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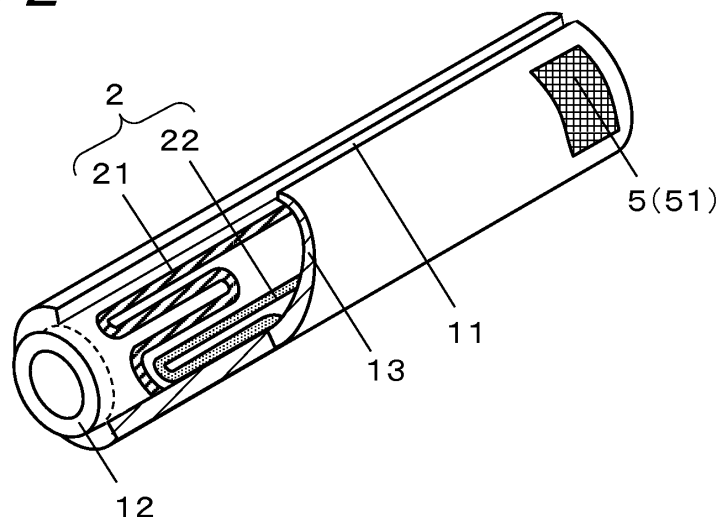
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(54) **HEATER**

(57) A heater according to the disclosure includes a ceramic body (1) having a rod shape or tubular shape, the ceramic body (1) including, in an outer peripheral surface thereof, a slit-shaped recess (11) extending from a front end toward a rear end of the ceramic body (1); and a heat-generating resistor (2) embedded inside the ceramic body (1). The heat-generating resistor (2) includes a first resistor (21) and a second resistor (22) which are disposed in parallel. The heat-generating re-

sistor (2) includes a first region (31) where the first resistor (21) and the second resistor (22) extend, in a meandering manner, in parallel along a circumferential direction of the ceramic body (1) between the front end and rear end of the ceramic body (1), and a second region (32) located near the slit-shaped recess (11), the second region (32) where only the first resistor (21) extends in a meandering manner.

FIG. 2



Description

Technical Field

[0001] The present disclosure relates to a heater used for fluid-heating purposes, powder-heating purposes, gas-heating purposes, oxygen sensors, soldering irons, etc.

Background Art

[0002] There is a heretofore known heater including: a ceramic body having a rod shape or cylindrical shape, the ceramic body including, in an outer peripheral surface thereof, a slit-shaped recess extending from a front end toward a rear end of the ceramic body; and a heat-generating resistor embedded inside the ceramic body, wherein the heat-generating resistor includes a first resistor and a second resistor which are disposed in parallel.

Citation List

Patent Literature

[0003]

Patent Literature 1: Japanese Unexamined Patent Publication JP-A 2013-134880

Patent Literature 2: Japanese Unexamined Patent Publication JP-A 2012-067468

Summary of Invention

[0004] A heater according to the disclosure includes: a ceramic body having a rod shape or cylindrical shape, the ceramic body including, in an outer peripheral surface thereof, a slit-shaped recess extending from a front end toward a rear end of the ceramic body; and a heat-generating resistor embedded inside the ceramic body. The heat-generating resistor includes a first resistor and a second resistor which are disposed in parallel. Moreover, the heat-generating resistor includes a first region in which the first resistor and the second resistor extend, in a meandering manner, in parallel along a circumferential direction of the ceramic body between the front end and rear end of the ceramic body, and a second region located near the slit-shaped recess, the second region in which only the first resistor extends in a meandering manner.

Brief Description of Drawings

[0005]

FIG. 1 is a schematic perspective view showing an example of a heater;

FIG. 2 is a fragmentary perspective view of the heater

shown in FIG. 1;

FIG. 3 is a sectional view taken along the line III-III of FIG. 1;

FIG. 4 is a developed view showing a pattern of a heat-generating resistor shown in FIG. 1;

FIG. 5 is a developed view showing a still another example of the pattern of the heat-generating resistor of the heater;

FIG. 6 is a developed view showing a still another example of the pattern of the heat-generating resistor of the heater; and

FIG. 7 is a developed view showing a still another example of the pattern of the heat-generating resistor of the heater.

Description of Embodiments

[0006] The conventional heater is not configured so that a heat-generating resistor is located in a slit-shaped recess of a ceramic body. This construction is disadvantageous in durability. That is, with a rise in temperature, the temperature of a region near the slit-shaped recess becomes lower than the temperature of surrounding regions, causing a temperature gradient. Consequently, under heat cycles, a microcrack may appear in the ceramic body due to resultant thermal stress, and, the propagation of the crack may lead to occurrence of a break at and around part of the heat-generating resistor located close to the slit-shaped recess.

[0007] Furthermore, the recent demand for heaters that effect a rise in temperature at higher rates has created the need for further enhancement in heater durability.

[0008] The disclosure has been made in view of the circumstances as discussed supra, and accordingly its object is to provide a highly durable heater with a heat-generating resistor which is less prone to a break.

[0009] The following describes an embodiment of the heater with reference to drawings.

[0010] FIG. 1 is a schematic perspective view showing an example of a heater, and FIG. 2 is a fragmentary perspective view of the heater shown in FIG. 1. Moreover, FIG. 3 is a sectional view taken along the line III-III of FIG. 1, and FIG. 4 is a developed view showing a pattern of the heat-generating resistor shown in FIG. 1.

[0011] The heater according to the disclosure shown in FIGS. 1 to 4 includes: a ceramic body 1 having a rod shape or cylindrical shape, the ceramic body 1 including, in an outer peripheral surface thereof, a slit-shaped recess 11 extending from a front end toward a rear end of the ceramic body; and a heat-generating resistor 2 embedded inside the ceramic body 1. The heat-generating resistor 2 includes a first resistor 21 and a second resistor 22 which are disposed in parallel. The heat-generating resistor 2 includes a first region 31 in which the first resistor 21 and the second resistor 22 extend, in a meandering manner, in parallel along a circumferential direction of the ceramic body 1 between the front end and rear

end of the ceramic body 1, and a second region 32 located near the slit-shaped recess 11, the second region 32 in which only the first resistor 21 extends in a meandering manner.

[0012] The ceramic body 1 is built as an elongated rod-shaped or tubular member. Examples of rod-shaped forms include a circular column and a rectangular column. For example, a long plate extending in a predetermined direction may also be construed as a rod-shaped form. Moreover, examples of tubular forms include a circular cylinder and a rectangular tube. In the heater according to this embodiment, the ceramic body 1 is shaped in a circular cylinder. For example, the ceramic body 1 has a length of 20 mm to 60 mm. For example, the outside diameter of the cylindrical sectional profile of the ceramic body 1, or the diameter of the circular sectional profile of the ceramic body 1, falls in the range of 2.5 mm to 5.5 mm.

[0013] When using the ceramic body 1 in tubular (cylindrical) form, the heater operates to apply heat to a heating target set in contact with the inner peripheral surface or outer peripheral surface of the ceramic body 1. On the other hand, when using the ceramic body 1 in rod-shaped form, the heater operates to apply heat to a heating target set in contact with the outer peripheral surface of the ceramic body 1.

[0014] The ceramic body 1 is made of an insulating ceramic material. Examples of the insulating ceramic material include alumina, silicon nitride, and aluminum nitride. Alumina is desirable from the standpoints of resistance to oxidation and manufacturability. Silicon nitride is desirable from the viewpoint of attaining excellence in strength, toughness, insulation properties, and heat resistance. Aluminum nitride is desirable from the viewpoint of attaining excellence in thermal conductivity. A compound of metal elements contained in the heat-generating resistor 2 may be contained in the ceramic body 1. For example, where the heat-generating resistor 2 contains tungsten or molybdenum, WSi_2 or $MoSi_2$ may be contained in the ceramic body 1.

[0015] Moreover, for example, the ceramic body 1 includes a rod-shaped or tubular core member 12 and a surface layer portion 13 disposed so as to cover a side surface of the core member 12. In addition, the ceramic body 1 includes, in its outer peripheral surface, the slit-shaped recess 11 extending from the front end toward the rear end of the ceramic body 1. For example, the depth of the recess 11 (the thickness of the surface layer portion 13) falls in the range of 0.1 mm to 1.5 mm. For example, the opening width of the recess 11 falls in the range of 0.3 mm to 2 mm. Where the ceramic body 1 has a cylindrical sectional profile or circular sectional profile, the opening width refers to the length of a curve extending along the outside diameter of the cross section of the ceramic body 1.

[0016] The heat-generating resistor 2 is embedded inside the ceramic body 1. Where the ceramic body is composed of the core member 12 and the surface layer portion 13, for example, the heat-generating resistor 2 is

interposed between the core member 12 and the surface layer portion 13.

[0017] The heat-generating resistor 2 generates heat by applying electric current to heat the ceramic body 1. For example, the heat-generating resistor 2 is constructed of a conductor composed predominantly of a high-melting-point metal such as tungsten (W), molybdenum (Mo), or rhenium (Re). As to the dimensions of the heat-generating resistor 2, for example, the width falls in the range of 0.3 mm to 2 mm, the thickness falls in the range of 0.01 mm to 0.1 mm, and the total length of the heat-generating resistor 2 falls in the range of 500 mm to 5000 mm. The dimensions are suitably determined in accordance with the temperature at which the heat-generating resistor 2 generates heat, the magnitude of voltage applied to the heat-generating resistor 2, etc.

[0018] Moreover, the heat-generating resistor 2 is disposed so that heat can be generated to the greatest extent on the front-end side of the ceramic body 1. In the embodiment shown in FIGS. 1 to 4, the heat-generating resistor 2 includes a folded portion (meandering portion) in which part of the heat-generating resistor 2 extends, in a meandering manner, along a circumferential direction of the ceramic body 1 at the front-end side of the ceramic body 1 lengthwise. Moreover, in the heat-generating resistor 2, a pair of linear portions is formed at the rear end of the folded portion. At the rear end of each linear portion, the heat-generating resistor 2 is electrically connected to a draw-out portion as described later. The heat-generating resistor 2 may be made to have any one of a circular cross section, an elliptical cross section, and a rectangular cross section. Instead of the folded portion only at the front-end side, a folded portion at both of the front-end side and the rear-end side may be imparted to the heat-generating resistor 2. The details of such a pattern of the heat-generating resistor 2 will be described later.

[0019] In the heat-generating resistor 2, the folded portion at the front-end side and the pair of linear portions at the rear-end side may be made of the same material. Moreover, to reduce unnecessary heat generation, the linear portion may be made lower in resistance value per unit length than the folded portion by adjusting the cross-sectional area of the linear portion to be greater than that of the folded portion, or by reducing the amount of the ceramic body 1-constituting material contained in the linear portion.

[0020] A draw-out portion is embedded in the rear-end side of the ceramic body 1. For example, the draw-out portion is built as a through hole conductor including one end electrically connected to the rear end of the heat-generating resistor 2 and the other end drawn out to a side surface of the rear-end side of the ceramic body 1. The draw-out portion may be made either of the same material as that used for the heat-generating resistor 2 or of a material which is lower in resistance value than the heat-generating resistor 2. The illustration of the draw-out portion is omitted from FIG. 4.

[0021] The side surface of the rear-end side of the ceramic body 1 is, on an as needed basis, provided with an electrode pad 5 which is electrically connected to the draw-out portion embedded inside the ceramic body 1. A lead terminal is joined to the electrode pad 5 to be electrically connected with an external circuit (external power supply). In the embodiment shown in FIGS. 1 to 4, there are provided three places to which the draw-out portion is drawn, and, the electrode pad 5 is disposed at each of the three places. As shown in FIG. 4, of the three electrode pads 5 disposed in different places, one connected via the draw-out portion to both of one end of the first resistor 21 and one end of the second resistor 22 is a first pad 51 which serves as a common pad, one connected via the draw-out portion to the other end of the first resistor 21 is a second pad 52, and one connected via the draw-out portion to the other end of the second resistor 22 is a third pad 53.

[0022] For example, the electrode pad 5 may be formed either of a molybdenum (Mo)- or tungsten (W)-made conductor layer alone or of the above-described conductor layer having, for example, a Ni-B- or Au-made plating layer formed on its surface. For example, the electrode pad 5 has a thickness of 50 μm to 300 μm , and a length, as well as a width, of 5 mm to 10 mm.

[0023] As shown in FIG. 4, the heat-generating resistor 2 includes the first resistor 21 and the second resistor 22 which are disposed in parallel. In the case where the first and second resistors 21 and 22 disposed in parallel are included in the heat-generating resistor 2, when the operating temperature of the heater is low, the amount of heat generation can be reduced by applying voltage to only one of the heat-generating resistors (for example, the first resistor 21), whereas, when the operating temperature is high, the amount of heat generation can be increased by applying voltage to a plurality of the heat-generating resistors (the first resistor 21 and the second resistor 22) simultaneously. That is, the amount of heat generation is easily adjustable.

[0024] Moreover, the heat-generating resistor 2 includes the first region 31 in which the first resistor 21 and the second resistor 22 extend, in a meandering manner, in parallel along the circumferential direction of the ceramic body 1 between the front end and rear end of the ceramic body 1, and the second region 32 located near the slit-shaped recess 11, the second region 32 in which only the first resistor 21 extends in a meandering manner.

[0025] As a pattern of the heat-generating resistor 2 in the first region 31, the first resistor 21 is located on the front-end side of the ceramic body 1, and the second resistor 22 is located on the rear-end side of the ceramic body 1 in parallel to the first resistor 21, and, the first resistor 21 and the second resistor 22 extend, in a meandering manner, along the circumferential direction of the ceramic body 1 between the front end and rear end of the ceramic body 1. Moreover, as a pattern of the heat-generating resistor 2 in the second region 32, only the first resistor 21 extends in a meandering manner. Thus,

on each side of the slit-shaped recess 11, there are provided three proximately-arranged first resistors 21, including one in the first region 31.

[0026] In the prior-art construction that does not employ such a design that only the first resistor 21 extends in a meandering manner in a region near the slit-shaped recess 11, even if the first resistor 21 is heated first for a rise in temperature, since the first resistor 21 extends in a meandering manner in a region away from the region near the slit-shaped recess 11, the temperature of the region near the slit-shaped recess 11 is low, whereas the temperature of the region away from the region near the slit-shaped recess 11 is high. This results in lack of uniformity in the distribution of temperature over the outer peripheral surface of the heater.

[0027] In this regard, in the heater according to the disclosure, upon heating the first resistor 21 first for a rise in temperature, the second region 31 in which only the first resistor 21 extends in a meandering manner, as well as the region near the slit-shaped recess 11, undergoes greater temperature rise. This makes it possible to attain a uniform temperature distribution over the outer peripheral surface of the heater during temperature rise, and thereby reduce thermal stress, with consequent enhancement in durability.

[0028] Moreover, in this construction, as shown in FIG. 4, since a distance is increased between the folded portion in the first resistor 21 and the folded portion in the second resistor 22 where the current fed from the first pad 51 serving as a common pad reaches first, the thermal stress applied to each folded portion can be dispersed, with consequent enhancement in durability in the heater.

[0029] The first resistor 21 may be made lower in resistance value than the second resistor 22. The lower the resistance value, the larger the current and the greater the amount of heat generation. Thus, the temperature of the region near the slit-shaped recess 11 rises at a higher rate. This makes it possible to attain a uniform temperature distribution over the outer peripheral surface of the heater, and thereby reduce thermal stress, with consequent enhancement in durability.

[0030] A way for making the first resistor 21 lower in resistance value than the second resistor 22 is to adjust the line width of the first resistor 21 to be greater (wider) than the line width of the second resistor 22 as shown in FIG. 5, for example. At this time, for example, the line width of the second resistor 22 is set to equal 1.1 to 1.5 times the line width of the first resistor 21. To determine whether such a condition is fulfilled, given that the first resistor 21 is not of uniform line width throughout and that the second resistor 22 is of uniform line width throughout, then a comparison is made between the line width of the thinnest (narrowest) part of the first resistor 21 and the line width of the second resistor 22. On the other hand, given that the second resistor 22 is not of uniform line width throughout and that the first resistor 21 is of uniform line width throughout, then a comparison

is made between the line width of the thickest (widest) part of the second resistor 22 and the line width of the first resistor 21. Moreover, given that neither the first resistor 21 nor the second resistor 22 is of uniform line width throughout, then a comparison is made between the line width of the thinnest (narrowest) part of the first resistor 21 and the line width of the thickest (widest) part of the second resistor 22.

[0031] Another way for making the first resistor 21 lower in resistance value than the second resistor 22 is to adjust the specific resistance of the first resistor 21 to be lower than the specific resistance of the second resistor 22. At this time, for example, the specific resistance of the first resistor 21 is set to equal 20 to 80% of the specific resistance of the second resistor 22. To fulfill such a condition, for example, a tungsten-molybdenum alloy is used to form the first resistor 21, and, a tungsten-rhenium alloy is used to form the second resistor 22. Even when the first resistor 21 and the second resistor 22 are made of the same conductor material, as long as the amount of addition of an insulating material, which is the same as that used for the ceramic body 1, to the second resistor 22 is greater than the amount of addition of the same material to the first resistor 21, the first resistor 21 can be made lower in specific resistance than the second resistor 22.

[0032] Moreover, as shown in FIG. 6, the first resistor 21 may be shaped so that its line width becomes smaller (narrower) gradually or stepwise with increasing proximity to the slit-shaped recess 11. In this case, the amount of heat generated in a portion of the first resistor 21 having a smaller line width (smaller sectional area) is greater than the amount of heat generated in other portions. Thus, the second region 31 in which only the first resistor 21 extends in a meandering manner, as well as the region near the slit-shaped recess 11, undergoes greater temperature rise. This makes it possible to attain a uniform temperature distribution over the outer peripheral surface of the heater, and thereby reduce thermal stress, with consequent enhancement in durability.

[0033] Whether such a design is obtained can be determined by line width comparison among part of the first resistor 21 located farthest away from the slit-shaped recess 11 (the midportion of the first resistor 21 as viewed in FIG. 6), part of the first resistor 21 located at the boundary between the first region 31 and the second region 32, and part of the first resistor 21 located closest to the slit-shaped recess 11. These parts refer to first resistor portions aligned in a circumferential direction of the ceramic body 1. To determine the line width of that one of such circumferentially aligned portions which is not uniform in line width throughout its length, the line widths of, respectively, the front end, the midportion, and the rear end of this portion in the lengthwise direction are measured, and the average of those measurements is taken as the line width of the portion.

[0034] In FIG. 6, while the second resistor 22 is of substantially uniform line width throughout, in the second

region 32, part of the first resistor 21 located closest to the slit-shaped recess 11 is smaller in line width than part of the first resistor 21 located farthest away from the slit-shaped recess 11. Even the thinnest part of the first resistor 21 is greater (wider) in line width than the second resistor 22. This allows further increase in the amount of heat generation in the vicinity of the slit-shaped recess 11.

[0035] Such a design that the first resistor 21 is shaped so that its line width becomes smaller (narrower) gradually or stepwise with increasing proximity to the slit-shaped recess 11 is not limited to one as shown in FIG. 6, but may be applicable to a case where the line width of the first resistor 21 is smaller (narrower) than that of the second resistor 22. In this case, the first resistor 21 may be entirely made smaller (narrower) in line width than second resistor 22. It is also possible to adopt a design wherein part of the first resistor 21 located farthest away from the slit-shaped recess 11 (the midportion of the first resistor 21 as viewed in FIG. 6) is made larger (wider) in line width than the second resistor 22, and part of the first resistor 21 located closest to the slit-shaped recess 11 (the portion having the smallest line width) is made smaller (narrower) in line width than the second resistor 22.

[0036] Moreover, as shown in FIG. 7, the first resistor 21 may be shaped so that the pitch of pattern segments becomes shorter gradually or stepwise with increasing proximity to the slit-shaped recess 11. The shorter the pitch of pattern segments, the denser the arrangement of the first resistor 21 portions and the greater the amount of heat generation therein. Also in this case, the second region 31 in which only the first resistor 21 extends in a meandering manner, as well as the region near the slit-shaped recess 11, undergoes greater temperature rise. This makes it possible to attain a uniform temperature distribution over the outer peripheral surface of the heater, and thereby reduce thermal stress, with consequent enhancement in durability.

[0037] The following describes an example of a heater manufacturing method. The following description deals with the case where the ceramic body is formed of alumina ceramics.

[0038] To produce the ceramic body 1 made of alumina ceramics composed predominantly of Al_2O_3 , a ceramic slurry prepared by blending Al_2O_3 with sintering aids such as SiO_2 , CaO , MgO , ZrO_2 , etc. is molded into sheet form to obtain a ceramic green sheet which constitutes the surface layer portion 13 of the ceramic body 1.

[0039] On one of the principal surfaces of the ceramic green sheet, a resistor paste for forming the heat-generating resistor 2 is applied to form a predetermined pattern by means of screen printing or otherwise. Moreover, on the other surface of the ceramic green sheet opposite the surface where the heat-generating resistor 2 is to be formed, a conductor paste for forming the electrode pad 5 is applied in a predetermined pattern by means similar to that for forming the pattern of the heat-generating re-

sistor 2. In addition, the ceramic green sheet is subjected to perforation work for electrical connection between the heat-generating resistor 2 and the electrode pad 5, and to conductor-paste filling process for formation of a through hole conductor which serves as the draw-out portion.

[0040] In the patterning of the heat-generating resistor 2, for example, as shown in FIG. 4, there are provided the first region 31 in which a plurality of resistor pattern segments (including the first resistor 21 and the second resistor) are laid out in parallel so as to extend from the common pad 51, and resistor pattern segments extend in a meandering manner longitudinally, and the second region 32 in which only the outermost resistor pattern segment (the first resistor 21) extends in a meandering manner longitudinally.

[0041] The resistor paste and the conductor paste are prepared by kneading high-melting-point metal such as W, Mo, or Re, which can be fired concurrently with the firing of the ceramic body-forming material, blended with a ceramic raw material, a binder, an organic solvent, etc. At this time, in conformity with the application of the heater, the heating position and the value of resistance in the heat-generating resistor 2 may be suitably adjusted by making changes to the length of each pattern segment made of the resistor-forming resistor paste or the conductive paste, the distance or gap between folded pattern segments, and the line width of each pattern segment.

[0042] Meanwhile, to form the core member 12, an alumina ceramic molded body in the form of a circular column or a circular cylinder is obtained by extrusion molding.

[0043] An adherent liquid containing dispersed alumina ceramics which is identical in composition with the alumina ceramic molded body is applied to the core member 12, and, the alumina ceramic green sheet for forming the surface layer portion 13 as described above is wound around the core member 12. In this way, there is obtained a unitary alumina molded product which constitutes the ceramic body 1.

[0044] The lengthwise extending slit-shaped recess 11 (slot) in the outer peripheral surface (side face) of the ceramic body 1 is created by winding the alumina ceramic green sheet (the surface layer portion 13) around the core member 12 so that a certain space can be left between the opposite ends of the sheet.

[0045] The unitary alumina molded product so obtained is fired in an atmosphere of non-oxidizing gas such as hydrogen gas or a mixture gas (forming gas) of nitrogen gas and hydrogen gas at a temperature of 1500°C to 1600°C, for example. Then, a Ni plating film is deposited onto the electrode pad 5 on the outer peripheral surface of the ceramic body 1 by electrolytic plating technique, for example. In this way, a unitary alumina sintered compact is produced.

[0046] Moreover, as a feeding portion, for example, a Ni-made lead terminal is joined to the electrode pad 5 via a brazing material such as a Ag brazing material or

solder. The lead terminal may be coated with an insulating material in advance. In this case, a part of the insulating material coating is removed for the connection of the lead terminal, and, the insulating material-free part of the lead terminal is connected to the electrode pad 5. As another alternative, after a Ni wire is connected to the electrode pad 5, an insulating tube may be attached to the Ni wire.

[0047] The heater according to this embodiment can be obtained in the manner thus far described.

Reference Signs List

[0048]

- 1: Ceramic body
- 11: Slit-like recess
- 12: Core member
- 13: Surface layer portion
- 2: Heat-generating resistor
- 21: First resistor
- 22: Second resistor
- 31: First region
- 32: Second region
- 5: Electrode pad
- 51: First pad
- 52: Second pad
- 53: Third pad

Claims

1. A heater, comprising:

a ceramic body having a rod shape or tubular shape, the ceramic body comprising, in an outer peripheral surface thereof, a slit-shaped recess extending from a front end toward a rear end of the ceramic body; and
a heat-generating resistor embedded inside the ceramic body,
the heat-generating resistor comprising a first resistor and a second resistor which are disposed in parallel,
the heat-generating resistor comprising a first region in which the first resistor and the second resistor extend, in a meandering manner, in parallel along a circumferential direction of the ceramic body between the front end and rear end of the ceramic body, and a second region located near the slit-shaped recess, the second region in which only the first resistor extends in a meandering manner.

2. The heater according to claim 1, wherein the first resistor is lower in resistance value than the second resistor.

3. The heater according to claim 1 or 2, wherein the first resistor is greater in line width than the second resistor.
4. The heater according to claim 1 or 2, wherein the first resistor is lower in specific resistance than the second resistor. 5
5. The heater according to any one of claims 1 to 4, wherein the first resistor is shaped so that a line width thereof becomes smaller gradually or stepwise with increasing proximity to the slit-shaped recess. 10
6. The heater according to any one of claims 1 to 5, wherein the first resistor is shaped so that a pitch of pattern segments becomes shorter gradually or stepwise with increasing proximity to the slit-shaped recess. 15

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FIG. 1

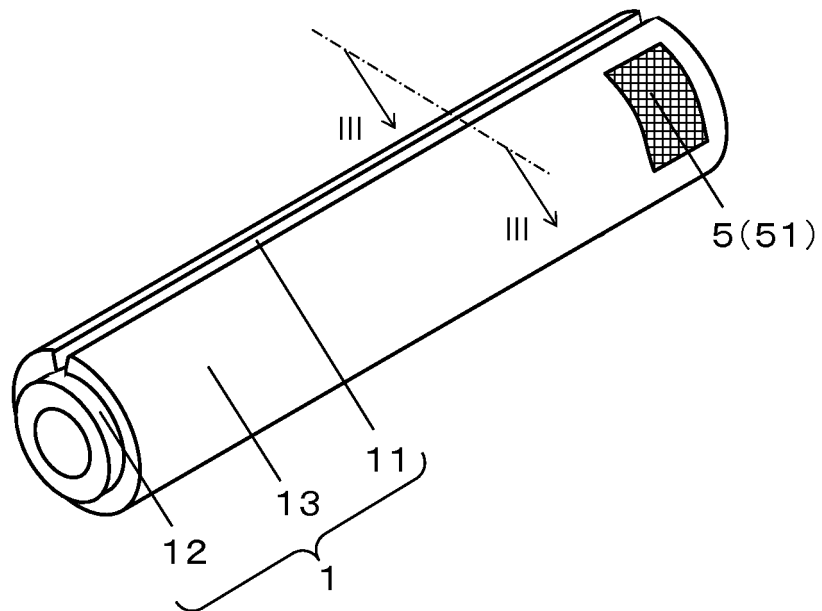


FIG. 2

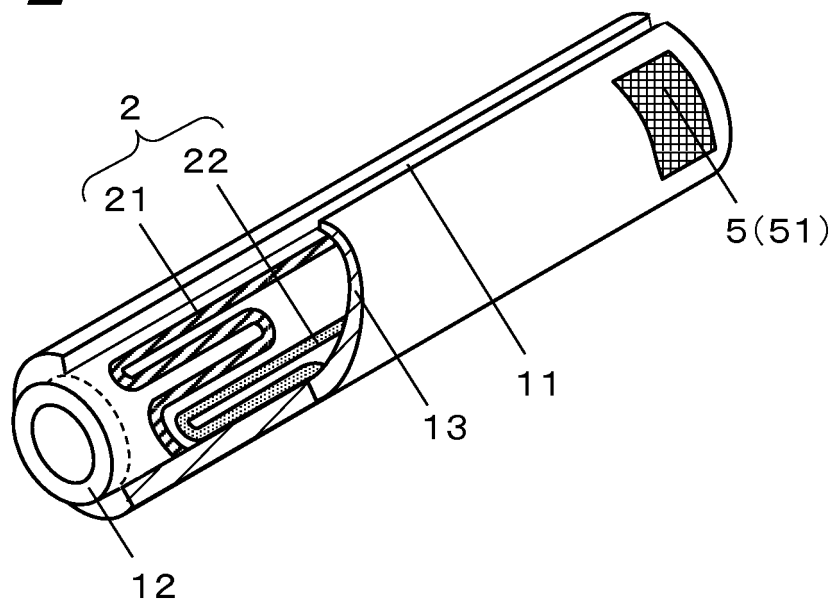


FIG. 3

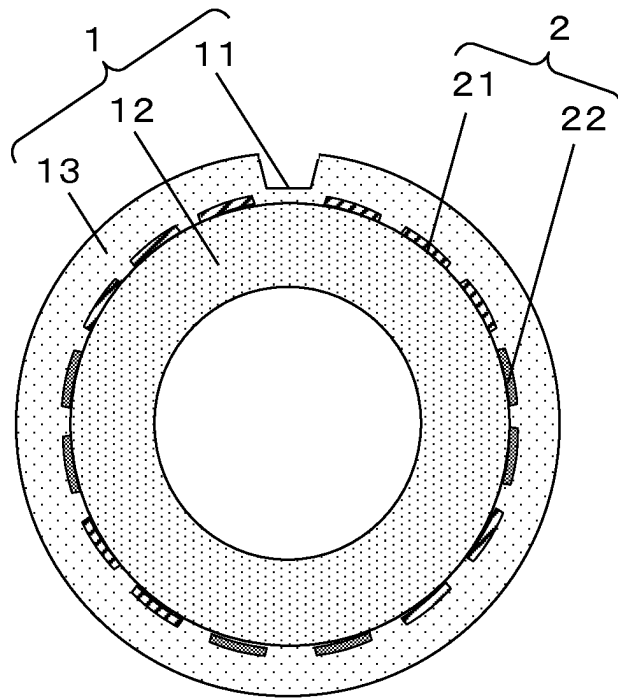


FIG. 4

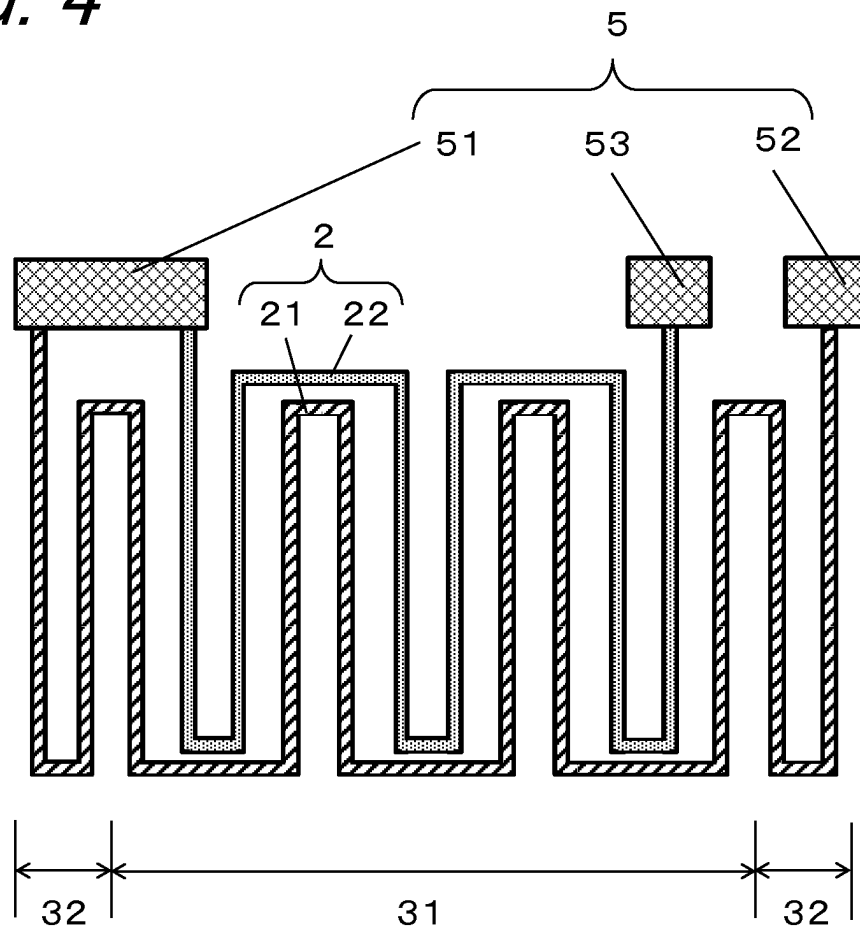


FIG. 5

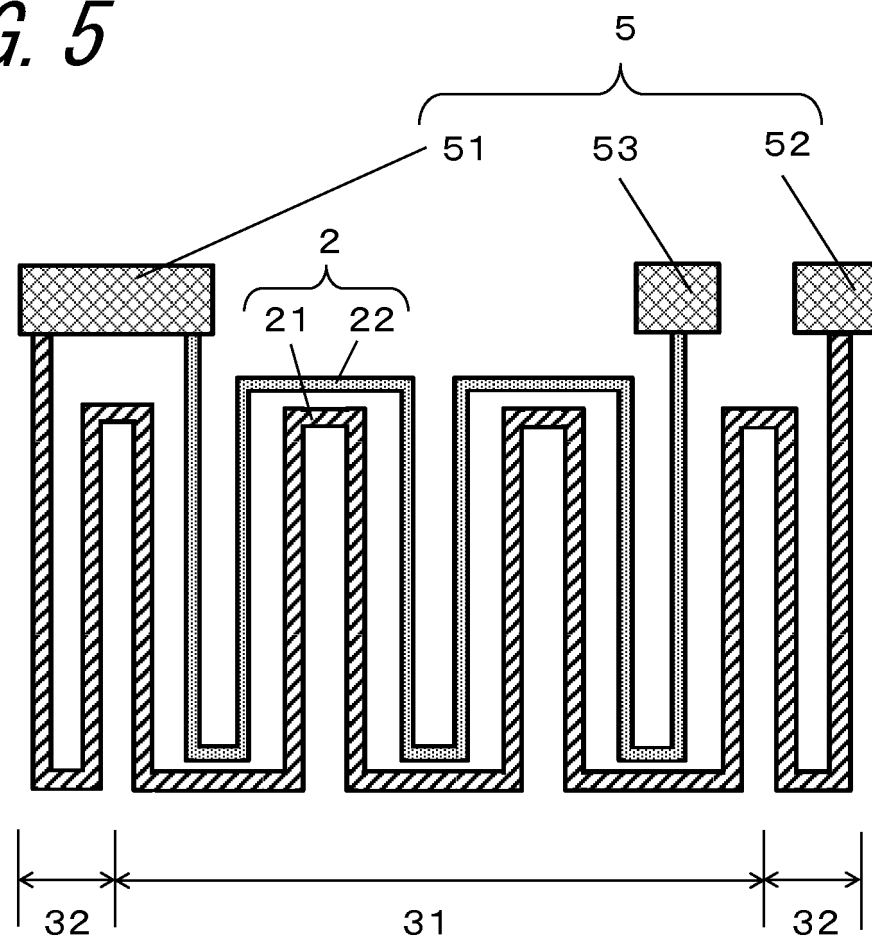


FIG. 6

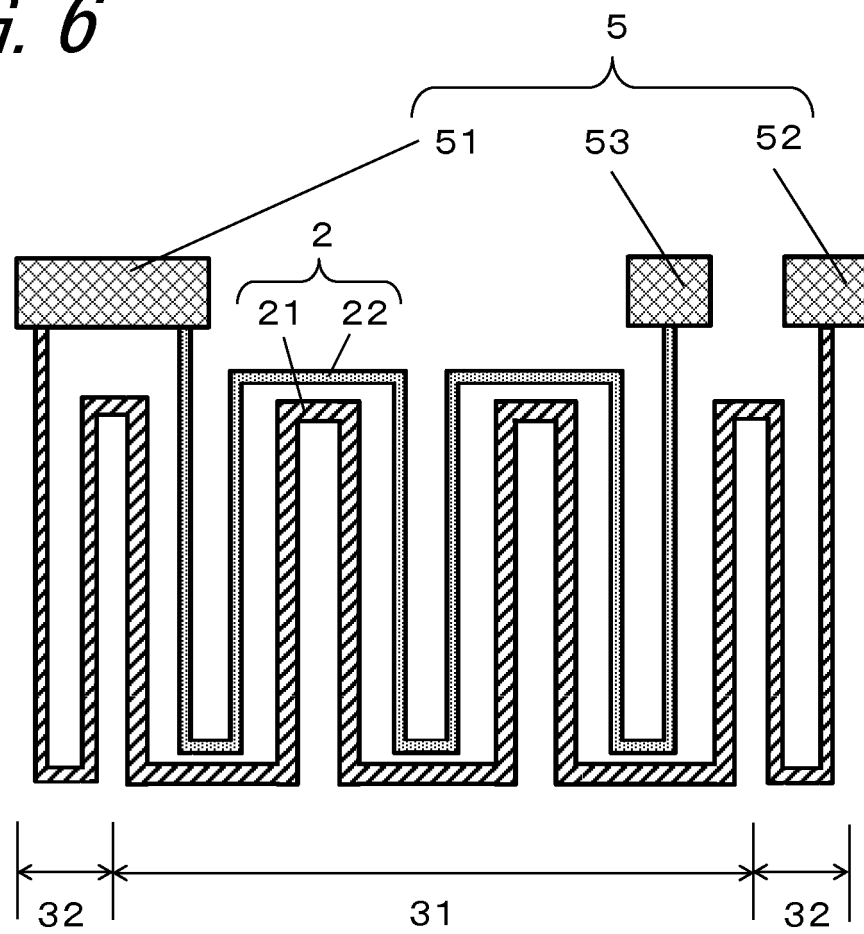
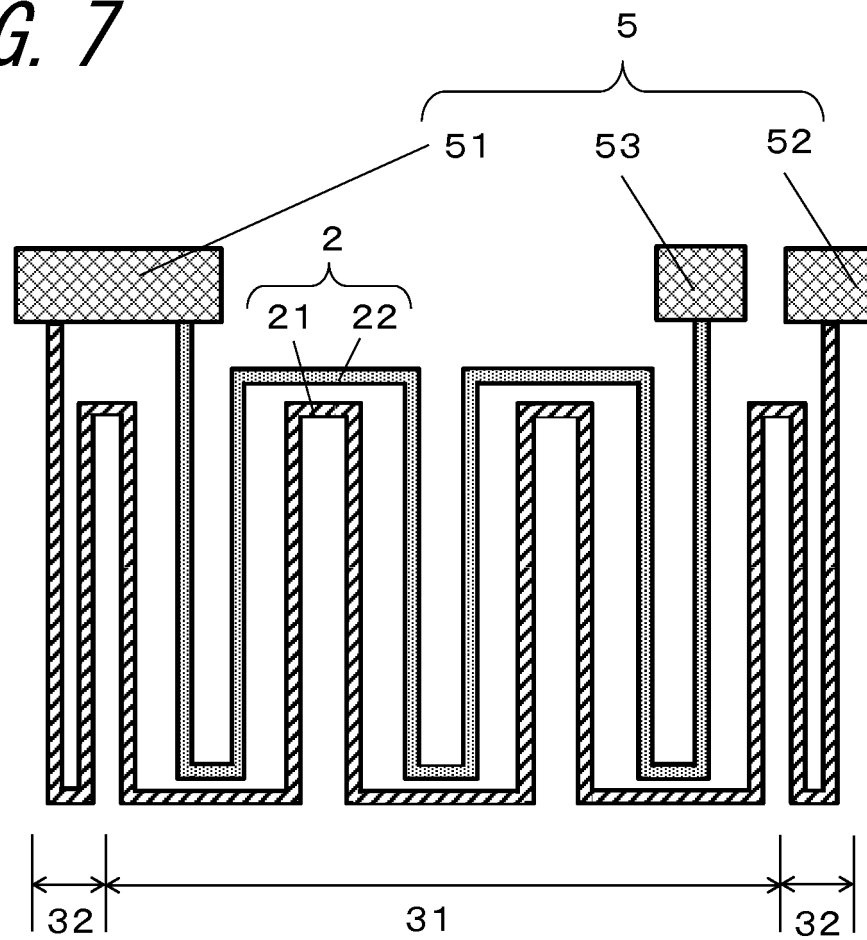


FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/016616

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. H05B3/48 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. H05B3/02-3/86, E03D9/08, F24H1/10, F24H9/18, F16L53/38

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2018

Registered utility model specifications of Japan 1996-2018

Published registered utility model applications of Japan 1994-2018

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 9-7741 A (NGK SPARK PLUG CO., LTD.) 10 January 1997, paragraph [0014], fig. 4 (Family: none)	5-6

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