

SPECIFICATION

METHOD FOR BONDING CERAMICS AND METAL AND A BONDED ASSEMBLY OF CERAMICS AND METAL BONDED BY SUCH METHOD

TECHNICAL FIELD

This invention relates to a method for bonding ceramics and metal together by brazing and a bonded assembly of ceramics and metal bonded by such the method and to bonding of an electrically insulating material (ceramics) and a metal in an operating rod that is electrically insulated for opening and closing the contacts of a switch for turning on and off the electric power.

BACKGROUND ART

A conventional method and a bonded assembly will be described in conjunction with Fig. 7.

Fig. 7 is a bonded assembly disclosed in Japanese Patent Laid-Open No. 1-299790, in which a nickel plate 4 and a tungsten plate 5 or the like are interposed as an intermediate material between alumina 1 as ceramics and nickel rod 2 as a metal. In the figure, 3 is a brazing material.

Since metal has a thermal expansion coefficient greater than the alumina and shrinks at a higher rate than alumina while the temperature is decreasing at which the molten brazing material is hardening, a compression stress is generated at the central portion of the alumina at which it is bonded to metal and a tensile stress is generated at its peripheral portion and stress remains at a room temperature. Such large residual tensile stress is undesirable because alumina is brittle against the tensile force while it is strong against the compression.

The intermediate material is a member for absorbing the above residual stress and used for obtaining the stability of the strength as the bonded assembly.

Other examples of the intermediate materials include, as described in

"Ceramic Bonding Technology", Nobuya Kishimoto and Tadakazu Suga, published by the Nikkan Kogyo News Paper, 1990, Niobium (Nb), molybdenum (Mo), aluminum (Al), copper (Cu), an alloy of iron-nickel-chromium (Fe-Ni-Cr), copper-carbon (Cu-C), aluminum-silicon carbide (Al-SiC), foam metal, porous material and the like.

The above intermediate materials were indispensable in the conventional bonding method and the bonded assembly according to such the method. Therefore, upon the bonding operation, the number of the parts are large, assembly is difficult and time consuming and the manufacturing cost is high.

Also, when the surface condition of the intermediate material is poor, a sufficiently strong bonding strength cannot be obtained, so that the surface condition must be sufficiently managed.

The present invention has as its object the provision of a bonding method and a bonded assembly in which above problems are solved and in which the bonding strength

DISCLOSURE OF INVENTION

The invention of claim 1 is, in a bonding method for bonding ceramics and a metal to each other by brazing, characterized in that a bonding surface area on the metal side is not exceeding 90% of a bonding area on the ceramics side.

The invention of claim 2 is, in a bonding method for bonding ceramics and a metal to each other by brazing, characterized in that a bonding surface area on the metal side is not exceeding 90% of a bonding area on the ceramics side so that the ceramics is not damage by a residual thermal stress.

The invention of claim 3 is, in the bonding method for bonding ceramics and a metal as claimed in claim 2, characterized in that the bonding surface is flat surface.

The invention of claim 4 is, in the bonding method for bonding ceramics and a metal as claimed in claim 2, characterized in that the ceramics is alumina, and the metal is copper, nickel or iron.

The invention of claim 5 is, in the bonding method for bonding ceramics and a metal as claimed in claim 2, characterized in that the ceramics is alumina,

and the metal is an alloy including as a main component at least one of copper, nickel and iron.

The invention of claim 6 is, in the bonding method for bonding ceramics and a metal as claimed in claim 2, wherein a brazing material with an active metal is used when there is no metallized surface formed on the bonding surface of the ceramics.

The invention of claim 7 is, in the bonding method for bonding ceramics and a metal as claimed in claim 6, wherein the active metal is titanium (Ti) or zirconium (Zr).

The invention of claim 8 is, in a bonded assembly of ceramics and a metal, characterized in that the assembly is bonded by a bonding method for bonding ceramics and a metal by brazing and that a bonding surface area on the metal side is not exceeding 90% of a bonding area on the ceramics side so that the ceramics is not damaged by a residual thermal stress.

The feature of the present invention is, as shown in Fig. 1 in sectional views of the bonded assembly of ceramics 10 and a metal 20, in the brazing bonding surface (hereinafter referred to simply as bonding surface) between the ceramics 10 and the metal 20, the bonding surface area of the metal 20 is made smaller than the bonding surface area of the ceramics 10 by making it not exceeding 90% of the bonding surface area of the ceramics 10, for example. Both bonding surfaces may be made flat for ceramics 10 and metal 20 for better results. By this bonding method, the tensile residual stress can be alleviated at the ceramics 10 side without using the intermediate material.

In this application, the bonding surface of the metal 20 means, literally, the entire surface that is brought into substantial contact with and bonded to the ceramics 10 side. On the other hand, the bonding surface of the ceramics 10 means the region out of which the tensile residual stress on the ceramics 10 due to the thermal expansion difference relative to the metal 20 becomes neglectably small and includes the surface portion at which it is in substantial contact with the metal 20 side as well as the surface in which the above surface portion and its extension that does not contact with metal 20 side. The negligibly small as to the residual tensile stress refers to the extent at which the stress does not show any undesirable effects on the stability of the strength required to the bonded assembly.

For use as an electrically insulating rod of a switch apparatus, the above-mentioned ceramics may preferably be alumina (alumina ceramics).

As for the metal, the preferable metal includes not only copper, but also alloys containing copper as a main component such as copper-zinc (Cu-Zn), copper-tin (Cu-Sn), copper-chromium (Cu-Cr), copper-zirconium (Cu-Zr), copper-beryllium (Cu-Be), copper-titanium (Cu-Ti), and nickel (Ni) and its alloys containing nickel as a main component such as nickel-copper (Ni-Cu), Monel and Inconel, and iron (Fe) and its alloys containing iron as a main component such as iron-nickel (Fe-Ni), Kovar and Incoloy. Monel, Inconel, Kovar and Incoloy are all trade names.

According to experiments, when the bonding surface area of the metal 20 exceeds 90%, a large thermal stress remains in the ceramics, resulting in the decrease in the strength of the brazed bonding and the generation of breakage of the ceramics upon the completion of the brazing.

When an active metal brazing material containing a suitable amount of titanium (Ti), zirconium (Zr) and the like is used, the step of metallizing or nickel plating the bonding surface may be omitted and still a bonded assembly exhibiting a sufficient bonding strength can be obtained.

Therefore, according to the present invention, the metallization or the nickel plating of the bonding surface of the members to be bonded can be eliminated.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagrammatic vertical sectional view showing one embodiment of the present invention;

Fig. 2 is a diagrammatic vertical sectional view showing a portion of the operating rod of a switch of the first embodiment;

Fig. 3 is a diagrammatic vertical sectional view showing the second embodiment of the present invention, (a) - (e) being figures showing the modified examples;

Fig. 4 is a diagrammatic vertical sectional view showing the third embodiment of the present invention, (a) - (e) being figures showing the modified examples;

Fig. 5 is a diagrammatic vertical sectional view showing the fourth

embodiment of the present invention, (a) - (e) being figures showing the modified examples;

Fig. 6 is a table showing the experimental results of the present invention; and

Fig. 7 is a typical vertical sectional view showing a conventional technique.

BEST MODES FOR CARRYING OUT THE INVENTION

The embodiments of the present invention will now be described with a bonded assembly of a ceramic and a metal taken as an example.

While the bonded assembly in this example is in the form of having ceramics as an insulator in the middle and having metal of the same kind is bonded at each end of the ceramics and having two bonded portions, only one of the bonded portions will be described because the two bonded portions are similar to each other.

Embodiment 1

In the embodiment shown in Fig. 2, in this first embodiment, an alumina ceramic rod 11 of $\phi 20 \times L20\text{mm}$ metallized and nickel plated at the brazing surface and a copper rod (Cu) 21 selected from the ones of L50mm and different outer diameter of $\phi 30, 20, 19, 18, 15$ and 10mm are stacked in an upright position with a brazing material (BAg-8) 31 having a thickness of 0.1mm sandwiched therebetween and heated at $800^\circ\text{C} \times 5\text{min.}$ under a vacuum of $1 \times 10^{-5}\text{Torr}$ to braze them.

After the brazing, the copper rods (Cu) 21 brazed at the opposite ends of the ceramic rod 11 are measured as to its tensile brazed strength by a tensile testing machine and the results as shown in the table of Fig. 6 were obtained.

According to the table, when the diameter of the copper rod (Cu) 21 is small, the breakage took place at the copper rod (Cu) 21, but the breakage moves to the ceramic rod 11 when the diameter of the copper rod (Cu) 21 becomes larger and when the diameter of the copper rod (Cu) 21 is larger than the diameter of the ceramic rod 11, cracks generate in the ceramic rod 11 at the time of completion of the brazing and it was not possible to subjected to the tensile test of the samples.

The breakage of the ceramic rod 11 is due to the residual thermal stress and particularly to the residual tensile stress, which causes the breakage of the ceramic rod 11 to initiate and significantly decrease the strength from the point about where the bonding surface area of the copper rod (Cu) 21 exceeds about 90% of the bonding surface area of the ceramics rod 11.

From these results, it is understood that the bonding surface area of the copper rod (Cu) 21 is equal to or less than about 90% of the bonding surface area of the ceramic rod 11.

Embodiment 2

In the embodiment shown in Fig. 2, an alumina ceramic rod 11 of $\phi 20 \times L20\text{mm}$ without being metallized at the brazing surface and a copper rod (Cu) 21 selected from the ones of L50mm and different outer diameter of $\phi 20$, 19 and 18mm are stacked in an upright position with an active brazing material 31 containing titanium (Ti) and having a thickness of 0.1mm, such as a commercially available brazing material of silver-copper-titanium (Ag-Cu-Ti), sandwiched therebetween and heated at $900^{\circ}\text{C} \times 5\text{min.}$ under a vacuum of $1 \times 10^{-5}\text{Torr}$ to braze them.

After the brazing, the brazed assembly was measured as to its tensile brazed strength by a tensile testing machine in a manner similar to that of the first embodiment and the results as shown in the table of Fig. 6 were obtained.

According to the table, the brazing strength was not very much different from the case where the metallized surface was bonded by a commercially available brazing material (B-Ag-8).

Embodiment 3.

In the embodiment shown in Fig. 2, an alumina ceramic rod 11 of $\phi 20 \times L20\text{mm}$ metallized and nickel plated at the brazing surface and a rod 21 selected from the ones of Monel, Ni, Fe, Fe-42Ni rod 21 of L50mm and different outer diameter of $\phi 19$ and 18mm are stacked in an upright position with a commercially available brazing material (B-Ag-8) 31 having a thickness of 0.1mm sandwiched therebetween and heated at $800^{\circ}\text{C} \times 5\text{min.}$ under a vacuum of $1 \times 10^{-5}\text{Torr}$ to braze them.

After the brazing, the brazed assembly was measured as to its tensile

brazed strength by a tensile testing machine in a manner similar to that of the first and second embodiments and the results as shown in the table of Fig. 6 were obtained.

According to the table, while there is a difference in the breaking strength, the breakage of the ceramic rod 11 was initiated from the point about where the bonding surface area of the metal rod 21 exceeds 90% of the bonding surface area of the ceramic rod 11 and the decrease in strength was significantly large.

This trend is similar to the case of copper (Cu) and the bonding surface area of the copper rod should be equal to or less than 90% of the bonding surface area of the alumina ceramics.

Embodiment 4.

Although the description has been made in terms of the cylindrical alumina ceramics 12 and the cylindrical metal rod 21 in the above first to third embodiments, the brazing bonding portion of the ceramics 11 and the metal 21 may be configured to have longitudinal cross-sections as shown in Figs. 3(a) to 3(e) as well as transverse cross-sections as shown in Figs. 4(a) to 4(i), for example as long as the configuration is within a range of not providing an undesirable effect on the strength stability required for the bonded assembly.

The bonding surface of the ceramics 11 side is not required to be flat over the entire surface and, as illustrated in Figs. 3(c) and 3(d), is sufficient when at least the bonding surface to which the metal 21 side bonding surface is substantially brought into contact, and the bonding area that does not contact does not have to be flat and may have properly cut surfaces.

Embodiment 5

In the fifth embodiment illustrated in Fig. 5, the metal 21 may not be solid shape, but may be hollow as shown in Fig. 5(a) as seen in the cross-sectional view of the brazing bonding surface, or may have slits as shown in Fig. 5(b).

INDUSTRIAL APPLICABILITY

According to the inventions as recited in claims 1 to 7, a reliable bonding method for the ceramics and the metal in which the intermediate material is not

needed and the number of the parts is reduced, the assembly is easy, the manufacturing cost is low and in which the bonding strength is high.

According to the invention as recited in claim 8, an inexpensive bonded assembly in which the ceramics and the metal are bonded with a sufficient brazing strength and which can be easily manufactured with a low manufacturing cost.

CLAIMS



1. A bonding method for bonding ceramics and a metal to each other by brazing characterized in that a bonding surface area on the metal side is not exceeding 90% of a bonding area on the ceramics side.
2. A bonding method for bonding ceramics and a metal to each other by brazing, characterized in that a bonding surface area on the metal side is not exceeding 90% of a bonding area on the ceramics side so that the ceramics is not damage by a residual thermal stress.
3. The bonding method for bonding ceramics and a metal as claimed in claim 2; wherein said bonding surface is flat surface.
4. The bonding method for bonding ceramics and a metal as claimed in claim 2, wherein said ceramics is alumina, and said metal is copper, nickel or iron.
5. The bonding method for bonding ceramics and a metal as claimed in claim 2, wherein said ceramics is alumina, and said metal is an alloy including as a main component at least one of copper, nickel and iron.
6. The bonding method for bonding ceramics and a metal as claimed in claim 2, wherein a brazing material with an active metal is used when there is no metallized surface formed on the bonding surface of the ceramics.
7. The bonding method for bonding ceramics and a metal as claimed in claim 6, wherein said active metal is titanium or zirconium.
8. A bonded assembly of ceramics and a metal characterized in that the assembly is bonded by a bonding method for bonding ceramics and a metal by brazing and that a bonding surface area on the metal side is not exceeding 90% of a bonding area on the ceramics side so that the ceramics is not damaged by a residual thermal stress.

ABSTRACT

This invention has been made to aim the provision of a method for bonding ceramics and metal without using an intermediate material and a bonded assembly of the ceramic and metal and is characterized in that a bonding surface area on the metal side is not exceeding 90% of a bonding area on the ceramics side

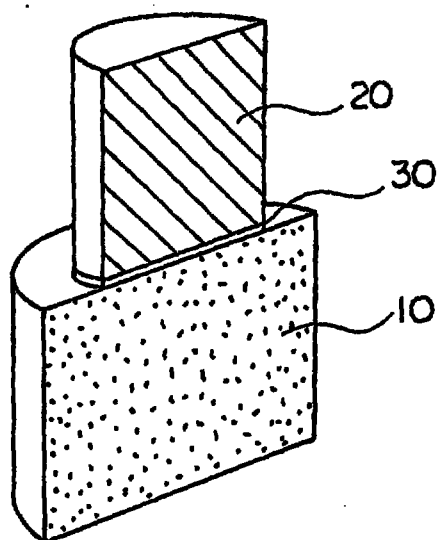
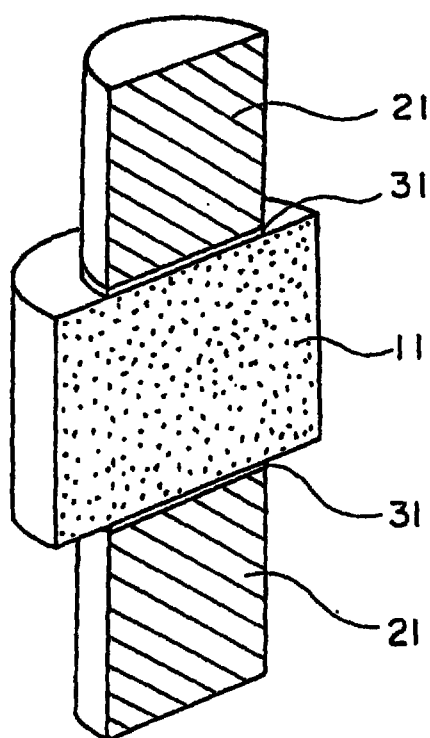
FIG. 1**FIG. 2**

FIG. 3

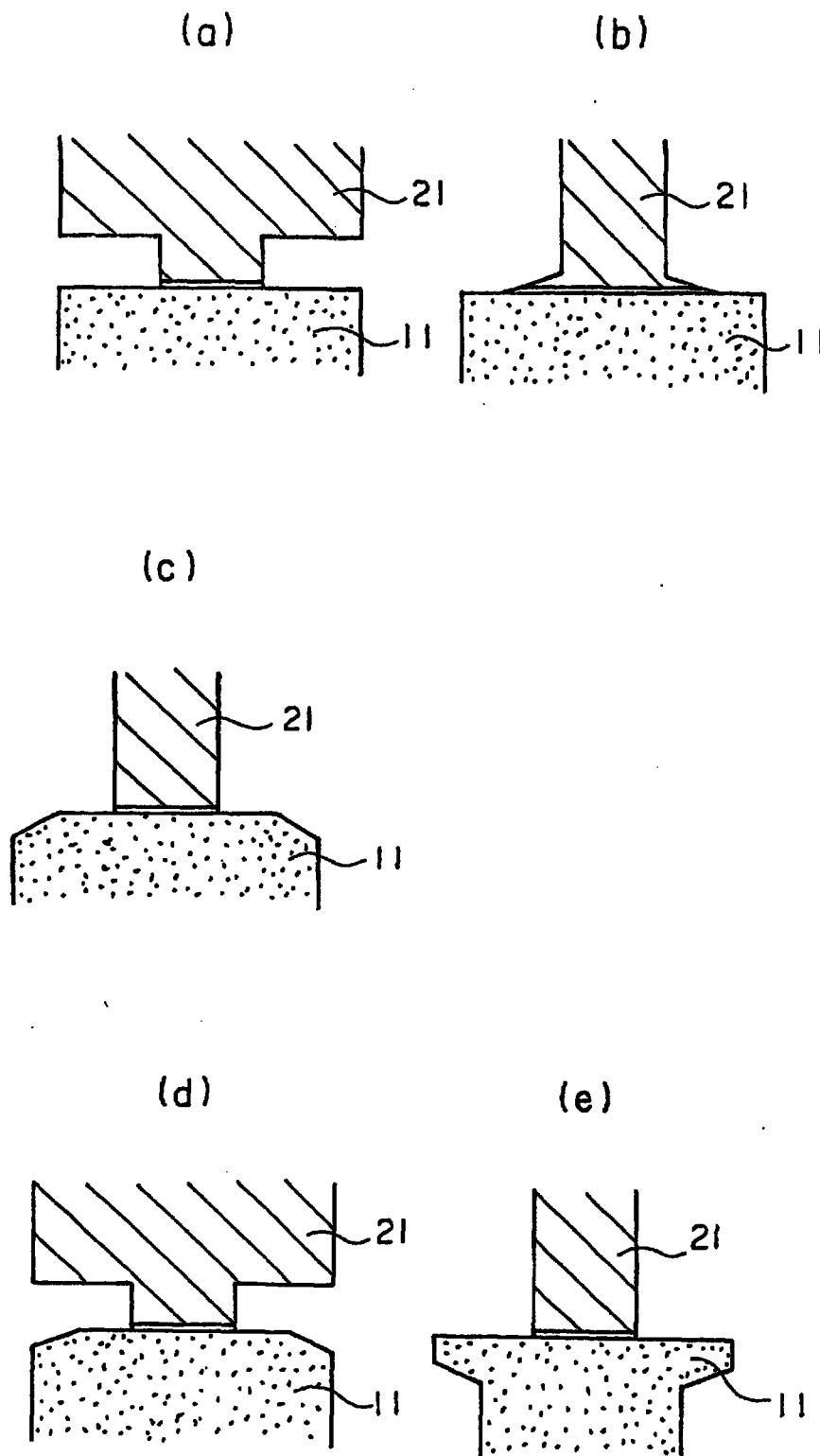


FIG. 4

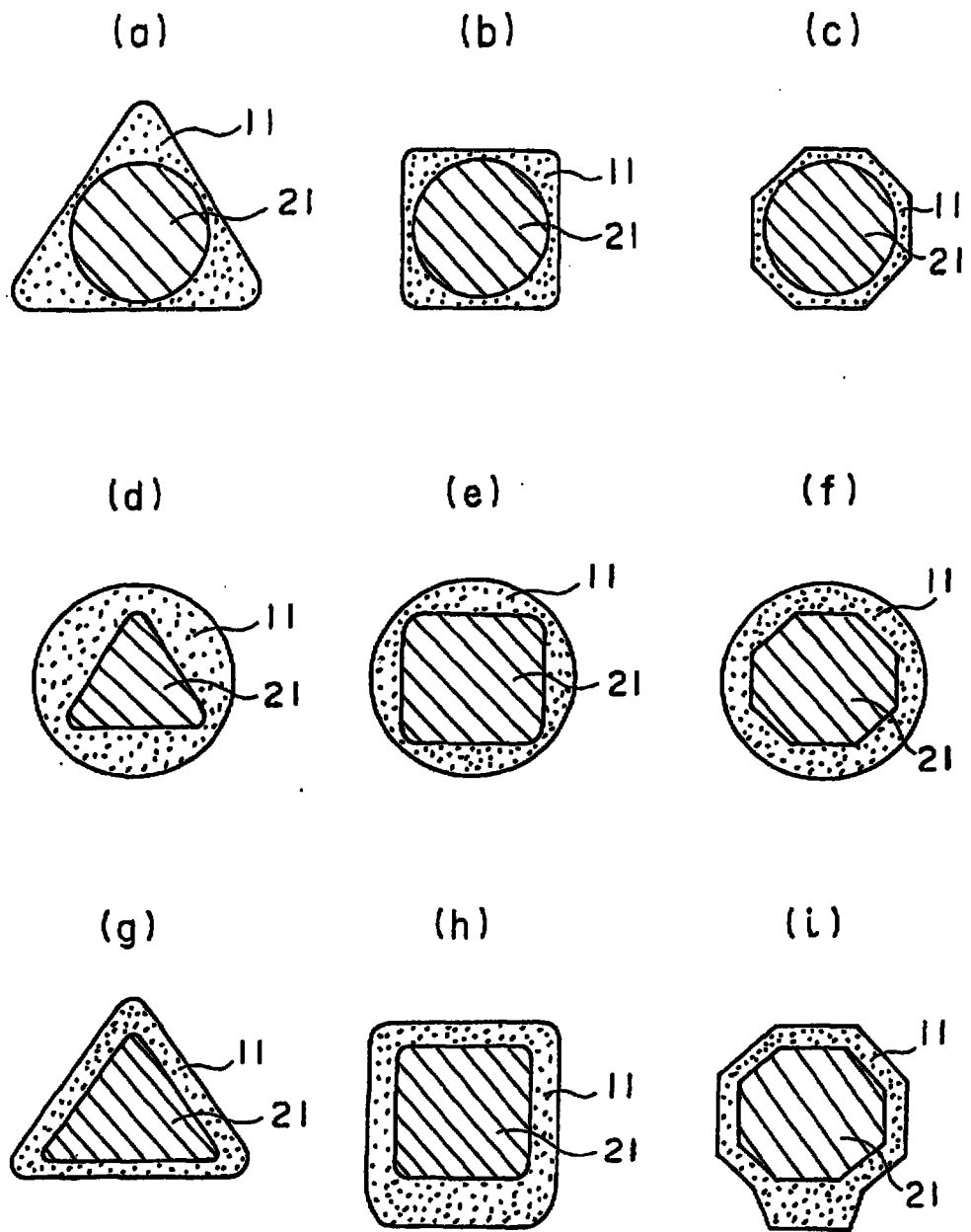


FIG. 5

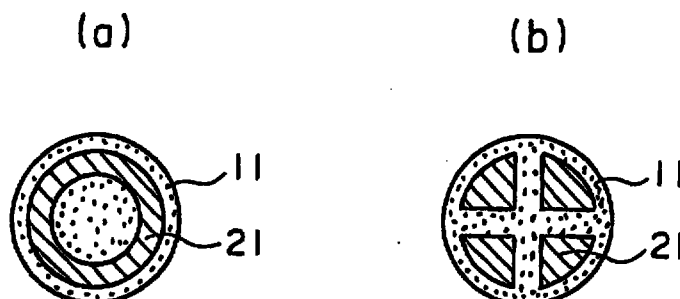


FIG. 6

No.	rod diameter (mm)	breaking strength (kgf)	breaking position	notes
1	copper ϕ 30	-	alumina	
2	copper ϕ 20	300	alumina	
3	copper ϕ 20	320	alumina	active brazing used
4	copper ϕ 19	6000	alumina	
5	copper ϕ 19	5900	alumina	active brazing used
6	copper ϕ 18	5600	copper rod	
7	copper ϕ 18	5620	copper rod	active brazing used
8	copper ϕ 15	3900	copper rod	
9	copper ϕ 10	1730	copper rod	
10	Monel ϕ 19	13000	alumina	
11	Monel ϕ 18	12500	Monel	
12	Ni ϕ 19	8500	alumina	
13	Ni ϕ 18	8100	Ni	
14	Fe ϕ 19	8600	alumina	
15	Fe ϕ 18	8100	Fe	
16	Fe-42Ni ϕ 19	13000	alumina	
17	Fe-42Ni ϕ 18	12500	Fe-42Ni	

FIG. 7

