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(54) **Attachment structure of glow plug**

Verbindungsstruktur für Glühkerze

Structure de connexion pour bougie de préchauffage

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(73) Proprietor: **Denso Corporation**
Kariya-city,
Aichi-pref. 448-8661 (JP)

(72) Inventors:
• **Murai, Hiroyuki**
Kariya-city,
Aichi-pref., 448-8661 (JP)
• **Hattori, Kouichi**
Kariya-city,
Aichi-pref., 448-8661 (JP)

(74) Representative: **TBK-Patent**
Bavariaring 4-6
80336 München (DE)

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention:

[0001] The present invention relates to an attachment structure of a glow plug including a pressure sensor for use in an internal combustion engine.

2. Description of Related Art:

[0002] JP-A-7-139736 discloses a glow plug including a combustion pressure sensor. In JP-A-7-139736, the glow plug is attached to a vehicle diesel engine, and includes a plug body having a heater and a pressure sensor detecting a combustion pressure based on force acting on the plug body in accordance with the combustion pressure.

[0003] As shown in FIG. 12, a first glow plug 100 including a pressure sensor 300 and second through fourth glow plugs 200 are attached to an engine head 1.

[0004] Each glow plug 100, 200 includes a plug body 700 and is connected to a common metal plate connecting bar 2 at a terminal screw 204a of a metal rod 204. The connecting bar 2 has four holes or grooves through which the terminal screws 204a of the glow plugs 100, 200 penetrate, respectively.

[0005] A ring crimp terminal 4 is crimped to a battery wire 3. The ring crimp terminal 4 is made of metal and includes a hole or a groove through which the terminal screw 204a penetrates. The ring crimp terminal 4 is connected to the leftmost fourth glow plug 200. The connecting bar 2 is fixed to the top surface of a nut 210 by a terminal nut 211.

[0006] A battery voltage is impressed to the metal rods 204 of the glow plugs 100, 200 in parallel, through the battery wire 3 and the connecting bar 2. The battery voltage is grounded to the engine head 1 through a heating coil 203, a sheath pipe 202 and a housing 201. Thereby, a heating body 206 including the heating coil 203 and the sheath pipe 202 heats for each engine cylinder.

[0007] In the first glow plug 100 including the pressure sensor 300, the ring-like pressure sensor 300 is fit and fixed to the housing 201 through the screw 201a. The pressure sensor 300 detects the combustion pressure based on force acting on the plug body 700. That is, the combustion pressure is detected as a displacement of the plug body 700 in the first plug 100. The displacement is transmitted to a piezoelectric element of the pressure sensor 300, and is converted into an electric output signal. The electric output signal is sent to a vehicle ECU through a lead wire 500, to be used for engine controls.

[0008] However, in a diesel engine of which an engine vibration is extremely larger than that of a gasoline engine, the connecting bar 2 is made of high rigidity material against a repeated stress.

[0009] Thus, a mechanical vibration due to a connect-

ing bar deflection at the connecting bar 2a between each glow plug 100, 200 is transmitted to the pressure sensor 300 through the plug body 700 without being absorbed by the connecting bar 2. Since the pressure sensor 300 also detects the mechanical vibration adding to the combustion pressure, the pressure sensor 300 detects the combustion pressure inaccurately.

[0010] Further, when the pressure sensor 300 is not firmly fixed to the engine head 1, the screw connection between the pressure sensor 300 and the plug body 700 through the screw 201a might be loosen caused by an engine vibration, so that the pressure sensor 300 itself mechanically vibrates. In this case, the mechanical vibration of the pressure sensor 300 worsens the accuracy of detecting the combustion pressure.

[0011] Further, as shown in FIG. 12, the plug body 700 includes a projection 200a protruding from the top surface of the engine head 1. The pressure sensor 300 is fixed to the outer surface of the plug housing 201 within the projection 200a while contacting the top surface of the engine head 1.

[0012] In the prior art, a projection length L of the projection 200a, which is a length from the top surface of a hexagon portion 312 of the pressure sensor 300 to the top end of the projection 200a is too long (about 60 mm). The long projections 200a causes the mechanical vibration of the plug body 700, of which a frequency is relatively close to a resonance frequency of the connecting bar 2, thereby reducing the accuracy of detecting the combustion pressure.

SUMMARY OF THE INVENTION

[0013] An object of the present invention is to suppress a mechanical vibration from influencing an output from a combustion pressure sensor.

[0014] According to a first aspect of the present invention, a glow plug including a pressure sensor is independently connected to an electric current supply member, which is separated from other glow plugs. That is, the glow plug including the pressure sensor is not connected to a common connecting bar with the other glow plugs as in the prior art, so that a mechanical vibration due to a connecting bar deflection between each glow plug does not influence the glow plug including the pressure sensor.

[0015] According to a second aspect of the present invention, all glow plugs are commonly connected to a flexible electric current supply member of which a resonance frequency is less than a combustion pressure frequency, so that, the mechanical vibration frequency of the flexible electric current supply member does not overlap the combustion pressure frequency. Thus, the mechanical vibration frequency of the flexible electric supply member is easily removed from the output signal of the pressure sensor.

[0016] In this way, according to the above described first and second aspect of the present invention, a mechanical vibration noise is substantially completely re-

moved from the output signal of the pressure sensor.

[0017] According to a third aspect of the present invention, a combustion pressure sensor including a piezoelectric element is at least partially embedded into an engine head, and the embedded portion of the combustion pressure sensor is pushed against the engine head in an axial direction of the glow plug and in other directions. Thus, the pressure sensor in which the piezoelectric element is installed is supported in plural directions. That is, the pressure sensor is firmly fixed to the engine head, thereby suppressing the vibration noise caused by the mechanical vibration of the pressure sensor from influencing on the output of the pressure sensor.

[0018] According to a fourth aspect of the present invention, a plug body includes a projection protruding from a top surface of an engine head in an axial direction of the glow plug, and a connection portion provided at the tip end area of the projection for connecting with an electric current supply member. A combustion pressure sensor is fixed to an outer surface of the projection abutting on the top surface of the engine head. A projection length (L) from the portion where the combustion pressure sensor is fixed to the tip end of the projection is less than 45 mm. Thus, the resonance frequency of the glow plug is higher than the combustion pressure frequency, and does not overlap the combustion pressure frequency, thereby suppressing the vibration noise caused by the mechanical vibration of the glow plug from influencing on the output of the pressure sensor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] Additional objects and advantages of the present invention will be more readily apparent from the following detailed description of preferred embodiments thereof when taken together with the accompanying drawings in which:

FIG. 1 is a cross sectional view showing a glow plug and an engine head (first embodiment);
 FIG. 2A is a cross sectional view showing a pressure sensor (first embodiment);
 FIG. 2B is a bottom view showing the pressure sensor;
 FIG. 3 is an enlarged view showing a piezoelectric element (first embodiment);
 FIG. 4 is a cross sectional view showing a lead connector (first embodiment);
 FIG. 5 is a plan view showing a lead wire (first embodiment);
 FIGS. 6A-6E are graphs explaining effects of the first embodiment;
 FIG. 7A is a cross sectional view showing a pressure sensor (second embodiment);
 FIG. 7B is a bottom view showing the pressure sensor (second embodiment);
 FIG. 8 is cross sectional view showing a pressure sensor of a modification (second embodiment);

FIGS. 9A and 9b are graphs explaining effects of the second embodiment;

FIG. 10 is a graph showing a relation between a projection length L of the glow plug and a resonance frequency of the glow plug (third embodiment);

FIGS. 11A-11C are graphs explaining effects of the third embodiment, and

FIG. 12 is a cross sectional view showing a glow plug and an engine head (Prior Art).

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

(First Embodiment)

[0020] As shown in FIG. 1, a first glow plug 100 and second through fourth glow plugs 200 are attached to an engine head 1. The first glow plug 100 includes a plug body 700 and a pressure sensor 300. The plug body 700 heats by receiving an electric current. The pressure sensor 300 detects engine combustion pressure based on a force caused by the combustion pressure acting on the plug body 700. The second, third and fourth glow plugs 200 also include a plug body 700 respectively.

[0021] The engine head 1 includes a glow hole penetrating through the engine head 1 from the outside thereof to the inside of a combustion chamber 1a for each engine cylinder. The plug bodies 700 are inserted into the glow holes respectively. The plug body 700 includes a metal housing 201 having a screw 201a formed at the outer surface thereof. The screw 201a is screwed to the glow hole to fix the housing 201 to the engine head 1.

[0022] The plug body 700 includes a sheath pipe 202 supported by the housing 201. The sheath pipe 202 is made of heat resisting and corrosion resisting alloy (for example, stainless SUS 310) and formed in a cylindrical pipe. The bottom end of the sheath pipe 202 is closed and the top end thereof opens. A heating coil 203 made of resistance wire such as NiCr, CoFe is provided in the bottom area of the sheath pipe 202. A metal rod 204 is inserted into the top area of the sheath pipe 202.

[0023] The heating coil 203 connects with the bottom end of the sheath pipe 202 and the lower end of the metal pipe 204. A heat resisting insulation powder 205 such as magnesia oxide is provided between the heating coil 203 and the sheath pipe 202, and between the metal rod 204 and the sheath pipe 202. The sheath pipe 202 is drawing formed by swaging, so that the density of the insulation powder 205 is increased, and the sheath pipe 202, the heating coil 203, and the metal rod 203 are firmly fixed.

[0024] The sheath pipe 202, the heating coil 203, and the insulation powder 205 form a heating body 206. The heating body 206 is disposed in the housing 201 in such a manner that the bottom end of the sheath pipe 202 is exposed to the combustion chamber 1a. The heating body 206 is press inserted into the housing 201, or brazed to the housing 201 by silver brazing.

[0025] A washer 207 made of insulating bakelite and

an O-ring 208 made of silicon or fluorine rubber are provided at the upper area of the metal rod 204. The washer 207 centers the metal rod 204, and the O-ring 208 seals a gap between the metal rod 204 and the housing 201.

[0026] The metal rod 204 is fixed to the housing 201 through an insulation bush 209 made of insulation resin such as phenol, and by a nut 210 screwed along a terminal screw (connection portion) 204a of the metal rod 204. The insulation bush 209 prevents an electrical short circuit from the metal rod 204 to the housing 201.

[0027] Each second, third, and fourth glow plug 200 is connected to a common connecting bar 2 at the terminal screw 204a. That is, the second, third, and fourth glow plugs 200 share the common connecting bar 2. The first glow plug 100 including the pressure sensor 300 is independently connected to a ring crimp terminal (electric current supply member) 400, which is a different member from the connecting bar 2.

[0028] The crimp terminal 400 is made of metal, and includes a hole or a slit through which the terminal screw 204a is inserted. The crimp terminal 400 is fixed to the terminal screw 204a by the nut 210 and a terminal nut 211. A battery wire 401 is electrically connected to the crimp terminal 400. Another battery wire 3 is electrically connected to the connecting bar 2 through another ring crimp terminal 4.

[0029] The electric wires 3, 401 are made of soft material and the outer surfaces thereof are electrically insulated. The electric wires 3, 401 are connected to a vehicle battery (not illustrated) through a relay. The battery supplies an electric current into each glow plug 100, 200. The heating body 206 of each cylinder heats at the same time, and assist the ignition of a diesel engine.

[0030] The heating body 206 is a metal heating body made of metal resistance wire. Alternatively, the heating body 206 may be a ceramic heating body made of electric conductive ceramics including nitride silicon and silicon molybdenum, which is insulated by an insulator made of insulating ceramic including nitride silicon.

[0031] As shown in FIG. 1, the pressure sensor 300 is formed in a ring, and fixed to a projection 200a of the plug body 700, which protrudes from the top surface of the engine head 1. The pressure sensor contacts 300 the top surface of the engine head 1.

[0032] As shown in FIGS. 2A and 2B, the pressure sensor 300 includes a nut 310, a piezoelectric element 320, a lead 330, a pedestal 340, and a metal casing 350. The nut 310 fixes a sensor body to the plug body 700. The piezoelectric element 320 outputs an electric signal based on the force caused by the combustion pressure. The lead 330 leads the electric signal to a lead wire 500. The nut 310 and the pedestal 340 support the piezoelectric element 320 and a part of the lead 330. The metal casing 350 protects the piezoelectric element 320 from dust and water. The nut 310 is made of metal and fixed to the housing 201. The nut 310 includes a screw 311 to fix the sensor body to the housing 201 through the screw 201a, and a hexagon portion 312. The nut 310 further

includes a large diameter portion 313 and a small diameter portion 314 below the hexagon portion 312. An insulation tube 315 made of silicon is provided around the small diameter portion 314.

[0033] The lead 330 electrically connects the piezoelectric element 320 to the lead wire 500. The lead 330 includes an electrode 331, an insulator 332, and hardware 333. The electrode 331 is made of metal and formed in a ring. The insulator 332 is disposed between the electrode 331 and the nut 310 to insulate them from each other. The insulator 332 is formed in a ring and made of insulating material such as mica, alumina, and the like. The electrode 331 and the insulator 332 are fit to the outer periphery of the small diameter portion 314 through the insulation tube 315.

[0034] The lead wire 500 is constructed by concentrically layering a signal output wire 501, an insulating cover 502, a ground sealed wire 503, and an insulation cover 504 from the inside to the outside thereof. The signal output wire 501 is insulated from the ground sealed wire 503. As shown in FIG. 2A, the signal output wire 501, the insulating cover 502, and the ground sealed wire 504 are partially exposed at one end of the lead wire 500.

[0035] The signal output wire 501 passes through a hole 316 of the nut 310 and a cutout 332a of the insulator 332, and is welded to the electrode 331 at the hole 331a of the electrode 331. The other end of the lead wire 500 connects to an outside circuit (for example, ECU) through a connector (not illustrated).

[0036] The hardware 333 is cylindrically formed and provided at the outer periphery of the lead wire 500, to fix the lead wire 500 to the nut 310. The hole 316 includes a holding hole 316a at the upper area thereof, and the hardware 333 is inserted into the holding hole 316a. The hardware 333 is mechanically fixed to the lead wire 500, and electrically connected to the ground sealed wire 503. An insulating cover 333a made of silicon covers the outer surface of the hardware 333 protruding from the engine head 1.

[0037] The piezoelectric element 320 is formed in a ring, and provided around the small diameter portion 314 through the insulating tube 315. As shown in FIG. 3, the piezoelectric element 320 is constructed by stacking three layers piezoelectric ceramics 321 combining a signal output washer ring 322 and a ground washer ring 323. Each piezoelectric ceramics 321 is formed in a ring disc and made of lead titanate, lead titanate lead zirconate, or the like. Both washer rings 322 and 323 do not contact each other. In the piezoelectric element 320, as shown in FIG. 3, a positive electrode is disposed to contact the signal output washer ring 322, and a negative electrode is disposed to contact the ground washer ring 322. In this way, three piezoelectric ceramics 321 are arranged in electrically parallel, so that the output sensitivities of these piezoelectric ceramics 321 are summed up, thereby improving the sensitivity of the piezoelectric element 320.

[0038] The pedestal 340 is made of metal and formed

in a ring. As shown in FIG. 2B, the pedestal 340 includes a small disk like rotation block 341 at the surface contacting the engine head 1, to easily fit to a disk like rotation block 317 of the nut 310. The rotation block 317 is formed at the bottom end of the small diameter portion 314. Thus, the nut 310 is firmly fixed to the pedestal 340, and does not rotate with respect thereto.

[0039] The cylindrical metal casing 350 made of metal such as SUS 304 is provided at the outer periphery surface of the pedestal 340. The metal casing 350 covers the entire outer periphery of the pressure sensor 300. The metal casing 350 is made by cylindrically drawing a thin metal plate having less than 0.5 mm thickness, and laser welded or copper brazed to the pedestal 340 entirely.

[0040] In the pedestal 340 integrated with the metal casing 350, the rotation block 341 appropriately faces the rotation block 317 of the nut 310. An O-ring 343 provided in a cutout groove of the small diameter portion 314 firmly contacts an inner diameter surface 342 of the pedestal 340. Further, the metal casing 350 is fit to the large diameter portion 313 of the nut 310, and YAG-laser-welded to the large diameter portion 313 at an inside contacting area 351 entirely.

[0041] In this way, a screw force of the nut 310 pushes and fixes the pedestal 340 to the engine head 1. The screw force of the nut 310 also holds the piezoelectric element 320, the electrode 331 and the insulator 332 between the nut 310 and the pedestal 340.

[0042] An assembly procedure of the pressure sensor 300 will be explained hereinafter.

[0043] The signal output wire 501 is welded to the hole 331a of the electrode 331. The hardware 333 is inserted into the holding hole 316a of the nut 310, and welded or copper brazed thereto. The insulator 332 is attached to the small diameter portion 314.

[0044] The lead wire 500 is inserted into the hole 316 from the insulator 332 side, and the electrode 331 connected to the lead wire 500 is fit to the small diameter portion 314. After the electrode 331 is appropriately positioned, the hardware 333 is mechanically fixed to the ground sealed wire 503. The insulation cover 333a covers the lead wire 500 and the hardware 333. In this way, the ground sealed wire 503 is electrically connected to the hardware 333.

[0045] The piezoelectric element 320 is attached to the small diameter portion 314. The pedestal 340 integrated with the metal casing 350 is upwardly fit to the small diameter portion 314, while making the rotation block 341 to contact the rotation block 317. The metal casing 351 is laser welded to the large diameter portion 313 while pressing the pedestal 340 to the nut 310.

[0046] In this way, assembling the pressure sensor 300 is completed. The pressure sensor 300 is fit to the plug body 700 from the heating body 206, and screwed to the plug body 700 by the screw 201a, the screw 311, and the hexagon portion 312.

[0047] A detecting mechanism of the pressure sensor

300 will be explained.

[0048] The combustion pressure inside the engine is transmitted to the screw 201a through the heating body 206 of the first glow plug 100 and the housing 201. The combustion pressure loosens the fastening torque of the screw 201a, which fastens the glow plug 100 to the engine head 1.

[0049] Thus, an axial force, caused by fastening the pressure sensor 300, acting on the piezoelectric ceramics 321 through the screw 311 of the nut 310 is also loosened, so that an electric signal output from the piezoelectric ceramics 321 based on the piezoelectric characteristic thereof varies. The electric signal is output through the electrode 331 and the lead wire 500, and to the outside circuit. The electric signal is converted into electric voltage and used as a combustion pressure wave signal for a combustion control.

[0050] As shown in FIG. 1, the first glow plug 100 including the pressure sensor 300 is independently connected to the ring crimp terminal 400, which is separated from the common crimp terminal 4 and the common connecting bar 2 for the second through fourth glow plugs 200. That is, the first glow plug 100 including the pressure sensor 300 is not connected to the common connecting bar 2 with the other glow plugs 200 as in the prior art, so that a mechanical vibration due to a connecting bar deflection between each glow plug 200 does not influence the first glow plug 100.

[0051] According to the above-described embodiment, the ring crimp terminal 400 is used as a first example. Alternatively, as shown in FIG. 4, the ring crimp terminal 400 may be replaced with a lead connector (electric current supply member) 410 as a second example. The lead connector 410 is connected to the terminal screw 204a. The lead connector 410 includes a cylindrical crimp terminal 411 which is easily attached and detached without an instrument.

[0052] A metal terminal nut 420 is screwed to the terminal screw 204a of the first plug 100 through a terminal screw 421. Further, a cutout groove 425 is crimped to fix the terminal nut 420 to the terminal screw 204a with the insulating bush 209.

[0053] The cylindrical crimp terminal 411 is connected to a battery wire 430. The lead connector 410 includes the cylindrical crimp terminal 411 integrated with a rubber cap 412 made of silicon rubber. The lead connector 410 further includes a cutout groove 413 and a collar 414. The terminal nut 420 further includes a projection terminal 423 and a collar 424. The lead connector 410 is attached to the terminal nut 420 by fitting the cylindrical crimp terminal 411 to the projection terminal 423, by fitting the cutout groove 413 to the collar 424, and by inserting the collar 414 into the cutout groove 425. In this way, the lead connector 410 is appropriately supported by the terminal nut 420 to cope with the mechanical vibration and detachment.

[0054] In the second example, as in the first example, the first glow plug 100 including the pressure sensor 300

is independently connected to the lead connector 410, which is separated from the common connecting bar 2 for the other glow plugs 200, so that a mechanical vibration of the connecting bar does not influence the first glow plug 100.

[0055] In the first and second examples, only the first glow plug 100 includes the pressure sensor 300. When two or more glow plugs include a pressure sensor respectively, each glow plug having the pressure sensor should be independently connected to each ring crimp terminal 400 or lead connector 410, which is connected to each battery wire separated from each other. When two or more glow plugs having the pressure sensors are provided in one engine cylinder, each glow plug should be independently connected to each ring crimp terminal 400 or lead connector 410.

[0056] According to the third example, as shown in FIG. 5, a single lead wire (flexible electric current supply member) 600 connects all glow plugs 100, 200. The lead wire 600 is used instead of the connecting bar 2 in the prior art in FIG. 12.

[0057] The lead wire 600 is made of flexible material having a resonance frequency lower than a combustion pressure frequency. The lead wire 600 includes a plurality of ring crimp terminals 610 corresponding to each glow plug 100, 200 and battery wires 620 connecting these ring crimp terminals 610. The ring crimp terminal 610 includes a hole connecting to the terminal screw 204a of the glow plug 100, 200. The battery wire 620 is made of flexible thin copper wire having a resonance frequency lower than the combustion pressure frequency. The battery wire 620 is electrically insulated at the outer surface thereof.

[0058] In this way, in the third example, all glow plugs 100, 200 are commonly connected to the lead wire 600. The mechanical vibration frequency of the lead wire 600 does not overlap the combustion pressure frequency, so that the outside circuit easily removes the mechanical vibration frequency of the lead wire 600 from the output signal of the pressure sensor 300.

[0059] According to the above described three examples of the first embodiment, the flexible material having an extremely low rigidity connects with the first glow plug 100 including the pressure sensor 300 instead of the conventional plate type connecting bar 2 having a high rigidity, which does not absorb a vibration. Thus, a mechanical vibration noise (0.5 KHz - 1.5 KHz) is substantially completely removed from the output signal of the pressure sensor 300 while attaining a fundamental function of the glow plug.

[0060] Effect of the present embodiment will be explained with reference to FIGS. 6A - 6E.

[0061] FIGS. 6A - 6E show test results under the condition that the engine works by 4000 rpm with a full load. FIG. 6A shows an output waveform of the first glow plug 100 when the conventional connecting bar 2 connects all four glow plugs 100, 200. FIG. 6B shows an output waveform of the first glow plug 100 when the first example

is applied. FIG. 6C shows an output waveform of the first glow plug 100 when the second example is applied. FIG. 6D shows an output waveform of the first glow plug 100 when the third example is applied. FIG. 6E shows an output waveform of the first glow plug 100 when no member connects with the first glow plug 100.

[0062] As is understood from these waveforms, according to the all examples of the present embodiment, saw tooth mechanical vibration noise (0.5 KHz - 1.5 KHz) shown in the prior art is removed as in an output waveform in FIG. 6E where no member influences the glow plug 100.

(Second Embodiment)

[0063] According to the second embodiment, as shown in FIG. 7A, a part of the pedestal 340 is embedded into the engine head 1 at a contact surface between the pressure sensor 300 and the engine head 1. The embedded portion of the pedestal is pushed in a plug axial direction and the other directions also, and fixed to the engine head 1.

[0064] The pedestal 340 includes a taper seat 344 at the outer bottom area thereof. The taper seat 344 inclines with respect to the contact surface by 123.0 degrees, for example. The engine head 1 includes a taper seat surface 1b to which the taper seat 344 is fit. The taper seat surface 1b inclines with respect to the contact surface by 120.0 degrees, which is slightly smaller than the inclination angle of the taper seat 344, so that the taper seat 344 is firmly fit by line contact to the taper seat surface 1b. The taper seat 344 is embedded into the engine head 1 as the embedded portion of the pedestal 340.

[0065] After the first glow 100 is attached to the engine head 1, the axial force of the glow plug 100 acting on the engine head 1 is distributed to a vertical force (plug axial direction force) and a horizontal force (plug radial direction force) against the taper seat surface 1b.

[0066] Thus, the pressure sensor 300 in which the piezoelectric element 320 is installed is supported in the two directions, and is prevented from vibrating in the two directions. As a result, the pressure sensor 300 is firmly fixed to the engine head 1, thereby suppressing the vibration noise caused by the mechanical vibration of the pressure sensor 300 from influencing on the pressure waveform. Here, as a modification of the present embodiment, as shown in FIG. 8, the vertical side wall of the pedestal 340 may be inserted into the engine head 1.

[0067] Effect of the present embodiment will be explained with reference to FIGS. 9A and 9B.

[0068] FIGS. 9A and 9B show test results under the condition that the engine works by 4000 rpm with a full load, and the glow plug 100 described in the first example of the first embodiment is used. FIG. 9A shows an output waveform of the first glow plug 100 when the conventional flat seat surface of the pedestal 340 is used. FIG. 9B shows an output waveform of the first glow plug 100 when the pedestal 340 includes the 123.0 degrees taper seat

344 shown in FIG. 7. As is understood from FIGS. 9A and 9B, when the taper seat 344 is fit to the engine head 1, the vibration noise is pretty removed.

(Third Embodiment)

[0069] An object of the present embodiment is to remove a mechanical vibration noise due to a projection length L of the projection 200a. As shown in FIGS. 1 and 12, the projection length L is defined as a length from the top surface of the hexagon portion 312 of the pressure sensor 300 to the top end of the projection 200a of the plug body 700.

[0070] FIG. 10 shows a test result of a relation between the projection length L and the resonance frequency of the first glow plug 100. A shaker and a vibration analyzer do this test. According to the present test, when the projection length L is less than 45 mm (preferably less than 40 mm based on plots in FIG. 10), the resonance frequency is more than 5 KHz that is higher than a frequency range of the combustion pressure.

[0071] That is, when the projection length L is larger than 45 mm, the resonance frequency of the glow plug 100 is higher than 100 Hz - 5 KHz that is needed for an engine combustion control. Here, a 5 KHz low-pass-filter eliminates a high frequency over 5 KHz from the output signal of the pressure sensor 300, so that the mechanical vibration noise involved in the glow plug 100 is easily removed at the frequency range needed for the engine combustion control.

[0072] Effect of the present embodiment will be explained with reference to FIGS. 11A-11C.

[0073] FIGS. 11A-11C show test results under the condition that the engine works by 4000 rpm with a full load, the glow plug 100 is independently connected to the crimp terminal 400 as described in the first example of the first embodiment, and that the pedestal 340 includes the 123.0 degrees taper seat 344 as in the second embodiment. FIG. 11A shows an output waveform of the first glow plug 100 when the projection length L is about 60 mm as in the prior art. FIG. 11B shows an output waveform of the first glow plug 100 when the projection length is 60 mm and the 5 KHz low-pass-filter is used. FIG. 11C shows an output waveform of the first glow plug 100 when the projection length L is less than 45 mm and the 5 KHz low-pass-filter is used. As is understood from FIGS. 11A - 11C, the resonance frequency of the glow plug 100 becomes higher by shortening the projection length L, and a high frequency of the resonance frequency is eliminated by the low-pass-filter, thereby improving S/N ratio of the combustion pressure waveform.

(Modifications)

[0074] Since the engine vibration varies in accordance with a vehicle body, the above-described first through third embodiments should be appropriately combined. Even when each of the above-described first through

third embodiments is used independently, the mechanical vibration noise influencing the output signal of the pressure sensor can be reduced. For example, the second embodiment or the third embodiment may be independently applied to the conventional structure shown in FIG. 12, or the second embodiment combined with the third embodiment may be applied to the conventional structure.

[0075] In the above-described embodiments, the piezoelectric element is used for the pressure sensor. Alternatively, a semiconductor pressure sensor and the like, which detects the engine combustion pressure based on the force caused by the combustion pressure acting on the plug body, may be used for the pressure sensor.

[0076] A first glow plug (100) and second through fourth glow plugs (200) are attached to an engine head (1). Each glow plug (100, 200) includes a plug body (700). The first glow plug (100) includes a pressure sensor (300), and is independently connected to a ring crimp terminal (400), which is separated from other glow plugs (200). Thus, a mechanical vibration due to a connecting bar (2) deflection between the second through fourth glow plugs (200) does not influence the first glow plug (100) including the pressure sensor (300).

Claims

1. An attachment structure of glow plugs (100, 200) comprising:

a plurality of glow plugs (100, 200) attached to an engine head (1), said glow plugs (100, 200) including plug bodies (700) respectively, and at least one of said glow plugs (100, 200) including a combustion pressure sensor (300) detecting a combustion pressure of the engine based on a force acting on said plug body (700),

characterized in that

said at least one glow plug (100) including said combustion pressure sensor (300) is independently connected to an electric current supply member (400, 410) that is electrically and mechanically separated from other glow plugs (200), said other glow plugs (200) are connected to a common connecting bar (2).

2. An attachment structure of glow plugs comprising:

a plurality of glow plugs (100, 200) attached to an engine head (1), said glow plugs (100, 200) including plug bodies (700) respectively, and at least one of said glow plugs (100, 200) including a combustion pressure sensor (300) detecting a combustion pressure of the engine based on a force acting on said plug body (700),

characterized in that

said glow plugs (100, 200) are commonly connected to a flexible electric supply member (600) having a resonance frequency lower than a frequency of the combustion pressure.

3. An attachment structure of a glow plug comprising:

a glow plug (100) attached to an engine head (1), said glow plug (100) including a plug body (700), and said glow plug (100) including a combustion pressure sensor (300) detecting a combustion pressure of the engine by converting a force acting on said plug body (700) into an electric signal based on the piezoelectric characteristic of a piezoelectric element (321), wherein said combustion pressure sensor (300) is at least partially embedded into said engine head (1),

characterized in that

the embedded portion of said combustion pressure sensor (300) has a taper seat (344) fitted to a taper seat surface (1b) of the engine head (1) so that the embedded portion is pushed against said engine head (1) in an axial direction of said glow plug (100) and in other directions.

4. An attachment structure of glow plugs according to claim 1 or 2, wherein

said combustion pressure sensor (300) is at least partially embedded into said engine head (1), and the embedded portion of said combustion pressure sensor (300) is pushed against said engine head (1) in an axial direction of said glow plug (100) and in other directions.

5. An attachment structure of glow plugs according to claim 1 or 2, wherein

the plug body (700) of said glow plug (100) including said combustion pressure sensor (300) includes a projection (200a) protruding from a top surface of said engine head (1) in an axial direction of said glow plug (100), a connection portion (204a) provided at the tip end area of said projection (200a) for connecting with an electric current supply member (400, 410, 600), said combustion pressure sensor (300) is fixed to an outer surface of said projection (200a) abutting on the top surface of said engine head (1), and a projection length (L) from the portion where said combustion pressure sensor (300) is fixed to the tip end of said projection (200a) is less than 45 mm.

6. An attachment structure of glow plugs according to claim 3 or 4, wherein

the plug body (700) of said glow plug (100) including said combustion pressure sensor (300) includes a

projection (200a) protruding from a top surface of said engine head (1) in an axial direction of said glow plug (100), a connection portion (204a) provided at the tip end area of said projection (200a) for connecting with an electric current supply member (2, 400, 410, 600),

said combustion pressure sensor (300) is fixed to an outer surface of said projection (200a) abutting on the top surface of said engine head (1), and a projection length (L) from the portion where said combustion pressure sensor (300) is fixed to the tip end of said projection (200a) is less than 45 mm.

7. The attachment structure according to claim 1, further comprising:

a battery wire (3) that is electrically connected to the connecting bar (2).

Patentansprüche

1. Halterungskonstruktion von Glühkerzen (100, 200) mit:

einer Vielzahl von an einem Zylinderkopf (1) angebrachten Glühkerzen (100, 200), wobei die Glühkerzen (100, 200) entsprechend Glühkörper (700) haben, und zumindest eine der Glühkerzen (100, 200) einen Verbrennungsdrucksensor (300) hat, der einen Verbrennungsdruck der Maschine ausgehend von einer auf den Glühkörper (700) wirkenden Kraft erfasst,

dadurch gekennzeichnet, dass

die zumindest eine Glühkerze (100), die den Verbrennungsdrucksensor (300) hat, unabhängig mit einem Zufuhrteil (400, 410) für elektrischen Strom verbunden ist, das elektrisch und mechanisch von anderen Glühkerzen (200) getrennt ist, wobei andere Glühkerzen (200) mit einem gemeinsamen Verbindungsstab (2) verbunden sind.

2. Halterungskonstruktion von Glühkerzen (100, 200) mit:

einer Vielzahl von an einem Zylinderkopf (1) angebrachten Glühkerzen (100, 200), wobei die Glühkerzen (100, 200) entsprechend Glühkörper (700) haben, und zumindest eine der Glühkerzen (100, 200) einen Verbrennungsdrucksensor (300) hat, der einen Verbrennungsdruck der Maschine ausgehend von einer auf den Glühkörper (700) wirkenden Kraft erfasst,

dadurch gekennzeichnet, dass

die Glühkerzen (100, 200) gemeinsam mit einem flexiblen, elektrischen Zufuhrteil (600) verbunden sind,

das eine Resonanzfrequenz aufweist, die niedriger ist als eine Frequenz des Verbrennungsdrucks.

3. Halterungskonstruktion von Glühkerzen, mit:

einer an einem Zylinderkopf (1) angebrachten Glühkerze (100), wobei die Glühkerze (100) einen Kerzenkörper (700) hat, und die Glühkerze (100) einen Verbrennungsdrucksensor (300) hat, der einen Verbrennungsdruck der Maschine durch das Umwandeln einer auf den Kerzenkörper (700) wirkenden Kraft in ein elektrisches Signal ausgehend von piezoelektrischen Kennzeichen eines piezoelektrischen Elements (321) erfasst, wobei der Verbrennungsdrucksensor (300) zumindest teilweise in den Zylinderkopf (1) eingebettet ist,

dadurch gekennzeichnet, dass

der eingebettete Abschnitt des Verbrennungsdrucksensors (300) einen konischen Sitz (344) aufweist, der mit einer konischen Sitzfläche (1b) des Zylinderkopfs (1) so gepasst ist, dass der eingebettete Abschnitt in einer axialen Richtung der Glühkerze (100) und in anderen Richtungen gegen den Zylinderkopf (1) geschoben wird.

4. Halterungskonstruktion von Glühkerzen nach Anspruch 1 oder 2, wobei

der Verbrennungsdrucksensor (300) zumindest teilweise in den Zylinderkopf (1) eingebettet ist, und der eingebettete Abschnitt des Verbrennungsdrucksensors (300) in einer axialen Richtung der Glühkerze (100) und in anderen Richtungen gegen den Zylinderkopf (1) geschoben wird.

5. Halterungskonstruktion von Glühkerzen nach Anspruch 1 oder 2, wobei

der Kerzenkörper (700) der Glühkerze (100) mit dem Drucksensor (300) einen Vorsprung (200a) hat, der von einer oberen Fläche des Zylinderkopfes (1) in eine axiale Richtung der Glühkerze (100) vorspringt, einen Verbindungsabschnitt (204a), der bei dem Bereich des Spitzenendes des Vorsprungs (200a) zum Verbinden mit einem Zufuhrteil (400, 410, 600) für elektrischen Strom bereitgestellt ist, wobei der Verbrennungsdrucksensor (300) an einer äußeren Fläche des Vorsprungs (200a) in Anlage mit der oberen Fläche des Zylinderkopfes (1) befestigt ist, und eine Länge (L) des Vorsprungs des Abschnitts, bei dem der Verbrennungsdrucksensor (300) befestigt ist, zu dem Spitzenende (200a) geringer ist als 45 mm.

6. Halterungskonstruktion von Glühkerzen nach Anspruch 3 oder 4, wobei

der Kerzenkörper (700) der Glühkerze (100) mit dem

Drucksensor (300) einen Vorsprung (200a) hat, der von einer oberen Fläche des Zylinderkopfes (1) in eine axiale Richtung der Glühkerze (100) vorspringt, einen Verbindungsabschnitt (204a), bei dem Bereich des Spitzenendes des Vorsprungs (200a) zum Verbinden mit einem Zufuhrteil (400, 410, 600) für elektrischen Strom bereitgestellt ist, wobei der Verbrennungsdrucksensor (300) an einer äußeren Fläche des Vorsprungs (200a) in Anlage mit der oberen Fläche des Zylinderkopfes (1) befestigt ist, und eine Länge (L) des Vorsprungs des Abschnitts, bei dem der Verbrennungsdrucksensor (300) befestigt ist, zu dem Spitzenende (200a) geringer ist als 45 mm.

7. Halterungskonstruktion nach Anspruch 1, ferner mit:

einem Batteriedraht (3), der elektrisch mit dem Verbindungsstab (2) verbunden ist.

Revendications

1. Structure de fixation de bougies de préchauffage (100, 200) comprenant :

une pluralité de bougies de préchauffage (100, 200) fixées à une culasse de moteur (1), lesdites bougies de préchauffage (100, 200) comprenant des corps de bougie (700) respectivement, et au moins l'une desdites bougies de préchauffage (100, 200) comprenant un capteur de pression de combustion (300) détectant une pression de combustion du moteur sur la base d'une force agissant sur ledit corps de bougie (700),

caractérisée en ce que

ladite au moins une bougie de préchauffage (100) comprenant ledit capteur de pression de combustion (300) est connectée de manière indépendante à un élément d'alimentation en courant électrique (400, 410) séparé d'autres bougies de préchauffage (200), lesdites autres bougies de préchauffage étant connectées à une barre de connexion commune (2).

2. Structure de fixation de bougies de préchauffage comprenant :

une pluralité de bougies de préchauffage (100, 200) fixées à une culasse de moteur (1), lesdites bougies de préchauffage (100, 200) comprenant des corps de bougie (700) respectivement, et au moins l'une desdites bougies de préchauffage (100, 200) comprenant un capteur de pression de combustion (300) détectant une pression de combustion du moteur sur la base d'une force agissant sur ledit corps de bougie (700),

caractérisée en ce que

lesdites bougies de préchauffage (100, 200) sont généralement connectées à un élément d'alimentation électrique souple (600) ayant une fréquence de résonance inférieure à une fréquence de la pression de combustion.

3. Structure de fixation d'une bougie de préchauffage comprenant :

une bougie de préchauffage (100) fixée à une culasse de moteur (1), ladite bougie de préchauffage (100) comprenant un corps de bougie (700), et ladite bougie de préchauffage (100) comprenant un capteur de pression de combustion (300) détectant une pression de combustion du moteur en convertissant une force agissant sur ledit corps de bougie (700) en un signal électrique sur la base de la caractéristique piézoélectrique d'un élément piézoélectrique (321), dans laquelle ledit capteur de pression de combustion (300) est au moins partiellement intégré dans ladite culasse de moteur (1),

caractérisée en ce que

la partie intégrée dudit capteur de pression de combustion (300) a un siège conique (344) monté sur une surface de siège conique (1b) de la culasse de moteur (1) de sorte que la partie intégrée soit poussée contre ladite culasse de moteur (1) dans une direction axiale de ladite bougie de préchauffage (100) et dans d'autres directions.

4. Structure de fixation de bougies de préchauffage selon la revendication 1 ou 2, dans laquelle ledit capteur de pression de combustion (300) est au moins partiellement intégré dans ladite culasse de moteur (1), et la partie intégrée dudit capteur de pression de combustion (300) est poussée contre ladite culasse de moteur (1) dans une direction axiale de ladite bougie de préchauffage (100) et dans d'autres directions.

5. Structure de fixation de bougies de préchauffage selon la revendication 1 ou 2, dans laquelle le corps de bougie (700) de ladite bougie de préchauffage (100) comprenant ledit capteur de pression de combustion (300) comprend une protubérance (200a) faisant saillie d'une surface supérieure de ladite culasse de moteur (1) dans une direction axiale de ladite bougie de préchauffage (100), une partie de connexion (204a) prévue au niveau de la région d'extrémité terminale de ladite protubérance (200a) pour une connexion à un élément d'alimentation en courant électrique (400, 410, 600), ledit capteur de pression de combustion (300) est fixé à une surface extérieure de ladite protubérance

(200a) en butée contre la surface supérieure de ladite culasse de moteur (1), et une longueur de projection (L) de la partie où ledit capteur de pression de combustion (300) est fixé jusqu'à l'extrémité terminale de ladite protubérance (200a) est inférieure à 45 mm.

6. Structure de fixation de bougies de préchauffage selon la revendication 3 ou 4, dans laquelle le corps de bougie (700) de ladite bougie de préchauffage (100) comprenant ledit capteur de pression de combustion (300) comprend une protubérance (200a) faisant saillie d'une surface supérieure de ladite culasse de moteur (1) dans une direction axiale de ladite bougie de préchauffage (100), une partie de connexion (204a) prévue au niveau de la région d'extrémité terminale de ladite protubérance (200a) pour une connexion à un élément d'alimentation en courant électrique (2, 400, 410, 600), ledit capteur de pression de combustion (300) est fixé à une surface extérieure de ladite protubérance (200a) en butée contre la surface supérieure de ladite culasse de moteur (1), et une longueur de projection (L) de la partie où ledit capteur de pression de combustion (300) est fixé jusqu'à l'extrémité terminale de ladite protubérance (200a) est inférieure à 45 mm.

7. Structure de fixation selon la revendication 1 comprenant en outre :

un fil de batterie (3) qui est électriquement connecté à la barre de connexion (2).

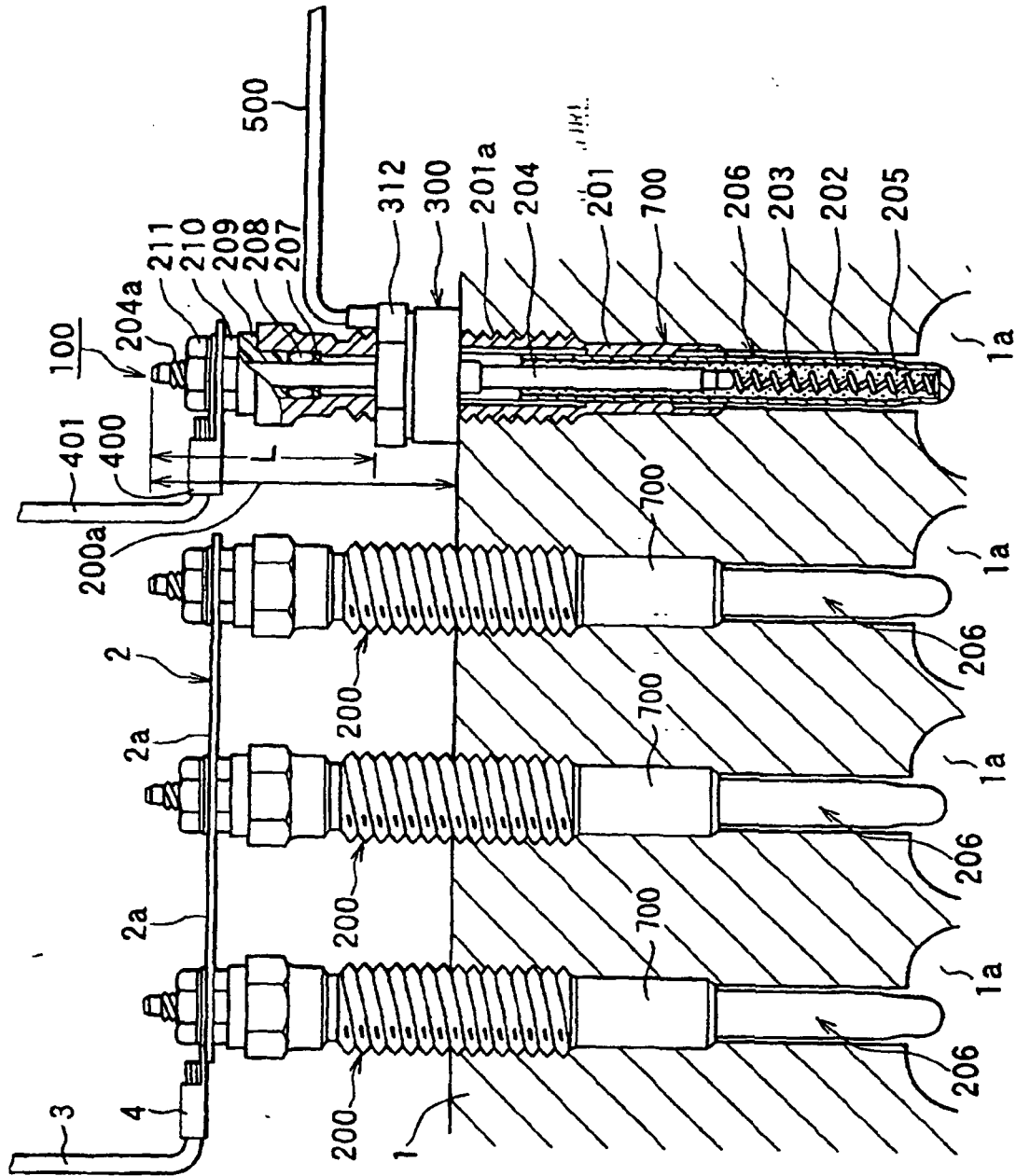


FIG. 1

FIG. 2A

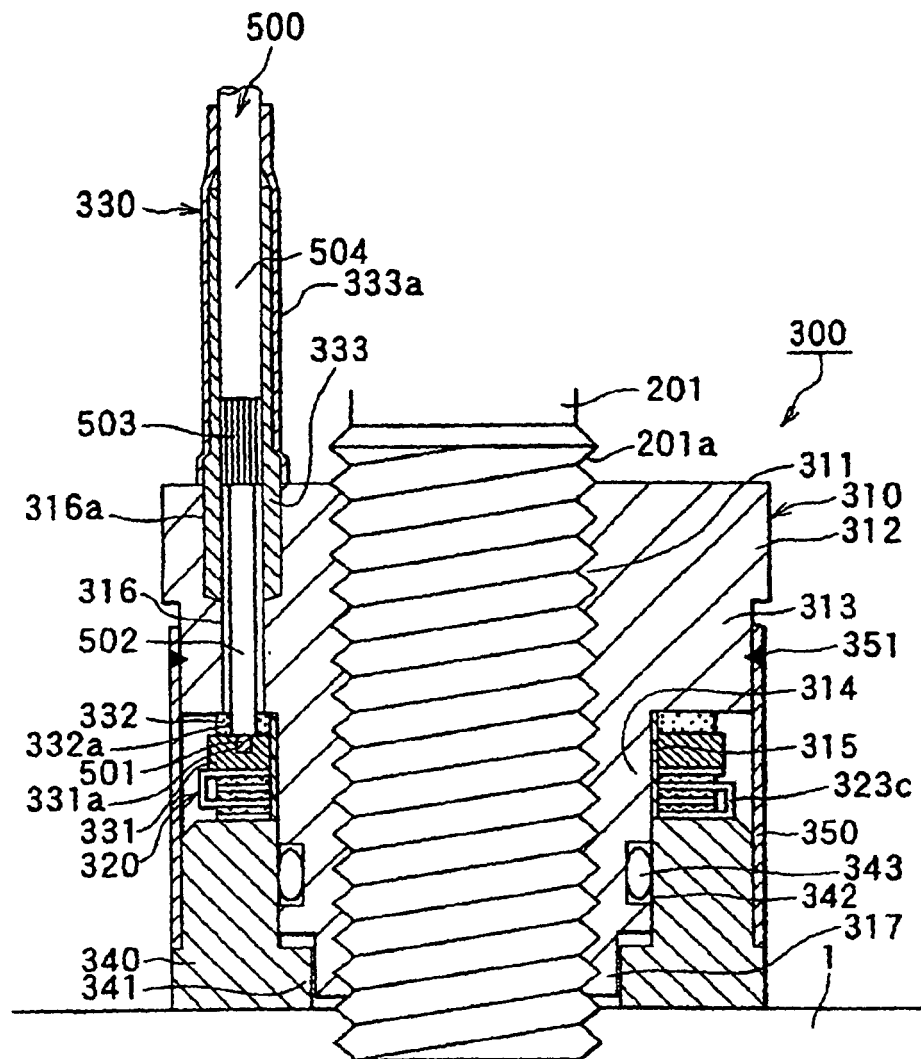


FIG. 2B

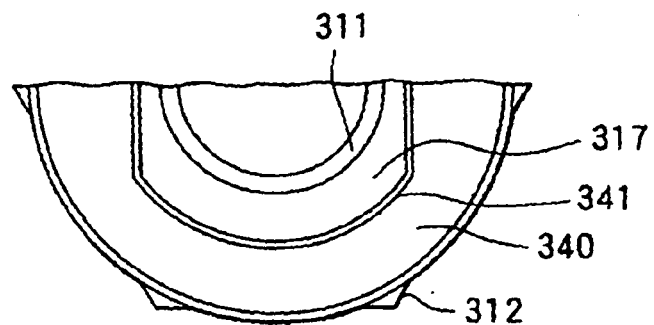


FIG. 3

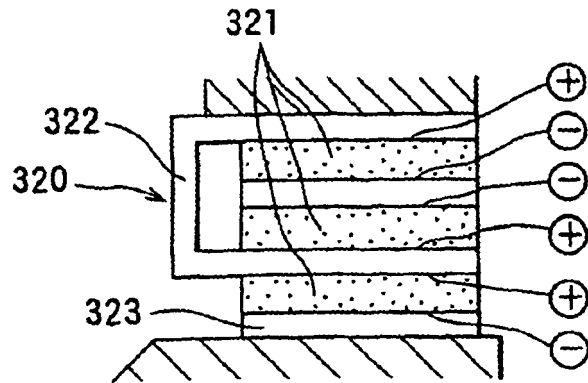


FIG. 4

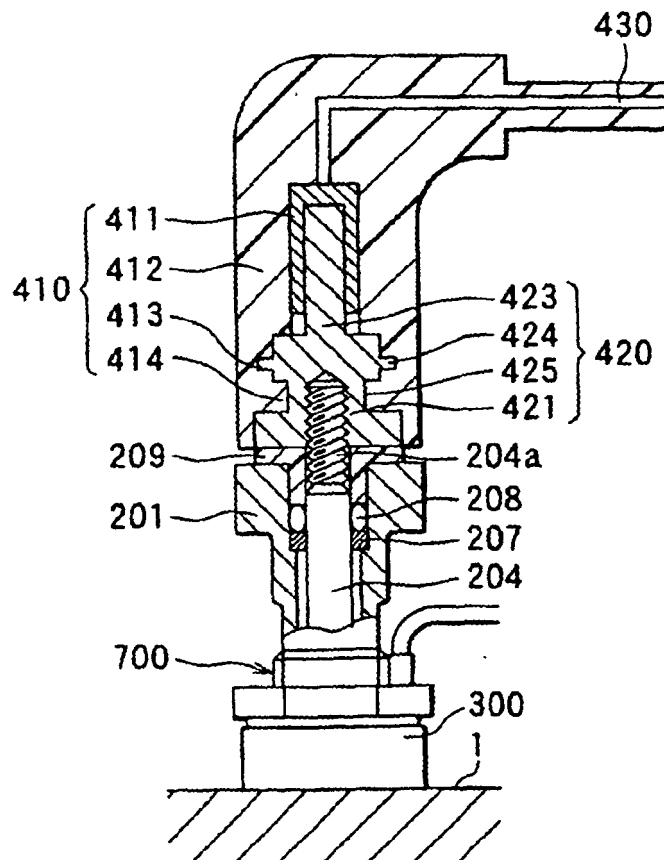


FIG. 5

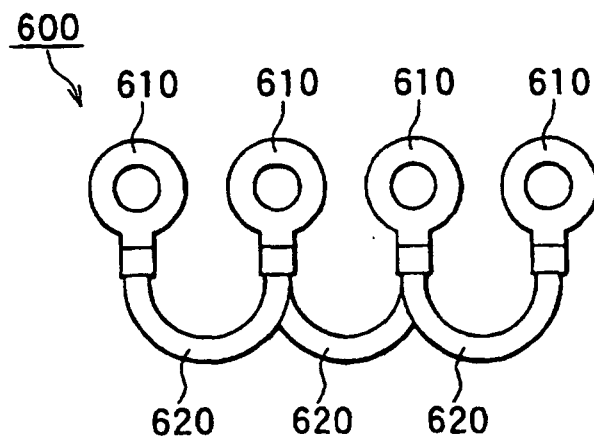


FIG. 8

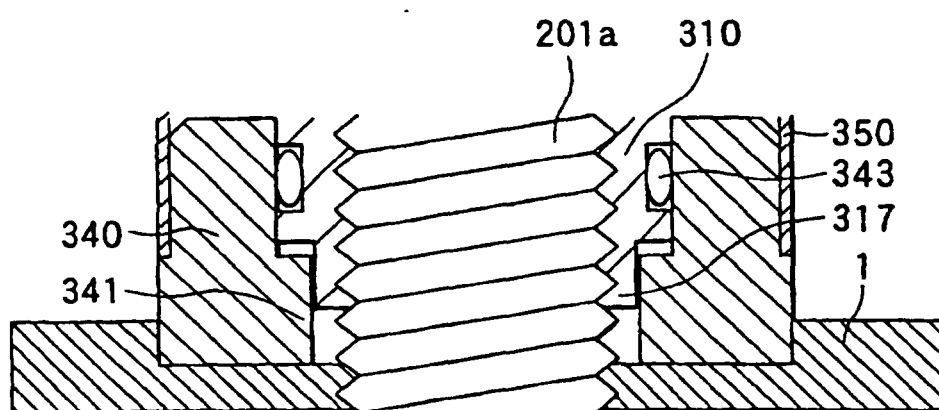


FIG. 6A

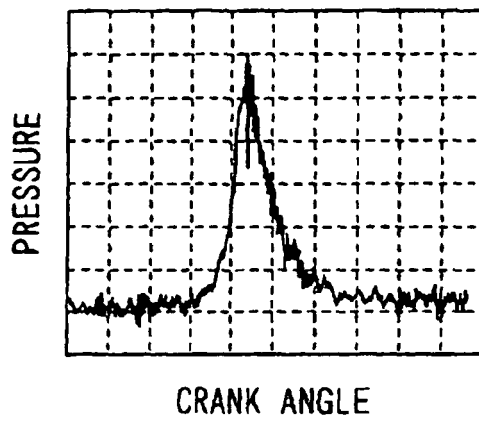


FIG. 6B

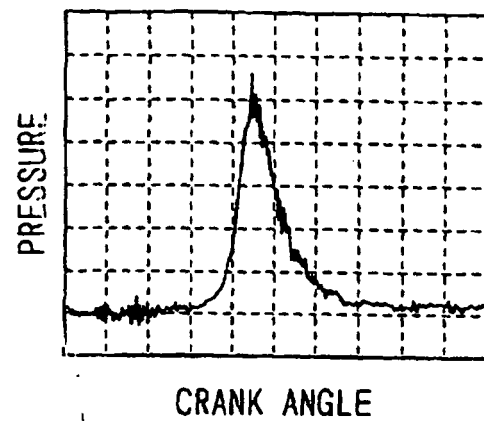


FIG. 6C

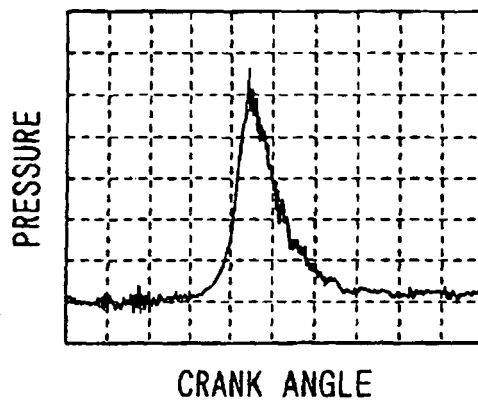


FIG. 6D

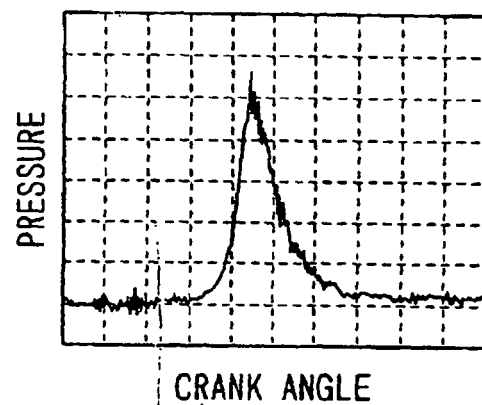


FIG. 6E

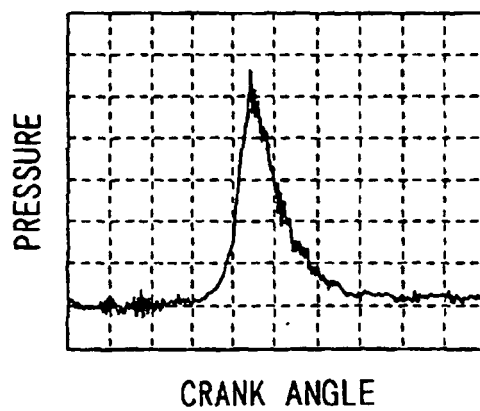


FIG. 7A

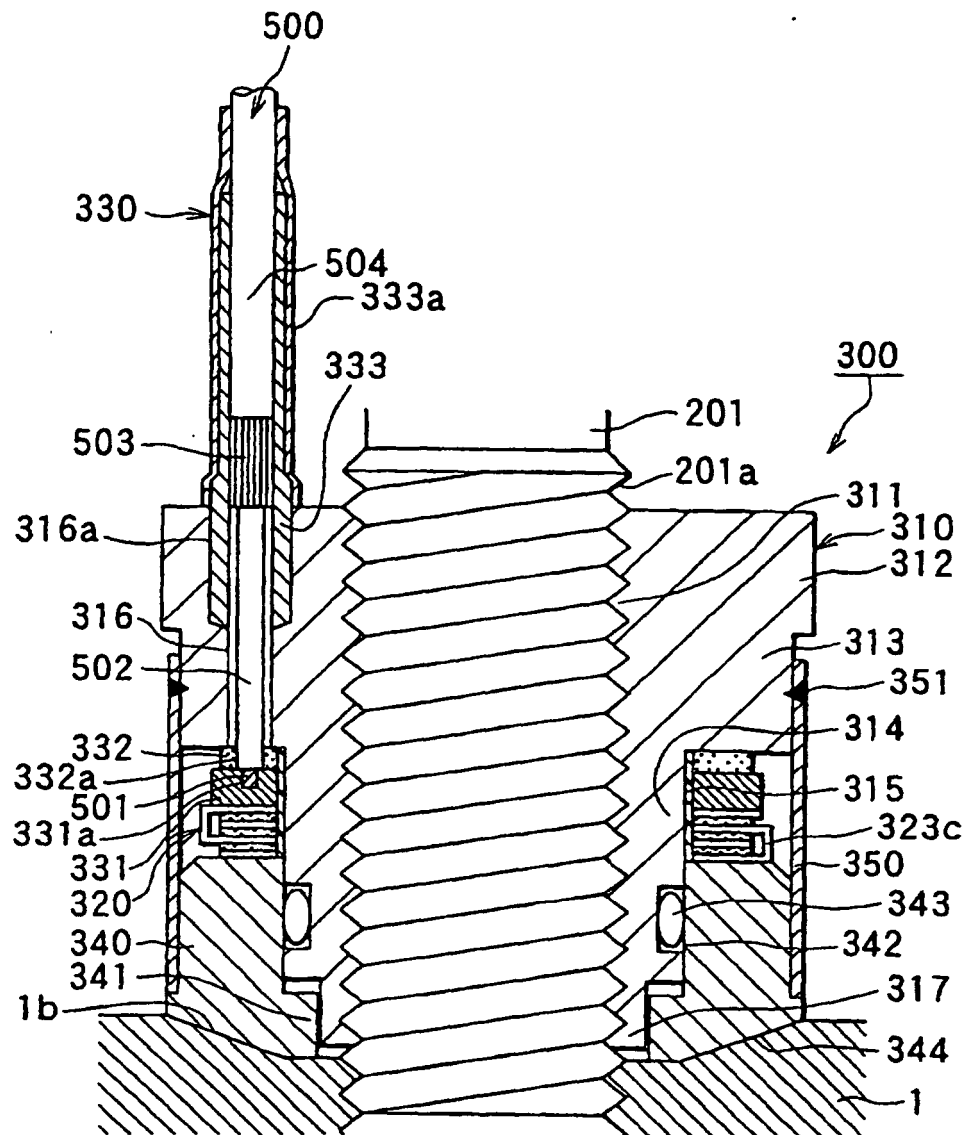


FIG. 7B

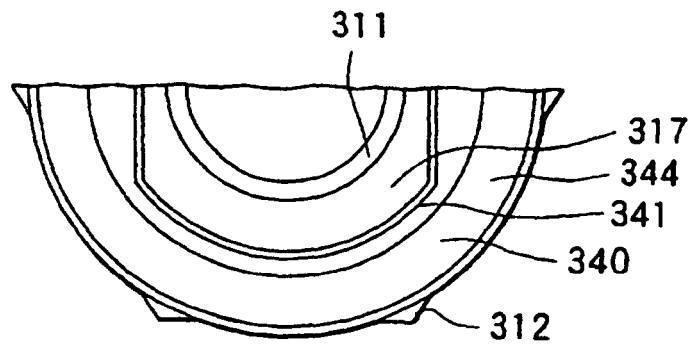


FIG. 9A

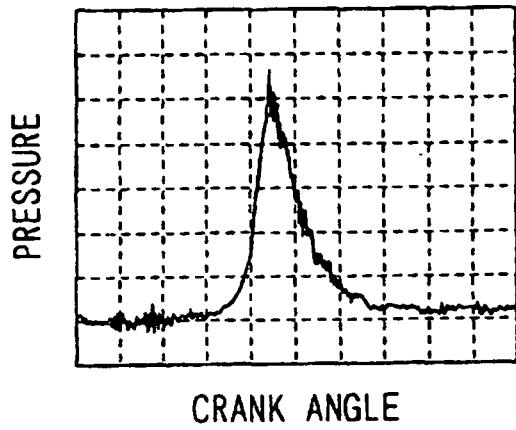


FIG. 9B

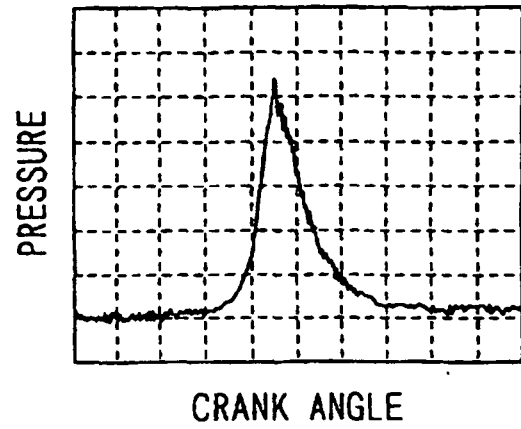


FIG. 10

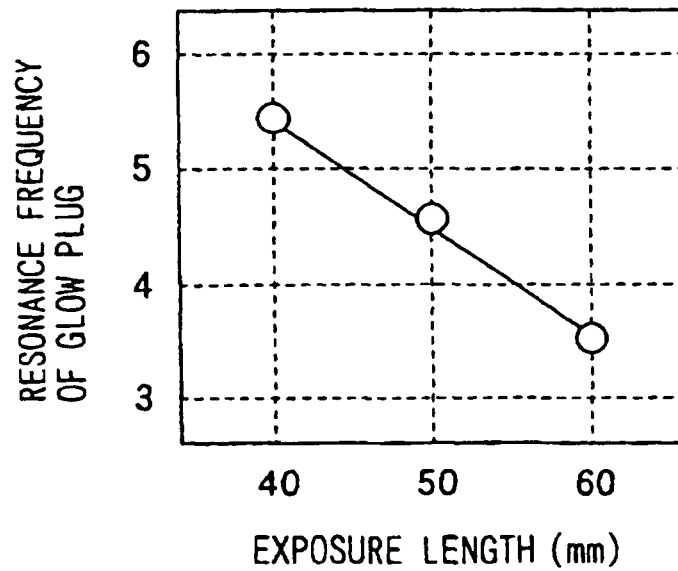


FIG. 11A

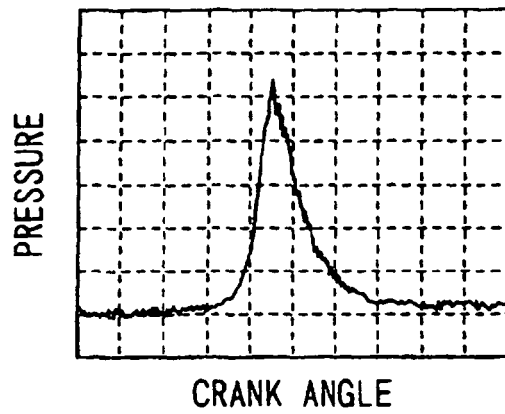


FIG. 11B

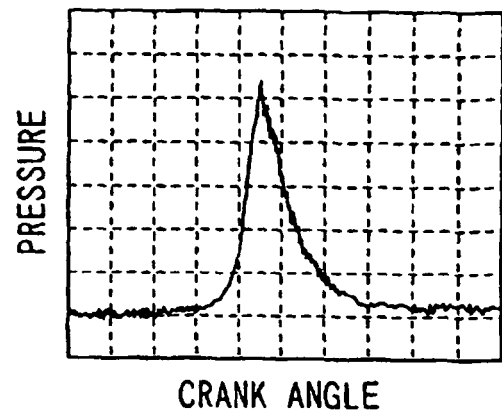


FIG. 11C

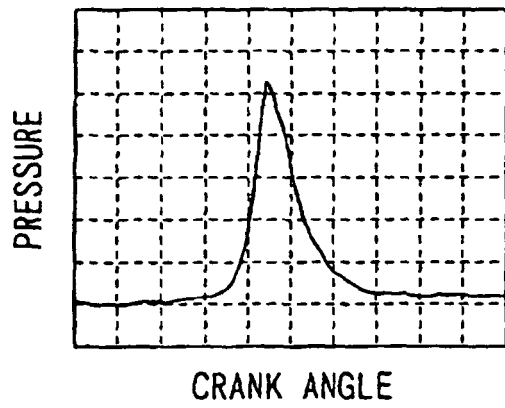
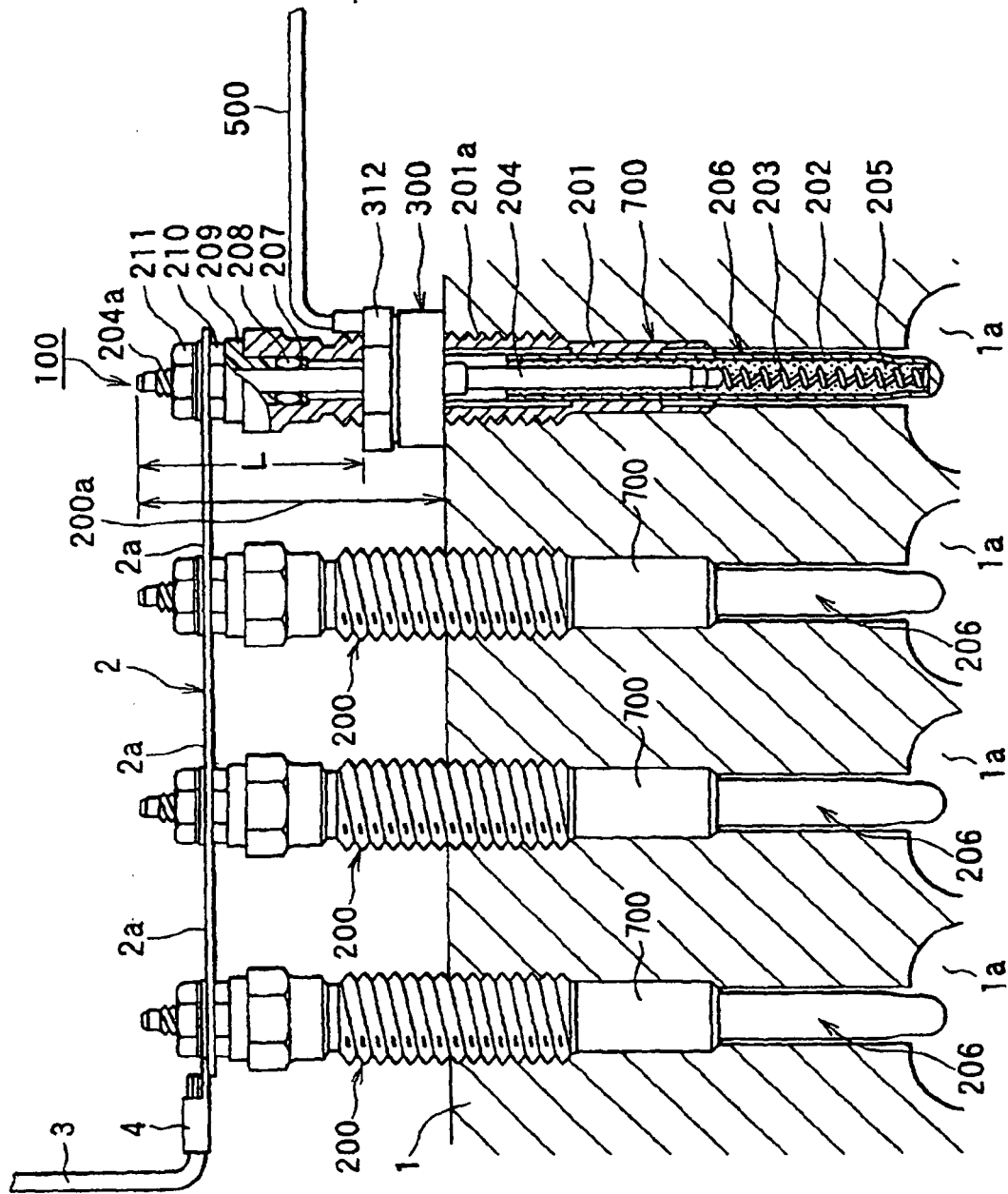


FIG. 12
PRIOR ART



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 7139736 A [0002] [0002]