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(54) **A method for operating a multi-stroke combustion engine**

(57) A method for operating a multi-stroke combustion engine provided with electronically controlled intake and exhaust valves, the method comprising the steps of:

- providing a set of different stroke operating modes,

- assigning a combustion frequency number  $N_i$  to each different stroke operating mode, said combustion frequency number indicating the number of strokes performed by a piston in a combustion cycle of said engine.

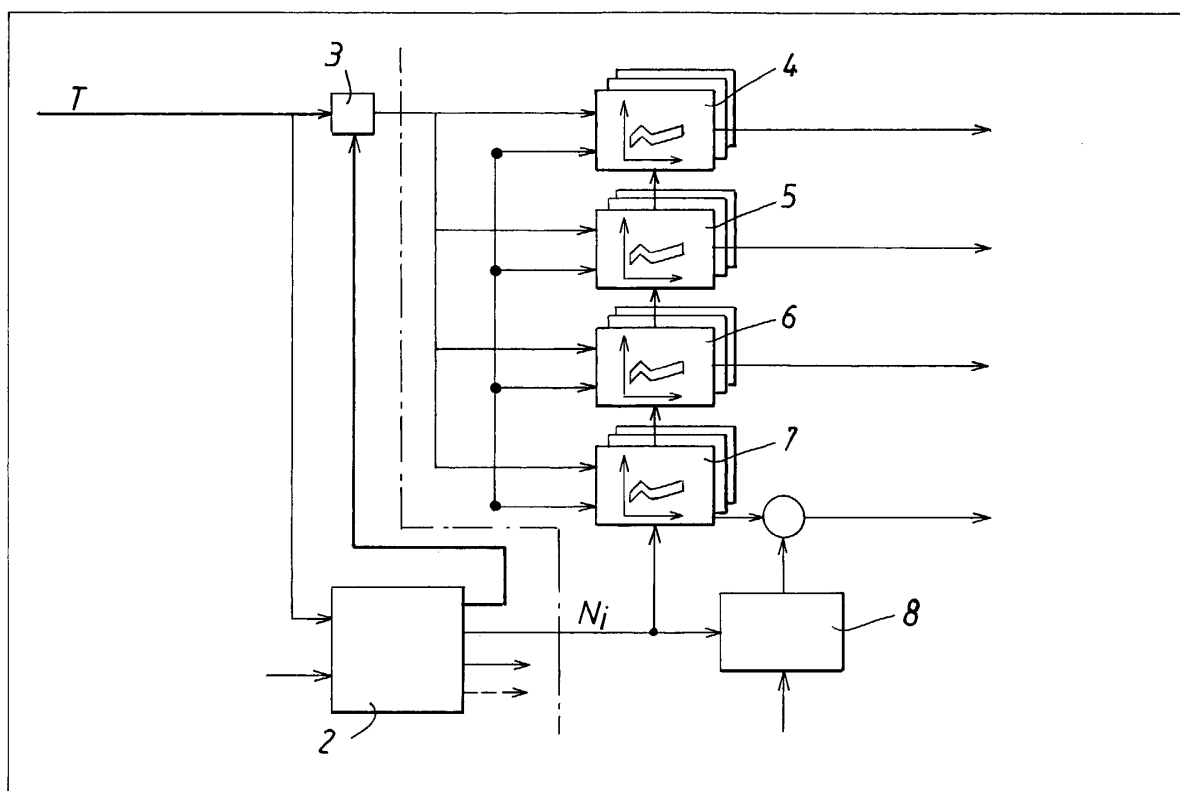


FIG.1

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## Description

### TECHNICAL FIELD

**[0001]** The invention relates to a method for operating a multi-stroke combustion engine according to the preamble of claim 1.

### BACKGROUND ART

**[0002]** Most current standard production car engines use a principle of operation known as four-stroke operation. These four strokes are referred to as the compression, expansion, exhaust and intake strokes. The principles of two-stroke operation and six-stroke operation are also known but restricted in their frequency of usage. An internal combustion engine that can operate under more than one stroke mode is defined as a multi-stroke engine. In U.S. Pat. No. 5,131,354, the two-, four- and six-stroke operation of an internal combustion engine is described. The six-stroke operation is described only in combination with engine start and warm-up.

**[0003]** In internal combustion engines, the decrease in combustion frequency reduces the maximum output, which can be described as the frequency of combustion times the maximum output per combustion. The maximum output per combustion is determined by the geometry of the engine.

**[0004]** A combination of multiple stroke operation modes can remove this restriction. However, previous considerations regarding the demand for high performance have prevented these more efficient engines with strokes greater than four from becoming more common. The complexity of the required system, which allows for a number of stroke operation modes, is extremely high. This complexity makes mass production not cost-effective or feasible today.

**[0005]** The system complexity is due to the requirements a combustion cycle sets in combination with the degree of freedom required for multi-stroke operation. Implicit with multi-stroke operation is that changes between two or more stroke modes have to be performed. A smooth transition between two such stroke modes places a high demand on the degree of freedom of the system.

**[0006]** A method for operating a combustion engine allowing a smooth transition between two such stroke modes is described in patent application US 2002/0083904, which is hereby incorporated by reference.

**[0007]** A drawback with known systems for controlling multi-stroke engines is that the number of parameters in use for performing engine control is extensive. This increases the difficulty of performing a smooth transition between two different stroke modes.

## DISCLOSURE OF INVENTION

**[0008]** An object of the invention is to reduce the difficulty of performing a smooth transition between two different stroke. A further object is to reduce the number of parameters that has to be re-set when changing stroke mode of the engine, such that the difficulty of performing a smooth transition between two different stroke modes is reduced.

**[0009]** This object is achieved by a method for operating a multi-stroke combustion engine according to the characterising portion of claim 1. The method according to the invention makes use of the process steps of assigning a torque factor  $F_i$  to at least two, and preferably each, different stroke operating mode in said set, wherein the torque factor is set such that the quota  $F_i / N_i$  is substantially the same for all stroke operating modes in said set. By substantially the same is intended that the quota does not substantially differ from each other in the different operating modes. Preferably the quota does not differ by more than 10% in the different operating modes. Thereafter the engine control parameters for said multi-stroke combustion engine are determined by a control unit using a stroke mode dependent torque signal as input signal. The stroke mode dependent torque signal is formed from a signal corresponding to requested torque  $T$  as an input, which is multiplied with said torque factor.

**[0010]** The combustion frequency is different in the different stroke modes. In the event a stroke mode where combustion occurs more frequently is used, each combustion should provide less power in order to ensure that the same mean output power is provided from the engine. Equivalently, in the event a stroke mode where combustion occurs less frequently is used, each combustion should provide more power in order to ensure that the same mean output power is provided from the engine.

**[0011]** For example, in the event a 2-stroke mode is used, the required power from each combustion is half of the required power from combustions in a 4 stroke mode in order to obtain the same mean output power from the engine. Furthermore, in the event an 8-stroke mode is used, the required power from each combustion is double the required power from combustions in a 4 stroke mode in order to obtain the same mean output power from the engine.

**[0012]** By using the stroke mode dependent torque signal in stead of the requested torque, the multi-stroke engine is controlled to provide the same mean output power, independent of which stroke operating mode is used. This reduces the difficulty of performing a smooth transition between two different stroke by reducing the amount of data that has to be calibrated in the engine management system.

## BRIEF DESCRIPTION OF DRAWINGS

**[0013]** An embodiment of the invention will be described below, with references to appended drawings, where:

- fig. 1 shows a block diagram for calculating the opening and closing time of exhaust valves and intake valves provided in the cylinder,
- fig. 2 shows a block diagram for calculating the injection time for fuel injectors provided in the engine,
- fig. 3 shows a block diagram for calculating the ignition time for spark plugs provided in the engine,
- fig. 4 shows a block diagram for calculation of a requested indicated torque from a requested braked torque, which is indicated by a maneuvering device, such as an accelerator pedal,
- fig. 5 shows a diagram of different operation states of an engine, and
- fig. 6' shows a list of combinations of running modes, i.e. operation states of an engine

## MODE(S) FOR CARRYING OUT THE INVENTION

**[0014]** Figure 1 shows a block diagram of first part of a control system 1 for operating a multi-stroke combustion engine. The engine is provided with a number of cylinders and two intake valves and two exhaust valves per cylinder. The invention is equally applicable to engines with alternative numbers of valves per cylinder, e.g. two, three or five.

**[0015]** Actuation of intake and exhaust cylinders at each cylinder of the engine are controllable by the control system. Thus, there is no cam shaft in the engine. Instead, each valve can be individually activated with a hydraulic, pneumatic, electromagnetic, piezoelectric or any other known activation aid, controlled by the control system. Through suitable actuation of the intake valves the amount of air admitted to respective cylinder can be controlled.

**[0016]** Figure 1 show specifically a block diagram for calculating the opening and closing time of exhaust valves and intake valves provided in the cylinder. A requested torque  $T$  is used as an input signal to a first part of the control system, which determines the opening and closing time of the intake and exhaust valves. The requested torque  $T$  is preferably transformed into a requested indicated torque  $T_{ind}$  from a requested braked torque  $T_{br}$  before used as an input to the first part of the control system. The requested braked torque is indicated by a maneuvering device controlled by the driver, such as an accelerator pedal or optionally by a cruise

control.

**[0017]** The requested torque  $T$  is used as input signal to a first function block 2, where a stroke operating mode is determined in dependence of the magnitude of the requested torque  $T$  and the engine speed  $n$ , which is a second input signal to the first function block 2. The stroke operating mode can be determined in a manner known to a person skilled in the art, for example as disclosed in DE19850584.

**[0018]** The engine can be operated in a plurality of different running modes. The running modes may include, in addition to different stroke operating modes, different valve number modes and valve open modes, as will be described in more detail with reference to figure 2.

**[0019]** The first function block 2 generates output signals including a combustion frequency number  $N$ , which is decided in dependence of the stroke operating mode selected, data concerning the ignition angle, ignition order and the next upcoming ignition and a torque factor  $F$  corresponding to the combustion frequency number  $N$  assigned to the stroke mode in operation.

**[0020]** For example, if the engine operates in a 4 stroke mode the frequency number will be set to  $N = 4$  and the torque factor will be set to  $F = 1$ . If the engine operates in a 6 stroke mode the combustion frequency number will be set to  $N = 6$  and the torque factor will be set to  $F = 1,5$ . Furthermore if the engine operates in a 2 stroke mode, the combustion frequency number will be set to  $N = 2$  and the torque factor will be set to  $F = 0,5$ .

**[0021]** If the engine operates in a mode where cylinder deactivation occurs in a specified pattern a combustion frequency number and a torque factor will be assigned in correspondence with the specified pattern. For instance if every fifth combustion is deactivated the torque factor will be set to 1,25 (1/0,8) and the combustion frequency will be set to  $N = 5$ .

**[0022]** The specified examples use the four stroke combustion mode as a norm, with a torque factor  $F = 1$  and a combustion frequency number  $N = 4$ . The invention operates with any choice of stroke mode as a norm. Furthermore it is the relative size of the torque factor between the different stroke modes that are of importance. This torque factor should be chosen such that it compensates linearly for the difference in the torque provided from a particular stroke mode in reference to a reference stroke mode. For example, if the particular stroke mode provides an average output torque, which is twice as high as the reference mode the torque factor should be set to  $F = 0,5$  in the case the reference mode has the torque factor  $F = 1$ .

**[0023]** The requested torque  $T$  is multiplied with the torque factor  $F$  at a second function block 3. A stroke mode dependent torque signal  $T_{sm}$  is thereby obtained. The stroke mode dependent torque signal  $T_{sm}$  together with a signal corresponding to engine speed  $n$  are used as input signals to a first set of maps 4 providing exhaust valve opening time  $EVO_j$  for respective cylinder  $j$  as a

function of said stroke mode dependent torque signal and engine speed. The first set of maps include at least one map per stroke operating mode. The calculation of the output signal corresponding to the exhaust valve opening time  $EVO_j$  is done in a manner known to the person skilled in the art, for example via interpolation in a matrix. An signal indicating in which running mode and in particular, in which stroke mode the engine is operating is generated from the first function block and used as an input signal for determination of which map in said first set of maps should be applied.

**[0024]** The stroke mode dependent torque signal  $T_{sm}$  together with a signal corresponding to engine speed  $n$  are also used as input signals to a second set of maps 5 providing exhaust valve closing time  $EVC_j$  for respective cylinder  $j$  as a function of said stroke mode dependent torque signal and engine speed  $n$ . The second set of maps 5 include at least one map per stroke operating mode. The calculation of the output signal corresponding to the exhaust valve closing time  $EVC_j$  is done in a manner known to the person skilled in the art, for example via interpolation in a matrix. An signal indicating in which running mode and in particular, in which stroke mode the engine is operating is generated from the first function block and used as an input signal for determination of which map in said second set of maps should be applied.

**[0025]** The stroke mode dependent torque signal  $T_{sm}$  together with a signal corresponding to engine speed  $n$  are furthermore used as input signals to a third set of maps 6 providing intake valve opening time  $IVO_j$  for respective cylinder  $j$  as a function of said stroke mode dependent torque signal and engine speed. The third set of maps include at least one map per stroke operating mode. The calculation of the output signal corresponding to the intake valve opening time  $IVO_j$  is done in a manner known to the person skilled in the art, for example via interpolation in a matrix. An signal indicating in which running mode and in particular, in which stroke mode the engine is operating is generated from the first function block and used as an input signal for determination of which map in said third set of maps should be applied.

**[0026]** The stroke mode dependent torque signal  $T_{sm}$  together with a signal corresponding to engine speed  $n$  are finally used as input signals to a fourth set of maps 7 providing intake valve closing time  $IVC_j$  for respective cylinder  $j$  as a function of said stroke mode dependent torque signal and engine speed. The fourth set of maps include at least one map per stroke operating mode. The calculation of the output signal corresponding to the intake valve closing time  $IVC_j$  is done in a manner known to the person skilled in the art, for example via interpolation in a matrix. An signal indicating in which running mode and in particular, in which stroke mode the engine is operating is generated from the first function block and used as an input signal for determination of which map in said fourth set of maps should be applied.

**[0027]** In a preferred embodiment as shown in figure 1, the intake valve closing time  $IVC_j$  is adjusted for any deviation of the air fuel mixture from a stoichiometric combustion condition. The deviation from a requested lambda value, in most cases a stoichiometric combustion condition, is calculated at a third function block 8. The third function block 8, which perform the function of a lambda controller, receives an input signal from a lambda sensor mounted in the exhaust gas conduit. The sensor indicates the present lambda (i.e. the air/fuel ratio) in the exhausts. A correction value  $\Delta IVC_j$  is decided in accordance with principles well known to a person skilled in the art in the third correction block. The calculation of the correction value can be performed for example in the manner disclosed in US 5752491, which is incorporated by reference. The adjustment of the Intake valve closing time  $IVC_j$  in the embodiment shown in figure 1 is done by adding the correction angle  $\Delta IVO_j$  to the intake valve closing time  $IVC_j$  provided as an output signal from the fourth set of maps.

**[0028]** Figure 2 shows a block diagram of second part 10 of a control system 1 for operating a multi-stroke combustion engine. Figure 2 shows specifically a block diagram for calculating the injection time  $t_j$  for respective injector at respective cylinder  $j$ .

**[0029]** A requested torque  $T$  is used as an input signal to the second part 10 of the control system. The requested torque  $T$  is preferably transformed into a requested indicated torque  $T_{ind}$  from a requested braked torque  $T_{br}$  before used as an input to the first part of the control system. The requested braked torque is indicated by a maneuvering device controlled by the driver, such as an accelerator pedal or optionally by a cruise control.

**[0030]** The requested torque  $T$  is multiplied with the torque factor  $F$  at a fourth function block 11. A stroke mode dependent torque signal  $T_{sm}$  is thereby obtained.

**[0031]** The stroke mode dependent torque signal  $T_{sm}$  is together with an input signal corresponding to the engine speed  $n$  used as input signals to a sixth function block 12, which performs a calculation of fuel mass for injection in dependence of said input signals. The calculations are performed in a manner known to the person skilled in the art, for example by interpolation in a matrix. The calculations are according to the example shown performed for providing stoichiometric combustion conditions. The output signal corresponding to fuel mass  $m_{stoi}$  providing stoichiometric conditions is adjusted in accordance with information from a seventh function block 13 which calculates a requested lambda value from input signals including engines speed and requested torque. The lambda value can, according to principles well known to a person skilled in the art, be allowed to deviate from stoichiometric conditions at high torque demand, where gasoline is used for preventing overheating. The lambda value could also deviate from stoichiometric if a lean burn mode is implemented or lean starts are used for minimising emissions.

**[0032]** The adjustment of the fuel mass is performed

in the embodiment shown in figure 2 at an eighth function block 14 by division of output signal corresponding to fuel mass  $m_{\text{sto}}i$  providing stoichiometric conditions by the lambda value calculated at the seventh function block 13.

**[0033]** The fuel mass is further adjusted for the amount of fuel, which adheres to the walls at a position located downstream of the injection ports. This adjustment is done in a ninth function block 15. The calculation of the correction value relating to the effect of adhered fuel incorporates an additive component corresponding to adhered fuel and a subtractive component corresponding to evaporated fuel from aggregation of adhered fuel. Calculations of this type are well known to persons skilled in the art. An example of a system for calculation of adjustment of fuel mass due to adhered fuel is given in US 5,701,871, which is incorporated by reference. The output signal  $m_{\text{actual}}$  from the ninth function block corresponds to the actual amount of fuel to be injected at respective injection port of the engine.

**[0034]** An injection time  $t_j$  for respective injector at respective cylinder  $j$  is calculated at a tenth function block 16. Such calculations are well known to person skilled in the art. In the embodiment shown a linear transform is performed by multiplying the output signal  $m_{\text{actual}}$  from the ninth function block corresponding to the actual amount of fuel with a base injection coefficient  $k$ .

**[0035]** The injection time  $t_j$  for respective injector at respective cylinder  $j$  is further adjusted for battery correction at an eleventh function block 17. Calculations of battery correction are well known to a person skilled in the art and will therefore not be described in detail. An example for how to calculate battery correction is given in US 5,531,208, which is hereby incorporated by reference.

**[0036]** Figure 3 shows a block diagram of a third part 20 of a control system for operating a multi-stroke combustion engine. Figure 2 shows specifically a block diagram for calculating the ignition time  $t_{\text{ign}j}$  for respective spark plug at respective cylinder  $j$ .

**[0037]** A requested torque  $T$  is used as an input signal to the third part 20 of the control system. The requested torque  $T$  is preferably transformed into a requested indicated torque  $T_{\text{ind}}$  from a requested braked torque  $T_{\text{br}}$  before used as an input to the first part of the control system. The requested braked torque is indicated by a maneuvering device controlled by the driver, such as an accelerator pedal or optionally by a cruise control.

**[0038]** The requested torque  $T$  is multiplied with the torque factor  $F$  at a twelfth function block 21. A stroke mode dependent torque signal  $T_{\text{sm}}$  is thereby obtained.

**[0039]** The stroke mode dependent torque signal  $T_{\text{sm}}$  is together with an input signal corresponding to the engine speed  $n$  and information concerning actual valve mode, which is determined in the first function block 2 (fig. 1), performing running mode selection, used as input signals to a thirteenth function block 22. In the thirteenth function block 22, the actual ignition angle for re-

spective cylinder is determined. The thirteenth function block 22 includes maps for determining the ignition angle as a function of engine speed, requested torque and current valve number mode. Calculations of ignition angle are well known to the person skilled in the art and will not be described in further detail. The actual ignition angle is compensated for events requiring a non optimum ignition time for a maximum torque response such as knocking and for retarding the ignition at low load due to the reduced temperature and pressure and thereby the mixtures ability to ignite. The actual ignition angle is used as an input signal to ignition means.

**[0040]** The stroke mode dependent torque signal  $T_{\text{sm}}$  is together with an input signal corresponding to the engine speed  $n$  and information concerning actual valve mode, which is determined in the first function block 2 (fig. 1), performing running mode selection, also used as input signals to a fourteenth function block 23. In the thirteenth function block 23, the optimal ignition time for respective cylinder is determined. The thirteenth function block 22 includes at least one map for each different stroke operating mode. The optimal ignition time is the ignition time, which would generate maximum output torque from the engine. A deviation from optimal ignition time can be necessary in the event that knocking occurs or at low load due to the reduced temperature and pressure and thereby the mixtures ability to ignite.

**[0041]** The output signal from the thirteenth and fourteenth function blocks are used as input signals to a fifteenth function block 24, where a difference signal  $\Delta\text{ign}$  is generated. The difference signal is used as an input signal when calculating a requested indicated torque from a requested generated torque as will be further explained with reference to figure 4.

**[0042]** Figure 4 shows a block diagram of fourth part 30 of a control system 1 for operating a multi-stroke combustion engine. Figure 4 shows specifically a block diagram for transforming an input signal corresponding to requested braked torque  $T_{\text{br}}$  into an output signal corresponding to requested indicated torque. The requested indicated torque corresponds to the torque the engine would generate if no pumplosses or energy conversions losses would occur and if the engine was running without friction. The requested braked torque is used as an input to a sixteenth function block 31 where compensation for internal friction of the engine is performed in a first compensation step. Estimation of internal friction is done in a seventeenth function block 32 using engine speed and temperature as input signals. The estimation is performed by interpolation in a matrix, which is based from measured test values. Such estimations are well known to a person skilled in the art and will therefore not be described in further detail.

**[0043]** The requested braked torque is furthermore compensated for pumplosses at an eighteenth functional block 33 in a second compensation step. The compensation is performed by adding a compensation component corresponding to the pumplosses to the output

signal from the sixteenth functional block 31. The pump losses are calculated in a conventional manner in an nineteenth functional block 34 using engine speed and requested torque as input signals. Pump losses are determined by interpolation in a matrix, which includes values based on experimental measurements. The manner of determining pump losses is well known to a person skilled in the art and will therefore not be described in detail.

**[0044]** The requested braked torque is furthermore compensated for energy conversion losses at an eighteenth functional block 35 in a third compensation step. The compensation is performed by adding a compensation component corresponding to the energy conversion losses to the output signal from the eighteenth functional block 33. The energy conversion losses are calculated in a conventional manner in an nineteenth functional block 36 using engine speed and requested torque as input signals. Calculation algorithms for determining energy conversion losses are performed by interpolation in a matrix. The torque values which are included in the matrix are formed by subtracting the skid torque for active valves which is obtained with active valves which are opening and closing according to a particular valve mode and the from the skid torque with all valves open. By skid torque is meant the torque which is required to turn the crankshaft of the engine, when the engine is not running.

**[0045]** In a fourth compensation step, the requested braked torque is compensated for deviations from optimal ignition. The compensation is performed in a twentieth functional block 37 by dividing the output signal from the eighteenth functional block 35 with a divisor estimated in a twenty first functional block 38. The divisor is determined in the twenty first functional block 38 using information  $\Delta \text{ign}$  about deviation of ignition time from optimal ignition time, theoretically providing maximum output torque. The signal  $\Delta \text{ign}$  is generated in a fifteenth functional block 24 (fig. 3). The divisor which corresponds to the loss of torque due to non optimal ignition time is determined as a function of the deviation from optimal ignition time. The determination of the divisor is done in a manner well known to persons skilled in the art and will therefore not be described in further detail.

**[0046]** In a fifth compensation step, the requested braked torque is compensated for deviations from stoichiometric condition. The compensation is performed in a twenty second functional block 39 by dividing the output signal from the twentieth functional block 37 with a divisor estimated in a twenty third functional block 40. The divisor is determined in the twenty third functional block 40 using information about a requested lambda value, which can deviate from stoichiometric condition. The requested lambda value is generated in a seventh functional block 13 (fig. 2). The divisor which corresponds to the change of provided output torque due to deviation from stoichiometric condition is determined in a manner well known to persons skilled in the art and

will therefore not be described in further detail.

**[0047]** Fig. 5 shows torque and engine speed regions for six different operation states. It should be borne in mind that the running modes included in the operation states are given below as examples, and a large number of alternative combinations of running modes are possible. Also, the torque and engine speed limits shown in fig. 5 are given by example only, and can be positioned anywhere in the torque-speed domain depending on design preferences.

**[0048]** A first operation state O1, for covering relatively low torque and speed intervals, includes the first valve number mode N1, i.e. leaving one inlet valve and one outlet valve closed during all strokes of the stroke cycles, the six stroke mode S2 and the Early Intake Valve Closing (EIVC) mode C1.

**[0049]** A second operation state O2, for covering approximately similar engine speed interval as the first operation state O1, but higher torque intervals, includes the second valve number mode N2, i.e. activating all valves to take in and expel air and exhaust, the four stroke mode S1 and the EIVC mode C1.

**[0050]** A third operation state O3, for covering higher engine speed intervals than the first operation state O1 in approximately similar torque intervals, includes the first valve number mode N1, the six stroke mode S2 and the Late Intake Valve Closing (LIVC) mode C2.

**[0051]** A fourth operation state O4, for covering approximately similar engine speed interval as the third operation state O3, but higher torque intervals, includes the second valve number mode N2, the four stroke mode S1 and the LIVC mode C2.

**[0052]** As can be seen in fig. 5, there is a fifth and a sixth operation state O5, O6 at low and high engine speeds, respectively, and at very low torque intervals. The fifth operation state O5 includes the first valve number mode N1, the six stroke mode S2 and the Late Intake Valve Opening (LIVO) mode C3. The sixth operation state O6 includes the first valve number mode N1, the cylinder deactivation mode S3 and the LIVC mode C2. Cylinder deactivation is performed by canceling fuel injection to a particular cylinder in order to operate the engine by a reduced number of cylinders. Cylinder deactivation is particularly advantageous in low load conditions. The manner of performing cylinder deactivation is well known to a person skilled in the art.

**[0053]** Above a number of running modes has been described, but it should be noted that the invention is applicable where engines are adapted to run in other running modes as well. Figure 6 shows a list of combinations of running modes, i.e. operation states of an engine.

**[0054]** Each operation state includes one running mode from each of the three groups valve number modes, stroke modes, and valve open modes. The valve number modes include the first, second, third and fourth valve number mode N1, N2, N3, N4. The stroke modes include the first and second stroke modes S1,

S2, and also third and fourth stroke modes S3, S4. The two latter modes refer to eight stroke and twelve stroke modes, respectively. Of course further stroke modes, e.g. a sixteen stroke mode, are possible, but not included in the list of table 1. The valve open modes include the EIVC mode C1, the LIVC mode C2, and the LIVO mode C3.

**[0055]** Since each operation state includes one running mode from each of the three groups described above, and two of the groups in this example contain four modes and the third contain three modes, there are forty eight possible operation states of the engine, including the combinations of running modes as suggested in table 1. The first six operation states 01-06 have been described above.

**[0056]** Again additional running modes are possible, at which the invention further describe below, is equally applicable. Also, other groups or types of running modes are possible, apart from the valve number modes, stroke modes, and valve open modes.

**[0057]** The invention is also applicable in cases where the operation states are composed of a lesser amount of running modes that in the cases described above.

**[0058]** For instance, the invention is applicable to situations where the engine is adapted to run in different running modes of one type only, e.g. different stroke modes only, without provision for changing between other types of modes.

## Claims

1. A method for operating a multi-stroke combustion engine, the method comprising the steps of:

- providing a set of different stroke operating modes,
- assigning a combustion frequency number  $N_i$  to at least two different stroke operating modes, said combustion frequency number indicating the number of strokes performed by a piston in a combustion cycle of said engine, **characterised in that** said method further comprises the method step of:
- assigning a torque factor  $F_i$  to said at least two different stroke operating modes in said set, wherein the torque factor is set such that the quota  $F_i / N_i$  is substantially the same for all stroke operating modes in said set.

2. A method according to claim 1 **characterised in that** said method further comprises the steps of :

- calculating engine control parameters for said multi-stroke combustion engine by a control unit using a signal corresponding to requested torque T as an input, multiplying said requested torque with said torque factor to obtain

a stroke mode dependent torque signal and using said stroke mode dependent torque signal for determination of engine control parameters, whereby the multi-stroke engine is controlled to provide the same mean output power, independent of which stroke operating mode is used.

3. A method according to claim 2, wherein said engine control parameters, which are calculated by using said stroke mode dependent torque signal, includes one or several of the following engine control parameters: spark advance, injection angle, injection duration, intake valve opening, intake valve closing, exhaust valve opening, exhaust valve closing, phasing between a first and a second intake valve provided in each cylinder of said multi-stroke combustion engine and phasing between a first and a second exhaust valve provided in each cylinder of said multi-stroke combustion engine.

4. A method according to claims 2 or 3, wherein said requested torque T is transformed to a requested indicated torque, representing the torque that is provided from the multi-stroke combustion engine before torque reduction due to pump losses, losses due to friction and losses due to energy conversion, before multiplication with said torque factor.

5. A method according to claim 4, wherein a transform from the requested torque to the requested indicated torque include compensation for any of or a combination of the following parameters: non optimal ignition, non optimal exhaust valve opening and non optimal fuel/air mixture.

6. A method according to claims 4 or 5, wherein said stroke mode dependent torque signal together with a signal corresponding to engine speed are used as input signals to a first set of maps providing exhaust valve opening time as a function of said stroke mode dependent torque signal and engine speed, said first set of maps including at least one map per stroke operating mode.

7. A method according to claim 6, wherein said exhaust valve opening time is further compensated for deviation from optimal exhaust valve opening time providing maximum output torque.

8. A method according to any of claims 4 - 7, wherein said stroke mode dependent torque signal together with a signal corresponding to engine speed are used as input signals to a second set of maps providing exhaust valve closing time as a function of said stroke mode dependent torque signal and engine speed, said second set of maps including at least one map per stroke operating mode.

9. A method according to any of claims 4 - 8, wherein said stroke mode dependent torque signal together with a signal corresponding to engine speed are used as input signals to a third set of maps providing intake valve opening time as a function of said stroke mode dependent torque signal and engine speed, said third set of maps including at least one map per stroke operating mode. 5
10. A method according to any of claims 4 - 9, wherein said stroke mode dependent torque signal together with a signal corresponding to engine speed are used as input signals to a fourth set of maps providing intake valve closing time as a function of said stroke mode dependent torque signal and engine speed, said fourth set of maps including at least one map per stroke operating mode. 10
11. A method according to claim 10, wherein said intake valve closing time is further compensated for deviation from optimal air/fuel mixture. 20
12. A method according to claim 11, wherein the amount of compensation of said intake valve closing time is calculated by a lambda control circuit, which establishes a correction signal which has a magnitude corresponding to the deviation from stoichiometric combustion. 25
13. A method according to claim 4 or 5, wherein said stroke mode dependent torque signal together with a signal corresponding to engine speed are used as input signals to a first fuel mass calculation map providing an output signal corresponding to a fuel mass providing stoichiometric combustion. 30
14. A method according to claim 13, wherein said output signal corresponding to a fuel mass providing stoichiometric combustion is adjusted for deviation from stoichiometric combustion. 35
15. A method according to claims 13 or 14, wherein said output signal corresponding to a fuel mass providing stoichiometric combustion is adjusted for wall wetting. 40
16. A method according to any of claims 13 - 15, wherein an injection time is calculated from said fuel mass. 45
17. A method according to claim 15, wherein said injection time is adjusted for battery correction. 50
18. A method according to claims 4 or 5, wherein said stroke mode dependent torque signal together with a signal corresponding to engine speed are used as input signals to a fifth set of maps providing actual ignition time as a function of said stroke mode dependent torque signal and engine speed, said fifth set of maps including at least one map per stroke operating mode. 55
19. A method according to claim 18, wherein said stroke mode dependent torque signal together with a signal corresponding to engine speed are used as input signals to a sixth set of maps providing ignition time giving optimum output torque as a function of said stroke mode dependent torque signal and engine speed, said sixth set of maps including at least one map per stroke operating mode.
20. A method according to claim 19, wherein the deviation between the ignition time giving optimum output torque and the actual ignition time is used as an input parameter in the transform from the requested torque to the requested indicated torque.
21. Method according to any of the preceding claims, **characterised in that** a combustion frequency number and a torque factor are assigned to each different stroke operating modes in said set.
22. Method according to any of the preceding claims, **characterised in that** said quota is constant for each different stroke operating modes in said set.



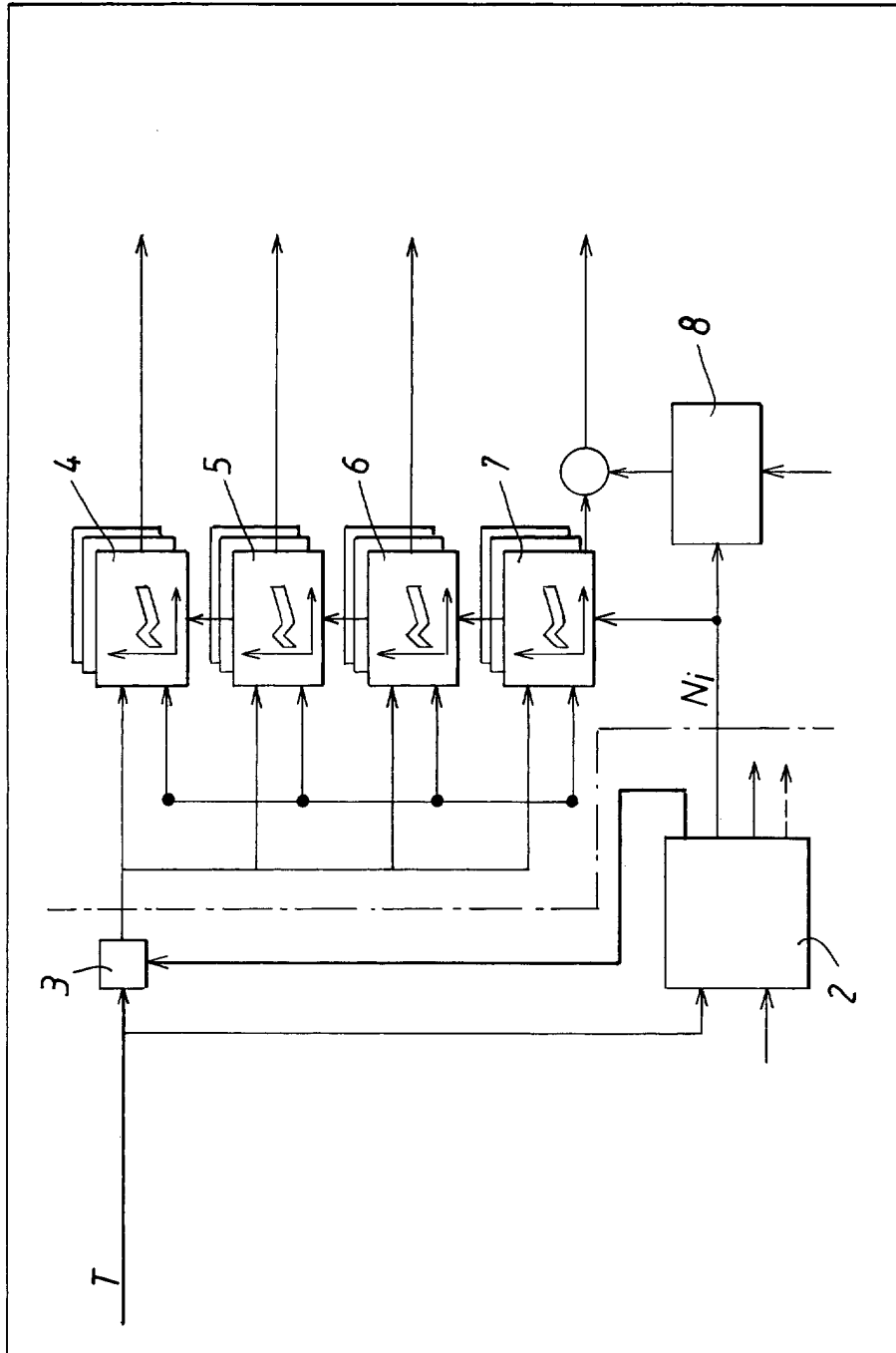
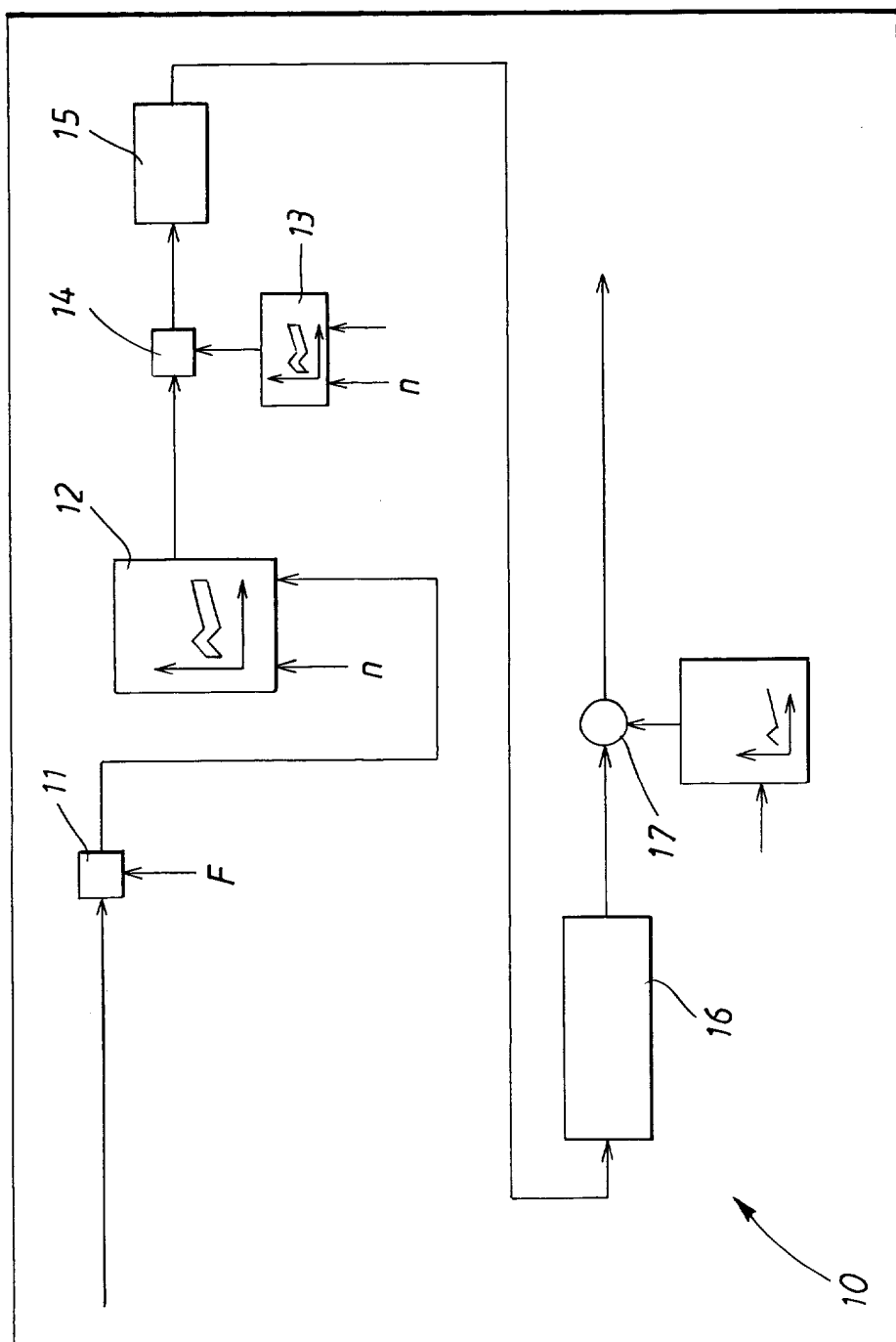


FIG. 1

FIG. 2

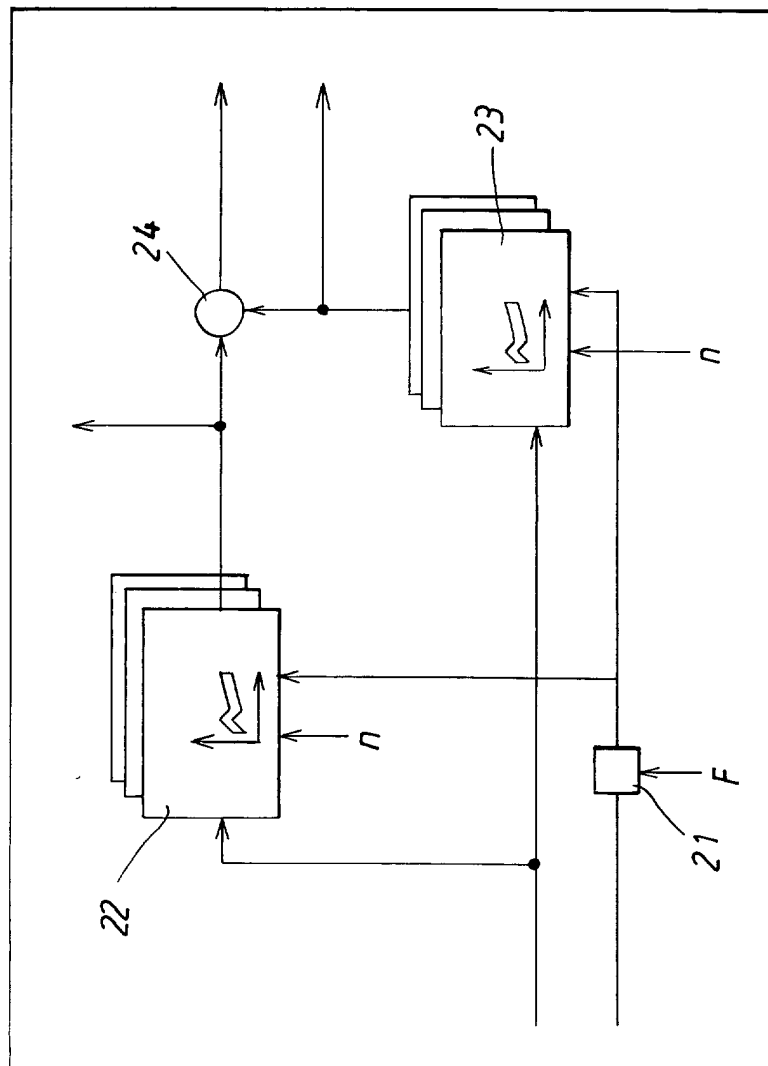


FIG. 3

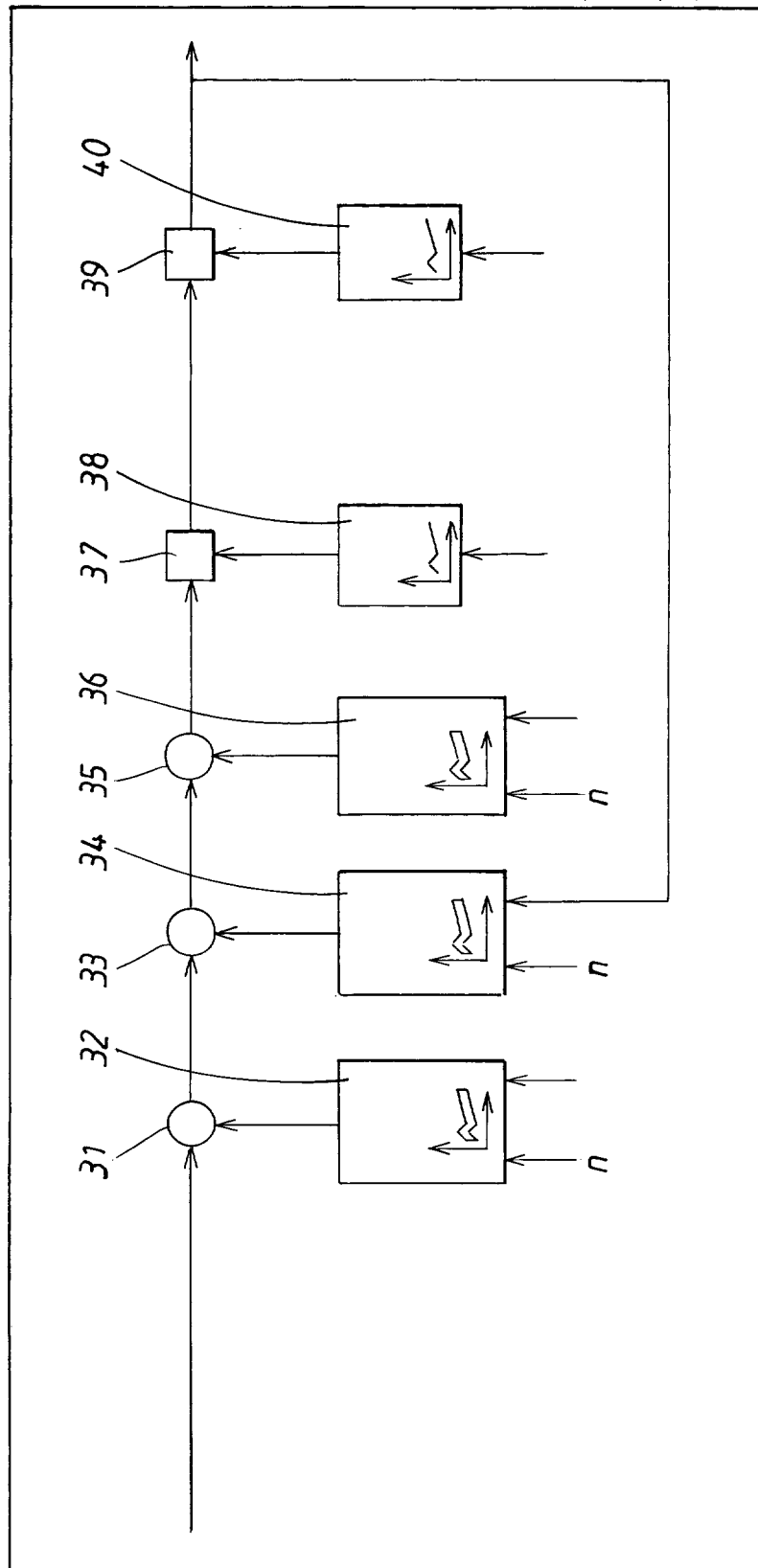


FIG. 4

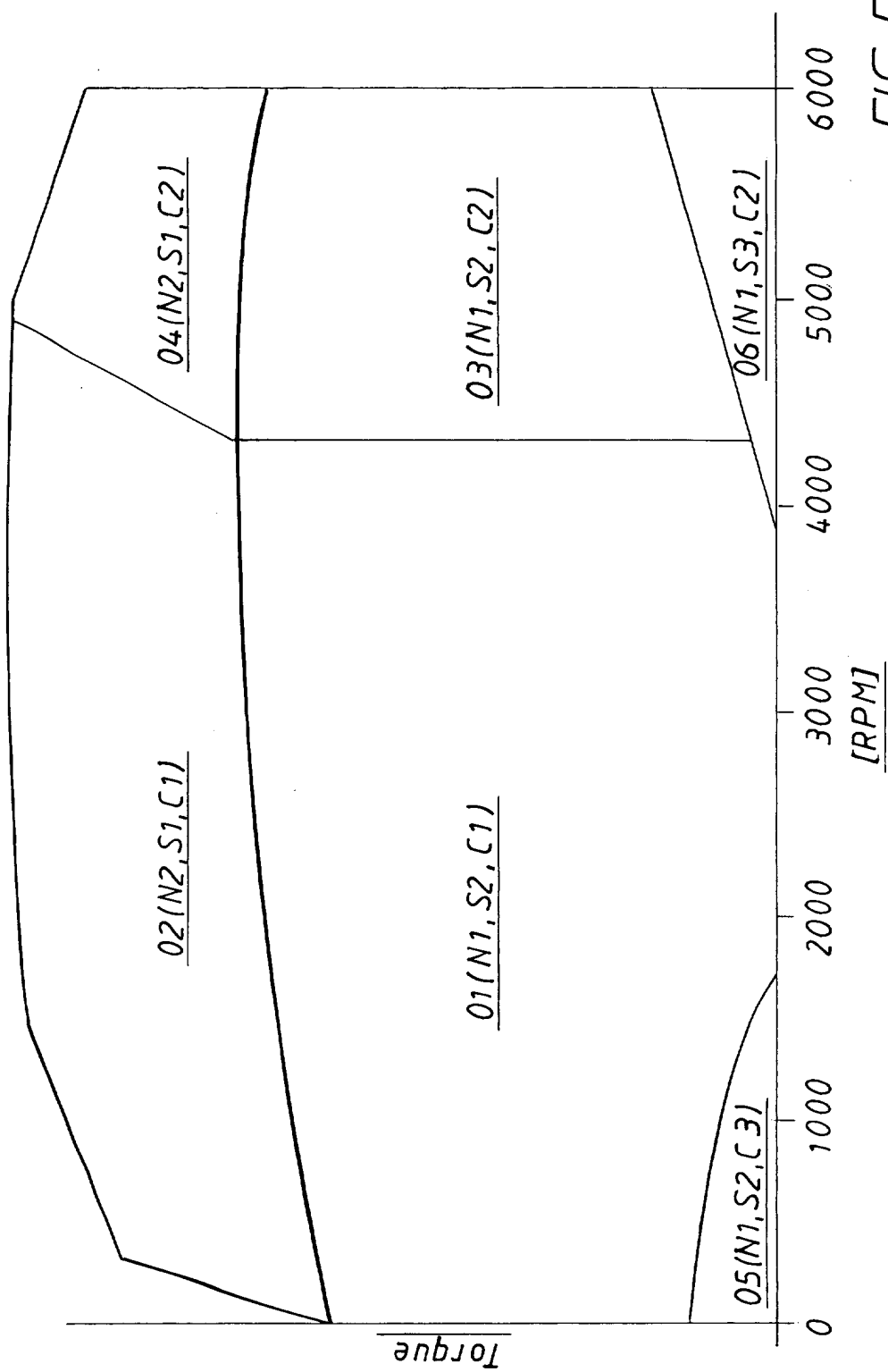


FIG. 5

| <i>Operation<br/>state</i> | <i>Valve<br/>number<br/>mode</i> | <i>Stroke<br/>mode</i> | <i>Valve<br/>open<br/>mode</i> |
|----------------------------|----------------------------------|------------------------|--------------------------------|
| 01                         | N1                               | S2                     | C1                             |
| 02                         | N2                               | S1                     | C1                             |
| 03                         | N1                               | S2                     | C2                             |
| 04                         | N2                               | S1                     | C2                             |
| 05                         | N1                               | S2                     | C3                             |
| 06                         | N1                               | S3                     | C2                             |
| 07                         | N1                               | S1                     | C1                             |
| 08                         | N1                               | S1                     | C2                             |
| 09                         | N1                               | S1                     | C3                             |
| 010                        | N1                               | S3                     | C1                             |
| 011                        | N1                               | S3                     | C3                             |
| 012                        | N1                               | S4                     | C1                             |
| 013                        | N1                               | S4                     | C2                             |
| 014                        | N1                               | S4                     | C3                             |
| 015                        | N2                               | S1                     | C3                             |
| 016                        | N2                               | S2                     | C1                             |
| 017                        | N2                               | S2                     | C2                             |
| 018                        | N2                               | S2                     | C3                             |
| 019                        | N2                               | S3                     | C1                             |
| 020                        | N2                               | S3                     | C2                             |
| 021                        | N2                               | S3                     | C3                             |
| 022                        | N2                               | S4                     | C1                             |
| 023                        | N2                               | S4                     | C2                             |
| 024                        | N2                               | S4                     | C3                             |
| 025                        | N3                               | S1                     | C1                             |
| 026                        | N3                               | S1                     | C2                             |
| 027                        | N3                               | S1                     | C3                             |
| 028                        | N3                               | S2                     | C1                             |
| 029                        | N3                               | S2                     | C2                             |
| 030                        | N3                               | S2                     | C3                             |
| 031                        | N3                               | S3                     | C1                             |
| 032                        | N3                               | S3                     | C2                             |
| 033                        | N3                               | S3                     | C3                             |
| 034                        | N3                               | S4                     | C1                             |
| 035                        | N3                               | S4                     | C2                             |
| 036                        | N3                               | S4                     | C3                             |
| 037                        | N4                               | S1                     | C1                             |
| 038                        | N4                               | S1                     | C2                             |
| 039                        | N4                               | S1                     | C3                             |
| 040                        | N4                               | S2                     | C1                             |
| 041                        | N4                               | S2                     | C2                             |
| 042                        | N4                               | S2                     | C3                             |
| 043                        | N4                               | S3                     | C1                             |
| 044                        | N4                               | S3                     | C2                             |
| 045                        | N4                               | S3                     | C3                             |
| 046                        | N4                               | S4                     | C1                             |
| 047                        | N4                               | S4                     | C2                             |
| 048                        | N4                               | S4                     | C3                             |

FIG. 6



European Patent  
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