



(11)

EP 1 939 435 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
02.07.2008 Bulletin 2008/27

(51) Int Cl.:
F02D 45/00 ^(2006.01) **F02P 15/08** ^(2006.01)
F02P 17/12 ^(2006.01)

(21) Application number: **06811530.2**

(86) International application number:
PCT/JP2006/320218

(22) Date of filing: **10.10.2006**

(87) International publication number:
WO 2007/046270 (26.04.2007 Gazette 2007/17)

(84) Designated Contracting States:
DE FR

(72) Inventor: **MIYASHITA, Shigeki**
Toyota-shi, Aichi 471-8571 (JP)

(30) Priority: **17.10.2005 JP 2005302243**

(74) Representative: **Intes, Didier Gérard André**
Cabinet Beau de Loménie
158, rue de l'Université
75340 Paris Cedex 07 (FR)

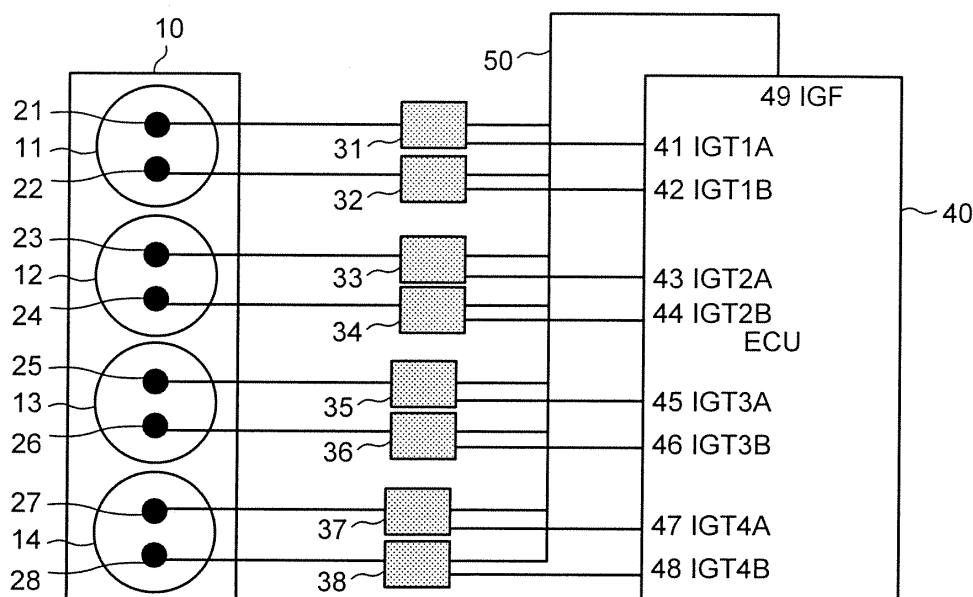
(71) Applicant: **TOYOTA JIDOSHA KABUSHIKI**
KAISHA
Toyota-shi
Aichi 471-8571 (JP)

(54) **IGNITION DEVICE FOR INTERNAL COMBUSTION ENGINE**

(57) An ignition apparatus which allows for an accurate diagnosis of a spark plug in an internal combustion engine provided with plural spark plugs for each cylinder is provided for an internal combustion engine. The ignition apparatus is for an internal combustion engine provided with plural spark plugs for each cylinder, and in-

cludes an input port which receives fail signals (S3, S4) generated corresponding to each of the plural spark plugs for diagnosis of the spark plugs. An input timing of the fail signal to the input port is made different for each of the plural fail signals. Ignition timings (S1, S2) of the plural spark plugs are set to different times.

FIG.1



EP 1 939 435 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to an ignition apparatus for an internal combustion engine.

BACKGROUND ART

[0002] Japanese Patent Application Laid-Open No. S63-205460 (Patent Document 1) describes that, in an internal combustion engine which includes plural cylinders each provided with one spark plug for an ignition thereof, an ignition control signal (ignition signal) is output at different timing for each spark plug of the cylinder so that the ignition control signals of the respective spark plugs of the cylinders do not overlap with each other.

[0003] Japanese Patent Application Laid-Open No. H08-128381 (Patent Document 2) discloses an ignition apparatus for an internal combustion engine, wherein the ignition apparatus outputs an ignition signal from an ECU to an igniter, and detects an ignition state based on a fail signal returned from the igniter. In the above ignition apparatus, a single signal line is employed as both a signal line for the ignition signal and a signal line for the fail signal; and when the fail signal overlaps with the ignition signal, the level of the fail signal is lowered relative to the level of the ignition signal.

[0004]

Patent Document 1: Japanese Patent Application Laid-Open No. S63-205460

Patent Document 2: Japanese Patent Application Laid-Open No. H08-128381

DISCLOSURE OF INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0005] In a conventional internal combustion engine provided with a single spark plug for each cylinder and a single, shared IGF port (IGF detection device) for all cylinders for failure detection, an output timing of the ignition signal is made different for each spark plug of the cylinder so that the ignition signals for different spark plugs of the cylinders do not overlap with each other. Thus, the returning fail signals corresponding to the respective ignition signals do not overlap with each other on entering the IGF port in the ignition apparatus, whereby an accurate diagnosis can be made for each spark plug with the single IGF port.

[0006] When the internal combustion engine is provided with plural spark plugs for each cylinder, however, plural spark plugs corresponding to one cylinder may be ignited simultaneously, resulting in concurrent return of the fail signals; then, at an occurrence of malfunction, a single IGF port is not sufficient to identify the spark plug which causes the malfunction. It is possible to provide

plural IGF ports for failure detection in the internal combustion engine provided with plural spark plugs for each cylinder so that each ignition device can be checked for proper ignition. Such an arrangement, however, increases required costs and spaces.

[0007] The technique disclosed in Patent Document 1 does not presuppose application in a multi-spark plugs ignition apparatus provided with plural spark plugs controlled to be ignited simultaneously. When the technique of Patent Document 1 is applied to a multi-spark plugs ignition apparatus, in which the number of IGF ports for failure detection is smaller than the number of spark plugs (for example, a system having only one IGF port), if the ignition signals are output simultaneously, plural fail signals overlap with each other on entering the IGF port, whereby the diagnosis of coils and spark plugs may not be made accurately.

[0008] An object of the present invention is to provide an ignition apparatus for an internal combustion engine provided with plural spark plugs for each cylinder, wherein an accurate diagnosis of the spark plugs can be realized.

MEANS FOR SOLVING PROBLEM

[0009] An ignition apparatus for an internal combustion engine according to the present invention is an ignition apparatus for an internal combustion engine provided with plural spark plugs for each cylinder, and the ignition apparatus includes an input port that receives a fail signal generated corresponding to each of the plural spark plugs for a diagnosis of the spark plugs, wherein an input timing to the input port is set differently timewise for each of the plural fail signals.

[0010] In the ignition apparatus for the internal combustion engine according to the present invention, an ignition timing is set differently timewise for each of the plural spark plugs.

[0011] In the ignition apparatus for the internal combustion engine according to the present invention, a time elapsed after an ignition timing of the spark plug until an input of the fail signal corresponding to the spark plug into the input port is made different timewise for each of the plural spark plugs.

[0012] In the ignition apparatus for the internal combustion engine according to the present invention, the ignition timing of the spark plug for which the time is long is set later than the ignition timing of the spark plug for which the time is short.

[0013] In the ignition apparatus for the internal combustion engine according to the present invention, a delay element or a delay circuit is provided in a signal line which conveys part of the plural fail signals up to the input port.

EFFECT OF THE INVENTION

[0014] According to the present invention, an accurate

diagnosis of spark plugs can be made for an internal combustion engine that is provided with plural spark plugs for each cylinder.

BRIEF DESCRIPTION OF DRAWINGS

[0015]

FIG. 1 is a schematic configuration diagram of an ignition apparatus for an internal combustion engine according to a first embodiment of the present invention;

FIG. 2 is a waveform chart of ignition signals and fail signals in the ignition apparatus for the internal combustion engine according to the first embodiment of the present invention;

FIG. 3 is a schematic configuration diagram of an ignition apparatus for an internal combustion engine according to a second embodiment of the present invention;

FIG. 4 is diagram of a detailed configuration of a delay circuit in the ignition apparatus for the internal combustion engine according to the second embodiment of the present invention;

FIG. 5 is a waveform chart of ignition signals and fail signals in the ignition apparatus for the internal combustion engine according to the second embodiment of the present invention; and

FIG. 6 is a waveform chart of ignition signals and fail signals in an ignition apparatus for an internal combustion engine according to a third embodiment of the present invention.

EXPLANATIONS OF LETTERS OR NUMERALS

[0016]

10 Engine
11 First Cylinder
12 Second Cylinder
13 Third Cylinder
14 Fourth Cylinder
21 Spark Plug
22 Spark Plug
23 Spark Plug
24 Spark Plug
25 Spark Plug
26 Spark Plug
27 Spark Plug
28 Spark Plug
31 Ignition Coil
32 Ignition Coil
33 Ignition Coil
34 Ignition Coil
35 Ignition Coil
36 Ignition Coil
37 Ignition Coil
38 Ignition Coil

40 ECU
41 Ignition-Signal Output Port IGT1A
42 Ignition-Signal Output Port IGT1B
43 Ignition-Signal Output Port IGT2A
44 Ignition-Signal Output Port IGT2B
45 Ignition-Signal Output Port IGT3A
46 Ignition-Signal Output Port IGT3B
47 Ignition-Signal Output Port IGT4A
48 Ignition-Signal Output Port IGT4B
49 IGF Port
50 Fail-Signal Line
51 First Fail-Signal Line
52 Second Fail-Signal Line
60 Delay Circuit
61 Inverter
62 Inverter
63 Capacitor
S1 Ignition Signal
S2 Ignition Signal
S3 Fail Signal
S4 Fail Signal

BEST MODE(S) FOR CARRYING OUT THE INVENTION

[0017] Exemplary embodiments of the present invention will be described in detail below with reference to the accompanying drawings.

30 First Embodiment

[0018] An ignition apparatus for an internal combustion engine according to a first embodiment will be described with reference to FIGS. 1 and 2. As shown in FIG. 1, a four-cylinder engine 10 includes cylinders each having two spark plugs among spark plugs 21 to 28. Specifically, a first cylinder 11 is provided with two spark plugs 21 and 22; and similarly, a second cylinder 12 is provided with two spark plugs 23 and 24; a third cylinder 13 is provided with two spark plugs 25 and 26; and a fourth cylinder 14 is provided with two spark plugs 27 and 28.

[0019] The spark plugs 21 to 28 are connected to secondary coils of ignition coils 31 to 38, respectively. Primary coils of the ignition coils 31 to 38 are connected to ignition-signal output ports IGT1A 41 to IGT4B 48, respectively, of an ECU 40. When the ignition signals (electric currents) are supplied from the ignition-signal output ports IGT1A 41 to IGT4B 48 to the primary coils of the ignition coils 31 to 38, high voltage is generated in the secondary coils of the ignition coils 31 to 38, and the spark plugs 21 to 28 are ignited. The fail signal is supplied to a single failure-detecting IGF port 49 of the ECU 40 via a shared fail-signal line 50 in the ignition apparatus.

[0020] In the first embodiment, the fail signal is generated on a trailing edge of the ignition signal in each ignition device. Therefore, when the plural spark plugs 21 to 28 are to be ignited in the first embodiment, different output timings are set for the ignition signals, so that the ignition

occurs at different times. Thus, the fail signals corresponding to the plural spark plugs 21 to 28 are prevented from overlapping with each other on entering the single IGF port 49.

[0021] Specifically, as shown in FIG. 2, there is a phase difference between an output of an ignition signal S1 which is supplied from the ignition-signal output port IGT1A to the spark plug 21 and an output of an ignition signal S2 which is supplied from the ignition-signal output port IGT1B to the spark plug 22. Therefore, a fail signal S3 generated on a trailing edge of the ignition signal S1 corresponding to the spark plug 21 enters the IGF port 49 at different timing from the entrance of a fail signal S4 generated on a trailing edge of the ignition signal S2 corresponding to the spark plug 22 to the IGF port 49.

[0022] Thus, even when fail signals corresponding respectively to the plural spark plugs 21 to 28 are supplied to the single IGF port 49 via the single fail-signal line 50, each fail signal always enters the IGF port 49 at a different time from the entrance of the other fail signals into the IGF port 49. Therefore, when a malfunction of the ignition device (including the coil and the spark plug) is detected, it can be accurately distinguished whether the malfunction occurs in the ignition device including the spark plug 21 and the coil 31 or in the ignition device including the spark plug 22 and the coil 32.

Second Embodiment

[0023] Next, a second embodiment will be described with reference to FIGS. 3 to 5.

In the second embodiment, the description of elements common to those of the first embodiment will not be repeated and elements different from those of the first embodiment alone will be described.

[0024] As shown in FIG. 3, fail signals corresponding to the first spark plugs 21, 23, 25, and 27 of the respective cylinders are supplied into the failure-detecting IGF port 49 of the ECU 40 via a first fail-signal line 51, whereas fail signals corresponding to the second spark plugs 22, 24, 26, and 28 of the respective cylinders are supplied into the failure-detecting IGF port 49 via a second fail-signal line 52. A delay circuit 60 is connected to the second fail-signal line 52.

[0025] As shown in FIG. 4, the delay circuit 60 includes two inverters 61 and 62 connected in series and a grounded capacitor 63 connected at an input side of the inverter 61. A signal is delayed while passing through the two inverters 61 and 62 connected in series.

[0026] Similarly to the first embodiment, the fail signal is generated on a trailing edge of the ignition signal commonly for all the ignition devices according to the second embodiment. The fail signal passing through the second fail-signal line 52 and the delay circuit 60, however, is input to the IGF port 49 at a delayed timing from the input of the fail signal passing through the first fail-signal line 51. When the plural spark plugs 21 to 28 are to be ignited in the second embodiment, the ignition signals may be

output at the same timing so as to make a concurrent ignition.

[0027] Specifically, as shown in FIG. 5, an output of the ignition signal S1 supplied from the ignition-signal output port IGT1A to the spark plug 21 and an output of the ignition signal S2 supplied from the ignition-signal output port IGT1B to the spark plug 22 are simultaneous. Thus, the fail signal S3 generated on the trailing edge of the ignition signal S1 corresponding to the spark plug 21 and the fail signal S4 generated on the trailing edge of the ignition signal S2 corresponding to the spark plug 22 are generated in the same time period. However, the input of the fail signal S4 into the IGF port 49 lags behind the input of the fail signal S3 by a delay time set by the delay circuit 60.

[0028] As can be seen from above, since the fail signals S3 and S4 always enter the IGF port 49 at different timings, it is possible, when the malfunction is detected in an ignition device (including the coil and the spark plug), to accurately distinguish whether a malfunction occurs in the ignition device including the spark plug 21 and the coil 31 or in the ignition device including the spark plug 22 and the coil 32.

[0029] In the second embodiment, a position where the delay circuit 60 is arranged is not limited to the position shown in FIG. 3. In the configuration as shown in FIG. 3, the fail signals corresponding to the respective first spark plugs 21, 23, 25, and 27 of the cylinders pass through the first fail-signal line 51, the fail signals corresponding to the respective second spark plugs 22, 24, 26, and 28 of the cylinder pass through the second fail-signal line 52, and the delay circuit 60 is connected to the second fail-signal line 52. If the ignition signals are output to the first spark plugs 21, 23, 25, and 27 of the plural cylinders simultaneously, signal transmission time is same for all the signals; and hence, the corresponding fail signals enter the IGF port 49 simultaneously. Therefore, it is difficult to accurately identify the ignition device which causes the malfunction. Similarly, if the ignition signals are output to the second spark plugs 22, 24, 26, and 28 of the plural cylinders simultaneously, signal transmission time is same for all the signals; and hence, the corresponding fail signals enter the IGF port 49 simultaneously. And therefore, it is difficult to accurately identify the ignition device which causes the malfunction. To deal with the above inconveniences, it is necessary to arrange a delay circuit in a signal line for each of the fail signals corresponding respectively to the plural spark plugs 21 to 28, to which the ignition signals may be supplied simultaneously, so that the signal transmission time is different on each signal line.

Third Embodiment

[0030] Next, a third embodiment will be described. The third embodiment relates to the second embodiment described above.

[0031] In the following, a circuit configuration having

the same configuration as the configuration according to the second embodiment shown in FIG. 3 will be described as an example of the third embodiment. In the second embodiment, the spark plug 21 and the spark plug 22 are ignited simultaneously, whereas in the third embodiment, the spark plug 21 and the spark plug 22 are ignited at different times. When the spark plug 21 and the spark plug 22 are ignited at different times, the ignition of the spark plug 22, which is connected to a fail-signal transmission path in which the delay circuit 60 is connected, lags behind the ignition of the spark plug 21.

[0032] Specifically, as shown in FIG. 6, the output of the ignition signal S2 from the ignition-signal output port IGT1B to the spark plug 22 lags behind the output of the ignition signal S1 from the ignition-signal output port IGT1A to the spark plug 21. Accordingly, the generation of the fail signal S4 on a trailing edge of the ignition signal S2 corresponding to the spark plug 22 lags behind the generation of the fail signal S3 on a trailing edge of the ignition signal S1 corresponding to the spark plug 21. Further, since the fail signal S4 further lags behind the fail signal S3 while passing through the delay circuit 60, the time difference between the input of the fail signal S3 and the input of the fail signal S4 into the IGF port 49 increases in comparison with that in the second embodiment (in which the ignition signals S1 and S2 are output simultaneously).

[0033] Thus, the fail signals S3 and S4 are always supplied to the IGF port 49 at different times, whereby when malfunction is detected in the ignition device (including the coil and the spark plug), it can be accurately distinguished whether the malfunction occurs in the ignition device including the spark plug 21 and the coil 31, or in the ignition device including the spark plug 22 and the coil 32.

[0034] On the contrary, if the ignition of the spark plug 21 lags behind the ignition of the spark plug 22, the difference in the ignition timing may be offset by the delay time generated in the delay circuit 60, and the difference in the input timing of the fail signal S3 and the fail signal S4 to the IGF port 49 may be eliminated. Even when the difference is not eliminated, it may become less. When there is only a slight difference in the input timing, the fail signals S3 and S4 are detected at a short interval, and the failure detection needs to be performed at a short time interval, which necessitates increased accuracy of detection circuit. In view of the above, the output of the ignition signal S2 is made to lag behind the output of the ignition signal S1 in the third embodiment.

[0035] As can be seen from the second and the third embodiment, when the configuration shown in FIG. 3 is adopted, the ignition timing can be changed flexibly for the spark plugs 21 and 22 of the same cylinder according to circumstances. Specifically, no matter whether the spark plugs 21 and 22 are ignited simultaneously (second embodiment) or the spark plugs 21 and 22 are ignited at different times (third embodiment), the fail signals S3 and S4 enter the IGF port 49 at different times, whereby the

diagnosis of the coils 31 and 32, and the spark plugs 21 and 22 can be made accurately.

[0036] Further, in the configuration without the delay circuit 60 as in the first embodiment, a substantially simultaneous ignition of the spark plugs 21 and 22 can be realized when the phase difference between the ignition timings of the spark plugs 21 and 22 is set small. Even if there is only a small phase difference between the ignition times of the spark plugs 21 and 22, as far as there is a phase difference, a difference between the input times of the fail signals S3 and S4 into the IGF port 49 can be secured, and the fail signals S3 and S4 can be detected separately, whereby the diagnosis of each ignition device can be made accurately.

INDUSTRIAL APPLICABILITY

[0037] As can be seen from above, an ignition apparatus for an internal combustion engine according to the present invention is useful when the internal combustion engine is provided with plural spark plugs for each cylinder, and more particularly, is suitable for making an accurate diagnosis of the spark plugs.

Claims

1. An ignition apparatus for an internal combustion engine provided with plural spark plugs for each cylinder, the ignition apparatus comprising:
 - an input port that receives a fail signal generated corresponding to each of the plural spark plugs for a diagnosis of the spark plugs, wherein
 - an input timing to the input port is set differently timewise for each of the plural fail signals.
2. The ignition apparatus for the internal combustion engine according to claim 1, wherein an ignition timing is set differently timewise for each of the plural spark plugs.
3. The ignition apparatus for the internal combustion engine according to claim 1, wherein a time elapsed after an ignition timing of the spark plug until an input of the fail signal corresponding to the spark plug into the input port is made different timewise for each of the plural spark plugs.
4. The ignition apparatus for the internal combustion engine according to claim 3, wherein the ignition timing of the spark plug for which the time is long is set later than the ignition timing of the spark plug for which the time is short.
5. The ignition apparatus for the internal combustion engine according to claim 3 or 4, wherein a delay element or a delay circuit is provided in a

signal line which conveys part of the plural fail signals up to the input port.

5

10

15

20

25

30

35

40

45

50

55

FIG.1

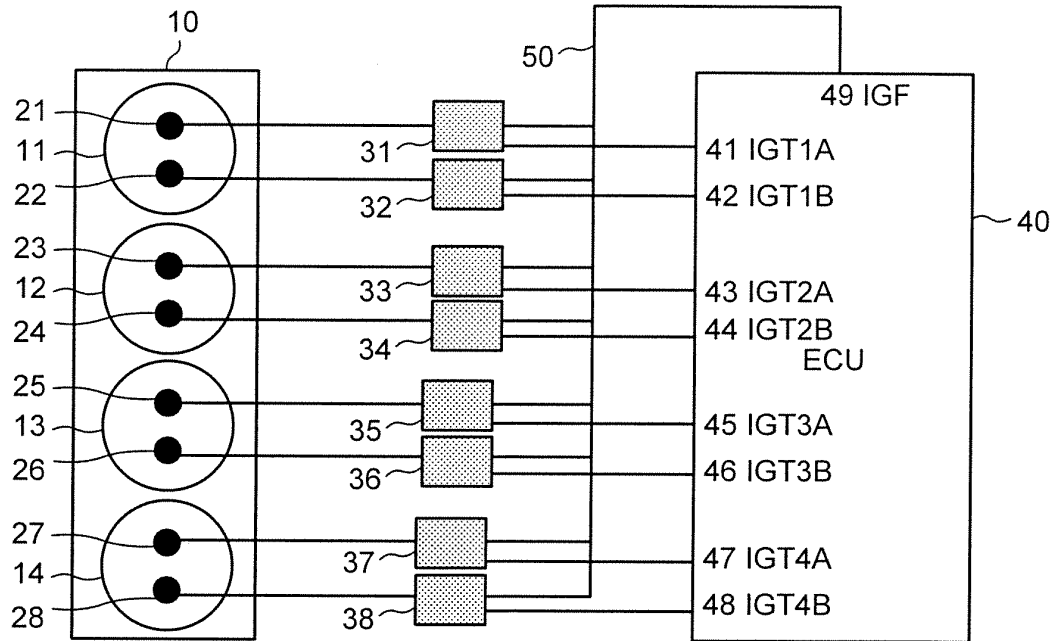


FIG.2

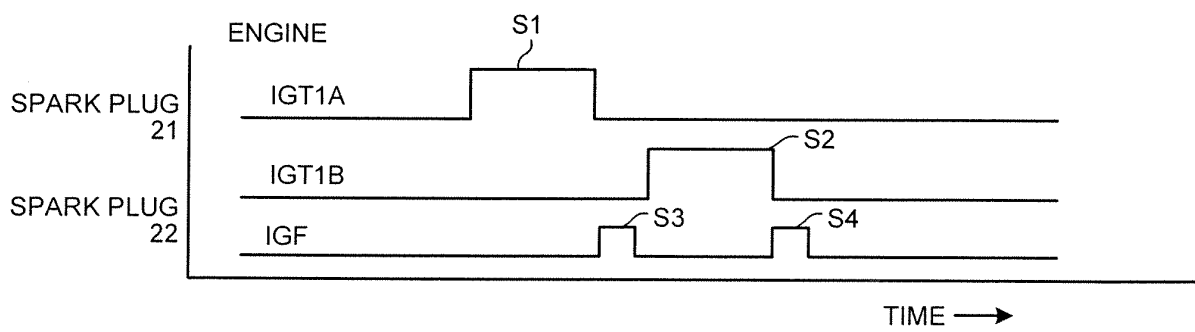


FIG.3

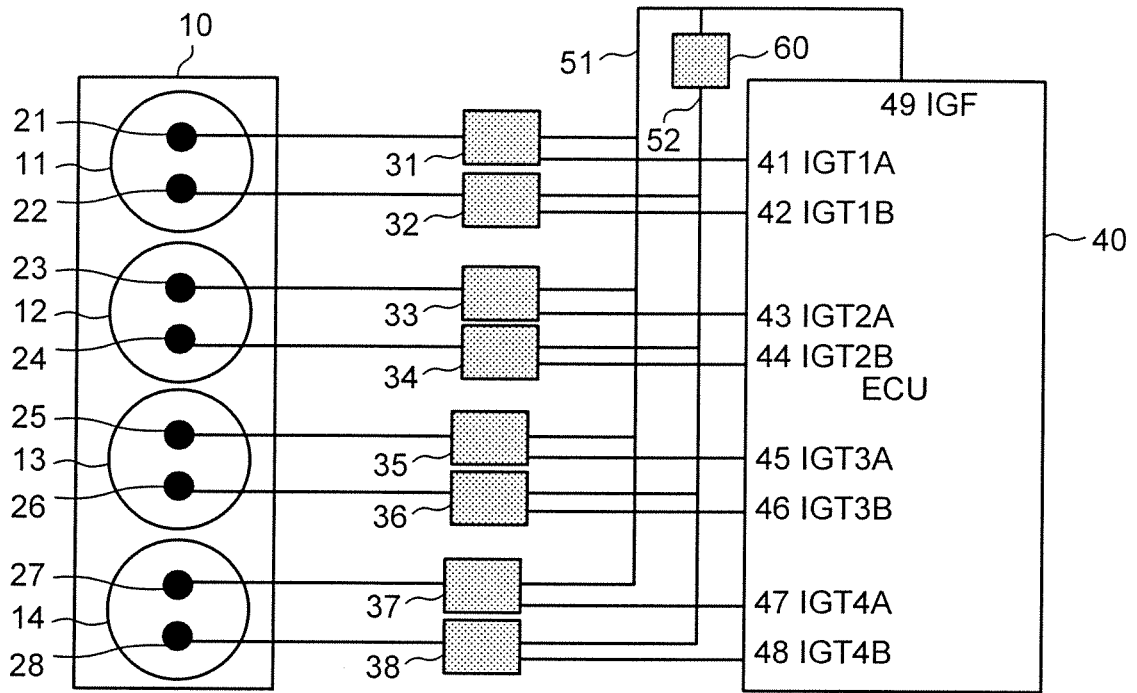


FIG.4

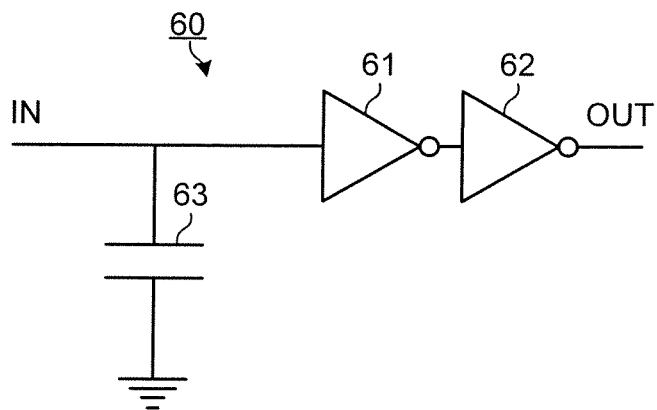


FIG.5

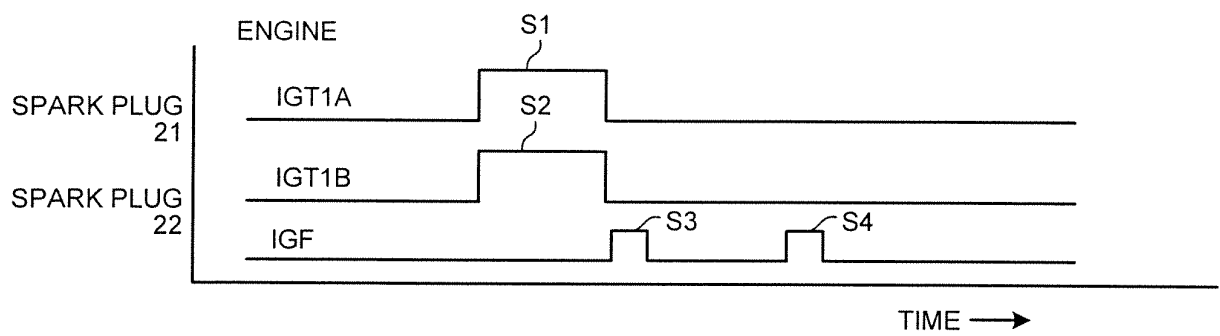
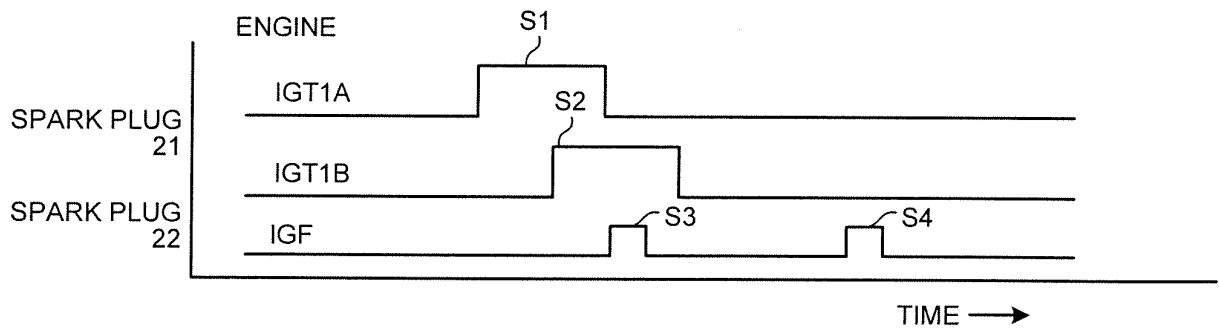


FIG.6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/320218

A. CLASSIFICATION OF SUBJECT MATTER

F02D45/00(2006.01) i, F02P15/08(2006.01) i, F02P17/12(2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F02D45/00, F02P15/08, F02P17/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2006
Kokai Jitsuyo Shinan Koho	1971-2006	Toroku Jitsuyo Shinan Koho	1994-2006

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 3-286186 A (Mazda Motor Corp.), 17 December, 1991 (17.12.91), Page 3, lower right column, lines 4 to 16; Fig. 3 (Family: none)	1-5
Y	JP 2002-266739 A (Mazda Motor Corp.), 18 September, 2002 (18.09.02), Par. Nos. [0009], [0013], [0022]; Fig. 1 (Family: none)	1, 2
Y	JP 58-192970 A (Jidosha Kogai Anzen Kiki Gijutsu Kenkyu Kumiai), 10 November, 1983 (10.11.83), Page 2, upper left column, lines 5 to 18 (Family: none)	1, 3-5



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
21 November, 2006 (21.11.06)Date of mailing of the international search report
28 November, 2006 (28.11.06)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP S63205460 B [0002] [0004]
- JP H08128381 B [0003] [0004]