(12) UK Patent Application (19) GB (11) 2 207 774 (13) A

(43) Application published 8 Feb 1989

(21) Application No 8813103

(22) Date of filing 3 Jun 1988

(30) Priority data
(31) 62/141924 (32) 5 Jun 1987 (33) JP

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(51) INT CL[4]
F02D 41/22 41/26

(52) Domestic classification (Edition J):
G3N 288A 374 402B 402X 404 GK2B
U1S 1991 G3N

(56) Documents cited
None

(58) Field of search
G3N
Selected US specifications from IPC sub-class F02D

# (54) System for detecting abnormal operation of a combustion engine

(57) An adaptive control system has a table (Fig.4, not shown), for storing adaptive control coefficients. An abnormality detecting system has a section for determining the number of times Nx the coefficients are updated (105), and for determining the number of divisions Ny in which the coefficient is out of a predetermined limit range ALP (106). The section produces an abnormality signal (108) when a coefficient exceeding the limit range in a particular division is updated more than a predetermined number of times Nz (107). In response to the abnormality signal, all of the coefficients in the table are set to a standard value (110).

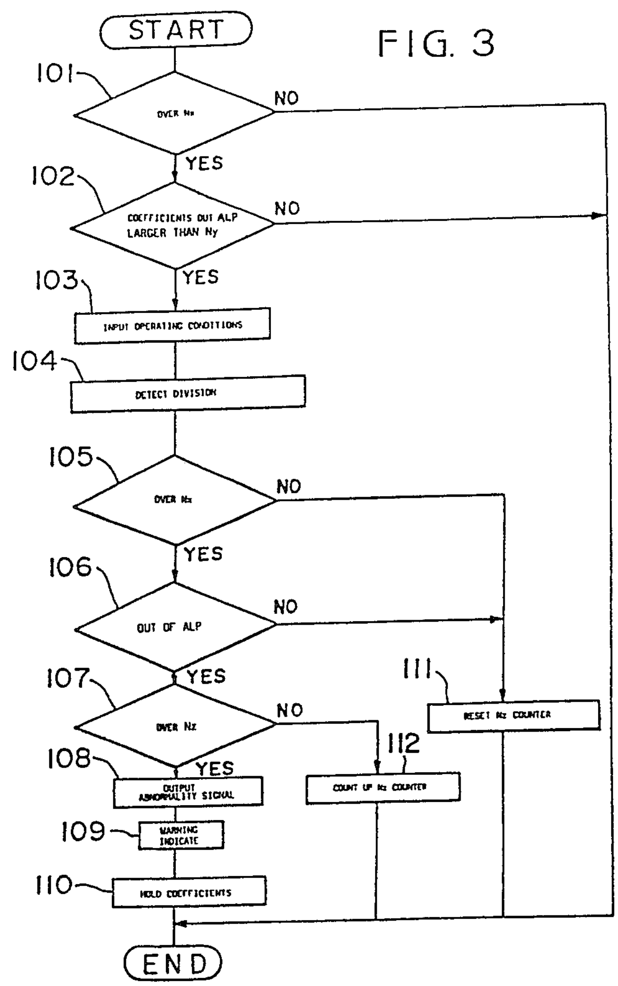


FIG. 3

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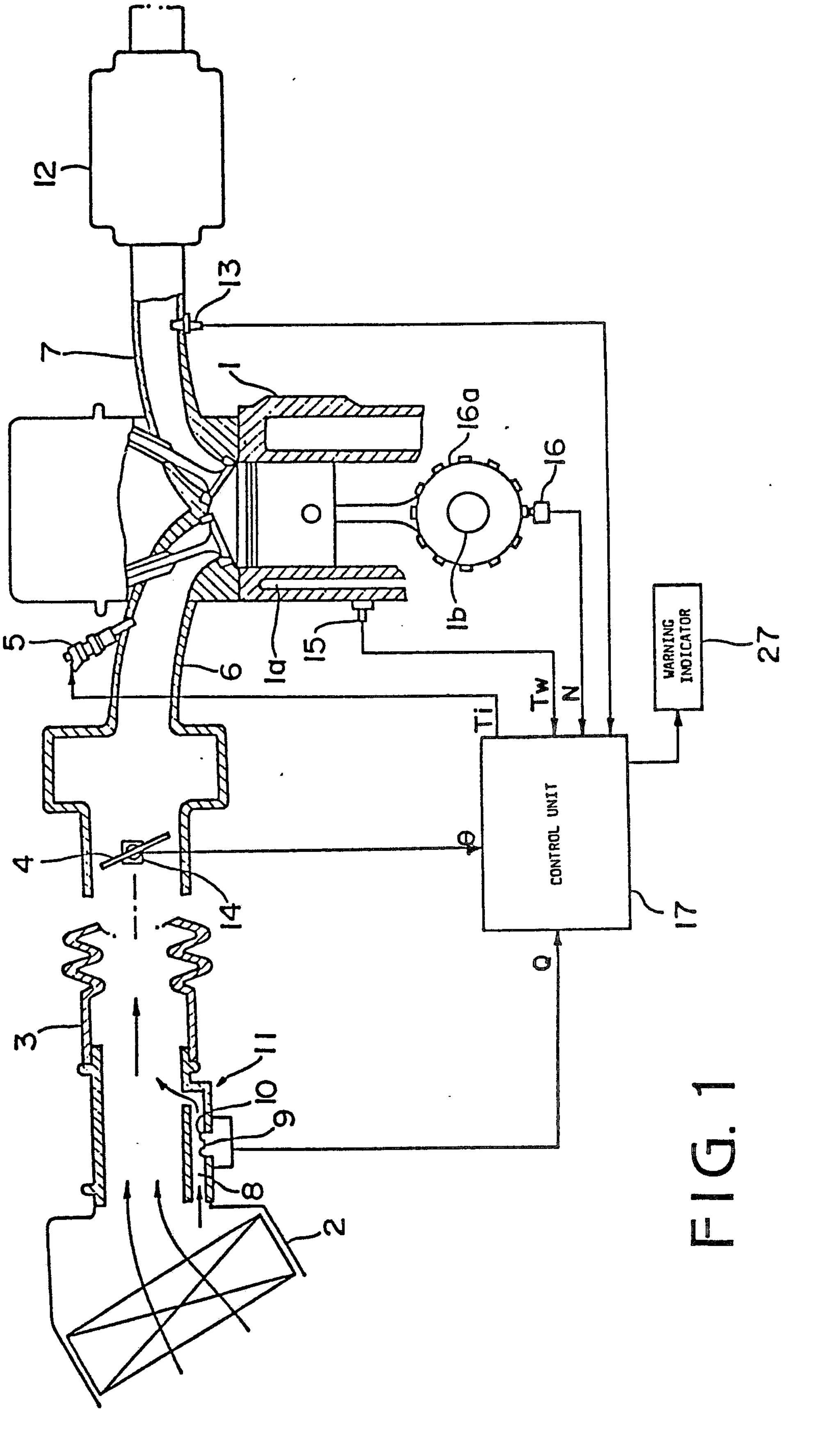

CONTROL UNIT
WARNING INDICATOR
Ti
Tw
N
θ
Q
1
1a
1b
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
16a
17
27

FIG. 1

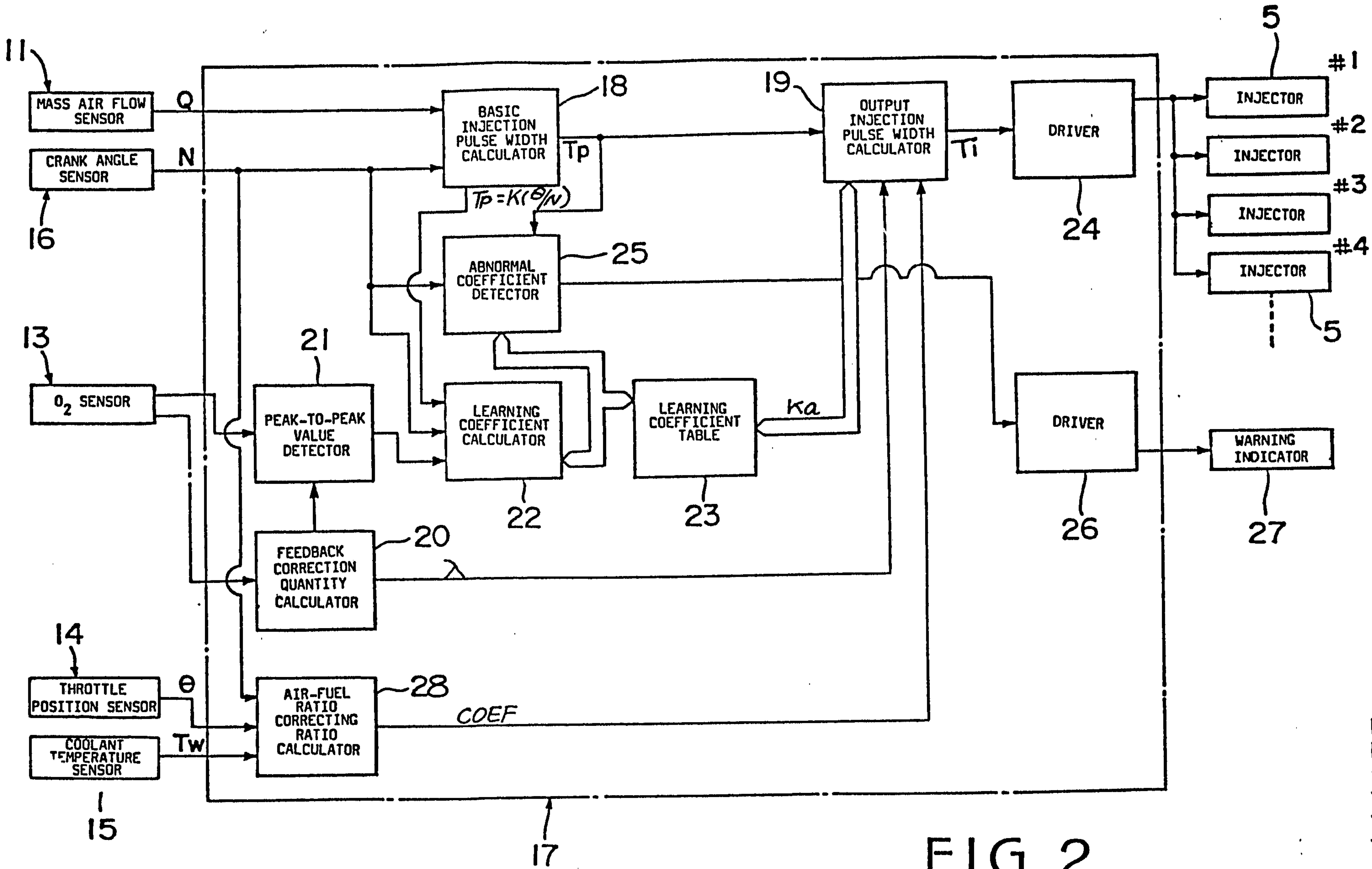
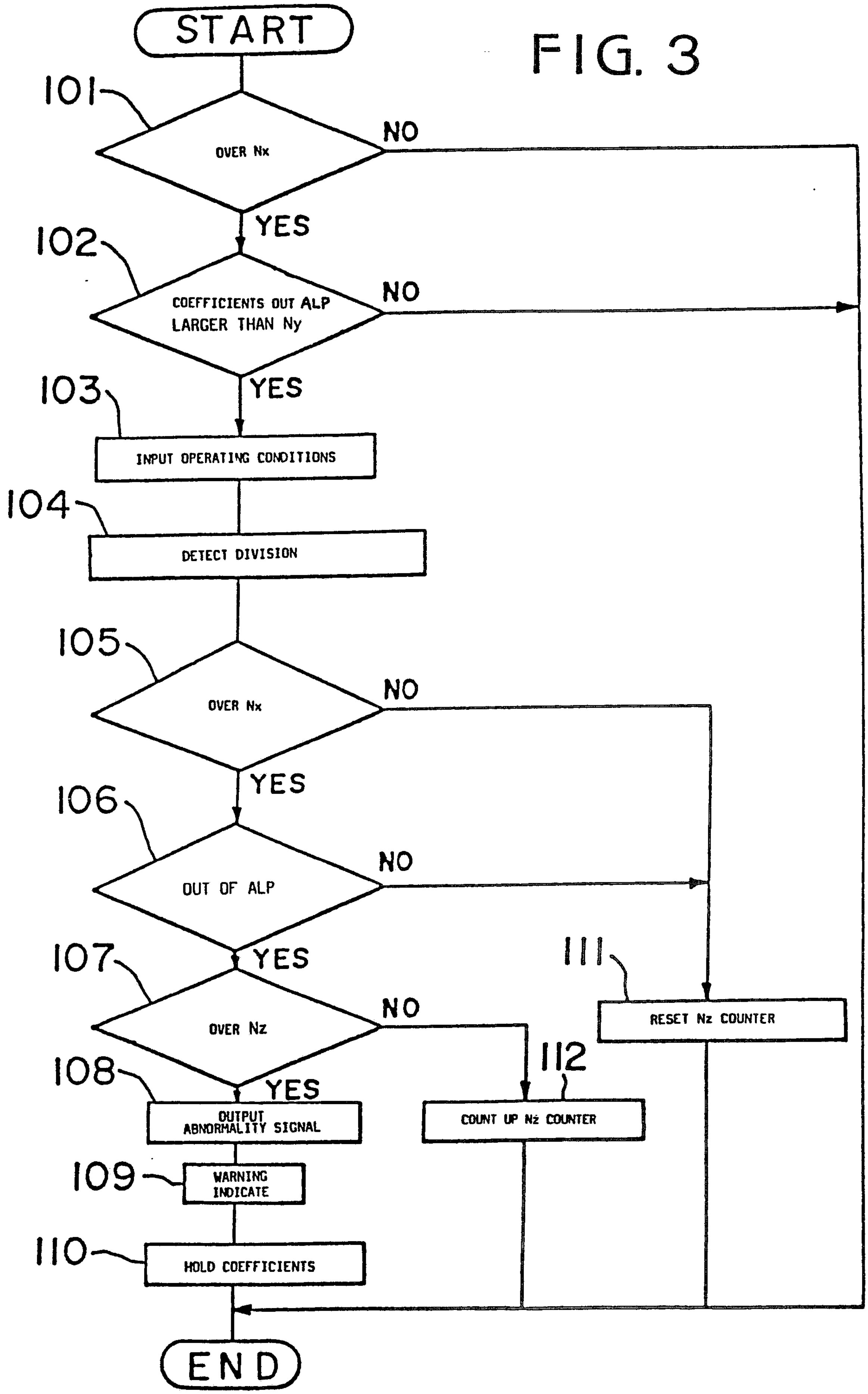

MASS AIR FLOW SENSOR
11
Q
CRANK ANGLE SENSOR
16
N
$O_2$ SENSOR
13
THROTTLE POSITION SENSOR
14
θ
COOLANT TEMPERATURE SENSOR
15
Tw
BASIC INJECTION PULSE WIDTH CALCULATOR
18
Tp
Tp=K(Q/N)
ABNORMAL COEFFICIENT DETECTOR
25
PEAK-TO-PEAK VALUE DETECTOR
21
LEARNING COEFFICIENT CALCULATOR
22
LEARNING COEFFICIENT TABLE
23
Ka
FEEDBACK CORRECTION QUANTITY CALCULATOR
20
λ
AIR-FUEL RATIO CORRECTING RATIO CALCULATOR
28
COEF
OUTPUT INJECTION PULSE WIDTH CALCULATOR
19
Ti
DRIVER
24
DRIVER
26
INJECTOR
INJECTOR
INJECTOR
INJECTOR
#1
#2
#3
#4
5
5
WARNING INDICATOR
27
17

FIG. 2

FIG. 3


START
101
OVER Nx
NO
YES
102
COEFFICIENTS OUT ALP LARGER THAN Ny
NO
YES
103
INPUT OPERATING CONDITIONS
104
DETECT DIVISION
105
OVER Nx
NO
YES
106
OUT OF ALP
NO
YES
107
OVER Nz
NO
YES
111
RESET Nz COUNTER
112
COUNT UP Nz COUNTER
108
OUTPUT ABNORMALITY SIGNAL
109
WARNING INDICATE
110
HOLD COEFFICIENTS
END

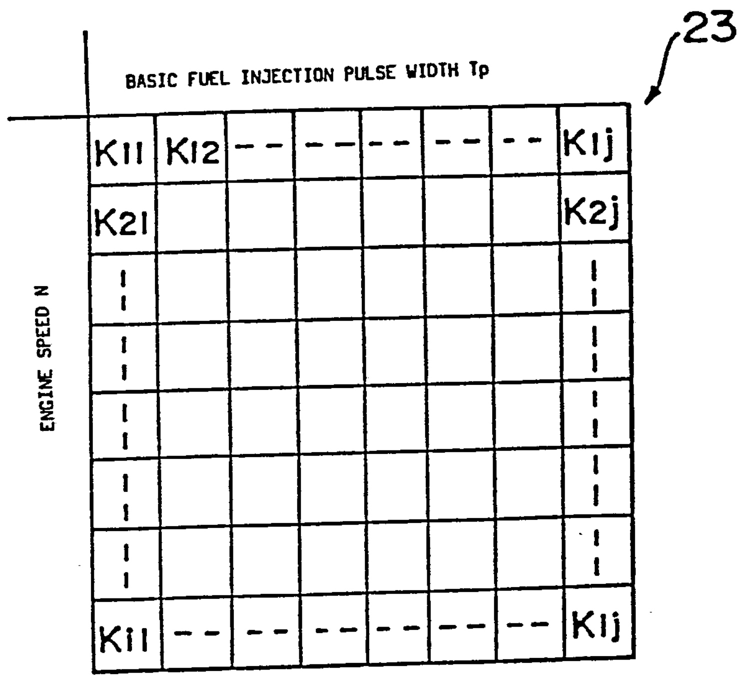

23
BASIC FUEL INJECTION PULSE WIDTH Tp
ENGINE SPEED N
K11
K12
K1j
K21
K2j
Ki1
Kij

FIG. 4

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"System for Detecting Abnormal Operation of a Combustion Engine"

The present invention relates to a system for detecting abnormal operation of an automotive engine having an adaptive mixture control system, and more particularly to a system which detects an abnormality caused by deviations of the learning coefficients.

In one type of electronic fuel-injection control, the amount of fuel to be injected into the engine is determined in accordance with engine operating variables such as mass air flow, engine speed and engine load. The amount of fuel is determined by an injection pulse width. The basic injection pulse width $T_P$ is obtained from the following formula.

$$T_P = K \times Q/N$$

where Q is mass air flow, N is engine speed, and K is a constant.

The desired injection pulse width $T_i$ is obtained by correcting the basic injection pulse $T_P$ with engine operating variables. In an adaptive control system, the desired injection pulse width is calculated from the following equation:

$$T_i = T_P \times (COEF) \times \alpha \times K_a$$

where COEF is a coefficient obtained by adding various correction or compensation coefficients such as coefficients of coolant temperature, throttle position, engine load, etc., $\alpha$ is a feedback correcting coefficient of an $O_2$-sensor provided in an exhaust passage, and $K_a$ is a correction derived by the adaptive process. The various coefficients such as coolant temperature coefficient and engine load, are obtained by looking up tables in accordance with sensor information. The value of the learning coefficient $K_a$ is read from a table in RAM in accordance with engine load.

In order to obtain information on engine operation, various sensors are provided in the engine. Those sensors inherently deteriorate in output characteristics with time. Accordingly, if the air-fuel ratio deviates considerably from a desired air-fuel ratio because of the deterioration of a sensor, a warning of abnormal operation of the engine should be given to the driver.

Japanese Patent Laid Open 55-112695 discloses a diagnostic system in which the number of occurrences of an abnormal signal from a sensor is counted, and when the number exceeds a predetermined number, a warning is given.

However, in an engine, the output of the sensor may vary widely in accordance with engine operating conditions, so such a system will not work.

In an adaptive control system, all the learning coefficients are arranged in the form of a lookup table comprising a plurality of rows and columns in accordance with the engine load. Coefficients in divisions at intersections of rows and columns are initially set to the same value, that is the number "1", since the fuel supply system is designed so that it will ideally provide the correct amount of fuel without the coefficient $K_a$. However, automobiles cannot be manufactured with complete consistency. Accordingly, the coefficients $K_a$ are adaptively updated in each automobile, when it is actually used. If an abnormality occurs in the engine, the values of the coefficients are considerably altered by the updating. When a coefficient in a division of the table exceeds a predetermined limit range, the division is registered as being abnormal. When the number of registered abnormal divisions exceeds a predetermined number, it is determined that the air-fuel ratio control system operation is abnormal. The abnormality is signalled and the value of each coefficient is set to one as a fail-safe value.

There are common driving conditions in which the motor vehicle is commonly driven and common divisions are included in the driving condition range. These divisions are more frequently updated and liable to be registered as abnormal divisions earlier than other divisions. If the predetermined number of abnormal divisions which signals the detection of an abnormality is made larger than the number of common divisions, the coefficients in other divisions are rarely updated. As a result, the detection of abnormality deteriorates. On the other hand, if the number of the abnormal divisions is made smaller than the number of common divisions, the system tends to register abnormalities as a result of small deviations.

The present invention seeks to provide a system which more accurately detects abnormal operation of an engine by detecting abnormal coefficients in the common divisions of the coefficient table.

According to the present invention, there is now provided a system for detecting abnormal operation of a combustion engine having an adaptive air-fuel ratio control system of the kind provided with a table having a plurality of divisions each of which stores a control coefficient, detector means for detecting the operating condition of the engine and producing a feedback signal dependent on the condition, a calculator for producing a basic fuel injection pulse width in accordance with engine operating conditions, corrector means for correcting the basic fuel injection pulse width using a coefficient obtained from the table in conjunction with the feedback signal, updating means for updating coefficients in the table with values relative to the feedback signal,

the abnormal operation detection means comprising:

first means for counting the number of updating operations and for producing a first signal when the number of updating operations is greater than a predetermined first number;

second means responsive to the first signal for determining the number of divisions in which each coefficient is out of a predetermined limit range and for producing a second signal if the number is greater than a predetermined second number;

third means responsive to the second signal for determining whether a coefficient exceeding the limit range in a particular division has been updated more than a predetermined number of times, and for producing a corresponding abnormality signal; and

means responsive to the abnormality signal for setting all coefficients in the table to a standard value.

In a preferred embodiment of the invention, the particular division is determined in accordance with engine operating conditions, and the third means produces the abnormality signal when the coefficient is successively updated more than the predetermined number of times. The system further comprises a warning indicator responsive to the abnormality signal for indicating the abnormality.

One embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a schematic illustration showing a fuel injection system for an automotive engine according to the present invention;

Figure 2 is a block diagram of the system of the present invention;

Figure 3 is a flow chart showing the operation of the system; and

Fig. 4 is a lookup table storing learning coefficients.

Referring to Fig. 1, an internal combustion engine 1 for a vehicle is supplied with air, passing through an air cleaner 2, an intake pipe 3, a throttle valve 4, and an intake manifold 6. A mass air flow meter 11 is provided in a bypass 8 at the downstream of the air cleaner 2. The air flow meter 11 comprises a hot wire 10 for detecting the quantity of intake air in the intake pipe 3 and a temperature compensator plug 9. An output signal of the air flow meter 11 is supplied to an electronic control unit 17 comprising a microcomputer. An $O_2$ sensor 13 and a catalytic converter 12 are provided in an exhaust passage 7. A throttle position sensor 14 is provided adjacent the throttle valve 4 for producing a throttle position signal θ. A coolant temperature sensor 15 is provided on a water jacket 1a of the engine 1 for producing a temperature signal Tw. A crank angle sensor 16 is mounted adjacent a disk 16a secured to a crankshaft 1b of the engine 1 for detecting engine speed. Output signals from these sensors 13, 14, 15 and 16 are supplied to the control unit 17. The control unit 17 determines a pulse width for fuel injected from injectors 5.

Referring to Fig. 2, the control unit 17 has a basic injection pulse width calculator 18 which is supplied with an air flow signal Q representing intake air quantity at the air flow meter 11 and with an engine speed signal N from the crank angle sensor 16 for calculating a basic injection pulse width Tp.

The output signal Tp is applied to an output injection pulse width calculator 19, where an output injection pulse width Ti is calculated by correcting the basic injection pulse width Tp in accordance with engine operating conditions as described hereinafter. A feedback correction quantity calculator 20 is provided for calculating a feedback correcting value $\lambda$ in accordance with a feedback signal from the $O_2$ sensor 13.

An air-fuel ratio correcting coefficient calculator 28 produces a correcting coefficient in accordance with the engine speed signal N, throttle position signal $\theta$ and temperature signal Tw. A peak-to-peak value detector 21 is supplied with an output signal of the $O_2$ sensor and with the feedback correcting value from the calculator 20, and produces a peak-to-peak value signal. The control unit 17 further comprises an adaptive coefficient calculator 22 and an adaptive coefficient table 23 connected to the calculators 19 and 22 by bus lines. As shown in Figure 4, the coefficient table 23 is a three-dimensional table having a plurality of divisions (8 x 8 = 64), each storing a coefficient Ka. The division is divided in accordance with engine speed N and basic injection pulse width Tp which represent the engine load.

The adaptive coefficient calculator 22 calculates an arithmetical average LMD of maximum and minimum values in the output of the peak-to-peak value detector 21 and calculates a new adaptive coefficient Kn from the following equation:

$$Kn = Ka + M \cdot \Delta LMD$$

where $\Delta$ LMD is a difference of the LMD from a desired value in feedback control, and M is a constant.

Further, the calculator 22 detects a corresponding division in accordance with engine speed N and basic injection pulse width Tp and updates the coefficient Ka in the detected division with the new coefficient Kn, when a steady state of engine operation continues during a predetermined cycles of the output signal of the $O_2$ sensor 13.

The output injection pulse width calculator 19 calculates the output injection pulse width Ti based on the outputs of the calculators 18, 20 and 28 and the updated coefficient derived from the table 23. The pulse width Ti is supplied to injectors through a driver 24.

In this embodiment of the present invention, an abnormal coefficient detector 25 connected to the table 23 by a bus line is provided for detecting corresponding divisions in accordance with engine speed N and basic injection pulse width Tp, and for producing an abnormality signal as described hereinafter. The abnormality signal is fed to a warning indicator 27 through a driver 26.

The abnormality detecting operation will be described hereinafter with reference to Figure 3. There is provided a predetermined number Nx for the total number of updating times, a predetermined limit range ALP for the value of adaptive coefficients, a predetermined number Ny of updated divisions and a predetermined number of times Nz for the sum of successive updating times in one division. The number of updating times is incremented by a counter for each updating of a coefficient in the table.

At a step 101, it is determined whether the number of updating times exceeds the pretermined number Nx. When the number of updating times is smaller than the number Nx, the program exits the routine. If the updating exceeds the set number Nx, even if at only one division of the table, the program proceeds to a step 102. At step 102 it is determined whether the number of divisions, in which the coefficients exceed the limit range ALP, exceeds the predetermined number of divisions Ny. The range ALP is, for example, ± 20% of the initial value of one (that is K = 0.8 ~ 1.2). If the number of divisions is larger than the number Ny, the program goes to a step 103 where the current engine operating condition is detected from engine speed N and basic fuel injection pulse width Tp. At step 104, a division in the table which corresponds to the detected engine operating condition is detected. At step 105, it is determined whether the number of updating times at the detected division exceeds the set number Nx. If the number is smaller than the set number Nx, an Nz counter for the number Nz is reset at a step 111. When the number is larger than the number Nx, it is determined whether the value of the coefficient in the detected division is out of the limit range ———

ALP at a step 106. If the answer is YES, it is determined whether the coefficient in the detected division has been successively updated a number of times more than the predetermined number of times Nz (Nz>2). If the number of updating times is smaller than Nz, the Nz counter is incremented by one at a step 112. If the coefficient is successively updated more than Nz times, the abnormality signal is produced from the abnormal coefficient detector 25 at a step 108. Further, at a step 109, the abnormality is indicated by the warning indicator 27. At the same time, at a step 110, the abnormal coefficient detector 25 supplies a signal to the learning coefficient calculator 22 which operates to set all of coefficients in the table to the standard value one (Ka = 1).

In accordance with the preferred embodiment of the present invention, since the number of updating times as a whole is determined, after which a coefficient in a particular division is detected to determine the abnormality, the detection is exactly performed.

While the presently preferred embodiment of the present invention has been shown and described, it is to be understood that this disclosure is for the purpose of illustration and that various changes and modifications may be made within the scope of the appended claims.

**CLAIMS**

1. A system for detecting abnormal operation of a combustion engine having an adaptive air-fuel ratio control system of the kind provided with a table having a plurality of divisions each of which stores a control coefficient, detector means for detecting the operating condition of the engine and producing a feedback signal dependent on the condition, a calculator for producing a basic fuel injection pulse width in accordance with engine operating conditions, corrector means for correcting the basic fuel injection pulse width using a coefficient obtained from the table in conjunction with the feedback signal, updating means for updating coefficients in the table with values relative to the feedback signal,

the abnormal operation detection means comprising:

first means for counting the number of updating operations and for producing a first signal when the number of updating operations is greater than a predetermined first number;

second means responsive to the first signal for determining the number of divisions in which each coefficient is out of a predetermined limit range and for producing a second signal if the number is greater than a predetermined second number;

third means responsive to the second signal for determining whether a coefficient exceeding the limit range in a particular division has been updated more than a predetermined number of times, and for producing a corresponding abnormality signal; and

means responsive to the abnormality signal for setting all coefficients in the table to a standard value.

2. A system according to claim 1 wherein the particular division is determined in accordance with current engine operating conditions.

3. A system according to claim 1 wherein the third means produces the abnormality signal when the coefficient is successively updated more than the predetermined number of times.

4. A system according to claim 1 further comprising a warning indicator responsive to the abnormality signal.

5. A system substantially as herein described with reference to the accompanying drawings.

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