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(54) CERAMIC HEATER

KERAMIKERHITZER

DISPOSITIF DE CHAUFFAGE EN CÉRAMIQUE

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(56) References cited:
EP-A1- 2 611 261
WO-A1-2013/073276
US-A1- 2001 042 746

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Description

[0001] The present invention relates to a ceramic heater for use in, for example, a hot-water bidet, a fan heater, an electric water heater, a 24-hour bath, a soldering iron, or a hair iron.

[0002] Conventionally, for example, a hot-water bidet uses a heat exchanging unit having a container (heat exchanger) made of resin. The heat exchanging unit has an elongated pipe-shaped ceramic heater disposed therein for warming washing water contained in the heat exchanger.

[0003] As shown in FIG. 7, the ceramic heater for such an application is manufactured as follows: a ceramic sheet 190 having a printed heater wiring circuit 400 is wound around a cylindrical ceramic tube 130, followed by co-firing (see Japanese Patent No. 3038039).

[0004] The ceramic heater heats water flowing through a gap between the inner wall of the heat exchanger and the outer circumference of the ceramic heater.

[0005] Incidentally, in the case where the size of the ceramic heater is reduced or a plurality of the heater wiring circuits 400 are provided, the number of wiring lines to be formed on the ceramic sheet 190 is restricted. Also, an electric resistance per heater wiring circuit 400 is determined by wiring length. If the wiring length is increased in order to maintain a predetermined resistance of the heater in a smaller area, the number of turns increases accordingly, resulting in an increase in wiring density.

[0006] In this case, the wiring line spacing of the heater wiring circuit 400 needs to be narrowed. However, in consideration of blurring of ink paste in screen-printing wiring, there is a limit on narrowing of wiring line spacing (e.g., 0.3 mm or so).

[0007] Thus, while the wiring line spacing is maintained at a predetermined value or greater, the number of turns of the heater wiring circuit 400 is increased. In this case, paired external terminals 430 for energizing the heater wiring circuit 400 are formed on the outer surface of the ceramic sheet 190 with a winding end space 191 of the ceramic sheet 190 intervening therebetween. The two external terminals 430 are connected respectively to end wiring lines 401 and 402 of the heater wiring circuit 400 which are located close to each other with the winding end space 191 intervening therebetween.

[0008] However, an increase in the number of turns of the heater wiring circuit 400 narrows a gap T between the end wiring lines 401 and 402. If the ceramic heater having a narrow gap T is energized in a dry state such as a water failure (generation of heat in the air), arc Ar is apt to be generated in the winding end space 191 between the end wiring lines 401 and 402 to which electricity is supplied from the external terminals 430 of different polarities, potentially resulting in breakage of the ceramic heater.

[0009] EP-A1-2611261 discloses a ceramic heater on which the precharacterizing portion of claim 1 is based. Ceramic heaters are also disclosed in US-A1-2001/042746 and WO-A1-2013/073276.

[0010] The present invention has been conceived in view of the above problem, and an object of the invention is to provide a ceramic heater having a plurality of heater wiring circuits and restraining generation of arc.

[0011] The present invention provides a ceramic heater as defined by claim 1.

[0012] According to the present ceramic heater, since the heater wiring circuit contains a material having a temperature coefficient of 3500 ppm/°C or more, in the case of a fixed wiring line width, the heater wiring circuit can be reduced in circuit length as compared with a heater wiring circuit which does not contain a material having a temperature coefficient of 3500 ppm/°C or more. Accordingly, the present heater wiring circuit can be reduced in the number of turns thereof as compared with a conventional heater wiring circuit. Eventually, since the distance between the connection terminals can be increased, there can be restrained the generation of arc which could otherwise result from the distance being reduced.

[0013] Notably, "the same plane of the heat-generating resistor" means a plane defined by the heat-generating resistor in a developed state. In the case of the ceramic heater including the heat-generating resistor in a wound state, "the same plane of the heat-generating resistor" means a cylindrical plane of a fixed diameter defined by the wound heat-generating resistor.

[0014] The temperature coefficient is less than 4300 ppm/°C. The temperature coefficient may be in excess of 3800 ppm/°C. Accordingly, since the distance between the connection terminals can be further increased, the generation of arc can be further restrained.

[0015] According to the present invention, a ceramic heater having a plurality of heater wiring circuits can restrain the generation of arc.

[0016] The invention will be further described by way of example with reference to the accompanying drawings, in which:

FIG. 1 is a front view of a ceramic heater according to an embodiment of the present invention.
FIG. 2 is a development view showing a ceramic sheet of the ceramic heater.
FIG. 3 is a sectional view taken along line A-A of FIG. 1.
FIG. 4 is a development view schematically showing heater wiring circuits of FIG. 2.

FIG. 5 is a development view showing heater wiring circuits to which the present invention is not applicable.
FIG. 6 is a graph showing the relation between the temperature coefficient of resistor ink and the electric resistance of the heater wiring circuit at high and low temperatures.
FIG. 7 is a fragmentary sectional view showing the heater wiring circuit of a conventional ceramic heater.

[0017] An embodiment of the present invention will next be described with reference to the drawings.

[0018] FIG. 1 is a front view showing a ceramic heater 11 according to an embodiment of the present invention; FIG. 2 is a development view showing a ceramic sheet 19 of the ceramic heater 11; FIG. 3 is a sectional view taken along line A-A of FIG. 1; FIG. 4 is a development view schematically showing heater wiring circuits 40a and 40b of FIG. 2; and FIG. 5 is a development view showing heater wiring circuits 50a and 50b to which the present invention is not applicable.

[0019] The ceramic heater 11 according to the embodiment of the present embodiment can be used, for example, for warming washing water in a heat exchanger of a heat exchanging unit of a hot-water bidet.

[0020] As shown in FIG. 1, the ceramic heater 11 includes a tubular ceramic substrate 13 in which a heat-generating resistor 40 is embedded and an annular flange 30 made of ceramic and bonded to the outer circumference of the ceramic substrate 13 via a bonding member 20. The flange 30 may have an axially extending slit.

[0021] The ceramic substrate 13 includes a cylindrical support member 17 made of ceramic and the ceramic sheet 19 wound circumferentially around the support member 17, and the support member 17 has a through hole 17h extending therethrough along the direction of an axial line O thereof. In the heat exchanger, the ceramic heater 11 heats water flowing through the through hole 17h and water present in a gap between the inner wall of the heat exchanger and the outer circumference of the ceramic heater 11.

[0022] The support member 17 and the ceramic sheet 19 can be formed of, for example, alumina. Notably, the ceramic sheet 19 does not completely cover the support member 17 along its circumference such that a slit 13s extending along the direction of the axial line O of the support member 17 is formed in a winding end space 19a of the ceramic sheet 19.

[0023] Meanwhile, as shown in FIG. 2, the heat-generating resistor 40 composed of a plurality of the heater wiring circuits 40a and 40b each having a meandering pattern is formed in the ceramic sheet 19 by printing or the like. Each of the heater wiring circuits 40a and 40b of the heat-generating resistor 40 has the following form: a plurality of wiring portions 40L (see the upper drawing of FIG. 4) extend along the direction of the axial line O, and turn portions 40m extend in a width direction at opposite ends of the wiring portions 40L and are connected to end portions of the adjacent wiring portions 40L, respectively. Opposite end wiring portions of the heater wiring circuits 40a and 40b are connected to three pad-shaped connection terminals 41, 42a, and 42b at one end with respect to the direction of the axial line O.

[0024] Specifically, as shown in FIG. 4, opposite end wiring portions 40L1 and 40L2 of the heater wiring circuit 40a are connected respectively to the connection terminal 41 serving as a common ground terminal and to the connection terminal 42a serving as a plus terminal. Similarly, opposite end wiring portions 40L3 and 40L4 of the heater wiring circuit 40b are connected respectively to the connection terminal 41 and to the connection terminal 42b serving as a plus terminal. In this manner, by means of the connection terminal 41 serving as a common ground terminal, even though the number of heater wiring circuits increases, the number of connection terminals and, in turn, external terminals can be reduced.

[0025] The connection terminals 41, 42a, and 42b are electrically connected to three (FIG. 1 shows only two of them) external terminals 43, respectively, formed on the outer circumferential surface (the back surface of FIG. 2) of the ceramic sheet 19, via unillustrated via conductors or the like.

[0026] The heat-generating resistor 40 and the connection terminals 41, 42a, and 42b can contain, for example, tungsten as a main component.

[0027] Meanwhile, as shown in FIG. 3, in the present embodiment, the connection terminal 41 and the connection terminal 42b face each other through the winding end space 19a of the ceramic sheet 19, and the opposite end wiring portions 40L3 and 40L4 of the heater wiring circuit 40b connected to the connection terminals 41 and 42b, respectively, are located close to each other with the winding end space 19a intervening therebetween.

[0028] Therefore, the generation of arc between the wiring portions 40L3 and 40L4 in the wiring end space 19a must be restrained.

[0029] Next, with reference to FIGS. 4 and 5, the heater wiring circuits 40a and 40b will be described.

[0030] As shown in FIG. 4, the heater wiring circuits 40a and 40b are disposed on the same plane of the heat-generating resistor 40 in such a manner as to overlap each other in a direction S (intersecting with the direction of the axial line O) in which the connection terminals 41, 42a, and 42b are juxtaposed.

[0031] Meanwhile, as shown in FIG. 5, heater wiring circuits 140a and 140b of a heat-generating resistor 140 do not overlap each other in the direction S in which connection terminals 51, 52a, and 52b are juxtaposed, and thus the present invention is not applicable thereto.

[0032] This is for the following reason: in the example of FIG. 5, since the heater wiring circuits 140a and 140b are disposed singly in the direction S (i.e., the winding direction of the ceramic sheet 19, or the narrow-width direction of the ceramic sheet 19), even though a plurality of heater wiring circuits are disposed, a wiring density D in the narrow-width

direction S does not increase; accordingly, the problem of generation of arc in the winding end space 19a is unlikely to arise.

[0033] By contrast, since the heater wiring circuits 40a and 40b shown in FIG. 4 overlap each other in the direction S, the wiring density D in the direction S increases, so that arc is apt to be generated in the winding end space 19a.

[0034] Notably, the expression "a plurality of heater wiring circuits overlap one another in the direction S in which the connection terminals are juxtaposed" means that at least the turn portions 40m of the heater wiring circuits 40a and 40b overlap each other in the direction S, and does not encompass the case where, as shown in FIG. 5, only end wiring portions 50L1 and 50L2 of the heater wiring circuits 140a and 140b connected to the connection terminals 51, 52a, and 52b overlap each other in the direction S.

[0035] According to the present invention, the heater wiring circuits 40a and 40b contain a material having a temperature coefficient of 3500 ppm/°C or more; thus, despite an increase in wiring density as a result of the heater wiring circuits 40a and 40b overlapping each other in the direction S, the generation of arc in the winding end space 19a can be restrained.

[0036] The reason for this will be described with reference to FIG. 6.

[0037] Notably, a general method for causing "the heater wiring circuits 40a and 40b to contain a material having a temperature coefficient of 3500 ppm/°C or more" is to use a resistor ink having a temperature coefficient of 3500 ppm/°C or more so as to form the heater wiring circuits 40a and 40b by printing or the like. Therefore, in the following description, attention is focused on the temperature coefficient of the resistor ink.

[0038] As shown in FIG. 6, in terms of heating capability of the heater, the electric resistance RH of the heater wiring circuit at the heating temperature (working temperature) H must be fixed regardless of the temperature coefficient k of the resistor ink. Meanwhile, by increasing the temperature coefficient k of the resistor ink of the heater wiring circuit, the electric resistance R1 of the heater wiring circuit at the low temperature L (e.g., room temperature) lower than the heating temperature H can be made smaller than the electric resistance R2 in the case where the temperature coefficient k is small.

[0039] The electric resistance RH of the heater wiring circuit is expressed by

$$RH = RL \times \{1 + k \times (H - L)\} \quad (1)$$

where RL is the electric resistance (R1, R2) of the heater wiring circuit at the temperature L.

[0040] The surface resistivity (sheet resistance) Rs of the heater wiring circuit is expressed by

$$RsH = RsL \times \{1 + k \times (H - L)\} \quad (2)$$

where RsH and RsL are surface resistivities of the heater wiring circuit at the temperatures H and L, respectively, and RsL is considered to be fixed.

[0041] With CL representing the circuit length of the heater wiring circuit and W representing the line width of a wiring portion of the heater wiring circuit, the circuit length CL is expressed by

$$CL = (RH/RsH) \times W \quad (3)$$

[0042] Since RH and W are fixed,

$$CL \propto (1/RsH) \quad (4)$$

[0043] The value of RsH increases with the temperature coefficient k as expressed by Exp. (2). Therefore, as expressed by Exp. (4), the higher the temperature coefficient k, the shorter the circuit length CL.

[0044] That is, by setting the temperature coefficient k of the resistor ink (i.e., the temperature coefficient k of the heater wiring circuits 40a and 40b) to be higher than a conventional level, the circuit length CL for attaining a target electric resistance RH at the heating temperature (working temperature) H can be reduced; accordingly, the number of turns of the heater wiring circuit can be reduced as compared with a conventional one. As a result, the distance T between the connection terminals at the winding end space 19a can be increased, so that there can be restrained the generation of arc, which could otherwise result from the distance T being reduced.

[0045] Meanwhile, when the temperature coefficient of the resistor ink of the heater wiring circuits 40a and 40b is less than 3500 ppm/°C, difficulty is encountered in sufficiently reducing the circuit length CL; as a result, the distance T between the connection terminals at the winding end space 19a is reduced, so that arc is apt to be generated in the winding end space 19a.

[0046] The temperature coefficient is less than 4300 ppm/°C. Particularly, a temperature coefficient of greater than

3800 ppm/°C is preferred. At a temperature coefficient of 4300 ppm/°C or more, the resistance at the room temperature becomes excessively small, potentially resulting in an excessively large rush current. For example, in the case where the ceramic heater for home use shares the power supply with other household appliances, input currents of other household appliances may possibly drop abruptly.

[0047] The resistor ink is metallization ink in the form of slurry formed by mixing tungsten powder and molybdenum powder, and ceramic powder (alumina or the like) as needed, and adding, to the mixture, solution formed by dissolving resin powder serving as a binder in a solvent. By increasing the content of ceramic powder in the metallization ink, the resistance can be increased. Also, by changing the mixing ratio of tungsten powder and molybdenum powder, the temperature coefficient can be adjusted.

[0048] Specifically, when the percentage of tungsten weight to the total of tungsten weight and molybdenum weight (tungsten weight/(tungsten weight + molybdenum weight)) is 70% or more, the temperature coefficient becomes equal to or greater than 3500 ppm/°C. When the percentage (tungsten weight/(tungsten weight + molybdenum weight)) is 85% to 100%, the temperature coefficient becomes greater than 3800 ppm/°C and less than 4300 ppm/°C.

[0049] Therefore, "a material having a temperature coefficient of 3500 ppm/°C or more" appearing in CLAIMS is tungsten powder and molybdenum powder remaining after sintering of the resistor ink.

[0050] The ceramic heater 11 can be manufactured, for example, as follows.

[0051] First, slurry of ceramic powder such as alumina powder is subjected to extrusion molding to form a member which is to become the support member 17, and the formed member is subjected to provisional firing. By use of similar slurry, a green sheet which is to become the ceramic sheet 19 is formed. The above metallization ink is printed on the surface of the green sheet in patterns of the heat-generating resistor 40 and the connection terminals 41, 42a, and 42b as shown in FIG. 2, followed by drying. Another green sheet is placed under pressure on the printed surface of the green sheet, thereby embedding the heat-generating resistor 40 and the connection terminals 41, 42a, and 42b between the two green sheets. Further, vias are formed on one side of a laminate of the two green sheets; a via conductor is charged into the vias; and an electrically conductive paste is printed at positions located immediately above the vias for forming green electrodes which are to become the external terminals 43, followed by drying.

[0052] Then, a ceramic paste is applied onto the other side of the laminate of the two green sheets; the laminate is wound onto and bonded to the support member 17; and the resultant assembly is fired.

[0053] The flange 30 is formed by compacting ceramic powder such as alumina powder by using a die and firing the resultant green compact.

[0054] The thus-manufactured flange 30 is bonded to the outer circumference of the thus-manufactured ceramic substrate 13 as follows: a solid bonding material 20 (glass) which is to become the bonding member 20 is disposed in a gap between the ceramic substrate 13 and the flange 30, followed by application of heat at a temperature equal to or higher than the melting temperature of glass.

[0055] The present invention is not limited to the above embodiment, and encompasses various modifications and equivalents within the ideas and scope of the present invention.

[0056] No particular limitation is imposed on the number and shape of the heater wiring circuits. No particular limitation is imposed on resistor ink; i.e., material used to form the heater wiring circuit.

[Description of Reference Numerals]

[0057]

11:	ceramic heater
40:	heat-generating resistor
40a, 40b:	heater wiring circuit
41, 42a, 42b:	connection terminal
O:	axial line
S:	direction of juxtaposition of connection terminals

Claims

1. A ceramic heater (11) comprising a heat-generating resistor (40) wherein:
a plurality of heater wiring circuits (40a, 40b) comprising turn portions (40m) and end wiring portions (40L1, 40L2), constituting the heat-generating resistor (40) and having connection terminals (41, 42a, 42b) to be connected to an external power supply are disposed on the same plane of the heat-generating resistor (40) in such a manner as to overlap one another such that both the turn portions (40m) and the end wiring portions (40L1, 40L2) of the heater wiring circuits (40a, 40b) are co-extensive, **characterized in that**:

the heater wiring circuits (40a, 40b) consist in a material having a temperature coefficient of electric resistance of 3500 ppm/°C or more and less than 4300 ppm/°C.

2. A ceramic heater (11) according to claim 1, wherein the temperature coefficient of electric resistance is in excess of 3800 ppm/°C.

Patentansprüche

1. Keramische Heizvorrichtung (11), umfassend einen hitzeerzeugenden Widerstand (40), wobei:
eine Mehrzahl von Heizvorrichtungsverdrahtungsschaltkreisen (40a, 40b), umfassend Wendeabschnitte (40m) und Endverdrahtungsabschnitte (40L1, 40L2), die den hitzeerzeugenden Widerstand (40) bilden und Verbindungsklemmen (41, 42a, 42b) aufweisen, die mit einer externen Leistungszufuhr verbunden werden sollen, auf derselben Ebene des hitzeerzeugenden Widerstands (40) auf eine solche Weise angeordnet sind, um derart miteinander zu überlappen, dass sowohl die Wendeabschnitte (40m) als auch die Endverdrahtungsabschnitte (40L1, 40L2) der Heizvorrichtungsverdrahtungsschaltkreise (40a, 40b), co-extensiv sind, **dadurch gekennzeichnet, dass**:
die Heizvorrichtungsverdrahtungsschaltkreise (40a, 40b) in einem Material bestehen, das einen Temperaturkoeffizienten eines elektrischen Widerstands von 3500 ppm/°C oder mehr und weniger als 4300 ppm/°C aufweist.

2. Keramische Heizvorrichtung (11) nach Anspruch 1, wobei der Temperaturkoeffizient eines elektrischen Widerstands mehr als 3800 ppm/°C beträgt.

Revendications

1. Elément chauffant en céramique (11) comprenant une résistance de génération de chaleur (40) dans lequel :
une pluralité de circuits de câblage d'élément chauffant (40a, 40b) comprenant des parties de spire (40m) et des parties de câblage d'extrémité (40L1, 40L2), constituant la résistance de génération de chaleur (40) et ayant des bornes de connexion (41, 42a, 42b) à connecter à une alimentation électrique externe sont disposés sur le même plan de la résistance de génération de chaleur (40) de manière à se chevaucher de sorte que les parties de spire (40m) et les parties de câblage d'extrémité (40L1, 40L2) des circuits de câblage de chauffage (40a, 40b) sont coextensives, **caractérisé en ce que** :
les circuits de câblage de chauffage (40a, 40b) consistent en un matériau ayant un coefficient de température de résistance électrique de 3500 ppm/°C ou plus et moins de 4300 ppm/°C.

2. Elément chauffant en céramique (11) selon la revendication 1, dans lequel le coefficient de température de résistance électrique dépasse 3800 ppm/°C.

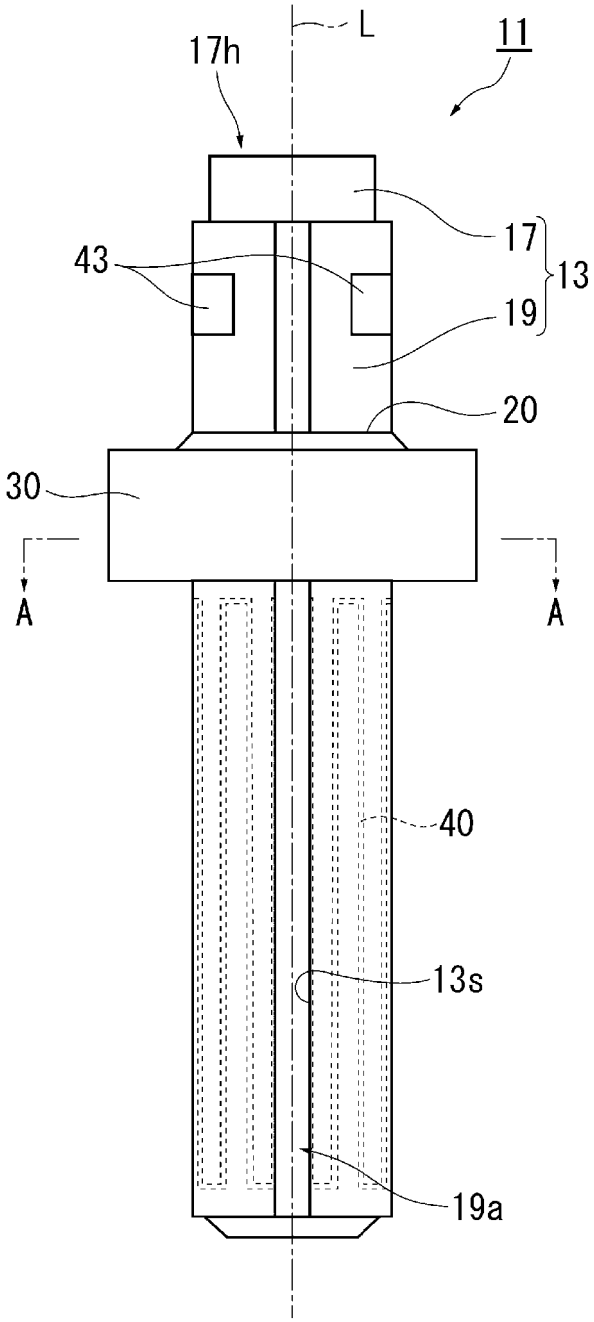


FIG. 1

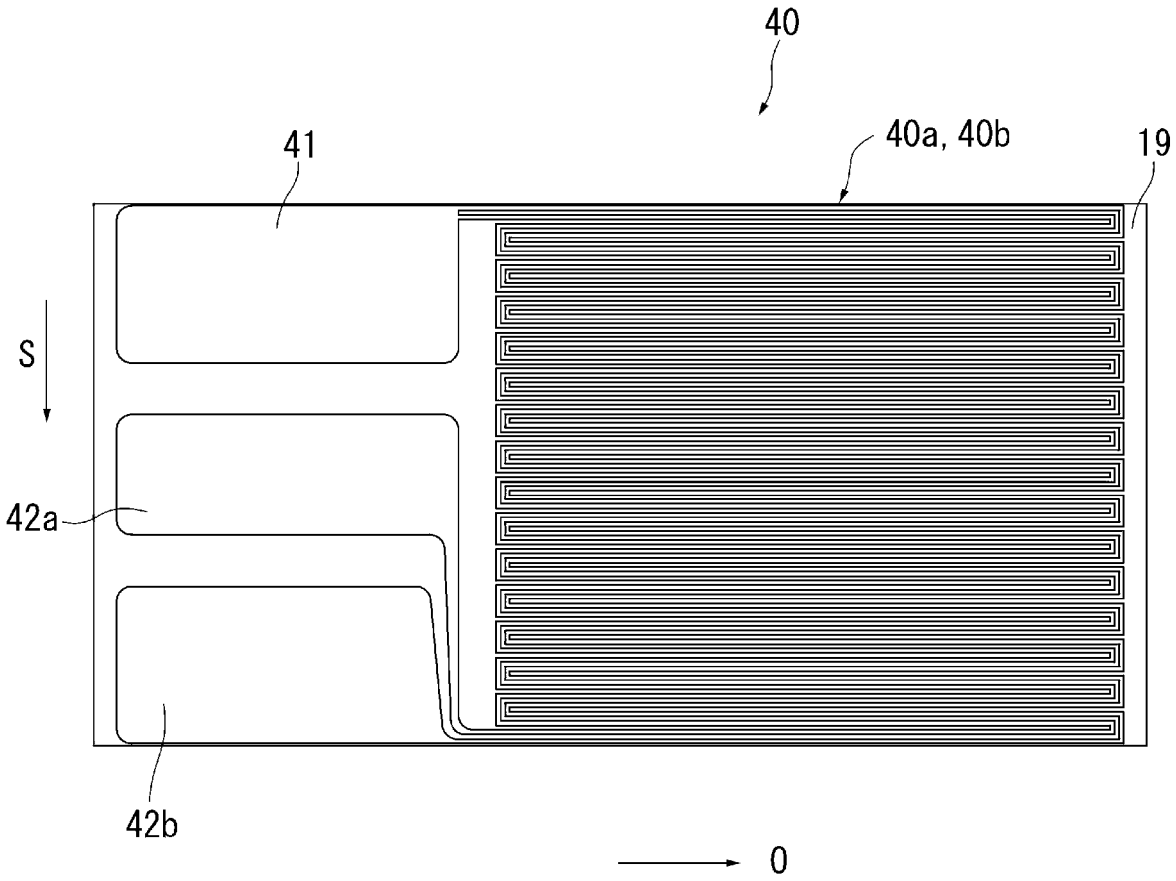


FIG. 2

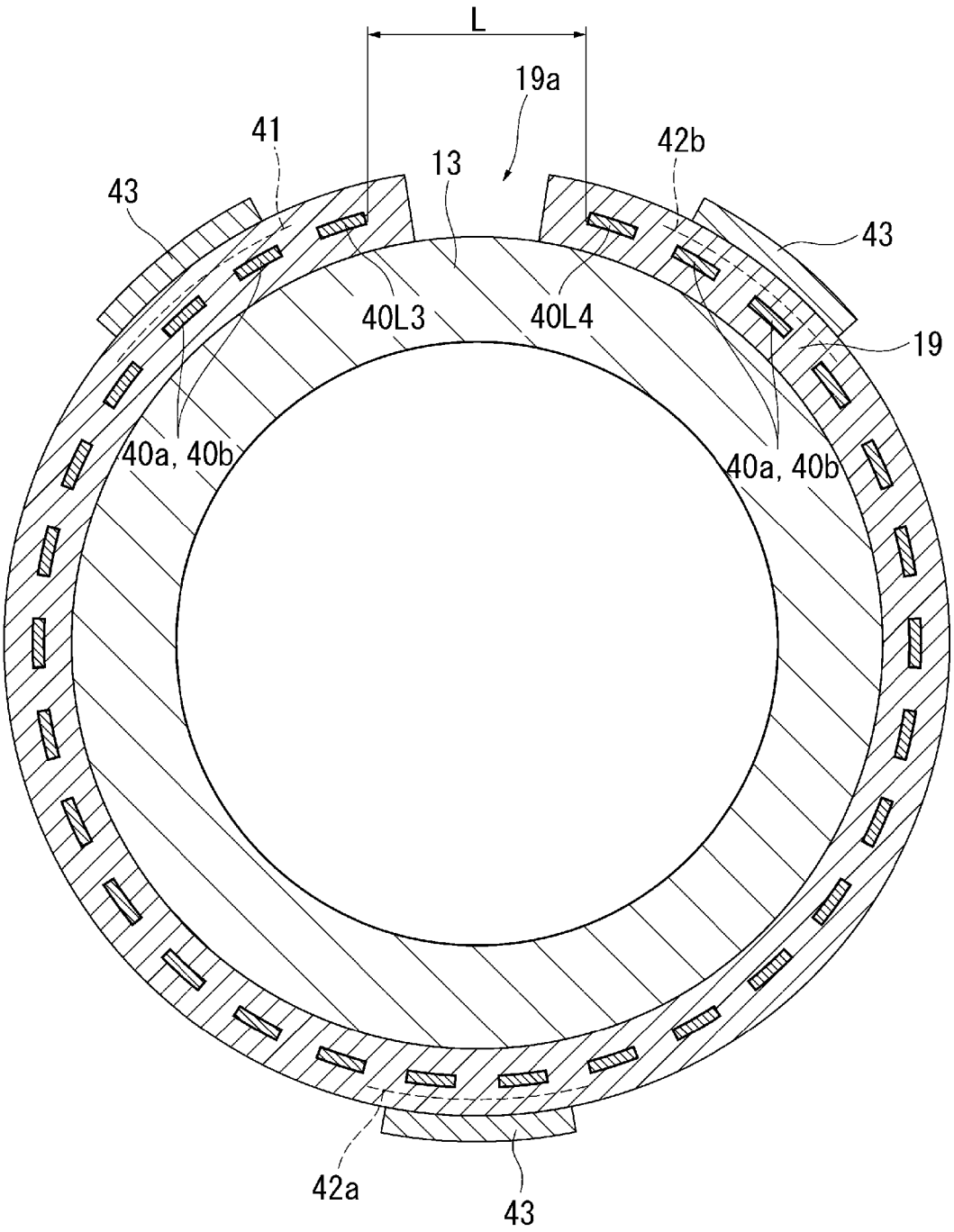


FIG. 3

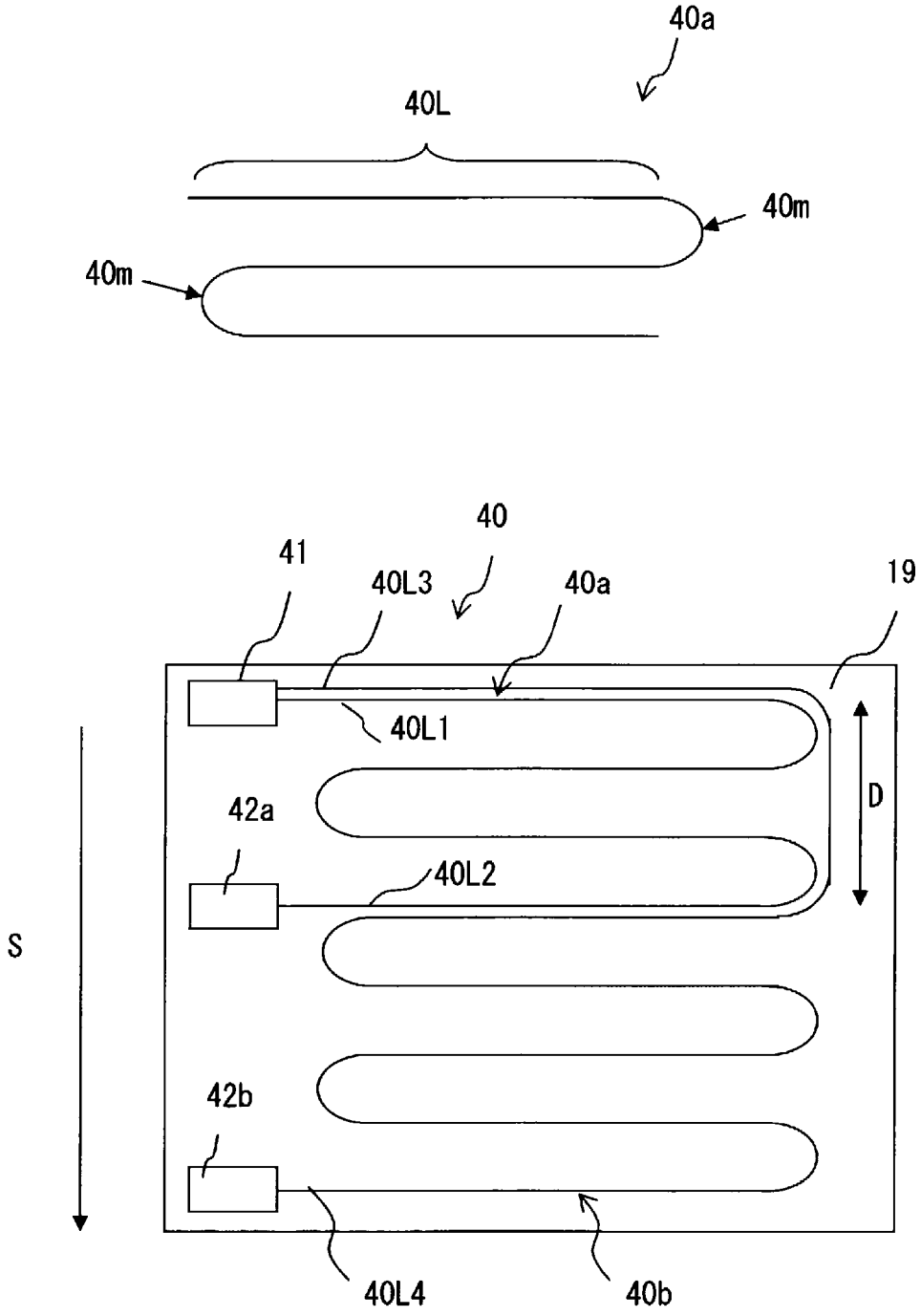


FIG. 4

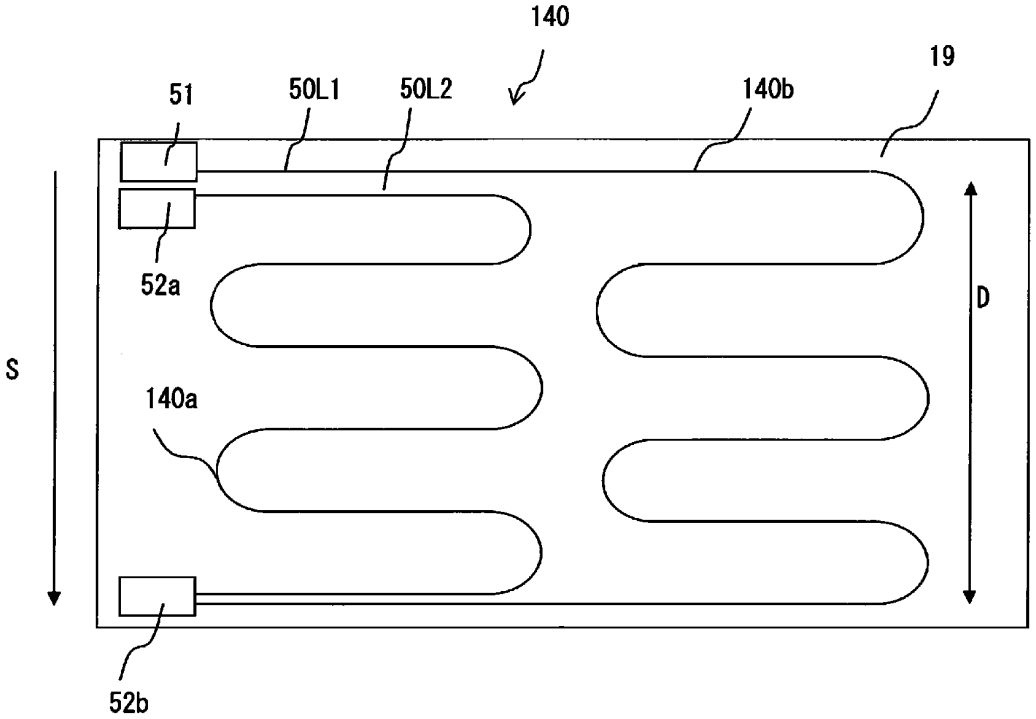

140
19
51
50L1
50L2
140b
52a
D
S
140a
52b

FIG. 5

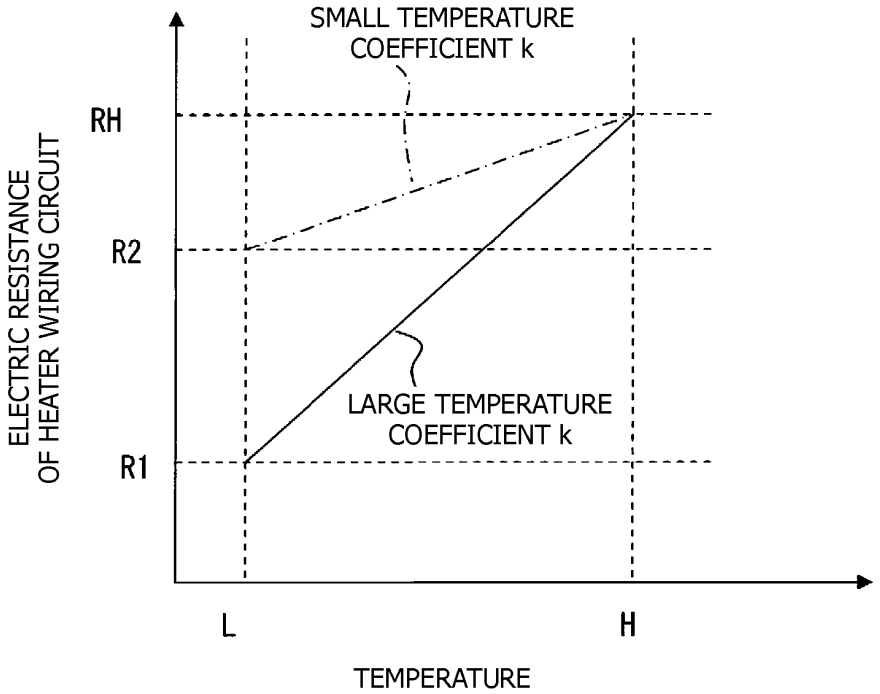

SMALL TEMPERATURE
COEFFICIENT k
RH
R2
R1
ELECTRIC RESISTANCE
OF HEATER WIRING CIRCUIT
LARGE TEMPERATURE
COEFFICIENT k
L
H
TEMPERATURE

FIG. 6

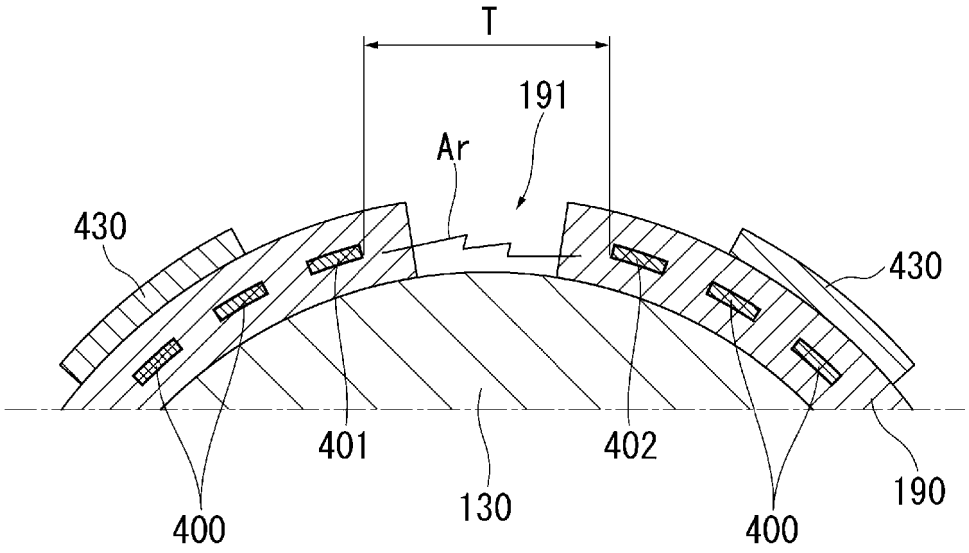


FIG. 7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 3038039 B **[0003]**
- EP 2611261 A1 **[0009]**
- US 2001042746 A1 **[0009]**
- WO 2013073276 A1 **[0009]**