(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 696 218 B9

(12) # CORRECTED EUROPEAN PATENT SPECIFICATION

(15) Correction information:
Corrected version no 1 (W1 B1)
Corrections, see
Claims EN 1, 3

(48) Corrigendum issued on:
15.09.2010 Bulletin 2010/37

(45) Date of publication and mention of the grant of the patent:
14.04.2010 Bulletin 2010/15

(21) Application number: **05425105.3**

(22) Date of filing: **25.02.2005**

(51) Int Cl.:
G01L 23/22 *(2006.01)* ***F02P 5/152*** *(2006.01)*

(54) **Knocking presence evaluation circuit for an internal combustion engine, knocking identification and control system and corresponding pressure signal processing method**

Verfahren und Vorrichtung zur Erfassung des Klopfens bei Brennkraftmaschinen, indentifizierung und Regelung des Klopfens und korrespondierende Verarbeitung des Signals.

Application à la détection du cliquetis dans un moteur à combustion interne, identification du cliquetis et système de contrôle et méthode correspondante de traitement de signal.

(84) Designated Contracting States:
DE FR GB IT

(43) Date of publication of application:
30.08.2006 Bulletin 2006/35

(73) Proprietor: **STMicroelectronics Srl**
20041 Agrate Brianza (MB) (IT)

(72) Inventors:
- **Taglialatela, Ferdinando**
  80014 Giugliano (Napoli) (IT)
- **Moselli, Giovanni**
  80028 Grumo Nevano (Napoli) (IT)
- **Lavorgna, Mario**
  80070 Bacoli (Napoli) (IT)

(74) Representative: **Ferrari, Barbara**
Botti & Ferrari S.r.l.
Via Cappellini, 11
20124 Milano (IT)

(56) References cited:
EP-A- 0 639 711
US-A- 4 343 278
US-A- 4 409 937
US-B1- 6 360 586
US-B1- 6 561 163

EP 1 696 218 B9

Description

Field of application

[0001] The present invention relates to a knocking presence evaluation circuit in an internal combustion engine.

[0002] More specifically the invention relates to a knocking presence evaluation circuit in an internal combustion engine having at least a pressure sensor facing in combustion chamber for each cylinder comprised in the engine itself and suitable to detect a pressure signal.

[0003] The invention also relates to a knocking identification and control system associated with an internal combustion engine.

[0004] The invention finally relates to a processing method of a pressure signal for the detection and evaluation of a combustion phenomenon in an internal combustion engine.

Prior art

[0005] As it is well known, knocking phenomena are particularly dangerous for internal combustion engines with controlled spark, implying, besides the emission of a characteristic metallic noise (the so called combustion shock), a whole series of consequences which can seriously damage the engine itself.

[0006] Knocking phenomena are in fact particularly dangerous for such engines, implying a whole series of consequences which can seriously jeopardize the operation thereof.

[0007] In fact, vibrations, engine power losses, increased heating are generally associated with knockings, reaching, under particularly severe conditions, the breakage of the engine mechanical parts.

[0008] In particular, the increased thermal charges, together with the mechanical stresses, can lead to the breakage of some components of the engine (such as pistons, piston rings, head gasket, valves, etc.) due to a well known hot fatigue phenomenon.

[0009] The identification and the analysis of the knocking phenomena in controlled spark engines thus represents an important factor for the electronic control of these engines.

[0010] For implementing a knocking control and identification strategy it is also known to use sensors suitable to monitor the combustion process which occurs inside an internal combustion engine, in order to evaluate the knocking presence and thus provide a control unit of the engine itself with a feedback.

[0011] Most engine currently on the market use suitable acoustic or accelerometric sensors (set on the frequency band 3 - 20 kHz) to detect the knocking presence.

[0012] Such sensors are placed in the engine block and they allow to identify the knocking presence in combustion chamber through the detection of the vibrations induced in the engine block.

[0013] Although advantageous under several aspects, this first solution has various drawbacks.

[0014] First of all, the sensors carry out an indirect measure of the knocking presence. In such case, the signal received through these sensors can be contaminated by disturbs independent from the knocking presence, such as for example, the natural mechanical vibrations the engine structure is subjected to during the operation thereof at high revolutions, vibrations which however do not depend on the knocking presence.

[0015] Moreover, in the case of some types of vibrational sensors such as resonant sensors, it is necessary to provide different sensors according to the type of engine.

[0016] To overcome these drawbacks a knocking presence identification method is alternatively known which analyses a signal received from a pressure sensor facing directly in the engine combustion chamber.

[0017] When the engine is subject to knocking, in fact, the pressure cycles in combustion chamber have typical oscillations with width peaks gradually decreasing in time whose frequency (oscillating between 3 and 20 kHz) depends on the propagation speed of the pressure waves in the cylinder during the knocking phenomenon, as schematically shown in figure 1.

[0018] A known model to identify the knocking presence starting form the pressure cycle in combustion chamber acquired by a pressure transducer facing directly in such chamber is described for example in the article by F. Millo and C.V. Ferraro entitled: "Knock in S.I. Engines: A comparison between different techniques for detection and control", SAE paper 982477, 1998.

[0019] In practice, however, this model and the others currently in use, provide a quite laborious, and in some cases little efficient, analysis of the pressure signal so as to discriminate the detonation presence or absence. In particular, it is known to use a predetermined knocking intensity critical threshold, beyond which the intervention of the engine unit control is started.

[0020] Another means for implementing a knocking control and identification strategy is disclosed in US-B1 6561163.

[0021] The technical problem underlying this invention is to provide a method for detecting in a simple and sure manner the knocking presence in an internal combustion engine overcoming the limitations and drawbacks still limiting the prior art methods.

Summary of the invention

[0022] The solution underlying the present invention is that of detecting and processing in real time a pressure signal in a combustion engine cylinder, such signal being suitably amplified and filtered by using soft-computing algorithms for drawing some values linked to the knocking and for sending them to a measurer of the knocking degree which outputs a knocking index, used by the engine unit for performing the knocking control of the engine itself.

[0023] On the basis of such solution idea the technical problem is solved by a knocking identification and control system of an internal combustion engine as previously indicated and defined by the characterising part of claim 1.

[0024] The problem is also solved by a knocking identification and control system of an internal combustion engine as previously indicated and defined by the characterising part of claim 21.

[0025] Finally, the problem is solved by a processing method of a pressure signal for the detection and evaluation of a combustion phenomenon in an internal combustion engine as previously indicated and defined by the characterising part of claim 29.

[0026] The characteristics and advantages of the circuit, of the system and of the method according to the invention will be apparent from the following description of an embodiment thereof given by way of indicative and non limiting example with reference to the annexed drawings.

Brief description of the drawings

[0027] In these drawings:

Figure 1 schematically shows the trend of a pressure signal in an internal combustion engine cylinder in the presence of knocking used by methods realised according to the prior art,

Figure 2 schematically shows a knocking identification and control system of an internal combustion engine suitable to implement the method according to the invention;

Figure 3 shows in greater detail a knocking presence evaluation circuit of the system of Figure 2;

Figure 4 shows in greater detail an inner block of the circuit of Figure 3;

Figure 5A shows in greater detail a further inner block of the circuit of Figure 3;

Figure 5B shows the trend vs time of an inner signal of the block of Figure 5A;

Figure 6 shows in greater detail a further inner block of the circuit of Figure 3;

Figures 7A-7E show, by way of example, the fuzzy set membership functions of some variables of the block of Figure 6, a fuzzy algorithm with relevant defuzzification and an estimation map of a *Knock-Index* signal;

Figure 8 shows in greater detail a further inner block of the circuit of Figure 3;

Figure 9 shows in greater detail the system of Figure 2.

Detailed description

[0028] With reference to the figures, and in particular to figure 2, 1 globally and schematically indicates a knocking identification and control of an internal combustion engine 2.

[0029] In particular, the control system 1 comprises a knocking presence evaluation circuit 4, being input a pressure signal *Pr_Sign* in combustion chamber, obtained by a suitable pressure sensor 3 facing in combustion chamber for each cylinder comprised in the internal combustion engine 2.

[0030] Hereafter in the description a sole pressure sensor will be referred to considering the exemplary case of a sole knocking cylinder, everything written and considered being subject to be extended in a similar way to other cylinders comprised in the internal combustion engine 2.

[0031] The knocking presence evaluation circuit 4 provides a closed loop control system 5 with a *Knock_Index* signal, in particular a knocking intensity index whose meaning will be more apparent hereafter in the description, the system comprising in turn a parameter control modification block 6 of the internal combustion engine 2, such parameter control modification block 6 providing the internal combustion engine 2 with a control signal CR.

[0032] In substance, in the knocking identification and control system 1, the knocking presence evaluation circuit 4 performs the processing of the pressure signal *Pr_Sign* for drawing therefrom useful parameters for the knocking evaluation. Moreover, the knocking presence evaluation circuit 4 takes care of processing the so measured parameters with soft-computing techniques in order to allot a knocking intensity index Knock_Index to each knocking phenomenon.

[0033] On the basis of this knocking intensity index *Knock_Index* the control parameter modification block 6 controls the control actions which substantially go towards a correction of the parameters allotted in the control maps of the internal combustion engine 2.

[0034] Advantageously, the knocking presence evaluation circuit 4 implements the method for processing a pressure signal in combustion chamber and for controlling an internal combustion engine according to the invention, which, as it will be hereafter clarified, processes the pressure signal *Pr_Sign* detected by the pressure sensor 3 by using soft-computing techniques for correlating each knocking detection with a determined knocking intensity index *Knock_index*, comprised between 0 and 1, to be supplied to the closed loop control system 5 for the adjustment of the internal combustion engine 2.

[0035] Such method starts from the consideration that a knocking phenomenon, generically indicated as knocking, shows itself with the presence in the pressure cycle of typical fluctuations at high frequency, whose width decreases in time.

[0036] In the case of a weak knocking, the width of such pressure oscillations is small, whereas in the case of a strong knocking such oscillations have a greater width.

[0037] Advantageously according to the invention, the method for processing the pressure signal *Pr_Sign* for the detection and evaluation of a combustion phenomenon in an internal combustion engine 2 comprises the steps of:

- receiving a pressure signal *Pr_Sign* from a pressure sensor 3, in the considered case facing in combustion chamber for each cylinder of an internal combustion engine 2;
- insulating the oscillations of such pressure signal *Pr_Sign* cycle, obtaining a derived pressure signal *Fl_Pr_Sign;* and
- obtaining, from such derived pressure signal, digital pulses corresponding to a knocking phenomenon.

[0038] In particular, such derived pressure signal *Fl_ Pr_*Sign is obtained by amplifying and filtering the pressure signal *Pr_Sign,* so as to eliminate the oscillations at high frequency, insulating the oscillations in a given typical frequency range of a knocking phenomenon, eliminating in such way the influence of the engine operation oscillations, but not linked to such phenomenon.

[0039] Moreover, the method according to the invention provides a measuring step of the number of digital pulses obtained from the derived pressure signal *Fl_Pr_*Sign and of the total duration of such digital pulses.

[0040] Advantageously according to the invention, the method also comprises an enable step of said measuring step, by means of a resetting signal, in particular supplied by a sensor of the cam shaft connected to the internal combustion engine 2.

[0041] The method thus comprises a processing step by means of soft-computing techniques of the measuring values in the measuring step for generating a knocking intensity index *Knock_index* to be used as control signal of the internal combustion engine 2.

[0042] By way of example, such processing step by means of soft-computing techniques provides the use of the fuzzy logic.

[0043] Advantageously according to the invention, the method also provides a control step for the internal combustion engine 2.

[0044] This control step uses the knocking intensity index *Knock_index* generated in the processing step for changing the internal combustion engine 2 parameters.

[0045] In particular, such control step comprises the generation of control actions further to the knocking detection for eliminating the presence of these phenomena.

[0046] The control actions act on a reduction of the spark advance with respect to a value mapped according to the value of the knocking intensity index *Knock_Index.*

[0047] Such control actions are performed until the knocking phenomenon fades away, i.e. in correspondence with a null value of the knocking intensity index *Knock_Index* generated by the processing step.

[0048] Advantageously according to the invention, this control step acts in real time on the operation of the internal combustion engine 2.

[0049] The knocking presence evaluation circuit 4 suitable to implement such method is shown in greater detail in Figure 2.

[0050] In particular, the knocking presence evaluation circuit 4 has an input terminal IN4 connected to the pressure sensor 3 of the internal pressure sensor 2 and receiving from it a pressure signal *Pr_Sign.*

[0051] Advantageously according to the invention, the knocking presence evaluation circuit 4 comprises:

- a processing block 7, suitable to perform a pressure signal Pr_Sign processing, insulating the oscillations, and to generate the derived pressure signal *Fl_Pr_Sign;*

- an acquisition block 8, suitable to measure the number and the total duration of the digital pulses obtained from the derived pressure signal *Fl_Pr_Sign;* and

- a soft-computing block 9, suitable to process the measures performed by the acquisition block 8 and to generate at an output terminal OUT4 of the knocking presence evaluation circuit 4 a knocking intensity index *Knock_index,*

such blocks 7, 8 and 9 being inserted in series with each other between the input terminal IN4 and the output terminal OUT4 of the knocking presence evaluation circuit 4, as schematically shown in Figure 3.

[0052] The knocking presence evaluation circuit 4 also comprises an enable block 10 connected to the soft-computing block 9.

[0053] In particular, the processing block 7 receives the pressure signal *Pr_Sign,* which is an analogic signal, and which performs the treatment in order to insulate the oscillations thereof. Advantageously according to the invention, the block 7 insulates the oscillations at high frequency, typical of a knocking, outputting the derived pressure signal *Fl_Pr_Sign.*

[0054] In substance, the derived pressure signal *Fl_Pr_Sign* is obtained by suitably adapting and filtering the pressure signal *Pr_Sign* of the pressure sensor 3.

[0055] Such derived pressure signal *Fl_Pr_Sign,* being input to the acquisition block 8, is processed by this latter so as to draw information relative to the knocking which can be used by the soft-computing block 9 for the calculation of the knocking intensity, in particular for the generation of the knocking intensity index *Knock_index.*

[0056] In particular, the acquisition block 8 outputs a first signal *Pul_Cnt* corresponding to the number of digital pulses measured for the derived pressure signal *Fl_Pr_Sign* and a second signal *Pul_Dur* corresponding to the total duration of such measured digital pulses.

[0057] Advantageously according to the invention, the enable block 10 enables such calculation in correspondence with a suitable engine crank angle, received by a sensor 11 of such crank angle.

[0058] In order to highlight the knocking presence, advantageously according to the invention, the pressure signal *Pr_Sign* outputting from the pressure signal 3 is suitably treated, in particular amplified and filtered by the processing block 7, as shown in greater detail in Figure 4.

[0059] In particular, the processing block 7 essentially comprises a charge amplifier 71 connected at input to an input terminal IN7, in turn connected to the pressure sensor 3 and receiving therefrom the pressure signal *Pr_Sign,* and connected at output to a filter 72, in turn connected at output to an output terminal OUT7 of the processing block 7, whereat there is the derived pressure signal *F_Pr_Sign.*

[0060] In substance, the charge amplifier 71 outputs a voltage signal *Vpr,* which is made pass through the filter 72, which is a band-pass (for example for the frequency range 3 KHz-20 KHz), in order to separate the high frequency oscillations of the pressure signal, such high frequency oscillations being due, as previously explained, to a knocking presence.

[0061] In such way, the processing block 7 allows to separate the high frequency oscillations, useful to evaluate the knocking presence, from those due to the normal combustion, which, as it has been seen, disturb the systems realised according to the prior art.

[0062] The derived pressure signal *Pr_Sign,* suitably processed by the block 7, is thus sent to a first input terminal IN8a of the acquisition block 8, as shown in greater detail in Figure 5A.

[0063] In particular, the acquisition block 8 comprises a comparator 81 having a first input terminal connected to the first input terminal IN8a of the acquisition block 8 and receiving therefrom the derived pressure signal *Fl_Pr_Sign,* a second input terminal connected to a threshold reference 82 suitable to supply a threshold value *Threshold* and an output terminal, whereat there is a signal *Dig_Puls.*

[0064] Such signal *Dig_Puls* has a step-like trend, i.e. with pulses of different duration, as shown for example in Figure 5B.

[0065] The acquisition block 8 also comprises a counter 83 having an input terminal Up connected to the output terminal of the comparator 81 and receiving therefrom the signal *Dig_puls* and an output terminal connected to a first output terminal OUT8a of the acquisition block 8, to which it supplies a first measure signal *Pul_Cnt,* corresponding to the number of the signal pulses *Dig_puls,* as it will be clarified hereafter.

[0066] The acquisition block 8 further comprises a timer 84 having a first input terminal Start and a second negated input terminal Stop, both connected to the output terminal of the comparator 81 and receiving therefrom the signal *Dig_puls,* as well as an output terminal connected to a second output terminal OUT8b of the acquisition block 8, to which it supplies a second measure signal *Pul_Dur,* corresponding to the global duration of the signal pulses *Dig_puls.*

[0067] In particular, each time the derived pressure signal *Fl_Pr_Sign* overcomes the threshold value *Threshold,* the comparator 81 enhances the value of the signal *Dig_puls* (rise edge of the signal *Dig_puls),* which in turn increases the counting value of the counter 83 acting on the input terminal Up. Simultaneously, on rise edge of the signal *Dig_puls* the timer 84 is triggered acting on the first input terminal Start.

[0068] In a similar way, when the derived pressure signal *Fl_Pr_Sign* decreases again below the threshold value *Threshold,* the comparator 81 decreases the signal value *Dig_puls* (fall edge of the signal *Dig_puls),* blocking the timer 84 by acting on the second input terminal Stop.

[0069] In particular, considering as output signal *Dig_puls* from the comparator 81 the one shown in Figure 5B it can be verified that, in correspondence with the edges in the instants indicated with T1 and T3, the counter 83 increases the value of *Pul_Cnt,* and the timer 84 is triggered. In a dual way, in correspondence with the edges in the instants indicated with T2 and T4, the timer 84 is blocked.

[0070] It thus occurs that, after the instant T4, the counter 83 outputs a value equal to two, corresponding to the counted pulses *(Pul_Cnt* = 2), and the timer outputs a value equal to $\Delta T1+\Delta T2$ *(Pul_Dur =* ($\Delta T1+\Delta T2$).

[0071] Moreover, the acquisition block 8 receives a reset signal *Reset,* applied to suitable reset terminals of the counter 83 and of the timer 84, for zeroing the output values *(Pul_Cnt* and *Pul_Dur).*

[0072] Advantageously according to the invention, this reset signal *Reset* is supplied by a sensor 11 of the cam shaft, which signals each engine cycle, which occurs each two revolutions of the crank shaft.

[0073] In substance, the acquisition block 8 digitalises the pressure analogue signal as processed by the processing block 7 and it draws parameters useful for determining the knocking presence and degree, in particular by measuring the number *Pul_Cnt* of digital pulses of the derived pressure signal *Fl_Pr_Sign* and their total duration *Pul_Dur.*

[0074] Moreover, advantageously according to the invention, the threshold value *Threshold* is suitably mapped and memorised for each condition of the internal combustion engine 2.

[0075] The soft-computing block 9 is shown in greater detail in Figure 6. In particular, such block 9 has a first input terminal IN9a connected to the first output terminal OUT8a of the acquisition block 8 and receiving therefrom the first measure signal *Pul_Cnt,* a second input terminal IN9b connected to the second input terminal OUT8b of the acquisition block 8 and receiving therefrom the second measure signal *Pul_Dur,* an enable terminal IN9c connected to the enable block 10 and receiving therefrom an enable signal *En_Kn_Mea,* as well as an output terminal OUT9, whereat there is the knocking intensity index *Knock_Index.*

[0076] The soft-computing block 9 essentially comprises a calculation block, indicated with 91, suitable to process the first measure signal *Pul_Cnt* and the second measure signal *Pul_Dur,* i.e. the number of digital pulses in the derived pressure signal *Fl_Pr_Sign* and their total duration, received at input and to supply the knocking intensity index *Knock_Index* calculated starting from the measure signals.

[0077] Advantageously, the soft-computing block 9 comprises a switch block 92, inserted between an output terminal of the calculation block 91 and the output terminal OUT9 of the soft-computing block 9, corresponding to the output terminal OUT4 of the knocking presence evaluation system 4.

[0078] In particular, the switch block 92 receives the enable signal *En_Kn_Mea* to enable the transfer to the output terminal OUT9 of the knocking intensity index *Knock_Index.*

[0079] Advantageously, the enable signal *En_Kn_Mea* allows such transfer of the knocking intensity index *Knock_Index* only when the possible knocking phenomenon has extinguished.

[0080] It should be noted that the use of soft-computing techniques, implemented by the block 9, is particularly advantageous in case of real time applications, in noisy environments, and it allows the employment of low cost sensors.

[0081] As it is well known, the soft-computing techniques are computational methodologies which merge in a synergetic way different aspects of other known technologies, in particular the fuzzy logic, neural networks, genetic algorithms and non-linear distributed systems so as to define and implement hybrid systems.

[0082] In particular, it is possible to use neuro-fuzzy-genetic systems, cellular neural networks, and fuzzy cellular networks which, each time, succeed in providing innovative solutions in the various fields of the intelligent control, in the classification, in the modelling and in the simulation of non-linear dynamic systems.

[0083] The knocking intensity evaluation is surely suited to a qualitative interpretation especially if it is necessary to characterise the knocking phenomenon independently from the attainment of a knocking critical threshold: herefrom the interpretation of the knocking phenomenon and the evaluation of intensity thereof by using soft-computing techniques.

[0084] In this way, the soft-computing block 9 returns at the output a knocking intensity index *Knock_Index* having a value variable between 0 and 1, which will be used by a feedback control loop, as it will be clarified hereafter in the description.

[0085] By way of example, the case wherein the soft-computing block 9 realises an estimator implemented in fuzzy logic is analysed.

[0086] The following fuzzy sets are thus considered:

➢ for the first measure signal *Pul_Cnt* (number of pulses)

- npulse-abs "pulses number absent",
- npulse-low "pulses number low"
- npulse-medium "pulses number medium"
- npulse-high "pulses number high"

and the relative membership functions, as shown in Figure 7A and globally indicated with MF1;

➢ for the second measure signal *Pul_Dur* (total duration of the pulses):

- tpulst-abs "pulses total duration absent"
- tpulst-low "pulses total duration low"
- tpulst-medium "pulses total duration medium"
- tpulst-high "pulses total duration high"

and the relative membership functions, as shown in Figure 7B and globally indicated with MF2.

[0087] The fuzzy estimator realised by the soft-computing block 9 thus implements a fuzzy algorithm which uses as antecedent parts the fuzzy sets of the above indicated signals Pul_Cnt and Pul_Dur and as consequent parts the fuzzy sets of the knocking intensity index *Knock_Index* thus defined:

- Kgrade-abs "knocking absent"
- Kgrade-low "knocking low"
- Kgrade-medium "knocking medium"
- Kgrade-high "knocking high"

and the relative membership functions, as shown in Figure 7C and globally indicated with MF3.

[0088] In particular, advantageously according to the invention, the fuzzy algorithm of the estimator comprises eight rules whose generic expression is of the type:

IF npulse-X AND tpulst-Y THEN Kgrade-Z

being X, Y, Z = {abs, low, medium, high}

[0089] The result of the fuzzy algorithm with corresponding defuzzification is shown in Figure 7D. For each value of the first measure signal *Pul_Cnt* and of the second measure signal *Pul_Dur*, the estimator outputs a value of the knocking intensity index *Knock_Index.*

[0090] The information obtained by the fuzzy estimator can be summarised also by means of a tridimensional map of the type shown in Figure 7E.

[0091] It should be noted that, for a correct operation of the knocking evaluation system 4, the calculation of the knocking intensity index *Knock_Index* should occur only after that the knocking phenomenon has reached its completion, i.e. in correspondence with a prefixed engine angle indicated with *anglex.*

[0092] Advantageously according to the invention, the knocking presence evaluation system 4 thus comprises the enable block 10 suitable to generate an enable signal *En_Kn_Mea* which respects the above constraint.

[0093] In particular, as shown in Figure 8, the enable block 10 has a first input terminal IN10a connected to a measure device of the engine angular position, indicated with 12, and receiving therefrom a detection signal *An_Pl,* in particular a pulse train wherefore it is possible to evaluate the engine angular position, for example the pulses generated in correspondence with each Z crank angles by the measure device 12 of the engine angular position, such as the phonic wheel.

[0094] The enable block 10 also has a second input terminal IN10b connected to the sensor 11 of the cam shaft and receiving therefrom the reset signal *Reset.*

[0095] The enable block 10 finally has an output terminal whereon the enable signal *En_Kn_Mea* is generated which enables the measure of the knocking intensity index *Knock_Index.*

[0096] In particular, the enable block 10 comprises a counter 101 having an input terminal Up connected to the measure device 12 of the engine angular position and receiving therefrom the detection signal *An_Pl,* as well as an enable terminal connected to the sensor 11 of the cam shaft and receiving therefrom the reset signal *Reset.*

[0097] The counter 101 finally comprises an output terminal whereon a counting value Vcount which, suitably multiplied in a multiplier node 102 by the value Z corresponding to the crank angles used by the measure device 12 of the engine angular position to generate the train of pulses of the detection signal *An_Pl,* supplies a signal corresponding to the engine angular position, indicated with *Eng_Angl.*

[0098] Substantially, such value Z, supplied to the multiplier node 102 by a reference block 103 is nothing but the engine angle value corresponding to two consecutive pulses of the detection signal *An_Pl.*

[0099] This engine angular position *Eng_Angl* is compared, in a comparator 105 with the engine angle *anglex* and, in the case wherein it is greater than such engine angle *anglex* (i.e. when the possible knocking phenomenon has extinguished), the enable signal *En_Kn_Mea* goes to a high logic value *(En_Kn_Mea*=1) and it enables the supply at output of the knocking intensity index *Knock_Index.*

[0100] In this way, the enable signal En_Kn_Mea allows the transfer of the knocking intensity index Knock_Index on the output terminal OUT4 of the knocking presence evaluation circuit 4 only when the possible knocking phenomenon has extinguished.

[0101] Advantageously, by using the reset signal *Reset,* the counter 101 is zeroes at each engine cycle, i.e. each two revolutions of the driving shaft in correspondence with a high logic value of the signal coming from the sensor 11 of the cam shaft.

[0102] The knocking intensity index *Knock_Index* calculated by the knocking presence evaluation circuit 4 is used to perform the control of the internal combustion engine 2, as schematically shown in Figure 9.

[0103] In particular, this Figure shows the knocking identification and control system 1 which essentially comprises a control loop LoopC of the internal combustion engine 2.

[0104] In particular, the control loop LoopC comprises the pressure sensor 3 connected to the internal combustion engine 2 and to the knocking presence evaluation circuit 4, in turn connected, by means of a converter ADC 13, to an electric control unit 14 of the internal combustion engine 2 itself, the control unit being provided with a control firmware 16.

[0105] The identification and control system 1 also comprises a subtractor node 15, inserted between the knocking presence evaluation circuit 4 and the converter ADC (Analog to Digital Converter) 13 and receiving a reference signal Rif.

[0106] In particular, once the knocking presence has been detected through the analysis of the pressure cycle and once the knocking intensity has been determined through the knocking presence evaluation circuit 4, the control unit 14 must take suitable control actions to eliminate the presence of such phenomena.

[0107] The knocking control actions act on a reduction of the spark advance with respect to a mapped value.

[0108] This is realised by supplying the firmware 16 of the control unit 14, through the converter ADC 13, with the knocking intensity index *Knock_Index* which is used by the firmware 16 itself to implement a correction of the mapped spark advance correction and suitably memorised in the firmware 16, indicated with *Map_Stored.*

[0109] In particular, the firmware 16 of the control unit 14 comprises a control structure 17 which calculates a value of the spark advance *Map_CR* according to the following rule:

$$Map\_CR = Map\_Stored + Adv\_Inj * Knock\_Index$$

being *Adv_Inj* a prefixed spark advance value, also suitably memorised in the firmware 16.

[0110] The control structure 17 is in particular a control structure of the closed loop proportional type, the value of the spark advance *Map_CR* being thus modified in the direction of a spark delay until the knocking phenomenon extinguishes, i.e. until the knocking intensity index value *Knock_Index* reaches a reference equal to zero.

[0111] This value of the spark advance *Map_CR* is thus sent to a management module of the spark 18, connected at output to the internal combustion engine 2 to which it supplies the control signal CR.

[0112] For better understanding the operation of the knocking identification and control system 1, the case is considered wherein, for a set engine point, a strong knocking phenomenon occurs with Knock_Index=0.9. It is to be also supposed that a value of Adv_Inj = 2 has been set. It will then occur that, for facing such strong knocking, the mapped value of the spark advance *Map_Stored* for that determined engine point is delayed at each cycle of an amount equal to Knock_Index *2, with starting value equal to 0.9*2

the delay being applied until a complete knocking absence is obtained with Knock_Index = 0, and *Map_CR = Map_Stored + Adv_Inj**Σi=1...n *(knock_Index)*$_i$ where n is the number of cycles within which the knocking extinguishes.

[0113] The value of the spark advance *Map_CR* calculated by the control structure 17 is sent to the management module of the spark 18 which progressively updates the control signal CR until the knocking is completely extinguished.

[0114] Through simple algorithms which provide at the input the previously calculated knocking intensity index *Knock_Index* it is thus possible to attend to a correction of the map values relative to the spark advance of the internal combustion engine 2.

[0115] It should be underlined how the precision in the knocking entity precision, obtained thanks to the knocking evaluation circuit 4 according to the present invention, consequently implies a higher precision and efficiency of the control performed on the internal combustion engine 2.

[0116] The knocking identification and control system 1 has been simulated by the Applicant in Simulink environment.

[0117] This simulation has allowed to verify that, by using the knocking identification and control system 1 according to the invention, in correspondence with each knocking phenomenon, an increase of the spark advance value occurs, as desired.

[0118] It should be noted that, advantageously according to the invention, the knocking identification and control system 1 allows to realise a more efficient and accurate knocking control, making the control unit 14, and in particular the control structure 17 together with the management module of the spark 18 contained therein, adopt the most suitable antiknocking actions, in relation with a current knocking level and independently from the attainment of a determined knocking critical threshold, thus overcoming the limits in the systems realised according to the prior art.

[0119] Advantageously according to the invention, this control is obtained by using information coming from an engine pressure signal processed with soft-computing techniques to evaluate the knocking presence and its intensity.

[0120] In particular, the knocking identification and control system 1 comprises a knocking presence evaluation circuit 4 suitable to generate a knocking intensity index which, suitably used by the control unit 14, changes the control law of the internal combustion engine.

[0121] The use of soft-computing techniques of the pressure signal to evaluate the knocking presence and intensity makes the system extremely innovative, sure and simple to be implemented, allowing a real time knocking control.

[0122] In substance, the main innovative characteristics of the proposed system are the following:

- ➢ use of soft-computing techniques to obtain a knocking intensity evaluation being efficient and simple to be implemented, thus succeeding in allotting a particular knocking intensity to each knocking phenomenon independently from the attainment of a prefixed intensity critical threshold;

- ➢ use of the pressure signal for drawing therefrom particular values related to the knocking phenomenon, obtaining a direct and more accurate measure of the knocking phenomenon with respect to that obtained by traditional vibrational sensors;

- ➢ use of a simple hardware structure which allows a real time knocking control, with elimination of the vibrational sensors in favour of low cost pressure sensors with a remarkable economic advantage;

- ➢ management of the small knocking phenomena too, by suitably adjusting the control actions, avoiding that such phenomena can, in time, damage the engine mechanical parts.

Claims

1. Knocking presence evaluation circuit in an internal combustion engine (2), the internal combustion engine having at least a pressure sensor (3) facing a combustion chamber for each cylinder comprised in the engine itself and suitable to detect a pressure signal (Pr_Sign), with the knocking presence evaluation circuit connected to said pressure sensor and adapted to receive therefrom a pressure signal, the knocking presence evaluation circuit having

- a processing block (7), connected, in
correspondence with an input terminal (1 N4) of said knocking presence evaluation circuit (4), to said pressure sensor (3) and adapted to receive therefrom said pressure signal (Pr_Sign), said processing block (7) adapted to perform a processing of said pressure signal (Pt_Sign) for insulating the oscillations and adapted to generate a derived pressure signal (Fl_Pr_Sign);
- an acquisition block (8), connected at input to said processing block (7) and adapted to receive therefrom said

derived pressure signal (Fl_Pr_Sign), said acquisition block (8) adapted to generate a first and a second measure signals (Pul_Cnt, Pul_Dw) respectively corresponding to a number and a total duration of digital pulses obtained from said derived pressure signal (Fl_Pt_Sign); and
- a soft-computing block (9) connected at input to said acquisition block (8) and adapted to receiving therefrom said first and second measure signals (Pul_Cnt, Pul_Dw) and connected to an output terminal (OUT4) of said knocking presence evaluation circuit (4), said block (9) adapted to supply the output terminal with a knocking intensity index (Knock_index), calculated by soft-computing techniques, starting from said first and second measure signals (Pul_Cnt, PU1_DLLT).

2. Knocking presence evaluation circuit according to claim 1, **characterised in that** it further comprises an enable block (10) connected to said soft-computing block (9) and supplying it with an enable signal (*En_Kn_Mea*).

3. Knocking presence evaluation circuit according to claim 1, **characterised in that** said processing block (7) comprises at least the series of a charge amplifier (71) connected at input to said pressure sensor (3) and of a filter (72), in turn connected at output to an output terminal (OUT7) of said processing block (7) suitable to supply said derived pressure signal (Fl_Pr_Sign).

4. Knocking presence evaluation circuit according to claim 3, **characterised in that** said charge amplifier (71) receives said pressure signal (*Pr_Sign*) and outputs a voltage signal (Vpr).

5. Knocking presence evaluation circuit according to claim 4, **characterised in that** said filter (72) is a band-pass filter suitable to filter said voltage signal (Vpr) and to eliminate the high and low frequency oscillations.

6. Knocking presence evaluation circuit according to claim 1, **characterised in that** said acquisition block (8) comprises at least a comparator (81) having a first input terminal connected to a first input terminal (IN8a) of said acquisition block (8) and receiving therefrom said derived pressure signal (*Fl_Pr_Sign*) generated by said processing block (7), a second input terminal connected to a threshold reference (82) suitable to supply a threshold value (*Threshold*) and an output terminal, a counting signal (*Dig_Puls*) being thereon and having a plurality of pulses of different duration.

7. Knocking presence evaluation circuit according to claim 6, **characterised in that** said acquisition block (8) further comprises a counter (83) having an input terminal (Up) connected to said output terminal of said comparator (81) and receiving therefrom said counting signal (*Dig_puls*) and an output terminal connected to a first output terminal (OUT8a) of said acquisition block (8), to which it supplies said first measure signal (*Pul_Cnt*), corresponding to a number of pulses of said counting signal (*Dig_puls*).

8. Knocking presence evaluation circuit according to claim 6, **characterised in that** said acquisition block (8) further comprises a timer (84) having a first input terminal (Start) and a second negated input terminal (Stop), both connected to said output terminal of said comparator (81) and receiving therefrom said counting signal (*Dig_puls*), as well as an output terminal connected to a second output terminal (OUT8b) of said acquisition block (8), to which it supplies said second measure signal (*Pul_Dur*), corresponding to a global duration of said pulses of said counting signal (*Dig_puls*).

9. Knocking presence evaluation circuit according to claims 7 and 8, **characterised in that** said counter (83) and said timer (84) have respective reset terminals receiving a reset signal (*Reset*).

10. Knocking presence evaluation circuit according to claim 9, **characterised in that** said reset signal (*Reset*) is generated by a sensor of the cam shaft (8) of said internal combustion engine (2) in correspondence with each engine cycle.

11. Knocking presence evaluation circuit according to claim 6, **characterised in that** said threshold value (*Threshold*) is mapped and memorised for each operation condition of said internal combustion engine (2).

12. Knocking presence evaluation circuit according to claim 1, **characterised in that** said soft-computing block (9) comprises at least a calculation block (91) receiving said first and second measure signals (*Pul_Cnt, Pul_Dur*) and being connected at output to said output terminal (OUT4) of said knocking presence evaluation circuit (4) whereon it generates said knocking intensity index (*Knock_Index*).

13. Knocking presence evaluation circuit according to claim 12, **characterised in that** said soft-computing block (9) further comprises a switch block (92), inserted between an output terminal of said calculation block (91) and said output terminal (OUT4) of said knocking presence evaluation circuit (4).

14. Knocking presence evaluation circuit according to claim 13, **characterised in that** said switch block (92) receives said enable signal (*En_Kn_Mea*) suitable to enable a transfer to said output terminal (OUT4) of said knocking intensity index (*Knock_Index*).

15. Knocking presence evaluation circuit according to claim 13, **characterised in that** said calculation block (91) implements a soft-computing technique chosen among fuzzy logic, neural networks, genetic algorithms and non linear distributed systems so as to define and implement hybrid systems.

16. Knocking presence evaluation circuit according to claim 13, **characterised in that** said calculation block (91) realises an estimator implemented with soft-computing techniques.

17. Knocking presence evaluation circuit according to claim 2, **characterised in that** said enable block (10) has a first input terminal (IN10a) connected to an angular position measure device (12) of said internal combustion engine (2) and receiving therefrom a detection signal (*An_Pl*), a second input terminal (IN10b) connected to a sensor of the cam shaft (11) of said internal combustion engine (2) and receiving therefrom a reset signal (*Reset*), as well as an output terminal whereon said enable signal (*En_Kn_Mea*) is generated.

18. Knocking presence evaluation circuit according to claim 17, **characterised in that** said enable block (10) comprises a counter (101) having an input terminal (Up) connected to said angular position measure device (12) and receiving therefrom said detection signal (*An_Pl*), an enable terminal connected to said sensor of the cam shaft (11) and receiving therefrom said reset signal (*Reset*), as well as an output terminal whereon a counting value (*Vcount*) is generated.

19. Knocking presence evaluation circuit according to claim 18, **characterised in that** said enable block (10) further comprises a multiplier node (102) connected to said counter (101) and suitable to multiply said counting value (*Vcount*) by a value (Z) from a reference block (103) corresponding to a crank angle value used by said angular position measure device (12) to generate a signal corresponding to an angular position of the engine (*Eng_Angl*).

20. Knocking presence evaluation circuit according to claim 19, **characterised in that** said enable block (10) further comprises a comparator (105) connected to said multiplier node (102) and receiving therefrom said signal corresponding to an angular position of the engine (*Eng_Angl*), and to an output terminal (OUT10) of said enable block (10), said comparator receiving a signal corresponding to an engine angle (*anglex*) which is an index of the knocking phenomenon extinction.

21. Knocking identification and control system associated to an internal combustion engine (2) and comprising a control loop (LoopC) connected to a pressure sensor (3) of said internal combustion engine (2), **characterised in that** said control loop (LoopC) comprises at least one knocking presence evaluation circuit (4) realised according to any of the preceding claims.

22. Knocking identification and control system according to claim 21, **characterised in that** said knocking presence evaluation circuit (4) is connected to an electric control unit (14) of said internal combustion engine (2) provided with a control firmware (16) by means of a converter ADC (13).

23. Knocking identification and control system according to claim 22, **characterised in that** it further comprises a subtractor node (15), inserted between said knocking presence evaluation circuit (4) and said converter ADC (13) and receiving a reference signal (Rif).

24. Knocking identification and control system according to claim 22, **characterised in that** said control unit (14) takes control action on the basis of the value of said knocking intensity index (*Knock_Index*) calculated by said knocking presence evaluation circuit (4) to eliminate the presence of knocking phenomena.

25. Knocking identification and control system according to claim 24, **characterised in that** said control actions act on a reduction of a spark advance value (Map_CR) with respect to a mapped value (*Map_Stored*).

26. Knocking identification and control system according to claim 25, **characterised in that** said firmware (16) of said control unit (14) comprises a control structure (17) suitable to calculate said spark advance value (*Map_CR*) according to the following rule:

$$Map\_CR = Map\_Stored + Adv\_Inj * Knock\_Index$$

being
Map_CR said spark advance value;
Map_Stored said mapped value;
Adv_Inj a prefixed spark advance value memorised in said firmware (16); and
Knock_Index said knocking intensity index.

27. Knocking identification and control system according to claim 26, **characterised in that** said control structure (17) is a control structure of the closed loop proportional type.

28. Knocking identification and control system according to claim 25, **characterised in that** said control unit (14) further comprises a spark management module (18), connected at input to said control structure (17) and connected at output to said internal combustion engine (2) to which it supplies a control signal (*CR*).

29. Method for processing a pressure signal (*Pr_Sign*) for the detection and evaluation of a combustion phenomenon in an internal combustion engine (2) comprising the steps of:

- receiving a pressure signal (*Pr_Sign*) detected by a pressure sensor (3) associated to said internal combustion engine (2);
- insulating oscillations of said pressure signal (*Pr_Sign*), obtaining a derived pressure signal (*Fl_Pr_Sign*);
- obtaining from said derived pressure signal (*Fl_Pr_Sign*) digital pulses corresponding to a knocking phenomenon;
- deriving pressure signal (*Fl_Pr_Sign*) by amplifying and filtering said pressure signal (*Pr_Sign*), so as to eliminate high frequency oscillations and insulate oscillations in a range of frequencies, typical of said knocking phenomenon;
- measuring of a number of digital pulses obtained from said derived pressure signal (*Fl_Pr_Sign*) generating a first measure signal (*Pul_Cnt*) and measuring of a total duration of said digital pulses generating a second measure signal (*Pul_Dur*); and
- processing using soft-computing techniques of said first and second measure signals (*Pul_Cnt, Pul_Dur*) to generate a knocking intensity index (*Knock_index*).

30. Processing method according to claim 29, **characterised in that** it further comprises an enable step of said measure step, using a reset signal.

31. Processing method according to claim 30, **characterised in that** said reset signal is supplied by a cam shaft sensor of said internal combustion engine (2).

32. Processing method according to claim 29, **characterised in that** it also comprises a control step of said internal combustion engine (2) which uses said knocking intensity index (*Knock_index*) generated in said processing step to modify operation parameters of said internal combustion engine (2).

33. Processing method according to claim 32, **characterised in that** said control step comprises a control action generation step further to detection of a knocking phenomenon to eliminate the presence of such phenomenon.

34. Processing method according to claim 33, **characterised in that** said control actions comprise a reduction of a spark advance value with respect to a mapped value according to said knocking intensity index (*Knock_Index*).

35. Processing method according to claim 34, **characterised in that** said control actions are performed until said knocking phenomenon extinguishes, in correspondence with a void value of said knocking intensity index (*Knock_Index*) generated by said processing step.

36. Processing method according to claim 33, **characterised in that** said control step acts in real time on the operation of said internal combustion engine (2).

Patentansprüche

1. Schaltung zur Beurteilung des Vorhandenseins von Motorklopfgeräuschen in einer Verbrennungskraftmaschine (2), wobei die Verbrennungskraftmaschine für jeden Zylinder mindestens einen in dem Motor selbst enthaltenen, einer Brennkammer gegenüberstehenden und zum Detektieren eines Drucksignals (Pr_Sign) geeigneten Drucksensor (3) aufweist, wobei die Schaltung zur Beurteilung des Vorhandenseins von Motorklopfgeräuschen in einer Verbrennungskraftmaschine mit dem Drucksensor verbunden und zum Entgegennehmen eines Drucksignals von diesem geeignet ist, wobei die Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung aufweist:

- einen entsprechend einem Eingangsanschluss (1 N4) der Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung (4) mit dem Drucksensor (3) verbundenen und zum Entgegennehmen des Drucksignals (Pr_Sign) geeigneten Verarbeitungsblock (7), wobei der Verarbeitungsblock (7) zum Durchführen einer Verarbeitung des Drucksignals (Pt_Sign) zwecks Isolieren der Schwingungen und zum Erzeugen eines abgeleiteten Drucksignals (Fl_Pr_Sign) eingerichtet ist;
- einen am Eingang mit dem Verarbeitungsblock (7) verbundenen und zum Entgegennehmen des abgeleiteten Drucksignals (Fl_Pr_Sign) von diesem geeigneten Erfassungsblock (8), wobei der Erfassungsblock (8) zum Erzeugen eines ersten und eines zweiten Messsignales (Pul_Cnt, Pul_Dw) entsprechend einer Anzahl beziehungsweise einer Gesamtdauer digitaler Impulse, welche aus dem Drucksignal (Fl_Pt_Sign) gewonnen werden, geeignet ist; und
- ein am Eingang mit dem Erfassungsblock (8) verbundener und zum Entgegennehmen des ersten und zweiten Messsignals (Pul_Cnt, Pul_Dw) von diesem geeigneter und mit einem Ausgangsanschluss (OUT4) der Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung (4) verbundener Softcomputingblock (9), wobei der Block (9) geeignet ist, den Ausgangsanschluss mit einem Motorklopfgeräusch-Intensitätsindex (Knock_index) zu versorgen, berechnet durch Softcomputirig-Techniken, ausgehend von dem ersten und dem zweiten Messsignal (Pul_Cnt, PU1_DLLT).

2. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 1, **dadurch gekennzeichnet, dass** es ferner aufweist: einen Freigabeblock (10), der mit dem Softcomputingblock (9) verbunden ist und diesen mit einem Freigabesignal (En_Kn_Mea) versorgt.

3. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 1, **dadurch gekennzeichnet, dass** der Verarbeitungsblock (7) mindestens die Reihenschaltung eines am Eingang mit dem Drucksensor (3) verbundenen Ladungsverstärkers (71) mit einem Filter (72) aufweist, welcher wiederum am Ausgang mit einem zum Liefern des abgeleiteten Drucksignals (Fl_Pr_Sign) geeigneten Ausgangsanschluss (OUT7) des Verarbeitungsblockes (7) verbunden ist.

4. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 3, **dadurch gekennzeichnet, dass** der Ladungsverstärker (71) das Drucksignal (Pr_Sign) entgegennimmt und ein Spannungssignal (Vpr) ausgibt.

5. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 4, **dadurch gekennzeichnet, dass** der Filter (72) ein zum Filtern des Spannungssignales (Vpr) und zum Eliminieren der hochfrequenten und niederfrequenten Schwingungen geeigneter Bandpassfilter ist.

6. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 1, **dadurch gekennzeichnet, dass** der Erfassungsblock (8) mindestens aufweist: einen Komparator (81) mit einem mit einem ersten Eingangsanschluss (IN8a) des Erfassungsblockes verbundenen und von diesem das durch den Erfassungsblock (7) erzeugte abgeleitete Drucksignal (Fl_Pr_Sign) entgegennehmenden ersten Eingangsanschluss, wobei ein zweiter Eingangsanschluss mit einer Schwellenwertreferenz (82) verbunden ist, welche geeignet ist, einen Schwellenwert (Threshold) bereitzustellen, und einen Ausgangsanschluss, wobei auf diesem ein Zählsignal (Dig_Puls) liegt und eine Mehrzahl an Impulsen von unterschiedlicher Dauer aufweist.

7. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 6, **dadurch gekennzeichnet, dass** der Erfassungsblock (8) ferner einen Zähler (83) aufweist, welcher einen mit dem Ausgangsanschluss des Komparators (81) verbundenen und von diesem das Zählsignal (Dig_puls) entgegennehmenden Eingangsanschluss sowie einen mit einem ersten Ausgangsschluss (OUT8a) des Erfassungsblockes (8) verbundenen Ausgangsanschluss aufweist, an welchen es das erste Messsignal (Pul_Cnt) entsprechend einer Anzahl von Impulsen des Zählsignales (Dig_puls) liefert.

8. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 6, **dadurch gekennzeichnet, dass** der Erfassungsblock (8) ferner aufweist: einen Zeitgeber (84) mit einem ersten Eingangsanschluss (Start) und einem zweiten invertierten Eingangsanschluss (Stop), wobei beide mit dem Ausgangsanschluss des Komparators (81) verbunden sind und von diesem das Zählsignal (Dig_puls) entgegennehmen, sowie auch einen Ausgangsanschluss, der mit einem zweiten Ausgangsanschluss (OUT8b) des Erfassungsblockes (8) verbunden ist, an den es das zweite Messsignal (Pul_Dur) entsprechend einer globalen Dauer der Impulse des Zählsignals (Dig_puls) liefert.

9. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 7 und 8, **dadurch gekennzeichnet, dass** der Zähler (83) und der Zeitgeber (84) entsprechende Rücksetzanschlüsse aufweisen, die ein Rücksetzsignal (Reset) entgegennehmen.

10. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 9, **dadurch gekennzeichnet, dass** das Rücksetzsignal (Reset) durch einen Sensor der Nockenwelle (8) der Verbrennungskraftmaschine (2) in Übereinstimmung mit jedem Maschinenzyklus erzeugt wird.

11. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 6, **dadurch gekennzeichnet, dass** der Schwellenwert (Threshold) für jeden Betriebszustand der Verbrennungskraftmaschine (2) abgebildet und gespeichert wird.

12. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 1, **dadurch gekennzeichnet, dass** der Softcomputingblock (9) mindestens einen das erste und das zweite Messsignal (Pul_Cnt, Pul_Dur) entgegennehmenden und mit dem Ausgangsanschluss (OUT4) der Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung (4) an dessen Ausgang verbundenen Berechnungsblock (91) aufweist, woraufhin dieser den Motorklopfgeräusch-Intensitätindex (Knock_Index) erzeugt.

13. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 12, **dadurch gekennzeichnet, dass** der Softcomputingblock (9) ferner einen zwischen einem Ausgangsanschluss des Berechnungsblockes (91) und dem Ausgangsanschluss (OUT4) der Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung (4) eingefügten Schalterblock (92) aufweist.

14. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 13, **dadurch gekennzeichnet, dass** der Schalterblock (92) das Freigabesignal (En_Kn_Mea), welches zum Freigeben einer Übertragung an den Ausgangsanschluss (OUT4) des Motorklopfgeräusch-Intensitätsindex (Knock_Index) geeignet ist, entgegennimmt.

15. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 13, **dadurch gekennzeichnet, dass** der Berechnungsblock (91) eine Softcomputingtechnik implementiert, welche ausgewählt ist aus Fuzzy-Logic, Neuronal-Netzwerk, genetischen Algorithmen und nichtlinearen verteilten Systemen, um so hybride Systeme zu definieren und zu implementieren.

16. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 13, **dadurch gekennzeichnet, dass** der Berechnungsblock (91) einen mit Soft-computing-Techniken implementierten Abschätzer realisiert.

17. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 2, **dadurch gekennzeichnet, dass** der Freigabeblock (10) einen mit einer Winkelstellungsmessvorrichtung (12) der Verbrennungskraftmaschine (2) verbundenen und von dieser ein Detektionssignal (An_PI) empfangenden ersten Eingangsanschluss (IN10a), einen mit einem Sensor der Nockenwelle (11) der Verbrennungskraftmaschine (2) verbundenen und von dieser ein Rücksetzsignal (Reset) entgegennehmenden zweiten Eingangsanschluss (IN10b) sowie auch einen Ausgangsanschluss aufweist, auf welchem das Freigabesignal (En_Kn_Mea) erzeugt wird.

18. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 17, **dadurch gekennzeichnet, dass** der Freigabeblock (10) einen Zähler (101) mit einem mit der Winkelstellungsmessvorrichtung (12) verbundenen und von dieser das Detektionssignal (An_PI) entgegennehmenden Eingangsanschluss (Up) wie auch einen Ausgangsanschluss, auf dem ein Zählerwert (Vcount) erzeugt wird, aufweist.

19. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 18, **dadurch gekennzeichnet, dass** der Freigabeblock (10) ferner einen mit dem Zähler (101) verbundenen und zum Multiplizieren des Zählerwertes (Vcount) mit einem Wert (Z) aus einem Bezugsblock (103) entsprechend einem durch die Winkelmessvorrichtung (12) benutzten Kurbelwinkel geeigneten Multipliziererknoten (102) zum Erzeugen eines Signals entsprechend einer Winkelstellung des Motors (Eng_Angl) aufweist.

20. Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung nach Anspruch 19, **dadurch gekennzeichnet, dass** der Freigabeblock (10) ferner einen mit dem Multipliziererknoten (102) verbundenen und von diesem das einer Winkelstellung des Motors (Eng_Angl) entsprechende Signal entgegennehmenden und mit einem Ausgangsanschluss (OUT10) des Freigabeblockes (10) verbundenen Komparator (105) aufweist, wobei der Komparator ein Signal entsprechend eines Motorwinkels (anglex) entgegennimmt, welches ein Index der Auslöschung des Motorklopfgeräusch-Phänomens ist.

21. Mit einer Verbrennungskraftmaschine (2) verknüpftes und eine mit einem Drucksensor (3) der Verbrennungskraftmaschine (2) verbundene Steuerungsschleife (LoopC) aufweisendes Motorklopfgeräusch-Identifikations- und Steuerungssystem, **dadurch gekennzeichnet, dass** die Steuerungsschleife (LoopC) mindestens eine Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung (4) aufweist, die gemäß irgendeinem der vorstehenden Ansprüche realisiert ist.

22. Motorklopfgeräusch-Identifikations- und Steuerungssystem nach Anspruch 21, **dadurch gekennzeichnet, dass** die Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung (4) mit einer unter Verwendung eines Konverter-ADC (13) mit einer Steuerungs-Firmware (16) versehenen elektrischen Steuerungseinheit (14) der Verbrennungskraftmaschine (2) verbunden ist.

23. Motorklopfgeräusch-Identifikations- und Steuerungssystem nach Anspruch 22, **dadurch gekennzeichnet, dass** es ferner einen Subtraktionsknoten (15) aufweist, der zwischen der Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung (4) und der Konverter-ADC (13) eingefügt ist und ein Bezugssignal (Rif) entgegennimmt.

24. Motorklopfgeräusch-Identifikations- und Steuerungssystem nach Anspruch 22, **dadurch gekennzeichnet, dass** die Steuerungseinheit (14) Steuerungsaktionen zum Eliminieren des Vorhandenseins des Motorklopfgeräusch-Phänomenes auf der Basis des Wertes des Motorklopfgeräusch-Intensitätsindex (Knock_Index) ausführt, welcher durch die Motorklopfgeräusch-Vorhandenseins-Beurteilungsschaltung (4) berechnet wird.

25. Motorklopfgeräusch-Identifikations- und Steuerungssystem nach Anspruch 24, **dadurch gekennzeichnet, dass** die Steuerungsaktionen auf einer Verminderung des Vorzündungswertes (Map_CR) im Hinblick auf den abgebildeten Wert (Map_Stored) basieren.

26. Motorklopfgeräusch-Identifikations- und Steuerungssystem nach Anspruch 25, **dadurch gekennzeichnet, dass** die Firmware (16) der Steuerungseinheit (14) eine Steuerungsstruktur (17) beinhaltet, die geeignet ist, den Vorzündungswert (Map_CR) gemäß der folgenden Regel zu berechnen:

$$\mathrm{Map\_CR} = \mathrm{Map\_Stored} + \mathrm{Adv\_Inj} * \mathrm{Knock\_Index}$$

wobei gilt

Map_CR der Vorzündungswert
Map_Stored der abgebildete Wert;
Adv_Inj ein vorher festgelegter Vorzündungswert, der in der Firmware (16) gespeichert ist; und
Knock_Index der Motorklopfgeräusch-Intensitätsindex.

27. Motorklopfgeräusch-Identifikations- und Steuerungssystem nach Anspruch 26, **dadurch gekennzeichnet, dass** die Steuerungsstruktur (17) eine Steuerungsstruktur des proportionalen geschlossenen Regelschleifentyps ist.

28. Motorklopfgeräusch-Identifikations- und Steuerungssystem nach Anspruch 25, **dadurch gekennzeichnet, dass** die Steuerungseinheit (14) ferner ein Zündfunken-Management-Modul (18) aufweist, welches am Eingang mit der Steuerungsstruktur (17) und am Ausgang mit der Verbrennungskraftmaschine (2), an welche es ein Steuerungssignal (CR) liefert, verbunden ist.

29. Verfahren zum Verarbeiten eines Drucksignals (Pr_Sign) zwecks Detektion und Beurteilung eines Verbrennungsphänomens in einer Verbrennungskraftmaschine (2), folgende Schritte aufweisend:

- Entgegennehmen eines durch einen Drucksensor (3), der mit der Verbrennungskraftmaschine (2) verknüpft ist, detektierten Drucksignals (Pr_Sign);
- Isolieren von Schwingungen des Drucksignals (Pr_Sign) zum Erzielen eines abgeleiteten Drucksignals (Fl_Pr_Sign);
- Erzielen von digitalen Impulsen entsprechend einem Motorklopfgeräusch-phänomen aus dem abgeleiteten Drucksignal (Fl_Pr_Sign);
- Ableiten eines Drucksignals (Fl_Pr_Sign) durch Verstärken und Filtern des Drucksignals (Pr_Sign), um so Hochfrequenzschwingungen zu eliminieren und Schwingungen in einem Bereich von Frequenzen zu isolieren, die typisch für das Motorklopfgeräusch-Phänomen sind;
- Messen einer Anzahl digitaler Impulse, die aus dem abgeleiteten Drucksignal (Fl_Pr_Sign) gewonnen sind, ein erstes Messsignal (Pul_Cnt) erzeugend und eine Gesamtdauer der digitalen Impulse messend, ein zweites Messsignal (Pul_Dur) erzeugend; und
- Verarbeiten des ersten und zweiten Messsignals (Pul_Cnt, Pul_Dur) unter Verwendung von Softcomputing-Techniken zum Erzeugen eines Motorklopfgeräusch-Intensitätsindex (Knock_Index).

30. Verarbeitungsverfahren nach Anspruch 29, **dadurch gekennzeichnet, dass** es ferner einen Freigabeschritt des Messschrittes beinhaltet, ein Rücksetzsignal verwendend.

31. Verarbeitungsverfahren nach Anspruch 30, **dadurch gekennzeichnet, dass** das Rücksetzsignal durch einen Nokkenwellensensor der Verbrennungskraftmaschine (2) geliefert wird.

32. Verarbeitungsverfahren nach Anspruch 29, **dadurch gekennzeichnet, dass** es ebenfalls einen den in dem Verarbeitungsschritt erzeugten Motorklopfgeräusch-Intensitätsindex (Knock_Index) verwendenden Schritt der Steuerung der Verbrennungskraftmaschine (2) beinhaltet, um Betriebsparameter der Verbrennungskraftmaschine (2) zu modifizieren.

33. Verarbeitungsverfahren nach Anspruch 32, **dadurch gekennzeichnet, dass** der Steuerungsschritt ferner einen Steuerungsaktions-Erzeugungsschritt über die Detektion eines Motorklopfgeräusch-Phänomens hinaus zwecks Elimination des Vorhandenseins eines solchen Phänomen umfasst.

34. Verarbeitungsverfahren nach Anspruch 33, **dadurch gekennzeichnet, dass** die Steuerungsaktionen eine Verminderung des Vorzündungswertes im Bezug auf einen abgebildeten Wert entsprechend des Motorklopfgeräusch-Intensitätsindex (Knock_Index) beinhalten.

35. Verarbeitungsverfahren nach Anspruch 34, **dadurch gekennzeichnet, dass** die Steuerungsaktionen durchgeführt werden, bis das Motorklopfgeräusch-Phänomen in Übereinstimmung mit einem Leerwert des durch den Verarbeitungsschritt erzeugten Motorklopfgeräusch-Intensitätsindex (Knock_Index) erlischt.

36. Verarbeitungsverfahren nach Anspruch 33, **dadurch gekennzeichnet, dass** der Steuerungsschritt in Echtzeit auf den Betrieb der Verbrennungskraftmaschine (2) einwirkt.

Revendications

1. Circuit d'évaluation de cognement dans un moteur à combustion interne (2), le moteur à combustion interne ayant au moins un capteur de pression (3) faisant face à une chambre de combustion pour chaque cylindre compris dans le moteur lui-même et adapté pour détecter un signal de pression (Pr_Sign), le circuit d'évaluation de cognement étant connecté audit capteur de pression et adapté pour recevoir de ce dernier un signal de pression,
le circuit d'évaluation de cognement comprenant

- un bloc de traitement (7), connecté, en liaison avec une borne d'entrée (IN4) dudit circuit d'évaluation de cognement (4), audit capteur de pression (3) et adapté pour recevoir de ce dernier un signal de pression (Pr_Sign), ledit bloc de traitement (7) étant adapté pour exécuter un traitement dudit signal de pression (Pr_Sign)

pour isoler les oscillations et adapté pour générer un signal de pression dérivé (Fl_Pr_Sign) ;
- un bloc d'acquisition (8), connecté par une entrée audit bloc de traitement (7) et adapté pour recevoir de ce dernier ledit signal de pression dérivé (Fl_Pr_Sign), ledit bloc d'acquisition (8) étant adapté pour générer des premier et deuxième signaux de mesure (Pul_Cnt, Pul_Dw) correspondant respectivement à un nombre et à une durée totale des impulsions numériques obtenues à partir dudit signal de pression dérivé (Fl_Pr_Sign) ; et
- un bloc de calcul électronique (9) connecté par une entrée audit bloc d'acquisition (8) et adapté pour recevoir de ce dernier lesdits premier et deuxième signaux de mesure (Pul_Cnt, Pul_Dw) et connecté à une borne de sortie (OUT4) dudit circuit d'évaluation de cognement (4), ledit bloc (9) étant adapté pour fournir à la borne de sortie un indice d'intensité de cognement (Knock_index), calculé par des techniques de calcul électronique, en commençant par lesdits premier et deuxième signaux de mesure (Pul_Cnt, Pul_DLLT).

2. Circuit d'évaluation de cognement selon la revendication 1, **caractérisé en ce qu'**il comprend en outre un bloc de validation (10) connecté audit bloc de calcul électronique (9) et lui fournissant un signal de validation (En_Kn_Mea).

3. Circuit d'évaluation de cognement selon la revendication 1, **caractérisé en ce que** ledit bloc de traitement (7) comprend au moins la série composée d'un amplificateur de charge (71) connecté par une entrée audit capteur de pression (3) et d'un filtre (72), connecté quant à lui par une sortie à une borne de sortie (OUT7) dudit bloc de traitement (7) adapté pour fournir ledit signal de pression dérivé (Fl_Pr_Sign).

4. Circuit d'évaluation de cognement selon la revendication 3, **caractérisé en ce que** ledit amplificateur de charge (71) reçoit ledit signal de pression (Pr_Sign) et sort un signal de tension (Vpr).

5. Circuit d'évaluation de cognement selon la revendication 4, **caractérisé en ce que** ledit filtre (72) est un filtre passe-bande adapté pour filtrer ledit signal de tension (Vpr) et éliminer les oscillations de haute fréquence et de basse fréquence.

6. Circuit d'évaluation de cognement selon la revendication 1, **caractérisé en ce que** ledit bloc d'acquisition (8) comprend au moins un comparateur (81) ayant une première borne d'entrée connectée à une première borne d'entrée (IN8a) dudit bloc d'acquisition (8) et recevant de ce dernier ledit signal de pression dérivé (Fl_Pr_Sign) généré par ledit bloc de traitement (7), une deuxième borne d'entrée connectée à une référence de seuil (82) adaptée pour fournir une valeur de seuil (Threshold) et une borne de sortie, un signal de comptage (Dig_Puls) y étant présent et ayant une pluralité d'impulsions de différentes durées.

7. Circuit d'évaluation de cognement selon la revendication 6, **caractérisé en ce que** ledit bloc d'acquisition (8) comprend en outre un compteur (83) ayant une borne d'entrée (Up) connectée à ladite borne de sortie dudit comparateur (81) et recevant de ce dernier ledit signal de comptage (Dig_Puls) et une borne de sortie connectée à une première borne de sortie (OUT8a) dudit bloc d'acquisition (8), à laquelle elle fournit ledit premier signal de mesure (Pul_Cnt), correspondant à un nombre d'impulsions dudit signal de comptage (Dig_Puls).

8. Circuit d'évaluation de cognement selon la revendication 6, **caractérisé en ce que** ledit bloc d'acquisition (8) comprend en outre un temporisateur (84) ayant une première borne d'entrée (Start) et une deuxième borne d'entrée inverse (Stop), toutes deux connectées à ladite borne de sortie dudit comparateur (81) et recevant de ce dernier ledit signal de comptage (Dig_Puls), ainsi qu'une borne de sortie connectée à une deuxième borne de sortie (OUT8b) dudit bloc d'acquisition (8), à laquelle elle fournit ledit deuxième signal de mesure (Pul_Dur), correspondant à une durée totale desdites impulsions dudit signal de comptage (Dig_Puls).

9. Circuit d'évaluation de cognement selon les revendications 7 et 8, **caractérisé en ce que** ledit compteur (83) et ledit temporisateur (84) ont des bornes respectives de réinitialisation recevant un signal de réinitialisation (Reset).

10. Circuit d'évaluation de cognement selon la revendication 9, **caractérisé en ce que** ledit signal de réinitialisation (Reset) est généré par un capteur d'arbre à cames (8) dudit moteur à combustion interne (2) en fonction de chaque cycle du moteur.

11. Circuit d'évaluation de cognement selon la revendication 6, **caractérisé en ce que** ladite valeur de seuil (Threshold) est mise en correspondance et mémorisée pour chaque condition de fonctionnement dudit moteur à combustion interne (2),.

12. Circuit d'évaluation de cognement selon la revendication 1, **caractérisé en ce que** ledit bloc de calcul électronique

(9) comprend au moins un bloc de calcul (91) recevant lesdits premier et deuxième signaux de mesure (Pul_Cnt, Pul_Dur) et connecté par une sortie à ladite borne de sortie (OUT4) dudit circuit d'évaluation de cognement (4) sur laquelle il génère ledit indice d'intensité de cognement (Knock_index).

13. Circuit d'évaluation de cognement selon la revendication 12, **caractérisé en ce que** ledit bloc de calcul électronique (9) comprend en outre un bloc de commutateur (92), inséré entre une borne de sortie dudit bloc de calcul (91) et ladite borne de sortie (OUT4) dudit circuit d'évaluation de cognement (4).

14. Circuit d'évaluation de cognement selon la revendication 13, **caractérisé en ce que** ledit bloc de commutateur (92) reçoit ledit signal de validation (En_Kn_Mea) adapté pour valider une transmission à ladite borne de sortie (OUT4) dudit indice d'intensité de cognement (Knock_index).

15. Circuit d'évaluation de cognement selon la revendication 13, **caractérisé en ce que** ledit bloc de calcul (91) met en oeuvre une technique de calcul électronique choisie entre une logique floue, des réseaux neuronaux, des algorithmes génétiques et des systèmes continus non linéaires de façon à définir et à mettre en oeuvre des systèmes mixtes.

16. Circuit d'évaluation de cognement selon la revendication 13, **caractérisé en ce que** ledit bloc de calcul (91) crée un estimateur mis en oeuvre par des techniques de calcul électronique.

17. Circuit d'évaluation de cognement selon la revendication 2, **caractérisé en ce que** ledit bloc de validation (10) a une première borne d'entrée (IN10a) connectée à un dispositif de mesure de position angulaire (12) dudit moteur à combustion interne (2) et recevant de ce dernier un signal de détection (An_Pl), une deuxième borne d'entrée (IN10b) connectée à un capteur de l'arbre à cames (11) dudit moteur à combustion interne (2) et recevant de ce dernier un signal de réinitialisation (Reset), ainsi qu'une borne de sortie sur laquelle ledit signal de validation (En_Kn_Mea) est généré.

18. Circuit d'évaluation de cognement selon la revendication 17, **caractérisé en ce que** ledit bloc de validation (10) comprend un compteur (101) ayant une borne d'entrée (Up) connectée audit dispositif de mesure de position angulaire (12) et recevant de ce dernier ledit signal de détection (An_Pl), une borne de validation connectée audit capteur de l'arbre à cames (11) et recevant de ce dernier ledit signal de réinitialisation (Reset), ainsi qu'une borne de sortie sur laquelle une valeur de comptage (Vcount) est générée.

19. Circuit d'évaluation de cognement selon la revendication 18, **caractérisé en ce que** ledit bloc de validation (10) comprend en outre un noeud multiplicateur (102) connecté audit compteur (101) et adapté pour multiplier ladite valeur de comptage (Vcount) par une valeur (Z) provenant d'un bloc de référence (103) correspondant à une valeur d'angle de vilebrequin utilisée par ledit dispositif de mesure de position angulaire (12) pour générer un signal correspondant à une position angulaire du moteur (Eng_Angl).

20. Circuit d'évaluation de cognement selon la revendication 19, **caractérisé en ce que** ledit bloc de validation (10) comprend en outre un comparateur (105) connecté audit noeud multiplicateur (102) et recevant de ce dernier ledit signal correspondant à une position angulaire du moteur (Eng_Angl), et à une borne de sortie (OUT10) dudit bloc de validation (10), ledit comparateur (105) recevant un signal correspondant à angle du moteur (anglex) qui est un indice d'extinction du phénomène de cognement.

21. Système d'identification et de contrôle de cognement associé à un moteur à combustion interne (2) et comprenant une boucle de régulation (LoopC) connectée à un capteur de pression (3) dudit moteur à combustion interne (2), **caractérisé en ce que** ladite boucle de régulation (LoopC) comprend au moins un circuit d'évaluation de cognement (4) produit selon l'une quelconque des revendications précédentes.

22. Système d'identification et de contrôle de cognement selon la revendication 21, **caractérisé en ce que** ledit circuit d'évaluation de cognement (4) est connecté à une unité de commande électrique (14) dudit moteur à combustion interne (2) munie d'un microprogramme de commande (16) au moyen d'un convertisseur ADC (13).

23. Système d'identification et de contrôle de cognement selon la revendication 22, **caractérisé en ce qu'**il comprend en outre un noeud soustracteur (15) inséré entre ledit circuit d'évaluation de cognement (4) et ledit convertisseur ADC (13) et recevant un signal de référence (Rif).

24. Système d'identification et de contrôle de cognement selon la revendication 22, **caractérisé en ce que** ladite unité de commande électrique (14) effectue une action de commande sur la base de la valeur dudit indice d'intensité de cognement (Knock_index) calculé par ledit circuit d'évaluation de cognement (4) pour supprimer la présence des phénomènes de cognement.

25. Système d'identification et de contrôle de cognement selon la revendication 24, **caractérisé en ce que** lesdites actions de commande agissent sur une réduction d'une valeur d'avance à l'allumage (Map_CR) par rapport à une valeur mise en correspondance (Map_Stored).

26. Système d'identification et de contrôle de cognement selon la revendication 25, **caractérisé en ce que** ledit microprogramme (16) de ladite unité de commande (14) comprend une structure de commande (17) adaptée pour calculer ladite valeur d'avance à l'allumage (Map_CR) en fonction de la règle suivante :

$$Map\_CR = Map\_Stored + Adv\_Inj * Knock\_index$$

où
Map_CR est ladite valeur d'avance à l'allumage ;
Map_Stored est ladite valeur mise en correspondance ;
Adv_Inj est une valeur prédéterminée d'avance à l'allumage enregistrée dans ledit microprogramme (16) ; et
Knock_index est ledit indice d'intensité de cognement.

27. Système d'identification et de contrôle de cognement selon la revendication 26, **caractérisé en ce que** ladite structure de commande (17) est une structure de commande du type proportionnel à boucle fermée.

28. Système d'identification et de contrôle de cognement selon la revendication 25, **caractérisé en ce que** ladite unité de commande (14) comprend en outre un module de gestion d'allumage (18), connecté par une entrée à ladite structure de commande (17) et connecté par une sortie audit moteur à combustion interne (2) auquel il fournit un signal de commande (Cr).

29. Procédé de traitement d'un signal de pression (Pr_Sign) pour la détection et l'évaluation d'un phénomène de combustion dans un moteur à combustion interne (2) comprenant les étapes consistant à :

- recevoir un signal de pression (Pr_Sign) détecté par un capteur de pression (3) associé audit moteur à combustion interne (2) ;
- isoler les oscillations dudit signal de pression (Pr_Sign), en obtenant un signal de pression dérivé (Fl_Pr_Sign) ;
- obtenir, à partir dudit signal de pression dérivé (Fl_Pr_Sign), des impulsions numériques correspondant à un phénomène de cognement ;
- dériver le signal de pression (Fl_Pr_Sign) en amplifiant et en filtrant ledit signal de pression (Pr_Sign), afin d'éliminer les oscillations de haute fréquence et d'isoler les oscillations dans une gamme de fréquences, caractéristiques dudit phénomène de cognement ;
- mesurer un nombre d'impulsions numériques obtenues à partir dudit signal de pression dérivé (Fl_Pr_Sign) en générant un premier signal de mesure (Pul_Cnt) et en mesurant une durée totale desdites impulsions numériques en générant un deuxième signal de mesure (Pul_Dur) ; et
- traiter, en utilisant des techniques de calcul électronique, lesdits premier et deuxième signaux de mesure (Pul_Cnt, Pul-Dur) pour générer un indice d'intensité de cognement (Knock_index).

30. Procédé de traitement selon la revendication 29, **caractérisé en ce qu'**il comprend en outre une étape de validation de ladite étape de mesure, en utilisant un signal de réinitialisation.

31. Procédé de traitement selon la revendication 30, **caractérisé en ce que** ledit signal de réinitialisation est fourni par un capteur d'arbre à cames dudit moteur à combustion interne (2).

32. Procédé de traitement selon la revendication 29, **caractérisé en ce qu'**il comprend également une étape de commande dudit moteur à combustion interne (2) qui utilise ledit indice d'intensité de cognement (Knock_index) généré à ladite étape de traitement pour modifier des paramètres de fonctionnement dudit moteur à combustion interne (2).

33. Procédé de traitement selon la revendication 32, **caractérisé en ce que** ladite étape de commande comprend une étape de génération d'une action de commande pour en outre détecter un phénomène de cognement afin de supprimer la présence de ce phénomène.

34. Procédé de traitement selon la revendication 33, **caractérisé en ce que** lesdites actions de commande comprennent une réduction d'une valeur d'avance à l'allumage par rapport à une valeur mise en correspondance en fonction dudit indice d'intensité de cognement (Knock_index).

35. Procédé de traitement selon la revendication 34, **caractérisé en ce que** lesdites actions de commande sont exécutées jusqu'à ce que ledit phénomène de cognement disparaisse, en fonction d'une valeur nulle dudit indice d'intensité de cognement (Knock_index) généré lors de ladite étape de traitement.

36. Procédé de traitement selon la revendication 33, **caractérisé en ce que** ladite étape de commande agit en temps réel sur le fonctionnement dudit moteur à combustion interne (2).

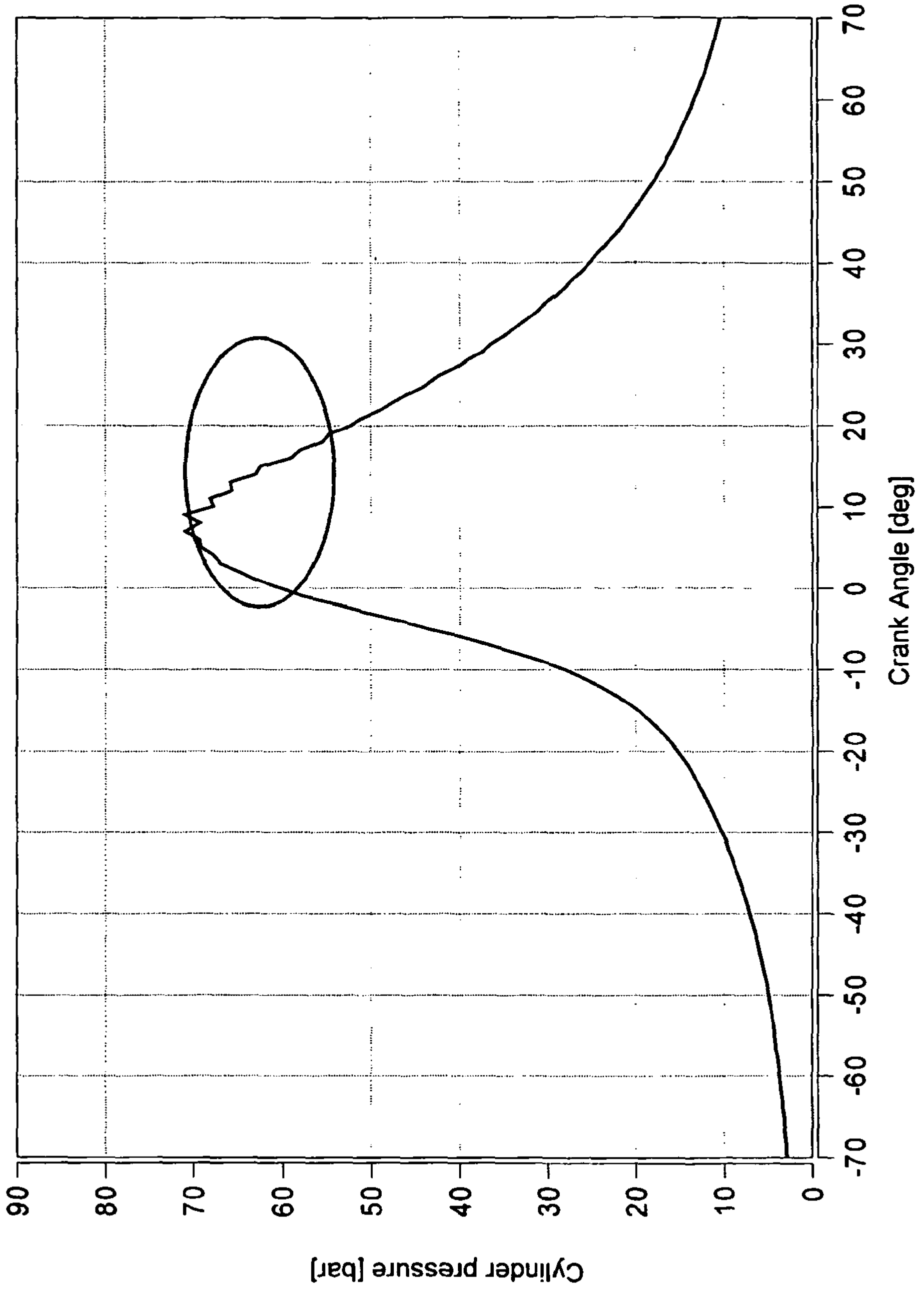


FIG. 1
PRIOR ART

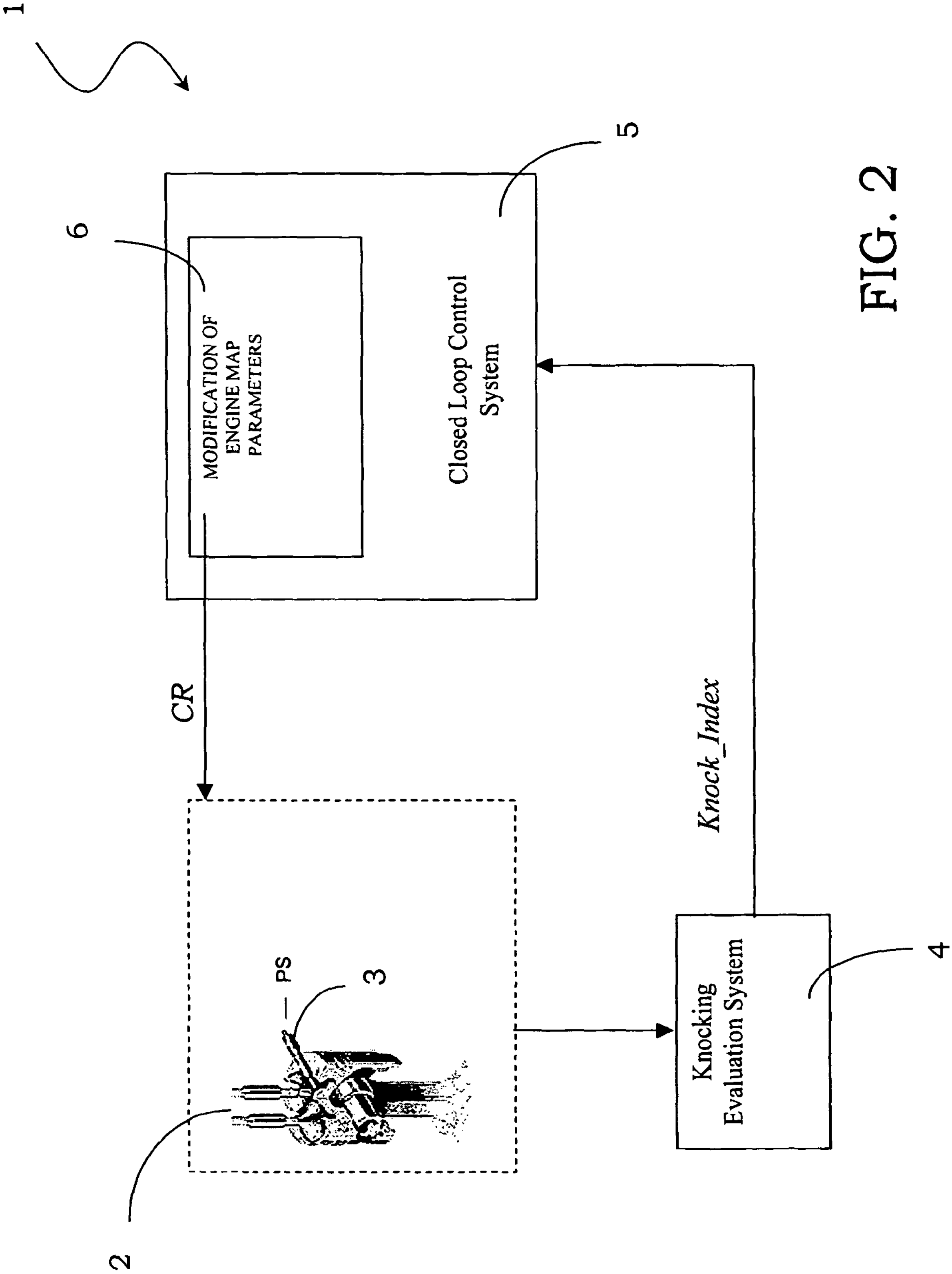
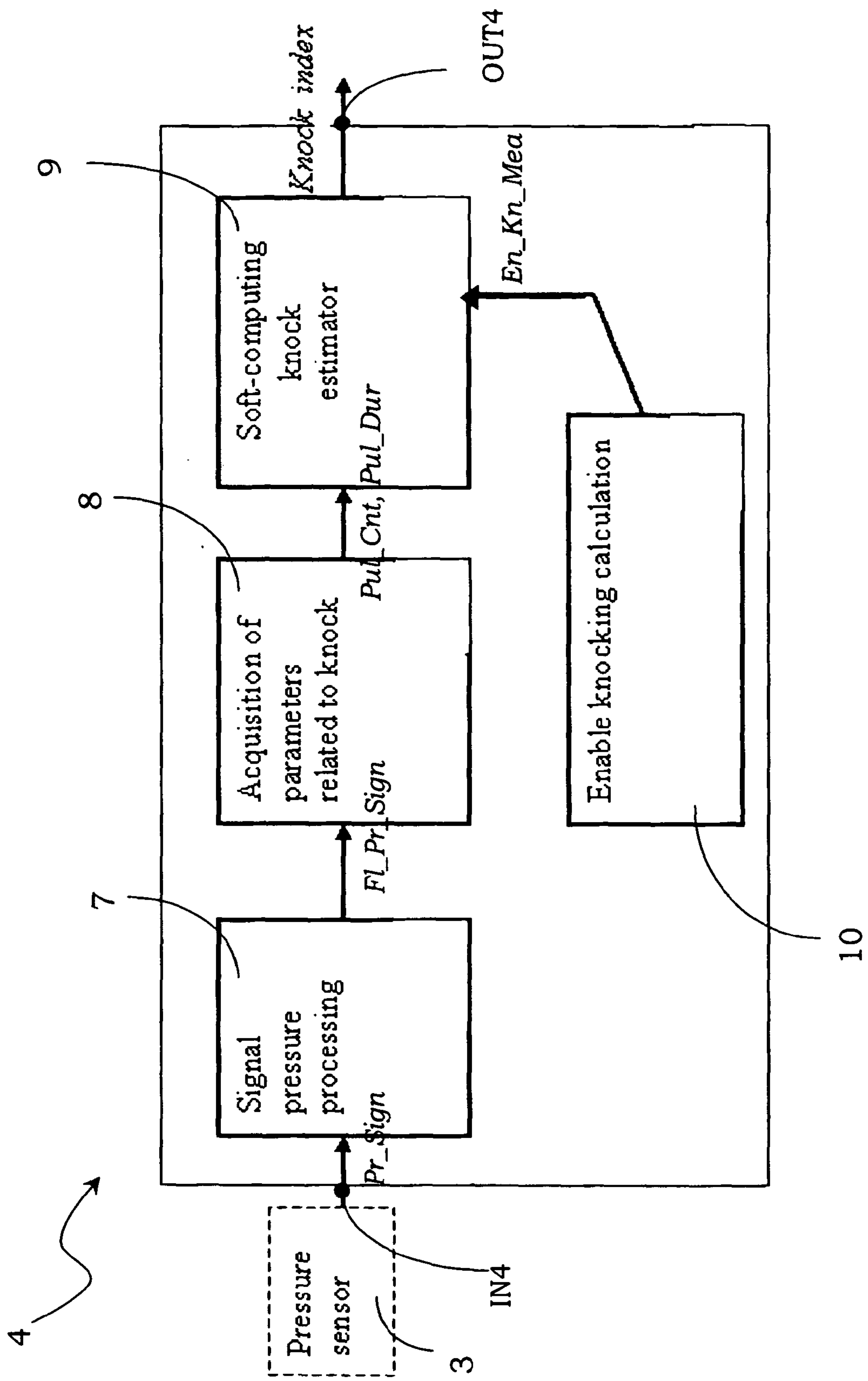

1
5
6
MODIFICATION OF
ENGINE MAP
PARAMETERS
Closed Loop Control
System
CR
Knock_Index
PS
3
2
Knocking
Evaluation System
4

FIG. 2



Pressure sensor
3
IN4
4
Pr_Sign
Signal pressure processing
7
Fl_Pr_Sign
Acquisition of parameters related to knock
8
Pul_Cnt, Pul_Dur
Soft-computing knock estimator
9
Knock_index
OUT4
En_Kn_Mea
Enable knocking calculation
10

FIG. 3

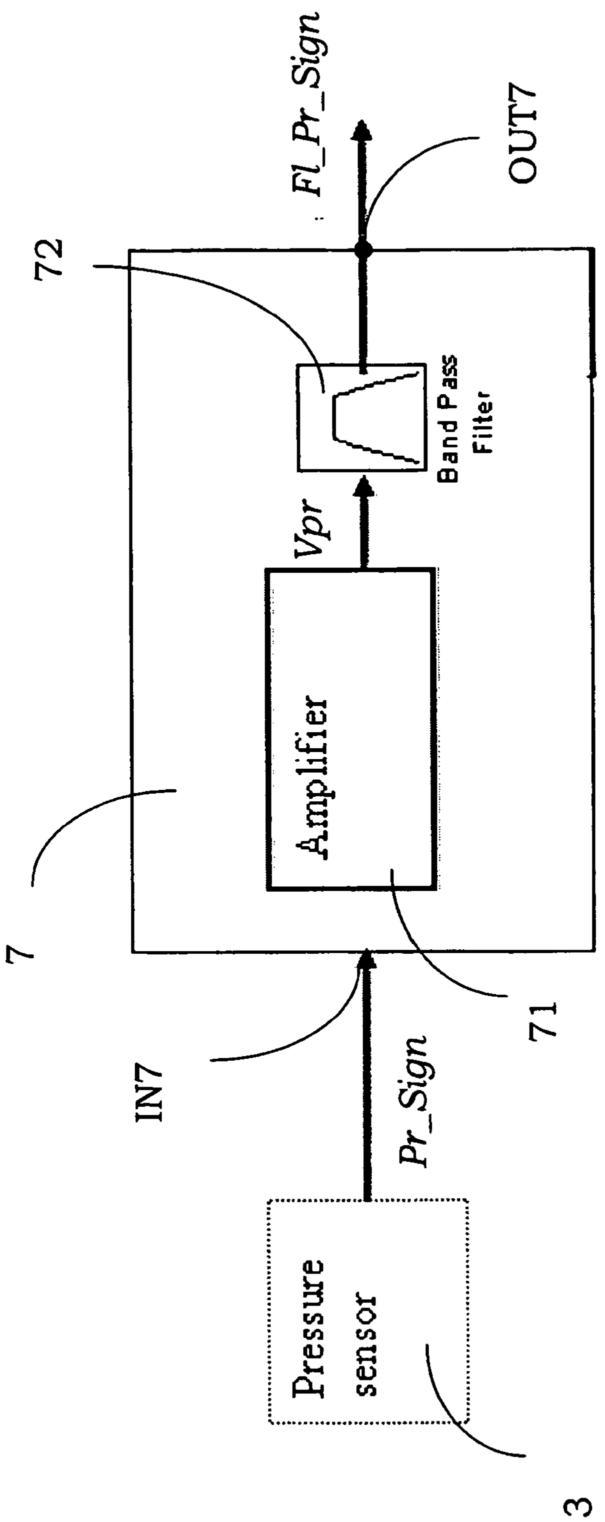

Fl_Pr_Sign
OUT7
72
Band Pass Filter
Vpr
Amplifier
7
71
IN7
Pr_Sign
Pressure sensor
3

FIG. 4

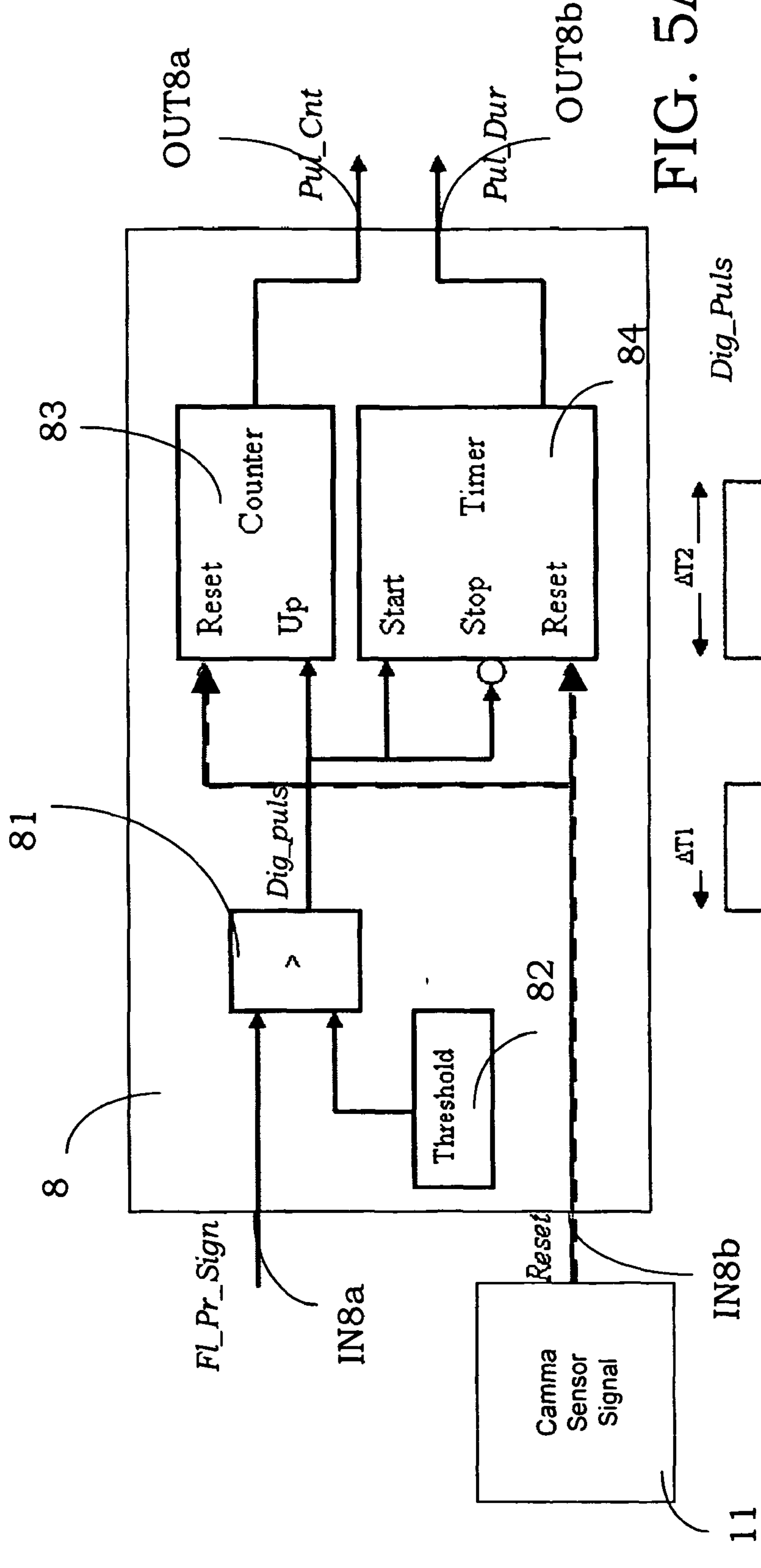

OUT8a
Pul_Cnt
Pul_Dur
OUT8b
83
Reset
Counter
Up
84
Start
Timer
Stop
Reset
81
Dig_puls
>
82
Threshold
8
Fl_Pr_Sign
IN8a
Reset
IN8b
Camma
Sensor
Signal
11

FIG. 5A

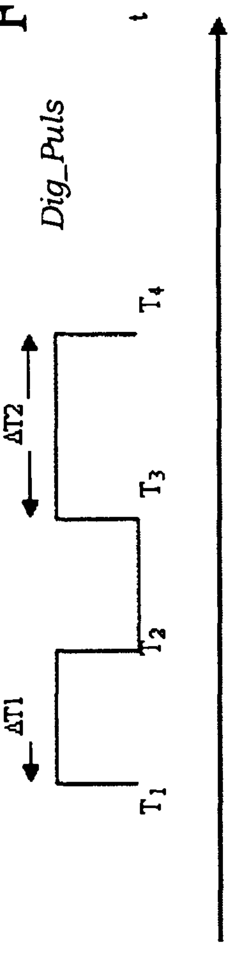

t
Dig_Puls
ΔT1
ΔT2
T_1
T_2
T_3
T_4

FIG. 5B

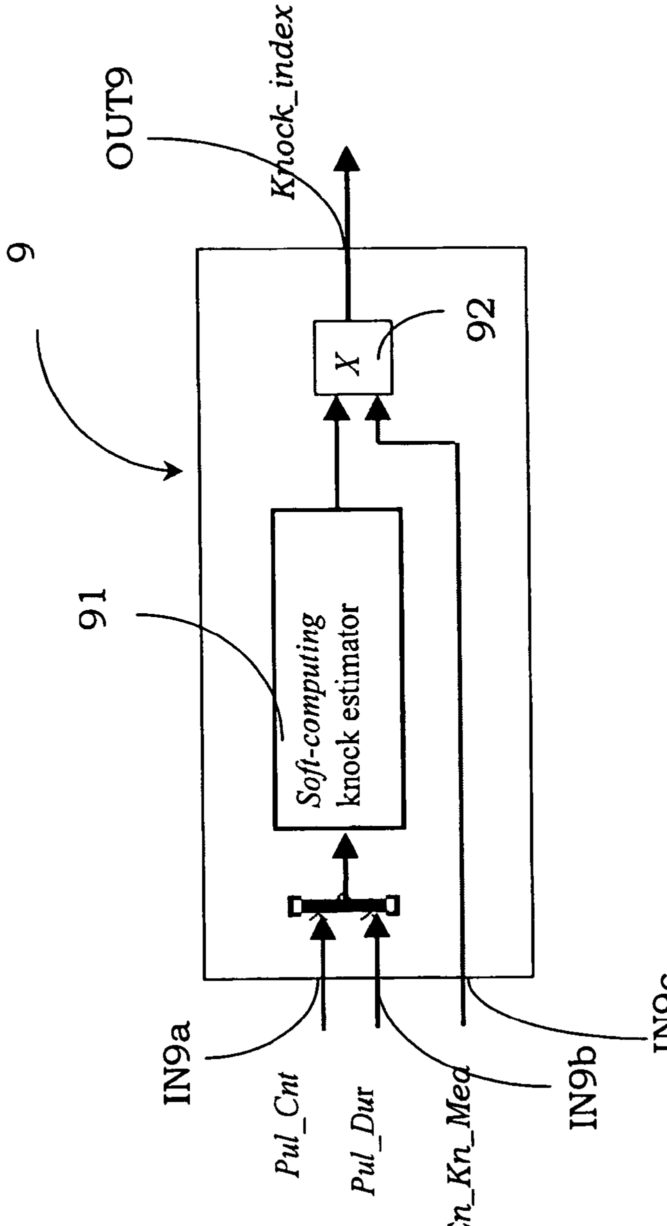

9
OUT9
Knock_index
92
X
91
Soft-computing
knock estimator
IN9a
Pul_Cnt
Pul_Dur
En_Kn_Med
IN9b
IN9c

FIG. 6

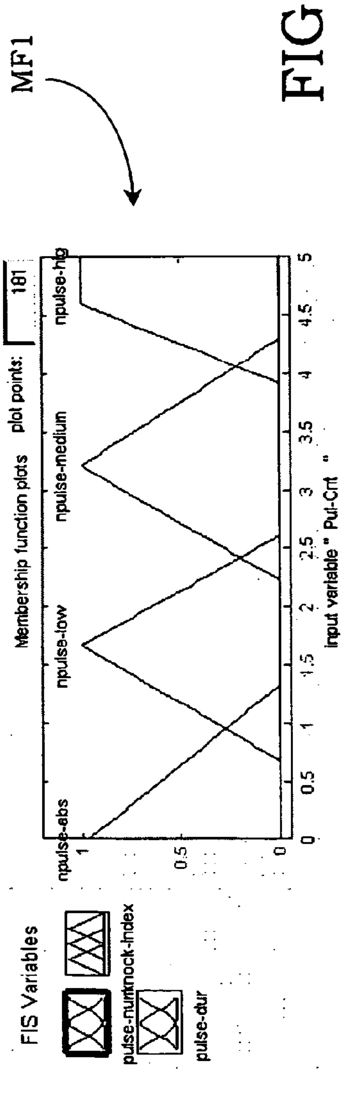


FIG. 7A

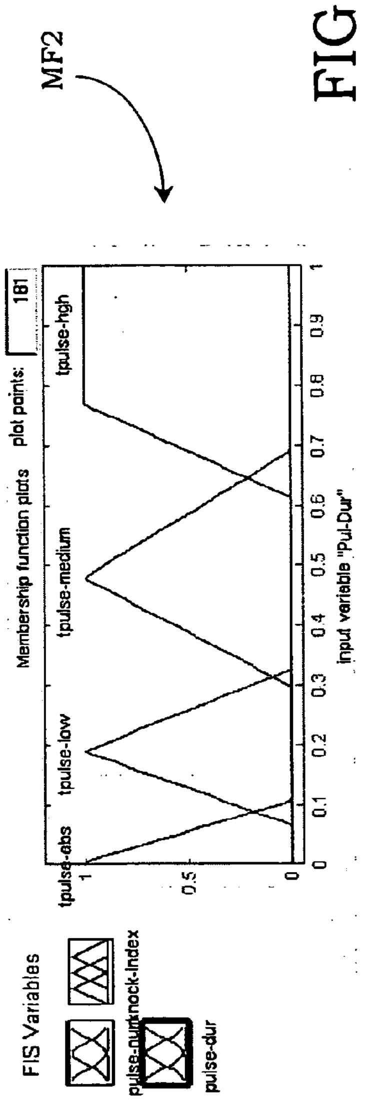


FIG. 7B

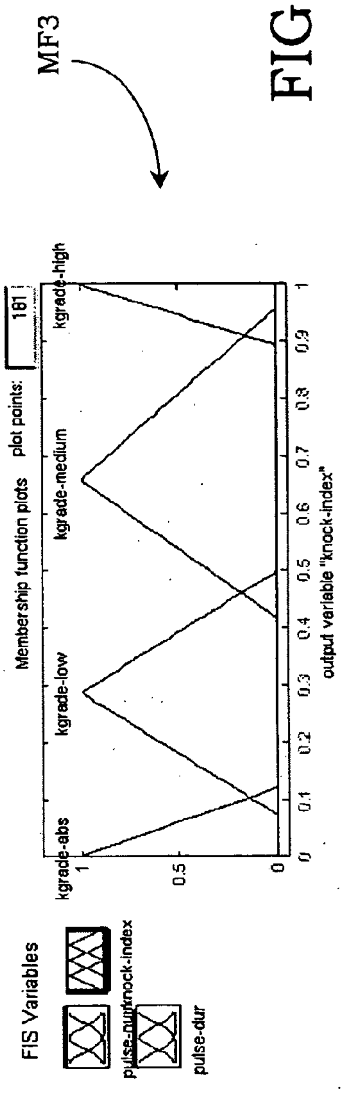


FIG. 7C

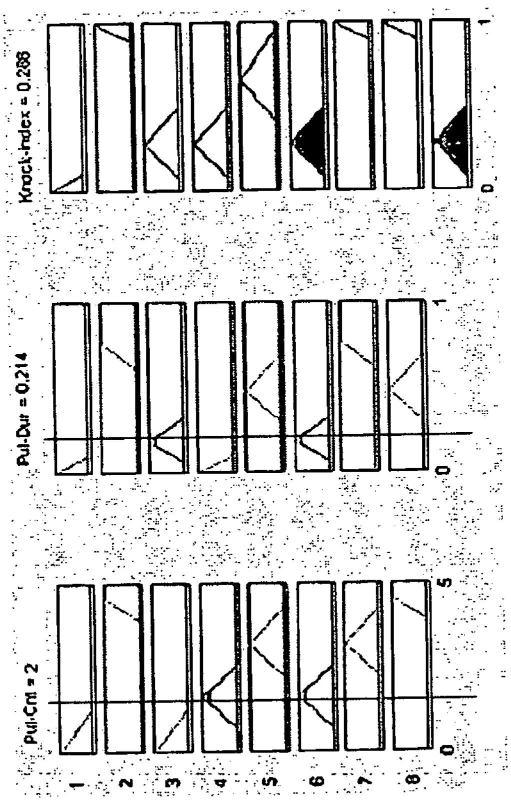

Pul-Cnt = 2
Pul-Dur = 0.214
Knock-index = 0.288

FIG. 7D

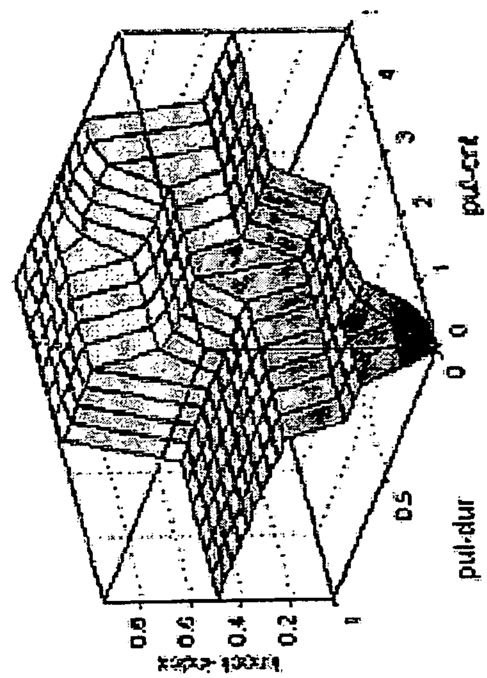

knock-index
pul-dur
pul-cnt

FIG. 7E

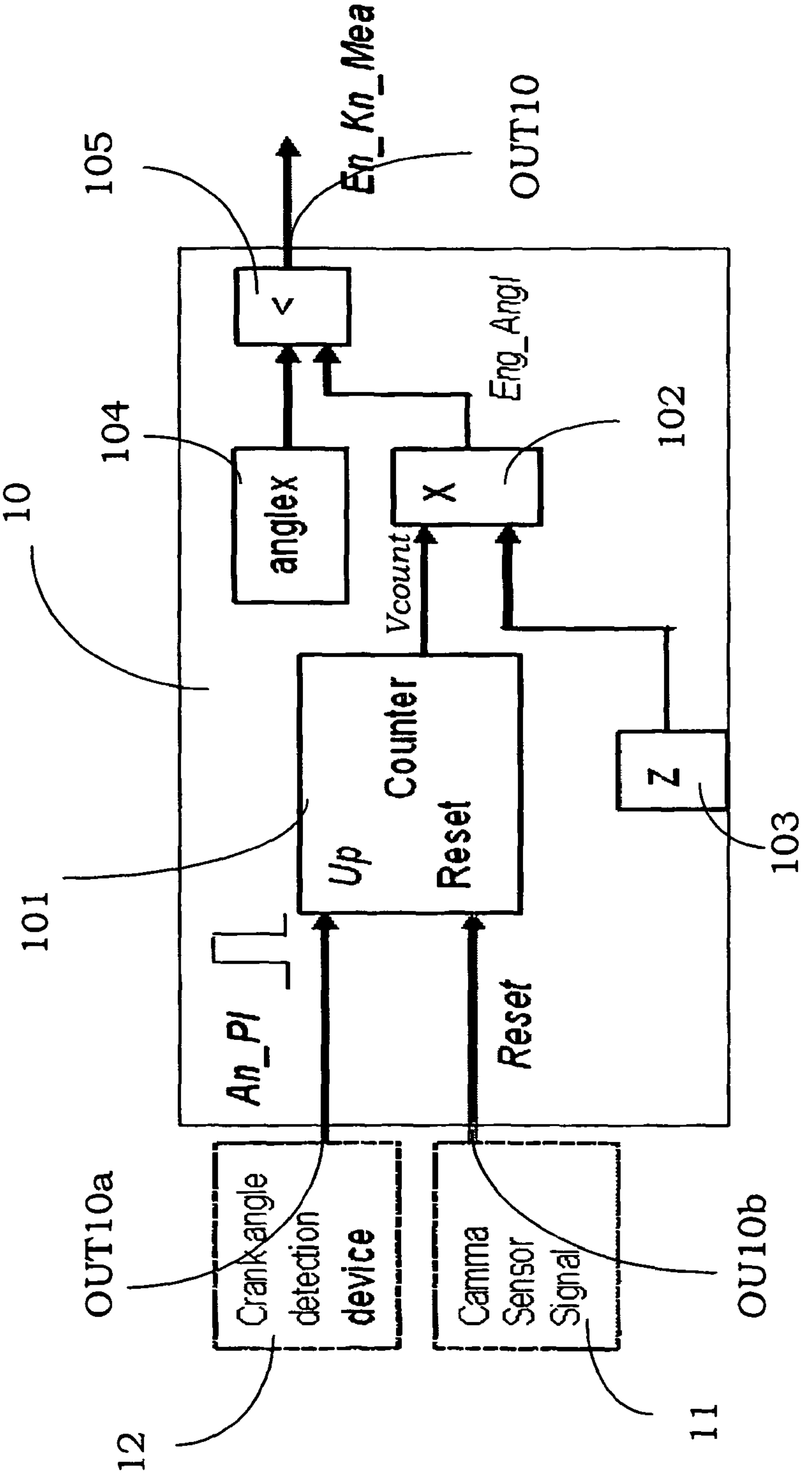

En_Kn_Mea
105
OUT10
10
104
anglex
<
Eng_Angl
102
X
Vcount
101
Up
Counter
Reset
Z
103
An_PI
Reset
OUT10a
Crank angle
detection
device
Camma
Sensor
Signal
OU10b
12
11

FIG. 8

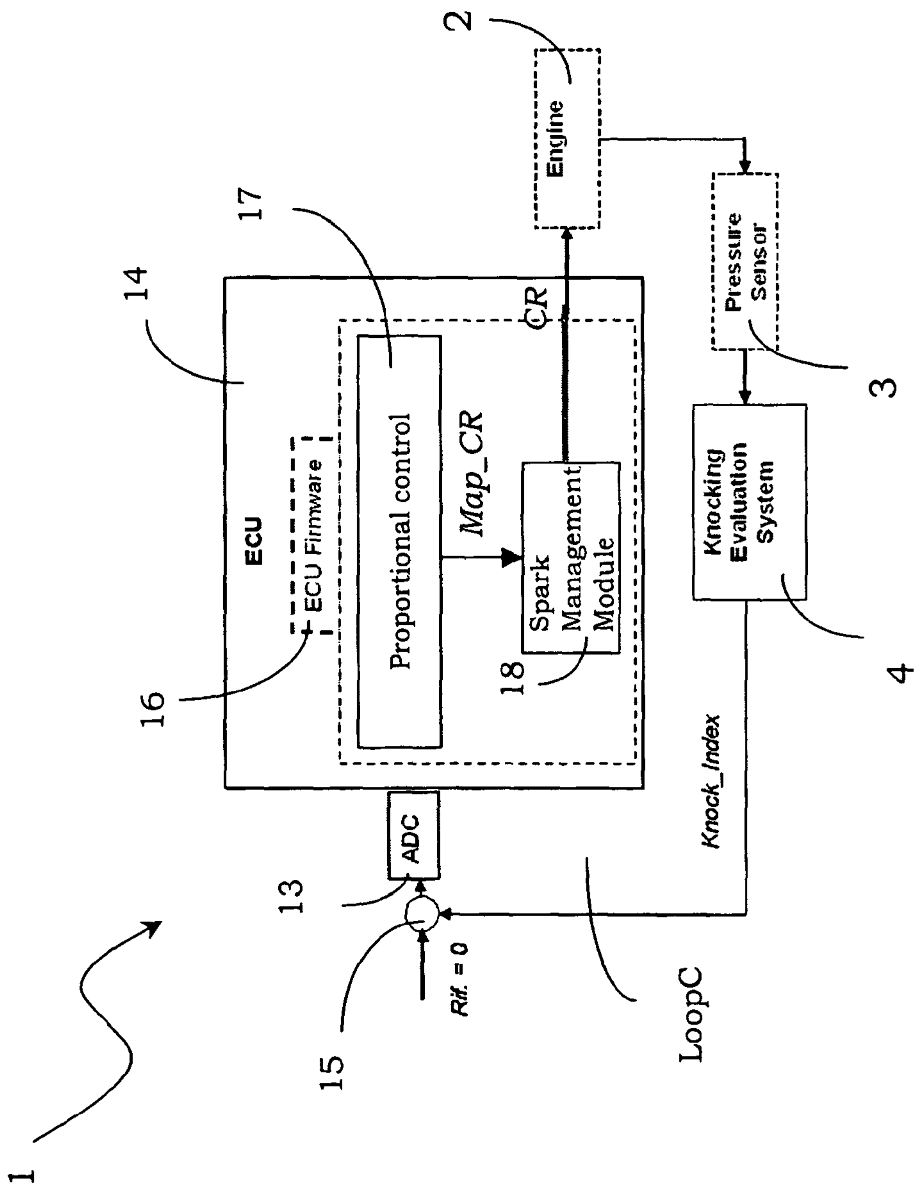

ECU
ECU Firmware
Proportional control
Map_CR
Spark Management Module
CR
Engine
Pressure Sensor
Knocking Evaluation System
Knock_Index
ADC
Rif. = 0
LoopC
1
2
3
4
13
14
15
16
17
18

FIG. 9

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 6561163 B1 **[0020]**

Non-patent literature cited in the description

- **F. Millo ; C.V. Ferraro.** Knock in S.I. Engines: A comparison between different techniques for detection and control. *SAE paper 982477,* 1998 **[0018]**