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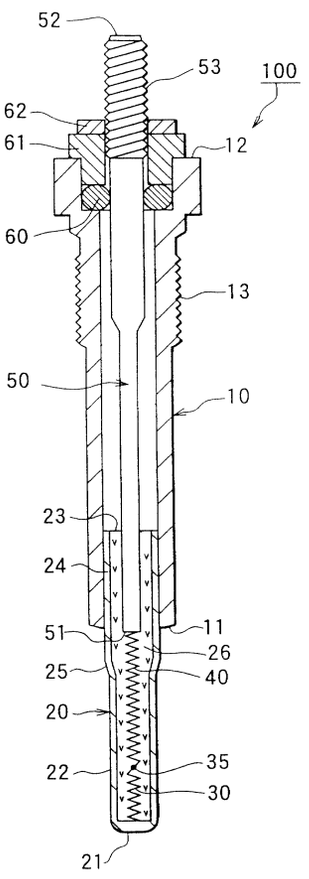
(54) Glow-plug

(57) In a glow plug, a metal heater case (20) has at one end thereof a smaller diameter portion (22) whose diameter is not larger than 4 mm and whose length is not shorter than 15 mm and has at the other end thereof a larger diameter portion (24). A first coil (30) is embedded via insulation powder (26) in the smaller diameter portion of the heater case and one end thereof is electrically conducted with the heater case. A second coil (40) is embedded via insulation powder (26) in and insulated with the heater case and one end thereof is connected to the other end of the first coil. A housing (10) holds the heater case by enveloping a part of the larger diameter portion of the heater case. A portion of the heater case corresponding to the first coil shows highest temperature in the heater case in 60 seconds after rated voltage is applied to the first and second coils.

FIG. 1



EP 1 102 007 A2

Description

[0001] The present invention relates to a glow plug.

[0002] Conventionally, a glow plug for diesel engines has a first coil and a second coil housed in a metal heater case held by a housing so as to be placed in order from an end of the heater case. The heater case facing the first and second coils is heated by supplying current to both of the coils so that the glow plug generates heat.

[0003] It is required for the glow plug that the heater case is rapidly heated to secure faster engine starting and current for after glow is further supplied for a relatively long time to stabilize combustion after the engine starting. Generally, current for after glow is supplied for continuously generating heat to the glow plug for two to five minutes after the engine starting so that a fire source may be formed in a combustion chamber to stabilize combustion just after the engine starting.

[0004] Further, as a recent tendency, a direct injection type diesel engine is coming out to meet exhaust gas regulations. In many cases, the direct injection engine has many intake and exhaust valves in the combustion chamber. Accordingly, it is preferable that a heater portion of the glow plug have a smaller diameter (not larger than 4.0 mm) and longer length (not shorter than 15 mm).

[0005] In a conventional glow plug for a swirl chamber type engine, the first coil is housed in a smaller diameter portion and the second coil is housed in a larger diameter portion. Therefore, temperature of a portion of the heater case corresponding to the first coil is higher than that corresponding to the second coil.

[0006] However, in another conventional glow plug in which the diameter of the heater portion is not larger than 4.0 mm, the length thereof is not shorter than 15 mm, and almost whole length of the second coil is housed in the smaller diameter portion, temperature of the heater case corresponding to the second coil is higher than that corresponding to the first coil since surface current density of the second coil is higher.

[0007] Accordingly, the second coil, whose corrosion resistance is inherently poorer than that of the first coil, is likely to be broken so that a life of the glow plug is shortened.

[0008] An object of the present invention is to provide a glow plug having a heater portion whose diameter is not larger than 4.0 mm and whose length is not shorter than 15 mm in which, though current for after glow is supplied for a longer time, a longer life of the glow plug may be secured.

[0009] To achieve the object, in the glow plug, a metal heater case (20) has at one end thereof a smaller diameter portion (22) whose diameter is not larger than 4 mm and whose length is not shorter than 15 mm and having at the other end thereof a larger diameter portion whose diameter is larger than that of the smaller diameter portion. A first coil (30) is embedded via insulation powder (26) in the smaller diameter portion of the heater case and one end of the first coil is electrically connected with the heater case. A second coil (40) is embedded via insulation powder (26) in the heater case, one end of the second coil is connected to the other end of the first coil, and at least more than half of the second coil is housed in the smaller diameter portion. A housing (10) holds the heater case by enveloping a part of the larger diameter portion of the heater case.

[0010] With the construction mentioned above, a portion of the heater case corresponding to the first coil shows highest temperature in the heater case when rated voltage is applied to the first and second coils and temperature of the heater case is saturated. Therefore, surface temperature of a portion of the heater case corresponding to the second coil becomes lower than that corresponding to the first coil. As a result, the second coil is unlikely to be broken so that the life of the glow pug may be prolonged.

[0011] It is preferable that surface temperature of the portion showing the highest temperature in the heater case is not larger than 950 °C for prolonging the life of the glow plug.

[0012] Further, preferably, the first and second coils are placed outside the housing. That is, the first and second coils do not exist inside the housing. This construction makes it easy to adjust temperature of the respective first and second coils.

[0013] Furthermore, it is preferred that an electric resistance value of the first coil at normal temperature is higher by 2 to 3.5 times than that of the second coil. Accordingly, the second coil generates more heat, compared to the first coil.

[0014] The glow plug having the construction mentioned above is applicable to an engine in which a length of the heater case protruding into a combustion chamber is not longer than 7mm. The highest temperature portion of the heater case may be easily provided within 7 mm from the end of the heater case.

[0015] Other features and advantages of the present invention will be appreciated, as well as methods of operation and the function of the related parts, from a study of the following detailed description, the appended claims, and the drawings, all of which form a part of this application. In the drawings:

Fig. 1 is a cross sectional view of a glow plug according to an embodiment of the present invention;
Fig. 2 is an enlarged view of a heater portion of the glow plug of Fig. 1;
Fig. 3A is a view showing dimensions of the heater portion of the spark plug of Fig. 1;
Fig. 3B is a view showing dimensions of the heater portion of a conventional spark plug;
Fig. 4 is a graph showing a test result with respect to temperature distribution on the heater portion;
Fig. 5 is a chart showing resistance values of test samples;
Fig. 6 is a chart showing conditions of an endurance

test; and

Fig. 7 is a chart showing an endurance test result.

[0016] A glow plug 100 shown in Figs. 1 and 2 is installed in each of a plurality of cylinders (not shown), for example, four cylinders, of a diesel engine. The glow plug serves to ignite fuel and to promote combustion at an engine starting time.

[0017] The glow plug 100 has a cylindrical housing 10 made of iron based material. The housing 10 is provided with a thread portion 13 for detachably fastening the glow plug to the cylinder. A long narrow cup shaped heater tube 20, which constitutes a heater portion, is partly inserted into an opening of the housing 10 on a side of an end 11 thereof and is fitted by brazing or press fitted to the housing 10.

[0018] The heater case 20 is made of conductive material (for example, stainless such as SUS 310S) having good heat resistance and good anti-oxidization characteristic. The heater case 20 is integrally provided on a side of a closed end 21 thereof with a smaller diameter portion 22 and on a side of an open end (23) thereof with a larger diameter portion 24 whose diameter is larger than that of the smaller diameter portion 22. The diameter of the smaller diameter portion 22 is not larger than 4 mm and a length thereof is not shorter than 15 mm.

[0019] The larger diameter portion 24 is internally fitted to and held by the housing on a side of the end 11. A part of the larger diameter portion 24 and a whole of the smaller diameter portion 22 are exposed out of the end 11 of the housing 10. A taper portion 25 is provided between the larger and smaller diameter portions 24 and 22 of the heater case 20. The diameter of taper portion 25 is gradually enlarged toward the larger diameter portion 24 from the smaller diameter portion 22.

[0020] A first coil 30 (first resistance) and second coil 40 (second coil) are placed in series inside the heater case 20 in an axial direction thereof. The first coil 30 is housed inside the smaller diameter portion 22. More than half of the second coil 40, which is placed on a side of an opening portion 23 of the heater case with respect to the first coil, is also housed inside the smaller diameter portion 22. Both of the first and second coils 30 and 40 are placed outside the housing 10.

[0021] An end 31 of the first coil 30 is electrically connected to the closed end 21 of the heater case 20 and another end 32 of the first coil 30 is electrically connected to an end 41 of the second coil 40. Another end 42 of the second coil 40 is electrically connected by welding to an end 51 of a center axis 50, which is inserted into the opening of the housing 10 and fixed to the housing 10. A part of the first coil 30 on a side of the end 32 and a part of the second coil on a side of the end 41 are folded each other to constitute a folding portion. The first and second coils 30 and 40 are connected by welding the folding portion so that molten portions 35 of the first and second coils 30 and 40 are formed.

[0022] A part of the center axis 50 on a side of the end 51 and the first and second coils 30 and 40 are embedded in insulation powder 26 made of heat resistant electric insulating material (for example, magnecia). Accordingly, the part of the center axis 50 on a side of the end 51 and the first and second coils 30 and 40 except the end 31 of the first coil 30 are electrically insulated from the heater case 20.

[0023] The first coil 30 is made of first conductive material (for example, nickel chromium alloy) whose resistance change ratio (resistance value at temperature 1000 °C / resistance value at 20 °C) between normal temperature and temperature 1000 °C (temperature of the first coil 30 at preheating) is very small, for example, near 1. The second coil 40 is made of second conductivematerial (for example, cobalt iron alloy) whose resistance change ratio mentioned above is relatively large, for example, 5 to 14.

[0024] The center axis 50 on a side of the end 51 is partly inserted into the heater case 20 on a side of the open end 23 thereof. A portion of the center axis 50 on a side of another end 52 is insulated from and fixed to the housing 10 on a side of another end 12 thereof with a nut 62 via a sealing member 60 such as an o ring, which is made of insulation elastic material such as fluorine rubber, and a resin insulation bush 61. The portion of the center axis 50 on a side of another end 52 is provided with a thread portion 53 to which a wiring element such as a connecting bar or a lead terminal extending from an electric source (not shown) is to be fixed.

[0025] In the glow plug 100 mentioned above, when rated current (for example, 11 V) is applied between the center axis 50 and the housing 10, which is grounded to an engine body, both of the first and second coils 30 and 40 generate heat. According to the embodiment of the present invention, when temperature of the heater case 20 is saturated after the rated voltage is applied to the glow plug 100, a portion of the heater case 20 corresponding to the first coil 30 shows highest temperature in the heater case 20.

[0026] Fig. 3A shows a dimension of the heater portion according to the embodiment mentioned above and Fig. 3B shows a dimension of the conventional heater portion (prior art) as a comparison.

[0027] Each of K1 and K2 is a diameter of the smaller diameter portion 22 of the heater case 20. Each of the diameter K1 of the present embodiment and the diameter K2 of prior art is ϕ3.5 mm. D1 or D2 is a thickness of the closed end 21 of the heater case 20. The thickness D1 of the present embodiment is 1.5 mm and the thickness D2 of prior art is 2 mm. L1 or L2 is a length of the smaller diameter portion 22. Each of the lengths L1 and L2 is 26 mm. LA1 or LA2 is an axial length of the first coil 30. The length LA1 of the present embodiment is 9 mm and the length LA2 of prior art is 5 mm. LB1 or LB2 is an axial length of the second coil 40. The length LB1 of the present embodiment is 25.5 mm and the length LB2 of prior art is 26 mm.

[0028] According to the present embodiment, a portion of the second coil 40 embedded in the insulation powder 26 in the larger diameter portion 24 is longer than that according to the prior art, as shown in Figs. 1 to 3. This serves to lower the temperature of the portion of the heater case 20 corresponding to the second coil 40, compared with the prior art. Further, if the length LB1 of the second coil 40 of the present embodiment is much longer than the length LB2 of the second coil of the prior art, the temperature of the portion of the heater case 20 corresponding to the second coil 40 becomes lower. This is because that the temperature of the second coil 40 of the present embodiment becomes lower than that of the prior art, if electric power applied to the respective present embodiment and prior art are same.

[0029] Furthermore, a ratio of the length LA1 of the first coil 30 to the length LB2 of the second coil 40 according to the present embodiment is larger than that according to the prior art so that a heat amount generating in the first coil 30 becomes larger than that in the second coil 40 when current is supplied to the coils 30 and 40 for heating.

[0030] The resistance values of the first and second coils 30 and 40 of the prior art are 0.29 Ω and 0.18 Ω at normal temperature, respectively. On the other hand, the resistance values of the first and second coils 30 and 40 of the present embodiment are 0.74 Ω and 0.24 Ω at normal temperature, respectively. A resistance ratio (the resistance value of the first coil 30 / the resistance value of the second coil 40) of the coils is about 3.1 in case of the present embodiment and about 1.6 in case of the prior art. A relative resistance value of the first coil 30 to the second coil 40 is higher, compared with that of the prior art.

[0031] It is common as a construction of the recent glow plug that a length of the heating portion protruding into a combustion chamber is not larger than 7 mm when the glow plug is installed in the engine. Therefore, it is required to start red heat on the heater portion protruding into the chamber and it is preferable to generate heat at the heater portion as nearer to the closed end 21 of the heater case 20 as possible.

[0032] Under the reason mentioned above, it is not preferable to make the length LA1 of the first coil 30 longer since a position where the red heat starts becomes more away from the closed end 21. It is concluded, therefore, that a maximum length LA1 of the first coil 30 is 14 mm. As a result, preferably, the resistance ratio (the resistance value of the first coil 30 / the resistance value of the second coil 40) is 2 to 3.5 at normal temperature on condition that a highest temperature portion of the heater case 20 at a heat generating time is placed within 7 mm from the closed end 21. Further, to prolong the life of the glow plug, it is preferred that temperature at the highest temperature portion is not higher than 950 °C.

[0033] An experimental test was conducted on samples of embodiments ①, ② and ③ according to the present embodiment and samples according to the prior art to study a temperature distribution on the heater portion. The resistance values of the first and second coils 30 and 40 and the resistance ratio (the resistance value of the first coil 30 / the resistance value of the second coil 40) of the respective present embodiment and prior art are shown in Fig. 5.

[0034] Fig. 4 shows a test result with respect to the temperature distribution on the heater portion. In Fig. 4, temperature (°C) on respective portions of the heater case 20 located away by respective length (mm) from the closed end 21 of the heater case 20 were measured and plotted as heater temperature on the respective samples. The heater temperature is temperature measured after a lapse of 60 seconds upon applying rated voltage (11 V), that is, when temperature of the heater case is saturated.

[0035] As understood from solid lines shown in Fig. 4, each of the embodiments ① ②and ③samples shows that the highest temperature portion of the heater case 20 is located on a portion of the heater case 20 corresponding to the first coil 30 (a portion away by 6 to 7 mm from the closed end 21). On the other hand, the prior art sample shows that the highest temperature portion of the heater case 20 is located on a portion of the heater case 20 corresponding to the second coil 40 (a portion away by about 15 mm from the closed end 21), as understood from a dotted line shown in Fig. 4.

[0036] As mentioned above, though the glow plug 100 according to the present embodiment has the heater portion whose diameter is not larger than 4.0 mm and whose length is not shorter than 15 mm, highest temperature of the portion of the heater case 20 corresponding to the second coil 40 is lower than that corresponding to the first coil 30 after a lapse of 60 seconds on starting the rated voltage application.

[0037] Next, an endurance test result on samples according to the present embodiment and the prior art, whose temperature distribution are shown in Fig. 4, is described hereinafter.

[0038] The endurance test was conducted on conditions shown in Fig. 6, that, after the rated voltage is applied to each of the samples for 70 seconds, each of the samples is heated and cooled for 3 minutes without current application.

[0039] Heating was conducted by placing the samples in an electric furnace at about 900 °C and cooling was conducted by taking the samples out of the furnace and exposing the samples to air ventilated with a fan. 70 seconds heating and 20 seconds coolingwere twice repeated. Temperature shown in Fig. 6 is surface temperature of the portion of the heater case corresponding to the first or second coil 30 or 40.

[0040] The endurance test on the samples was conducted by repeating cycles whose one cycle is based on a current supply and heating & cooling pattern shown in Fig. 6 and finding out a number of cycles in which the first and second coils 30 and 40 of the respective sam-

ples are broken. As shown in Fig. 7, the grow plug 100 according to the present embodiment has a longer lifetime, compared with the conventional glow plug.

[0041] Though the second coil 40 is broken by oxidization in the case of the conventional glow plug, the first coil 30 is broken in the case of the present embodiment.

[0042] As a result, the glow plug of the present embodiment can realize a longer lifetime by arranging the portion of the heater case corresponding to the first coil as a highest temperature portion in the heater case and, further, secure much longer life by setting the highest temperature portion to temperature not higher than 950 °C, compared with the conventional glow plug. Accordingly, it is concluded that the glow pug having the heater portion whose diameter is not larger than 4.0 mm and whose length is not shorter than 15 mm can endure a longer current supply for after glow so that longer life may be assured.

[0043] Further, according to the present embodiment, as the first and second coils 30 and 40 are located outside the housing 10, heat dissipation of the first and second coils are good so that temperature control of both of the coils 30 and 40 may be easily conducted.

[0044] In a glow plug, a metal heater case (20) has at one end thereof a smaller diameter portion (22) whose diameter is not larger than 4 mm and whose length is not shorter than 15 mm and has at the other end thereof a larger diameter portion (24). A first coil (30) is embedded via insulation powder (26) in the smaller diameter portion of the heater case and one end thereof is electrically conducted with the heater case. A second coil (40) is embedded via insulation powder (26) in and insulated with the heater case and one end thereof is connected to the other end of the first coil. A housing (10) holds the heater case by enveloping a part of the larger diameter portion of the heater case. A portion of the heater case corresponding to the first coil shows highest temperature in the heater case in 60 seconds after rated voltage is applied to the first and second coils.

Claims

1. A glow plug comprising:

a metal heater case (20) having at one end thereof a smaller diameter portion (22) whose diameter is not larger than 4 mm and whose length is not shorter than 15 mm and having at the other end thereof a larger diameter portion (24) whose diameter is larger than that of the smaller diameter portion;
a first coil (30), which is embedded via insulation powder (26) in the smaller diameter portion of the heater case and whose one end is electrically conducted with the heater case;
a second coil (40), which is embedded via insulation powder (26) in the heater case, whose one end is connected to the other end of the first coil and whose more than half in length is housed in the smaller diameter portion; and
a housing (10) holding the heater case by enveloping a part of the larger diameter portion of the heater case,
wherein a portion of the heater case corresponding to the first coil shows highest temperature in the heater case when rated voltage is applied to the first and second coils and temperature of the heater case is saturated.

2. A glow plug according to claim 1, wherein surface temperature of the portion showing the highest temperature in the heater case is not larger than 950 °C.

3. A glow plug according to claim 1 or 2, wherein the first and second coils are placed outside the housing.

4. A glow plug according to any one of claims 1 to 3, wherein an electric resistance value of the first coil at normal temperature is higher by 2 to 3.5 times than that of the second coil.

5. A glow plug according to any one of claims 1 to 4, wherein a length of the heater case protruding into a combustion chamber is not longer than 7mm, when the glow plug is installed in an engine.

FIG. 1

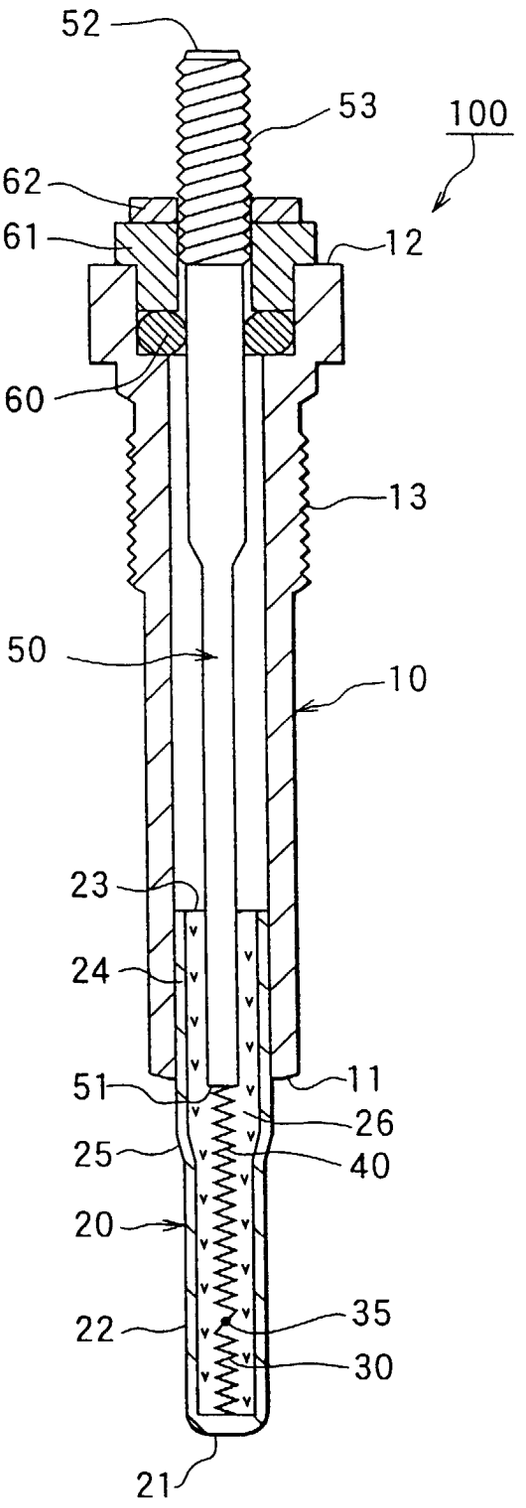

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FIG. 2

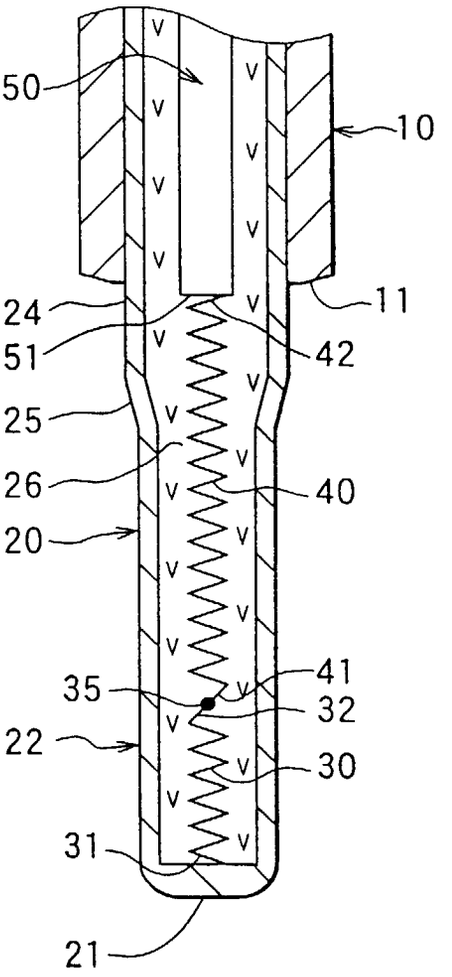
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FIG. 3A

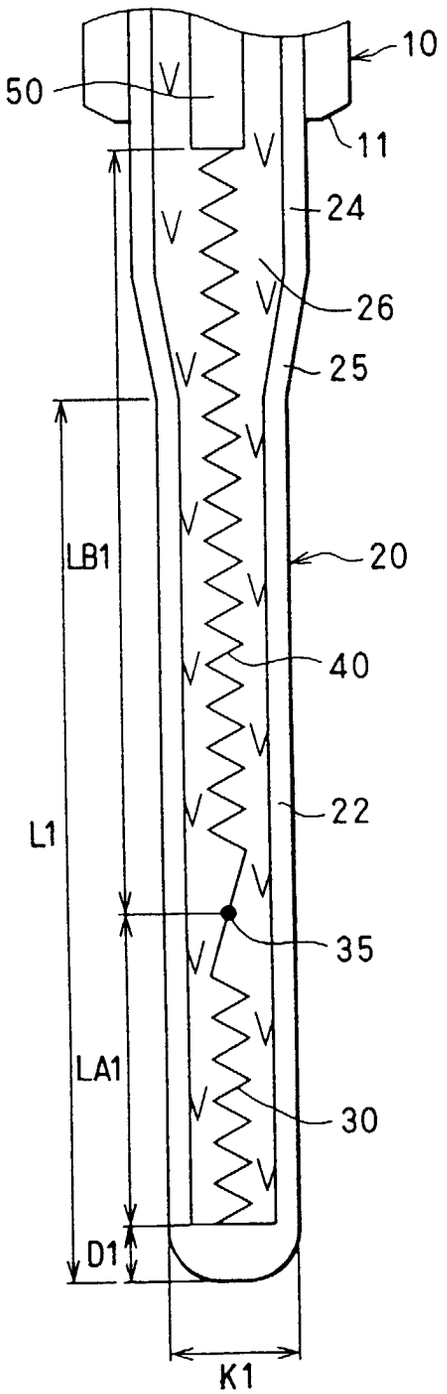


FIG. 3B

PRIOR ART

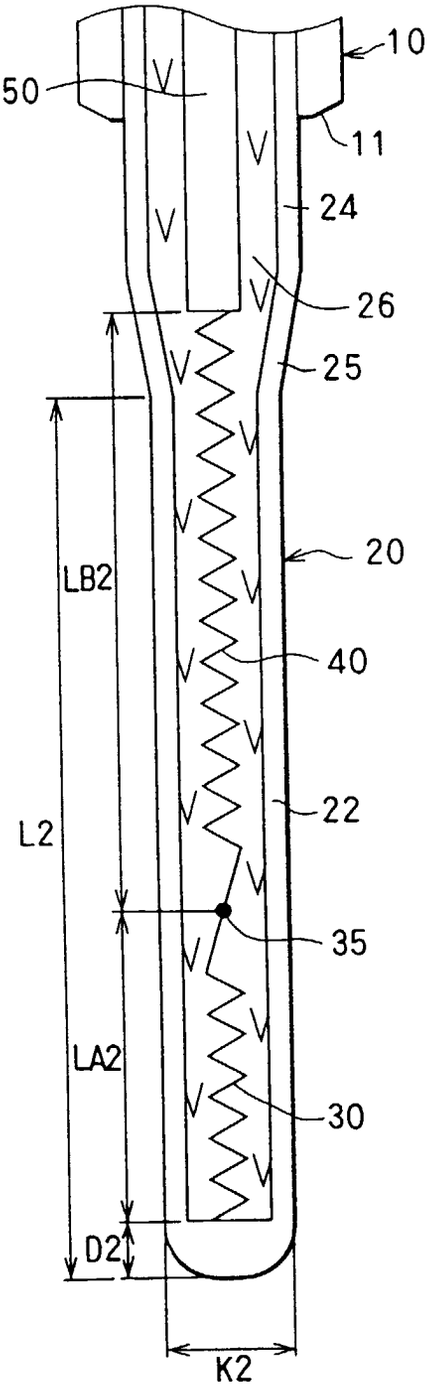


FIG. 4

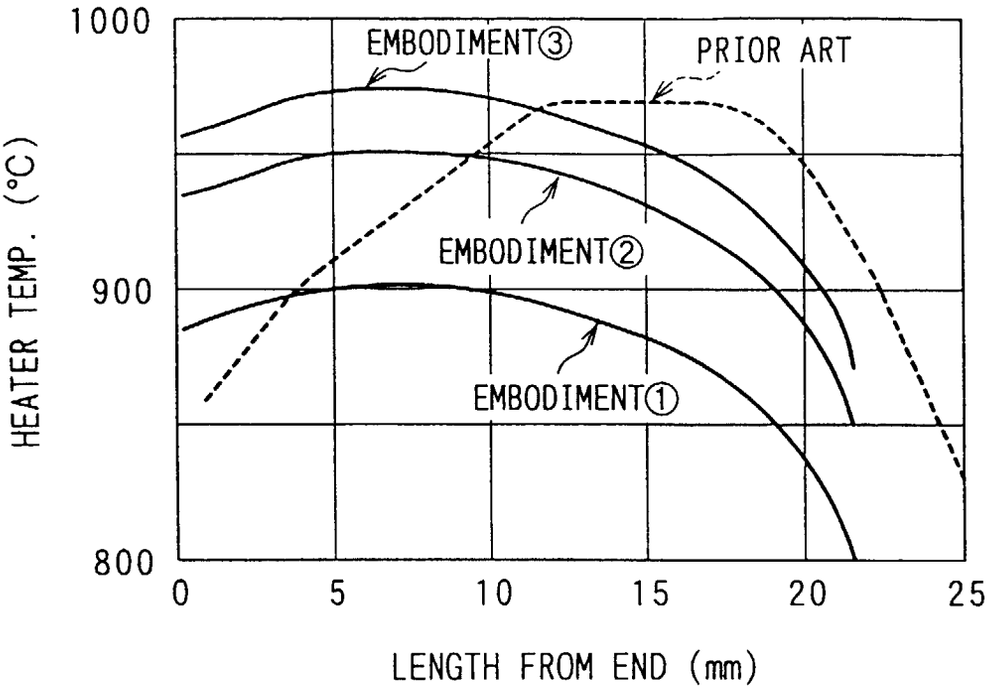


FIG. 5

		FIRST COIL (Ω)	SECOND COIL (Ω)	RESISTANCE RATIO
PRIOR ART		0.29	0.18	1.6
EMBODIMENT	①	0.74	0.24	3.1
	②	0.84	0.24	3.5
	③	0.96	0.24	4.0

FIG. 6

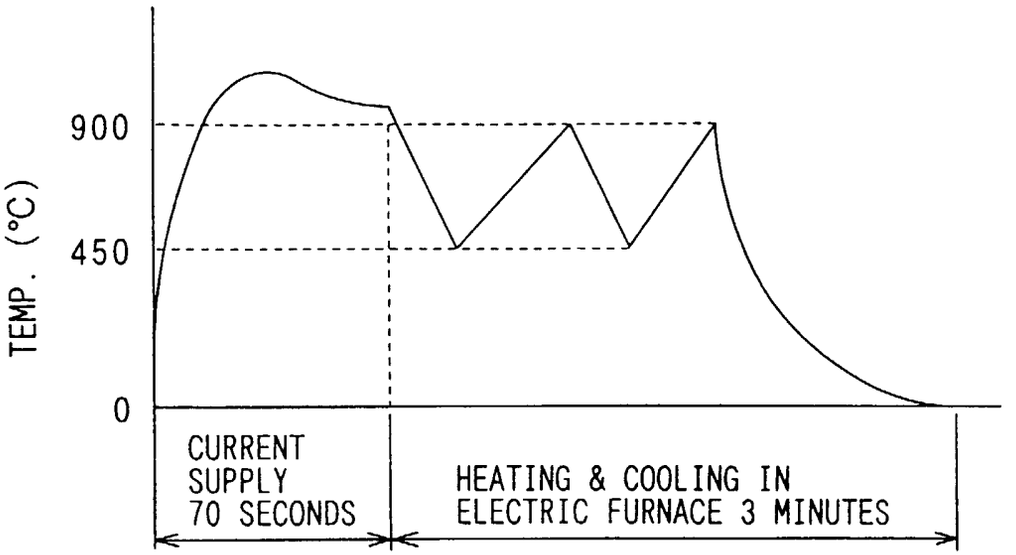
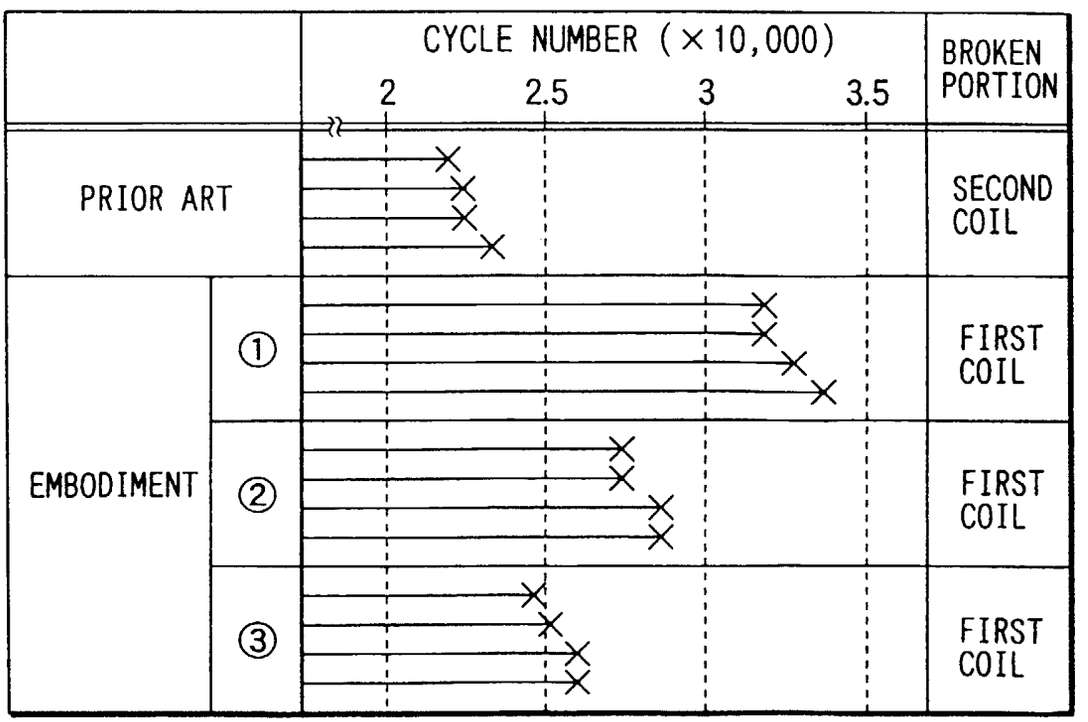

900
450
0
TEMP. (°C)
CURRENT SUPPLY 70 SECONDS
HEATING & COOLING IN ELECTRIC FURNACE 3 MINUTES

FIG. 7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FIRST COIL