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Description

[0001] The present invention relates to an engine and, in particular, to a stroke discriminating device in four-stroke having a plurality cylinder engine of fuel injection type.

[0002] A fuel injection type, four-stroke engine is configured, for example, to inject and supply fuel to an intake port or the like in an intake stroke and further to ignite the fuel at a moment around the end of a compression stroke. Accordingly, it is necessary to determine that in which strokes respective cylinders exist.

[0003] On the other hand, in the four-stroke engine, the intake, compression, combustion and exhaust strokes are performed while the crankshaft rotates twice (720°). Thus, the intake stroke and the combustion stroke, or the compression stroke and the exhaust stroke cannot be discriminated from each other only by detecting phases (rotational angular positions) of a crankshaft.

[0004] Conventionally, for example in JP10-227252A, a stroke discriminating device is suggested as one of those for the four-stroke engine. The suggested stroke discriminating device discriminates between the intake stroke and the combustion stroke, and between the compression stroke and the exhaust stroke, from mutual relationships between a phase of the crankshaft and intake pressures of the respective cylinders that change periodically.

[0005] However, the conventional stroke discriminating device discussed above has intake pressure detection tubes, which are connected to intake conduits of multiple cylinders respectively, merge together to detect a compound intake pressure, and discriminates the strokes from each other using a periodical change of the compound intake pressure that occurs with the rotation of the crankshaft, or discriminates the strokes using a stroke discriminating sensor(s).

[0006] Thus arises a problem that a structure for compounding the intake pressures is complicated. Also, there are problems regarding a space and an economical burden if the stroke discriminating sensor is used. Further, the crankshaft needs to rotate twice or more if the stroke discrimination is made by those measures. The discrimination among the strokes can take much time, accordingly.

[0007] As a result, for example, a self-starting motor is required to rotate longer when the engine is started, and the engine is likely to be judged sensuously that its startability is inferior.

[0008] Under the conventional circumstances discussed above, an object of the present invention is to provide an engine having a stroke discriminating device that has a simple structure and can reduce the number of rotation of the crankshaft that is necessary to complete the stroke discrimination.

[0009] This objective is solved in an inventive manner by an engine, in particular four-stroke engine, having at least two cylinders, which ignition timings differ from each other, and a stroke discriminating device for discriminating strokes of said at least two cylinders based upon a difference between intake pressures detected by intake pressure sensors for individually detecting intake pressures of said at least two cylinders.

[0010] Preferably, the stroke discriminating means compares a difference of one of the detected intake pressures and a pre-determined pressure threshold value with the other one of the detected intake values.

[0011] Further, preferably the engine comprises a plurality of cylinders, which ignition timings differ from each other, wherein any two of said plurality of cylinders are provided with intake pressure sensors for individually detecting intake pressures, and wherein the stroke discriminating means discriminates the strokes of said two cylinders based upon a difference between the intake pressures detected by said two intake pressure sensors.

[0012] Still further, preferably the engine comprises a plurality of cylinders, which ignition timings differ from each other, wherein each cylinder of the engine is provided with intake pressure sensors for individually detecting intake pressures, and wherein the stroke discriminating means discriminates the strokes of the cylinders based upon a difference between the intake pressures detected by intake pressure sensors for two cylinders out of said plurality of cylinders.

[0013] According to a preferred embodiment, the engine is a two-cylinder engine, wherein the stroke discriminating device is adapted to compare a first intake pressure of a first cylinder, one of said two cylinders, and a second intake pressure of a second cylinder, the other of the two cylinders, occurring at the same moment, to determine a pressure threshold value, and to determine that the first cylinder is in an intake stroke if said first intake pressure is lower than a difference between said second intake pressure and said pressure threshold value.

[0014] According to a further preferred embodiment, the engine is a four-cylinder engine, wherein the stroke discriminating means is adapted to compare a first intake pressure of a first cylinder, one of the four cylinders, and a second intake pressure of a second cylinder, another of the four cylinders, occurring at the same moment, to determine a pressure threshold value, and to determine that said first cylinder is in an intake stroke if said first intake pressure is lower than a difference between said second intake pressure and said pressure threshold value.

[0015] Beneficially, there is further provided a rotational speed detecting means for detecting an engine speed, wherein the stroke discriminating means is adapted to discriminate the strokes of two of the cylinders based upon a difference between the intake pressures of said two cylinders detected by said intake pressure sensors if the engine speed detected by the rotational speed detecting means is less than a predetermined speed threshold value.

[0016] In the following, the present invention is ex-

plained in further detail with respect to several embodiments thereof in conjunction with the accompanying drawings, wherein:

Fig. 1 is a whole constructive view of a stroke discriminating device of a first embodiment,

Fig. 2 is a constructive block diagram of a cylinder discriminating device in the stroke discriminating device of the first embodiment;

Figs. 3 is a diagram of an intake pressure change characteristic for describing a stroke discriminating operation of the stroke discriminating device of the first embodiment;

Fig. 4 is a flowchart for describing the stroke discriminating operation of the stroke discriminating device of the first embodiment;

Fig. 5 is a diagram of an intake pressure characteristic of a stroke discriminating device of a second embodiment in which the teaching of the present embodiment is applied to a four-cylinder engine;

Fig. 6 is a flowchart for describing a processing operation of the stroke discriminating device in the second embodiment;

Fig. 7 is a flowchart for describing a processing operation of a stroke discriminating device in a variation of the second embodiment;

Fig. 8 is a flowchart for describing a processing operation of a stroke discriminating device in another variation of the second embodiment;

Fig. 9 is a characteristic diagram, showing relationships between an engine speed and an intake pressure for describing timings at which a stroke discrimination of a third embodiment is performed; and

Fig. 10 is a flowchart for describing a processing operation of a stroke discriminating device in the third embodiment.

[0017] Hereunder, embodiments are described with reference to the accompanying drawings, in which:

[0018] Fig. 1 is a view, schematically showing the whole configuration for describing a cylinder discriminating device in accordance with a first embodiment.

[0019] As shown in Fig. 1, the cylinder discriminating device of the present embodiment has a V-type, two-cylinder engine 1, in the first place. In the V-type, two-cylinder engine 1, a first cylinder 3 and a second cylinder 4 are disposed above a crankcase 2 to form a Vee bank with a predetermined bank angle.

[0020] First and second cylinder heads 5, 6 are disposed above and coupled with the first and second cylinders 3, 4, respectively.

[0021] Within a first cylinder bore 3a and a second cylinder bore 4a which are formed in the first cylinder 3 and the second cylinder 4, respectively, a piston 7 and a piston 8 are slidably disposed, respectively.

[0022] The piston 7 and the piston 8 are coupled with a crank pin 11a of a crankshaft 11, which is common to both of the cylinders, by a connecting rod 9 and a connecting rod 10, respectively.

[0023] Generally, the pistons 7 and 8 move up and down with the rotation of the crankshaft 11 to perform the intake, compression, combustion and exhaust strokes in sequence.

[0024] An intake port 5a and an exhaust port 5b are formed together in the cylinder head 5 disposed atop the first cylinder bore 3a. The intake port 5a and the exhaust port 5b are opened and closed by an intake valve 12 and an exhaust valve 12a, respectively, both of which are disposed at openings which are communicatively formed to the cylinder head. Also, an ignition plug 5c is disposed between the intake port 5a and the exhaust port 5b.

[0025] Similarly, an intake port 6a and an exhaust port 6b are formed together in the second cylinder head 6 disposed atop the second cylinder bore 4a. The intake port 6a and the exhaust port 6b are opened and closed by an intake valve 13 and an exhaust valve 13a, respectively, both of which are disposed at openings which are communicatively formed to the cylinder head. Also, an ignition plug 6c is disposed between the intake port 6a and the exhaust port 6b.

[0026] Additionally, portions of the intake ports 5a and 6a are unitarily formed with and within the cylinder heads 5 and 6, respectively, and the remainder portions thereof are formed with intake pipes or the like other than the cylinder heads 5, 6.

[0027] Also, fuel injection valves 14 and 15 are disposed adjacent to the intake valves 12 and 13 upstream thereof in the intake ports 5a and 6a, respectively. In addition, throttle valves 16 and 17 are disposed upstream of the fuel injection valves 14 and 15, respectively.

[0028] Also, a first intake pressure sensor 18 and a second intake pressure sensor 19 that detect an intake pressure are connected to portions located upstream and adjacent to the throttle valves 16 and 17, respectively. An air cleaner 20, which is common to both cylinders, is connected to ends of the intake ports 5a and 6a at upstream ends of the sensors.

[0029] Additionally, the first intake pressure sensor 18 and the second intake pressure sensor 19 are usually furnished to detect an operational load of an engine in general. In this embodiment, however, detection values of the intake pressure sensors that are provided for detecting the loads are also utilized for discriminating strokes.

[0030] Also, a crank sensor 21 is furnished to detect a

rotational angular position of the crankshaft 11 (rotational number of the crankshaft 11) that rotates within the crankcase 2. This crank sensor 21 is positioned, for example, opposing to projections and recesses engraved with a preset pitch on a circumferential surface or the like of an encoder that is mounted on an end of the crankshaft 11. The crank sensor 21 generates crank pulses appearing corresponding to the pitch of the projections and recesses. The engine speed is detected by the density of the crank pulses per unit time.

[0031] A detection value output from this crank sensor 21 and detection value outputs from the first intake pressure sensor 18 and the second intake pressure sensor 19 are inputted to an electronic control unit (ECU) 22.

[0032] The control unit (ECU) 22 is a control device to control an operational condition of this V-type, two-cylinder engine 1, and controls a fuel injection timing and an ignition timing based upon the detection values inputted from the first and second intake pressure sensors 18 and 19 and the crank sensor 21.

[0033] Fig. 2 is a block diagram of a stroke discriminating device in connection with the V-type, two-cylinder engine 1. Incidentally, in Fig. 2, blocks that have the same functions as those shown in Fig. 1 are indicated by the same reference numerals as Fig. 1.

[0034] As shown in Fig. 2, the electronic control unit (ECU) 22 of the cylinder discriminating device in this embodiment comprises a CPU (central processing unit) 23, a power supply circuit 24 connected to the CPU 23 through a bus, an input I/F (interface) circuit 25 and an actuator drive circuit 26.

[0035] Electric power is inputted to the power supply circuit 24 from an external main power source. Outputs of the detection values of the crank sensor 21, #1 (first cylinder, indicated similarly hereunder) intake pressure sensor 18 and #2 intake pressure sensor 19 are inputted to the input I/F (interface) circuit 25.

[0036] The CPU 23 is supplied with the electric power from the power supply circuit 24, and controls drive timings of injectors of the fuel injection valves 14 and 15 and ignition coils of the ignition plugs 5c and 6c through the actuator drive circuit 26 based upon the detection values of the crank sensor 21, #1 intake pressure sensor 18 and #2 intake pressure sensor 19, inputted through the input I/F (interface) circuit 25.

[0037] For instance, the top dead center and the bottom dead center are determined from the output values of the crank sensor 21, and the ignition timing is controlled to be advanced or retarded, using the top dead center as a reference.

[0038] In the stroke discrimination of the present embodiment, the control unit 22 compares a first intake pressure "#1Pb" of the first cylinder 3a and a second intake pressure "#2Pb" of the second cylinder 4a with each other, and determines that the first cylinder 3a is in the intake stroke if the first intake pressure "#1Pb" is lower than a difference between the second intake pressure "#2Pb" and a predetermined pressure threshold value.

[0039] Fig. 3 is a diagram, showing an intake pressure change characteristic for describing a stroke discriminating operation of the stroke discriminating device in this embodiment. Fig. 3 shows, in sequence from the top, an operation timing of a starter SW (switch), operation timings of the first cylinder's strokes, operation timings of the second cylinder's strokes, crank pulses, an intake pressure waveform of the first cylinder, and an intake pressure waveform of the second cylinder.

[0040] In the V-type, two-cylinder engine 1 of this embodiment, as shown in Fig. 3, the respective strokes are decided such that the second cylinder bore 4a is in the combustion stroke while the first cylinder bore 3a is in the intake stroke. Accordingly, the first cylinder bore 3a and the second cylinder bore 4a can be cylinders that have different ignition timings.

[0041] Additionally, in this regard, the crank pin 11a is common to the first cylinder bore 3a and the second cylinder bore 4a as shown in Fig. 1. However, because the first cylinder bore 3a and the second cylinder bore 4a form the Vee bank, intervals of the ignition timings are irregularly parted intervals corresponding to this bank angle. Specifically, for example, an initial ignition interval is "360°- the bank angle" and the next ignition interval is "360°+ the bank angle."

[0042] For example, as shown in Fig. 3, the intake pressure in the intake ports does not change so much during strokes such as the compression, combustion and exhaust strokes in which the intake valves 12 and 13 are closed. The intake pressure, however, falls greatly during a stroke such as the intake stroke in which the intake valves are open.

[0043] Thus, in all the engines that have a phase difference between intake strokes of respective cylinders, the intake pressures of both cylinders greatly differ from each other at a moment when one of the cylinders is in the intake stroke. The cylinder that has a lower intake pressure thus can be determined to be in the intake stroke at the moment when the difference between the intake pressures occurs.

[0044] In this occasion, a range between a crank angle at a moment when the great difference between the intake pressures occurs first and another crank angle at a moment when the great difference between the intake pressures occurs second is "360°- the bank angle" or "360°+ the bank angle" in the V-type, two-cylinder engine 1. The discrimination of the intake stroke thus ends while the crankshaft 11 generally rotates once. That is, the number of rotation of the crankshaft that is necessary to complete the stroke discrimination can be reduced to once.

[0045] Fig. 4 is a flowchart, illustrating the stroke discriminating operation of the stroke discriminating device configured in accordance with the first embodiment.

[0046] In Fig. 4, upon a start of the intake stroke discriminating operation, instantaneous values "#1Pb" and "#2Pb", detected by the first intake pressure sensor 18 and the second intake pressure sensor 19 are read (step

S1).

[0047] Then, "the first intake pressure #1Pb" and "the second intake pressure #2Pb - the pressure threshold value" are compared with each other (step S2).

[0048] If "the first intake pressure #1Pb" is smaller than "the second intake pressure #2Pb - the pressure threshold value" in this determination ("Yes" in S2), the first cylinder bore 3a is determined to be in the intake stroke (step S3), and the stroke discriminating operation ends (step S6).

[0049] Also, in the determination in the step S2, if "the first intake pressure #1Pb" is not smaller than "the second intake pressure #2Pb - the pressure threshold value," i.e., when "the first intake pressure #1Pb" is larger than "the second intake pressure #2Pb - the pressure threshold value" ("No" in S2), "the second intake pressure #2Pb" and "the first intake pressure #1Pb - the pressure threshold value" are uninterruptedly compared with each other (step S4).

[0050] If "the second intake pressure #2Pb" is smaller than "the first intake pressure #1Pb - the pressure threshold value" ("Yes" in S4), the second cylinder bore 4a is determined to be in the intake stroke (step S5). Then, the stroke discriminating operation ends (step S6).

[0051] On the other hand, if "the second intake pressure #2Pb" is not smaller than "the first intake pressure #1Pb - the pressure threshold value," i.e., when "the second intake pressure #2Pb" is larger than "the first intake pressure #1Pb - the pressure threshold value" ("No" in S2), the program returns to the process of the step S1 and the processes of steps S1 to S5 are repeated.

[0052] As thus described, in the present embodiment, a difference between the first intake pressure #1Pb and the second intake pressure #2Pb is discriminated using the predetermined pressure threshold value. If a predetermined difference is discriminated, a cylinder which has a lower intake pressure is determined to be in the intake stroke.

[0053] Thus, the number of rotation of the crankshaft 11 that is necessary to complete the stroke discrimination can be reduced generally to once. A period of time for rotating a self-starting motor when the engine is started can be greatly shortened, and engine start feeling can be greatly improved, accordingly.

[0054] Also, the structure is quite simple because the intake pressure sensors which are usually furnished for detecting the operational loads of the engine in general is used to make the stroke discrimination. In addition, because no new sensors need to be added, the stroke discriminating device does not invite a rise of cost and thus is economical.

[0055] Fig 5 is a diagram of an intake pressure characteristic of a stroke discriminating device configured in accordance with a second embodiment in which the teaching of the present embodiment is applied to a four-cylinder engine. Fig. 5 shows, in sequence from the top, #1 (first cylinder, indicated similarly hereunder) stroke, #2 stroke, #3 stroke, #4 stroke, #1 intake pressure waveform, #2 intake pressure waveform, #3 intake pressure waveform, and #4 intake pressure waveform.

[0056] Fig. 6 is a flowchart, illustrating a processing operation of the stroke discriminating device in the second embodiment.

[0057] In this second embodiment, all the intake ports of the first to fourth cylinders have the intake pressure sensor.

[0058] In the second embodiment, as shown in Fig. 6, instantaneous values #1Pb, #2Pb, #3Pb and #4Pb of the intake pressures of all the cylinders are read (step S11).

[0059] Initially, "the first intake pressure #1Pb" and "the fourth intake pressure #4Pb - the pressure threshold value" are compared with each other (step S12).

[0060] In this comparative discrimination, if "the first intake pressure #1Pb" is smaller than "the fourth intake pressure #4Pb - the pressure threshold value" ("Yes" in S12), the first cylinder is determined to be in the intake stroke (step S13). Then, the stroke discrimination ends.

[0061] On the other hand, in the comparative discrimination in the step S12, if "the first intake pressure #1Pb" is not smaller than "the fourth intake pressure #4Pb - the pressure threshold value," i.e., when "the first intake pressure #1Pb" is larger than "the fourth intake pressure #4Pb - the pressure threshold value" ("No" in S12), "the second intake pressure #2Pb" and "the third intake pressure #3Pb - the pressure threshold value" are uninterruptedly compared with each other (step S14).

[0062] If "the second intake pressure #2Pb" is smaller than "the third intake pressure #3Pb - the pressure threshold value" ("Yes" in S14), the second cylinder is determined to be in the intake stroke (step S15). Then, the stroke discriminating operation ends.

[0063] Similarly, if "the third intake pressure #3Pb" is smaller than "the second intake pressure #2Pb - the pressure threshold value," the third cylinder is determined to be in the intake stroke (steps S16 and S17).

[0064] Also, if "the fourth intake pressure #4Pb" is smaller than "the first intake pressure #1Pb - the pressure threshold value," the fourth cylinder is determined to be in the intake stroke (steps S18 and S19).

[0065] As thus described, in the second embodiment, all of the four cylinders have the intake pressure sensor, and each sensor detects a difference between the intake pressures of the respective cylinders. The intake cylinder is discriminated based upon the differences. Thus, the number of rotation of the crankshaft that is necessary to complete the stroke discrimination can be reduced generally to a half rotation. The startability is further improved in this embodiment, accordingly.

[0066] Although all of the four cylinders have the intake pressure sensor in the second embodiment, two of those four cylinders may have the intake pressure sensor, and thereby, the same actions and effects as the first embodiment can be obtained. This arrangement is described below as a variation of the second embodiment.

[0067] Fig. 7 is a flowchart, illustrating a processing operation of the stroke discriminating device in the vari-

ation of the second embodiment.

[0068] In this variation, only two cylinders in the four-cylinder engine have the intake pressure sensor. In the variation shown in Fig. 7, the first cylinder and the fourth cylinder have the intake pressure sensor.

[0069] In Fig. 7, first, instantaneous values of the first intake pressure #1Pb and the fourth intake pressure #4Pb are read (step S21).

[0070] If "the first intake pressure #1Pb" is smaller than "the fourth intake pressure #4Pb - the pressure threshold value," the first cylinder is determined to be in the intake stroke (steps S21 to S23).

[0071] On the other hand, if "the fourth intake pressure #4Pb" is smaller than "the first intake pressure #1Pb - the pressure threshold value," the fourth cylinder is determined to be in the intake stroke (steps S24 and 25).

[0072] Fig. 8 is a flowchart, illustrating a processing operation of the stroke discriminating device in another variation of the second embodiment. In the variation shown in Fig. 8, the first cylinder and the third cylinder have the intake pressure sensor.

[0073] In Fig. 8, first, instantaneous values of the first intake pressure #1Pb and the third intake pressure #3Pb are read (step S31).

[0074] If "the first intake pressure #1Pb" is smaller than "the third intake pressure #3Pb - the pressure threshold value," the first cylinder is determined to be in the intake stroke (steps S31 to S33).

[0075] On the other hand, if "the third intake pressure #3Pb" is smaller than "the first intake pressure #1Pb - the pressure threshold value," the third cylinder is determined to be in the intake stroke (steps S34 and S35).

[0076] As described above, the same actions and effects as those of the first embodiment can be obtained only when two cylinders of the four cylinders have the intake pressure sensor.

[0077] Turning to another aspect, occasionally, inconvenience such as a backfire due to imperfect combustion is likely to occur if, for example, ignition timings are deviated in a range of high engine speed such as 4,000 to 5,000 rpm under an engine brake is made with a throttle being closed.

[0078] The imperfect combustion and the backfire occur when an amount of fuel that are injected to each cylinder is not proper, or when the ignition timings do not meet the intake or compression stroke, and indicate that the stroke discrimination by the control unit against the engine is not appropriate.

[0079] In connection with a third embodiment, a processing operation of a stroke discriminating device that properly performs the stroke discrimination for a four-stroke engine irrespective of those performed in a low speed or in a high speed is described.

[0080] Fig. 9 is a characteristic diagram that indicates relationships between an engine speed and an intake pressure for describing timings at which the stroke discrimination of the third embodiment is performed.

[0081] Fig. 9 shows, in sequence from the top, #1 (first cylinder, indicated similarly hereunder) stroke, #2 stroke, crankshaft encoder pulses, #1 intake pressure waveform and #2 intake pressure waveform both at the start time, and #1 intake pressure waveform and #2 intake pressure waveform both in a high speed operation.

[0082] As shown in Fig. 9, in a low speed at the start time of the engine, the #2 intake pressure waveform is the minimum at the timing t1 of the crankshaft encoder pulse output and the #2 intake stroke is discriminated. Also, the #1 intake pressure waveform is the minimum at the timing t2 of the crankshaft encoder pulse output and the #1 intake stroke is discriminated.

[0083] Accordingly, all the control unit (ECU) 22 needs to do at the start time of the engine is to make ignitions at ignition timings that are decided based upon the intake stroke that has been discriminated as described above.

[0084] However, in a high speed operation of the engine, as indicated by the #1 intake pressure waveform and the #2 intake pressure waveform both of which appear at the bottom of Fig. 9 for showing the high speed operation, the large-small relationships between the instantaneous values "#1Pb" and "#2Pb" of the first intake pressure sensor 18 and the second intake pressure sensor 19 those of which are given in the #1 intake pressure waveform and the #2 intake pressure waveform, respectively, at the timings t1 and t2 of the foregoing crankshaft encoder pulse output are reversed in comparison with those at the start of the engine.

[0085] That is, in the high speed operation, the magnitudes of the respective intake pressures at the timings t1 and t2 of the crankshaft encoder pulse outputs, at which the intake stroke should be determined by the intake pressures, are reversed from those at the start time of the engine.

[0086] Thus, if the ignition control is conducted using the discrimination performed for the #2 intake stroke and the #1 intake stroke at the timings t1 and t2 of the crankshaft encoder pulse outputs in a low speed, the control can be improper.

[0087] In this embodiment, the stroke discrimination is performed in a range lower than a predetermined engine speed so as to maintain the improvement of the startability and also to inhibit the imperfect combustion, the backfire and so forth in the high speed operation from occurring.

[0088] Fig. 10 is a flowchart, illustrating a processing operation of the stroke discriminating device in the third embodiment as such discussed.

[0089] In Fig. 10, the electronic control unit (ECU) power supply is activated, and the instantaneous values #1Pb" and #2Pb" of the first intake sensor 18 and the second intake pressure sensor 19 are read (step S42).

[0090] At this moment, in this embodiment, a determination whether the engine speed is less than a predetermined speed threshold value or not is performed (step 43).

[0091] The predetermined speed threshold value of the foregoing engine speed is, in Fig. 9, an engine speed

adjacent to the speed at which the large-small relationships of the values #1Pb and #2Pb are reversed at the timings t1 and t2 of the crankshaft encoder pulse outputs.

[0092] If the engine speed is less than the predetermined speed threshold value ("Yes" in S43), the control unit executes the steps S44 to S48, completes the stroke discrimination process of the cylinders, and moves to the sequential ignition/ injection control (step S49).

[0093] Additionally, the processes of the steps S44 to S48 are the same as the steps S2 to S6 of the stroke discriminating process in the first embodiment shown in Fig. 4.

[0094] On the other hand, if the engine speed exceeds the predetermined engine speed in the determination of the engine speed at the step S43 ("No" in S43), the control unit conducts, for the time being, a process using an ignition/ injection control (group control) in which the same phases are applied in common to those two cylinders, without discriminating the intake stroke (step S41), and repeats the processes of the steps S42 and S43.

[0095] Therefore, in the high speed operation, the inconveniences such as the imperfect combustion and the backfire that are caused by conducting the ignition/ injection control in accordance with the strokes that have been discriminated in the low speed operation when the engine starts can be inhibited from occurring, although the large-small relationships between the first intake pressure #1Pb and the second intake pressure #2Pb are reversed from those at the start time.

[0096] Additionally, in the third embodiment, the stroke discrimination process of the cylinders based upon the engine speed was described in connection with the two-cylinder engine. Needless to say, however, not being limited to the engine, the four-cylinder engine described in the foregoing second embodiment can be applied with the stroke discrimination process of the cylinders based upon the engine speed.

[0097] As thus described, regardless of a two-cylinder engine or a four-cylinder engine, by adding the condition that an engine speed is less than a threshold value, the discrimination of the intake stroke can be performed more accurately, and the inconveniences such as the imperfect combustion and the backfire in a high speed operation can be inhibited.

[0098] Within the foregoing description, there is described a particularly preferable embodiment of a stroke discriminating device for a four-stroke engine.

[0099] This preferable stroke discriminating device for a four-stroke engine is configured by comprising: a plurality of cylinders which ignition timings differ from each other; intake pressure sensors for individually detecting intake pressures of any two of said plurality of cylinders; and stroke discriminating means for discriminating the strokes of said two cylinders based upon a difference between the intake pressures detected by said two intake pressure sensors.

[0100] In accordance with this stroke discriminating device, each stroke of the cylinder is discriminated based upon the difference between the intake pressures of two cylinders which ignition timings differ from each other. That is, for example, the first cylinder is determined to be in the intake stroke if the first intake pressure is lower than the difference between the second intake pressure and the threshold value. Thus, the number of rotation of the crankshaft that is necessary to complete the stroke discrimination can be reduced.

[0101] This stroke discriminating device is configured, for example, to compare a first intake pressure of a first cylinder and a second intake pressure of a second cylinder, occurring at the same moment, and to determine that the first cylinder is in an intake stroke if the first intake pressure is lower than a difference between the second intake pressure and a predetermined pressure threshold value.

[0102] Also, even more accurate intake strokes of having a plurality cylinder can be determined by adding the determination whether the engine speed is less than the speed threshold value before discriminating the strokes of the cylinders based upon the difference between the intake pressures.

[0103] Thereby, an inconvenience such that, for example, an engine stops during a high engine speed under a condition that an engine brake is made can be avoided.

[0104] Likewise, there is described a beneficial embodiment of the stroke discriminating device for a four-stroke engine configured by comprising: a plurality of cylinders which ignition timings differ from each other; intake pressure sensors for individually detecting intake pressures of any two of said plurality of cylinders; rotational speed detecting means for detecting an engine speed; and stroke discriminating means for discriminating the strokes of said two cylinders based upon a difference between the intake pressures of said two cylinders detected by said intake pressure sensors if the engine speed detected by the rotational speed detecting means is less than a predetermined speed threshold value.

[0105] The stroke discriminating means are configured, for example, to compare a first intake pressure of a first cylinder and a second intake pressure of a second cylinder, occurring at the same moment, and determine a speed threshold value, if said engine speed is less than said predetermined speed threshold value; and configured to determine that said first cylinder is in an intake stroke if said first intake pressure is lower than a difference between said second intake pressure and said speed threshold value.

[0106] Thus, in short, in order to provide a cylinder discriminating device for a four-stroke engine that has a simple structure and can reduce the number of rotation of a crankshaft that is necessary for completion of the stroke discrimination according to a most preferred embodiment, there are included intake pressure sensors for detecting intake pressures of two cylinders in a plurality of cylinders which ignition timings differ from each other, wherein the stroke discriminating means discriminates each stroke of the cylinders based upon a difference be-

tween the intake pressures detected by those two intake pressure sensors.

Claims

1. Four-stroke engine (1), having at least two cylinders (3,4), which ignition timings differ from each other, and a stroke discriminating device for discriminating strokes of said at least two cylinders (3,4) based upon a difference between intake pressures (Pb) detected by intake pressure sensors (18,19) for individually detecting intake pressures (Pb) of said at least two cylinders (3,4).

2. Engine according to claim 1, **characterized in that** the stroke discriminating means compares a difference of one of the detected intake pressures and a pre-determined pressure threshold value with the other one of the detected intake values.

3. Engine according to claim 1 or 2, **characterized in that** the engine comprises a plurality of cylinders, which ignition timings differ from each other, wherein any two of said plurality of cylinders are provided with intake pressure sensors for individually detecting intake pressures, and wherein the stroke discriminating means discriminates the strokes of said two cylinders based upon a difference between the intake pressures detected by said two intake pressure sensors.

4. Engine according to one of the claims 1 to 3, **characterized in that** the engine comprises a plurality of cylinders, which ignition timings differ from each other, wherein each cylinder of the Engine is provided with intake pressure sensors for individually detecting intake pressures, and wherein the stroke discriminating means discriminates the strokes of the cylinders based upon a difference between the intake pressures detected by intake pressure sensors for two cylinders out of said plurality of cylinders.

5. Engine according to one of the claims 2 to 4, **characterized in that** the engine is a two-cylinder engine, wherein the stroke discriminating device is adapted to compare a first intake pressure (#1 Pb) of a first cylinder (3), one of said two cylinders (3,4), and a second intake pressure (#2Pb) of a second cylinder (4), the other of the two cylinders (3,4), occurring at the same moment, to determine a pressure threshold value, and to determine that the first cylinder (3) is in an intake stroke if said first intake pressure (#1 Pb) is lower than a difference between said second intake pressure (#2Pb) and said pressure threshold value.

6. Engine according to one of the claims 2 to 4, **characterized in that** the engine is a four-cylinder engine, wherein the stroke discriminating means is adapted to compare a first intake pressure (#1Pb) of a first cylinder (#1), one of the four cylinders (#1,#2,#3,#4), and a second intake pressure (#2Pb) of a second cylinder (#2), another of the four cylinders (#1,#2,#3,#4), occurring at the same moment, to determine a pressure threshold value, and to determine that said first cylinder (#1) is in an intake stroke if said first intake pressure (#1Pb) is lower than a difference between said second intake pressure (#2Pb) and said pressure threshold value.

7. Engine according to one of the claims 1 to 6, **characterized by** a rotational speed detecting means (21) for detecting an engine speed, wherein the stroke discriminating means is adapted to discriminate the strokes of two of the cylinders based upon a difference between the intake pressures of said two cylinders detected by said intake pressure sensors if the engine speed detected by the rotational speed detecting means is less than a predetermined speed threshold value.

Patentansprüche

1. Viertaktmotor (1), der wenigstens zwei Zylinder (3, 4), deren Zündzeitpunkte sich voneinander unterscheiden, und eine Hub-Unterscheidungseinrichtung aufweist, mit der Hübe der wenigstens zwei Zylinder (3, 4) auf Basis einer Differenz zwischen Ansaugdrücken (Pb) unterschieden werden, die durch Ansaugdruck-Sensoren (18, 19) zum individuellen Erfassen von Ansaugdrükken (Pb) der wenigstens zwei Zylinder (3, 4) erfasst werden.

2. Motor nach Anspruch 1, **dadurch gekennzeichnet, dass** die Hub-Unterscheidungseinrichtung eine Differenz zwischen einem der erfassten Ansaugdrücke und einem vorgegebenen Druck-Schwellenwert mit dem anderen der erfassten Ansaugwerte vergleicht.

3. Motor nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** der Motor eine Vielzahl von Zylindern umfasst, deren Zündzeitpunkte sich voneinander unterscheiden, wobei jeweils zwei der Vielzahl von Zylindern mit Ansaugdruck-Sensoren zum individuellen Erfassen von Ansaugdrücken versehen sind und die Hub-Unterscheidungseinrichtung die Hübe der zwei Zylinder auf Basis einer Differenz zwischen den durch die zwei Ansaugdruck-Sensoren erfassten Drücken unterscheidet.

4. Motor nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** der Motor eine Vielzahl von Zylindern umfasst, deren Zündzeitpunkte sich voneinander unterscheiden, wobei jeder Zylinder des

Motors mit Ansaugdruck-Sensoren zum individuellen Erfassen von Ansaugdrücken versehen ist und die Hub-Unterscheidungseinrichtung die Hübe der Zylinder auf Basis einer Differenz zwischen den durch die Ansaugdruck-Sensoren für zwei Zylinder der Vielzahl von Zylindern erfassten Ansaugdrücke unterscheidet.

5. Motor nach einem der Ansprüche 2 bis 4, **dadurch gekennzeichnet, dass** der Motor ein Zweizylindermotor ist, wobei die Hub-Unterscheidungseinrichtung so eingerichtet ist, dass sie einen ersten Ansaugdruck (#1Pb) eines ersten Zylinders (3), d. h. eines der zwei Zylinder (3, 4), und einen zweiten Ansaugdruck (#2Pb) eines zweiten Zylinders (4), d. h. des anderen der zwei Zylinder (3, 4), die in dem gleichen Moment auftreten, vergleicht, um einen Druck-Schwellenwert zu bestimmen, und feststellt, dass sich der erste Zylinder (3) in einem Ansaughub befindet, wenn der erste Ansaugdruck (#1Pb) niedriger ist als eine Differenz zwischen dem zweiten Ansaugdruck (#2Pb) und dem Druck-Schwellenwert.

6. Motor nach einem der Ansprüche 2 bis 4, **dadurch gekennzeichnet, dass** der Motor ein Vierzylindermotor ist, wobei die Hub-Unterscheidungseinrichtung so eingerichtet ist, dass sie einen ersten Ansaugdruck (#1Pb) eines ersten Zylinders (#1), d. h. eines der vier Zylinder (#1, #2, #3, #4), sowie einen zweiten Ansaugdruck (#2Pb) eines zweiten Zylinders (#2), d. h. eines anderen der vier Zylinder (#1, #2, #3, #4), die in dem gleichen Moment auftreten, vergleicht, um einen Druck-Schwellenwert zu bestimmen, und feststellt, dass sich der erste Zylinder (#1) in einem Ansaughub befindet, wenn der erste Ansaugdruck (#1 Pb) niedriger ist als eine Differenz zwischen dem zweiten Ansaugdruck (#2Pb) und dem Druck-Schwellenwert.

7. Motor nach einem der Ansprüche 1 bis 6, **gekennzeichnet durch** eine Drehzahl-Erfassungseinrichtung (21) zum Erfassen einer Motordrehzahl, wobei die Hub-Unterscheidungseinrichtung so eingerichtet ist, dass sie die Hübe von zwei der Zylinder auf Basis einer Differenz zwischen den **durch** die Ansaugdruck-Sensoren erfassten Ansaugdrücken der zwei Zylinder unterscheidet, wenn die **durch** die Drehzahl-Erfassungseinrichtung erfasste Motordrehzahl unter einem vorgegebenen Drehzahl-Schwellenwert liegt.

Revendications

1. Moteur à quatre temps (1) comportant au moins deux cylindres (3, 4) dont les réglages d'allumage sont différents l'un de l'autre, et un discriminateur de courses de piston pour distinguer les courses de piston dans lesdits cylindres (3, 4) sur la base d'une différence entre les pressions d'amission (Pb) détectées par des capteurs de pression d'admission (18, 19) pour détecter individuellement les pressions d'admission (Pb) desdits cylindres (3, 4).

2. Moteur selon la revendication 1, **caractérisé en ce que** les moyens discriminateurs de courses de piston comparent une différence entre l'une des pressions d'admission détectées et une valeur seuil de pression prédéterminée, avec l'autre valeur d'admission détectée.

3. Moteur selon la revendication 1 ou 2, **caractérisé en ce qu'**il comprend plusieurs cylindres dont les réglages d'allumage sont différents les uns des autres, étant précisé que deux des cylindres sont pourvus de capteurs de pression d'admission pour détecter individuellement des pressions d'admission, et que les moyens discriminateurs de courses de piston distinguent les courses de piston dans ces deux cylindres sur la base d'une différence entre les pressions d'admission détectées par les deux capteurs de pression d'admission.

4. Moteur selon l'une des revendications 1 à 3, **caractérisé en ce qu'**il comprend plusieurs cylindres dont les réglages d'allumage sont différents les uns des autres, étant précisé que chaque cylindre du moteur est pourvu de capteurs de pression d'admission pour détecter individuellement les pressions d'admission, et que les moyens discriminateurs de courses de piston distinguent les courses de piston dans les cylindres sur la base d'une différence entre les pressions d'admission détectées par les capteurs de pression d'admission pour deux cylindres parmi la totalité des cylindres.

5. Moteur selon l'une des revendications 2 à 4, **caractérisé en ce qu'**il s'agit d'un moteur à deux cylindres, étant précisé que le discriminateur de courses de piston est apte à comparer une première pression d'admission (#1Pb) d'un premier cylindre (3), l'un des deux cylindres (3, 4), et une seconde pression d'admission (#2Pb) d'un second cylindre (4), l'autre des deux cylindres (3, 4), apparaissant au même moment, afin de déterminer une valeur seuil de pression, et à déterminer que le premier cylindre (3) est dans une course d'admission si ladite première pression d'admission (#1Pb) est inférieure à une différence entre la seconde pression d'admission (#2Pb) et la valeur seuil de pression.

6. Moteur selon l'une des revendications 2 à 4, **caractérisé en ce qu'**il s'agit d'un moteur à quatre cylindres, étant précisé que les moyens discriminateurs de courses de piston sont aptes à comparer une première pression d'admission (#1Pb) d'un premier cy-

lindre (#1), l'un des quatre cylindres (#1,#2,#3,#4), et une seconde pression d'admission (#2Pb) d'un second cylindre (#2), un autre parmi les quatre cylindres (#1,#2,#3,#4), apparaissant au même moment, afin de déterminer une valeur seuil de pression et de déterminer que le premier cylindre (#1) est dans une course d'admission si la première pression d'admission (#1Pb) est inférieure à une différence entre la seconde pression d'admission (#2Pb) et ladite valeur seuil de pression.

7. Moteur selon l'une des revendications 1 à 6, **caractérisé par** des moyens de détection de vitesse de rotation (21) pour détecter une vitesse de moteur, étant précisé que les moyens discriminateurs de courses de piston sont aptes à distinguer les courses de piston dans deux des cylindres sur la base d'une différence entre les pressions d'admission des deux cylindres détectées par les capteurs de pression d'admission si la vitesse du moteur détectée par les moyens de détection de vitesse de rotation est inférieure à une valeur seuil de vitesse prédéterminée.

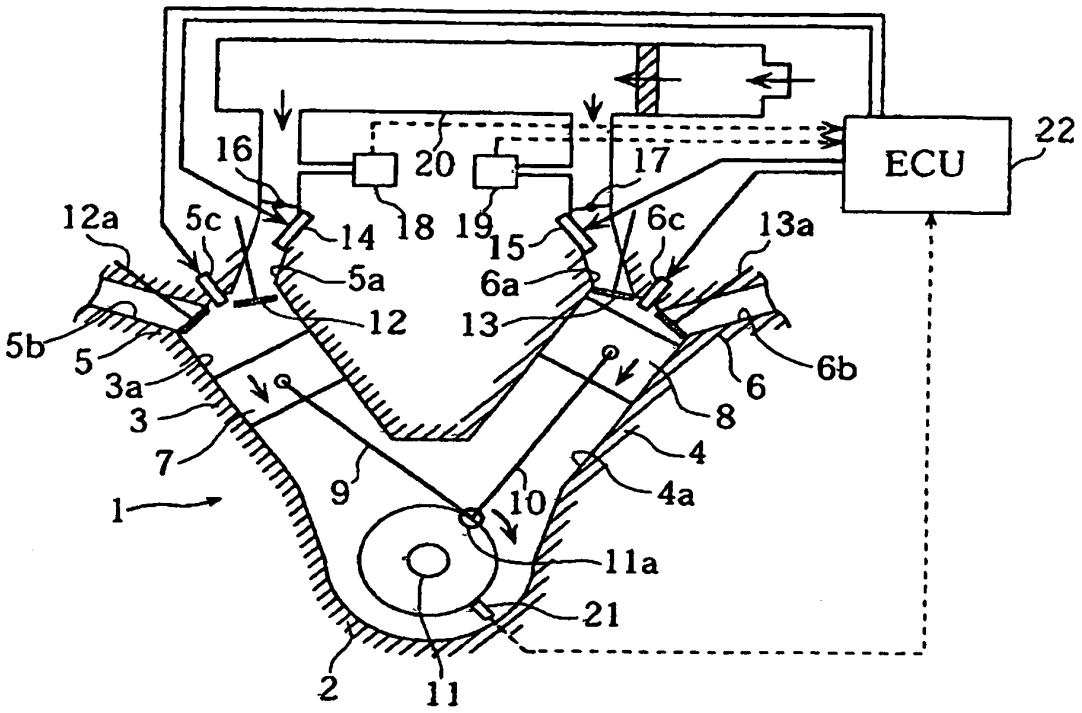
ECU
22
16
20
17
18
19
15
14
12a
5c
6c
13a
5a
6a
12
13
5b
5
3a
6b
6
3
8
7
4
9
10
4a
1
11a
21
2
11

FIG. 1

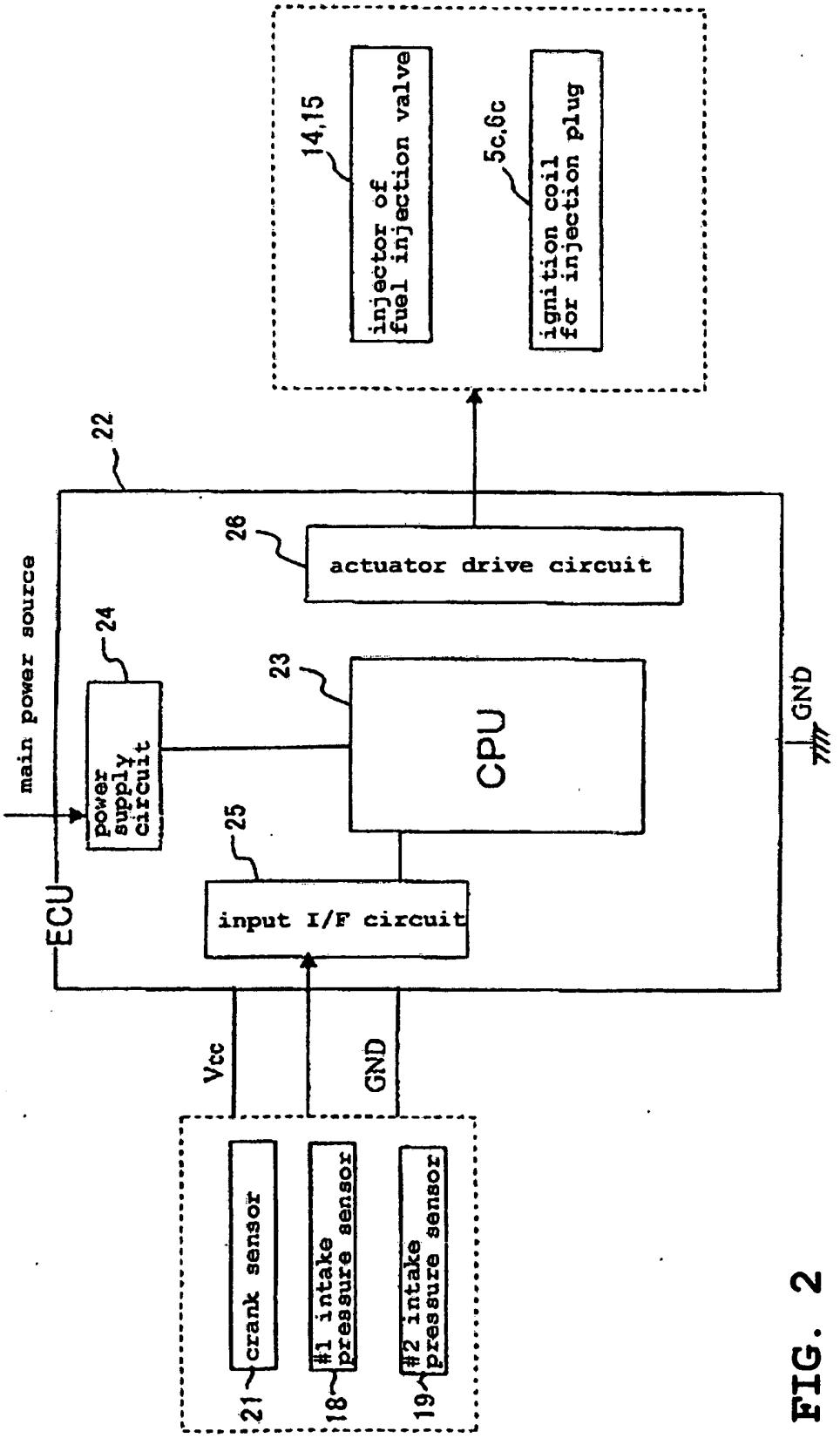
14,15
injector of fuel injection valve
5c,6c
ignition coil for injection plug
22
26
actuator drive circuit
24
23
CPU
main power source
power supply circuit
GND
25
input I/F circuit
ECU
Vcc
GND
crank sensor
#1 intake pressure sensor
#2 intake pressure sensor
21
18
19

FIG. 2

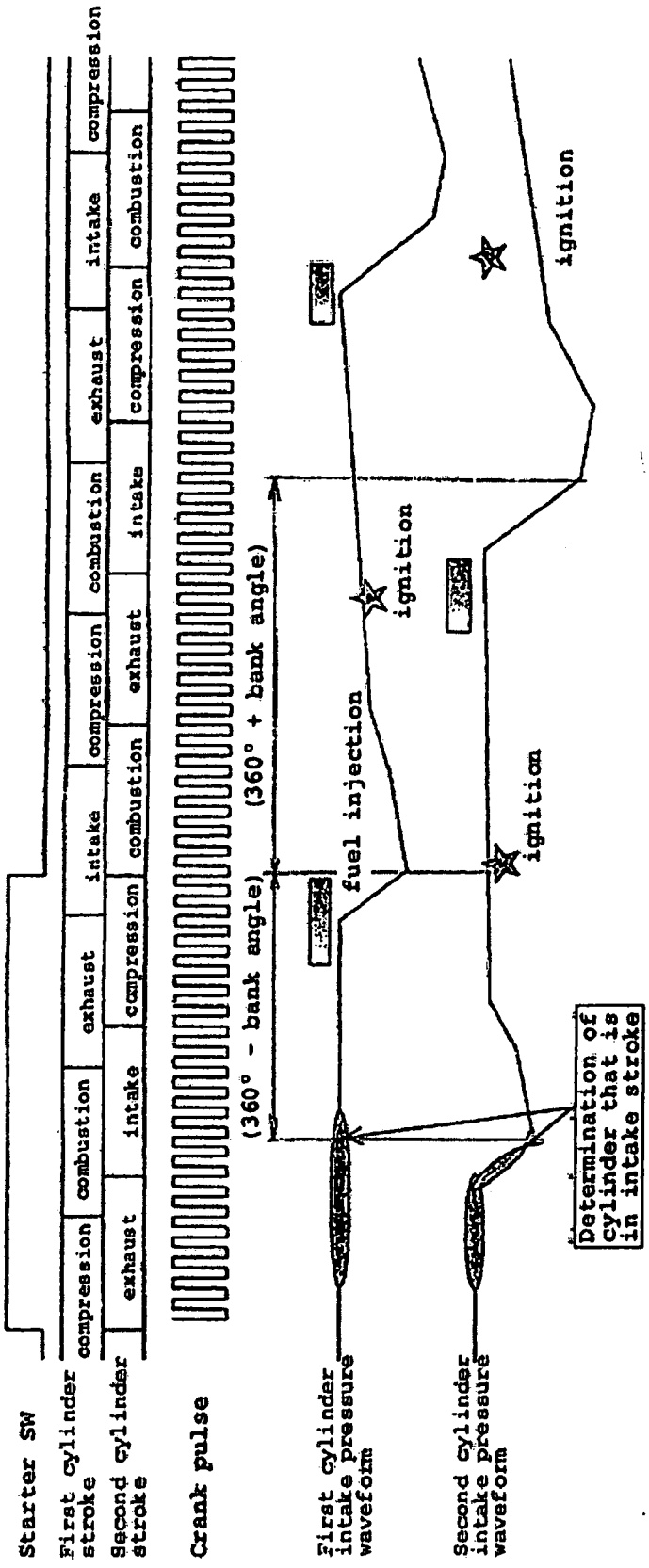
Starter SW
First cylinder stroke
compression
combustion
exhaust
intake
compression
combustion
exhaust
intake
compression
Second cylinder stroke
exhaust
intake
compression
combustion
exhaust
intake
compression
combustion
Crank pulse
(360° - bank angle)
(360° + bank angle)
fuel injection
ignition
ignition
ignition
First cylinder intake pressure waveform
Second cylinder intake pressure waveform
Determination of cylinder that is in intake stroke

FIG. 3

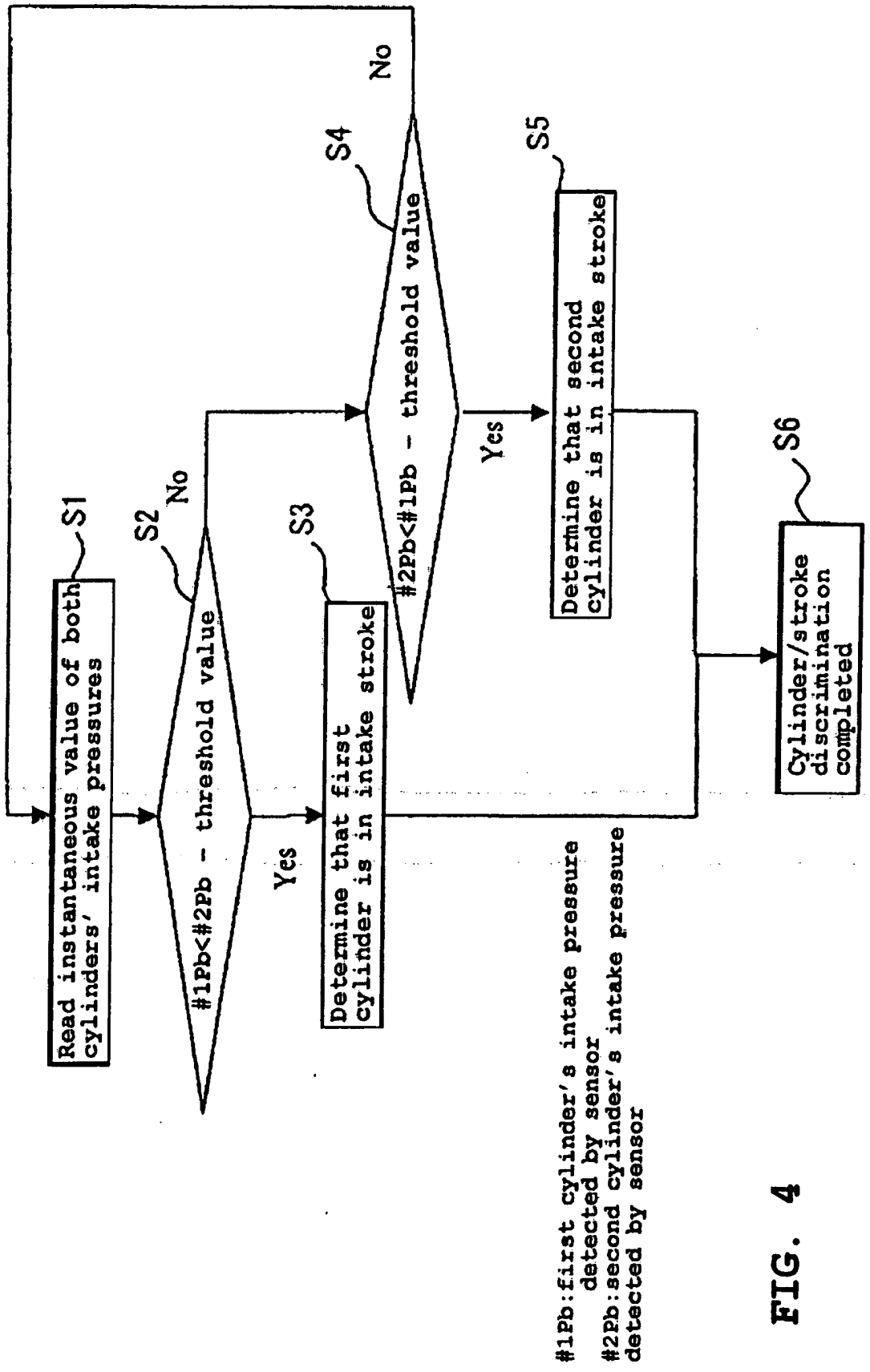
Read instantaneous value of both cylinders' intake pressures
S1
#1Pb<#2Pb - threshold value
S2
No
Yes
Determine that first cylinder is in intake stroke
S3
#2Pb<#1Pb - threshold value
S4
No
Yes
Determine that second cylinder is in intake stroke
S5
Cylinder/stroke discrimination completed
S6
#1Pb:first cylinder's intake pressure detected by sensor
#2Pb:second cylinder's intake pressure detected by sensor

FIG. 4

REGARDING FOUR-CYLINDER ENGINE

#1 stroke	compression	combustion	exhaust	intake	compression	combustion	exhaust	intake	compression
#2 stroke	intake	compression	combustion	exhaust	intake	compression	combustion	exhaust	intake
#3 stroke	combustion	exhaust	intake	compression	combustion	exhaust	intake	compression	combustion
#4 stroke	exhaust	intake	compression	combustion	exhaust	intake	compression	combustion	exhaust

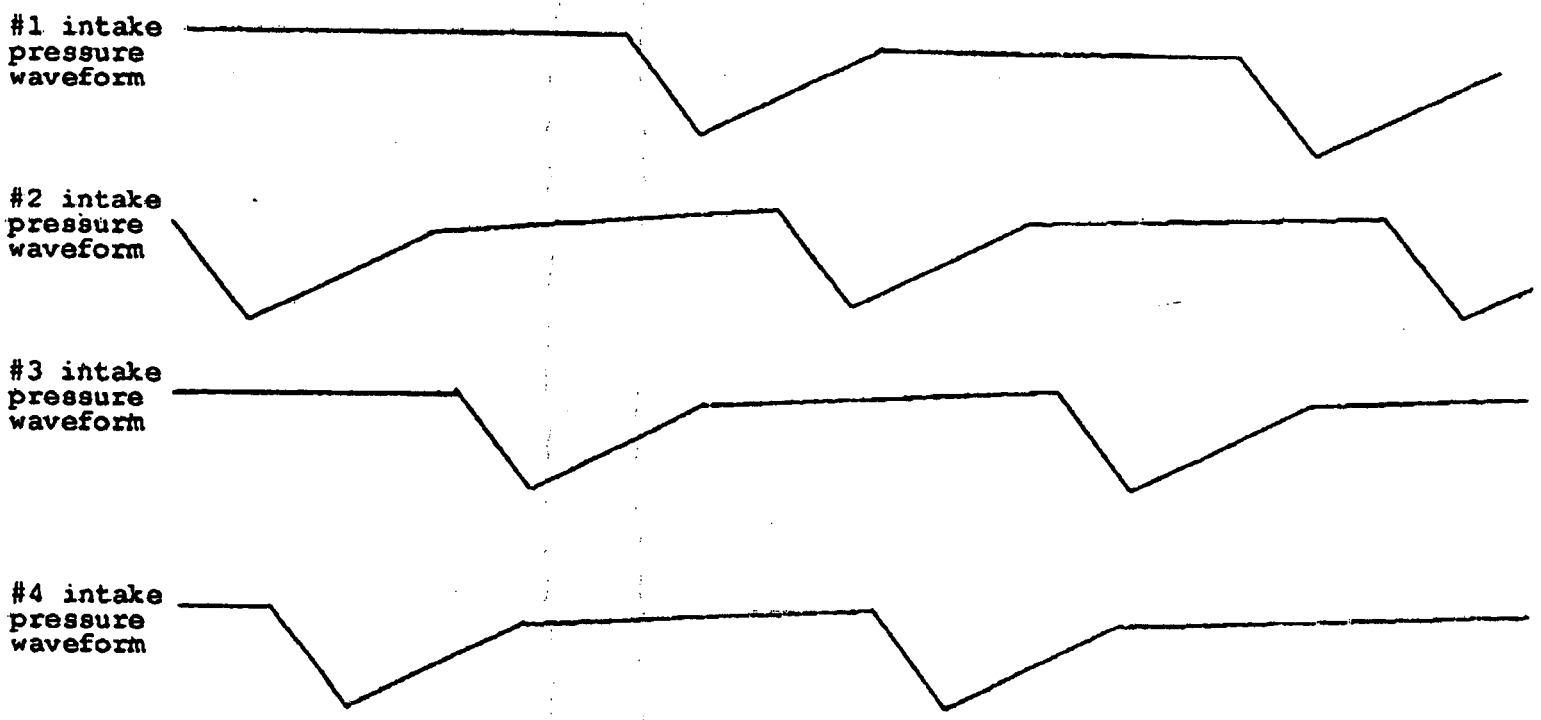

FIG. 5

EP 1 609 975 B1

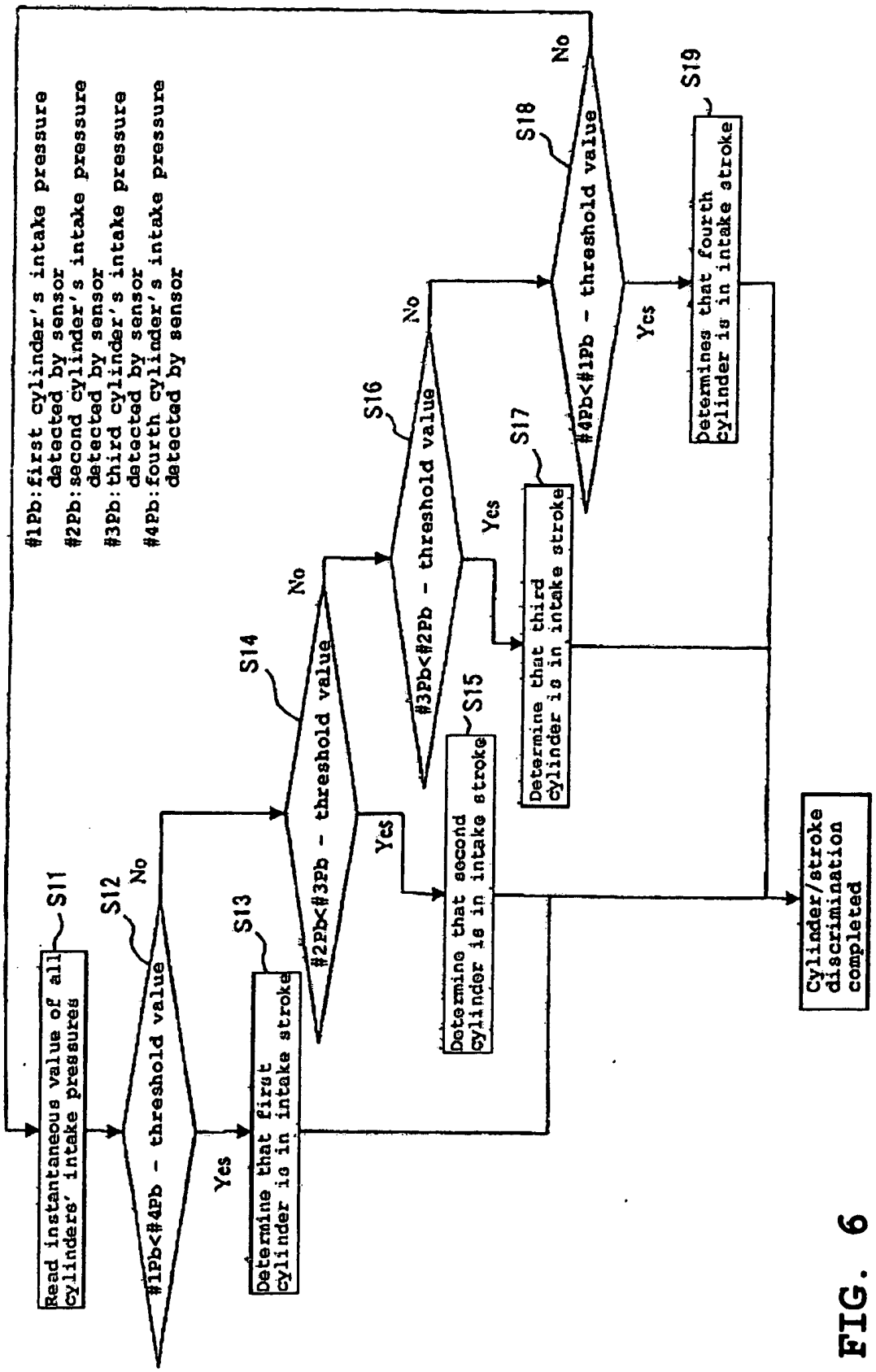
#1Pb:first cylinder's intake pressure detected by sensor
#2Pb:second cylinder's intake pressure detected by sensor
#3Pb:third cylinder's intake pressure detected by sensor
#4Pb:fourth cylinder's intake pressure detected by sensor
Read instantaneous value of all cylinders' intake pressures
S11
S12
#1Pb<#4Pb - threshold value
No
Yes
S13
Determine that first cylinder is in intake stroke
S14
#2Pb<#3Pb - threshold value
No
Yes
S15
Determine that second cylinder is in intake stroke
S16
#3Pb<#2Pb - threshold value
No
Yes
S17
Determine that third cylinder is in intake stroke
S18
#4Pb<#1Pb - threshold value
No
Yes
S19
Determines that fourth cylinder is in intake stroke
Cylinder/stroke discrimination completed

FIG. 6

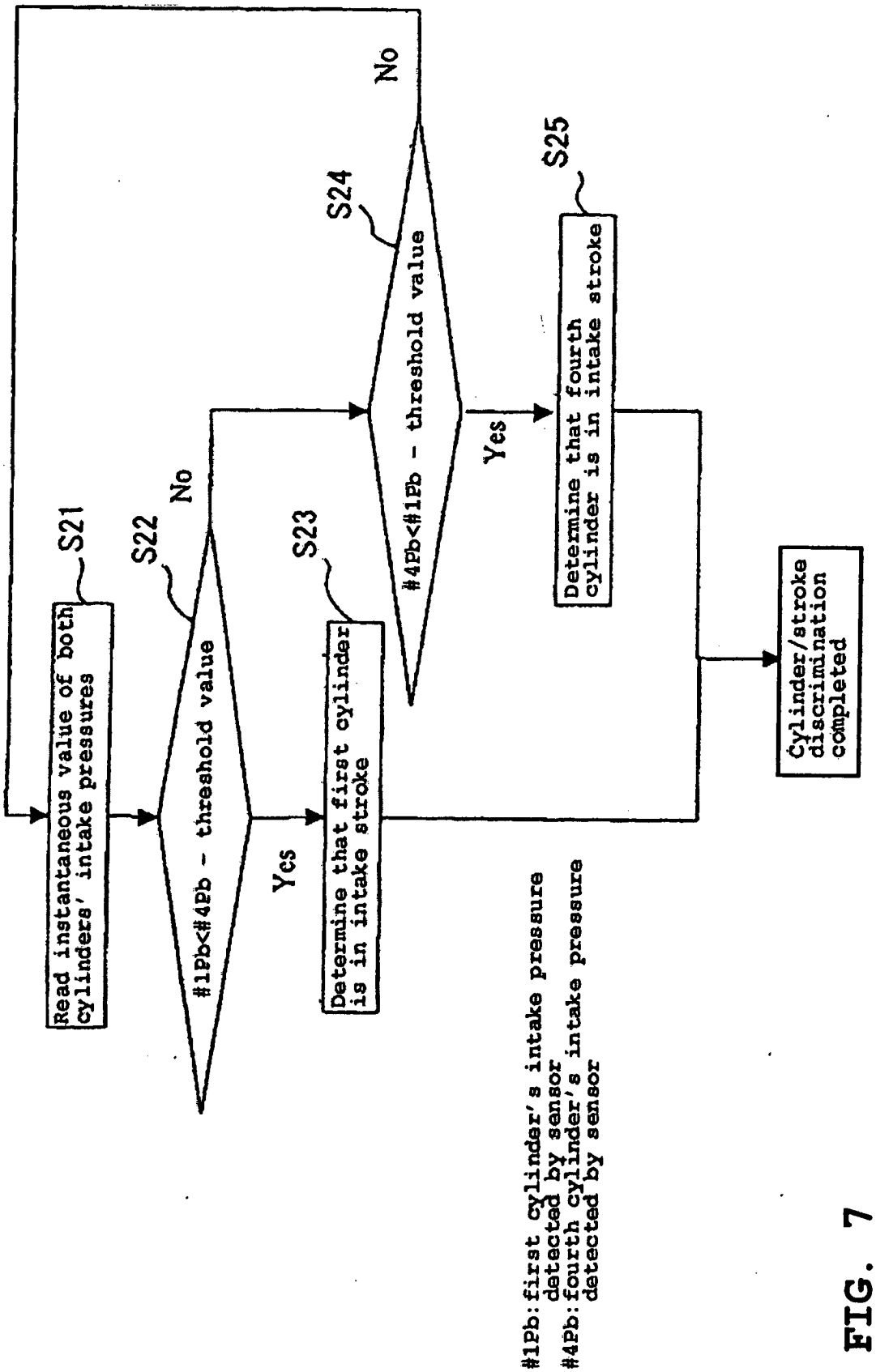
Read instantaneous value of both cylinders' intake pressures
S21
#1Pb<#4Pb - threshold value
S22
No
Yes
Determine that first cylinder is in intake stroke
S23
#4Pb<#1Pb - threshold value
S24
No
Yes
Determine that fourth cylinder is in intake stroke
S25
Cylinder/stroke discrimination completed
#1Pb: first cylinder's intake pressure detected by sensor
#4Pb: fourth cylinder's intake pressure detected by sensor

FIG. 7

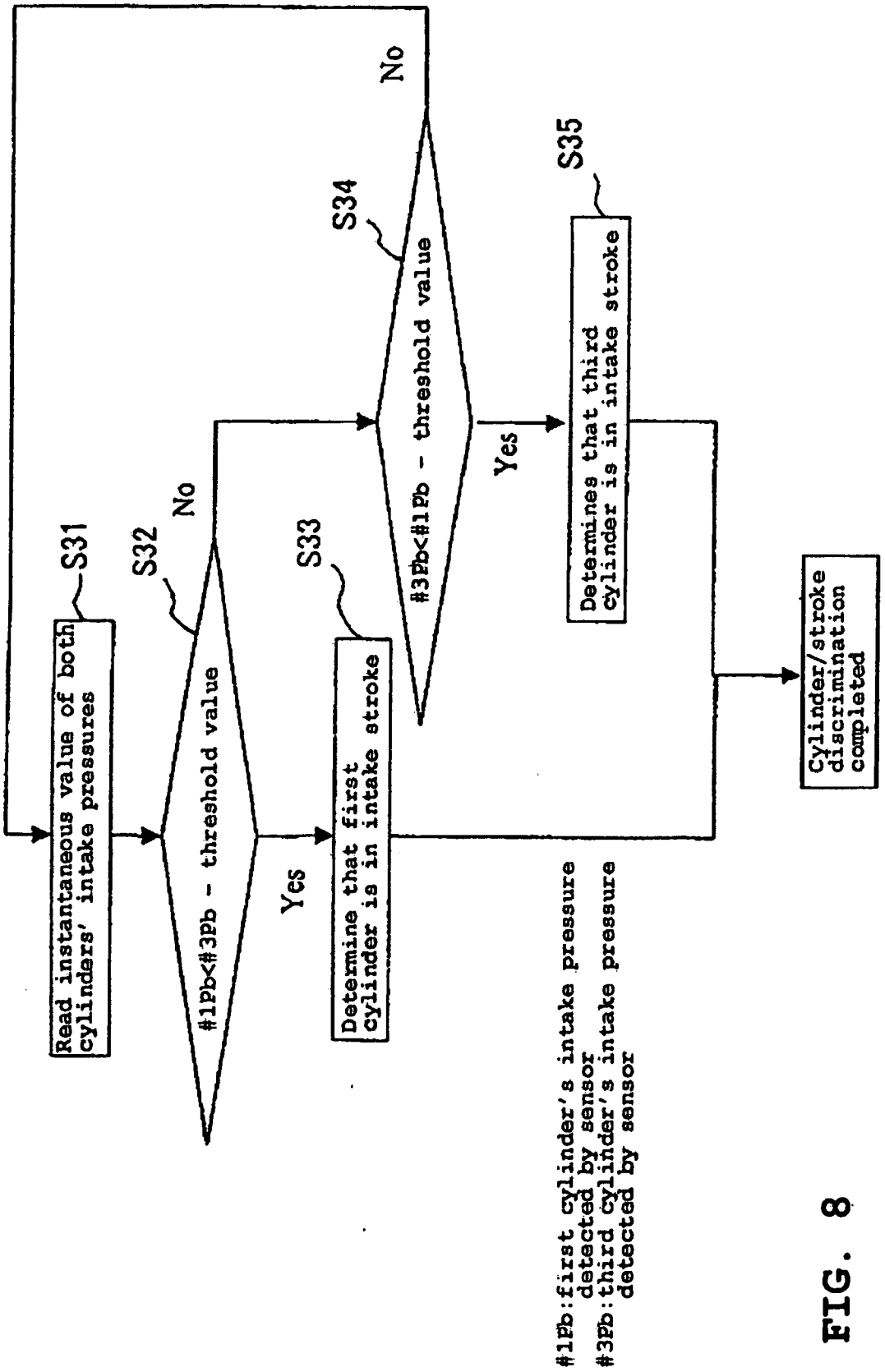
Read instantaneous value of both cylinders' intake pressures
S31
#1Pb<#3Pb - threshold value
S32
No
Yes
Determine that first cylinder is in intake stroke
S33
#3Pb<#1Pb - threshold value
S34
No
Yes
Determines that third cylinder is in intake stroke
S35
Cylinder/stroke discrimination completed
#1Pb:first cylinder's intake pressure detected by sensor
#3Pb:third cylinder's intake pressure detected by sensor

FIG. 8

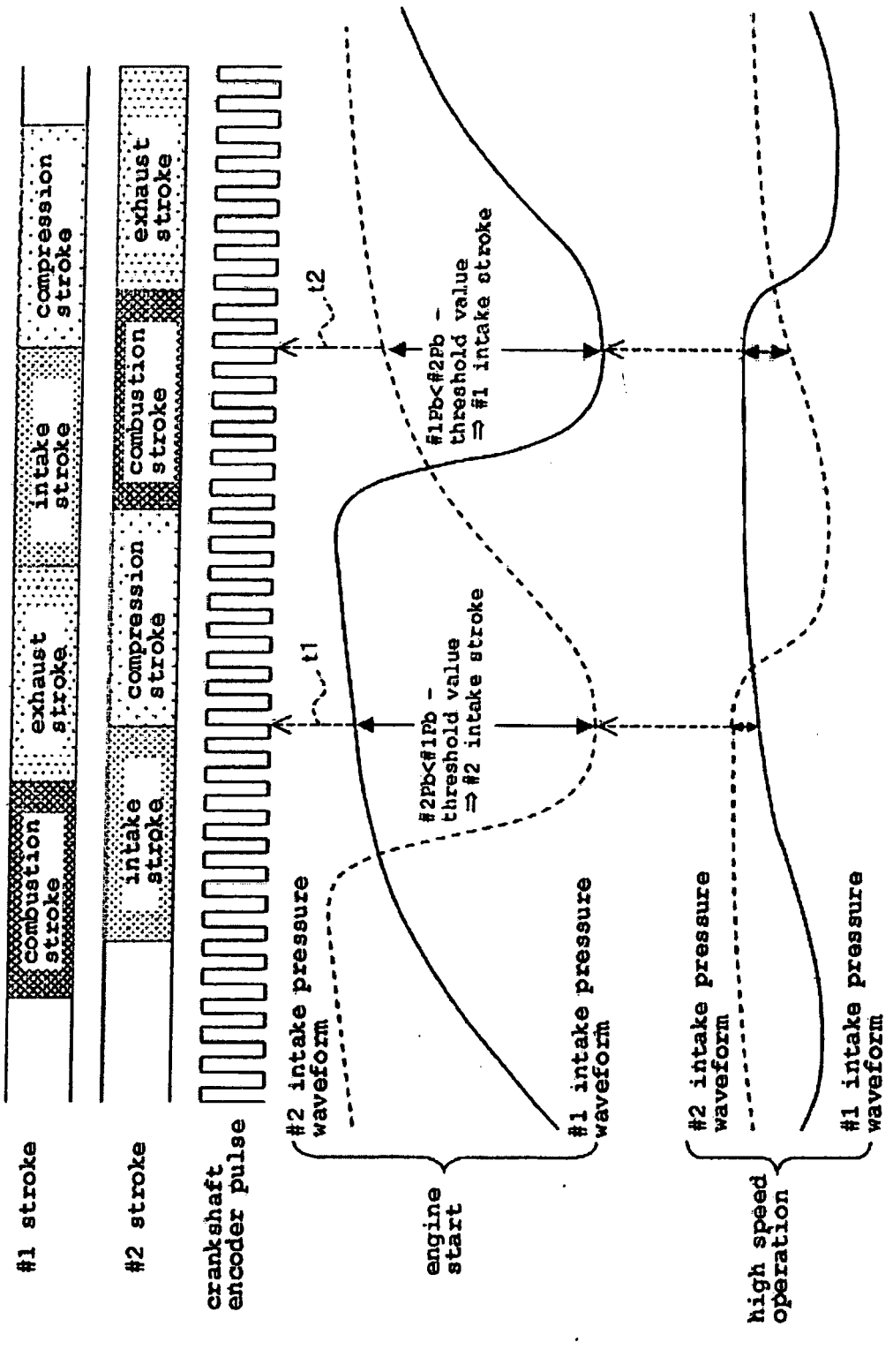
#1 stroke
combustion stroke
exhaust stroke
intake stroke
compression stroke
#2 stroke
intake stroke
compression stroke
combustion stroke
exhaust stroke
crankshaft encoder pulse
t1
t2
#2 intake pressure waveform
#1 intake pressure waveform
#2Pb<#1Pb - threshold value ⇒ #2 intake stroke
#1Pb<#2Pb - threshold value ⇒ #1 intake stroke
engine start
high speed operation

FIG. 9

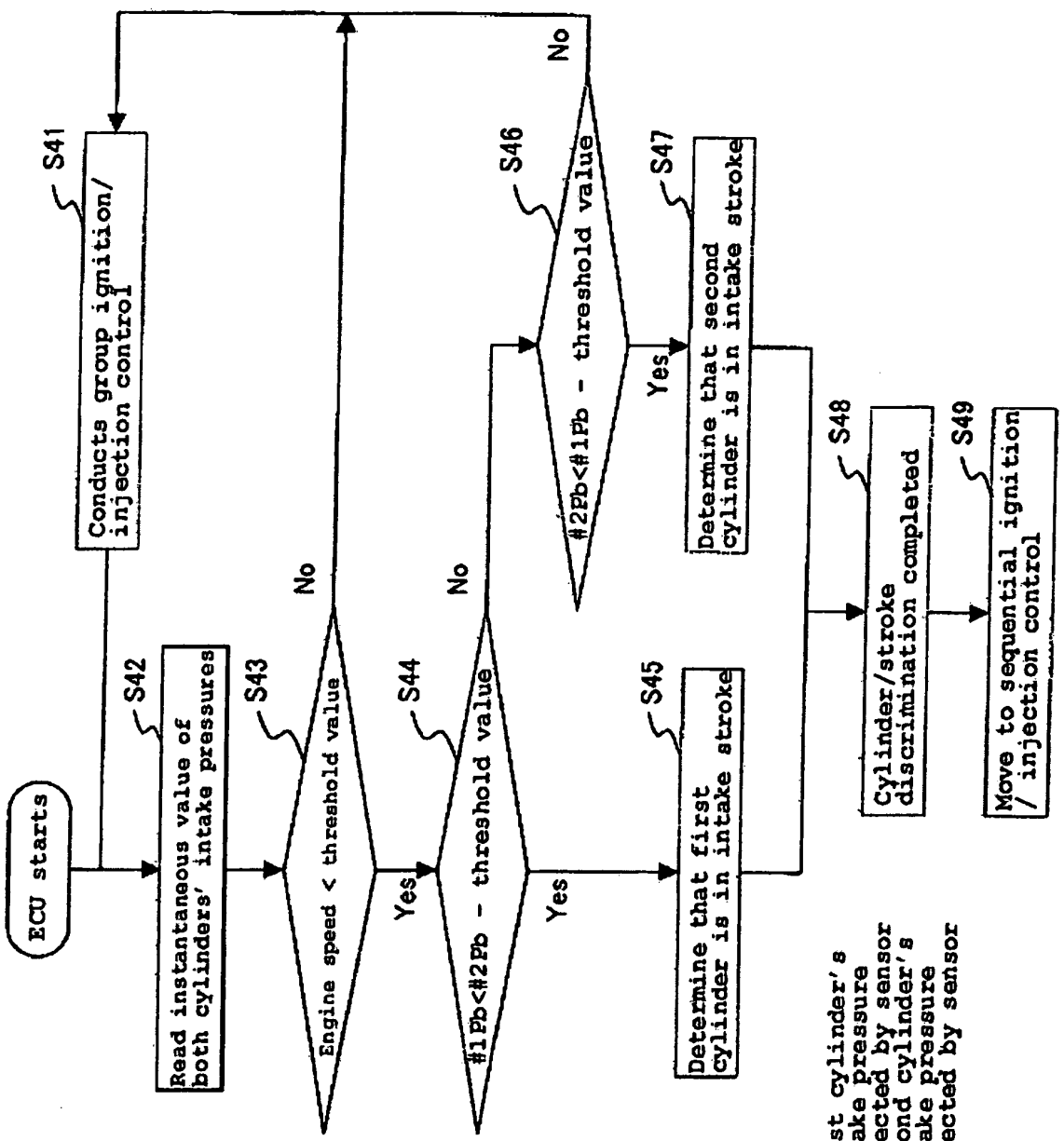
ECU starts
S41
Conducts group ignition/ injection control
S42
Read instantaneous value of both cylinders' intake pressures
S43
Engine speed < threshold value
No
Yes
S44
#1Pb<#2Pb - threshold value
No
Yes
S45
Determine that first cylinder is in intake stroke
S46
#2Pb<#1Pb - threshold value
No
Yes
S47
Determine that second cylinder is in intake stroke
S48
Cylinder/stroke discrimination completed
S49
Move to sequential ignition / injection control
#1Pb: first cylinder's intake pressure detected by sensor
#2Pb: second cylinder's intake pressure detected by sensor

FIG. 10

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 10227252 A **[0004]**