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(54) **CERAMIC HEATER**

(57) The present invention provides a ceramic heater capable of improving reliability through prevention of potential dielectric breakdown of heater wiring. The ceramic heater of the present invention includes a ceramic sheet 19 which has heater wiring 41 incorporated therein and is wound circumferentially around a support member 17. The heater wiring 41 includes wiring portions 44 extending along the axial direction of the support member 17, and connecting portions each connecting the adjacent wiring portions 44. The ceramic heater satisfies a rela-

tional expression $t \geq 0.2$ mm and at least one of relational expressions $L/V \geq 9/500$ and $w/V \geq 3/500$, where t is the thickness from a surface 46 of the heater wiring 41 to an outer circumferential surface 47 of the ceramic sheet 19, V is a voltage applied to the heater wiring 41, w is the distance from an end edge of the heater wiring 41 to an end surface 48 of the ceramic sheet 19, and L is the distance between paired wiring portions 44 disposed opposite each other with a winding end portion 20 intervening therebetween.

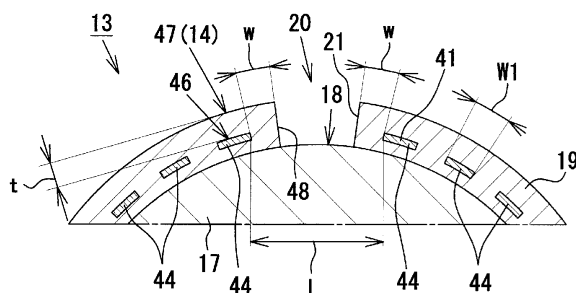


FIG. 3

Description

TECHNICAL FIELD

5 **[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, and a hair iron, and more particularly to a ceramic heater having a structure in which a ceramic sheet having heater wiring incorporated therein is wound circumferentially around a support member.

10 BACKGROUND ART

[0002] Usually, a hot-water bidet uses a heat exchanging unit having a container (heat exchanger) made of resin. The heat exchanging unit is equipped with a tubular ceramic heater for warming washing water contained in the heat exchanger.

15 **[0003]** A known ceramic heater of this type is manufactured as follows: a ceramic sheet having printed heater wiring is wound around a cylindrical support member made of ceramic, followed by co-firing (see, for example, Patent Document 1).

PRIOR ART DOCUMENT

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PATENT DOCUMENT

[0004] Patent Document 1: Japanese Patent No. 3038039 (FIG. 1, etc.)

25 SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

30 **[0005]** Incidentally, since a ceramic heater for use in a hot-water bidet is under water at all times, the ceramic heater is hardly energized for heating in a dry state. Meanwhile, in the event of a water failure or piping trouble, the ceramic heater may possibly be energized for heating in a dry state. However, activation of heating in a dry state generates a potential difference between paired heater wiring portions located opposite each other with a winding end portion of a ceramic sheet intervening therebetween to thereby cause generation of heat from the heater wiring portions, potentially resulting in melting of glass components present in a region of the ceramic sheet in the vicinity of the heat-generating heater wiring portions. In this case, because of easier movement of electrons, partial discharges occur between the paired heater wiring portions located opposite each other with the winding end portion intervening therebetween, resulting in dielectric breakdown. Furthermore, sparks generated in partial discharges melt ceramic components present in the ceramic sheet, thereby raising a problem of breakage of the ceramic heater.

35 **[0006]** The present invention has been conceived in view of the above problem, and an object of the invention is to provide a ceramic heater capable of improving reliability through prevention of potential dielectric breakdown of heater wiring.

MEANS FOR SOLVING THE PROBLEM

45 **[0007]** Means (means 1) for solving the above problem is a ceramic heater comprising a support member made of ceramic, and a ceramic sheet having heater wiring incorporated therein, and wound circumferentially around the support member. The ceramic heater is characterized in that the heater wiring comprises a plurality of wiring portions extending along an axial direction of the support member, and connecting portions each connecting the adjacent wiring portions, and characterized by satisfying a relational expression $t \geq 0.2 \text{ mm}$ and at least one of relational expressions $L/V \geq 9/500$ and $w/V \geq 3/500$, where t (mm) is a thickness in the ceramic sheet from a surface of the heater wiring to an outer circumferential surface of the ceramic sheet, V (V) is a voltage applied to the heater wiring, w (mm) is a distance from an end edge of the heater wiring to an end surface of the ceramic sheet at a winding end portion of the ceramic sheet, and L (mm) is a distance between paired wiring portions disposed opposite each other with the winding end portion intervening therebetween.

50 **[0008]** According to the invention described in means 1, dielectric breakdown strength can be enhanced by satisfying the relational expression $t \geq 0.2 \text{ mm}$ and at least one of the relational expressions $L/V \geq 9/500$ and $w/V \geq 3/500$. As a result, since melting of glass components present in a region of the ceramic sheet in the vicinity of the winding end portion is prevented, there can be prevented dielectric breakdown between the paired heater wiring portions located

opposite each other with the winding end portion intervening therebetween, and breakage of the ceramic heater can be prevented. Therefore, reliability of the ceramic heater can be improved.

[0009] Preferably, the above-mentioned ceramic heater satisfies at least one of relational expressions $t/V \geq 1/500$ and $w/t \geq 3$. Further, preferably, in the ceramic heater, a slit which extends along the axial direction of the support member and through which an outer circumferential surface of the support member is exposed is formed at the winding end portion, and a relational expression $0.2 \leq L - 2w \leq 1.5$ is satisfied, where a width of the slit is derived from the expression $L - 2w$. Since establishment of the above conditions more reliably enhances dielectric breakdown strength, there can be reliably prevented dielectric breakdown between the paired heater wiring portions located opposite each other with the winding end portion intervening therebetween, and breakage of the ceramic heater can be reliably prevented. Therefore, reliability of the ceramic heater can be further improved.

[0010] The above-mentioned ceramic heater comprises the support member made of ceramic and the ceramic sheet wound circumferentially around the support member. Preferred examples of ceramic used to form the support member and the ceramic sheet include alumina, aluminum nitride, silicon nitride, boron nitride, zirconia, titania, and mullite. Particularly preferably, the support member and the ceramic sheet are formed of alumina. As a result of use of alumina, the ceramic heater excellent in thermal resistance, chemical resistance, and strength can be manufactured at low cost. The ceramic sheet has a heat generating element (heater wiring) formed of, for example, tungsten, molybdenum, or tantalum. Preferably, heater wiring contains at least one of tungsten and molybdenum as a main component. As a result, since heater wiring can reliably adhere to the ceramic sheet, reliability of the ceramic heater further improves.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

[FIG. 1] Front view showing a ceramic heater according to the present embodiment.

[FIG. 2] Plan view showing the ceramic heater.

[FIG. 3] Sectional view taken along line A--A of FIG. 1.

[FIG. 4] Explanatory view showing a ceramic sheet in a development elevation.

[FIG. 5] Set of explanatory views consisting of views (a) to (d) and showing a method of manufacturing the ceramic heater.

[FIG. 6] Explanatory view showing a method of manufacturing a ceramic heater according to another embodiment.

MODES FOR CARRYING OUT THE INVENTION

[0012] A ceramic heater according to an embodiment of the present invention and a method of manufacturing the ceramic heater will next be described with reference to the drawings.

[0013] A ceramic heater 11 of the present embodiment is used for warming washing water contained in a heat exchanger of a heat exchanging unit of a hot-water bidet, for example.

[0014] As shown in FIGS. 1 and 2, the ceramic heater 11 includes a cylindrical heater body 13 made of ceramic and an annular flange 15 made of a metal and fitted externally to the heater body 13. The flange 15 is an annular member formed by bending a metal plate of, for example, stainless steel and has a concave (cup-shaped) central portion.

[0015] In the present embodiment, as shown in FIG. 2, a space of the concave portion of the flange 15 surrounded by an outer circumferential surface 14 of the heater body 13 and an inner surface of the flange 15 serves as a glass receptacle 35. The glass receptacle 35 is filled with glass 33, and the heater body 13 and the flange 15 are fixed together through the molten glass 33. In FIG. 2, the glass 33 is hatched.

[0016] As shown in FIGS. 1 to 3, the heater body 13 is composed of a cylindrical support member 17 made of ceramic and a ceramic sheet 19 wound circumferentially around the support member 17. In the present embodiment, the support member 17 and the ceramic sheet 19 are formed of ceramic such as alumina (Al_2O_3). The thermal expansion coefficient of alumina ranges from $50 \times 10^{-7}/\text{K}$ to $90 \times 10^{-7}/\text{K}$, and, in the present embodiment, the thermal expansion coefficient is $70 \times 10^{-7}/\text{K}$ (30°C to 380°C). In the present embodiment, the support member 17 has an outside diameter of 12 mm, an inside diameter of 8 mm, and a length of 65 mm, and the ceramic sheet 19 has a thickness of 0.5 mm and a length of 60 mm. The ceramic sheet 19 does not completely cover the support member 17 along its circumference. As a result, a winding end portion 20 of the ceramic sheet 19 has a slit 21 which extends along the axial direction of the support member 17 and through which an outer circumferential surface 18 of the support member 17 is exposed.

[0017] As shown in FIGS. 3 and 4, the ceramic sheet 19 has a heater wiring 41 in a meandering pattern and a pair of internal terminals 42 incorporated therein. In the present embodiment, the heater wiring 41 and the internal terminals 42 contain tungsten (W) as a main component. The internal terminals 42 are electrically connected to respective external terminals 43 (see FIG. 1) formed on the outer circumferential surface of the ceramic sheet 19 via unillustrated via conductors or the like.

[0018] The heater wiring 41 includes a plurality of wiring portions 44 extending along the axial direction of the support member 17, and connecting portions 45 each connecting the adjacent wiring portions 44. As viewed from a thickness direction of the ceramic sheet 19, the paired wiring portions 44 located at respective opposite end portions of the ceramic sheet 19 are disposed opposite each other with a winding end portion 20 (see FIG. 3) of the ceramic sheet 19 intervening therebetween, and first ends (upper ends in FIG. 4) of the paired wiring portions 44 are connected to the respective internal terminals 42, whereas second ends (lower ends in FIG. 4) of the paired wiring portions 44 are connected via the connecting portions 45 to the second ends (lower ends in FIG. 4) of the adjacent wiring portions 44, respectively. Also, as viewed from the thickness direction of the ceramic sheet 19, the wiring portions 44 located between the above-mentioned paired wiring portions 44 are connected to one another such that the first end is connected via the connecting portion 45 to the first end of the adjacent wiring portion 44, whereas the second end is connected via the connecting portion 45 to the second end of the adjacent wiring portion 44.

[0019] As shown in FIGS. 3 and 4, the wiring portion 44 of the present embodiment has a line width $W1$ of 0.60 mm and a thickness of 15 μm . Similarly, the connecting portion 45 of the present embodiment has a line width $W2$ of 0.60 mm and a thickness of 15 μm . That is, the line width $W1$ of the wiring portion 44 is identical to the line width $W2$ of the connecting portion 45. Also, since the wiring portion 44 is identical in thickness to the connecting portion 45, the wiring portion 44 is identical in cross-sectional area to the connecting portion 45.

[0020] As shown in FIG. 3, in the ceramic sheet 19, a thickness t from surfaces 46 of the wiring portions 44 (heater wiring 41) to an outer circumferential surface 47 of the ceramic sheet 19 is 0.2 mm. Also, at the winding end portion 20, a distance w from end edges of the wiring portions 44 (heater wiring 41) to respective end surfaces 48 of the ceramic sheet 19 is 0.7 mm. The "distance w " is a length along the circumferential direction of the cylindrical support member 17. Further, a distance L between the paired wiring portions 44 disposed opposite each other with the winding end portion 20 intervening therebetween is 2.4 mm. The "distance L " is the length of a straight line connecting the end edges of the paired wiring portions 44. The width of a slit 21 formed at the winding end portion 20 is derived from the expression $L - 2w$ and is 1 mm in the present embodiment.

[0021] A method of manufacturing the ceramic heater 11 of the present embodiment will next be described.

[0022] First, clayey slurry which contains alumina as a main component is charged into a conventionally known extruding machine (not shown) to form a tubular member. After being dried, the formed tubular member is subjected to provisional firing at a predetermined temperature (e.g., about 1,000°C), thereby achieving the support member 17 (see FIG. 5(a)).

[0023] By use of a ceramic material which contains alumina powder as a main component, first and second ceramic green sheets 51 and 52 which are collectively to become the ceramic sheet 19 are formed. A well-known forming method such as a doctor blade method can be used to form the ceramic green sheets. By use of a conventionally known paste printing apparatus (not shown), an electrically conductive paste (in the present embodiment, tungsten paste) is printed on the surface of the first ceramic green sheet 51. As a result, a green electrode 53 which is to become the heater wiring 41 and the internal terminals 42 is formed on the surface of the first ceramic green sheet 51 (see FIG. 5(b)). The position of the green electrode 53 is adjusted, for example, in consideration of shrinkage during firing in addition to the position of the heater wiring 41.

[0024] After the electrically conductive paste is dried, the second ceramic green sheet 52 is laminated onto the printed side (side on which the green electrode 53 is formed) of the first ceramic green sheet 51, followed by application of pressing force in the sheet laminating direction. As a result, the ceramic green sheets 51 and 52 are united into a green sheet laminate 54 (see FIG. 5(c)). The thickness of the second ceramic green sheet 52 is adjusted, for example, in consideration of shrinkage during firing in addition to the thickness t from the outer wiring portions 46 of the heater wiring 41 to the outer circumferential surface 47 of the ceramic sheet 19. Further, by use of the paste printing apparatus, the electrically conductive paste is printed on the surface of the second ceramic green sheet 52. As a result, green electrodes 55 which are to become the external terminals 43 are formed on the surface of the second ceramic green sheet 52.

[0025] Next, ceramic paste (alumina paste) is applied onto one side of the green sheet laminate 54, and the green sheet laminate 54 is wound onto and bonded to the outer circumferential surface 18 of the support member 17 (see FIG. 5(d)). At this time, the size of the green sheet laminate 54 is adjusted such that end portions of the green sheet laminate 54 do not overlap each other. Next, after a drying process, a debinding process, etc., are performed according to well-known methods, simultaneous firing is performed at a predetermined temperature (e.g., about 1,400°C to 1,600°C) for sintering alumina and tungsten contained in the green sheet laminate 54 (the ceramic green sheets 51 and 52 and the green electrodes 53 and 55). As a result, alumina contained in the ceramic green sheets 51 and 52 and tungsten contained in the electrically conductive paste are simultaneously sintered such that the green sheet laminate 54 becomes the ceramic sheet 19, the green electrode 53 becomes the heater wiring 41 and the internal terminals 42, and the green electrodes 55 become the external terminals 43. Subsequently, the external terminals 43 are plated with nickel, achieving the heater body 13.

[0026] Next, a stainless steel plate is formed into the cup-shaped flange 15 through pressing by use of a die. Then, the flange 15 is externally fitted to the heater body 13 at a predetermined attachment position. Subsequently, the heater

body 13 and the flange 15 are fixed together through the molten glass 33, completing the ceramic heater 11.

<Experimental examples>

[0027] Examples of experiments conducted to evaluate the performance of the ceramic heater 11 of the present embodiment will next be described.

[0028] First, samples for measurement were prepared as follows. A prepared sample A was a ceramic heater having a thickness t (see FIG. 3) of 0.18 mm from the surface of the heater wiring (wiring portions) to the outer circumferential surface of the ceramic sheet, a distance w (see FIG. 3) of 0.6 mm from the end edges of the heater wiring (wiring portions) to the respective end surfaces of the ceramic sheet, a distance L (see FIG. 3) of 1.4 mm between the paired wiring portions disposed opposite each other with the winding end portion intervening therebetween, and a width $L - 2w$ of 0.2 mm of the slit formed at the winding end portion. A prepared sample B was a ceramic heater having a thickness t of 0.18 mm, a distance w of 1 mm, a distance L of 3 mm, and a width $L - 2w$ of 1 mm. A prepared sample C was a ceramic heater having a thickness t of 0.2 mm, a distance w of 0.5 mm, a distance L of 3 mm, and a width $L - 2w$ of 2 mm. A prepared sample D was a ceramic heater having a thickness t of 0.2 mm, a distance w of 0.7 mm, a distance L of 1.6 mm, and a width $L - 2w$ of 0.2 mm. A prepared sample E was the ceramic heater 11 of the present embodiment; i.e., a ceramic heater having a thickness t of 0.2 mm, a distance w of 0.7 mm, a distance L of 2.4 mm, and a width $L - 2w$ of 1 mm. A prepared sample F was a ceramic heater having a thickness t of 0.2 mm, a distance w of 1 mm, a distance L of 3 mm, and a width $L - 2w$ of 1 mm. A prepared sample G was a ceramic heater having a thickness t of 0.3 mm, a distance w of 1 mm, a distance L of 2.4 mm, and a width $L - 2w$ of 0.4 mm. A prepared sample H was a ceramic heater having a thickness t of 0.3 mm, a distance w of 1 mm, a distance L of 3 mm, and a width $L - 2w$ of 1 mm. A prepared sample I was a ceramic heater having a thickness t of 0.4 mm, a distance w of 1.3 mm, a distance L of 3 mm, and a width $L - 2w$ of 0.4 mm. A prepared sample J was a ceramic heater having a thickness t of 0.4 mm, a distance w of 1.3 mm, a distance L of 3.8 mm, and a width $L - 2w$ of 1.2 mm. A prepared sample K was a ceramic heater having a thickness t of 0.4 mm, a distance w of 1.5 mm, a distance L of 4.5 mm, and a width $L - 2w$ of 1.5 mm. A prepared sample L was a ceramic heater having a thickness t of 0.5 mm, a distance w of 1.3 mm, a distance L of 3 mm, and a width $L - 2w$ of 0.4 mm. A prepared sample M was a ceramic heater having a thickness t of 0.5 mm, a distance w of 1.5 mm, a distance L of 3.8 mm, and a width $L - 2w$ of 0.8 mm. A prepared sample N was a ceramic heater having a thickness t of 0.5 mm, a distance w of 1.3 mm, a distance L of 3 mm, and a width $L - 2w$ of 0.4 mm. A prepared sample O was a ceramic heater having a thickness t of 0.5 mm, a distance w of 1.5 mm, a distance L of 4.3 mm, and a width $L - 2w$ of 1.3 mm. A prepared sample P was a ceramic heater having a thickness t of 0.5 mm, a distance w of 1.5 mm, a distance L of 4.3 mm, and a width $L - 2w$ of 1.3 mm. A prepared sample Q was a ceramic heater having a thickness t of 0.5 mm, a distance w of 1.5 mm, a distance L of 4.5 mm, and a width $L - 2w$ of 1.5 mm. The samples A to Q were prepared 10 pieces each.

[0029] Next, Nichrome wires were soldered to pairs of internal terminals (heater wiring) provided in the ceramic sheets of the samples for measurement (samples A to Q), and the samples for measurement were mounted in dry condition on a base. Then, a voltage V (100 Vac, 140 Vac, 200 Vac, or 240 Vac) was applied between the paired internal terminals for six minutes, and the surface temperatures of the ceramic sheets were measured by use of a thermographic camera. Specifically, a voltage of 100 Vac was applied to the samples A to E; a voltage of 140 Vac was applied to the samples F to H, L, and M; a voltage of 200 Vac was applied to the samples I, J, and P; and a voltage of 240 Vac was applied to the samples K, N, O, and Q. Also, the values of t/V , w/t , L/V , and w/V were calculated for the samples A to Q. Further, through observation, a determination was made as to whether or not dielectric breakdown occurred between the paired wiring portions located opposite each other with the winding end portion intervening therebetween, and in the event of occurrence of dielectric breakdown, the time of occurrence of dielectric breakdown was measured and recorded. Among the samples A to Q, those samples having an incidence of dielectric breakdown of 60% or more (i.e., six or more of the 10 samples suffered dielectric breakdown) were judged to be "Failure"; those samples having an incidence of dielectric breakdown of 30% to 50% (i.e., three to five of the 10 samples suffered dielectric breakdown) were judged to be "Fair"; those samples having an incidence of dielectric breakdown of 10% to 20% (i.e., one or two of the 10 samples suffered dielectric breakdown) were judged to be "Good"; and those samples having an incidence of dielectric breakdown of 0% (i.e., all of the 10 samples were free from occurrence of dielectric breakdown) were judged to be "Excellent." Table 1 shows the results of the above experiments.

[Table 1]

	Dimensions and applied voltage					Ratios				Result of energization	
	t	w	L	$L - 2w$	V	t/V	w/t	L/V	w/V	Dielectric breakdown	Judgement
A	0.18	0.6	1.4	0.2	100	0.90/500	3.3	7.00/500	3.00/500	8/10	Failure
B	0.18	1	3	1	100	0.90/500	5.6	15.00/500	5.00/500	6/10	Failure

(continued)

5		Dimensions and applied voltage					Ratios				Result of energization	
		t	w	L	L - 2w	V	t/V	w/t	L/V	w/V	Dielectric breakdown	Judgement
	C	0.2	0.5	3	2	100	1.00/500	2.5	15.00/500	2.50/500	4/10	Fair
	D	0.2	0.7	1.6	0.2	100	1.00/500	3.5	8.00/500	3.50/500	1/10	Good
	E	0.2	0.7	2.4	1	100	1.00/500	3.5	12.00/500	3.50/500	0/10	Excellent
10	F	0.2	1	3	1	140	0.71/500	5	10.71/500	3.57/500	4/10	Fair
	G	0.3	1	2.4	0.4	140	1.07/500	3.3	8.57/500	3.57/500	2/10	Good
	H	0.3	1	3	1	140	1.07/500	3.3	10.71/500	3.57/500	0/10	Excellent
15	I	0.4	1.3	3	0.4	200	1.00/500	3.3	7.50/500	3.25/500	2/10	Good
	J	0.4	1.3	3.8	1.2	200	1.00/500	3.3	9.50/500	3.25/500	0/10	Excellent
	K	0.4	1.5	4.5	1.5	240	0.83/500	3.8	9.38/500	3.13/500	5/10	Fair
20	L	0.5	1.3	3	0.4	140	1.79/500	2.6	10.71/500	4.64/500	5/10	Fair
	M	0.5	1.5	3.8	0.8	140	1.79/500	3	13.57/500	5.36/500	0/10	Excellent
	N	0.5	1.3	3	0.4	240	1.04/500	2.6	6.25/500	2.71/500	10/10	Failure
25	O	0.5	1.5	4.3	1.3	240	1.04/500	3	8.96/500	3.13/500	1/10	Good
	P	0.5	1.5	4.3	1.3	200	1.25/500	3	10.75/500	3.75/500	0/10	Excellent
	Q	0.5	1.5	4.5	1.5	240	1.04/500	3	9.38/500	3.13/500	0/10	Excellent

[0030] As a result, the following was confirmed. The samples A and B having a thickness t of less than 0.2 mm had an incidence of dielectric breakdown of 60% or more and therefore were judged to be "Failure." The sample N having a thickness t of 0.2 mm or more, but having a ratio L/V of less than 9/500 and a ratio w/V of less than 3/500 had an incidence of dielectric breakdown of 60% or more. The samples C to M and O to Q having a thickness t of 0.2 mm or more and a ratio L/V of 9/500 or more or a ratio w/V of 3/500 or more had an incidence of dielectric breakdown of 50% or less. Further, among the samples C to M and O to Q, the samples D, E, G to J, M, and O to Q having a ratio t/V of 1/500 or more and a ratio w/t of 3 or more had an incidence of dielectric breakdown of 20% or less. Particularly, among the samples D, E, G to J, M, and O to Q, the samples E, H, J, M, P, and Q having a ratio L/V of 9/500 or more and a ratio w/V of 3/500 or more were free from occurrence of dielectric breakdown.

[0031] The above experimental results have proved that satisfaction of all of the relational expressions $t \geq 0.2$ mm, $L/V \geq 9/500$, $w/V \geq 3/500$, $t/V \geq 1/500$, and $w/t \geq 3$ prevents the occurrence of dielectric breakdown.

[0032] Therefore, the present embodiment can achieve the following effects.

- (1) Since the ceramic heater 11 of the present embodiment has a thickness t of 0.2 mm, a distance w of 0.7 mm, a distance L of 2.4 mm, and a voltage V of 100 Vac, the ceramic heater 11 satisfies the relational expression $t \geq 0.2$ mm as well as the relational expressions $L/V \geq 9/500$ and $w/V \geq 3/500$, whereby dielectric breakdown strength can be enhanced. As a result, since melting of glass components present in a region of the ceramic sheet 19 in the vicinity of the winding end portion 20 is prevented, there can be prevented dielectric breakdown between the paired wiring portions 44 located opposite each other with the winding end portion 20 intervening therebetween, and breakage of the ceramic heater 11 can be prevented. Therefore, reliability of the ceramic heater 11 can be improved.
- (2) According to the present embodiment, the paired internal terminals 42 formed in the ceramic sheet 19 are disposed inside the paired wiring portions 44 located opposite each other with the winding end portion 20 of the ceramic sheet 19 intervening therebetween (see FIG. 4). Accordingly, when the ceramic sheet 19 is wound circumferentially around the support member 17, the two internal terminals 42 are located opposite each other in the radial direction of the support member 17. As a result, since the distance between the two internal terminals 42 increases, the occurrence of discharge between the two internal terminals 42 can be prevented.

[0033] The present embodiment may be modified as follows.

- According to the above embodiment, ceramic paste is applied onto one side of the green sheet laminate 54, and

the green sheet laminate 54 is wound onto and bonded to the outer circumferential surface 18 of the support member 17. However, as shown in FIG. 6, a portion of the ceramic paste 61 may be applied in such a manner as to cover the end surfaces of the green sheet laminate 62 which is to become the ceramic sheet, and an outer circumferential surface 64 of a support member 63. Notably, even in this case, the distance w is the length from the end edge of the heater wiring (a green electrode 65) to the end surface of the ceramic sheet (the green sheet laminate 62).

- According to the above embodiment, the support member 17 of the ceramic heater 11 has a tubular shape; however, the support member may have a rod shape. That is, the ceramic heater may be used in a product (e.g., a fan heater) other than a hot-water bidet.
- The ceramic heater 11 of the above embodiment is energized through application of AC voltage between the paired internal terminals 42, but may be energized through application of DC voltage between the paired internal electrodes 42.

[0034] Next, besides the technical ideas described in claims, technical ideas understood from the above embodiment are enumerated below.

(1) A ceramic heater comprises a support member made of ceramic, and a ceramic sheet having heater wiring incorporated therein, and wound circumferentially around the support member, and is characterized in that the heater wiring comprises a plurality of wiring portions extending along an axial direction of the support member, and connecting portions each connecting the adjacent wiring portions, and characterized by satisfying a relational expression $t \geq 0.2$ mm, at least one of relational expressions $L/V \geq 9/500$ and $w/V \geq 3/500$, and relational expressions $t/V \geq 1/500$ and $w/t \geq 3$, where t (mm) is a thickness in the ceramic sheet from a surface of the heater wiring to an outer circumferential surface of the ceramic sheet, V (V) is a voltage applied to the heater wiring, w (mm) is a distance from an end edge of the heater wiring to an end surface of the ceramic sheet at a winding end portion of the ceramic sheet, and L (mm) is a distance between paired wiring portions disposed opposite each other with the winding end portion intervening therebetween.

(2) A ceramic heater according to the above means 1, wherein the line width of the individual wiring portions is identical with the line width of the individual connecting portions.

DESCRIPTION OF REFERENCE NUMERALS

[0035]

11: ceramic heater

17, 63: support member

18, 64: outer circumferential surface of support member

19: ceramic sheet

20: winding end portion

21: slit

41: heater wiring

44: wiring portion

45: connecting portion

46: surface of heater wiring

47: outer circumferential surface of ceramic sheet

48: end surface of ceramic sheet

L : distance between paired wiring portions disposed opposite each other with winding end portion intervening therebetween

t : thickness from surface of heater wiring to outer circumferential surface of ceramic sheet

V : voltage

w : distance from end edge of heater wiring to end surface of ceramic sheet

Claims

1. A ceramic heater comprising a support member made of ceramic, and a ceramic sheet having heater wiring incorporated therein, and wound circumferentially around the support member, the ceramic heater being **characterized in that** the heater wiring comprises a plurality of wiring portions extending along an axial direction of the support member, and connecting portions each connecting the adjacent wiring portions, and **characterized by** satisfying a relational expression $t \geq 0.2$ mm and at least one of relational expressions L/V

$\geq 9/500$ and $w/V \geq 3/500$, where t (mm) is a thickness in the ceramic sheet from a surface of the heater wiring to an outer circumferential surface of the ceramic sheet, V (V) is a voltage applied to the heater wiring, w (mm) is a distance from an end edge of the heater wiring to an end surface of the ceramic sheet at a winding end portion of the ceramic sheet, and L (mm) is a distance between paired wiring portions disposed opposite each other with the winding end portion intervening therebetween.

2. A ceramic heater according to claim 1, wherein at least one of relational expressions $t/V \geq 1/500$ and $w/t \geq 3$ is satisfied.
3. A ceramic heater according to claim 1 or 2, wherein a slit which extends along the axial direction of the support member and through which an outer circumferential surface of the support member is exposed is formed at the winding end portion, and a relational expression $0.2 \leq L - 2w \leq 1.5$ is satisfied, where a width of the slit is derived from the expression $L - 2w$.
4. A ceramic heater according to any one of claims 1 to 3, wherein the support member and the ceramic sheet are formed of alumina.
5. A ceramic heater according to any one of claims 1 to 4, wherein the heater wiring contains at least one of tungsten and molybdenum as a main component.

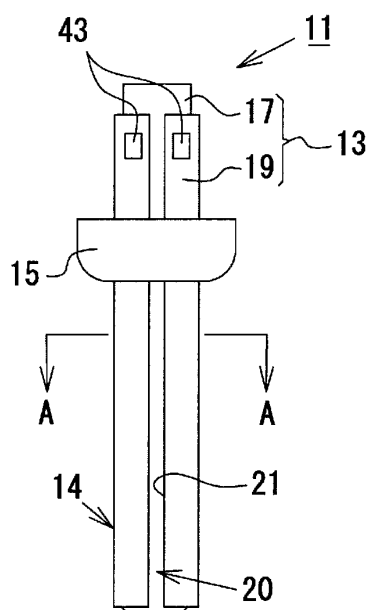


FIG. 1

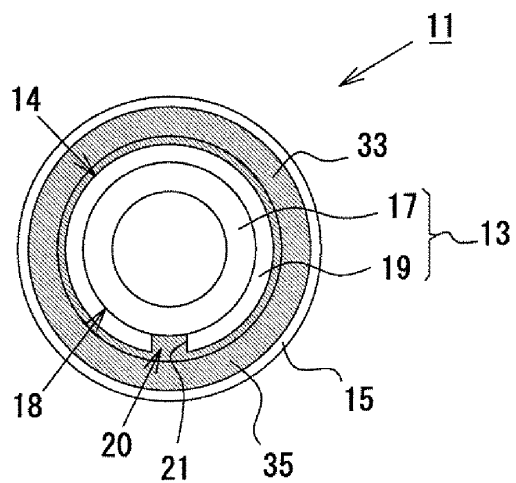


FIG. 2

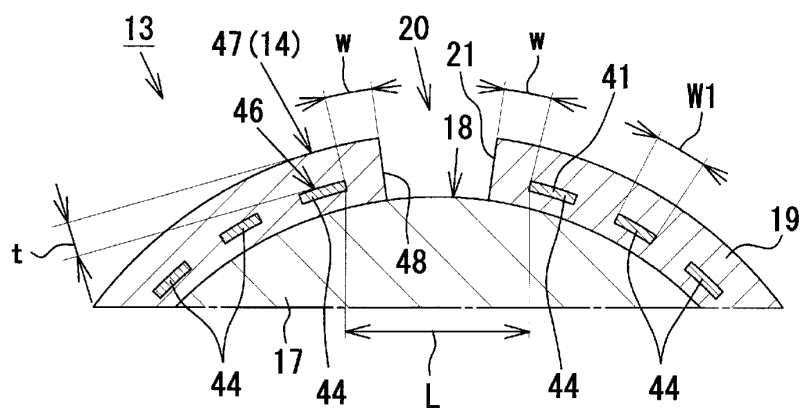


FIG. 3

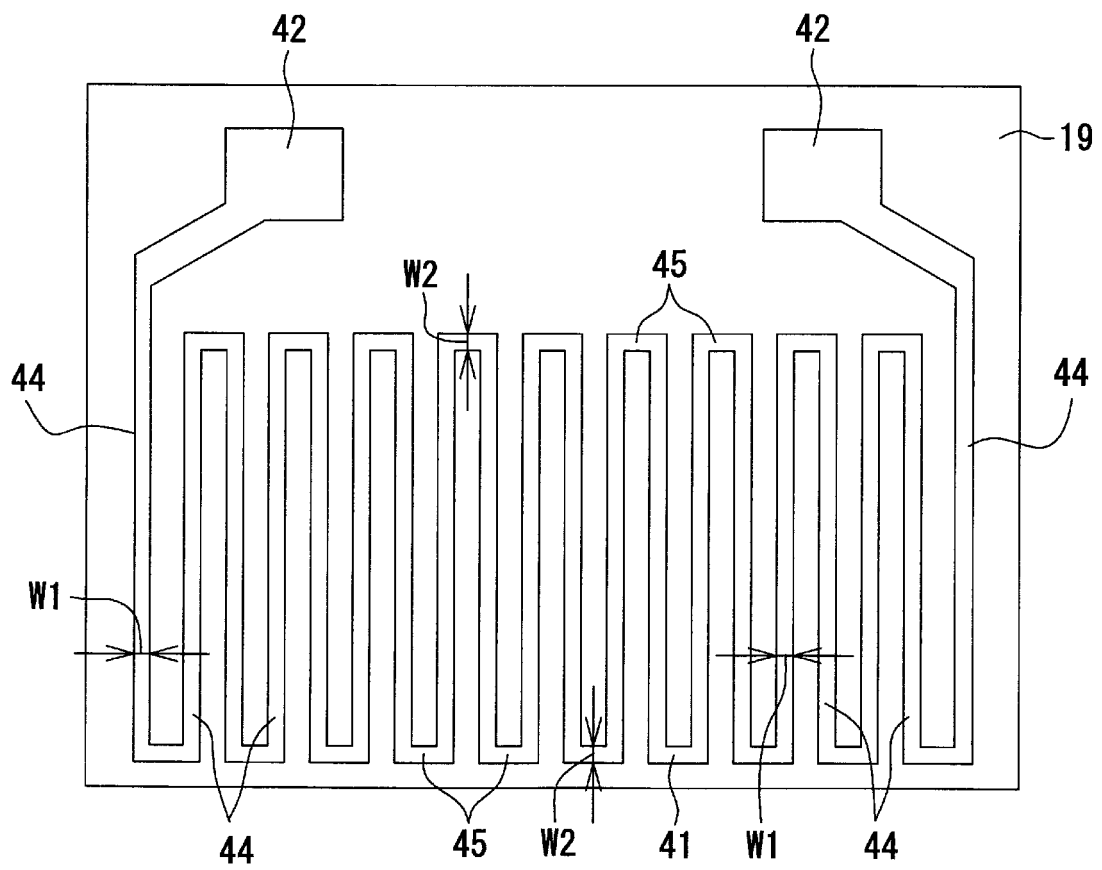


FIG. 4

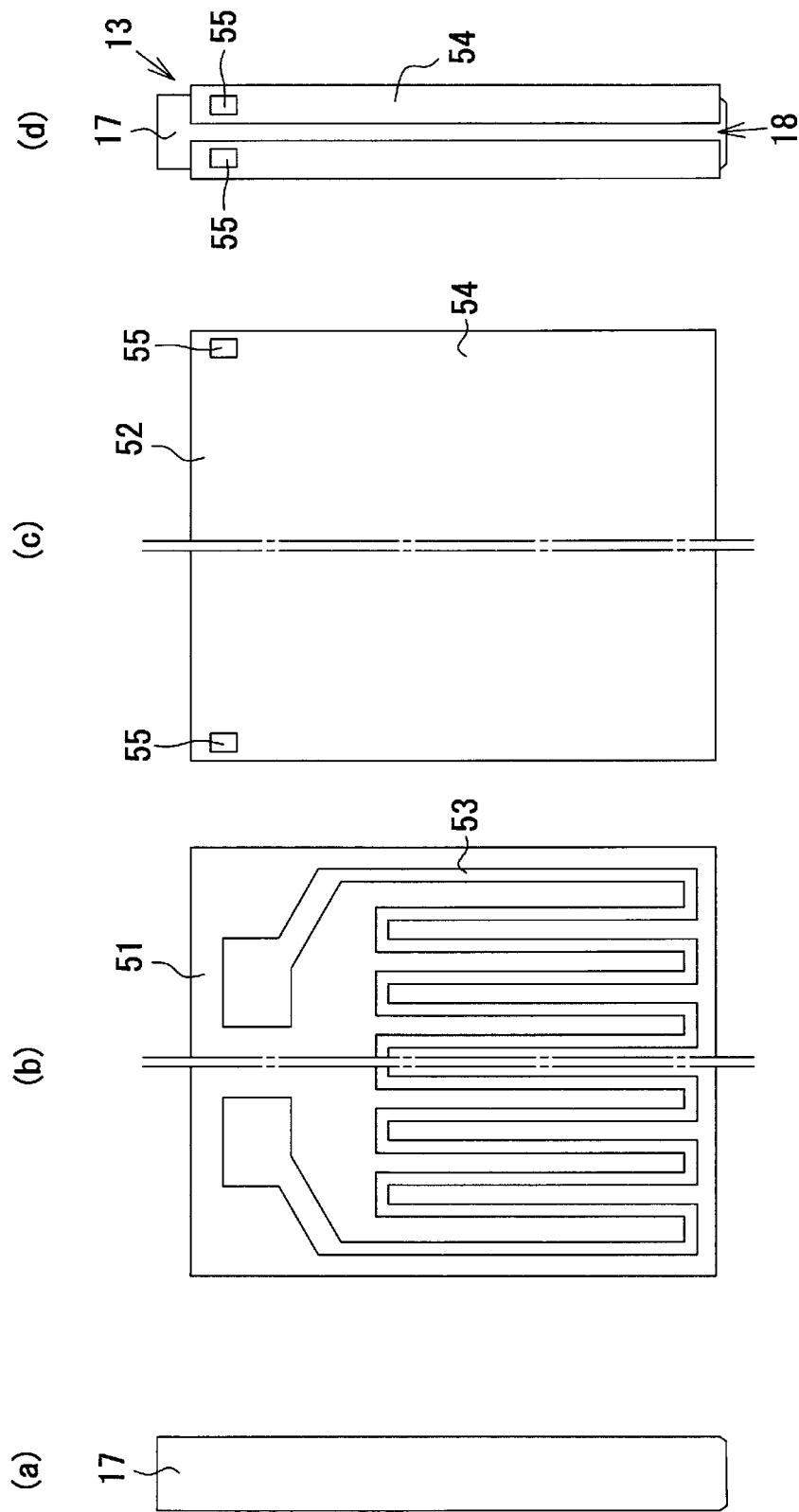


FIG. 5

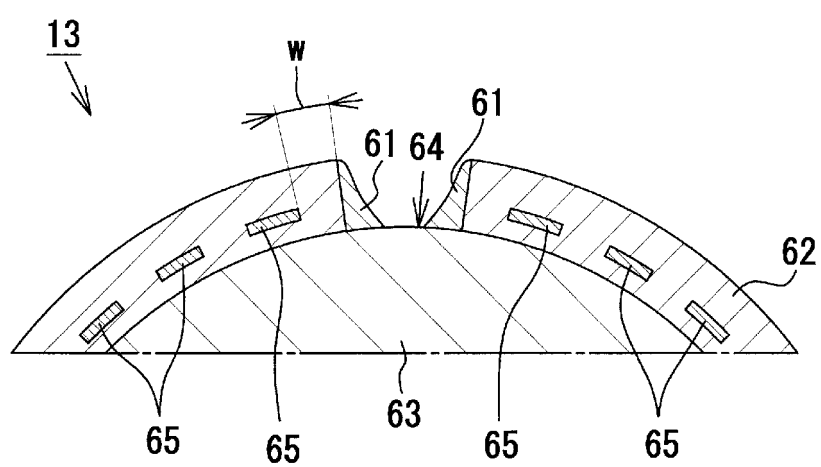


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/088805

A. CLASSIFICATION OF SUBJECT MATTER

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)

H05B3/48

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2017
 Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

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.
Y	JP 9-052784 A (NGK Spark Plug Co., Ltd.), 25 February 1997 (25.02.1997), paragraphs [0012] to [0016]; fig. 3 to 6 (Family: none)	1-5
Y	JP 2001-284031 A (Toto Ltd.), 12 October 2001 (12.10.2001), paragraphs [0015], [0041] (Family: none)	1-5

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search
08 March 2017 (08.03.17)Date of mailing of the international search report
21 March 2017 (21.03.17)

Name and mailing address of the ISA/
 Japan Patent Office
 3-4-3, Kasumigaseki, Chiyoda-ku,
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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 3038039 B [0004]