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

(11) Publication number: **0 625 635 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **94107599.6**

(51) Int. Cl.^{5}: **F02D 41/26**

(22) Date of filing: **16.05.94**

(30) Priority: **17.05.93 IT BO930213**

(43) Date of publication of application: **23.11.94 Bulletin 94/47**

(84) Designated Contracting States: **DE ES FR GB**

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(54) Electronic system for computing injection time.

(57) An electronic system comprising first computing means (42, 140) supplied with a number of information signals (X1,...XN,Qt) measured in the engine and generating an injection time (T) computed on the basis of a characteristic (T = F(X1,...XN,Qt)) depending on the aforementioned signals; means (50, 56, 150, 180) for processing an expansion of the characteristic, which expansion is computed, as a function of a previously computed injection time and of a first value (Qt) of the significant information signal used for computing the injection time, about the first value (Qt) of the significant signal; and second computing means (56, 180) supplied with the expansion of the characteristic and with a second value (Qt + 1) of the significant signal, and generating an approximate injection time (Tn) computed as a function of the expansion of the characteristic and of the second value of the significant signal.

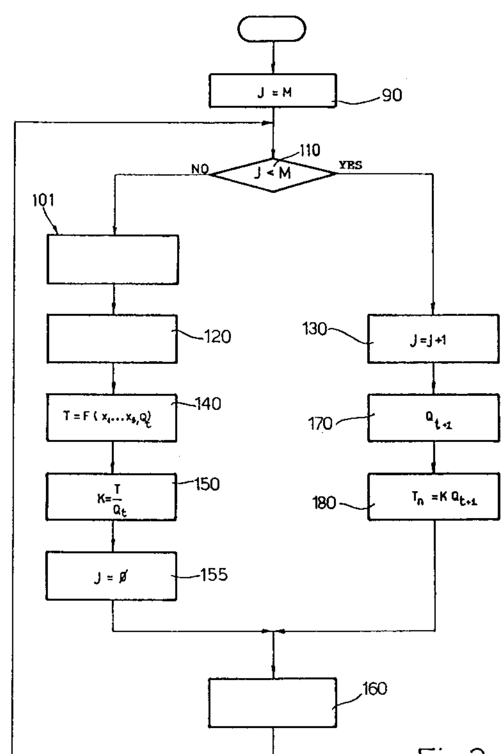

Fig.2

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The present invention relates to an electronic system for computing the fuel injection time of an internal combustion engine.

Electronic systems for computing injection time are known wherein an electronic microprocessor system is supplied with a number of signals relative to parameters typical of an internal combustion engine (e.g. air intake and/or pressure, position of the throttle valve in the air intake manifold, air intake temperature, engine cooling water temperature, battery voltage, etc..), and processes the signals to generate an output signal controlling the fuel injection system.

Known computing systems take some time (normally in the order of a few tens of milliseconds) to process all the incoming information signals, so that, during transient operating states of the engine (e.g. sharp acceleration), they fail to respond promptly to rapid variations in the input signals, thus resulting in an inadequate output control signal.

Processing of the information signals may be accelerated using faster microprocessors, but only at the expense of increasing the total cost of the computing system.

It is an object of the present invention to provide a low-cost electronic computing system designed to enable high-speed processing.

According to the present invention, there is provided an electronic system for computing the fuel injection time of an internal combustion engine, characterized by the fact that it comprises:

first computing means supplied with a number of information signals (X1,...XN,Qt) measured in said engine;

said first computing means generating at the output an injection time (T) computed on the basis of a characteristic (T = F(X1,... XN,Qt)) depending on said information signals;

means for processing an expansion of said characteristic (T = F(X1,...XN,Qt)), which expansion is computed, as a function of a previously computed injection time (T) and of a first value (Qt) of at least one significant information signal used for computing said injection time, about said first value (Qt) of said significant signal;

second computing means supplied with said expansion of said characteristic (T = F(X1,...XN,Qt)) and with a second value (Qt + 1) of said significant signal;

said second computing means generating at the output an approximate injection time (Tn) computed as a function of the expansion of said characteristic (T = F(X1,...XN,Qt)) and of said second value (Qt + 1) of said significant signal.

A preferred, non-limiting embodiment of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows a circuit block diagram of an electronic injection system in accordance with the teachings of the present invention;

Figure 2 shows a logic block diagram of the operations performed by the Figure 1 system.

Number 1 in Figure 1 indicates an electronic injection time computing system in which an electronic control system 3 is connected to the injection control device 5 of a fuel injection system 7 (shown schematically) of an internal combustion engine, in particular a vehicle petrol engine (not shown). Electronic control system 3 comprises an analog-digital interface 13; a central microprocessor unit 15; and an actuating interface 17 output-connected by a number of control lines 20 to injection control device 5. Analog-digital interface 13 presents a number of inputs 22a-22n connected by respective lines 24a-24n to sensors 26a-26n in the engine. More specifically, sensors 26a-26n comprise, for example, a sensor for detecting air intake temperature; a sensor for detecting the water temperature of the engine cooling system (not shown); a sensor for detecting the stoichiometric composition of the exhaust gas; two sensors for detecting the position of mechanical members (not shown) on the engine (engine speed and stroke); a sensor for detecting the voltage of the vehicle battery (not shown); a sensor for detecting the position of the throttle valve (not shown) in the intake manifold; an intake air supply sensor; a sensor for detecting the absolute pressure in the intake manifold; and a sensor for detecting the pressure inside the combustion chamber.

Analog-digital interface 13 presents an input 28 connected by a respective line 29 to a sensor 30 for generating an output signal correlated to an engine parameter which, as explained later on, may be said to be highly significant, and indeed the most significant of the parameters detected by sensors 26a-26n, for injection time computing purposes. Sensor 30 may conveniently be formed by the sensor for detecting air supply to the engine, the position of the throttle valve in the intake manifold, intake air pressure, the pressure inside the combustion chamber, or any other parameter of potential interest. Interface 13 also presents a number of outputs 32a-32n at which are present the respective digital values X1,...XN of the signals produced by sensors 26a-26n; and an output 36 at which is present the digital value Qt of the signal produced by sensor 30. Outputs 32a-32n are connected to processing unit 15 by respective lines 34a-34n, and output 36 by line 37 to the input 40e of a selecting device 40.

Processing unit 15 comprises a first computing circuit 42 having a first input 43 connected by line 45 to a first output 40a of selecting device 40, and further inputs 42a-42n connected respectively to lines 34a-34n. Circuit 42 also presents an output 47 connected by line 48 to a first input of actuating interface 17, and comprises a number of algebraic computing circuits (not shown) for producing a characteristic T = F(X1,...XN,Qt) which, for the set of values X1,...XN,Qt of the signals supplied to the input of circuit 42, gives an output variable T representing an injection time. Unit 15 also comprises a computing circuit 50 having two inputs 51, 52 connected to lines 45, 48, and an output 54 connected to a second computing circuit 56.

At output 54, computing circuit 50 generates a signal which is the quotient of the signals at inputs 52 and 51. The second computing circuit 56 presents an input 58 connected to a second output 40b of device 40, and an output 60 connected by line 62 to a second input of interface 17, and generates an output signal which is the product of the signal at input 58 and the signal on line 54.

Operation of system 1 will now be described with reference to the Figure 2 block diagram showing the sequence of operations performed by electronic control system 3.

To begin with, in block 90, the content J of a counter (not shown) is set to a value M (where M is a whole number) according to logic operation:

J = M

Block 90 then goes on to block 110 controlling selecting device 40. More specifically, in the event the content of counter J equals M, input 40e of device 40 is connected to output 40a, and block 110 goes on to block 101. Conversely, input 40e of device 40 is connected to output 40b, and block 110 goes on to block 130. Block 101 provides, by means of interface 13, for analog-digital conversion of the signals generated by sensors 26a-26n and sensor 30, and for storing the values X1,...XN and Qt of the signals in memory 13a (Figure 1). Block 101 then goes on to block 120, which provides for reading in memory 13a the value Qt of the signal generated by sensor 30. Block 120 is followed by block 140 which provides for computing an injection time T on the basis of values X1,...XN and Qt of all the signals supplied to circuit 42. More specifically, time T is computed (in known manner) by means of characteristic T = F(X1,...XN,Qt) of circuit 42.

Block 140 is followed by block 150 which provides for generating a coefficient K; which coefficient K is generated by circuit 50 on the basis of the signals supplied to inputs 43 and 52, and as the ratio between injection time T computed by circuit 42 and the value Qt read by block 120, according to the equation:

K = T/Qt

Block 150 is followed by block 155 which resets the content of counter J, and then goes on to block 160 where the injection time T computed in block 140 is transferred to actuating interface 17, which provides for opening the injectors (not shown) according to the computed value T. At this point, block 160 goes back to block 110. Block 130 increases the content of the counter by one unit according to operation J = J + 1, and is followed by block 170 in which is detected a sensor 30 signal value Qt + 1 subsequent to value Qt formerly used for computing injection time T. Block 170 provides, by means of interface 13, for analog-digital conversion of the signal generated by sensor 30, and for storing the value Qt + 1 of the signal in memory 13a.

Block 170 is followed by block 180 where the value Qt + 1 detected in block 170 is supplied by means of device 40 to circuit 56 which computes an approximate injection time Tn by multiplying value Qt + 1 by the coefficient K computed in block 150, according to the equation:

Tn = K*Qt + 1

The approximate injection time supplied by circuit 56 is a linearization of the characteristic T = F(X1,...XN,Qt) about value Qt assumed by the variable at the last complete recomputation by block 140, taking as a constant the contribution to the variation produced by the other variables X1,...XN. This is effected by means of an expansion (to the first term) of characteristic T = F(X1,...XN,Qt) according to the following type of equation:

Tn = T° + d(T)/d(Qt)*(Qt + 1 - Qt)

If sensor 30 detects the quantity of air in the intake manifold, the derivative is approximated with the incremental ratio, so that, assuming T° = 0:

Tn = T/Qt*Qt + 1

i.e. Tn = K*Qt + 1, which is precisely the expression implemented by circuits 50 and 56 for approximating the characteristic.

Block 180 then goes on to block 160 where, via line 62, the value Tn computed in block 180 is transferred to actuating interface 17 which provides for opening the injectors (not shown) according to the computed value Tn.

The calculation in block 140, therefore, is effected relatively slowly by means of characteristic T = F(X1,...XN, Qt), whereas that of circuit 56 is extremely fast by virtue of being reduced to a single algebraic multiplication of coefficient K and value Qt + 1 of the signal generated by sensor 30.

As such, injection time is initially computed exactly (and fairly slowly) in block 140 by means of circuit 42, and is subsequently approximated (at a faster rate) M consecutive times by circuit 56.

For a given microprocessor, therefore, the overall speed of system 1 is greater than that of known systems.

System 1 is therefore also capable of "following" even rapid transient operating states of the engine; all of which advantages are achieved with no need for more complex microprocessors, or for increasing the capacity of the memories interacting with the microprocessor.

System 1 is also easily implementable, even on not particularly high-capacity microprocessors, by virtue of employing straightforward algebraic operations (division and multiplication).

To those skilled in the art it will be clear that changes may be made to the system as described and illustrated herein without, however, departing from the scope of the present invention.

In particular, the parameter detected by sensor 30 and considered significant for injection time computation purposes may be other than those described by way of example, depending on the type of parameters detected by the sensors as a whole, and the type of performance demanded of the engine. Moreover, as shown by the dotted line in Figure 1, the number of sensors may be other than as indicated. Finally, instead of a single parameter, a subset of engine parameters may be employed as significant parameters for computing approximate injection time.

Claims

1. An electronic system for computing the fuel injection time of an internal combustion engine, characterized by the fact that it comprises:

   first computing means (42, 140) supplied with a number of information signals (X1,...XN,Qt) measured in said engine;

   said first computing means (42, 140) generating at the output an injection time (T) computed on the basis of a characteristic (T = F(X1,... XN,Qt)) depending on said information signals;

   means (50, 56, 150, 180) for processing an expansion of said characteristic (T = F(X1,...XN,Qt)), which expansion is computed, as a function of a previously computed injection time (T) and of a first value (Qt) of at least one significant information signal used for computing said injection time, about said first value (Qt) of said significant signal;

   second computing means (56, 180) supplied with said expansion of said characteristic (T = F(X1,...XN,Qt)) and with a second value (Qt + 1) of said significant signal;

   said second computing means (56, 180) generating at the output an approximate injection time (Tn) computed as a function of the expansion of said characteristic (T = F(X1,...XN,Qt)) and of said second value (Qt + 1) of said significant signal.

2. A system as claimed in Claim 1, characterized by the fact that said processing means comprise means (50, 56, 150, 180) for linearizing said characteristic (T = F(X1,...XN,Qt)) about said first value (Qt) of said significant signal.

3. A system as claimed in Claim 2, characterized by the fact that said means (50, 56, 150, 180) for linearizing said characteristic (T = F(X1,...XN,Qt)) process a coefficient (K) computed as a function of a previously computed injection time (T) and of said first value (Qt) of said significant information signal; said second computing means being supplied with said coefficient (K) and with said second value (Qt + 1) of said significant signal; and said second computing means generating at the output an approximate injection time (Tn) computed as a function of said coefficient (K) and of said second value (Qt + 1) of said significant signal.

4. A system as claimed in Claim 3, characterized by the fact that said processing means (50, 150) produce said coefficient (K) as the ratio between said injection time (T) and said first value (Qt) of said significant signal used for computing said injection time (T).

5. A system as claimed in Claim 3, characterized by the fact that said second computing means (56, 180) generate said approximate injection time (Tn) as the product of said coefficient (K) and said second value (Qt + 1) of said significant signal.

6. A system as claimed in any one of the foregoing Claims, characterized by the fact that it comprises selecting means (40, 110) for selecting said first computing means (42, 140) or said second computing means (56, 180) for supplying injection actuating means (160) with said injection time (T) computed by said first means or with said approximate injection time (Tn).

7. A system as claimed in any one of the foregoing Claims, characterized by the fact that said significant signal is relative to at least one parameter selectable from among the

stoichiometric composition of the exhaust gas, engine speed, the pressure inside the combustion chamber, battery voltage, the position of the throttle valve in the intake manifold, air intake, and the absolute pressure in the intake manifold.

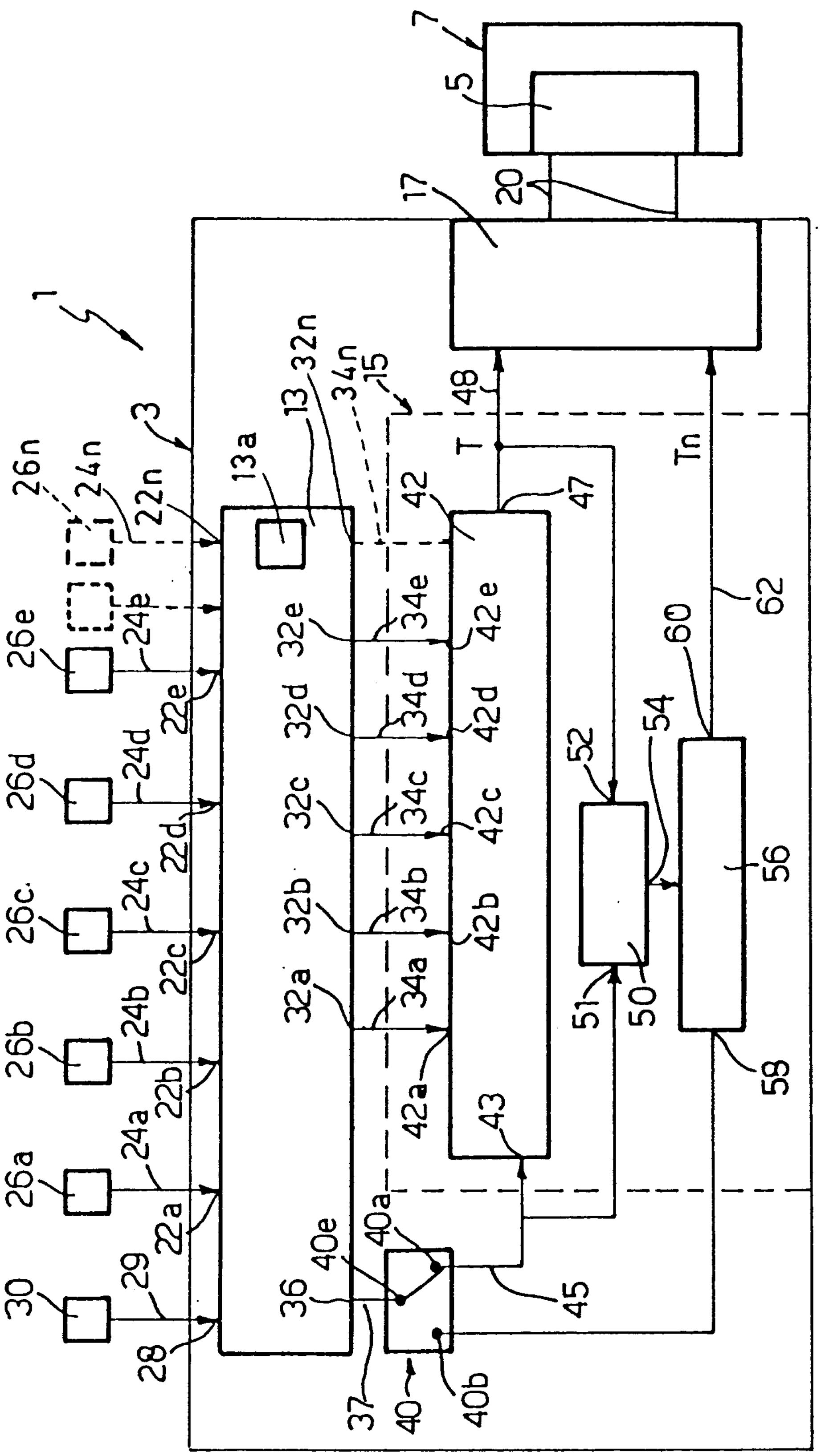
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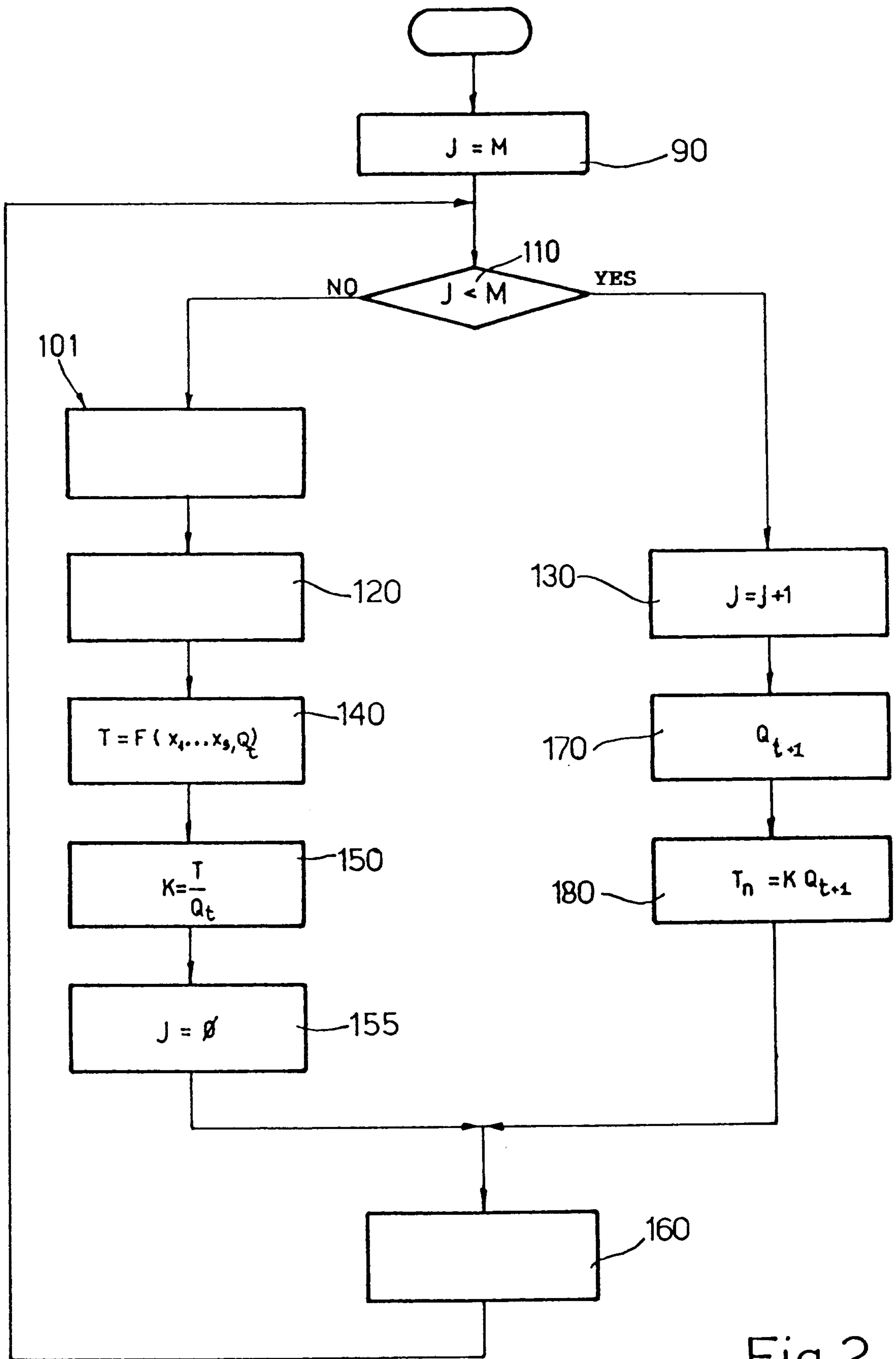
Fig.1



J = M
90
110
NO
J < M
YES
101
120
130
J = J + 1
140
T = F (x1 . . . x5, Qt)
170
Qt+1
150
K = T/Qt
180
Tn = K Qt+1
J = Ø
155
160

Fig.2

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EUROPEAN SEARCH REPORT

Application Number
EP 94 10 7599

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	EP-A-0 230 638 (WEBER S.R.L.) 5 August 1987 * column 2, line 1 - line 14 * * column 4, line 25 - column 6, line 4 * * column 16, line 18 - line 41 * ---	1-5	F02D41/26
A	US-A-4 945 485 (TAKANORI FUJIMOTO ET AL.) 31 July 1990 * the whole document * ---	1-5	
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A	PATENT ABSTRACTS OF JAPAN vol. 12, no. 360 (M-746) 27 September 1988 & JP-A-63 116 983 (NISSAN MOTOR CO LTD) 21 May 1988 * abstract * ---		TECHNICAL FIELDS SEARCHED (Int.Cl.5)
A	US-A-4 908 559 (KURAKAKE ET AL.) 13 March 1990 -----		F02D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23 August 1994	Moualed, R

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