temperature (3) of the fluid of

the engine cooling system, and according to a percentage value (4) of the braking torque required by the retarder;
- evaluating the contribution to the fan rotating speed deriving from the engine system, according to the difference between a reference temperature value (2) of the fluid of the engine cooling system and a measured current temperature (3) of the fluid of the engine cooling system, and according to a measured value (5) of the current fan speed;
- obtaining said fan rotating speed by adding up the contributions given by said retarder and engine system.

2. Control method as in the claim 1, further comprising the steps of:

- evaluating the contribution to the fan rotating speed deriving from an air-conditioning unit, according to the difference between a reference pressure value of the gas of the air-conditioning cooling system (6), and a current measured value (7) of the gas pressure, and according to a current speed of the fan;
- obtaining said fan rotating speed from the highest value between said sum of the contributions given by said retarder and engine system, and said contribution deriving from the air-conditioning unit.

3. Control method as in claim 1 or 2, wherein each one of said contributions to the fan rotating speed deriving from said retarder, engine system and air-conditioning unit is determined according to parallel branches which process the input data according to criteria of integration, derivation, and multiplication which are added up and limited in order to obtain an output value.

4. Method for controlling the rotation speed of a fan of the engine cooling circuit in a vehicle, said fan being coupled to said engine unit by means of an electromagnetic joint coupling, the method comprising the steps of:

- evaluating the contribution to the fan rotating speed deriving from the presence of a retarder in the engine unit, according to the difference between a reference temperature value (2) of the fluid of the engine cooling system and a measured current temperature (3) of the fluid in the engine cooling system, and according to a percentage value (4) of the braking torque required by the retarder;
- evaluating the contribution to the fan rotating speed deriving from the engine system, according to the difference between a reference temperature value (2) of the fluid of the engine cooling system and a measured current temperature (3) of the fluid in the engine cooling system, and according to a measured value (5) of the current speed of the fan;
- obtaining a first value of the fan rotating speed by adding up the contributions given by said retarder and engine system;
- comparing said first speed value with respect to preassigned discrete values of the fan speed, and providing a second value of the fan rotating speed as one among a null value, an intermediate value and a maximum value of direct coupling between said coupling and said fan;
- evaluating a measurement (10) of the current fuel consumption with respect to a threshold (11);
- choosing said fan rotating speed as said first speed value if said measurement (10) of the current fuel consumption is higher than the threshold, otherwise as said second speed value.

5. Control method as in the claim 4, further comprising steps of:

- evaluating the contribution to the fan rotating speed deriving from an air-conditioning unit, according to the difference between a reference pressure value of the gas of the air-conditioning cooling system (6), and a measured current value (7) of the gas pressure, and according to a current speed of the fan;
- obtaining said first value of the fan rotating speed from the highest between said sum of the contributions given by said retarder and engine system, and said contribution deriving from the air-conditioning unit.

6. Control method as in claim 4 or 5, further comprising an evaluation step of the wear degree of said electromagnetic coupling comprising the steps of:

- evaluating the difference between a measured engine speed value and a measured fan speed value;
- using the difference in order to find in a stored table, an increment value of the instant wear of said electromagnetic coupling;
- integrating said increment value of the instant wear adding it up to previous values starting from a first usage of said electromagnetic coupling;
- comparing said integrated value with a tabular value (68), which provides in output a value of expected wear, or tolerable wear, as a function of the overall kilometres covered by the vehicle;
- choosing of said fan rotating speed as said first speed value if said integrated value is lower than

said expected wear value, otherwise as said second speed value.

7. Control method as in claim 6, further comprising a comparison step of a measured temperature value of said electromagnetic coupling with respect to a threshold temperature value:

- choosing said fan rotating speed as said first speed value if said measured temperature value is lower than threshold temperature value, otherwise as said second speed value.

8. Control method as in claim 4 or 5, wherein each one of said contributions to the fan rotating speed deriving from said retarder, engine system and air-conditioning unit is determined according to parallel branches which process the input data according to criteria of integration, derivation, and multiplication which are added up and limited in order to obtain an output value.

9. Control method as in claim 3 or 8, wherein the contribution to the fan rotating speed deriving from said retarder (INT) is evaluated by means of the difference between said reference temperature value (2) and the measured value (3); the difference is provided to said three parallel branches which comprise three multiplications by constant values (M1, M2, M3); a first multiplication (M1) is directly provided to an adder (S2); a second multiplication (M2) feeds an integrator (I2) whose second input receives said percentage value (4) of braking torque required by the retarder and whose output is provided to a second input of the adder (S2); a third multiplication (M3) is provided to a derivator (D2) whose output is provided to a third input of the adder (S2); said adder (S2) providing the sum to a saturator, whose output provides said contribution to the fan rotating speed deriving from the presence of the retarder (INT).

10. Control method as in claim 3 or 8, wherein the contribution to the fan rotating speed deriving from said engine unit (ENG) is evaluated by means of the difference between said reference temperature value (2) and the measured value (3); the difference is provided to said three parallel branches which comprise three multiplications by constant values (M4, M5, M6); a first multiplication (M4) is directly provided to an adder (S3); a second multiplication (M5) feeds an integrator (I3) whose second input receives said measured value (5) of fan current speed and whose output is provided to a second input of the adder (S3); a third multiplication (M6) is provided to a derivator (D3) whose output is provided to a third input of the adder (S3); said adder (S3) providing the sum to a saturator, whose output provides said contribution to the fan rotating speed deriving from said engine unit (ENG).

11. Control method as in claim 3 or 8, wherein the contribution to the fan rotating speed deriving from said air-conditioning unit (CLI) is evaluated by means of the difference between the reference pressure value (6) of the gas of the cooling circuit and a current measured pressure value (7) of the gas; the difference is provided to said three parallel branches which comprise three multiplications by constant values (M7, M8, M9); a first multiplication (M7) is directly provided to an adder (S4) ; a second multiplication (M6) feeds an integrator (I4) whose second input receives said current fan speed value and whose output is provided to a second input of the adder (S4) ; a third multiplication (M9) is provided to a derivator (D4) whose output is provided to a third input of the adder (S4) ; said adder (S4) providing the sum to a saturator, whose output provides said contribution to the fan rotating speed deriving from said air-conditioning unit (CLI).

12. Apparatus for controlling the rotation speed of an engine cooling circuit fan, comprising an electronic control unit comprising means for performing the steps of the method according to any of the previous claims, and an interface for converting the output data of said electronic control unit into a control signal for a coupling device between said cooling circuit fan and said vehicle engine.

13. Computer program comprising program code means suitable for performing the steps of any claim from 1 to 11, when such program is run on a computer.

14. Computer-readable means comprising a recorded program, said computer-readable means comprising program code means suitable for performing the steps according to the claims from 1 to 11, when said program is run on a computer.

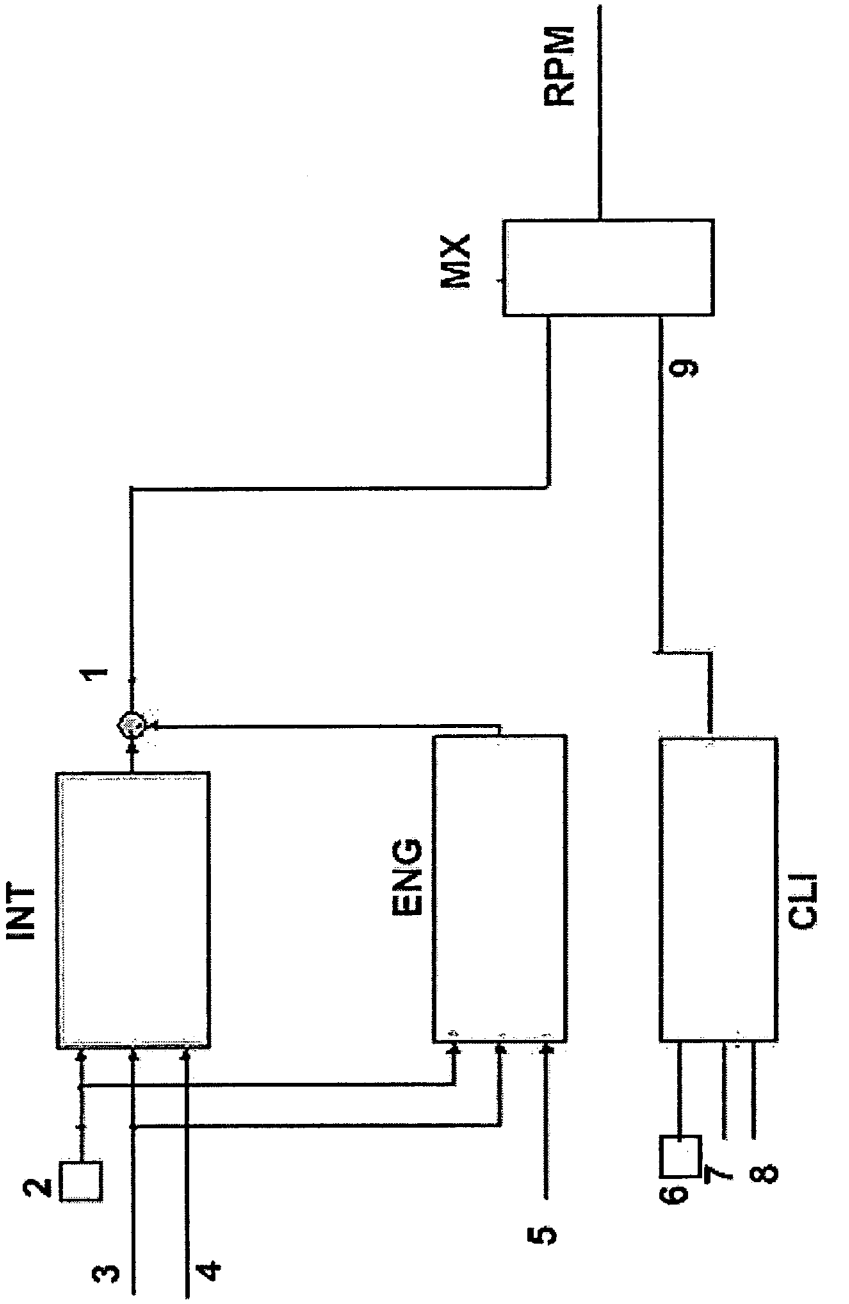

FIG. 1

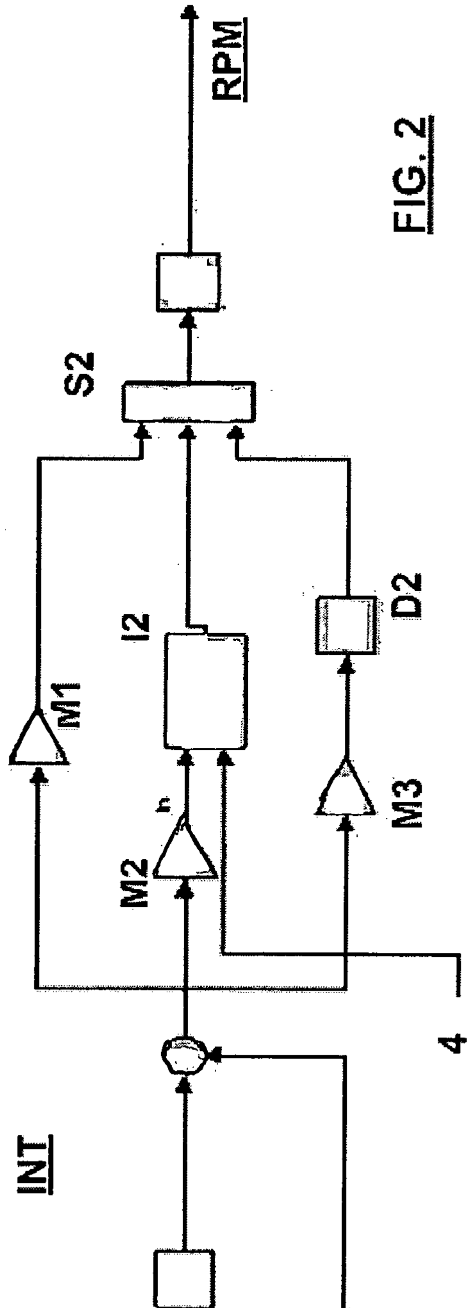

FIG. 2

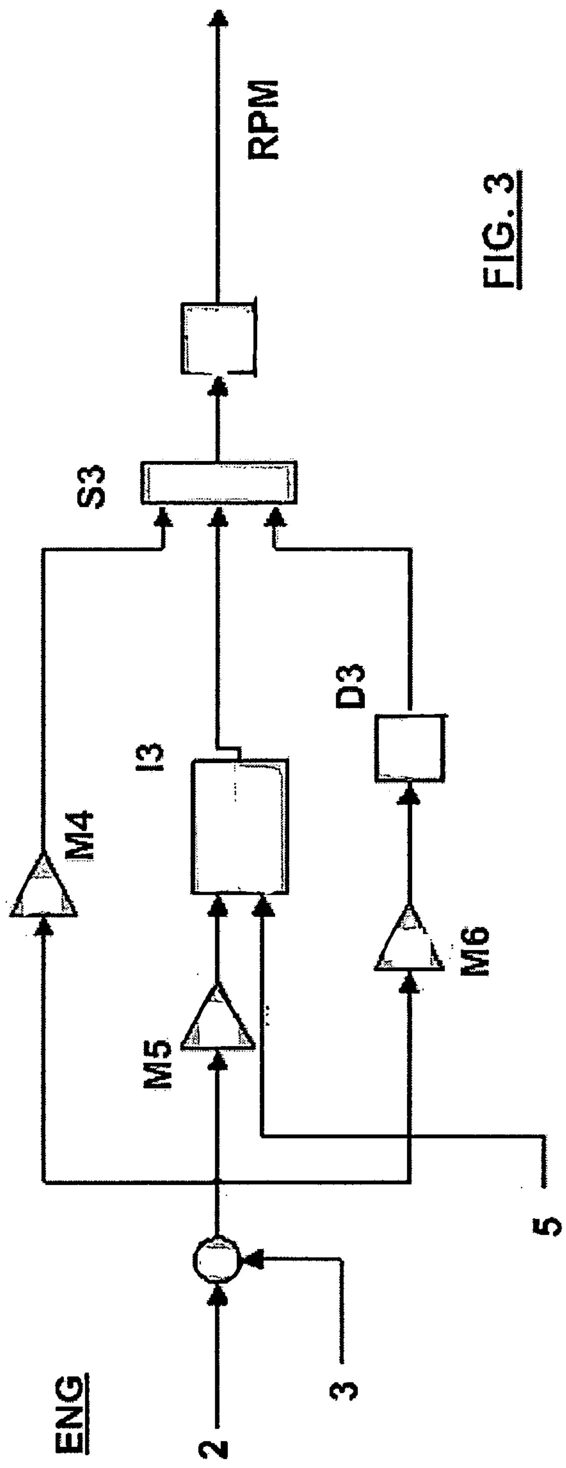

FIG. 3

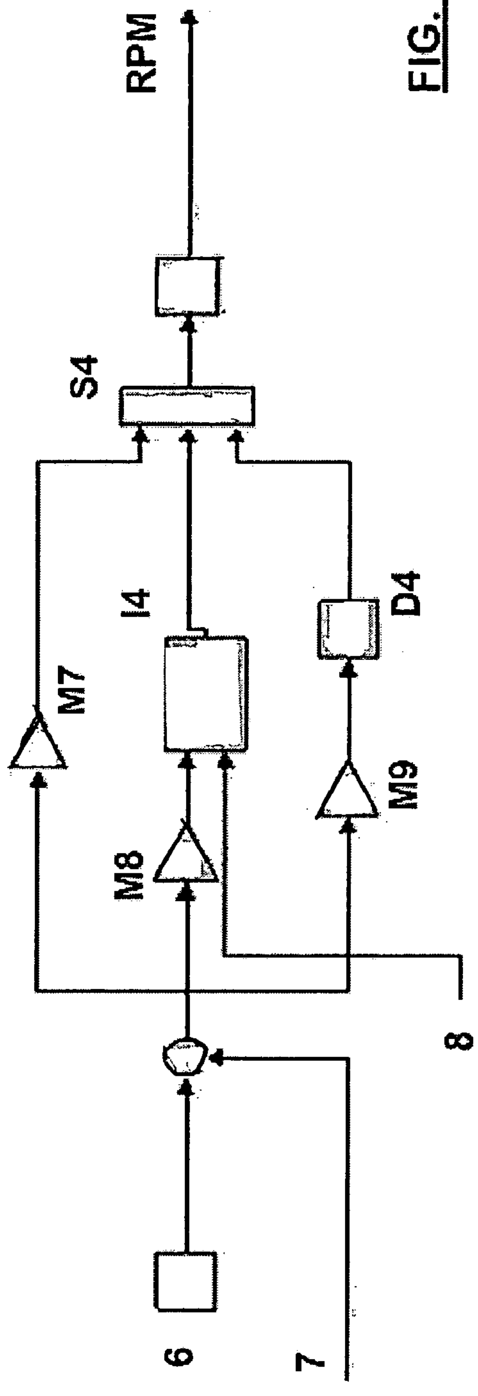

FIG. 4

CLI

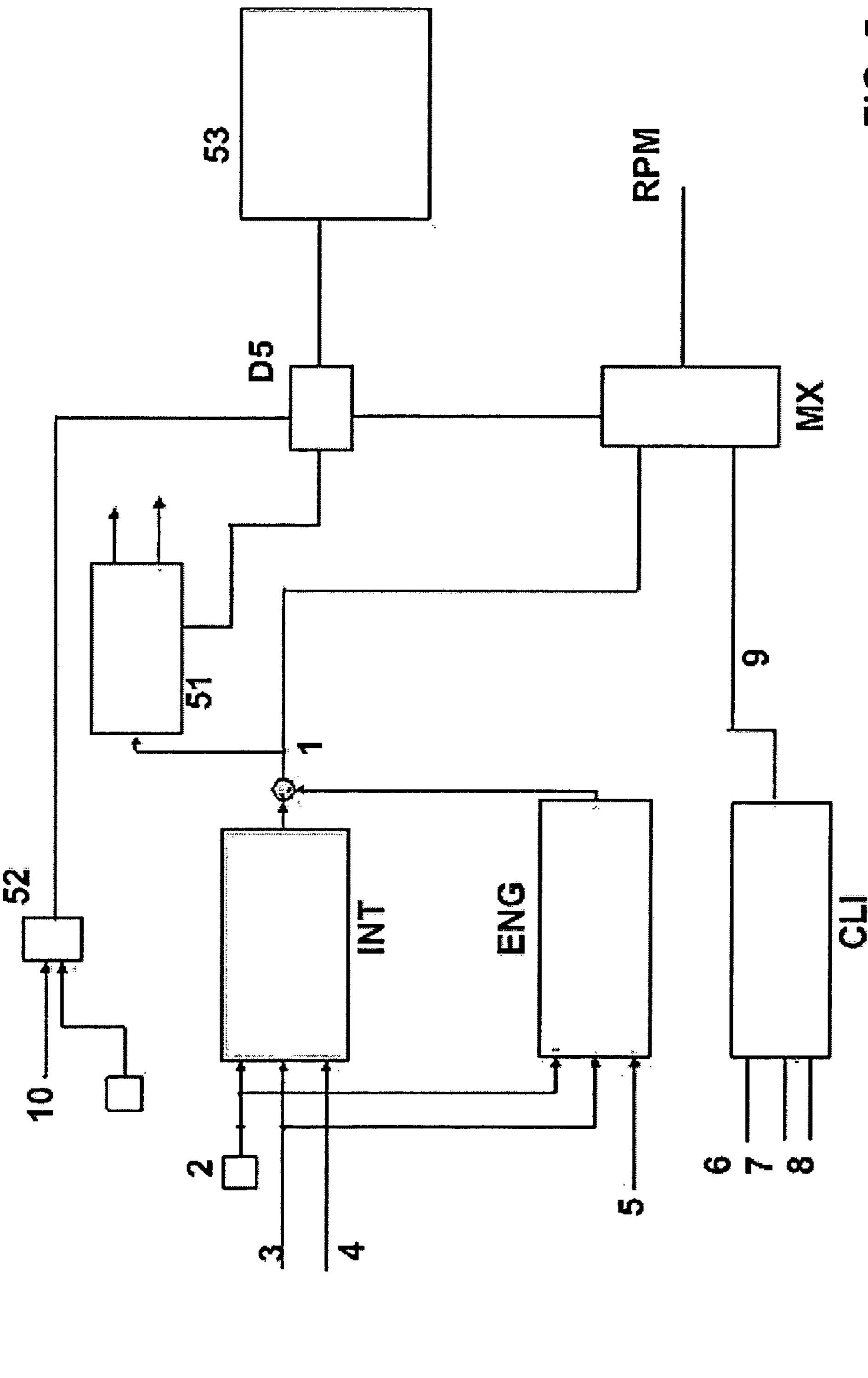

FIG. 5

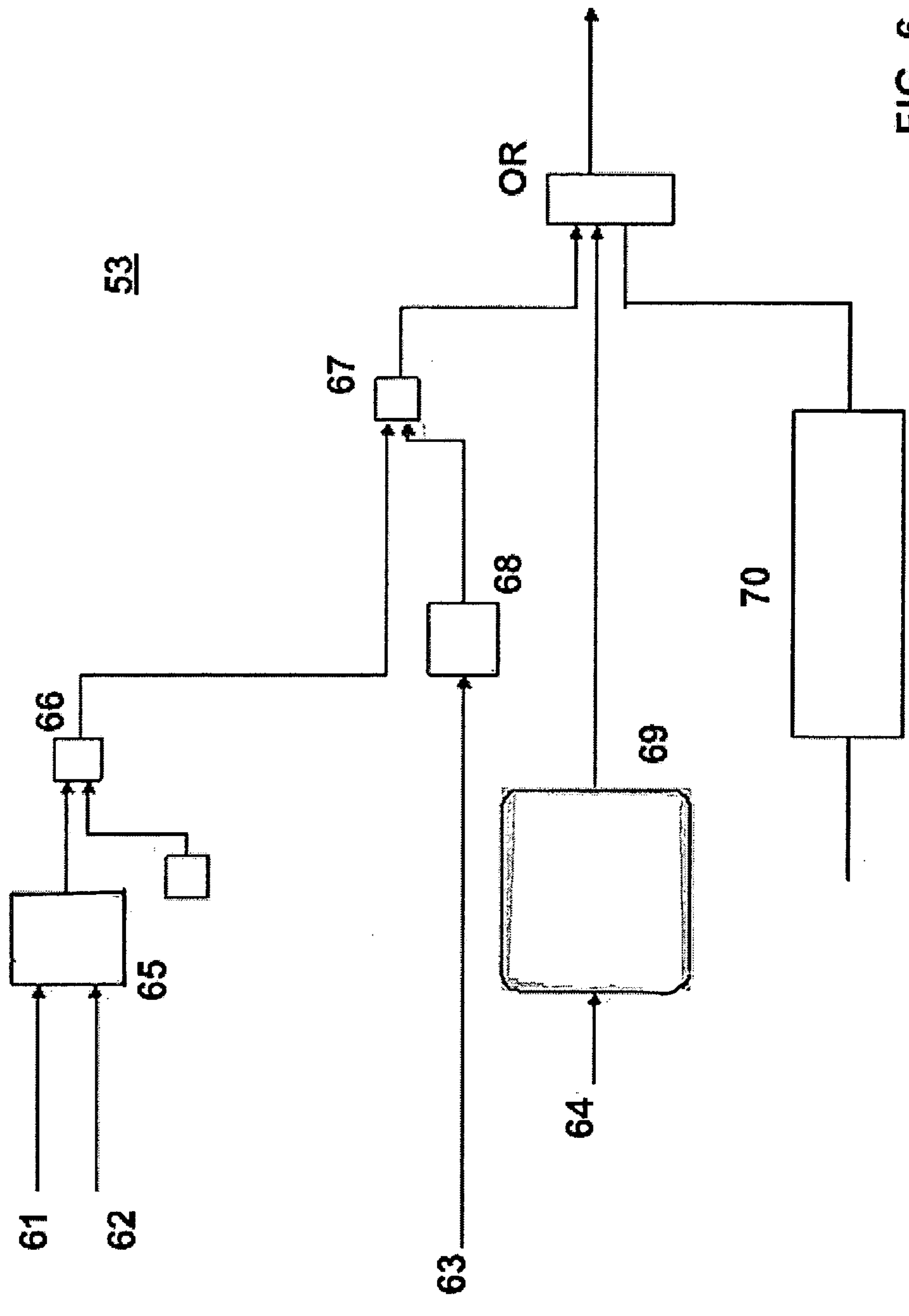

FIG. 6

Europäisches Patentamt
European Patent Office
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EUROPEAN SEARCH REPORT

Application Number
EP 09 42 5469

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2008/069104 A1 (MIZOGUCHI NORIHIDE [JP] ET AL) 12 June 2008 (2008-06-12) & US 2010/064991 A1 (MIZOGUCHI NORIHIDE [JP] ET AL) 18 March 2010 (2010-03-18) * paragraphs [0070], [116], [0113] - [0123], [0146] - [0147]; figures 1,3,12 * -----	1-3, 12-14	INV. F01P7/04 F16D48/06
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	11 June 2010	Luta, Dragos

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