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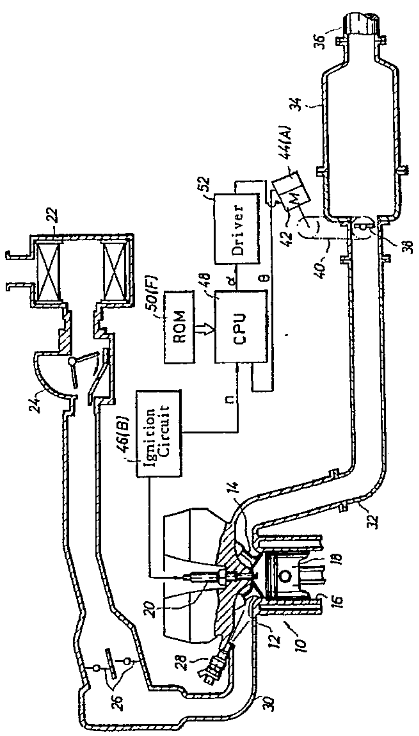
(54) **Control system for controlling DC control motor which controls operation condition of internal combustion engine.**

(57) A control system for controlling a DC control motor which controls an internal combustion engine to follow-up a target value varying continuously depending on the operation condition of the engine, the current flowing through the DC control motor being controlled through pulse width modulation. The control system comprises: means for detecting the operation condition of the engine; processor means for calculating and setting a target value depending on the operation condition of the engine; detector means for detecting the up-to-date value of the DC control motor; discriminator means for discriminating a difference between the target value and the up-to-date value to supply an output signal for changing the duty ratio of the current flowing through the DC control motor depending on the difference; a driver for energizing the DC control motor in response to the output signal from the discriminator means; and monitor means for controlling the changing rate of the up-to-date value and for increasing the duty ratio when the changing rate of the up-to-date value is less than a programmed rate.

FIG.1



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BACKGROUNDOF THE INVENTION:

Field of the Invention;

The present invention relates generally to a control system for controlling operation condition of an engine for a motor vehicle, and particularly to a control system for controlling a DC control motor which controls operation of an internal combustion engine to follow-up a target value varying continuously depending on the operation condition of the engine.

Prior Art Statement;

During cruising of a motor vehicle, the rotation speed of the engine is changed greatly and the loading applied on the engine is also changed within a wide range. In consideration of the foregoing, it has been proposed to detect the operation conditions of the engine and to open or close a variety of control valves depending on the result of detection so as to achieve optimum control of the engine. For example, Japanese Patent Laid-Open Publication No. 126222/1987 teaches a system wherein an exhaust gas control valve is disposed at a vicinity of the downstream end of the exhaust pipe, and the exhaust gas control valve is fully opened to utilize the kinetic effect of the exhaust system at the maximum extent so as to increase the output of the engine when the engine is operated within its high speed range. The exhaust gas control valve is closed to about one half of the full open angle, when the engine is operated within its medium speed range, to prevent formation of trough of torque due to the reverse effect of kinetics in the exhaust system. Another proposal has been made to change the effective length of the exhaust pipe by the provision of control valves on the connection pipes connecting the plural exhaust pipes and by opening or closing the control valves depending on the change in rotation speed of the engine.

When such a control valve is opened and closed by means of a DC motor which is controlled through pulse width modulation system (hereinafter referred to as "PWM system"), the duty ratio of the current flowing through the DC motor is controlled depending on the difference between the target value and the up-to-date and/or depending on the change in loading applied on the DC motor. However, in the event where the difference between the target value and the up-to-date value is relatively small and the duty ratio is also small and where carbon or dust sticks to the control valve to increase the torque for actuating the control valve, the control valve cannot be moved by the motor to be kept stopping.

OBJECTSAND SUMMARY OF THE INVENTION:

An object of this invention is to provide a control system for controlling a DC control motor which controls an internal combustion engine to follow-up a target value varying continuously depending on the operation condition of the engine by controlling the current flowing through the DC control motor by pulse width modulation, so as to solve the aforementioned problem that the control valve cannot be moved by the DC control motor in the event where the difference between the target value and the up-to-date value is relatively small and the duty ratio is also small and where carbon or dust sticks to the control valve to increase the torque for actuating the control valve.

According to an aspect of this invention, provided is a control system for controlling a DC control motor which controls an internal combustion engine to follow-up a target value based on the operation condition of the engine through pulse width modulation, wherein the speed of the DC control motor is monitored and the duty ratio of the current flowing through the DC controllmotoris increased when the changing rate of the up-to-date value is less than the programmed rate. It is thus possible to ensure actuation of the DC control motor even if the difference between the target value and the up-to-date value is small or the loading applied on the DC control motor is high.

The object of this invention is achieved by the provision of a control system for controlling a DC control motor which controls an internal combustion engine to follow-up a target value varying continuously depending on the operation condition of said engine, said DC control motor being controlled through pulse width modulation, said control system comprising:

means for detecting the operation condition of said engine;

processor means for calculating and setting a target value depending on said operation condition of said engine;

detector means for detecting the up-to-date value of said DC control motor;

discriminator means for discriminating a difference between said target value and said up-to-date value to supply an output signal for changing the duty ratio of the current flowing through said DC control motor depending on said difference;

a driver for energizing said DC control motor in response to said output signal from said discriminator means; and

monitor means for monitoring the changing rate of said up-to-date value and for increasing said duty ratio when said changing rate of said up-to-date value is less than a programmed rate.

DESCRIPTIONOF THE APPENDED DRAWINGS:

The above and other objects and advantages of this invention will be apparent from the following detailed description of preferred embodiments thereof with reference to the appended drawings, in which:

Fig. 1 is a schematic view showing an embodiment of the control system, according to this invention, which is associated with an exhaust system of an internal combustion engine;

Fig. 2 is a block diagram showing the control system of Fig. 1;

Fig. 3 is a flow chart showing the operation of the control system of Fig. 2.

DESCRIPTIONOF PREFERRED EMBODIMENTS:

Referring to Figs. 1 to 3, an embodiment of this invention will now be described in detail. Initially referring to Fig. 1, a four-cycle internal combustion engine is denoted by 10, and has an intake valve 12 and an exhaust valve 14 which are opened and closed by valve actuating means (not shown) at predetermined timing. The engine 10 is further provided with a cylinder 16, a piston 18 which cooperates with the cylinder 16, and an ignition plug 20 which ignites the compressed fuel-air mixture in the cylinder 16. The intake system of the engine 10 includes an air cleaner 22, an air flow meter 24, a throttle valve 26 and a fuel injection valve 28. Air is sucked through the air cleaner 22 at a flow rate determined by the rotation speed of the crank shaft (not shown) of the engine 10 and the open angle of the throttle valve 26. The flow rate of the sucked air is measured by the air flow meter 24. The optimal quantity of fuel corresponding to the sucked air quantity and adapted to the operation conditions (for example, temperature of the engine) is calculated by a computer (not shown) and supplied through a fuel injection valve 28 which injects the supplied fuel into the intake pipe 30.

The exhaust system includes a first exhaust pipe 32 having one end opened and closed by the exhaust valve 14, an expansion chamber 34 connected with the other or downstream end of the first exhaust pipe 32, and a second exhaust pipe 36 connected to the downstream end of the expansion chamber 34. A control valve, a butterfly valve 38 in the illustrated embodiment, is disposed at a vicinity of the downstream end of the first exhaust pipe 32 to control the flow of exhaust gases. The control valve 38 is opened and closed by an actuator, a DC servomotor 42 in the illustrated embodiment, through a wire 40. The servomotor 42 is fitted with a potentiometer 44 which serves as the means A for detecting the up-to-date open angle θ (i.e. the up-to-date value) of the control valve 38 by detecting the angular position of the servomotor 42.

The ignition plug 20 is connected to an ignition circuit 46 which is utilized as the means B for detecting the operation condition of the engine 10. The rotation speed n of the engine 10 is detected from the ignition circuit 46. A central processor unit (CPU) or digital microprocessor is generally denoted by 48 and includes a processor C for calculating and setting the target value, a discriminator D, and monitor means E' for monitoring the rotation speed of the actuator (servomotor 42). The processor C reads-out the data corresponding to the rotation speed n from a read-only memory (ROM) which stores a control map, and calculates the target open angle θ_0 of the control valve 38. The ROM 50 is shown as the comparator means F for comparing with the control map in Fig. 2. The discriminator D discriminates the difference between the target open angle θ_0 and the up-to-date open angle θ to generate a control signal α which is fed to a driver 52. When the signal α is a signal for controlling the electric current flowing through the servomotor 42, for example, by the pulse width modulating system, the duty ratio of the current flowing through the servomotor 42 is changed depending on the difference between θ_0 and θ, and also depending on the change in loading applied on the servomotor 42. The flow direction of the electric current is determined so that the open angle of the control valve 38 is increased when θ is smaller than θ_0 and the open angle of the control valve 38 is decreased when θ is larger than θ_0.

The rotation speed monitor means E' monitors the rotation speed of the servomotor. Since the rotation speed of the actuator or servomotor is determined depending to the load applied thereto, a signal is fed to the discriminator means D to increase the duty ratio stepwisely when the rotation speed is less than a programmed level.

The operation of the illustrated embodiment will now be described with reference to Fig. 3. The illustrated embodiment operates to repeat the operation sequence including the sub-routine shown in Fig. 3 within every predetermined time period, for example within 2 milliseconds. One cycle period for flowing the current through the servomotor is set to 2 milliseconds x 4 = 8 milliseconds. Within this one cycle period, the duty ratio of the current may be changed stepwisely to take a value which is shifted from one to four times of 2 milliseconds. In this embodiment, the duty ratio may be selected stepwisely from the four ratios D(1), D-(2), D(3) and D(4). D(1) means that the duty ratio is 25%, D(2) means that the duty ratio is 50%, D(3) means that the duty ratio is 75%, and D(4) means that the duty ratio is 100%. CPU 48 repeats the sub-routine of Fig. 3 within every 2 millisecond cycle. At the initial step, CPU 48 discriminates whether the target value θ is changed or not (Step 200). For this purpose, the target value θ_0 at time T is compared with the target value θ_0(T - t) at the time before the time T by $\underline{t}$. If the change in target value θ_0 is smaller than a predetermined range, it is judged that the target value is not changed. If the change in target value θ_0 is larger than the predetermined range, it is judged that the target value θ_0 is changed. In case where the target value is θ_0 is changed, new duty ratio D(n) corresponding to the new target value θ_0(T) is calculated by using the data stored in ROM 50 (Step 202), and counting of the time duration τ is initiated from the standard time T (Step 204).

After the lapse of one cycle period (after 2 milliseconds), it is discriminated again to know whether the target value θ_0 is changed or not (Step 200) If the target value θ_0 is not changed at this time, the up-to-date value $\theta(T + \tau_0)$ is read-in at the point when the counted time reaches $\tau = \tau_0$ (Step 206). The difference of the up-to-date value $\theta(T + \tau_0)$ and the up-to-date value θ(T) at the time point T is discriminated to judge whether the difference is more than the pre-set value $\underline{a}$ or not (Step 208). This operation is the one for learning the rotation speed of the servomotor 42, since the movement within a predetermined time period is obtained thereby, the movement being represented by the following equation of:

$$\{\Theta(T+\tau_0)-\Theta(T)\}/\tau_0$$

If the absolute value of the rotation speed is more than a programmed value a/τ_0, it is judged that the load applied on the servomotor 42 is not excessively high to continue the operation at the duty ratio D(n) determined at the step 202.

If the absolute value of the rotation speed is less than a programmed value a/τ_0, it is judged that the load applied on the servomotor 42 is excessively high to raise the duty ratio of the current flowing through the servomotor 42 by one step (Step 210). For example, the duty ratio is raised from D(1) to D(2), from D(2) to D(3), and from D(3) to D(4), respectively. If the duty ratio D before this step 210 is D(4), the operation is continued at the duty ratio D(4) since no higher duty ratio is not present (Steps 212 and 214).

As will be seen from the foregoing, since the duty ratio is raised stepwisely one by one if the rotation speed of the servomotor 42 is less than the pre-set level, the current flowing through the servomotor 42 is increased to ensure the actuation thereof.

In this embodiment, the present invention is applied for the actuation of the exhaust gas control valve 38 disposed at the downstream end of the exhaust pipe 32 so that the valve 38 is opened when the engine is operated within its high speed range and the valve 38 is closed when the engine is operated within its medium speed range to prevent formation of trough of torque. However, the present invention may be applied to control other control valves. For example, a control valve for controlling the effective pipe length of an intake pipe may be controlled within the scope and spirit of this invention.

Claims

1. A control system for controlling a DC control motor (42) which controls an internal combustion engine (10) to follow-up a target value varying continuously depending on the operation condition of said engine (10), said DC control motor (42) being controlled through pulse width modulation, said control system comprising:

   means (B) for detecting the operation condition of said engine (10);

   processor means (C) for calculating and setting a target value (θ_0) depending on said operation condition of said engine (10);

   detector means (A) for detecting the up-to-date value (θ) of said DC control motor (42);p

   discriminator means (D) for discriminating a difference between said target value (θ_0) and said up- to-date value (θ) to supply an output signal (α) for changing the duty ratio of the current flowing through said DC control motor (42) depending on said difference;

   a driver (52) for energizing said DC control motor (42) in response to said output signal (α) from said discriminator (D) means; and

   monitor means (E') for monitoring the changing rate of said up-to-date value (θ) and for increasing said duty ratio when said changing rate of said up-to-date value (θ) is less than a programmed rate.

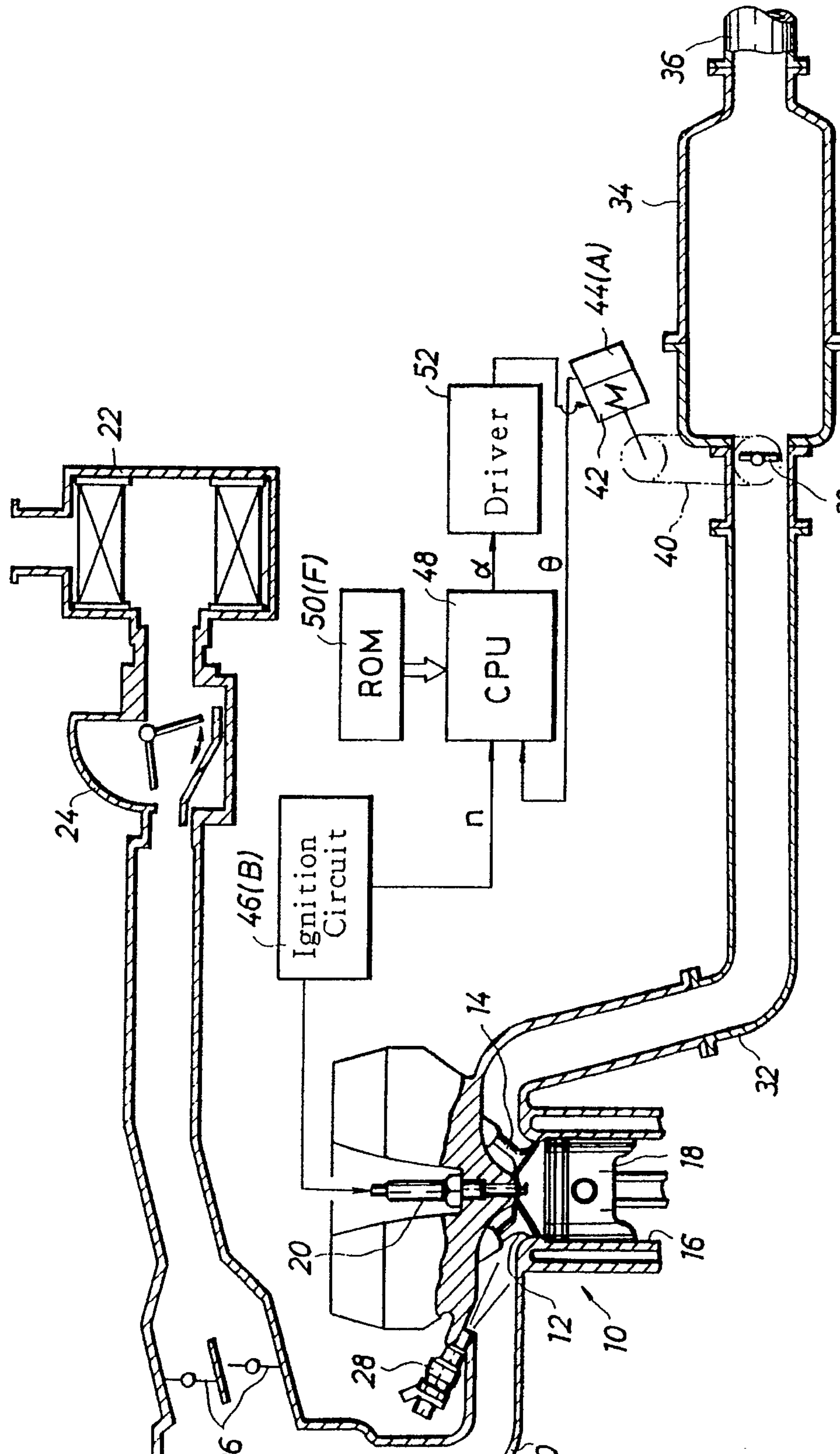
2. The control system for controlling said DC control motor (42) according to claim 1, wherein said engine (10) has an exhaust pipe (32) and an exhaust gas control valve (38) disposed at the vicinity of the downstream end of said exhaust pipe (32), and wherein said exhaust gas control valve (38) is opened and closed by said DC control motor (42).

3. The control system for controlling said DC control motor (42) according to claim 2, wherein said exhaust gas control valve (38) is a butterfly valve.

4. The control system for controlling said DC control motor (42) according to claim 1, wherein said means (B) for detecting the operation condition of said engine (10) comprises an ignition circuit (46) for igniting said engine (10).

5. The control system for controlling said DC control motor (42) according to claim 1, wherein said processor means (C), said discriminator means (D) and said monitor means (E') are digital microprocessors.

FIG.1



22
24
26
28
30
10
12
16
18
20
14
32
46(B)
Ignition Circuit
n
50(F)
ROM
48
CPU
α
θ
52
Driver
44(A)
M
42
40
38
34
36

FIG. 2

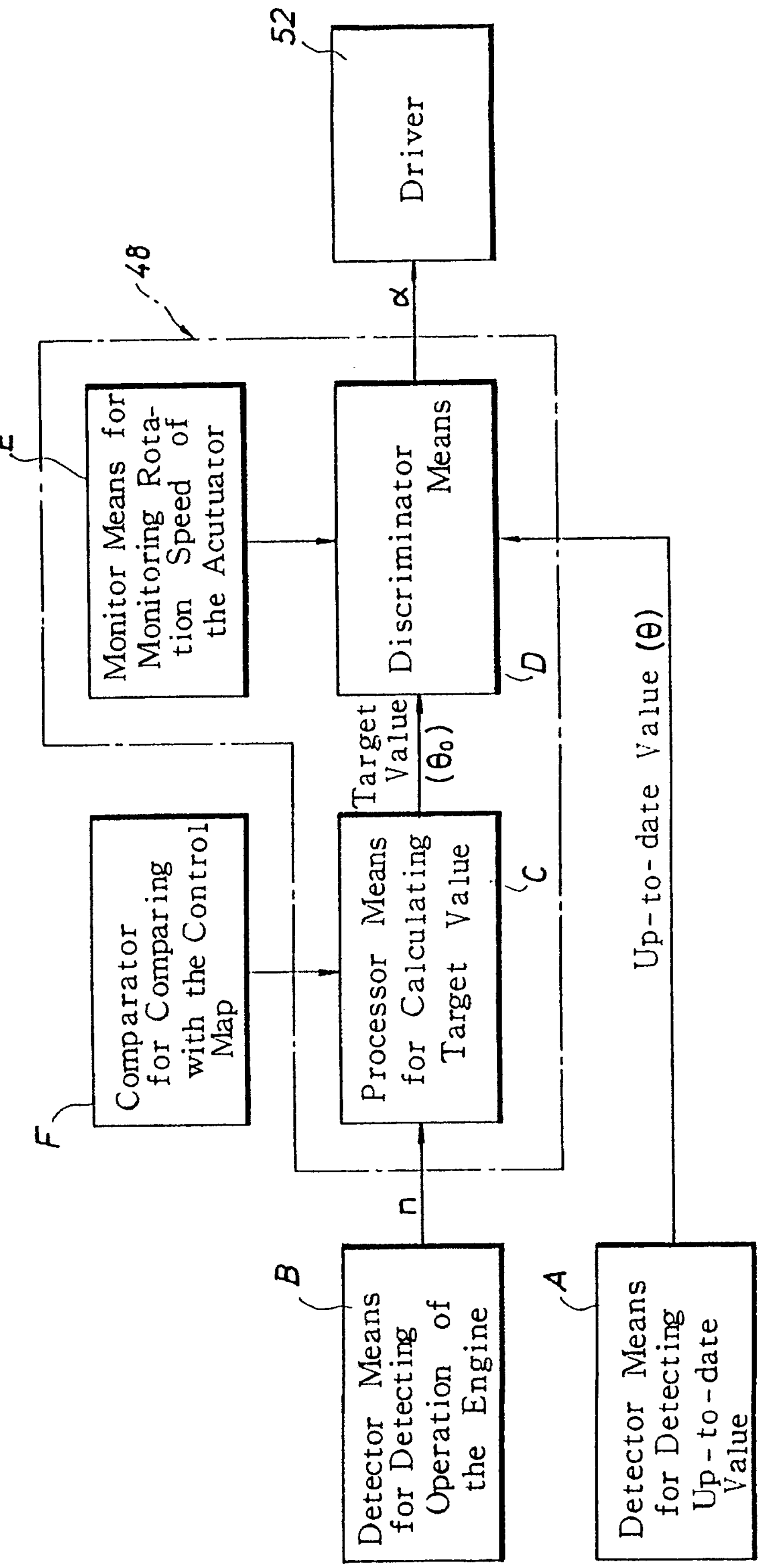
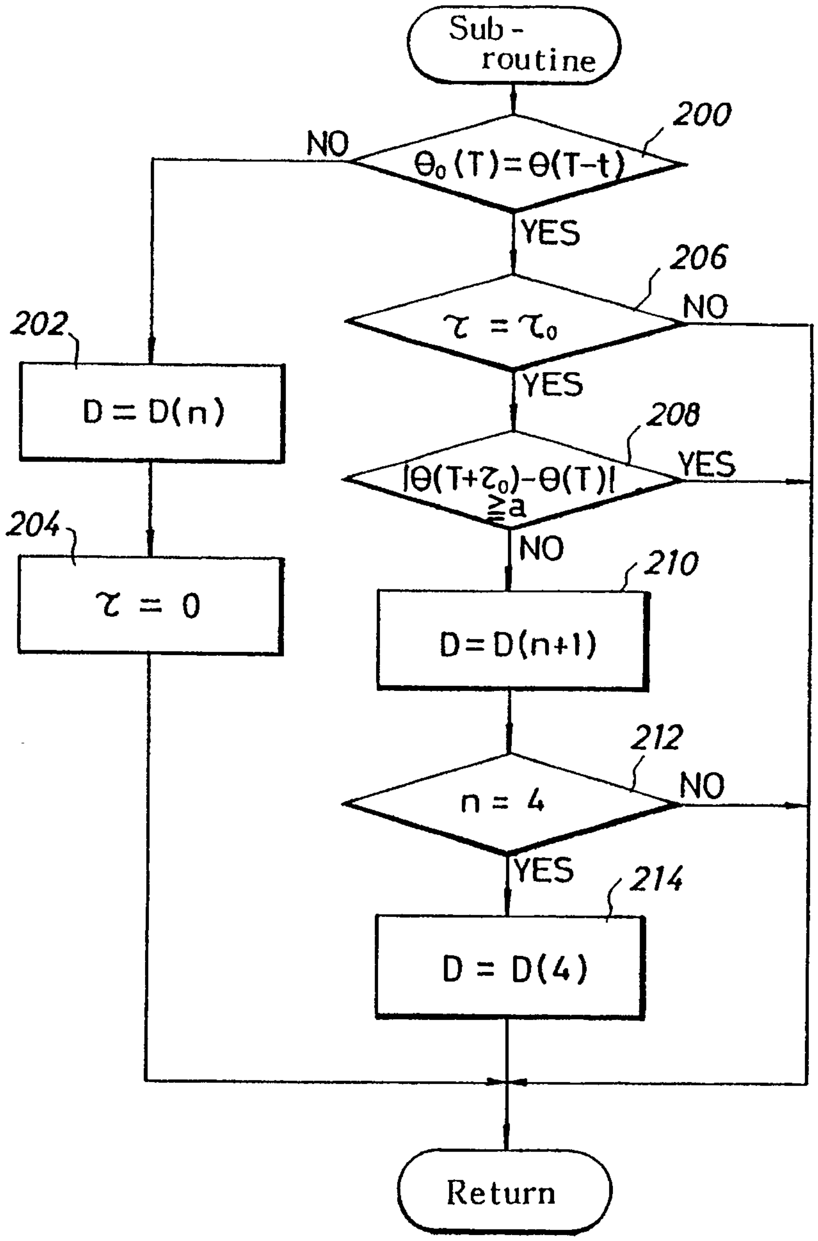

Detector Means for Detecting Operation of the Engine
B
Detector Means for Detecting Up-to-date Value
A
n
Up-to-date Value (θ)
Comparator for Comparing with the Control Map
F
Processor Means for Calculating Target Value
C
Target Value (θ₀)
Monitor Means for Monitoring Rotation Speed of the Acutuator
E'
Discriminator Means
D
48
α
Driver
52

FIG. 3


Sub-routine
200
$\theta_0(T)=\theta(T-t)$
NO
YES
206
$\tau=\tau_0$
NO
YES
208
$|\theta(T+\tau_0)-\theta(T)| \geqq a$
YES
NO
202
D = D(n)
204
$\tau = 0$
210
D = D(n+1)
212
n = 4
NO
YES
214
D = D(4)
Return