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(11) **EP 0 727 569 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
21.08.1996 Bulletin 1996/34

(51) Int. Cl.⁶: **F01N 7/10**

(21) Application number: **96101266.3**

(22) Date of filing: **30.01.1996**

(84) Designated Contracting States:
DE FR GB

(30) Priority: **06.02.1995 JP 17805/95**

(71) Applicant: **TOYOTA JIDOSHA KABUSHIKI
KAISHA
Aichi-ken 471 (JP)**

(72) Inventors:
• **Yoshima, Watanabe,
c/o Toyota Jidosha K.K.
Toyota-shi, Aichi (JP)**

• **Naofumi, Magarida,
c/o Toyota Jidosha K.K.
Toyota-shi, Aichi (JP)**

(74) Representative: **Tiedtke, Harro, Dipl.-Ing. et al
Patentanwaltsbüro
Tiedtke-Bühling-Kinne & Partner
Bavariaring 4
80336 München (DE)**

(54) **Exhaust device of internal combustion engine**

(57) An exhaust device comprises an exhaust manifold (1). A boss (6) for a heat insulator, a boss (8) for an EGR gas, and a boss (10) for a sensor are formed on an outer peripheral surface of the exhaust manifold (1). An outer end portion of the side wall surface of the boss (6) for the heat insulator and the outer end portion of the side wall surface of the boss (8) for the EGR gas are

connected by a bridge member (11), and an outer end portion of the side wall surface of the boss (8) for the EGR and the outer end portion of the side wall surface of the boss (10) for the sensor are connected by a bridge (12) member as well.

Fig. 2A

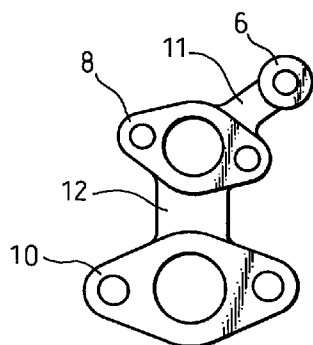
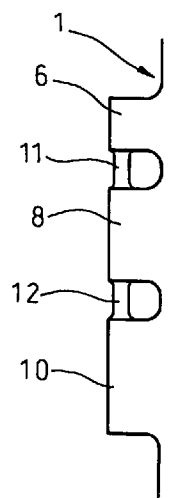


Fig. 2B



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an exhaust device of an internal combustion engine.

2. Description of the Related Art

An exhaust manifold comprises a plurality of tubes for affixing to an engine body and a gathering portion at which these tubes merge with each other. In such an exhaust manifold, there are parts of high temperature and parts of low temperature, and therefore a considerable difference occurs in the amount of heat expansion inside of the exhaust manifold. If a difference is caused in the amount of thermal expansion in this way, a large compressive thermal stress or tensile thermal stress is locally caused inside the wall surface of the exhaust manifold and this causes the occurrence of cracks. In this case, the region in which the compressive thermal stress occurs or the region in which the tensile thermal stress occurs differs depending upon the construction of the exhaust manifold.

Therefore, so as to reduce such a compressive thermal stress or a tensile thermal stress, an exhaust manifold in which the thickness of the tube walls of the exhaust manifold is gradually increased from the inlet side of the flow of the exhaust gas toward the outlet side of the flow of the exhaust gas is well known (see Japanese Unexamined Utility Model Publication (Kokai) No. 62-987290).

Recently, the temperatures of exhaust gases have gradually become higher along with the increase in engine output. Along with this, the temperature of the exhaust manifold has gradually become higher. However, when the temperature of the exhaust manifold becomes high, in comparison with a case where a compressive strain is produced due to a compressive thermal stress, in the case where tensile strain is produced due to tensile thermal stress, cracks occur far more easily. Namely, when compressive strain occurs, there is slippage at part of the crystal structure which destroys it, but in this case, a considerably long time is required for growth to a crack. Contrary to this, when tensile strain occurs, a large number of microcracks are caused in the internal portion. If the temperature of the exhaust manifold is high, these microcracks grow into cracks in a relatively short time. Accordingly, when the temperature of the exhaust manifold is high, occurrence of tensile distortion exerts a greater influence upon the occurrence of cracks than the occurrence of the compressive strain. Accordingly, in an exhaust manifold in which the temperature becomes high, it is necessary to mainly prevent the occurrence of cracks caused by tensile strain.

The occurrence of cracks due to this tensile strain cannot be prevented just by making the tube walls of the exhaust manifold thicker as in the above-mentioned well known exhaust manifold. Namely, when the tube walls of the exhaust manifold are made thicker, the tensile stress which locally occurs inside the tube wall becomes smaller, but even in this case, if the temperature of the exhaust manifold becomes high, a large number of microcracks occur. In so far as tensile stress acts, these microcracks gradually grow into cracks. Therefore, cracks still occur at a relatively early stage.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an exhaust device which is capable of preventing cracks from occurring.

According to the present invention, there is provided an exhaust device of an internal combustion engine, comprising an exhaust manifold having an outer wall portion in which a tensile stress occurs at least when the engine is operated and means for periodically providing a compressive stress for the outer wall portion of the exhaust manifold.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be more fully understood from the description of the preferred embodiments of the invention set forth below, together with the accompanying drawings, in which:

- Fig. 1 is a front view of an exhaust manifold;
- Fig. 2A is a front view of a portion of the exhaust manifold according to the present invention;
- Fig. 2B is a side view of Fig. 2A;
- Fig. 3 is a side view of another embodiment of a portion of the exhaust manifold;
- Fig. 4 is a front view of a further embodiment of the exhaust manifold;
- Fig. 5A is a side view of the exhaust manifold shown in Fig. 4;
- Fig. 5B is a side view of a still further embodiment of the exhaust manifold;
- Fig. 6 is a side view of a still further embodiment of the exhaust manifold; and
- Fig. 7 is a flow chart for controlling the actuator.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 shows an exhaust manifold 1 provided for the three cylinders of one bank of a 6-cylinder V-engine. This exhaust manifold 1 has three tubes 2. Flanges 3 for mounting to the engine body are affixed to the front end portions of the tubes 2. These tubes 2 merge at the manifold gathering portion 4. A mounting flange 5 is also affixed to the exhaust gas outflow port of the mani-

fold gathering portion 4. For example, a catalytic converter is attached to the mounting flange 5.

Four outwardly projecting columnar bodies for supporting a heat insulator covering the exhaust manifold 1, that is, the bosses 6, an outwardly projecting columnar body having an EGR gas takeout bore 7 for taking out the exhaust gas recirculation gas (hereinafter referred to as an EGR gas) formed therein, that is, a boss 8, and an outwardly projecting columnar body having an insertion bore 9 for inserting an oxygen concentration sensor formed therein, that is, a boss 10, are integrally formed on the exhaust manifold 1. One boss 6 among the four bosses 6 for the heat insulator is formed on the manifold gathering portion 4, while the remaining three heat insulator bosses 6 are formed on the tubes 2. Also, the boss 8 for the EGR gas and the boss 10 for the sensor are formed on the manifold gathering portion 4. In the embodiment shown in Fig. 1, the boss 8 for the EGR gas is arranged at a distance from the boss 6 for the heat insulator and boss 10 for the sensor on the manifold gathering portion 4 and between these bosses 6 and 10.

When these bosses 6, 8, and 10 are provided, these bosses 6, 8, and 10 function as types of cooling fins, that is, at the part where these bosses 6, 8, and 10 are provided, the area of the heat radiating surface becomes greater and therefore the temperature becomes lower in comparison with the wall surface portion of the exhaust manifold 1 where these bosses 6, 8, and 10 are not provided. Accordingly, the amount of thermal expansion at the part where these bosses 6, 8, and 10 are formed becomes smaller in comparison with the amount of thermal expansion at the part where these bosses 6, 8, and 10 are not formed, and therefore tensile stress will occur inside the wall surface of the exhaust manifold 1 at the periphery of the bosses 6, 8, and 10. This tensile stress becomes the largest inside the wall surface of the exhaust manifold 1 between the bosses 6, 8, and 10, that is, inside the wall surface of the exhaust manifold 1 between the boss 6 for the heat insulator of the manifold gathering portion 4 and the boss 8 for the EGR gas and between the boss 8 for the EGR gas and the boss 10 for the sensor.

Also, the tensile stress generated among these bosses 6, 8, and 10 becomes further larger when the temperature of the exhaust manifold 1 rises after the start of the engine. Namely, these bosses 6, 8, and 10 have a large heat capacity, and therefore after the start of the engine, the temperature rises at a slow speed in comparison with the rise of temperature of the exhaust manifold 1 and, thus, during this time, the temperature difference between the bosses 6, 8, and 10 and the wall surface of the exhaust manifold 1 on which these bosses 6, 8, and 10 are not formed becomes large. Accordingly, during this time, a large tensile stress will occur between the bosses 6, 8, and 10. In any case, when such bosses 6, 8, and 10 are formed on the exhaust manifold 1, whenever the engine is operated, a tensile stress occurs inside the wall surface of the

exhaust manifold 1 between the bosses 6, 8, and 10, and thus cracks will be caused between the bosses 6, 8, and 10 in the end.

Therefore, in the embodiment according to the present invention, as shown in Figs. 2A and 2B, the outer end portion of the side wall surface of the boss 6 for the heat insulator and the outer end portion of the side wall surface of the boss 8 for the EGR gas are connected by a bridge member 11 extending separated by a certain distance from the outer peripheral wall surface of the exhaust manifold 1,

When the engine starts being operated, the temperature of the outer peripheral wall of the exhaust manifold 1 gradually becomes higher. At this time, the temperatures of the bosses 6, 8 and 10 slowly rise with respect to the rise of the temperature of the exhaust manifold 1 as mentioned above. At this time, the temperatures of the bridge members 11 and 12 further slowly rise with respect to the rise of the temperature of the exhaust manifold 1. Accordingly, even if the temperature of the exhaust manifold 1 becomes considerably high, the temperatures of the bridge members 11 and 12 do not rise so much, and thus the amounts of thermal expansion of the bridge members 11 and 12 become considerably smaller than the amount of thermal expansion of the outer peripheral wall of the exhaust manifold 1 between the bosses 6, 8, and 10. As a result, a compressive stress will occur in the outer peripheral wall of the exhaust manifold 1 between the bosses 6, 8, and 10. Subsequently, after a short time, the temperatures of the bridge members 11 and 12 rise, and therefore tensile stress occurs again inside the outer peripheral wall of the exhaust manifold 1 between the bosses 6, 8, and 10.

In this way, in this embodiment, whenever the engine starts to be operated, that is, periodically, in a state where the temperature of the exhaust manifold 1 is relatively high, a compressive stress is generated inside the outer peripheral wall of the exhaust manifold 1 between the bosses 6, 8, and 10. As a result, the micro-cracks which occur when the tensile stress acts upon the interior of the outer peripheral wall of the exhaust manifold 1 between the bosses 6, 8, and 10 are repaired by the compressive stress which is periodically generated, and thus it becomes possible to prevent cracks from occurring in the outer peripheral wall of the exhaust manifold 1 between the bosses 6, 8, and 10.

In the embodiment shown in Figs. 2A and 2B, the bridge members 11 and 12 are cast simultaneously when casting the exhaust manifold 1. Namely, in this embodiment, the bridge members 11 and 12 are formed integrally with the corresponding bosses 6, 8, and 10 when casting the exhaust manifold 1.

Figure 3 shows another embodiment. Note that, in Fig. 3, 13 denotes a heat insulator, and 14 denotes an EGR gas conduit. In this embodiment, a mounting flange 15 affixed to the tip portion of the EGR conduit 14 is formed large so as to be able to cover the top face of the boss 6 for the heat insulator. This mounting flange

15 is tightly secured to the top portion of the boss 8 for the EGR gas by using for example a nut. The end portion of this mounting flange 15 is tightly secured to the top portion of the boss 6 for the heat insulator together with the heat insulator 13 by for example a bolt. Accordingly, in this embodiment, the mounting flange 15 of the EGR gas conduit 14 constitutes the bridge member.

Figure 4 and Figs. 5A and 5B show still another embodiment. Note that, in the embodiment, similar constituent elements to those in Fig. 1 are indicated by the same reference numerals.

As shown in Fig. 4 and Fig. 5A, in this embodiment, the exhaust manifold 1 is for a four-cylinder internal combustion engine, and the catalytic converter 16 is attached to the mounting flange 5 formed at the manifold gathering portion 4. This catalytic converter 16 is supported by the engine body by a stay 17. In this way, when the exhaust manifold 1 and the catalytic converter 16 extend curved as a whole when seen from the mounting flange 3 of the tube 2, even outside of this curved structure, the largest tensile stress is apt to occur at the part having the smallest cross-sectional area. In the embodiment shown in Fig. 4 and Fig. 5A, it is the outside portion indicated by X of the manifold gathering portion 4 where this largest tensile stress occurs.

Therefore, in this embodiment, the bridge member 18 is provided so as to straddle the outside portion X of the manifold gathering portion 4 in which the largest tensile stress occurs. This bridge member 18 is cast simultaneously with the casting of the exhaust manifold 1 so as to be separated by a certain distance from the outer peripheral wall surface of the exhaust manifold 1. Also in this embodiment, for a short time after the start of the engine, the temperature of the bridge member 18 does not rise so much, therefore the amount of thermal expansion of the bridge member 18 is small, and thus during this time, a compressive stress is generated in the outside portion X of the manifold gathering portion 4 under a state where the temperature of the outer peripheral wall of the exhaust manifold 1 is relatively high. Accordingly, also in this embodiment, the microcracks are repaired by this compressive stress, and thus the generation of cracks can be prevented.

Figure 5B shows a further embodiment. In this embodiment, bosses 19 are formed on the outer peripheral wall surface of the exhaust manifold 1 on the two sides of the outside portion X of the manifold gathering portion 4 where the largest tensile stress occurs. The top portions of these bosses 19 are connected with each other by the bridge member 20.

Figure 6 shows a further embodiment. Note that, in this embodiment, similar constituent elements to those in Fig. 5A and Fig. 5B are indicated by the same reference numerals. In this embodiment, the catalytic converter 16 is supported by still another supporting device 21 in addition to the stay 17. This supporting device 21 is provided with an actuator 22 made of a hydraulic cylinder supported by the engine body 1. A hydraulic piston

23 of this actuator 22 is connected to the catalytic converter 16 via a link member 24. An oil pressure chamber 25 in the actuator 22 is connected to the exhaust port of the hydraulic pump 28 via an opening/closing valve 26 controlled by the output signal of an electronic control unit 30, and the oil inside the hydraulic chamber 25 is returned to the oil reservoir 29 via a throttle 27.

When the opening/closing valve 26 is opened, pressurized oil is supplied into the oil pressure chamber 25 via the opening/closing valve 26. When the pressurized oil is supplied into the oil pressure chamber 25, the catalytic converter 16 is pivoted in the clockwise direction about the pivot 28 by the hydraulic piston 23, and thus a compressive stress is generated in the outside portion X of the manifold gathering portion 4.

The electronic control unit 30 comprises a digital computer which is provided with a read only memory (ROM) 32, a random access memory (RAM) 33, a microprocessor (CPU) 34, an input port 35, and an output port 36, all of which are connected to each other by a bidirectional bus 31. An output signal of an air flow meter 40 indicating the amount of intake air and, for example, the output signal of an exhaust temperature sensor 43 indicating the exhaust gas temperature inside the exhaust manifold 1 are input to the input port 35 via respectively corresponding AD converters 37. Further, the output pulse of a rotational speed sensor 41 indicating the rotational speed of the engine, the output pulse of a vehicle speed sensor 42 indicating the vehicle speed, and an ON/OFF signal of an ignition switch 44 are input to the input port 35. On the other hand, the output port 36 is connected to the opening/closing valve 26 via a drive circuit 28.

Figure 7 shows a routine for controlling the actuator 22. This routine is executed by for example interruption at every predetermined time period.

Referring to Fig. 7, first, at step 50, it is decided whether or not the drive conditions for the actuator 22 have been established. When the drive conditions for the actuator 22 have been established, the processing routine proceeds to step 51, at which it is decided whether or not for example the temperature T_e of the exhaust gas flowing inside the exhaust manifold 1 is higher than a predetermined set temperature, for example, 800°C . When $T_e > 800^\circ\text{C}$, the processing routine proceeds to step 52, at which the actuator 22 is driven for a constant time. Namely, in the embodiment shown in Fig. 6, the opening/closing valve 26 is opened at this time, and pressurized oil is supplied into the oil pressure chamber 25, whereby a compressive stress is generated in the outside portion X of the manifold gathering portion 4.

When the tensile stress acts upon the outside portion X of the manifold gathering portion 4 for a long period when the temperature of the exhaust manifold 1 is high, microcracks occur in the outside portion X of the manifold gathering portion 4. At this time, if a compressive stress is generated in the outside portion X of the

manifold gathering portion 4 for an extremely short time in a state where the temperature of the exhaust manifold 1 is high, the microcracks can be repaired. Accordingly, in the routine shown in Fig. 7, at step 50, it is decided whether or not an appropriate period has elapsed after the occurrence of compressive stress in the outside portion X of the manifold gathering portion 4. It is determined that the drive conditions have been established when an appropriate time has elapsed.

For example, at step 50, how many times the engine has been operated is counted from the ON/OFF signal of the ignition switch 44. When the engine has been operated several dozen times, it is determined that the conditions for driving have been established. In this case, the actuator 22 is periodically driven just one time whenever the engine is operated several dozens of times. Also, as step 50, the cumulative value of the traveling distance is calculated based on the output signal of the vehicle sensor 42, or the cumulative value of the engine rotational speed is calculated. It is also possible to determine that the drive conditions have been established when these cumulative values exceed constant values. Also, at step 50, it is also possible to count the number of times the exhaust gas temperature T_e has exceeded 800°C and determine that the drive conditions have been established when this number of times exceeds a constant value.

On the other hand, at step 51 of Fig. 7, it is decided whether or not the exhaust gas temperature T_e becomes 800°C or more based on the output signal of the exhaust temperature sensor 43. Instead of providing such an exhaust temperature sensor 43, it is also possible to preliminarily store the relationship among the exhaust gas T_e , engine rotational speed, intake air amount, and the ignition advance angle in the ROM 32 and to find the exhaust gas temperature T_e from this stored relationship.

Also, while a hydraulic cylinder is used as the actuator 22 in the embodiment shown in Fig. 6, it is also possible to use a piezoelectric element or solenoid as this actuator 22.

According to the present invention, the occurrence of cracks in the exhaust manifold can be prevented, and therefore the service life of the exhaust manifold can be prolonged.

While the invention has been described by reference to specific embodiments chosen for purposes of illustration, it should be apparent that numerous modifications could be made thereto by those skilled in the art without departing from the basic concept and scope of the invention.

An exhaust device comprising an exhaust manifold. A boss for a heat insulator, a boss for an EGR gas, and a boss for a sensor are formed on an outer peripheral surface of the exhaust manifold. An outer end portion of the side wall surface of the boss for the heat insulator and the outer end portion of the side wall surface of the boss for the EGR gas are connected by a bridge member, and an outer end portion of the side wall surface of

the boss for the EGR and the outer end portion of the side wall surface of the boss for the sensor are connected by a bridge member as well.

Claims

1. An exhaust device of an internal combustion engine, comprising:
an exhaust manifold having an outer wall portion in which a tensile stress occurs at least when the engine is operated and
means for periodically providing a compressive stress to said outer wall portion of the exhaust manifold.
2. An exhaust device as set forth in claim 1, wherein said means is comprised of a bridge member which extends, separated by a certain distance from said outer wall portion, so as to straddle said outer wall portion and is connected at its two end portions to an outer wall surface of the exhaust manifold.
3. An exhaust device as set forth in claim 2, wherein said bridge member is formed integrally with the exhaust manifold.
4. An exhaust device as set forth in claim 2, wherein at least one pair of outwardly projecting bosses is integrally formed on the outer wall surface of the exhaust manifold and said bridge member is formed integrally with said bosses.
5. An exhaust device as set forth in claim 2, wherein at least one pair of outwardly projecting bosses is integrally formed on the outer wall surface of the exhaust manifold and the two end portions of said bridge member are affixed to said bosses.
6. An exhaust device as set forth in claim 5, wherein at least one boss has a gas passage formed therein and a mounting flange of a conduit to be connected to said gas passage constitutes said bridge member.
7. An exhaust device as set forth in claim 1, wherein the exhaust manifold comprises tubes and a gathering portion and wherein the outer wall portion in which a tensile stress occurs is an outer wall portion of said gathering portion.
8. An exhaust device as set forth in claim 7, wherein the exhaust manifold extends so as to gradually face downward the further away from the body of the engine and wherein the outer wall portion in which the tensile stress occurs is the outer wall portion of said gathering portion positioned at a side opposite to the body of the engine.

9. An exhaust device as set forth in claim 8, wherein a catalytic converter is attached to the gathering portion of the exhaust manifold.
10. An exhaust device as set forth in claim 1, wherein said means comprises an actuator which is periodically driven. 5
11. An exhaust device as set forth in claim 10, wherein the exhaust manifold comprises tubes and a gathering portion, the catalytic converter is connected to said gathering portion, and said actuator is arranged between the catalytic converter and the body of the engine. 10

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Fig.1

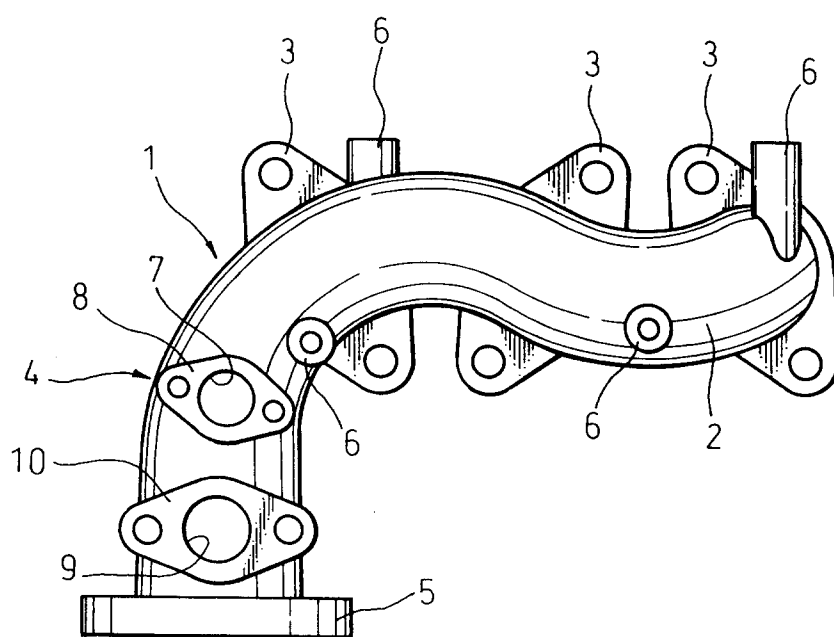


Fig. 2A

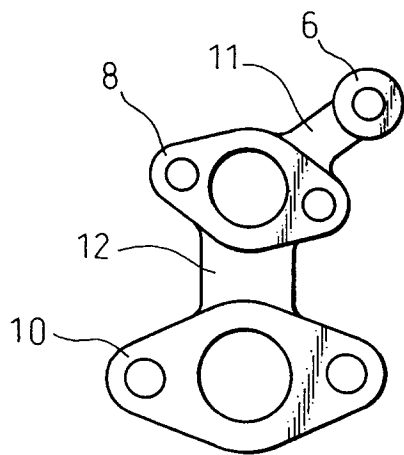


Fig. 2B

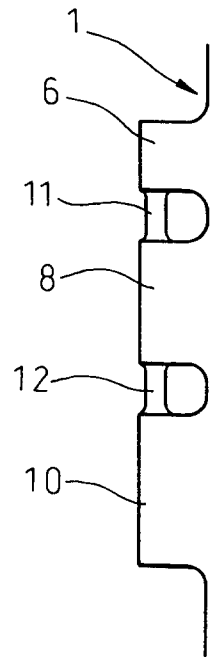


Fig. 3

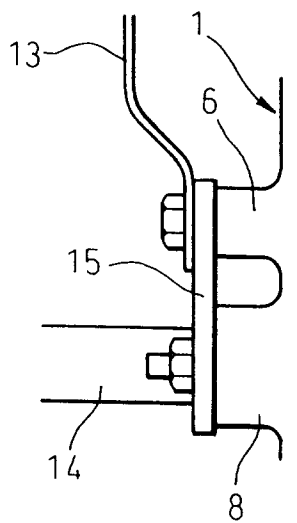


Fig.4

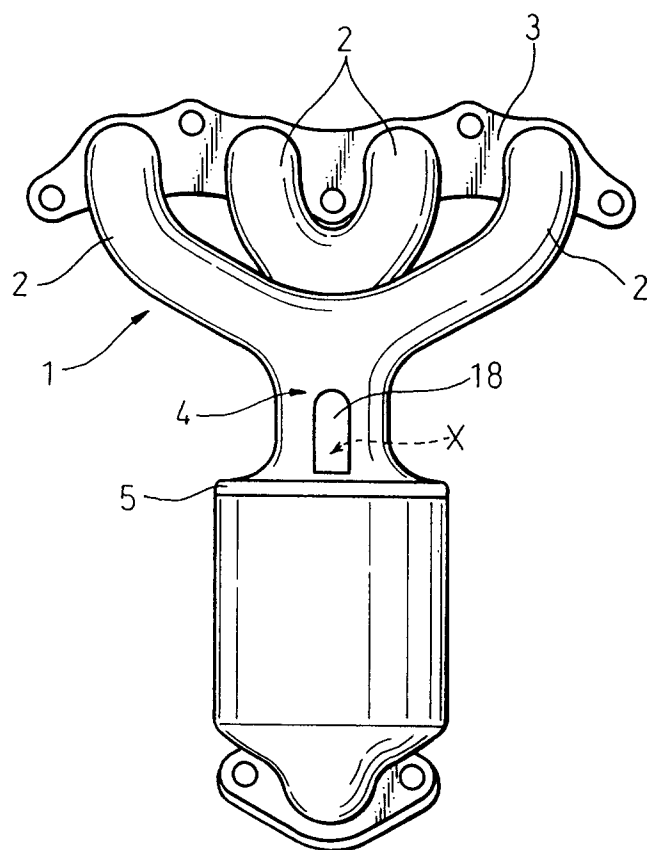


Fig.5A

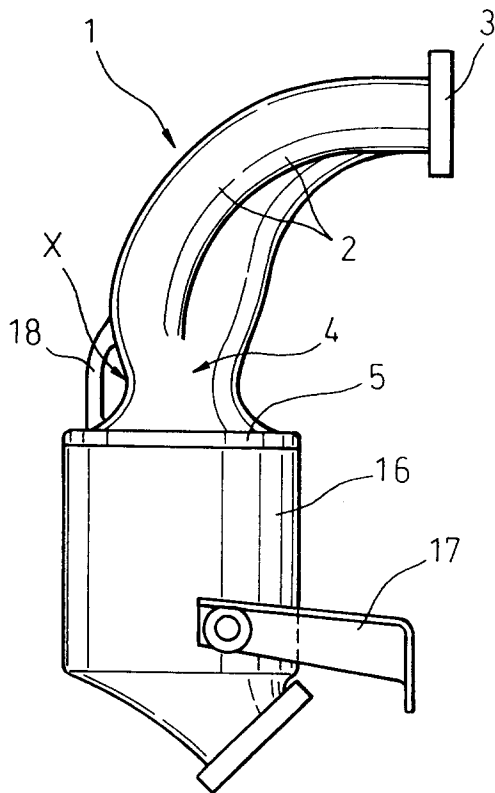


Fig.5B

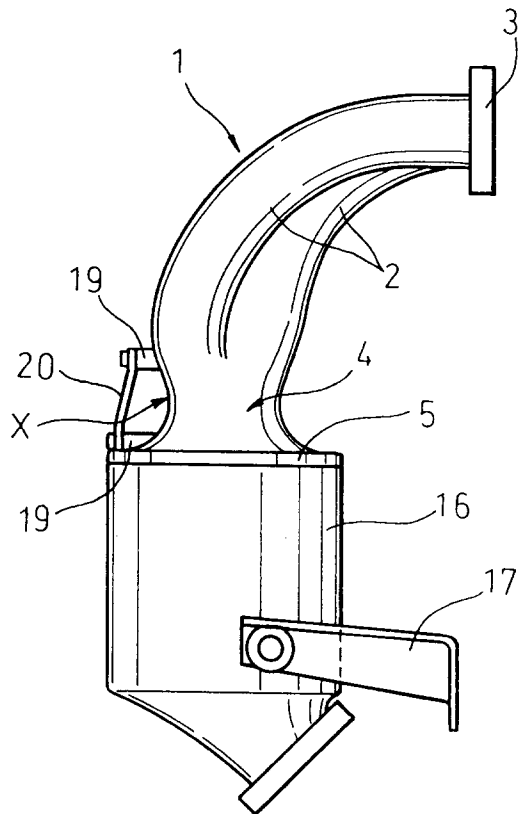


Fig.6

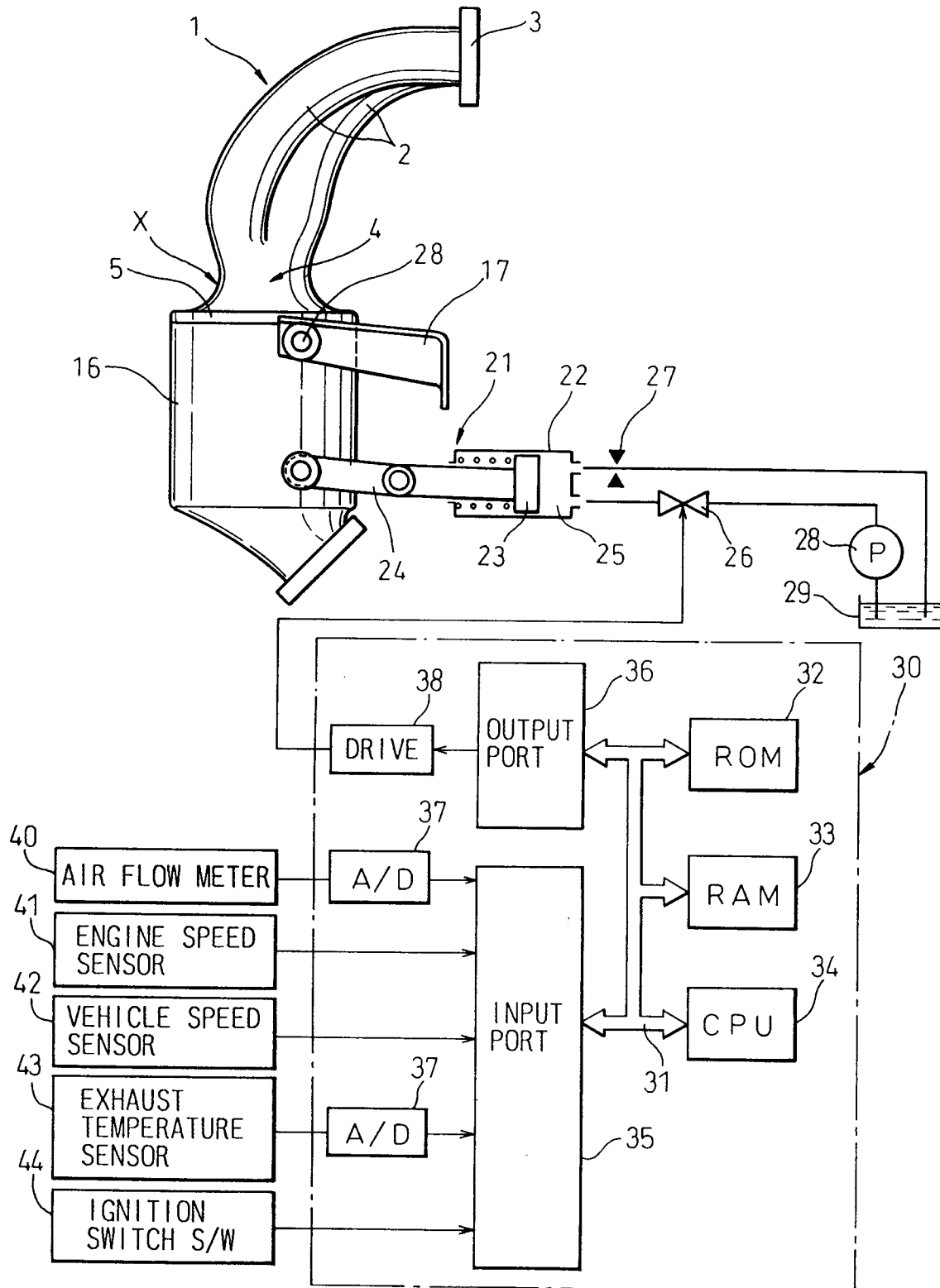
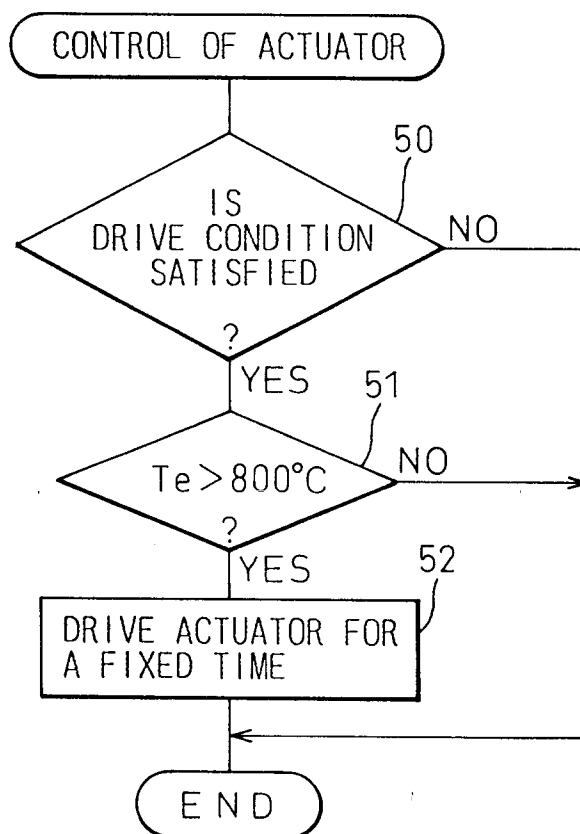


Fig.7





European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 96 10 1266

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	FR-A-2 549 530 (WITZENMANN GMBH METALLSCHLAUCH-FABRIK PFORZHEIM) * page 6, line 12 - page 8, line 4; figures 1-4 *	1,2,7	F01N7/10
X	--- PATENT ABSTRACTS OF JAPAN vol. 9, no. 183 (M-400) [1906] , 30 July 1985 & JP-A-60 050217 (MAZDA), 19 March 1985, * abstract *	1	
A	--- US-A-4 924 669 (TSUTSUMI) * column 1, line 17 - line 27; figures 5-7 *	1,2,5	
A	--- US-A-5 233 832 (MOORE)		
A	--- DE-A-39 25 802 (BAYERISCHE MOTOREN WERKE) -----		
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			F01N
Place of search		Date of completion of the search	Examiner
THE HAGUE		28 May 1996	Friden, C
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