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(54) **Engine control apparatus**

(57) In an air-cooled engine, the temperature of the engine is detected with high accuracy to control fuel injection in optimal conditions. In order to detect the temperature of the engine, a first temperature sensor (21) and second temperature sensor (22) are provided at two spaced portions respectively on a cylinder block (11), and based on the function of a temperature difference between temperatures T_1 and T_2 respectively detected by the first temperature sensor (21) and second temperature sensor (22) and the thermal resistance specific to the engine, a calculating circuit (34) calculates the engine temperature T_0 inside the engine. In this way, the detection (estimation) accuracy of the engine temperature is improved and the optimal engine control is performed.

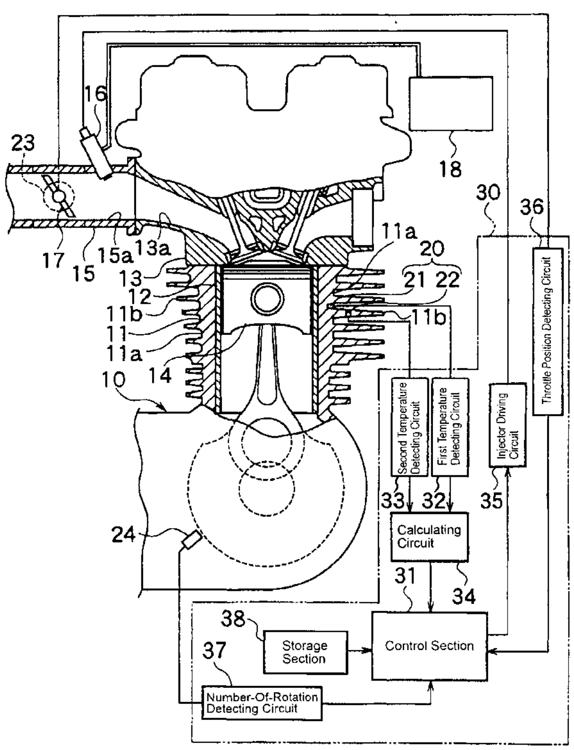

FIG. 1

EP 1 369 572 A2

Description

Background of the invention

Field of the Invention

[0001] The present invention relates to an engine control apparatus that controls operating conditions of an engine based on information such as the temperature of the engine, and more particularly, to an engine control apparatus that controls operating conditions of an engine using the temperature of the engine that is an air-cooled engine which has an electronic fuel injection system and is mounted on a vehicle such as a two-wheeled vehicle.

Description of the Related Art

[0002] There is known an engine control apparatus that uses the temperature of an engine as a single piece of information to control operating conditions of the engine, and Japanese Laid-Open Patent Publication H07-34927 discloses an apparatus that uses a plurality of temperature sensors as a method of detecting the temperature of an engine.

[0003] The apparatus disclosed in the publication is provided with a water-temperature sensor that detects the temperature of cooling water flowing inside a water jacket of a cylinder block and with an oil-temperature sensor that detects the temperature of lubricating oil in an oil pan, and estimates the temperature of the engine based on a difference between the detected cooling-water temperature and lubricating-oil temperature.

[0004] In other words, up to a predetermined time after starting cooling the engine, since a constant relationship (temperature gradient) is obtained between the temperature of a wall surface of a combustion chamber (heat source) i.e. the temperature of the engine and the cooling-water temperature, detecting the cooling-water temperature enables estimation of the actual temperature of the engine (for example, the temperature of the wall surface of the combustion chamber). However, for example, in the case of restarting the engine after half warming up, since the constant relationship is not obtained, the temperature of the engine is estimated using the information on the difference between the lubricating-oil temperature and cooling-water temperature.

[0005] In a water-cooled engine, as described above, it is possible to estimate and obtain the actual temperature of the engine by measuring the cooling-water temperature. However, in an air-cooled engine, cooling-water is not present and it is impossible to measure the cooling-water temperature.

[0006] Further, in a vehicle such as a two-wheeled vehicle mounted with a cooled engine or an air-cooled engine having cooling fins, when the temperature is measured at a single point of the outer wall of the cylinder head or cylinder block, the constant relationship is obtained between the detected temperature and the actual engine temperature inside the engine in steady operating conditions, while there are cases that the same constant relationship as in the steady conditions is not obtained in non-steady (transient) operating conditions such as running conditions at idle operation and warming-up operating conditions.

[0007] In other words, as shown in Fig.6, the heat transmission property of an engine can be approximated using the constant relationship between a distance X from the heat source and temperature T, for example, T=aX+b (where a is the temperature gradient) in general steady operating conditions without traveling wind, and it is possible to estimate the actual engine temperature (temperature of the wall surface of the combustion chamber) T_0 (at a point P_0) only by measuring the temperature Tn (at a point Pn).

[0008] Meanwhile, in the case of low load with traveling wind such as a case of running down a hill in idle operating conditions, the temperature T of the outside (outer wall region) of the engine in the cooling fin and its vicinity decreases to Ts (at a point Ps), but the actual engine temperature T of the inside (wall surface of the combustion chamber) of the engine is the temperature T_0 or a little less that is approximately equal to the temperature in steady operations.

[0009] Accordingly, when the engine temperature T is estimated based on the temperature Ts detected by the temperature sensor using the relationship, T=aX+b', using temperature gradient an approximated in steady operations without being modified, the engine temperature T_0' (at a point P_0') is obtained that is lower than the actual engine temperature T_0. When a fuel injection amount or others are controlled based on the temperature T_0', the engine is not controlled in originally preferable operating conditions.

Summary of the invention

[0010] In view of the foregoing, it is an object of the present invention to provide an engine control apparatus capable of detecting the temperature of an engine with high accuracy eliminating effects of ambience such as traveling wind and outside-air temperature to control the engine in optimal operating conditions, while using existing parts, simplifying the structure and reducing the cost.

[0011] An engine control apparatus of the present invention has temperature detecting means for detecting the temperature of an engine, and control means for controlling operating conditions of the engine based on at least information detected in the temperature detecting means, where the temperature detecting means includes a first temperature sensor and a second temperature sensor that detect respective temperatures of two spaced portions in a combustion chamber demarcating member that demarcates a combustion chamber of the engine, and the control means includes calculating means that calculates the engine temperature inside the engine based on information detected by the first temperature sensor and the second temperature sensor.

[0012] According to this configuration, the first temperature sensor and the second temperature sensor detect respective temperatures of different positions (for example, different positions on a cylinder head or different positions on a cylinder block) of the combustion chamber demarcating member, and based on the detected temperature information, the calculating means estimates the actual engine temperature (effective engine temperature) inside the engine by calculation. Thus, since the engine temperature is estimated based on temperatures detected in at least two positions on the combustion chamber demarcating member (for example, cylinder head or cylinder block), the accuracy is improved, and the optimal engine control is performed.

[0013] In the above configuration, the calculating means calculates the engine temperature inside the engine based on a function of a temperature difference obtained from the first temperature sensor and the second temperature sensor and the thermal resistance of the engine.

[0014] According to this configuration, the calculating means performs calculation on the function of a temperature difference obtained from two pieces of temperature information and the thermal resistance specific to the engine, using as its inputs the two pieces of temperature information obtained from the first temperature sensor and the second temperature sensor, to estimate the actual engine temperature. By thus using a function expression of the temperature difference and thermal resistance, the calculation processing is simplified and the processing speed is increased.

[0015] In the above configuration, the first temperature sensor is attached to an outer wall of the combustion chamber demarcating member, and the second temperature sensor is attached to a base region of a cooling fin formed on the outer wall.

[0016] According to this configuration, since the temperature of the base region of the cooling fin is generally lower than that of the outer wall of the combustion chamber demarcating member (for example, cylinder head or cylinder block), a definite temperature difference is obtained and it is possible to obtain a constant relationship (function) where the temperature decreases in inverse proportion to a distance from a heat source (for example, a wall surface of the combustion chamber).

[0017] In the above configuration, the first temperature sensor and the second temperature sensor are composed of an integrally formed one-piece temperature sensor.

[0018] According to this configuration, providing only a single one-piece temperature sensor enables detections of respective temperatures of two portions on the combustion chamber demarcating member (for example, cylinder head or cylinder block), and it is thus possible to simplify handling, mounting and other operations of the sensor.

[0019] In the above configuration, the one-piece temperature sensor is attached to the outer wall of the combustion chamber demarcating member or the base region of the cooling fin formed on the outer wall.

[0020] According to this configuration, it is possible to place the one-piece temperature sensor readily only by providing a single mounting hole or the like on the combustion chamber demarcating member (for example, cylinder head or cylinder block).

[0021] In the above configuration, the control means obtains load conditions of the engine based on the information detected by the first temperature sensor and the second temperature sensor to control a fuel injection amount.

[0022] According to this configuration, the control means obtains the load conditions (operating conditions) of the engine based on the obtained two pieces of temperature information, and using the obtained load conditions and a predetermined control map, controls fuel injection so that a proper fuel amount is injected. The optimal fuel injection is thus performed in response to actual load conditions of the engine.

[0023] In the above configuration, the engine to be controlled is an air-cooled engine.

[0024] According to this configuration, in the air-cooled engine, since cooling water is not present and the temperature of cooling water cannot be adopted as a target for detection, the present invention is particularly effective as a method of estimating the actual engine temperature inside the engine from the temperature in the vicinity of the outer wall of the combustion chamber demarcating member (for example, cylinder head or cylinder block).

Brief description of the drawings

[0025]

Fig. 1	is a system diagram illustrating one embodiment of an engine control apparatus according to the present invention;
Fig. 2(a)	is a cross-sectional view illustrating a state of a mounted first temperature sensor and second temperature sensor that are temperature detecting means composing part of the engine control apparatus;
Fig. 2(b)	is a heat transmission property in the state;
Fig. 3	is a graph to explain a detection method by the temperature detecting means;
Fig. 4	is an equivalent circuit that is an electric circuit as a substitution for heat transmission paths of the engine;

Fig. 5(a) is a cross-sectional view illustrating a state of a mounted one-piece temperature sensor in another embodiment of the engine control apparatus according to the present invention;

Fig. 5(b) is a view illustrating a heat transmission property in the state; and

Fig. 6 is a graph illustrating a detection method by a conventional temperature sensor.

Detailed description of the preferred embodiments

[0026] Embodiments of the present invention will be described below specifically with reference to accompanying drawings.

[0027] Figs. 1 to 4 illustrate one embodiment of an engine control apparatus according to the present invention. Fig. 1 is a system diagram of the entire apparatus including the engine. Fig. 2(a) is a cross-sectional view showing temperature sensors as the temperature detecting means. Fig. 2(b) is a heat transmission property in the state. Fig. 3 is a graph to explain a temperature detection function. Fig. 4 is an equivalent circuit that is an electric circuit as a substitution for heat transmission property of the engine.

[0028] Herein, an engine to be controlled is an air-cooled 4 cycle engine 10 mounted on a vehicle such as a two-wheeled vehicle. As shown in Fig. 1, the engine 10 has a cylinder block 11 on which a plurality of cooling fins 11b is formed to project from an outer wall 11a and which is of a combustion chamber demarcating member that demarcates part of a combustion chamber, a cylinder liner 12 that is engaged in a bore of the cylinder block 11, a cylinder head 13 which is coupled to an upper end of the cylinder block 11 and is of the combustion chamber demarcating member that demarcates part of the combustion chamber, a piston 14 that reciprocates inside the cylinder liner 12, an intake pipe 15 that forms an intake passage 15a communicating with an intake port 13a of the cylinder head 13, an injector 16 that is attached to the intake pipe 15, a throttle valve 17 that opens and closes the intake passage 15a, a fuel tank 18 that supplies the fuel to the injector 16, an ignition plug and coil (not shown) and others.

[0029] As shown in Fig. 1, a control apparatus of the engine 10 has temperature detecting means 20 that detects the temperature of the cylinder block 11, a throttle position sensor 23 that detects an angle of the throttle valve 17, a rotation sensor 24 that detects the number of rotations of a crank shaft, control means 30 that controls operating conditions of the engine 10 based on information detected by the temperature detecting means 20, throttle position sensor 23, rotation sensor 24, etc, and others.

[0030] The temperature detecting means 20 is comprised of a first temperature sensor 21 mounted on the outer wall 11a of the cylinder block 11, and a second temperature sensor 22 mounted on a base region of the cooling fin formed on the outer wall 11a of the cylinder block 11.

[0031] The first temperature sensor 21 and second temperature sensor 22 are each composed of, for example, a thermocouple using thermistor and Seebeck effect, and as shown in Fig. 2(a), are disposed respectively at positions distances X1 and X2 apart from an inner wall surface 12a, on the assumption that the temperature of the inner wall surface 12a of the cylinder liner 12 is equivalent to the wall surface temperature T_0 of the combustion chamber (heat source).

[0032] In this case, as shown in Fig. 2(b), the heat transmission property indicating the mutual relationship between the detection temperature T_1 of the first temperature sensor 21, detection temperature T_2 of the second temperature sensor 22 and outside-air temperature Tout is represented by a constant relationship expressed by an approximately liner temperature gradient in a region of the cylinder liner 12 and cylinder block 11.

[0033] Herein, in mounting the first temperature sensor 21 and second temperature sensor 22, holes are provided on the outer wall 11a of the cylinder block 11 and the cooling fin 11b to mount the sensors, whereby the sensors are attached or detached readily.

[0034] The control means 30 controls fuel injection amounts, injection timing, ignition timing, etc. as appropriate to control operating conditions of the engine 10, and as shown in Fig. 1, is formed of a first temperature detecting circuit 32 connected to the first temperature sensor 21, a second temperature detecting circuit 33 connected to the second temperature sensor 22, a calculating circuit 34 as calculating means, an injector driving circuit 35 that drives the injector 16, a throttle position detecting circuit 36 connected to the throttle position sensor 23, a number-of-rotation detecting circuit 37 connected to the rotation sensor 24, a storage section 38 that beforehand stores information on control map and others, and so on.

[0035] The first temperature detecting circuit 32 and second temperature detecting circuit 33 convert analog signals output from the first temperature sensor 21 and second temperature sensor 22 into digital signals to output as voltage signals V1 and V2, respectively.

[0036] Based on the output information (detection information) of the first temperature detecting circuit 32 (first temperature sensor 21) and second temperature detecting circuit 33 (second temperature sensor 22), the calculating circuit 34 performs predetermined calculating processing to calculate the engine temperature T_0 inside the engine.

[0037] A method of calculating and estimating the actual engine temperature T_0 inside the engine 10 will be described based on Fig. 3. For example, in general steady operating conditions without traveling wind, the first temperature sensor 21 detects the temperature T_1 (at a point P_1), the second temperature sensor 22 detects the temperature T_2 (at a point P_2), and the temperature gradient a (=AT/AX) is calculated from the temperature difference ΔT between the temperatures T_1 and T_2, and the spacing distance ΔX between points of the temperatures.

[0038] Accordingly, the relationship between the distance X from the heat source and temperature T is approximated by the function such that T=aX+b, and the engine temperature T_0 is calculated at the inner wall surface 12a (at a point P_0) of the cylinder liner 12 in the vicinity of the combustion chamber.

[0039] Meanwhile, in the case of low load with traveling wind such as running down a hill in idle operating conditions, since the temperature of the outside (outer wall region) of the engine in the cooling fin and its vicinity decreases, the first temperature sensor 21 detects the temperature T_1' (at a point P_1'), the second temperature sensor 22 detects the temperature T_2' (at a point P_2')(herein $T_1'<T_1$ and $T_2'<T_2$), and the temperature gradient a' (=ΔT'/AX') is calculated from the temperature difference $\Delta T'$ between the temperatures T_1' and T_2', and the spacing distance $\Delta X'$ between points of the temperatures.

[0040] Accordingly, the relationship between the distance X from the heat source and temperature T is approximated by the function such that T=a'X+b', and the engine temperature T_0 is calculated at the inner wall surface 12a (at a point P_0) of the cylinder liner 12 in the vicinity of the combustion chamber.

[0041] In this way, temperature differencesΔT and $\Delta T'$ are obtained from temperatures T_1 and T_1' detected in the first temperature sensor 21, and T_2 and T_2' detected in the second temperature sensor 22, and the heat transmission property (temperature gradients a and a') of the engine 10 is further obtained, whereby it is possible to estimate the actual engine temperature T_0 inside the engine in response to load conditions (operating conditions) of the engine 10 with high accuracy and with ease.

[0042] When simplifying the heat transmission paths of the engine 10 and substituting an electric circuit, the paths are represented by an equivalent circuit as shown in Fig. 4. In addition, in the equivalent circuit, a heat value inside the engine 10 is represented by Ieng(W), the engine temperature is represented by Veng (°C), the thermal resistance of the cylinder liner 12 is represented by Rsyl(°C/W), the heat capacity of the cylinder liner 12 is represented by Csyl, the thermal resistance of the cylinder block 11 is represented by Rsyb(°C/W), the heat capacity of the cylinder block 11 is represented by Csyb, the detection temperature of the first temperature sensor 21 (S1) is represented by V1 (°C), the detection temperature of the second temperature sensor 22 (S2) is represented by V2 (°C), the thermal resistance between the first temperature sensor 21 and second temperature sensor 22 is represented by R12 (°C/W), the thermal resistance between the second temperature sensor 22 and outside air is represented by R2a (°C/W), and the outside-air temperature Tout is represented by Vout R12 (°C).

[0043] In the equivalent circuit, the heat value Ieng inside the engine 10 is as follows:

$$\text{Ieng}=(\text{V1-V2})/\text{R12 (W)}$$

[0044] The engine temperature Veng inside the engine 10 is calculated from the following equation:

$$\text{Veng}=\text{Ieng}\times(\text{Rsyl+Rsyb})$$

$$=(\text{V1-V2})\times(\text{Rsyl+Rsyb})/\text{R12 } (^\circ\text{C})$$

[0045] In other words, the calculating circuit 34 obtains a linear function indicating the constant relationship from the temperature difference (V1-V2) obtained from temperatures V1 and V2 continuously detected and thermal resistance R12, Rsyl and Rsyb specific to the engine, and based on the linear function, calculates the actual engine temperature Veng inside the engine. In this way, the calculation is simplified, and it is made possible to perform prompt calculation processing, enabling the prompt control with high accuracy in response to load conditions of the engine 10.

[0046] The operation of controlling the engine 10 in the control apparatus will be described below.

[0047] First, when the first temperature sensor 21 and second temperature sensor 22 detect temperatures of the cylinder block 11, the detection signals are input to the calculating circuit 34 respectively through the first temperature detecting circuit 32 and second temperature detecting circuit 33, and based on the input signals, the calculating circuit 34 calculates the engine temperature T_0 inside the engine 10 and inputs the calculation result to the control section 31.

[0048] When the throttle position sensor 23 detects the angle of the throttle valve 17, the detection signal is input to the control section 31 through the throttle position detecting circuit 36. When the rotation sensor 24 detects the number of rotations of the engine 10, the detection signal is input to the control section 31 through the number-of-rotation detecting circuit 37.

[0049] Based on the information detected by the sensors 21, 22, 23 and 24, the control map stored in the storage section 38 and so on, the control section 31 obtains the load conditions, operating condition and the like of the engine 10, calculates an optimal fuel injection amount (fuel injection time and fuel injection timing) at any given time, and issues a control signal. When the control signal is issued, the injector 16 is driven based on a driving signal from the injector driving circuit 35, and a required amount of fuel is injected at required timing. Further, when the control section 31 issues a control signal to the injection coil, the injection plug makes a spark at required timing.

[0050] Thus, the engine 10 is controlled to be in optimal operating conditions corresponding to the load conditions.

[0051] In particular, since the engine temperature T_0 is estimated using the first temperature sensor 21 and second temperature sensor 22, effects are eliminated that are caused by, for example, a driving condition of the vehicle such as a two-wheeled vehicle mounted with the engine 10, the presence or absence of traveling wind and outside-air temperature, and the actual engine temperature T_0 is obtained with high accuracy. As a result, in response to conditions such as the running condition and load condition, the engine is controlled in optimal operating conditions and the drivability is improved.

[0052] Fig. 5 illustrates another embodiment of the engine control apparatus according to the present invention. In the apparatus according to the another embodiment, as shown in Fig. 5, a single temperature sensor 200 is attached as the temperature detecting means onto the outer wall 11a of the cylinder block 11 as the combustion chamber demarcating member. The temperature sensor 200 is a one-piece temperature sensor composed of integrally formed first temperature sensor 210 that detects the temperature at a position X1' apart from the inner wall 12a of the cylinder liner 12 and second temperature sensor 220 that detects the temperature at a position X2' apart from the inner wall 12a.

[0053] Also in the one-piece temperature sensor 200, as in the foregoing, temperatures T_1 and T_2 (or T_1' and T_2') of two portions on the cylinder block 11 are detected, and the actual engine temperature T_0 is calculated.

[0054] In the apparatus, in particular, since it is possible to detect respective temperatures of two portions on the cylinder block 11 only by attaching a single one-piece temperature sensor 200, handling, mounting and other operations of the sensor are simplified.

[0055] In addition, while the one-piece temperature sensor 200 is attached to the outer wall 11a of the cylinder block 11 herein, the sensor 200 may be attached to the cooling fin lib.

[0056] The above-mentioned embodiments illustrate the case where the control apparatus of the present invention is applied to the air-cooled engine 10 mounted on a vehicle such as a two-wheeled vehicle. However, the present invention is not limited to the case, and the apparatus is applicable to air-cooled engines mounted on leisure vehicles, work vehicles, other vehicles, work machines or the like.

[0057] Further, while the above-mentioned embodiments illustrate the case where the air-cooled engine 10 is an engine to be controlled, the present invention is not limited to the case. The control apparatus of the present invention is similarly applicable to water-cooled engines as long as a definite temperature difference is obtained in detecting temperatures of two portions on the combustion chamber demarcating member (on the cylinder block or cylinder head).

[0058] In particular, since there are water-cooled engines provided with cooling fins from the viewpoint of performance enhancement or appearance, as in the above-mentioned embodiments, it is possible to attach two temperature sensors on the outer wall of the cylinder block and cooling fin.

[0059] Further, while the above-mentioned embodiments illustrate the case where the temperature detecting means (first temperature sensors 21 and 210 and second temperature sensors 22 and 220) are attached onto the cylinder block 11 as the combustion chamber demarcating member, the present invention is not limited to the case. The means may be attached onto the cylinder head 13 as the combustion chamber demarcating member where cooling fins are formed to project from the outer wall.

[0060] As described above, according to the engine control apparatus of the present invention, two temperature sensors that detect respective temperatures of two portions on the combustion chamber demarcating member are adopted as the temperature detecting means for detecting the temperature of the engine, and based on the information detected by the two temperature sensors, the actual engine temperature inside the engine is estimated, whereby the accuracy is improved and the optimal engine control is performed.

[0061] In particular, the engine temperature inside the engine is calculated based on the function of a temperature difference obtained from the two temperature sensors and thermal resistance specific to the engine, whereby the calculation processing is simplified and made fast, and it is possible to perform prompt and optimal control in response to load conditions of the engine.

[0062] Further, adopting a one-piece temperature composed of integrally formed two temperature sensors simplifies the handling, mounting and other operations of the sensor.

[0063] Furthermore, since load conditions of the engine are obtained based on the information detected by the two temperature sensors to control a fuel injection amount, optimal fuel injection is performed in response to the actual load conditions of the engine and the drivability of the vehicle such as a two-wheeled vehicle is improved.

Claims

1. An engine control apparatus comprising:

temperature detecting means for detecting a temperature of an engine; and
control means for controlling operating conditions of the engine based on at least information detected in the temperature detecting means,

wherein the temperature detecting means includes a first temperature sensor and a second temperature sensor that detect respective temperatures of two spaced portions in a combustion chamber demarcating member that demarcates a combustion chamber of the engine, and the control means includes calculating means that calculates an engine temperature inside the engine based on information detected by the first temperature sensor and the second temperature sensor.

2. The engine control apparatus according to claim 1, wherein the calculating means calculates the engine temperature inside the engine based on a function of a temperature difference obtained from the first temperature sensor and the second temperature sensor and thermal resistance of the engine.

3. The engine control apparatus according to claim 1 or 2, wherein the first temperature sensor is attached to an outer wall of the combustion chamber demarcating member, and the second temperature sensor is attached to a base region of a cooling fin formed on the outer wall.

4. The engine control apparatus according to any one of claims 1 to 3, wherein the first temperature sensor and the second temperature sensor are composed of an integrally formed one-piece temperature sensor.

5. The engine control apparatus according to claim 4, wherein the one-piece temperature sensor is attached to the outer wall of the combustion chamber demarcating member or the base region of the cooling fin formed on the outer wall.

6. The engine control apparatus according to any one of claims 1 to 5, wherein the control means obtains load conditions of the engine based on the information detected by the first temperature sensor and the second temperature sensor to control a fuel injection amount.

7. The engine control apparatus according to any one of claims 1 to 6, wherein the engine is an air-cooled engine.

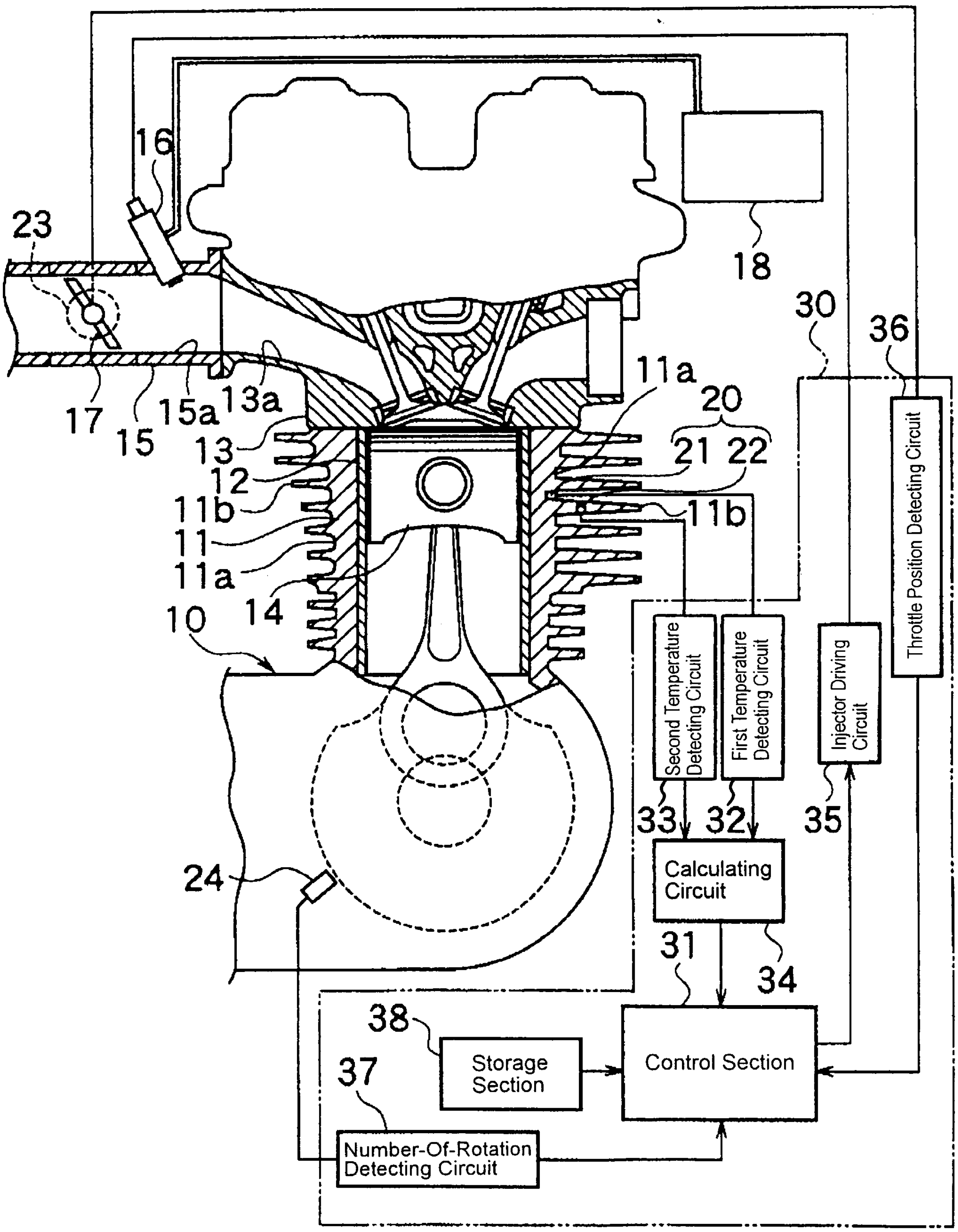
16
23
18
30
36
17
15
15a
13a
11a
20
13
21
22
12
11b
11
11a
14
10
11b
Throttle Position Detecting Circuit
Second Temperature Detecting Circuit
First Temperature Detecting Circuit
Injector Driving Circuit
33
32
35
Calculating Circuit
24
31
34
38
Storage Section
Control Section
37
Number-Of-Rotation Detecting Circuit

FIG. 1

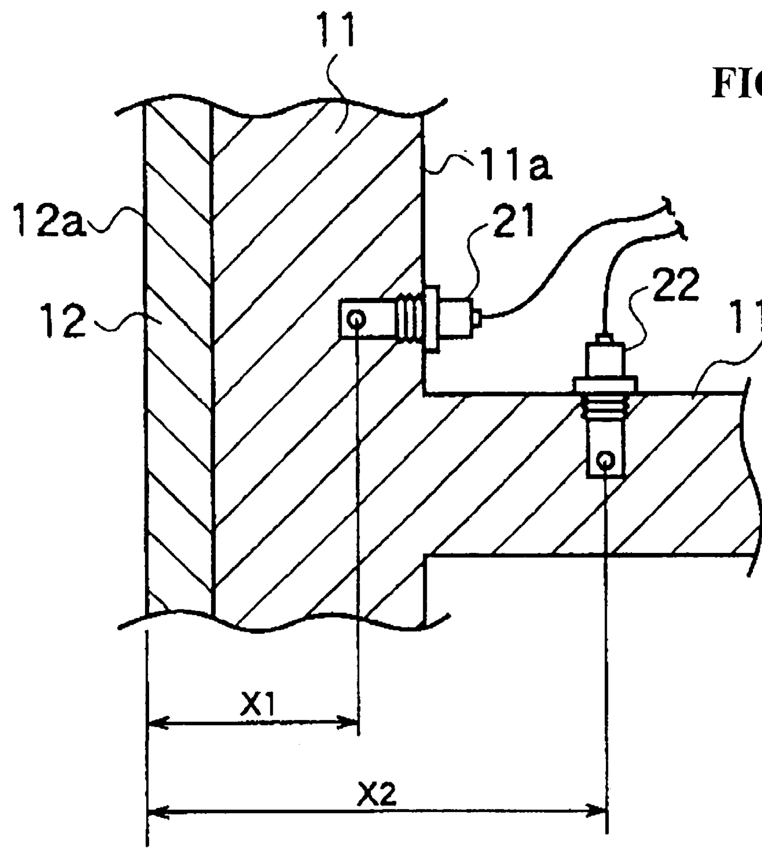

FIG. 2 (a)

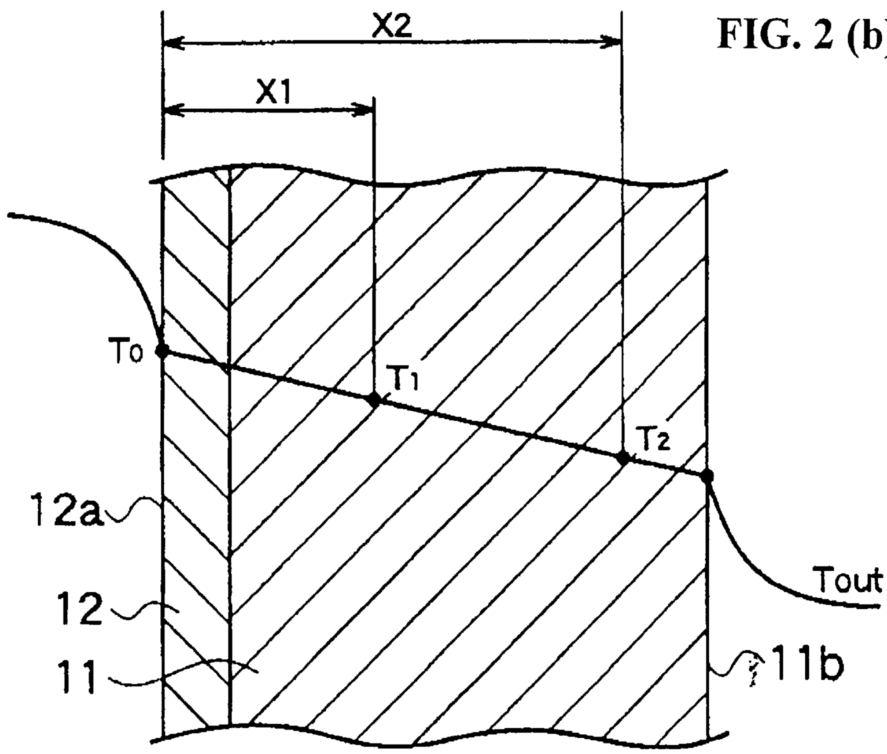

FIG. 2 (b)

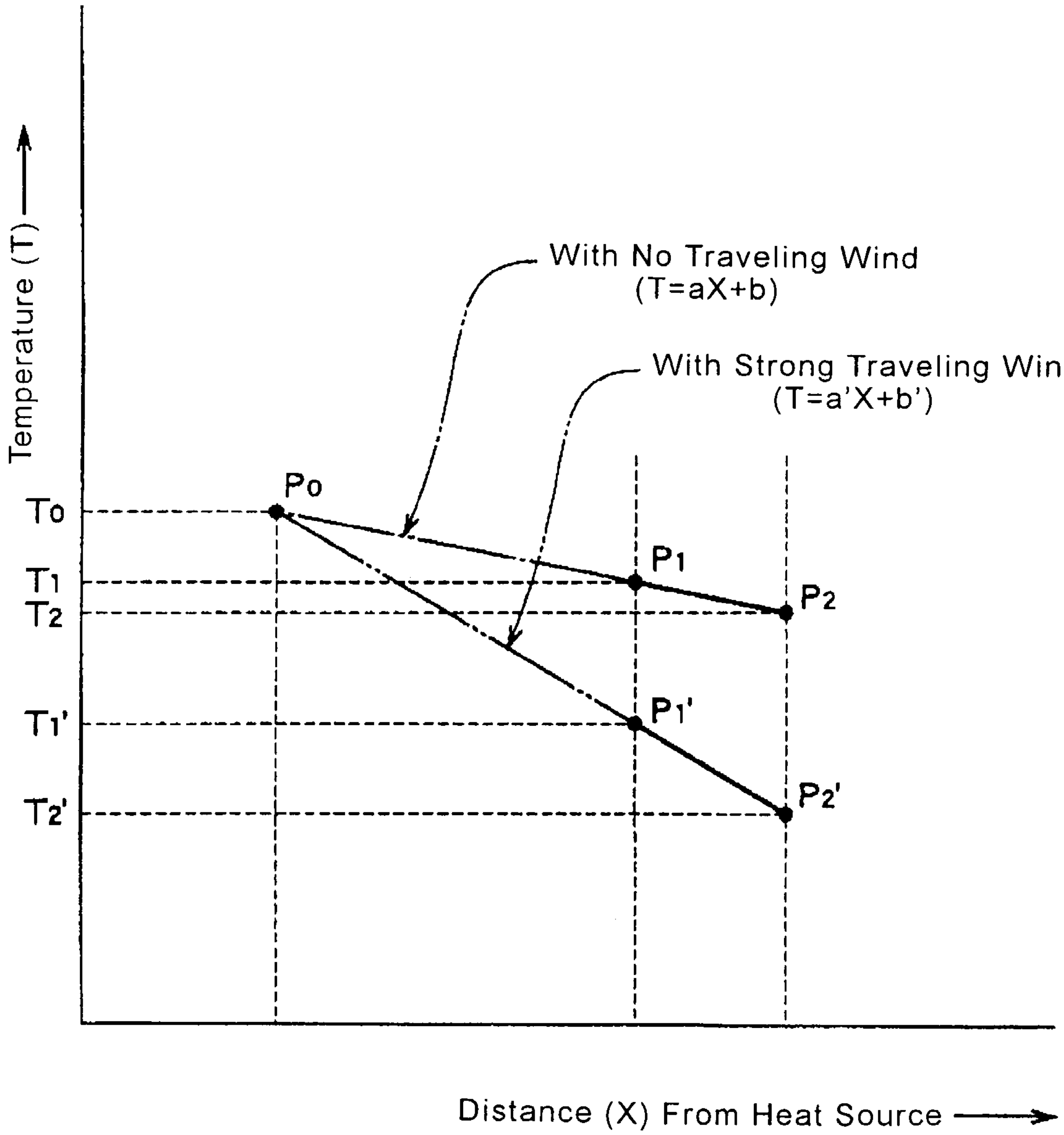
Temperature (T)
With No Traveling Wind
(T=aX+b)
With Strong Traveling Wind
(T=a'X+b')
Po
P1
P2
P1'
P2'
To
T1
T2
T1'
T2'
Distance (X) From Heat Source

FIG. 3

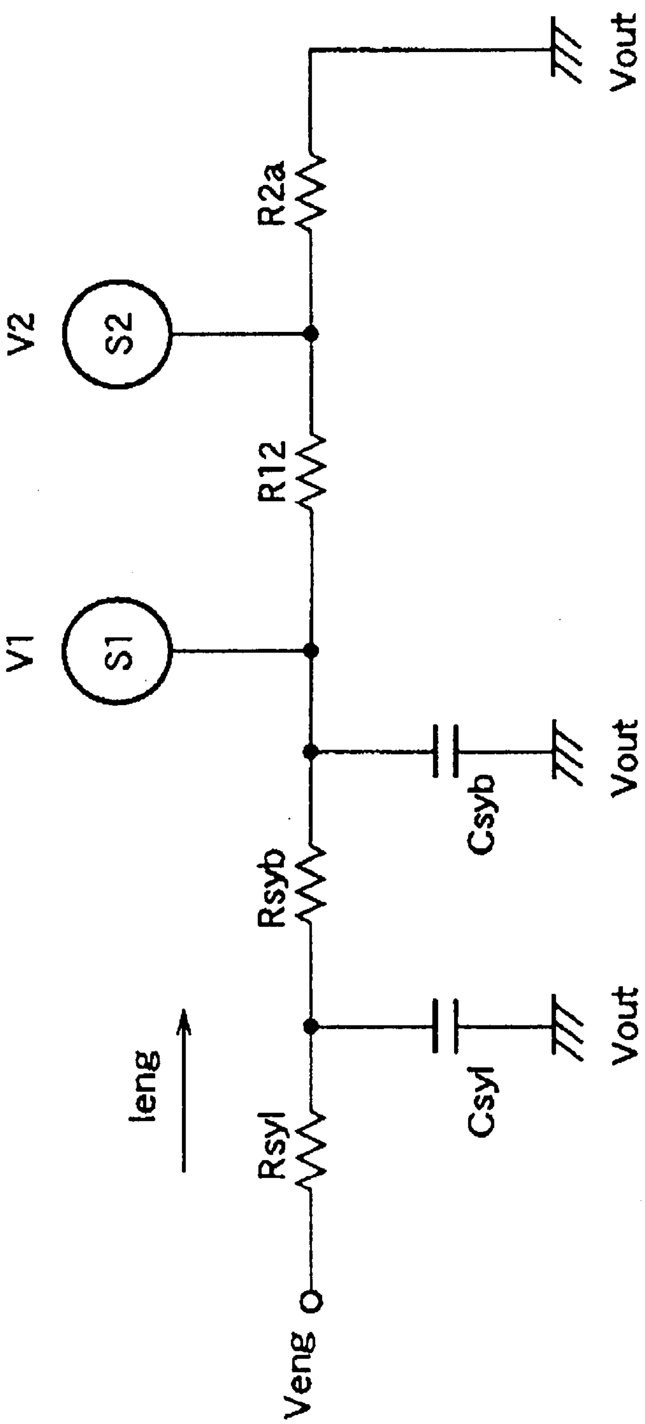
Veng
Rsyl
Ieng
Csyl
Vout
Rsyb
Csyb
Vout
V1
S1
R12
V2
S2
R2a
Vout

FIG. 4

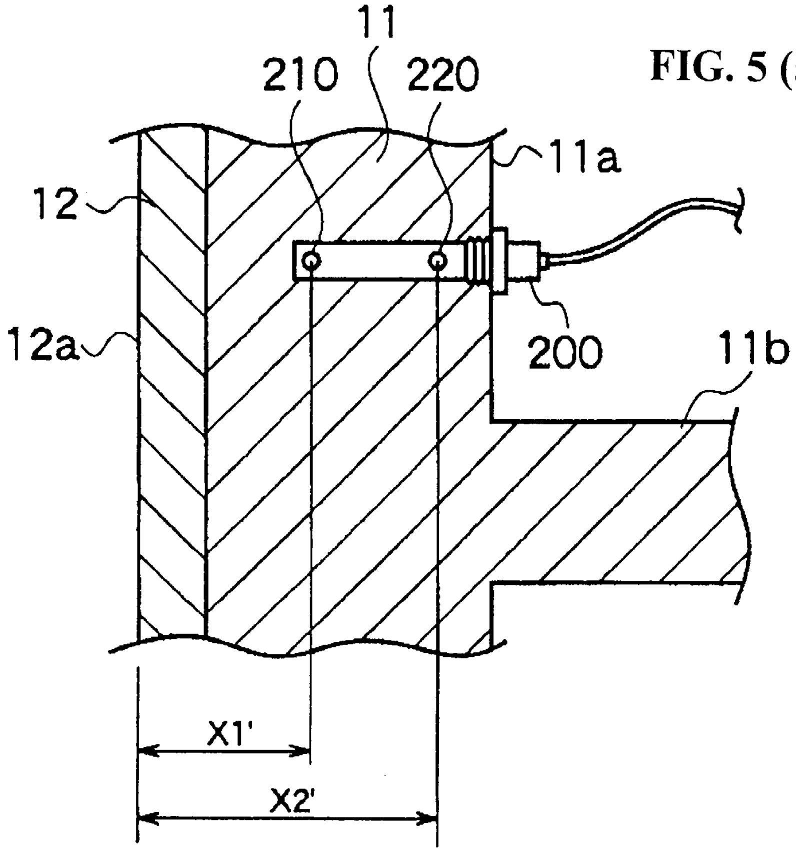
11
210
220
11a
12
12a
200
11b
X1'
X2'

FIG. 5 (a)

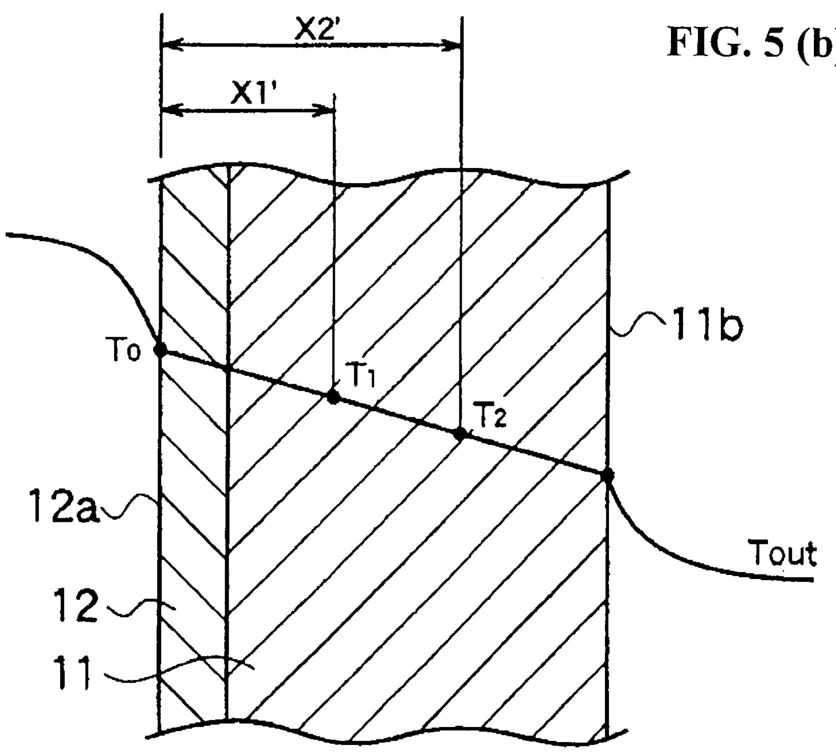
X2'
X1'
11b
To
T1
T2
12a
Tout
12
11

FIG. 5 (b)

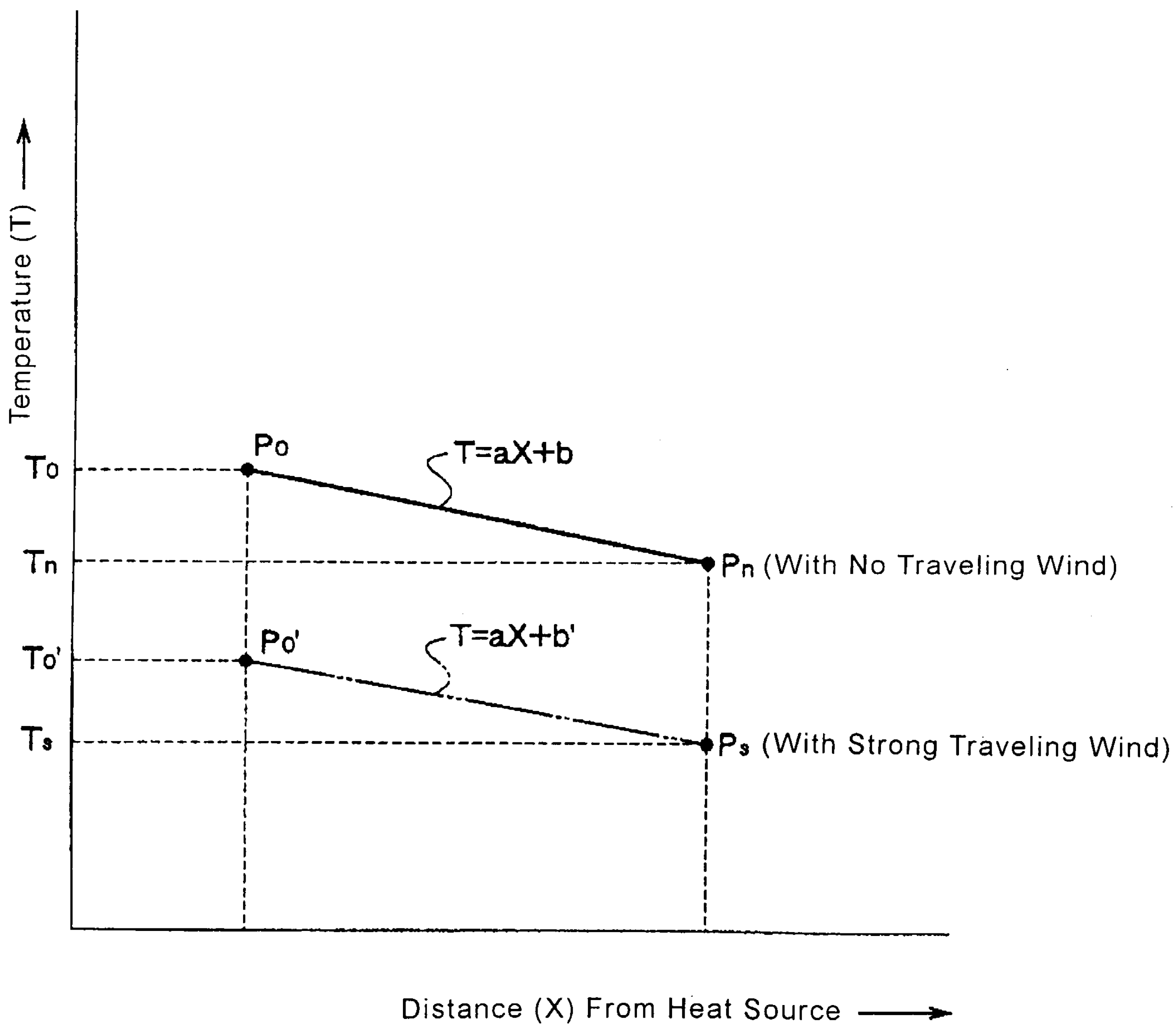
Temperature (T)
To
Tn
To'
Ts
Po
T=aX+b
Pn (With No Traveling Wind)
Po'
T=aX+b'
Ps (With Strong Traveling Wind)
Distance (X) From Heat Source

FIG. 6