

19



Europäisches Patentamt
European Patent Office
Office européen des brevets



11 Publication number:

0 607 872 A2

12

EUROPEAN PATENT APPLICATION21 Application number: **94100446.7**51 Int. Cl.⁵: **F23Q 7/00**22 Date of filing: **13.01.94**30 Priority: **14.01.93 JP 22011/93**43 Date of publication of application:
27.07.94 Bulletin 94/3084 Designated Contracting States:
DE FR IT71 Applicant: **NIPPONDENSO CO., LTD.**
1-1, Showa-cho
Kariya-city Aichi-pref., 448(JP)72 Inventor: **Makino, Sigeharu**
18967, Kurobe,
Ano-cho
Toyoake-shi, Aichi-ken(JP)
Inventor: **Koyama, Taiji**
288, Aza Asahi,
Asahi-machi
Toyohashi-shi, Aichi-ken(JP)
Inventor: **Tsuji, Nobuyuki**
62-2, Araya,
Shimosawaki,
Mito-cho
Hoi-gun, Aichi-ken(JP)74 Representative: **Bühling, Gerhard, Dipl.-Chem.**
et al
Patentanwaltsbüro
Tiedtke-Bühling-Kinne & Partner
Bavariaring 4
D-80336 München (DE)54 **Glow plug for diesel engine.**

57 A glow plug for a diesel engine is provided which includes generally a heating coil (1). The heating coil is provided with a first resistance element (11) and a second resistance element (12) connected in series with the first resistance element and having a resistance temperature coefficient positively higher than that of the first resistance element. The second resistance element (12) is made of a Co-Fe alloy whose compositions fall in a range where a change in phase from a body-centered cubic lattice arrangement to a face-centered cubic lattice arrangement does not occur and a change in phase from a close-packed hexagonal lattice arrangement to the face-centered cubic lattice arrangement does not occur even when the second

resistance element is subjected to a temperature change from a given room temperature to 1000 °C. The first resistance element (11) is welded at its end to an end of the second resistance element (12) to form a connection therebetween which consists of part of material forming the first resistance element and part of the Co-Fe alloy forming the second resistance element (12), the material forming the first resistance element (11) being so selected as to prevent compositions of the Co-Fe alloy in the connection from changing in phase from the body-centered cubic lattice arrangement to the face-centered cubic lattice arrangement and from the close-packed hexagonal lattice arrangement to the face-centered cubic lattice arrangement.

EP 0 607 872 A2

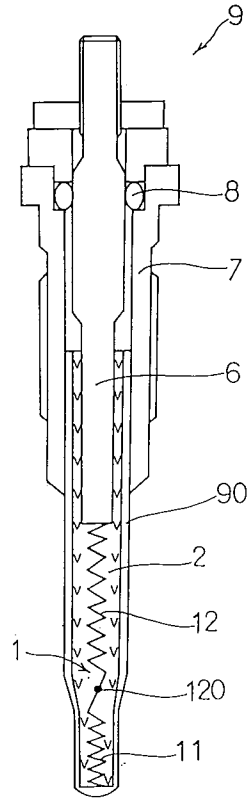


Fig. 1.

FIELD OF THE INVENTION

The present invention relates generally to a glow plug which is designed to preheat an auxiliary chamber of a diesel engine for assuring quick starting, and more particularly to an extended life of a heating coil arrangement for such a glow plug.

BACKGROUND ART

A glow plug is well known in the art as a preheating element serving to heat a diesel engine above a self-starting temperature during a starting mode of engine operation. Shortening a heating time period of the glow plug makes it possible to start the diesel engine quickly.

Japanese Patent First Publication No. 2-110212 discloses a glow plug including a filament type resistance wire element disposed in a heat-resistant insulating material with which a plug tube is filled. The resistance wire element is formed with a plurality of resistant filaments, each having different chemical compositions, welded in series with each other. The plurality of resistant filaments include first, second, and third coils. The first coil is made of a Fe-Cr-Al alloy. The second coil is made of a 75Wt%Co-25Wt%Fe alloy. The third coil is made of a 92Wt%Co-8Wt%Fe alloy.

The above prior art glow plug, however, has suffered from a drawback in that a sudden change in temperature under severe operational conditions such as quick heating causes the resistance wire element to expand and contract, resulting in wire breakage.

This wire breakage is found to be caused by the second coil. The 75Wt%Co-25Wt%Fe (74At%Co-26At%Fe) alloy used in the second coil, as shown in Fig. 7, has an α/γ transformation point in the vicinity of 800 °C. Therefore, due to heating of the second coil during the engine starting operation and combustion in the engine, the temperature of the second coil will pass repeatedly through the α/γ transformation point, resulting in a change in volume to create a strain on the second coil. This causes the second coil to be broken.

In order to avoid the above drawback, the inventors of this application have proposed an arrangement wherein the first coil consists of a Fe-Cr-Al alloy and the second coil is made of a 92Wt%Co-8Wt%Fe alloy in view of the fact that they have a rate of change in resistance which is smaller than that of the 75Wt%Co-25Wt%Fe alloy, but greater than that of Fe or Ni commonly used in the art, and do not have the α/γ transformation point. Experiments were conducted with respect to a glow plug formed with the first coil and the second coil thus constructed. The experiments show that the glow plug provides quicker heating

but remains indicating a short life (see the second comparative example C2 in Fig. 5).

Additionally, upon checking the life-tested glow plugs, as constructed above, it was found that a wire-breakage existed in a welded connection between the first and second coils for the following reasons. Since the content of Fe in the Fe-Cr-Al alloy of the first coil is 70Wt% and the content of Fe in the second coil is 8Wt%, a Fe-Co weight ratio of the welded connection shows 78 : 92 (i.e., atomic percentage ratio of 47 : 53), the welded connection, as is clear from Fig. 7, has the α/γ transformation point. Therefore, the volume of the welded connection is subject to change due to coil heating and combustion heating of the engine, resulting in a strain on the welded connection, causing wire-breakage to occur prematurely.

SUMMARY OF THE INVENTION

It is therefore a principal object of the present invention to avoid the disadvantages of the prior art.

It is another object of the present invention to provide an extended service life of a glow plug for preheating a diesel engine.

According to one aspect of the present invention, there is provided an electric resistance element which comprises a first resistance element having a given electric resistance and a second resistance element, connected in series with the first resistance element, having a resistance temperature coefficient positively higher than that of the first resistance element and providing a function of modifying a current to the first resistance element. The second resistance element is made of a Co-Fe alloy whose compositions fall in a range where a change in phase from a body-centered cubic lattice arrangement to a face-centered cubic lattice arrangement does not occur and a change in phase from a close-packed hexagonal lattice arrangement to the face-centered cubic lattice arrangement does not occur even when the second resistance element is subjected to a temperature change from a given room temperature to 1000 °C. The first resistance element is welded at its end to an end of the second resistance element to form a connection therebetween which consists of part of material forming the first resistance element and part of the Co-Fe alloy forming the second resistance element, the material forming the first resistance element being so selected as to prevent compositions of the Co-Fe alloy in the connection from changing in phase from the body-centered cubic lattice arrangement to the face-centered cubic lattice arrangement and from the close-packed hexagonal lattice arrangement to the face-centered cubic lattice arrangement.

In the preferred mode, the second resistance element contains 78At% to 95At% of Co and a remaining content of Fe. The first resistance element is made of a Ni-Cr alloy.

A third resistance element may further be provided which connects between the first resistance element and the second resistance element in series therewith.

The first resistance element may alternatively be made of a Fe-Cr-Al alloy. The third resistance element is made of Ni.

The first resistance element has a Fe content of 68Wt% to 72Wt%.

The Fe-Cr-Al alloy of the first resistance element has a Fe content of 68Wt% to 72Wt%. The Co-Fe alloy of the second coil has a Fe content of 7W% to 9W%. The volume ratio of the second to first resistance elements in a connection therebetween lies in a range from 1 : 0.15 to 1 : 0.25.

According to another aspect of the present invention, there is provided a glow plug for an internal combustion engine which comprises a housing, a heater tube extending from an end of the housing, an insulating member arranged in the heater tube, and a resistance element. The resistance element includes at least two elements: a heating element and a regulating element connected in series with each other. The regulating element is electrically arranged upstream from the heating element. The regulating element assumes a positive resistance temperature coefficient higher than that of the heating element for regulating a current flowing to the heating element. The regulating element is made of a Co-Fe alloy whose compositions fall in a range where a change in phase from a body-centered cubic lattice arrangement to a face-centered cubic lattice arrangement does not occur and a change in phase from a close-packed hexagonal lattice arrangement to the face-centered cubic lattice arrangement does not occur even when the second resistance element is subjected to a temperature change from a given room temperature to 1000 °C. The heating element is welded at its end to an end of the regulating element to form a connection therebetween which includes material of which the first resistance element is made and the Co-Fe alloy forming the regulating element. The material forming the heating element is so selected as to prevent compositions of the Co-Fe alloy in the connection from changing in phase from the body-centered cubic lattice arrangement to the face-centered cubic lattice arrangement and from the close-packed hexagonal lattice arrangement to the face-centered cubic lattice arrangement.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more fully from the detailed description given hereinbelow and from the accompanying drawings of the preferred embodiment of the invention, which, however, should not be taken to limit the invention to the specific embodiment but are for explanation and understanding only.

In the drawings:

Fig. 1 is a cross-sectional view which shows a glow plug according to the present invention.

Fig. 2 is a cross-sectional view which shows a glow plug according to an alternative embodiment of the invention. Fig. 3 illustrates a connection between first and second coils of a heating coil of a glow plug.

Fig. 4 illustrates energizing testing conditions for testing the life of a glow plug.

Fig. 5 is a table which shows the test results of glow plugs performed under the conditions, as shown in Fig. 4.

Fig. 6 is a graph which shows temperature rise characteristics of a glow plug.

Fig. 7 is a graph which shows the relation between a Co-Fe ratio of an alloy forming a second coil and a transformation temperature.

Fig. 8 is a graph which shows the relation between temperature and a resistance change rate of an alloy forming a heating coil.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, wherein like numbers refer to like parts in several views, particularly to Fig. 1, there is shown a glow plug 9 according to the present invention which is commonly used in internal combustion engine such as a diesel engine to provide additional heat required for insuring quicker starting.

The glow plug 9 includes generally a housing 7, a heater tube 90 partially inserted into the housing 7, and a heating coil 1 disposed within an insulating member 2 provided in the heater tube 90. The heating coil 1 is formed of a resistant filament including a first coil 11 serving as a heating element and a second coil 12 functioning as a regulating element for regulating a current flowing to the first coil. The first and second coils are connected in series by an arc welding process to form a welded connection 120.

The first coil 11 is made of a Ni-Cr alloy which contains Ni of 80Wt% and Cr of 20Wt%. The second coil 12 is made of a Co-Fe alloy which contains Co of 92Wt% and Fe of 8Wt%. The Co-Fe alloy represents a rate of change in resistance (i.e., a resistance temperature coefficient) of about

13 in a range from the room temperature to 1000 °C. This value, as can be seen in Fig. 8, is greater than those of Fe, Ni, and the first coil 11. It is desired that the Fe content of the second coil 12 fall in a range from 5At% to 22At%. When the Fe content is less than 5At%, it will cause the ϵ/γ transformation to occur, resulting in a change in volume. Alternatively, when the Fe content is more than 22At%, the α/γ transformation may occur. Additionally, it is preferable that the Co content of the second coil 12, as shown in Fig. 7, lie in a range from 78At% to 95At%. The welded connection 120 between the first and second coils 11 and 12 has a Co-Fe atomic percentage ratio of 91.6 : 8.4. The Fe content of the welded connection 120 which is less than or equal to 22Wt% is desirable. When more than 22Wt%, it will cause the welded connection 120 to assume the α/γ transformation at an operational temperature of the glow plug 9.

The heater tube 90 has a smaller diameter end portion which is bottomed. Outer and inner diameters of the heater tube 90 are so selected that the insulating member 2 around the first coil 11 is denser than that around the second coil 12.

The insulating member 2 is made of insulating powder such as MgO. The heater tube 90 is formed of a heat-resistant alloy (e.g., SUS310S).

The first coil 11 of the heating coil 1 is welded to the bottom of the heater tube 90, while the second coil 12 is welded to the end of a core shaft 6 which is disposed coaxially in the housing 7. The core shaft 6 is electrically connected at its end to a positive terminal of a battery (not shown).

The housing 7 is so constructed as to mount the glow plug 9 in an engine head. The heater tube 90 is brazed to the housing 7.

Arranged between the housing 7 and the core shaft 6 is an O-ring 8 made of fluororubber.

The operation and effect of the glow plug thus constructed will be discussed below.

When the heating coil 1 is energized, it will glow to heat the glow plug 9, providing additional heating required for insuring quicker starting of the engine.

The heating coil 1, as mentioned above, includes the first and second coils 11 and 12. The second coil 12, as shown in Fig. 8, has the resistance temperature coefficient positively higher than that of the first resistance element, and is made of the Co-Fe alloy whose compositions, as shown in Fig. 7, fall in a range where a change in phase from a body-centered cubic lattice arrangement to a face-centered cubic lattice arrangement does not occur and a change in phase from a close-packed hexagonal lattice arrangement to the face-centered cubic lattice arrangement does not occur even when the second coil 12 is subjected to a temperature change from a given room temperature to

1000 °C. The connection 120 between the first and second coils 11 and 12 shows the Co-Fe atomic percentage ratio of 91.6 : 8.4 so that it lies, as is clear from Fig. 7, out of a range wherein changes in phase from the body-centered cubic lattice arrangement to the face-centered cubic lattice arrangement and from the close-packed hexagonal lattice arrangement to the face-centered cubic lattice arrangement occur. It will be appreciated that even when the temperature is changed rapidly, the connection 120 does not expand and contract so that it shows stable mechanical properties. Accordingly, the connection 120 is not broken even when the heating coil is heated rapidly many times so that the service life of the glow plug 9 is increased greatly.

The O-ring 8 arranged between the core shaft 6 and the housing 7 serves to prevent oil and/or water from leaking into the housing 7. This avoids the heating coil 1 from being oxidized undesirably.

The second coil 12 includes the Co-Fe alloy which assumes a relatively great rate of change in resistance of about 13 under the variation in temperature from the room temperature to 1000 °C. In addition, the insulating member 2 is arranged to be denser around the first coil than that around the second coil 12. Therefore, the glow current controlling effect caused by a temperature rise of the second coil 12 is enhanced.

Further, the heater tube 90 includes the smaller diameter end portion in which the first coil is disposed and the large diameter middle portion in which the second coil is arranged so that the saturation temperature of the heating coil 1 is maintained safety and the temperature rising speed thereof is also improved greatly.

Referring to Fig. 2, there is shown a second embodiment according to the present invention.

The glow plug 9 of this embodiment is, as is clear from the drawing, different from the above first embodiment only in that the heating coil 1 includes first, second, and third coils 11, 12, and 13. The third coil is welded to form a connection 130 between the first and third coils 11 and 13 and a connection 230 between the third and second coils 13 and 12. Other arrangements are the same as in the first embodiment and explanation thereof in detail will be omitted here.

The third coil 13 is made of Ni of 100Wt%. The first coil 11 is made of a 70Wt% Fe-25Wt% Cr-5Wt%Al alloy. It is desirable that the Fe content of the first coil 11 fall in a range from 68Wt% to 72Wt%. Thus, the connection 130 between the first and third coils 11 and 13 does not contain Co at all so that the α/γ transformation does not occur. Additionally, the second coil 12 is made of a 92Wt%Co-8Wt%Fe alloy. It is preferable that the Fe content of the second coil 12 range from 7Wt% to 9Wt%.

The connection 230 between the third and second coils 13 and 12 shows a Co-Fe atomic percentage ratio of 91.6 : 8.4, and thus the content of Fe is small so that the α/γ transformation, as will be appreciated from Fig. 7, does not occur. Therefore, the service life of the glow plug is increased greatly without the connections 130 and 230 being broken.

Fig. 3 shows an essential part of a third embodiment according to the invention. The heating coil 1 of this embodiment, similar to the first embodiment, includes first and second coils 11 and 12 which are welded to form a connection 120 by a laser beam welding process. The connection 120 is constructed by adjusting the output and the focal depth of a laser beam to have a 1:0.2 ratio of the volume B of a fused portion 121 of the first coil 11 to the volume A of a fused portion 122 of the second coil 12.

Similar to the second embodiment, the first coil 11 is made of a 70Wt% Fe-25Wt% Cr-5Wt%Al alloy. The second coil 12 is also made of a 92Wt%Co-8Wt%Fe alloy. The connection 120 between the first and second coils 11 and 12 shows a Co-Fe atomic percentage ratio of 80 : 20.

Other arrangements and operation are the same as the first embodiment and explanation thereof in detail will be omitted here.

In the third embodiment, the B-A volume ratio of the connection 120, as stated above, falls in a range from 0.15 to 0.25 and thus the content of Fe in the connection 120 is low. Therefore, the α/γ transformation does not occur in the connection 120. The life of the glow plug is increased greatly without the connection 120 being broken.

Energizing cycle tests were performed with respect to the glow plugs constructed according to the above first, second, and third embodiments (examples 1,2, and 3). The glow plugs were, as shown in Fig. 4, applied with current for seventy minutes to be heated up to about 1000 °C after which it is maintained at approximately 900 °C. Subsequently, cooling and heating processes were conducted in an electric furnace three times in three minutes, and then cooled down to the room temperature. These were assumed to be one cycle and repeated continuously.

In order to compare the results of the tests of the glow plugs of the invention, additional comparative experiments were performed with respect to prior art glow plugs (see comparative examples C1 and C2).

The glow plug of the comparative example C1 includes a first coil made of a 70Wt%Fe-25Wt%Cr-15Wt%Al alloy and a second coil made of Ni. Other arrangements are substantially the same as the first embodiment. The glow plug of the comparative example C2 includes a first coil made of a 70Wt%Fe-25Wt%Cr-15Wt%Al alloy and a second

coil made of a 92Wt%Co-8Wt%Fe alloy. Other arrangements are substantially the same as the comparative example.

The energizing cycle tests, as explained above, were performed four times with respect to the above examples, respectively. Fig. 5 is a table showing the results of the tests. As will be appreciated from the table, the lifespans of the examples 1, 2, and 3 all exceed over 20000 cycles. In all the examples 1, 2, and 3, the wire-breakage has occurred at the central portion of the first coil which is subjected to the intensest heat. Therefore, the glow plugs according to the invention may be used until their inherent service lives have expired.

Additionally, the comparative example C1 shows substantially the same results as in the first to third embodiments, however, the use of Ni having a ratio of change in resistance of 6 in the second coil gives rise to a problem in regard to quick heating when a statutory temperature is the same as the examples according to the present invention. The comparative example C2 exhibits an extremely shortened service life. There is a wire-breakage in a connection between the first and second coils.

Fig. 6 shows the relation between energizing time and temperature-rising speed in the glow plugs according to the first embodiment of the invention and the comparative example C1.

As will be clear from the graph, when the glow plug according to the first embodiment is heated up to 800 °C within 4.5 minutes, the statutory temperature is maintained at 900 °C which permits the glow plug to be energized constantly. This eliminates the need for reducing a voltage level applied to the glow plug after starting the engine, thereby eliminating the use of an after-glow resistor, a sub-relay, and their attachment harnesses. Thus, the manufacturing costs are reduced greatly.

The glow plug of the comparative example C1 shows a statutory temperature above 1000 °C. It is thus, required to decrease the voltage applied to the glow plug after the engine starts.

While the present invention has been disclosed in terms of the preferred embodiment in order to facilitate better understanding thereof, it should be appreciated that the invention can be embodied in various ways without departing from the principle of the invention. Therefore, the invention should be understood to include all possible embodiments and modification to the shown embodiments which can be embodied without departing from the principle of the invention as set forth in the appended claims.

A glow plug for a diesel engine is provided which includes generally a heating coil (1). The heating coil is provided with a first resistance element (11) and a second resistance element (12)

connected in series with the first resistance element and having a resistance temperature coefficient positively higher than that of the first resistance element. The second resistance element (12) is made of a Co-Fe alloy whose compositions fall in a range where a change in phase from a body-centered cubic lattice arrangement to a face-centered cubic lattice arrangement does not occur and a change in phase from a close-packed hexagonal lattice arrangement to the face-centered cubic lattice arrangement does not occur even when the second resistance element is subjected to a temperature change from a given room temperature to 1000 °C. The first resistance element (11) is welded at its end to an end of the second resistance element (12) to form a connection therebetween which consists of part of material forming the first resistance element and part of the Co-Fe alloy forming the second resistance element (12), the material forming the first resistance element (11) being so selected as to prevent compositions of the Co-Fe alloy in the connection from changing in phase from the body-centered cubic lattice arrangement to the face-centered cubic lattice arrangement and from the close-packed hexagonal lattice arrangement to the face-centered cubic lattice arrangement.

Claims

1. An electric resistance element comprising:
 - a first resistance element (11) having a given electric resistance; and
 - a second resistance element (12) connected in series with said first resistance element (11), said second resistance element having a resistance temperature coefficient positively higher than that of said first resistance element and providing a function of regulating a current to said first resistance element (11),
 - wherein said second resistance element (12) is made of a Co-Fe alloy whose compositions fall in a range where a change in phase from a body-centered cubic lattice arrangement to a face-centered cubic lattice arrangement does not occur and a change in phase from a close-packed hexagonal lattice arrangement to the face-centered cubic lattice arrangement does not occur even when the second resistance element is subjected to a temperature change from a given room temperature to 1000 °C, and
 - wherein said first resistance element (11) is welded at its end to an end of said second resistance element (12) to form a connection therebetween which includes part of material forming said first resistance element and part of the Co-Fe alloy forming said second resistance element (12), the material forming said first resistance element (11) being so selected as to prevent compositions of the Co-Fe alloy in the connection from changing in phase from the body-centered cubic lattice arrangement to the face-centered cubic lattice arrangement and from the close-packed hexagonal lattice arrangement to the face-centered cubic lattice arrangement.
2. An electric resistance element as set forth in claim 1, wherein said second resistance element (12) contains 78At% to 95At% of Co and a remaining content of Fe.
3. An electric resistance element as set forth in claim 1 or 2, wherein said first resistance element (11) is made of a Ni-Cr alloy.
4. An electric resistance element as set forth in claim 1, wherein a third resistance element (13) is further provided, said third resistance element (13) connecting between said first resistance element (11) and said second resistance element (12) in series therewith.
5. An electric resistance element as set forth in claim 1 or 2, wherein said first resistance element (11) is made of a Fe-Cr-Al alloy, a third resistance element (13) being further provided which is made of Ni.
6. An electric resistance element as set forth in claim 5, wherein said first resistance element (11) has a Fe content of 68Wt% to 72Wt%.
7. An electric resistance element as set forth in claim 1, wherein said first resistance element (11) is made of Fe-Cr-Al alloy having a Fe content of 68Wt% to 72Wt%, said second resistance element (12) being made of a Co-Fe alloy having a Fe content of 7W% to 9W%, a volume ratio of said second to first resistance elements in a connection therebetween lying in a range from 1 : 0.15 to 1 : 0.25.
8. A glow plug for an internal combustion engine comprising:
 - a housing (7);
 - a heater tube (90) extending from an end of said housing (7);
 - an insulating member (2) arranged in said heater tube (90); and
 - a resistance element (1),
 said resistance element (1) including at least two elements: a heating element (11) and a regulating element (12) connected in series with each other, said regulating element (12)

being electrically arranged upstream from said heating element (11), said regulating element (12) assuming a positive resistance temperature coefficient higher than that of the heating element (11) for regulating a current flowing to said heating element (11),

wherein said regulating element (12) is made of a Co-Fe alloy whose compositions fall in a range where a change in phase from a body-centered cubic lattice arrangement to a face-centered cubic lattice arrangement does not occur and a change in phase from a close-packed hexagonal lattice arrangement to the face-centered cubic lattice arrangement does not occur even when the second resistance element is subjected to a temperature change from a given room temperature to 1000 °C, and

wherein said heating element (11) is welded at its end to an end of said regulating element (12) to form a connection therebetween which includes material of which said first resistance element is made and the Co-Fe alloy forming said regulating element (12), the material forming said heating element (11) being so selected as to prevent compositions of the Co-Fe alloy in the connection from changing in phase from the body-centered cubic lattice arrangement to the face-centered cubic lattice arrangement and from the close-packed hexagonal lattice arrangement to the face-centered cubic lattice arrangement.

9. A glow plug as set forth in claim 8, wherein said regulating element (12) contains 78At% to 95At% of Co and a remaining content of Fe.

10. A glow plug as set forth in claim 8 or 9, wherein said heating element (11) is made of a Ni-Cr alloy.

11. A glow plug as set forth in claim 8, wherein a second regulating element (13) is further provided, said second regulating element (13) connecting between said heating element (11) and said regulating element (12) in series therewith.

12. A glow plug as set forth in claim 8 or 9, wherein said heating element (11) is made of a Fe-Cr-Al alloy, a second regulating element (13) being further provided which is made of Ni.

13. A glow plug as set forth in claim 12, wherein said heating element (11) has a Fe content of 68Wt% to 72Wt%.

14. A glow plug as set forth in claim 8, wherein said heating element (11) is made of Fe-Cr-Al alloy having a Fe content of 68Wt% to 72Wt%, said regulating element (12) being made of a Co-Fe alloy having a Fe content of 7W% to 9Wt%, a volume ratio of said regulating element to said heating element in a connection therebetween falling in a range from 1 : 0.15 to 1 : 0.25.

15. A glow plug as set forth in claim 8, wherein said heater tube (90) has a smaller diameter end portion which is bottomed, outer and inner diameters of said heater tube (90) being so selected that said insulating member (2) around the heating element (11) is denser than that around the regulating element (12).

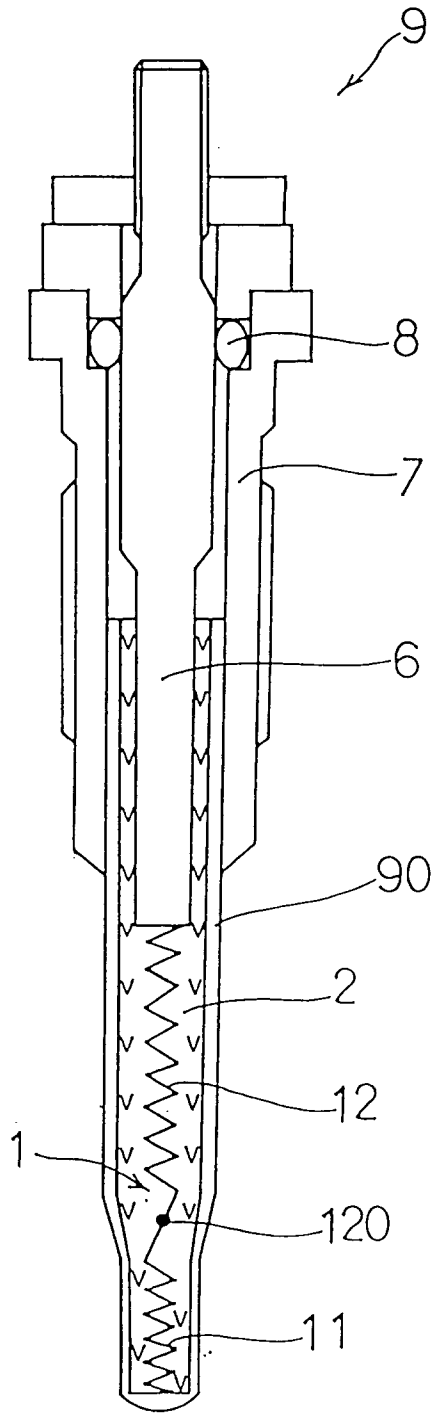


Fig. 1.

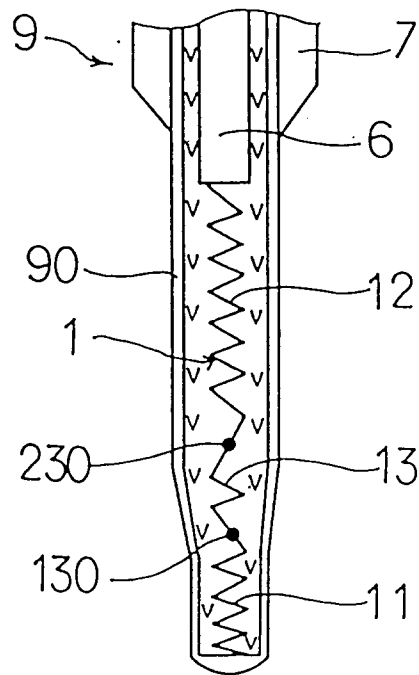


Fig. 2

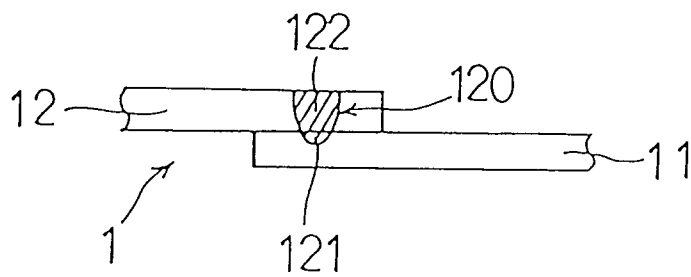


Fig. 3

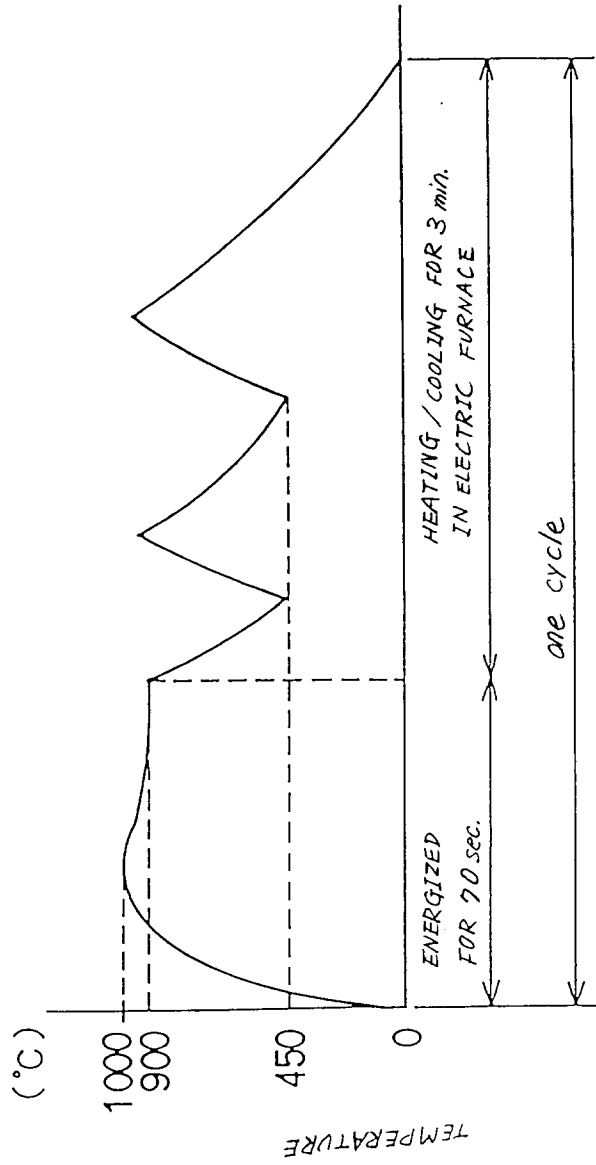


Fig. 4

	FIRST COIL MATERIAL	SECOND COIL MATERIAL	THIRD COIL MATERIAL	FUSED VOLUME RATIO (B:A)	SERVICE LIVE		WIRE - BREAKAGE
					10000	20000 cycle	
EXAMPLE 1	NiCr	Co 92 Fe 8	—	1 : 1	X X X X	FIRST COIL	
EXAMPLE 2	FeCrAl	Co 92 Fe 8	Ni	1 : 1 (2nd-3rd coil ratio)	X X X X	FIRST COIL	
EXAMPLE 3	FeCrAl	Co 92 Fe 8	—	1 : 0.2	X X X X	FIRST COIL	
COMPARATIVE EXAMPLE C1	FeCrAl	Ni	—	1 : 1	X X X X	FIRST COIL	
COMPARATIVE EXAMPLE C2	FeCrAl	Co 92 Fe 8	—	1 : 1	X X X X	CONNECTION BETWEEN FIRST AND SECOND COILS	

Fig. 5

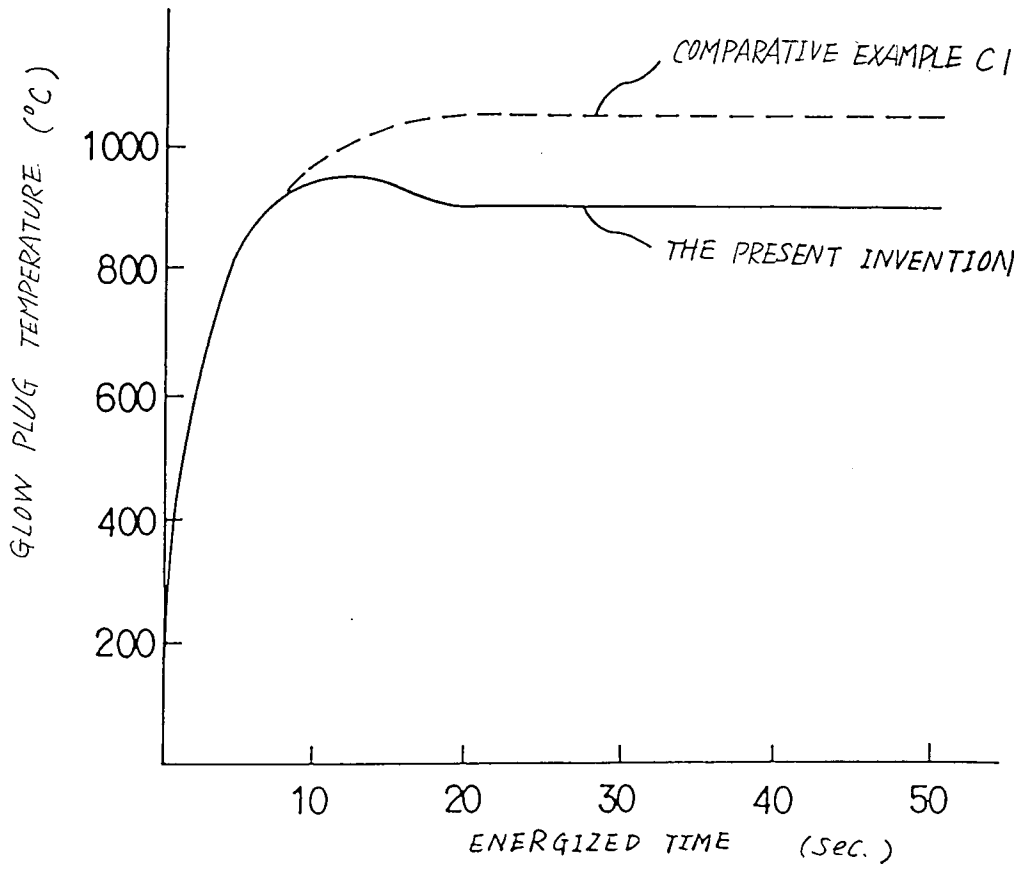


Fig. 6

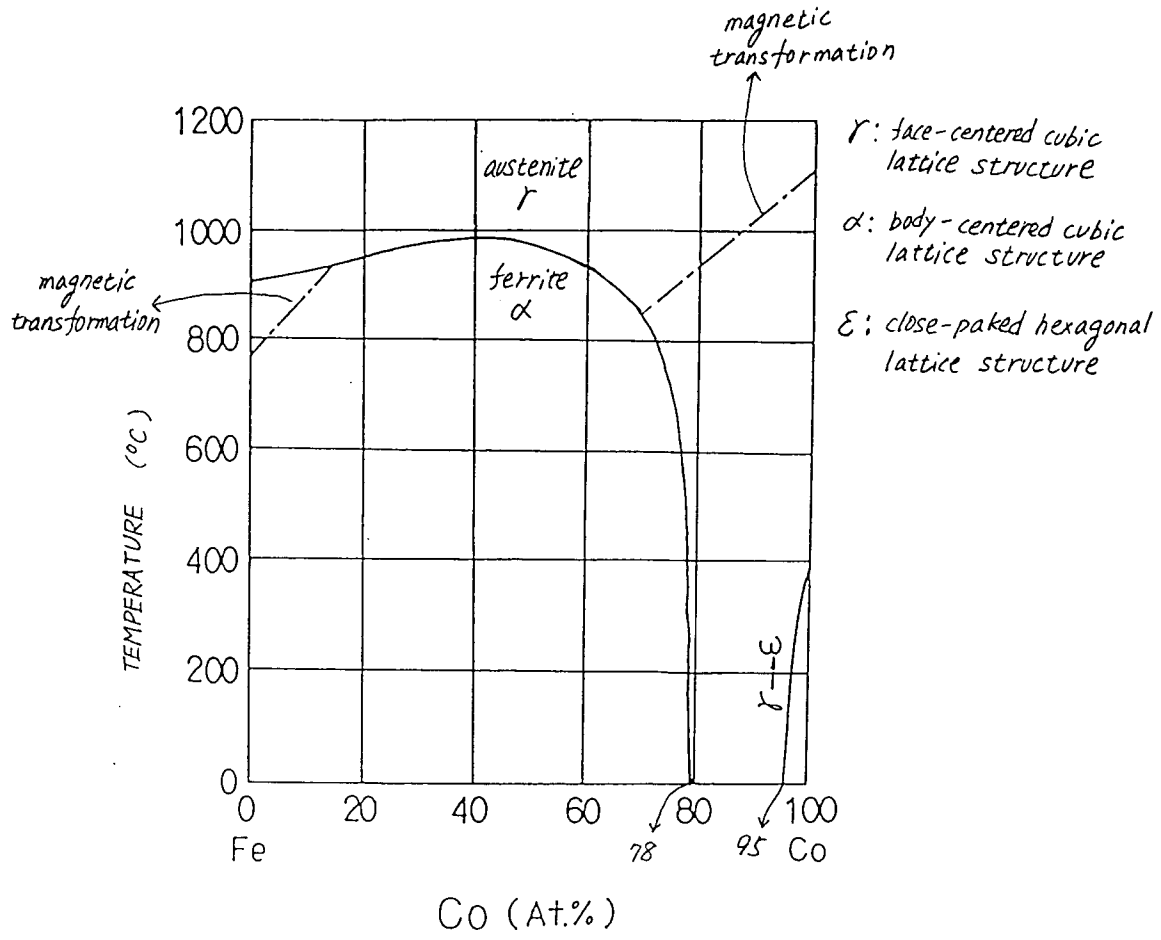


Fig. 7

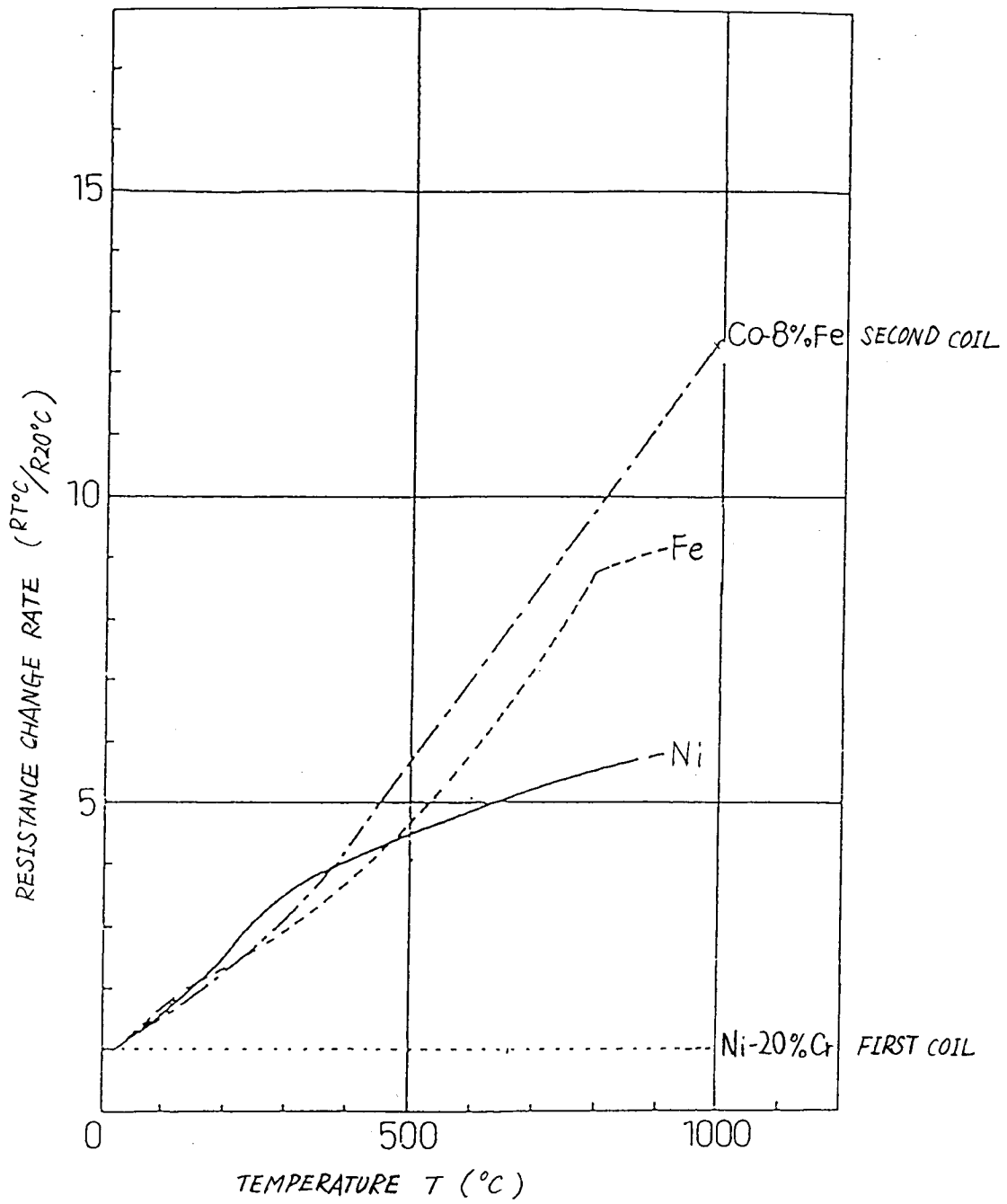


Fig. 8