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(71) Applicant: **NGK SPARK PLUG CO., LTD.**

Nagoya-shi, Aichi-ken (JP)

(72) Inventors:

• **Gotoh, Shunsuke, c/o NGK Spark Plug Co., Ltd.
Nagoya, Aichi (JP)**

• **Kumada, Chiaki, c/o NGK Spark Plug Co. LTD
Nagoya, Aichi (JP)**

(74) Representative: **Nicholls, Michael John**

J.A. KEMP & CO.

14, South Square

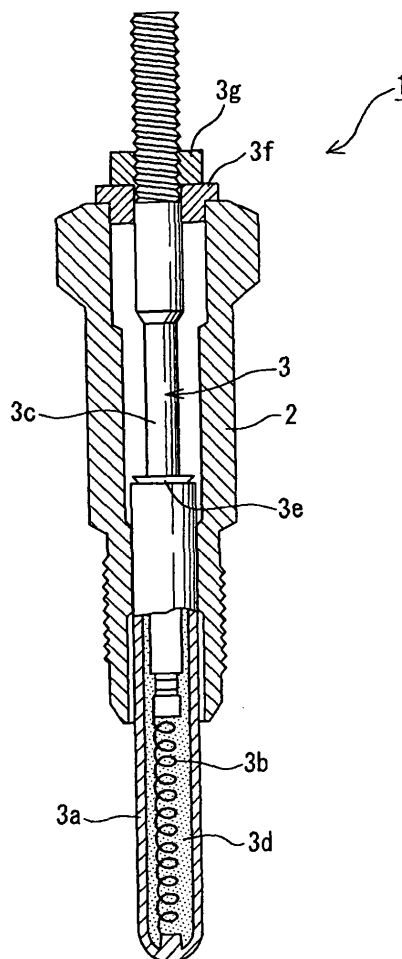
Gray's Inn

London WC1R 5JJ (GB)

(54) **Method for manufacturing sheathed heater and method for manufacturing glow plug**

(57) A sheathed heater (3) is manufactured by a method in which, after an insulating powder (3d) and a coil (3b) are confined in a metallic sheath (3a), the metallic sheath (3a) is swaged to a reduced diameter. The method is characterized in that before the metallic sheath (3a) is swaged, the coil (3b) is annealed through application of heat to the coil (3b). Since the coil (3b) is softened through annealing, while following a reduction in the diameter of the metallic sheath (3a) effected by swaging, the coil (3b) reduces its diameter without involvement of deformation, such as crinkling, bending, or corrugation.

FIG. 4



Description

[0001] The present invention relates to a method for manufacturing a sheathed heater in which an insulating powder and a coil are confined in a metallic sheath and which generates heat through application of electricity to the coil, as well as to a method for manufacturing a glow plug including the sheathed heater.

[0002] A sheathed heater and a glow plug including the sheathed heater will be described with reference to FIG. 4. A glow plug 1 is composed substantially of a tubular metallic shell 2 and a sheathed heater 3, which axially extends through the metallic shell 2.

[0003] The sheathed heater 3 includes a metallic sheath 3a, which has a substantially hemispherical closed distal end and an opened rear end. A coil 3b and a distal end portion of a round-bar-type center electrode 3c are placed in the metallic sheath 3a. The metallic sheath 3a is filled with an insulating powder 3d (e.g., a magnesia powder), and a rubber insulating packing 3e is interposed between the center electrode 3c and the inner surface of an opening portion of the metallic sheath 3a to thereby seal the opening. The center electrode 3c is disposed such that its distal end is located in a longitudinally intermediate portion of the interior of the metallic sheath 3a and electrically connected to one end of the coil 3b, whereas its rear end portion extends along the axis of the metallic shell 2 and projects outward from the metallic shell 2. The coil 3b is electrically connected to the inner surface of the closed distal end of the metallic sheath 3a. Accordingly, the center electrode 3c and the metallic sheath 3a are electrically connected together via the coil 3b.

[0004] The sheathed heater 3 is manufactured by the steps of: placing the coil 3b in the metallic sheath 3a; inserting the center electrode 3c into the metallic sheath 3a; charging the insulating powder 3d into the metallic sheath 3a; and then swaging the metallic sheath 3a to reduce the diameter of the metallic sheath 3a to the required diameter (see, for example, Japanese Patent Application Laid-Open (kokai) No. 6-109248).

[0005] In order to reduce the size of the glow plug 1, reducing the diameter of the sheathed heater 3 has been practiced. As a result, today, a sheathed heater 3 having an outside diameter of 4.4 mm to 3.5 mm is developed.

[0006] However, through observation by use of a radiographic apparatus, it was confirmed that some small-diameter sheathed heaters 3 manufactured by a conventional method involve an anomalous deformation of the internal coil 3b, as shown in FIG. 5. In some cases, such an anomalously deformed coil 3b may suffer imposition of an excessive thermal stress on a deformed portion, possibly resulting in breaking of the coil 3b at the deformed portion to thereby shorten the life of the sheathed heater 3.

[0007] Investigation of the cause for such an anomalous deformation of the coil 3b has revealed that the coil 3b is anomalously deformed in the course of swaging the metallic sheath 3a to reduce its diameter.

[0008] An anomalous deformation of the coil 3b has relevance to a swaging rate (diameter reduction rate). Specifically, even at a swaging rate less than 1/1.2, which does not raise any problem in terms of durability, the coil 3b is anomalously deformed to a slight extent; and the degree of anomalous deformation increases with the swaging rate.

[0009] The present invention has been accomplished in view of the foregoing, and an object of the invention is to provide a method for manufacturing a sheathed heater in which anomalous deformation of a coil caused by swaging of a metallic sheath can be prevented or alleviated, as well as a method for manufacturing a glow plug including the sheathed heater.

[0010] According to a first aspect of the present invention, there is provided a method for manufacturing a sheathed heater in which, after an insulating powder and a coil are confined in a metallic sheath, the metallic sheath is swaged to a reduced diameter, characterized in that, before the metallic sheath is swaged, the coil is annealed through application of heat to the coil.

[0011] Since annealing softens the coil, while following a reduction in the diameter of the metallic sheath effected by swaging, the coil reduces its diameter without involvement of deformation, such as crinkling, bending, or corrugation.

[0012] In a sheathed heater having a swaging rate less than 1/1.2, the deformation of a coil, if any, is of such a very low level as not to raise any problem in practical use. However, in view that a deformed portion of the coil is highly likely to become a point of breaking, the present invention, which can prevent or alleviate such coil deformation, can be evaluated as excellent in terms of effectively lengthening sheathed heater life to the greatest possible extent. Therefore, the present invention is effective for lengthening sheathed heater life to the greatest possible extent regardless of the swaging rate. In view that anomalous deformation of a coil that arises at a swaging rate of 1/1.2 or higher is highly likely to cause a problem in practical use, the present invention exhibits particularly high usefulness at a swaging rate of 1/1.2 or higher.

[0013] Preferably, the above-described annealing is performed by heating the coil through application of electricity to the coil. In this case, since the coil itself of the sheathed heater can be used as a heat-generating element, the coil can be quickly heated to a high temperature without involvement of any waste.

[0014] Preferably, the confined coil is annealed through application of heat, after the insulating powder and the coil are confined in the metallic sheath. Since the coil that is confined with the insulating powder in the metallic sheath is annealed, the annealing work does not need to consider oxidation of the coil during heating; and, in contrast to the

case of annealing bare coils, the coils do not become entangled and are thus easy to handle, thereby facilitating work. In the case where electricity is applied to the coil confined in the metallic sheath so as to cause the coil itself to generate heat, as compared with the case where heat is applied from outside the metallic sheath, the coil can be heated to a high temperature far more quickly without involvement of any waste, and a required portion can be heated in a pinpoint manner without exerting adverse thermal effect on other components, such as the metallic sheath and a rubber packing.

[0015] The coil may be formed of an alloy that contains Co. When the confined coil is annealed through application of heat in a state in which the insulating powder and the coil are confined in the metallic sheath, the coil is not oxidized during heating. Therefore, even when the coil is formed of a Co-containing alloy, which is likely to oxidize in a high-temperature atmosphere, the annealing of the coil can be performed without the oxidation problem.

[0016] According to a second aspect of the present invention, there is provided a method for manufacturing a glow plug comprising a sheathed heater in which an insulating powder and a coil are confined in a metallic sheath, characterized in that the sheathed heater is manufactured by a method according to any one of the above-described methods of the invention.

[0017] Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

FIG. 1 is a half-sectional front view of a sheathed heater as viewed before swaging;

FIG. 2 is a front view of the sheathed heater as viewed after swaging;

FIG. 3 is a sectional view of a heat generating portion of the sheathed heater;

FIG. 4 is a vertical sectional view of a glow plug; and

FIG. 5 is a sectional view of a heat generating portion of a sheathed heater manufactured by a conventional method.

[0018] As shown in FIG. 1, a sheathed heater 3 includes a metallic sheath 3a, which has a substantially hemispherical closed distal end and an opened rear end. A coil 3b and a distal end portion of a round-bar-type center electrode 3c are placed in the metallic sheath 3a. The metallic sheath 3a is filled with an insulating powder 3d (e.g., a magnesia powder), and a rubber insulating packing 3e is interposed between the center electrode 3c and the inner surface of an opening portion of the metallic sheath 3a to thereby seal the opening.

[0019] The center electrode 3c is disposed such that its distal end is located in a longitudinally intermediate portion of the interior of the metallic sheath 3a and electrically connected to one end of the coil 3b. The other end of the coil 3b is electrically connected to the inner surface of the closed distal end of the metallic sheath 3a. Accordingly, the center electrode 3c and the metallic sheath 3a are electrically connected together via the coil 3b. The coil 3b is formed of a metal; e.g., pure Fe, an Fe-Cr-Al alloy, or a Co-containing alloy, such as Co-Fe-Ni or Co-Ni.

[0020] FIG. 1 shows the sheathed heater 3 at an intermediate stage of manufacture. Usually, at this stage of manufacture, the metallic sheath 3a is swaged to reduce its diameter to a required value. According to the present invention, at this stage of manufacture, the coil 3b is annealed, and then swaging is performed. In annealing of the coil 3b, the coil 3b may be heated to about 2/3 the melting point of a metal used to form the coil 3b and then slow-cooled. For example, in the case where the coil 3b is made of Fe-Cr-Al, the coil 3b is heated to about 900°C and then slow-cooled.

[0021] The coil 3b is heated either by externally heating a distal end portion of the metallic sheath 3a by use of a burner or the like or by causing the coil 3b itself to generate heat through application of electricity to the coil 3b. FIG. 1 shows a method of causing the coil 3b to generate heat through application of electricity to the coil 3b; specifically, an electric cable 4 is connected to the center electrode 3c and the metallic sheath 3a at respective end portions to thereby apply electricity to the coil 3b. Conditions of electricity application to the coil 3b can be uniquely determined from the specifications of the coil 3b and an annealing temperature. For example, in the case of the sheathed heater 3 for use in glow plugs for diesel engines, a direct current of 11 V is applied for 30 seconds, whereby the coil 3b can be heated to a required annealing temperature of about 900°C.

[0022] After the coil 3b confined in the metallic sheath 3a is annealed as described above, the metallic sheath 3a is swaged to a reduced diameter. While following a reduction in the diameter of the metallic sheath 3a, the coil 3b undergoes a reduction in diameter without involvement of deformation, such as crinkling, bending, or corrugation. Therefore, the coil 3b is free of a deformed portion, such as a distorted portion, where thermal stress concentrates, and is thus free of breaking which could otherwise result from such thermal stress. Thus, the sheathed heater 3 can be manufactured to have excellent durability and high quality.

[0023] A glow plug 1 shown in FIG. 4 is manufactured as follows. The metallic sheath 3a of the sheathed heater 3 is press-fitted into a metallic shell 2. Next, an insulating ring 3f and a round nut 3g are attached to the center electrode 3c of the sheathed heater 3. Then, the round nut 3g is tightened.

Coil Deformation and Durability Test:

[0024] As shown in Table 1, samples of the sheathed heater 3 were divided into the following three groups: No. 1 to

No. 3, No. 4 to No. 6, and No. 7 to No. 9. In each of these groups, the same material was used for the coil 3b, and the metallic sheath 3a had the same outside diameter. Samples Nos. 1, 4, and 7 were manufactured by a conventional method in which the metallic sheath 3a was swaged without annealing the coil 3b; samples Nos. 2, 5, and 8 were manufactured by a method of the present invention in which the metallic sheath 3a was heated for 1 minute by use of a burner so as to assume a temperature of about 900°C for annealing the internal coil 3b, and was then swaged; and samples Nos. 3, 6, and 9 were manufactured by a method of the present invention in which a direct current of 11V was applied to the coil 3b for 30 seconds so as to heat the coil 3b itself (at this time, the temperature of the metallic sheath 3a rose to about 900°C) for annealing the coil 3b, and then the metallic sheath 3a was swaged. Then, all of the samples were examined for coil deformation by use of a radiographic apparatus. Also, the samples were subjected to a durability test; specifically, subjected to test cycles, each cycle consisting of application of 11 Vdc for 10 sec → application of 13 Vdc for 300 sec → OFF for 60 sec. The test results are shown in Table 1.

Table 1

Coil Deformation and Durability Test -						
No.	Coil Material	Sheath dia.	Annealing method	Coil deformation	Durability	Overall evaluation
1	Fe-Cr-Al	3.5 mm	Not annealed	Present	X	X
2	Fe-Cr-Al	3.5 mm	Burner	Slightly present	O	Δ
3	Fe-Cr-Al	3.5 mm	Electricity	Absent	O	O
4	Co-Fe-Ni	3.5 mm	Not annealed	Present	X	X
5	Co-Fe-Ni	3.5 mm	Burner	Slightly present	O	Δ
6	Co-Fe-Ni	3.5 mm	Electricity	Absent	O	O
7	Co-Fe-Ni	4.4 mm	Not annealed	Present	X	X
8	Co-Fe-Ni	4.4 mm	Burner	Slightly present	O	Δ
9	Co-Fe-Ni	4.4 mm	Electricity	Absent	O	O

[0025] As shown in Table 1, samples Nos. 1, 4, and 7, which were manufactured by a conventional method in which the coil 3b was not annealed, involved anomalous deformation of the coil 3b and failed to attain a required durability of 5,000 cycles or more in the durability test.

[0026] By contrast, samples Nos. 2, 5, and 8, which were manufactured by the method of the present invention in which the coil 3b was annealed by use of a burner, involved a slight deformation of the coil 3b; however, the deformation was relatively minor. Also, the samples attained the required durability of 5,000 cycles or more in the durability test.

[0027] Samples Nos. 3, 6, and 9, which were manufactured by the method of the present invention in which the coil 3b was annealed through application of electricity thereto, did not involve deformation of the coil 3b and attained the required durability of 5,000 cycles or more in the durability test.

[0028] While the present invention has been described with reference to embodiments, the present invention is not limited thereto. For example, according to the embodiments, after an insulating powder and a coil are confined in a metallic sheath, the confined coil is heated to be annealed. However, the coil may be annealed and then confined in the metallic sheath, followed by swaging. In this case, if the coil is made of a material that oxidizes when heated, the coil is preferably annealed in an atmosphere of an inert gas, such as argon or nitrogen, or in a vacuum.

Claims

1. A method for manufacturing a sheathed heater (3) in which, after an insulating powder (3d) and a coil (3b) are confined in a metallic sheath (3a), the metallic sheath (3a) is swaged to a reduced diameter, **characterized in that:**

before the metallic sheath (3a) is swaged, the coil (3b) is annealed through application of heat to the coil (3b).

2. A method for manufacturing a sheathed heater (3) according to claim 1, wherein the annealing is performed by heating the coil (3b) through application of electricity to the coil (3b).

3. A method for manufacturing a sheathed heater (3) according to claim 1 or 2, wherein, after the insulating powder (3d) and the coil (3b) are confined in the metallic sheath (3a), the confined coil (3b) is annealed through application

of heat to the coil (3b).

4. A method for manufacturing a sheathed heater (3) according to claim 3, wherein the coil is formed of an alloy that contains Co.

5. A method for manufacturing a glow plug (1) comprising a sheathed heater (3) in which an insulating powder (3d) and a coil (3b) are confined in a metallic sheath (3a), **characterized in that:**

the sheathed heater (3) is manufactured by a method according to any one of claims 1 to 4.

FIG. 1

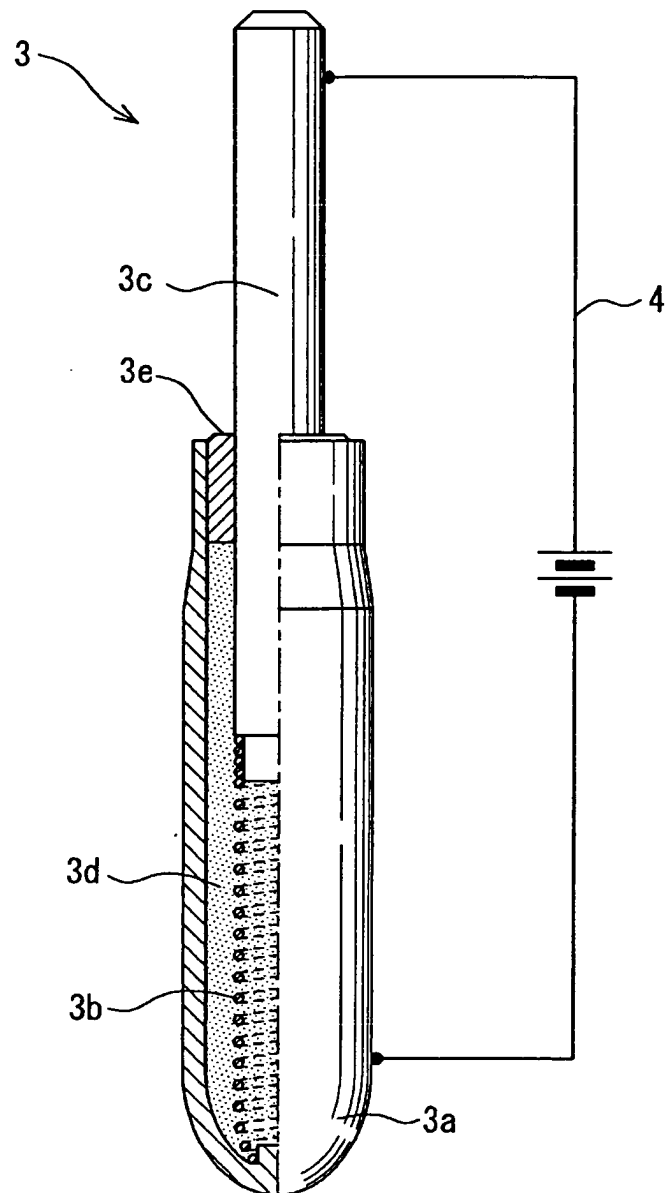


FIG. 2

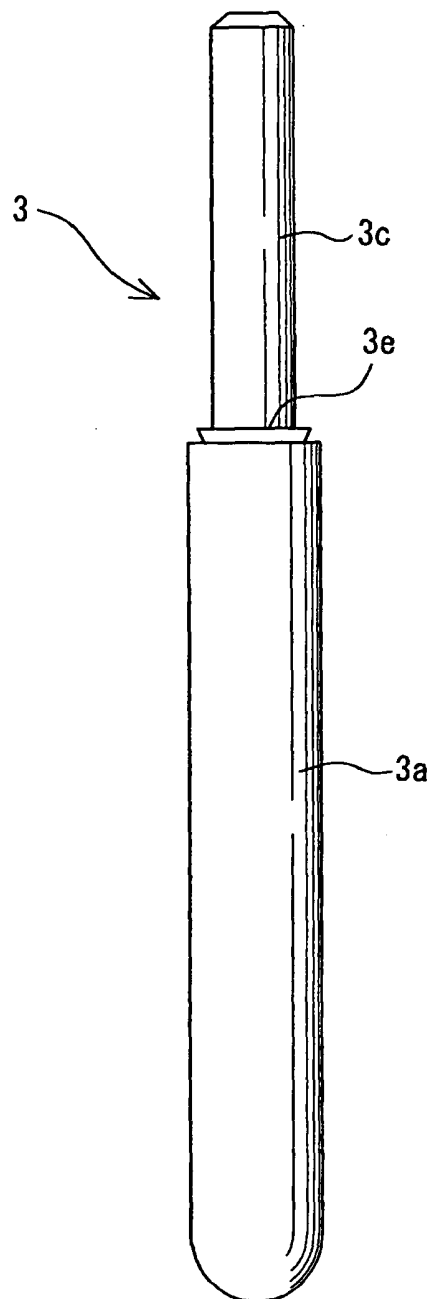


FIG. 3

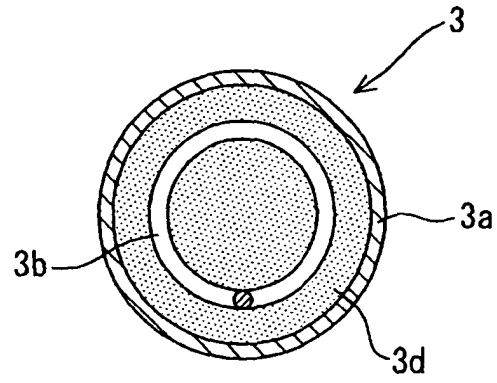


FIG. 5

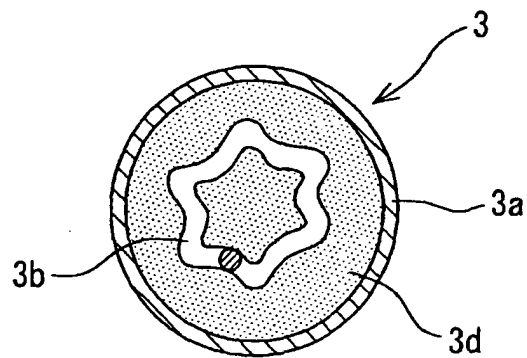
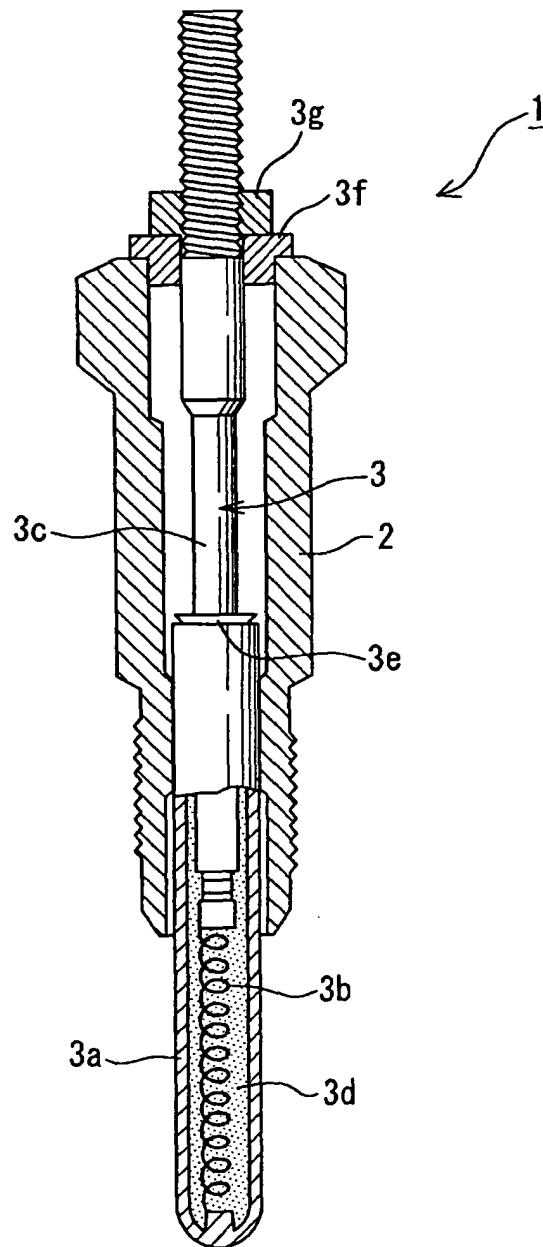


FIG. 4





European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 04 25 0764

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	EP 0 858 084 A (IRCA SPA) 12 August 1998 (1998-08-12) * column 1, line 50 - column 2, line 18; figures 1-4 *	1-5	H05B3/52 F23Q7/00 F23Q7/22
A	US 4 603 667 A (IMHOF ERNST ET AL) 5 August 1986 (1986-08-05) * column 2, line 15 - line 61 * * column 3, line 41 - line 60 *	1-5	
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A	US 3 252 122 A (BAXTER ROBERT D) 17 May 1966 (1966-05-17) * column 3, line 6 - line 22; figures 1,2 * * column 3, line 53 - line 69 *	1-5	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
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The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 18 May 2004	Examiner Gea Haupt, M
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 04 25 0764

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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18-05-2004

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