

Nov. 8, 1966

H. S. J. PIJLS

3,283,401

METHOD OF CONNECTING OBJECTS MADE OF MATERIALS HAVING  
DIFFERENT THERMAL COEFFICIENTS OF EXPANSION BY MEANS  
OF A THERMOSETTING GLUE WITH THE USE  
OF AN AUXILIARY PIECE  
Filed Nov. 13, 1963

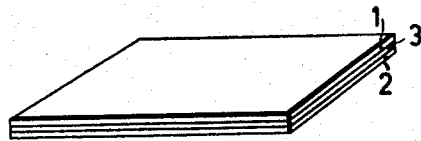


FIG. 1

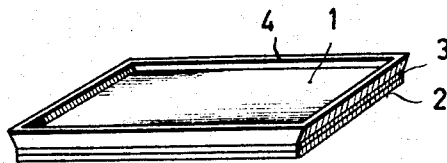


FIG. 2

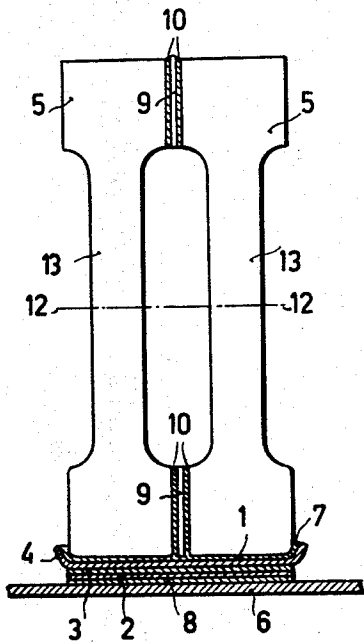


FIG. 3

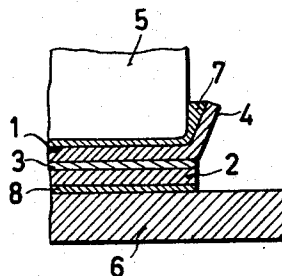


FIG. 4

INVENTOR

HERMANUS ST. J. PIJLS

BY

*Frank R. Dufair*

AGENT

1

3,283,401

**METHOD OF CONNECTING OBJECTS MADE OF MATERIALS HAVING DIFFERENT THERMAL COEFFICIENTS OF EXPANSION BY MEANS OF A THERMOSETTING GLUE WITH THE USE OF AN AUXILIARY PIECE****Hermanus Stephanus Josephus Pijls, Emmasingel, Eindhoven, Netherlands, assignor to North American Philips Company, Inc., New York, N.Y., a corporation of Delaware**

Filed Nov. 13, 1963, Ser. No. 323,317

Claims priority, application Netherlands, Nov. 22, 1962, 285,841

4 Claims. (Cl. 29—470)

This invention relates to a method of connecting objects made of materials having different coefficients of expansion by means of a thermosetting glue with the use of an auxiliary piece.

It is often necessary in engineering to connect together objects made of materials having different coefficients of expansion. If for making the connection a glue is chosen which hardens at elevated temperature, for example higher than 150° C., so great stresses may arise in the objects upon cooling that cracks result in the objects to be connected together. It is known that such stresses may be decreased by providing between the two objects to be connected an auxiliary piece in the form of an intermediate layer made from a material having a co-efficient of expansion which lies between the coefficients of expansion of the materials of which the objects are constituted. However, to arrive at a satisfactory result, the said intermediate layer must usually be fairly thick, for example 10 mm. or more, which may in technical respect cause many difficulties of other character. Tests have revealed that stresses occur in the material of the lower coefficient of expansion when using a glue which hardens at elevated temperature. If such material has only a low tensile strength, such as many ceramic materials, the stresses may cause cracks a few millimetres above the glue seam. This phenomenon occurs more particularly if a ceramic object of great thickness is secured to a thin metal plate, for example from 1 to 3 mm. thick.

It has been found that permanent stresses can be avoided especially in the said cases by using layer-shaped auxiliary pieces of a suitable shape and structure. The invention is based upon recognition of the fact that permanent stresses will not occur after cooling in objects connected together by means of glue at elevated temperature if between the objects a layer exists of a material which can creep by the action of forces which occur during cooling of the glued connection. It has been found that this may be achieved in practice by using a stratified auxiliary piece comprising two or more metal foils or thin sheets between which and connected thereto a layer of a metal exists which starts to creep at normal temperatures already at a load of about 1 kg./cm.<sup>2</sup> or lower, such as may occur in gluing. Such metals are, for example, lead, tin, zinc, bismuth and certain alloys of these metals.

The method according to the invention is thus characterized by the use of an auxiliary piece comprising two or more metal foils or sheets between which and connected thereto a layer of a metal is present which starts to creep by the action of the forces which occur during cooling of the glued connection.

It has been found that excellent results are already obtained by using an auxiliary piece comprising two metal plates and between them a layer of a metal which starts to creep by the action of the forces occurring in gluing.

In order that the invention may be readily carried into effect, it will now be described in detail, by way of example, with reference to the accompanying diagrammatic drawing, in which:

2

FIGURES 1 and 2 are perspective views of auxiliary pieces which can be used for securing objects having rectangular basal surfaces;

FIGURE 3 is a cross-sectional view, in natural size, of a ceramic object connected to a metal plate in accordance with the invention;

FIGURE 4 shows a portion of FIGURE 3 on an enlarged scale.

The auxiliary piece shown in FIGURE 1 comprises two metal foils or sheets 1 and 2. A favorable thickness for these metal foils is, for example, 0.3 mm. Satisfactory results can also be obtained with thicker or thinner foils, provided the foil can follow the small deformations of the ceramic object and be handled. The foils may consist of any arbitrary metal, provided a thermosetting glue satisfactorily adheres thereto, such as copper and copper alloys. The adhesion to metals capable of creeping is usually not sufficient. Especially with tin and lead it has been found impossible to obtain an adhesion which is sufficiently resistant to shocks. It is furthermore preferable for the metal to be such as to follow the deformation of the ceramic body. A suitable metal is, for example, copper. Also alloys such as brass, tombac and the like can be used. Between the foils 1 and 2 and connected thereto is a thin layer 3 of a metal or metal alloy which can creep by the action of the forces which occur in gluing. For example, a thin layer of a soldering metal, such as lead-tin solder (for example Pb-Sn 40-60, 50-50 and the like) has been found very suitable within the scope of the invention. The layer may be extremely thin, for example 0.1 mm. or thinner.

The auxiliary piece shown in FIGURE 2 fundamentally has the same structure as the auxiliary piece shown in FIGURE 1, only the metal foil has an upright edge 4. Glue provided on the layer 1 is prevented by the upright edge 4 from flowing away in all directions. The auxiliary pieces may have any arbitrary shape which has been matched to the objects to be glued together. They may have surfaces of circular, rectangular or any other shape. The auxiliary pieces may especially be used in connecting together objects which cannot or with difficulty only be soldered or glued together directly or be connected in another way.

In order that the invention may be readily carried into effect, it will be explained more particularly with reference to the connection of an object of ceramic material to a metal.

FIGURE 3 is a sectional view of a so-called transducer which can be used in converting electrical energy into mechanical energy and conversely. In this example, the transducer comprises two bodies 5 of Ferroxcube each having a length of 97 mm. between which thin plates 9 of Ferroxdure are present. The bodies 5 and the plates 9 are connected together by glued connections 10. The assembly is glued to a metal surface 6, for example, the base of a vessel of rustless steel (thickness of metal 2 mm.) with the use of an auxiliary piece as shown in FIGURE 2. A glue layer 7 is present between the auxiliary piece and the transducer. Another glue layer 8 exists between the auxiliary piece and the metal plate 6, which layer 8 consists, for example, of the same glue as that used for the glue layer 7. It is alternatively possible to use different kinds of glue for the two glue layers.

An essential part of ultrasonic cleaning equipment is the so-called transducer the function of which is to convert the electrical energy supplied into mechanical oscillations. The element bringing about said conversion is often made of a ceramic material, for example, Ferroxcube. In order to obtain satisfactory efficiency and easy handling, one or more of such elements are glued to or in a container or vessel of erosion-resistant and chemical-resistant material, usually rustless steel. In this con-

3

struction the glue layer is subject to great varying forces (10 to 50 kg./cm.<sup>2</sup>) of high frequencies (20 to 40 kc./s.). To achieve a minimum dissipation of energy in the glue layer due to mechanical losses occurring, the glue layer must be thin and consist of a hard glue. It is also desirable that the glue layer should retain its strength up to about 100° C. because it must often be possible for the cleaning liquid to be heated up to said temperature. Thermosetting glues fulfilling these requirements can be obtained on the basis of ethoxyline resins and are commercially sold. The suitable hardening temperature for these glues usually lies between 150° C. and 250° C.

However, upon cooling from the hardening temperature of the glue (usually 150°), so great stresses occur in the Ferroxcube due to the different coefficients of expansion of Ferroxcube ( $7 \times 10^{-6}$ ) and rustless steel ( $16.2 \times 10^{-6}$ ) that breakage often occurs a few millimetres above the glue layer.

By using in accordance with the method according to the invention an auxiliary piece as shown in FIGURE 1 or 2, comprising two copper foils each 0.3 mm. thick and between them a soldering layer of about 0.1 mm. thick, and a glue on the basis of ethoxyline resin, it was ensured that cracks no longer occur in the Ferroxcube body even if the glue was hardened at 170° to 180° C. and the whole was cooled down to -80° C. In the finished transducer, the parts 13 of the bodies 5 are surrounded by coils (not shown). Due to the action of electric alternating-current produced in said coils, the bodies 5 become alternately longer and shorter. It has been found that a given lengthening or shortening could be double that in a connection glued in another way. Any breakage due to overload occurs at the centre 12 of the bodies 5, from which it appears that any appreciable stresses no longer exist in the bodies 5.

Satisfactory results may also be obtained with auxiliary pieces made of other metals.

The securement may take place in a simple manner by melting the required amount of glue in the auxiliary piece and by placing the transducer in position and, if desired,

4

hardening the glue. Subsequently, the glue 8 is provided between the auxiliary piece and the metal plate 6 and the assembly heated to the temperature required for hardening the glue.

Similar results are obtained by using auxiliary pieces as shown in FIGURE 1. FIGURE 4 serves only for clarifying purposes. The reference numerals used in FIGURE 4 have the same meaning as in FIGURE 3.

The invention has been explained with reference to the securement of objects having rectangular basal surfaces to be glued together. Similar results are obtained with basal surfaces of other shape, for example circular shape. The auxiliary pieces can be matched to such shapes in a simple manner.

What is claimed is:

1. In the method of joining together objects of different coefficients of expansion with a thermosetting glue the improvement which comprises interposing between each two of said objects an auxiliary member shaped to fit the abutting contours of the adjacent objects, said member comprising a thin inner sheet of a metal capable of starting to creep when subjected to the forces generated by the cooling of the thermosetting glue and two thin outer metal sheets, of a metal other than that of the inner sheet, in contact with said inner sheet, the outer surfaces of said outer sheets being in contact with the glue.

2. The improvement as defined by claim 1 wherein the auxiliary member comprises an inner layer of solder joining together two copper sheets.

3. The improvement of claim 1 wherein the auxiliary member is container shaped.

4. The improvement of claim 1 wherein a metal object is joined to a ceramic object.

No references cited.

JOHN F. CAMPBELL, *Primary Examiner.*

L. J. WESTFALL, *Assistant Examiner.*