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(54) Current self-control type glow plug

Glühkerze mit Selbsregelung des Stromes

Bougie à incondescence et à autoréglage de courant

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- **PATENT ABSTRACTS OF JAPAN vol. 11, no. 191 (M-600), 19 June 1987 & JP-A-62 017521 (NGK SPARK PLUG CO LTD), 26 January 1987,**

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Description

[0001] The present invention relates to a current self-control type glow plug used in a diesel engine.

[0002] A glow plug has conventionally been used as a diesel engine start aiding device. As shown in Figure 6, a glow plug 40 has a heater part 37, which is installed in a sub-chamber 39 formed in a cylinder head 38 of a diesel engine. The glow plug 40 operates as follows. When an engine key 36 is turned on to connect a switch 41, a battery 40 supplies electric current to the heater part 37 of the glow plug 40, quickly heating it to a sufficiently high temperature so that fuel, when it contacts the heater part 37, gets ignited.

[0003] Because a conventional plug is heated rapidly, it is fabricated by embedding a tungsten wire in silicon nitride ceramic and sintering it. The tungsten wire has a resistance of 0.1 Ω at room temperature for a 12-V power supply and carries a current of 120 A. When with elapse of time the glow plug is heated from the room temperature to 900°C, the tungsten wire has a resistance of 0.4 Ω at this temperature, and the current is 30 A. To control the current a separate resistor is necessary. Normally, if a metal wire with a large resistance-temperature coefficient is connected in series with the above tungsten wire resistor, as the glow plug is heated, the resistance of the tungsten wire increases and the resistance of the current control resistor also increases until the tungsten wire resistance stabilizes at 1 Ω, and at this time the current is 12 A. That is, for a conventional glow plug used in a diesel engine, when the 12-V battery supplies current according to a controller command, the initial current is 120 A. But, as the heater coil temperature rises, the resistance increases until it stabilizes at 1 Ω. Therefore, the current is controlled by the controller so that the resistance of the heater coil of the glow plug is stabilized and held at 1 Ω.

[0004] Another type of conventional glow plug has been developed which self-controls its resistance at 1 Ω without the use of a controller. Tungsten and nickel have a characteristic that the resistance increases with temperature. Therefore, as the temperature rises, the resistance increases, and the current decreases and is limited. A self-control type glow plug is made up of a tungsten coil and a nickel coil connected in series, with the tungsten coil embedded in a ceramic such as Si_3N_4. That is, in the self-control type glow plug, a conductor with a small resistance is arranged in a heating body of the heater coil and is connected to a nickel coil with a large resistance installed on the upstream side of the conductor. When a current flows, the nickel coil of the self-control type glow plug is heated, the resistance increases, the current decreases, and the amount of heat generated by the heating body of the heater coil is thus controlled.

[0005] JP 62-017521 discloses a self-control glow plug for reducing the scatter in temperature rise characteristic by connecting in series a resistance body which is a formation of a metallic film on the outer surface of a cylindrical ceramic insulator.

[0006] Conventional self-control type glow plugs include those disclosed in Japanese Patent Publication Nos. 34052/1992 and 19404/1985, and Japanese Patent Laid-Open Nos. 157423/1984 and 106326/1983.

[0007] The self-control type glow plug disclosed in the Japanese Patent Publication No. 34052/1992, for example, has a current control resistor connected in series with a heating body to control the heating body temperature when a current is supplied and the temperature is high. In this glow plug, the heating coil and the resistor coil are connected in series and embedded in a ceramic sintered material, thus forming an integral ceramic heater. The heating coil is made of a tungsten-rhenium alloy wire which has a positive resistance-temperature coefficient of less than four times, and the resistor coil is made of a pure tungsten wire or a pure molybdenum wire.

[0008] A sheathed glow plug disclosed in the Japanese Patent Publication No. 19404/1985 is a self-control type sheathed glow plug, in which a heating coil and a resistor coil are directly connected to each other between the inner bottom of a heat resistant, bottomed metal tube and a center electrode, and the winding pitch of the resistor coil is dense in the area close to a fitting on the central electrode side and coarse in the area close to the heating body side.

[0009] These conventional self-control type glow plugs, however, are not satisfactory in terms of strength, heat shock durability and high-temperature resistance when used in a high-temperature combustion chamber of a thermally-insulated engine. Because the heating coil formed of a tungsten carbide wire and the resistor coil formed of a nickel wire are connected together to make a glow plug of such materials having different resistance-temperature coefficients, or formed in different shapes, the conventional self-control type glow plugs have drawbacks that the nickel wire may be broken due to overheat during use or deteriorated with time and that they have a complex structure. Consequently the conventional glow plugs are not satisfactory in terms of cost and strength.

[0010] For a ceramic glow plug of current self-control type, the resistance in an upstream region of the current path of the heater coil must increase very sharply. Normally, in the glow plug a saturation current flows at about 1 Ω for a 12-V supply voltage and the temperature is kept at about 900°C. To heat the glow plug instantly, a resistance of approximately 0.1 Ω is required at room temperature. usually, a wire used as a heating coil has a resistance-temperature coefficient of the order of 4×10^{-3}, and therefore it is impossible to saturate the current at 900°C.

[0011] The glow plug installed in a combustion chamber is heated in a short period of time by the current supplied and functions as an engine start aiding device to facilitate ignition and combustion of fuel. In diesel engines, however, above a certain temperature, the fuel can be ignited and burned without the aid of a glow plug. Hence, when the combustion chamber is heated above a certain temperature, it is necessary to interrupt current supply to the glow plug and stop its heating function. Conventional glow plugs need a current interruption device to stop current supply. Therefore a current self-control type glow plug has been developed. The conventional current self-control type glow plug, although it can automatically reduce the current flowing through the heating coil, does not have a function to interrupt the current through the heating coil. To interrupt current through the heating coil, an interrupting device such as a timer is required. Such a current interrupting device, however, has a complex mechanism in order to change the current supply period according to the engine conditions.

[0012] A primary aim of this invention is to overcome the above-mentioned problems and provide a current self-control type glow plug, wherein a coil which comprises a heating coil part constituting a heating part and a control coil part constituting a current control part is installed in a ceramic pipe, and current flowing through the coil is controlled to generate an appropriate amount of heat; current control means (referred to as PTC means) which has a positive resistance-temperature coefficient and has a function that the resistance sharply increases above a specified temperature is connected between the coil and a connector; the current flowing through the coil is automatically stopped in response to an elevated temperature higher than a specified temperature by the current interruption function of the PTC means; and a specific resistance of the PTC means is minimized by adopting an appropriate structure of the PTC means.

[0013] It is another aim of this invention to provide a current self-control type glow plug, which is characterized in that the glow plug comprises a hollow body in which a connector is installed through insulating members, a ceramic pipe attached to the hollow body, a coil comprising a heating coil part and a control coil part connected in series with each other and installed inside the pipe projecting from the hollow body, and PTC means installed in the hollow body, connected in series with the heating coil portion having an electrical resistance which increases sharply above a specified temperature to reduce electric current to the coil significantly; and the PTC means preferably comprise positive resistance-temperature coefficient terminals (PTC terminals) connected in parallel at one end to the connector and at the other end to the coil terminal of the coil, or current control disks (PTC disks) having a positive resistance-temperature coefficient and connected in parallel at one end to the connector and at the other end to the coil terminal of the coil.

[0014] The present invention provides a current self-control type glow plug including a hollow body having a connector through insulating members, a ceramic pipe fitted to the hollow body, and a coil having a heating coil part and a control coil part connected in series with each other, the heating coil part being provided inside the pipe protruding from the hollow body, and the control coil part being provided in the pipe; wherein the glow plug further includes current control means having a positive resistance-temperature coefficient installed in the hollow body, the current control means having one end thereof connected to the connector and the other end connected in series with the coil, whereby as the electrical resistance of the current control means increases sharply above a specified temperature, current flowing through the coil is automatically stopped in response to an elevated temperature higher than the specified temperature.

[0015] The coil is made of a material flaying a positive resistance-temperature coefficient. The front end portion of the pipe in which the heating coil part is arranged constitutes a heating part, and the intermediate portion of the pipe where the control coil part is provided constitutes the current control part. The control coil part installed in the intermediate portion of the pipe is covered with an insulating material to reliably heat-insulate the control coil part from the pipe. Therefore, heat generated from the heating part containing the heater coil by supplying current from a battery to the coil is dissipated outside. On the other hand, heat generated from the control coil part is insulated, heating the control coil part. As the temperature of the control coil part rises, the current flowing through the control coil part is reduced. Thus, the control coil part constitutes a reliable current control part. That is, when current is passed through the coil, the front end portion of the pipe containing the heating coil part constitutes a heating part, and emits heat. When the control coil part is heated above a specified temperature, its resistance becomes large, limiting the current flowing through the coil, preferably of tungsten wire, thus self-regulating the amount of heat emitted from the ceramic pipe to an appropriate value.

[0016] When the connector and the coil are connected together by PTC terminals which constitute the PTC means and which are thin and have large areas, it is possible to reduce the resistance of the PTC means when the temperature is low. At the same time, as the temperature in the region where the PTC means is provided rises, the resistance of the PTC means sharply increases, automatically shutting off the current to the coil. In such a way, the PTC means can have a timer function of stopping electric current when the temperature is high. Specifically, when the temperature of the region of the PTC means exceeds a specified temperature, the resistance of the PTC means rises rapidly. In this case, if the coil terminal in contact with the PTC terminals of the PTC means are formed into metal disks, the metal disks are evenly heated by the current application, and the entire PTC means is heated, resulting in a sharp increase in the resistance of the PTC means.

When the resistance of the PTC means increases, the current to the coil is automatically interrupted to stop the function of the current self-control type glow plug.

[0017] When the coil is energized, the electric resistance of the PTC means must be small. When the PTC means are connected in parallel to each other by PTC terminals, the resistance of the entire PTC means becomes small when the temperature is low. That is, the PTC means have a very large resistivity (coefficient) k, as high as 1 Ω.cm whereas normal metals have 1×10^{-5} Ω.cm. If such PTC means are directly connected to a metal wire, a very large area is required. The resistance of a substance is generally expressed as $R=k.L/A$, where L represents the length and A represents the area. From this equation, for the PTC means, the value L/A must be 10^{-5} to have the same resistance as that of the metal. Therefore, the PTC means must be formed into such a shape that the conduction thickness is small and the area is large. This is the necessary condition to impart a current self-control type glow plug with a timer function. When resistors are connected in parallel, the net resistance is small. For example, when n PTC terminals are used,

$$1/R = 1/R_1 + 1/R_2 + ... + 1/R_n$$

where R is the total resistance, and R_1, R_2, ..., R_n are respective resistances. Assuming that the resistances of the PTC terminals are equal value of R_1,

$$1/R = n \times 1/R_1.$$

Therefore,

$$R = R_1/n.$$

The total resistance of the PTC means becomes small.

[0018] Preferably, the coil terminals are metal disks spaced from each other on the connector, and the PTC terminals are PTC disks corresponding to the metal disks. When the PTC means are constituted by PTC disks which are connected at one end to the connector and at the other end to the coil terminal, the resistance R of the PTC means is inversely proportional to the area A. That is,

$$R = k.L/A.$$

[0019] Alternatively, the PTC disks may be constituted by a spiral member wound between the connector and the coil terminal. In this case, the resistance can be reduced by increasing the area of the member.

[0020] As the engine runs smoothly and the combustion heat from the combustion chamber or the heat generated by the coil is transferred to the PTC means, the PTC means is heated above a predetermined temperature, and the resistance of the PTC means increases exponentially, cutting off the current to the coil to stop the function of the current self-control type glow plug.

[0021] When the pipe is formed of highly heat-resistant Si_3N_4 ceramic, the pipe exhibits excellent heat resistance and acid resistance and also has a high strength at high temperatures.

[0022] Preferably, the glow plug includes a first ceramic filler in the area where the heating coil is installed and a second ceramics filler in the body-side end of the pipe made of Si_3N_4 containing TiO_2 which does not contract during baking. Therefore no gap between the fillers and the pipe is formed. Further, that ceramic material has a good heat conductivity. Because of these characteristics, the fillers can properly seal the intermediate portion of the pipe, and the pipe can be well sealed.

[0023] The PTC means preferably comprise PTC terminals connected in parallel which are made of semiconductive $BaTiO_3$ sintered material or $PbTiO_3$ sintered material. It is therefore possible to reduce the overall resistance of the PTC means at low temperatures, so that smooth current supply to the PTC means is assured until it is heated to a predetermined temperature. That is, the PTC terminals of $TaTiO_3$ sintered material constituting the PTC means, when heated to 120-130°C, sharply increase their resistance to 10^4-10^5 Ω. Therefore, if the PTC means comprise, e.g., 10 PTC terminals, the overall resistance of the PTC means is 10^3-10^4 Ω allowing the PTC means to function as a dielectric.

[0024] The PTC means may be formed to have a large area. In this case also, the resistance of the PTC means is small at low temperatures and current flows smoothly through the PTC means until its temperature reaches a predetermined value. When the PTC means is heated above a predetermined temperature, it interrupts the current through the coil.

[0025] The coil is preferably formed of a tungsten wire or nickel wire having a positive resistance-temperature coefficient. The control coil part installed in the intermediate portion of the pipe is preferably covered with a heat-insulating material and insulated from the pipe. Thus, the temperature of the control coil part will quickly increase to raise the resistance, thereby properly controlling the current flowing through the coil.

[0026] The current self-control type glow plug, therefore, is suited for application as a diesel engine start aiding device. Moreover, it does not require a timer to interrupt current nor waste the power of the battery.

[0027] Preferred embodiments of the present invention will now be described hereinbelow by way of example only with reference to the accompanying drawings, in which:

Figure 1 is a schematic cross section of an embodiment of a current self-control type glow plug of this invention;

Figure 2 is a graph showing the relation between the temperature and resistance of PTC means (current control means having a positive resistance-temperature coefficient);

Figure 3 is an enlarged cross section of an embodiment of a PTC means built in the current self-control type glow plug of Figure 1;

Figure 4 is an enlarged cross section of another embodiment of the PTC means built in the current self-control type glow plug of Figure 1;

Figure 5 is an enlarged cross section of still another embodiment of the PTC means built in the current self-control type glow plug of Figure 1; and

Figure 6 is a schematic diagram showing the arrangement of a conventional glow plug installed in the combustion chamber of a diesel engine.

[0028] Now, referring to the accompanying drawings, embodiments of the current self-control type glow plug according to this invention will be described.

[0029] The current self-control type glow plug is mainly made up of a hollow body 1 having a terminal or connector 12 mounted in a hollow portion 21 through an insulator 19 such as an insulating bushing, a ceramic pipe 2, a coil 3 comprising a tungsten wire, current control means 10 with a positive resistance-temperature coefficient for connecting the coil 3 to the connector 12, and ceramic fillers 6, 7 with which both ends of the pipe 2 are filled. The hollow body 1 is made of a metal such as a heat resisting alloy and has a thread 22 for fitting this glow plug to another component. On the connector 12 is screwed a positioning and fixing nut 18 that positions and fixes the connector 12 to the hollow body 1. The ceramic pipe 2 can be securely joined to the hollow body 1 by metalizing the outer surface 23 of the ceramic pipe 2 and fitting the ceramic pipe 2 in the inner surface 24 of the hollow body 1. A front end portion 15 that constitutes a heating part of the ceramic pipe 2 protrudes from the end 25 of the hollow body 1. The current control means 10 have one end thereof connected to an end 8 of the coil 3 and the other end 9 connected to the connector 12 through a connector part 13. The other end 9 of the coil 3 is connected to the hollow body 1 for electrical grounding.

[0030] In this current self-control type glow plug, a conductor having the connector 12 is projected into the hollow portion 21 of the hollow body 1, and the ceramic pipe 2 constituting the heater part or the front end portion 15 is fixed to and projected from the body 1. The ceramic pipe 2 is sealed at both ends by the first ceramic filler 6 and the second ceramics filler 7. The ceramic pipe 2 has its front end portion 15 closed and an intermediate portion 16 having a hollow portion 26. In the hollow portion 26 of the pipe 2 is installed a double pipe made of an insulating material 11 such as SiC ceramic fibers which encloses the control coil part 5 of the coil 3 both from inside and outside. Hence, the control coil part 5 of the coil 3 is heat-insulated from the pipe 2. The inside of the hollow portion 26 is in a vacuum or filled with N_2 gas to prevent oxidation of the coil 3. An electrode-side end portion 17 of the pipe 2 is sealed by the second ceramic filler 7.

[0031] In this current self-control type glow plug, the coil 3 is of a tungsten wire or nickel wire of a material having a positive resistance-temperature coefficient. The coil 3 comprises a heating coil part 4 placed in contact with the inner wall surface 20 of the front end portion 15 of the pipe 2 and a control coil part 5 arranged out of contact with the inner wall surface 20 of the intermediate portion 16 of the pipe 2. The front end portion 15 is filled with the first ceramic filler 6 with a good heat conductivity, which presses the heating coil part 4 to the inner wall surface 20 of the pipe 2. The body-side end portion 17 of the pipe 2 is filled with the second ceramic filler 7, which is in close contact with the inner wall surface 20 of the pipe 2 and with the outer surfaces of the end portions 8, 9 of the coil 3. Thus, the hollow portion 26 in the intermediate portion 16 of the pipe 2 is sealed by the first and second ceramic fillers. The connector 12 is provided at its end with the connector part 13, and the end 8 of the coil 3 is provided with an annular coil terminal 28. The coil terminal 28 is installed inside the inner wall surface of the hollow body 1 with an insulating material 29 interposed therebetween, and comprises a number of current control disks 27 with a positive resistance-temperature coefficient which are spaced from each other longitudinally and extend radially inwardly from the inner wall surface of the coil terminal 28.

[0032] This current self-control type glow plug is characterized by the current control means 10, which connect, in the hollow portion 21 of the hollow body 1, the connector portion 13 of the connector 12 and the end 8 of the coil 3. The current control means 10 are made of a material whose electric resistance exponentially increases above a certain temperature, i.e., a material having a positive resistance-temperature coefficient which interrupts the current flowing through the coil 3 by its electric resistance that increases sharply above a predetermined temperature. In other words the current control means 10 are a kind of temperature-rise sensitive current interrupting member. The current control means 10 are made of a semiconductive $BaTiO_3$ sintered material (or $PbTiO_3$ sintered material). The current control means 10 comprises two or more PTC terminals 27 each having one end connected to the coil terminal 28 of the coil 3 and the other end to the connector part 13 so that PTC terminals are all parallelly connected to the coil terminal 28 and the connector part 13.

[0033] Metal disks 14 are disk members spaced longitudinally from each other on the connector portion 13 by spacers (PTC spacers) 35 having a positive resistance-temperature coefficient. The metal disks 14 and the current control disks 27 which are parallelly connected to the coil terminal 28 are alternately arranged in such a way that the faces of each metal disk 14 are in contact with the faces of the adjacent current control disks 27. In this arrangement where the metal disks 14 are spaced by the PTC spacers 35, electric current flows through the metal disks 14 at low temperatures but, at elevated temperatures, the current flow through the PTC spacers 35 is reduced, interrupting the electric conduction between the metal disks 14 and accordingly substantially interrupting the current from the connector part 13 to the coil terminal 28.

[0034] The current control disks 27 of $BaTiO_3$ sintered material, as shown in Figure 2, have a PTC function or dielectric function whereby as the temperature increases to 120-130°C, the resistance of the current control disks 27 increases to 10^4-10^5 Ω. That is, when the current control disks 27 are heated to 120°C, their resistance increases to 10^4 Ω. Assume that there are 10 current control disks 27 constituting the PTC means 10. Because the current control disks 27 are connected in parallel, the total resistance of the current control means 10 is 10^3 Ω, so that almost no current flows through the current control means 10.

[0035] Therefore, when current is supplied to the coil 3, heat generated in the heating coil part 4 and the control coil part 5 of the coil 3 and in the metal disks 14 connected to the connector part 13, or the combustion heat from the combustion chamber is transferred to the current control disks 27. After a specified period of time, the PTC terminals 27 are heated to about 120°C. When the current control disks 27 are heated to higher than 120°C, their resistance sharply rises, interrupting the current to the coil 3. The time during which the current control disks 27 are heated above 120°C can be arbitrarily set by appropriately determining the conditions of design and structure such as of the combustion chamber, cylinder head, cooling jacket and current self-control type glow plug. If the current self-control type glow plug is used as the start aiding device for a diesel engine, the time from the start of current supply to the current interruption is about 3-5 minutes. In this case, the current control means 10 are able to cut off the current supply to the coil 3 in three to five minutes.

[0036] In this current self-control type glow plug, the ceramic which is the material of the pipe 2 is Si_3N_4, and the ceramic which is the material of the first ceramic filler 6 and the second ceramic filler 7 contains Si_3N_4 and TiO_2, and in some cases, TiN_2. The coil 3 is formed of a single, continuous tungsten wire having a large diameter at the first coil part 4, and a small diameter at the control coil part 5. The heating coil part 4 of the coil 3 can generate sufficient heat to heat the front end part 15 in a short period of time, thus constituting a heater part. The heat of the control coil part 5 is not dissipated, so that its resistance increases with its temperature rise, thus constituting a current control part that controls the electric current.

[0037] In this current self-control type glow plug, the pipe 2 is preferably made of Si_3N_4 ceramic which is resistant to heat and very strong. The ceramic fillers 6, 7 are made of Si_3N_4 with a excellent heat resistance and a strength at elevated temperatures, and preferably Si_3N_4 ceramic containing 10% TiO_2 and, if necessary, TiN_2. The use of Si_3N_4 ceramic containing TiO_2 and TiN_2 improves the heat conductivity and the fillers made of this ceramic do not contract during sintering, so that the fillers has a good pipe sealing capability. When the hollow portion 26 of the pipe 2 is not sealed in a vacuum nor filled with N_2 gas, the tungsten wire and nickel wire constituting the coil 3 need to be covered with SiC or WC to prevent oxidation. The coating can prevent oxidation of the coil 3 and improves the anticorrosion and the durability.

[0038] Constructed as described above, the current self-control type glow plug functions as follows. Electric current from the battery is supplied through the connector 12, connector part 13 and current control means 10 to the coil 3. The control coil part 5 of the coil 3 is so arranged in the hollow portion 26 as to be heat-insulated, and the heating coil part 4 is arranged in contact with the inner wall surface 20 of the pipe 2, so that the front end portion 15 of the pipe 2 is heated by the heating coil part 4 and functions as a heater part. Thus, the front end portion 15 of the pipe 2, when installed in the combustion chamber, can function as an engine start aiding device. Heat generated by the heating coil part 4 is dissipated through the pipe 2, while heat of the control coil part 5 is not released so that the control coil part 5 becomes extremely hot compared with the heating coil part 4. As the control coil part 5 becomes hot, it functions as the current control wire, increasing its resistance with the rising temperature to reduce the current flowing through the coil 3, thus self-controlling the amount of heat generated by the front end portion 15. When the temperature of the control coil part 5 lowers, the current through the coil 3 again flows, so that the front end portion 15 is heated by the heating coil part 4. In this manner, the front end portion 15 as the heater part is controlled to keep generating an optimum amount of heat at all times and to function properly as a start aiding device in the combustion chamber.

[0039] Because the pipe 2 incorporating the heating coil part 4 in contact therewith is exposed to the outside of the combustion chamber, heat can be released from the pipe 2. For example, the temperature of the front end portion 15 is maintained at 900°C and the resistance of the heating coil part 4 is 0.4 Ω. On the other hand, the control coil part 5, installed and heat-insulated in the sealed hollow portion 26, is heated to, for instance, 1,800°C and its resistance becomes 0.6 Ω. The total resistance of the heating coil portion 4 and the control coil portion 5 therefore is 1 Ω, and stabilized.

[0040] The current self-control type glow plug is stabilized, the heating coil part 4 and the control coil part 5 continue to generate heat, and therefore good combustion is repetitively performed in the combustion chamber. As the engine begins to run smoothly, heat from the combustion chamber is transferred to the current control means 10, with the result that the metal disks 14 constituting the connector portion 13 are heated raising the temperature of the current control disks 27 to, say, 120-130°C. When the current control means 10 are heated to 120-130°C, the resistance of each current control disk 27 of the current control means 10 increases sharply to, say, 10^4-10^5 Ω. The increased resistance of 10^4-10^5 Ω results in that the current control means 10 substantially does not conduct any current, cutting off the power supply to the coil 3.

[0041] Next, referring to Figure 4, another embodiment of the current self-control type glow plug according to this invention will be described. The second embodiment has the same construction as that of the first embodiment except the current control means. The current control means 10 of this embodiment are formed in an annular ring 31, which is connected to the inner wall surface of an annular member 30 of the coil terminal 28 through a conductive ring 34. The annular ring 31 and the coil terminal 28 are insulated from each other by an insulating member 33. Further, the coil terminal 28 is connected to the end 8 of the coil 3, and the annular ring 31 is connected to the connector part 13. Because the current control means 10 are formed in the annular ring 31, its area can be made large. Therefore, the current control means 10, which have a low resistance at low temperatures, increase their resistance to a very large value as they are heated to above 120°C, interrupting the current supply to the coil 3.

[0042] Next, referring to Figure 5, still another embodiment of the current self-control type glow plug according to this invention will be described. This embodiment has the same construction as those of the preceding embodiments except the current control means. The current control means 10 of this embodiment have a current control terminal formed into a circular spiral body 32 that contacts the inner wall surface of the annular member 30 of the coil terminal 28, to increase the area of the current control means 10. The function is similar to that of the current self-control type glow plug shown in Figure 4.

[0043] When this current self-control type glow plug is used as a start aiding device of the diesel engine, it automatically interrupts the current supply to the coil 3 according to the combustion condition in the engine. This prevents unnecessary continuation of heating the current self-control type glow plug, avoiding waste of the battery power.

Claims

1. A current self-control type glow plug including a hollow body (1) having a connector (12) through insulating members (19), a ceramic pipe (2) fitted to the hollow body (1), and a coil (3) having a heating coil part (4) and a control coil part (5) connected in series with each other, the heating coil part (4) being provided inside the pipe (2) protruding from the hollow body (1), and the control coil part (5) being provided in the pipe (2); wherein the glow plug further includes current control means (10) having a positive resistance-temperature coefficient installed in the hollow body (1), the current control means (10) having one end thereof connected to the connector (12) and the other end connected in series with the coil (3) , whereby as the electrical resistance of the current control means (10) increases sharply above a specified temperature, current flowing through the coil (3) is automatically stopped in response to an elevated temperature higher than the specified temperature.

2. A current self-control type glow plug according to claim 1, wherein the resistance of the current control means (10) having a positive resistance-temperature coefficient increases sharply above a temperature close to a predetermined cooling water temperature to interrupt the current supply to the coil (3).

3. A current self-control type glow plug according to claim 1 or claim 2, wherein the current control means (10) comprises current control disks (27) constituting a terminal and made of a material which has a positive resistance-temperature coefficient and whose resistance sharply increases above a specified temperature, and the current control disks (27) are connected in parallel at one end to the connector part (13) of the connector (12) and at the other end to the coil terminal (28) of the coil (3).

4. A current self-control type glow plug according to claim 3, wherein the faces of the current control disks (27) spaced from each other and arranged on the coil terminal (28) are in close contact with the faces of metal disks (14) spaced from each other and arranged on the connector part (13), and the current control disks (27) and the metal disks (14) are alternately stacked.

5. A current self-control type glow plug according to claim 1 or claim 2, wherein the current control means (10) comprises an annular ring (31) arranged between the connector (13) and the coil terminal (28).

6. A current self-control type glow plug according to claim 1 or claim 2, wherein the current control means (10) comprises a spiral member (32) wound between the connector (13) and the coil terminal (28).

7. A current self-control type glow plug according to any one of claims 1 to 6, wherein the current control means (10) is made of a $BaTiO_3$ sintered material or a $PbTiO_3$ sintered material.

8. A current self-control type glow plug according to any one of claims 1 to 7, wherein the coil (3) is formed of a tungsten wire or a nickel wire having a positive resistance-temperature coefficient.

9. A current self-control type glow plug according to any one of claims 1 to 8, wherein the pipe (2) is made of Si_3N_4 having an excellent heat resistance.

10. A current self-control type glow plug according to any one of claims 1 to 9, wherein a first ceramic filler (6) with which is filled the area where the heating coil part (4) is provided and a second ceramic filler (7) with which is filled an end portion of the pipe (2) on the body side to seal an intermediate portion of the pipe (2) are made of Si_3N_4 ceramic containing TiO_2.

11. A current self-control type glow plug according to any one of claims 1 to 10, wherein the heating coil part (4) is provided in contact with the inner wall of a front end portion (15) of the pipe (2), and the control coil portion (5) is provided out of contact with the inner wall of an intermediate portion (16) of the pipe (2).

12. A current self-control type glow plug according to any one of claims 1 to 11, wherein the front end portion (15) of the pipe (2) where the heating coil part (4) is provided constitutes a heating portion, and the control coil part (5) provided in the intermediate portion (16) of the pipe (2) constitutes a current control part.

Patentansprüche

1. Glühkerze mit Stromselbststeuerung, welche aufweist: einen hohlen Körper (1) mit einem durch Isolierteile (19) geführten Verbinder (12), ein in den hohlen Körper (1) eingesetztes Keramikrohr (2) sowie eine Spule (3) mit einem Heizspulenteil (4) und einem steuerspulenteil (5), die miteinander in Reihe geschaltet sind, wobei der Heizspulenteil (4) innerhalb des aus dem hohlen Körper (1) vorstehenden Rohres (2) vorgesehen ist und der Steuerspulenteil (5) im Rohr (2) vorgesehen ist, dadurch gekennzeichnet, daß die Glühkerze eine Stromsteuereinrichtung (10) mit einem positiven Widerstandstemperaturkoeffizienten aufweist, der in den hohlen Körper (1) eingesetzt ist, ein Ende der Stromsteuereinrichtung (10) mit dem Verbinder (12) und das andere Ende in Reihe mit der Spule (3) verbunden ist, wodurch, da der elektrische Widerstand der Stromsteuereinrichtung (10) oberhalb einer bestimmten Temperatur scharf ansteigt, der durch die Spule (3) fließende Strom automatisch unterbrochen wird in Abhängigkeit von einer erhöhten Temperatur, die höher ist als die bestimmte Temperatur.

2. Glühkerze mit Stromselbststeuerung nach Anspruch 1, bei welcher der Widerstand der Stromsteuereinrichtung (10) mit einem positiven Widerstandstemperaturkoeffizienten oberhalb einer Temperatur nahe einer vorbestimmten Kühlwasserstemperatur scharf ansteigt, um die Stromzuführung zu der Spule (3) im wesentlichen zu unterbrechen.

3. Glühkerze mit Stromselbststeuerung nach Anspruch 1 oder 2, bei welcher die Stromsteuereinrichtung (10) Stromsteuerscheiben (27) aufweist, welche einen Anschluß bilden und aus einem Material bestehen, das einen positiven Widerstandstemperaturkoeffizienten besitzt und deren Widerstand oberhalb einer bestimmten Temperatur scharf ansteigt, und die Stromsteuerscheiben (27) an einem Ende parallel zum Anschlußteil (13) des Verbinders (12) geschaltet und am anderen Ende mit dem Spulenanschluß (28) der Spule (3) verbunden sind.

4. Glühkerze mit Stromselbststeuerung nach Anspruch 3, bei welcher die stirnflächen der im Abstand voneinander und am Spulenanschluß (28) angeordneten Stromsteuerscheiben (27) in engem Kontakt mit den Stirnflächen von Metallscheiben (14) stehen, die in gegenseitigem Abstand und am Anschlußteil (13) angeordnet sind, und die Stromsteuerscheiben (27) und die Metallscheiben (14) abwechselnd aufeinandergestapelt sind.

5. Glühkerze mit Stromselbststeuerung nach Anspruch 1 oder 2, bei welcher die Stromsteuereinrichtung (10) einen Kreisring (31) aufweist, der zwischen dem Verbinderanschluß (13) und dem Spulenanschluß (28) angeordnet ist.

6. Glühkerze mit Stromselbststeuerung nach Anspruch 1 oder 2, bei welcher die Stromsteuereinrichtung (10) einen Spiralteil (32) aufweist, der zwischen den Verbinderanschluß (13) und den Spulenanschluß (28) gewickelt ist.

7. Glühkerze mit Stromselbststeuerung nach einem der Ansprüche 1 bis 6, bei welcher die Stromsteuereinrichtung (10) aus einem $BaTiO_3$-Sintermaterial oder einem $PbTiO_3$-Sintermaterial besteht.

8. Glühkerze mit Stromselbststeuerung nach einem der Ansprüche 1 bis 7, bei welcher die Spule (3) aus einem Wolframdraht oder einem Nickeldraht mit positivem Widerstandstemperaturkoeffizienten gebildet ist.

9. Glühkerze mit Stromselbststeuerung nach einem

der Ansprüche 1 bis 8, bei welcher das Rohr (2) aus Si_3N_4 mit einer ausgezeichneten Hitzebeständigkeit besteht.

10. Glühkerze mit Stromselbststeuerung nach einem der Ansprüche 1 bis 9, bei welcher ein erster keramischer Füllteil (6), mit dem der Bereich gefüllt ist, in welchem der Heizspulenteil (4) vorgesehen ist, und ein zweiter keramischer Füllteil (7), mit dem ein Endabschnitt des Rohrs (2) auf der Körperseite zur Abdichtung eines Zwischenabschnitts des Rohrs (2) ausgefüllt ist, aus Si_3N_4-Keramik besteht, die TiO_2 enthält.

11. Glühkerze mit Stromselbststeuerung nach einem der Ansprüche 1 bis 10, bei welcher der Heizspulenteil (4) in Kontakt mit der Innenwand eines vorderen Endabschnitts (15) des Rohrs (2) vorgesehen ist und der Steuerspulenteil (5) außer Kontakt mit der Innenwand eines Zwischenabschnitts (16) des Rohrs (2) vorgesehen ist.

12. Glühkerze mit Stromselbststeuerung nach einem der Ansprüche 1 bis 11, bei welcher der vordere Endabschnitt (15) des Rohrs (2), wo der Heispulenteil (4) vorgesehen ist, einen Heizteil bildet, und der im Zwischenteil (16) des Rohrs (2) vorgesehene Steuerspulenteil (5) einen Stromsteuerteil bildet.

Revendications

1. Bougie de préchauffage de type à commande automatique de courant comprenant un corps creux (1) comportant un connecteur (12) traversant des éléments isolants (19), un tube en céramique (2) monté sur le corps creux (1), et une bobine (3) comportant une partie (4) formant bobine chauffante et une partie (5) formant bobine de commande connectées en série l'une avec l'autre, la partie (4) formant bobine chauffante étant disposée à l'intérieur du tube (2) en saillie du corps creux (1), et la partie (5) formant bobine de commande étant disposée dans le tube (2) ; dans laquelle la bougie de préchauffage comprend en outre un moyen (10) de commande de courant, ayant un coefficient positif de résistance-température, installé dans le corps creux (1), une des extrémités du moyen (10) de commande de courant étant connectée avec le connecteur (12) et l'autre extrémité étant connectée en série avec la bobine (3), ce par quoi, lorsque la résistance électrique du moyen (10) de commande de courant augmente brutalement au-delà d'une température spécifiée, un courant passant dans la bobine (3) est arrêté automatiquement en réponse à une température élevée plus haute que la température spécifiée.

2. Bougie de préchauffage de type à commande automatique de courant selon la revendication 1, dans laquelle la résistance du moyen (10) de commande de courant, ayant un coefficient positif de résistance-température, augmente brutalement au-delà d'une température proche d'une température prédéterminée d'eau de refroidissement pour interrompre la délivrance de courant à la bobine (3).

3. Bougie de préchauffage de type à commande automatique de courant selon la revendication 1 ou la revendication 2, dans laquelle le moyen (10) de commande de courant comprend des disques (27) de commande de courant constitués d'une borne et d'une matière qui a un coefficient positif de résistance-température et dont la résistance augmente brutalement au-delà d'une température spécifiée, et dans laquelle les disques (27) de commande de courant sont connectés en parallèle, au niveau d'une extrémité, avec la partie (13) de connecteur du connecteur (12) et, au niveau de l'autre extrémité, avec la borne (28) de bobine de la bobine (3).

4. Bougie de préchauffage de type à commande automatique de courant selon la revendication 3, dans laquelle les faces des disques (27) de commande de courant, espacés les uns des autres et agencés sur la borne (28) de bobine, sont en contact serré avec les faces des disques métalliques (14) espacés les uns des autres et agencés sur la partie (13) de connecteur, et dans laquelle les disques (27) de commande de courant et les disques métalliques (14) sont empilés en alternance.

5. Bougie de préchauffage de type à commande automatique de courant selon la revendication 1 ou la revendication 2, dans laquelle le moyen (10) de commande de courant comprend un anneau circulaire (31) agencé entre le connecteur (13) et la borne (28) de bobine.

6. Bougie de préchauffage de type à commande automatique de courant selon la revendication 1 ou la revendication 2, dans laquelle le moyen (10) de commande de courant comprend un élément en spirale (32) enroulé entre le connecteur (13) et la borne (28) de bobine.

7. Bougie de préchauffage de type à commande automatique de courant selon l'une quelconque des revendications 1 à 6, dans laquelle le moyen (10) de commande de courant est constitué d'une matière frittée à base de $BaTiO_3$,ou d'une matière frittée à base de $PbTiO_3$.

8. Bougie de préchauffage de type à commande automatique de courant selon l'une quelconque des revendications 1 à 7, dans laquelle la bobine (3) est formée d'un fil de tungstène, ou d'un fil de nickel, ayant un coefficient positif de résistance-température.

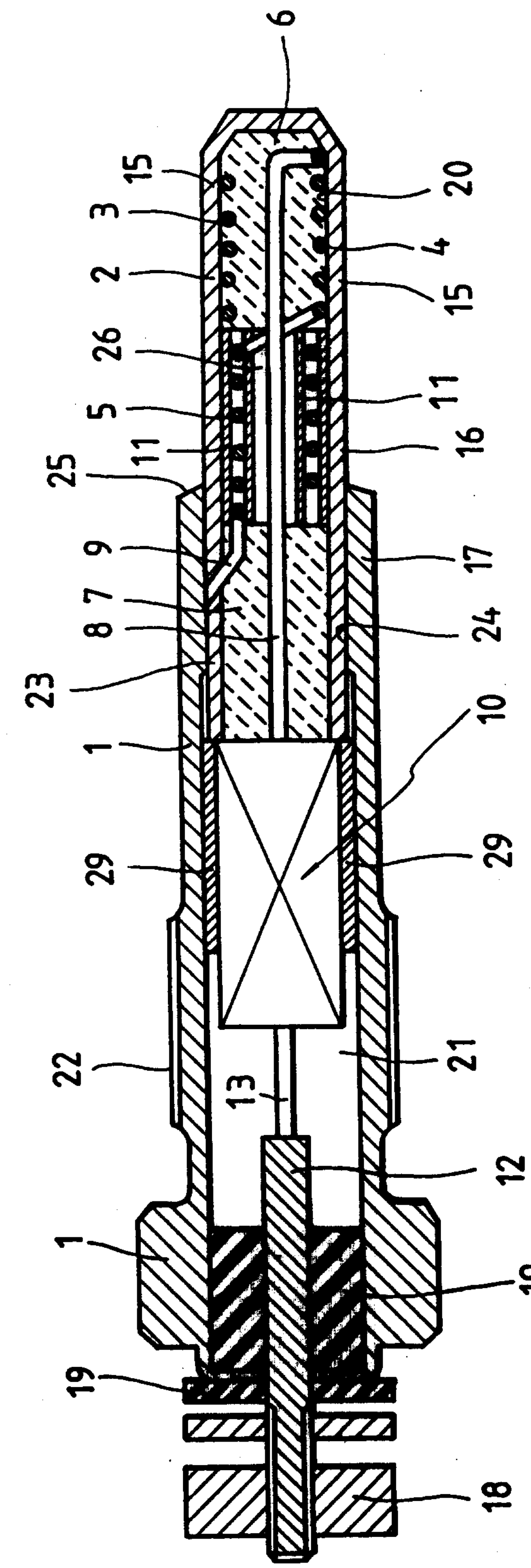
9. Bougie de préchauffage de type à commande automatique de courant selon l'une quelconque des revendications 1 à 8, dans laquelle le conduit (2) est constitué de Si_3N_4 ayant une excellente résistance à la chaleur.

10. Bougie de préchauffage de type à commande automatique de courant selon l'une quelconque des revendications 1 à 9, dans laquelle une première matière de remplissage à base de céramique (6) qui remplit la zone où est réalisée la partie (4) formant bobine chauffante, et une seconde matière de remplissage à base de céramique (7) qui remplit une partie d'extrémité du tube (2), située du côté corps, pour sceller une partie intermédiaire du tube (2), sont constituées de céramique de Si_3N_4 contenant du TiO_2.

11. Bougie de préchauffage de type à commande automatique de courant selon l'une quelconque des revendications 1 à 10, dans laquelle la partie (4) formant bobine chauffante est disposée en contact avec la paroi intérieure d'une partie (15) d'extrémité avant du tube (2), et la partie (5) formant bobine de commande est disposée hors de contact avec la paroi intérieure d'une partie intermédiaire (16) du tube (2).

12. Bougie de préchauffage de type à commande automatique de courant selon l'une quelconque des revendications 1 à 11, dans laquelle la partie (15) d'extrémité avant du tube (2), où est disposée la partie (4) formant bobine chauffante, constitue une partie chauffante, et dans laquelle la partie (5) formant bobine de commande, disposée dans la partie intermédiaire (16) du tube (2), constitue une partie de commande de courant.

FIG. 1


6
15
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2
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1
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19

FIG. 2

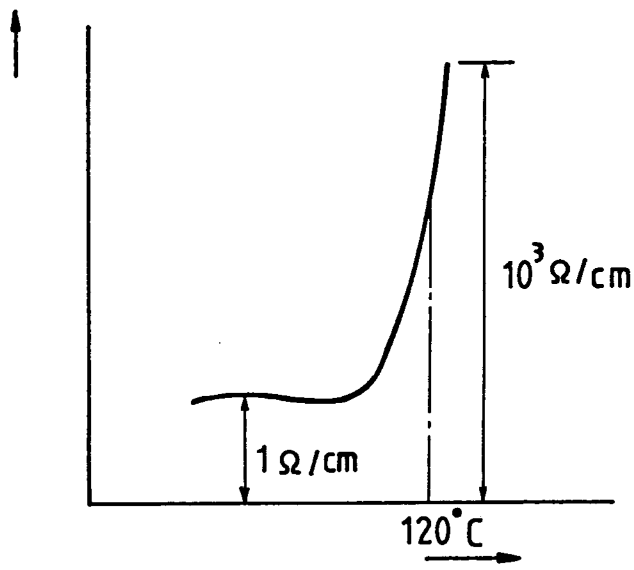

FIG. 3

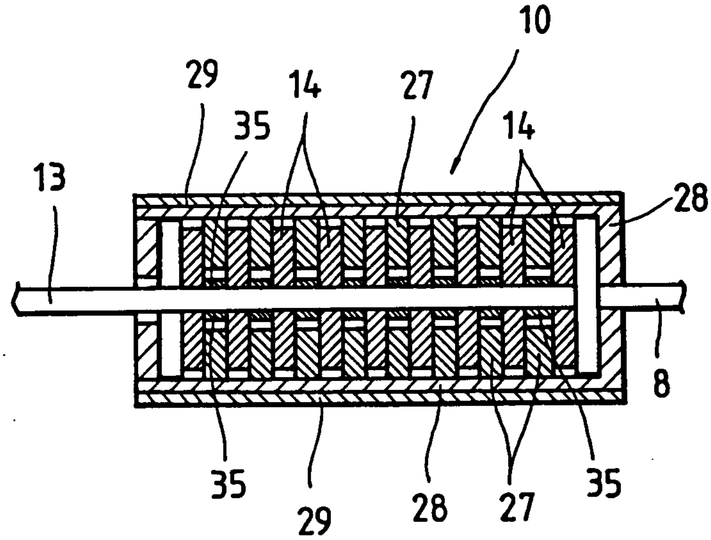

FIG. 4

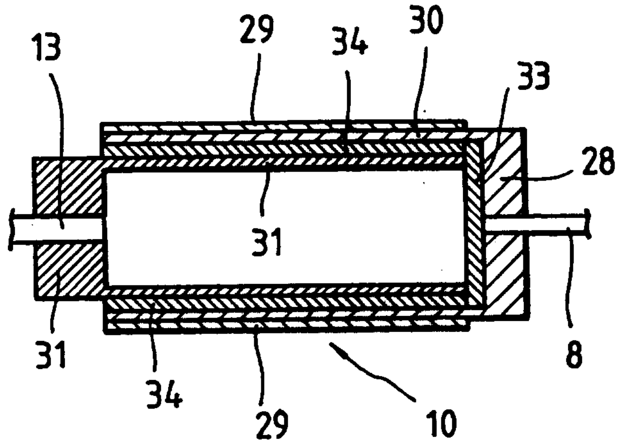

FIG. 5

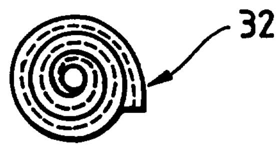

FIG. 6