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METHOD OF CEMENTING CERAMIC TRANSDUCERS

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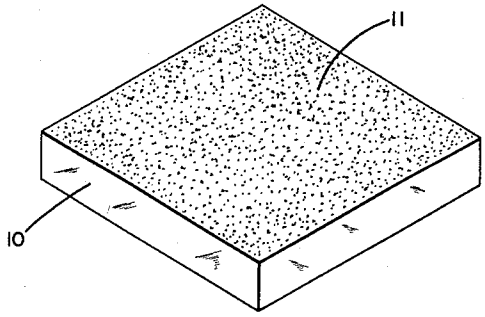


FIG. 1

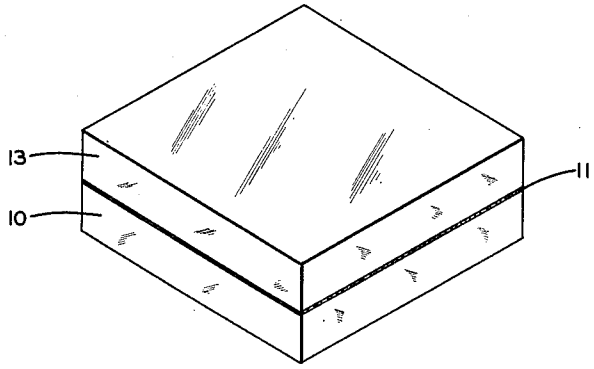


FIG. 2

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METHOD OF CEMENTING CERAMIC TRANSDUCERS

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5 Claims. (Cl. 154—75)

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This invention relates to a method of cementing together two faces of a fired ceramic transducer material which is comprised almost wholly of barium titanate.

In recent years, ceramic electromechanical transducers have come into an extensive amount of use. Such transducers are generally comprised of a fired ceramic material which is comprised mainly of barium titanate, although the material may, in some cases, have added thereto a few weight percent of some metal oxide in order to provide some particular operating characteristic. Some such transducers have only fractional percentages of other materials in the composition as impurities and it will be understood that, as used in the present specification, the term "a material which is comprised almost wholly of barium titanate" is intended to include any of the materials mentioned above.

The transducers which are made of the materials of the type here under consideration are effective to change mechanical energy into electrical energy or to change electrical energy into mechanical energy, or both. They have found a considerable amount of use as the transducing device in microphones, phonograph pickups, devices for introducing sound energy into a liquid medium, devices for producing mechanical energy from sound energy in a liquid medium, etc. Several such transducers are described and claimed in United States Letters Patent No. 2,486,560, granted on November 1, 1949, on an application of Robert B. Gray filed on September 20, 1946. Also, such transducers have been used in various forms, such as plates, disks, cylinders, focused bowls, hollow spheres, etc. It is characteristic of transducers of the type here under consideration that they may be constructed in fairly large sizes, and, in fact, this characteristic is to a considerable extent responsible for their relatively wide acceptance within the last few years.

Transducing materials of the type here under consideration, however, must be fired to relatively high temperatures and, because of this requirement, some very severe difficulties and limitations have been encountered in their production. For example, the shrinkage in a body composed of barium titanate transducing material upon firing is some 40% by volume and some 13% by length. Due to this fact, large pieces of material have a very decided tendency to crack at some point during the firing process. Also, the material becomes quite plastic at the higher temperatures in the firing cycle and, if large bodies are being fired, this characteristic of the material

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tends to cause the bodies to become distorted so that the fired body no longer corresponds, in some cases even approximately, to that of the formed body before firing. For many transducer applications, it is very desirable to have large pieces of titanate transducing material, such as plates or bodies such as focused bowls of considerable thickness and, due to the characteristics of the material mentioned above, extreme difficulties are encountered in the manufacture thereof. It would be very desirable, therefore, to be able to assemble a number of pieces of fired ceramic transducer material and fasten them together in such a way that the ultimate composite body has, for the purpose intended, substantially the characteristics of a single, unitary body of the ceramic material under consideration.

It is an object of the invention to provide an improved method of forming fired ceramic transducer bodies which are comprised almost wholly of barium titanate.

It is still another object of the invention to provide a method of cementing together two faces of a fired ceramic transducer material which is comprised almost wholly of barium titanate.

In accordance with the invention, the method of cementing together two faces of a fired transducing material which is comprised almost wholly of barium titanate comprises placing on at least one of said faces a thin layer of cementing material comprising at least 88 percent but less than 98 percent by weight of barium titanate and less than 12 percent and at least 2 percent by weight of one of the silicates from the group consisting of aluminum silicate and sodium silicate. The method also comprises placing the other of the faces in contact with the above-mentioned layer and the one face and heating the material while the faces are in engagement to a temperature within the range of 1300 to 1400 degrees centigrade.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description, taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

Fig. 1 of the drawing illustrates a plate of fired ceramic transducer material which may be utilized in forming a composite ceramic body by use of the method of the invention and Fig. 2 illustrates a composite body which is made by using the method of the invention.

Referring now to Fig. 1 of the drawings, the numeral 10 designates a plate of fired ceramic

transducer material which is comprised of barium titanate, although, as stated specifically above, a few weight percent of some other material may be included therein in order to provide certain desired transducer characteristics. One method of forming and firing such a titanate body is described in the Gray patent mentioned above. The process of the invention will be described in connection with the plate **10** by showing how the plate **10** can be cemented to a similar plate so that the composite body, at least for many purposes, will have operating characteristics similar to a single body of the ceramic transducer material involved. One of the steps of the invention therefore comprises placing upon one of the faces of the block **10** a thin layer of cementing material which comprises at least 88% but less than 98% by weight of barium titanate and less than 12%, but at least 2% by weight of one of the silicates from the group comprising aluminum silicate and sodium silicate. This cementing material may be in the form of a finely divided powder which is sprinkled over the face of the plate **10** as indicated by the numeral **11** of Fig. 1 and in any case, the percentage of silicate used in the cementing material should be greater than that in the fired material to be cemented.

In Fig. 2 there is illustrated a composite body of the type which is provided when the plate **10** is cemented to a similar plate **13** by the use of the cementing material **11**. Elements which are similar to those of Fig. 1 have identical reference numerals. In order to effectuate the cementing of the plates **10** and **13** together, the face of plate **10**, which has thereon the distributed powder as explained in connection with Fig. 1, is placed in contact with one of the faces of the plate **13** as illustrated in Fig. 2. The two plates are then placed in a furnace and the composite body is heated, while the faces are in engagement, to a temperature within the range of 1300° to 1400° C.

Tests have shown that a cementing material in accordance with the invention, which comprises 96% by weight of barium titanate and 4% by weight of aluminum silicate, has a tensile strength which is about half of that of a fired body of ceramic transducer material which is comprised of barium titanate with only fractional impurities of other materials. These tests have also shown that the transducer characteristics of the fired cementing material are approximately 50% of that of the fired ceramic transducer material just mentioned, while the coefficient of capacity of the fired cementing material is about 1200 as compared to about 1600 for the fired transducer material. The materials just mentioned illustrate a preferred embodiment of the invention for cementing a fired material which, before firing, has the following composition:

	Per cent
Barium titanate ($BaTiO_3$)	97.7
Aluminum oxide (Al_2O_3)	0.8
Silica (SiO_2)	0.5
Strontium oxide (SrO)	0.3
Sodium oxide (Na_2O)	0.2
Magnesium oxide (MgO)	0.2
Calcium oxide (CaO)	0.1
Phosphorous oxide (P_2O_5)	0.1
Zirconia (ZrO_2)	0.05
Ferric oxide (Fe_2O_3)	0.03

Also, another preferred cement which may be utilized in accordance with the invention is one which comprises 96% by weight of barium titanate and 4% by weight of sodium silicate.

Considering again the body of Fig. 2, it will be seen, from the test results given above, that a composite body including the plates **10** and **13** can be produced which, for many applications, is substantially the equivalent of a single unitary body of the ceramic transducer material involved. It will readily be apparent that the likelihood of the body being spoiled, due to shrinkage and cracking in the material during firing or due to the distortion of the material under its own weight when it becomes plastic during the firing cycle, is very much reduced due to the fact that the bulk of the material is first fired in very much smaller volumes. Upon the refiring which is necessary in order to cure the cement, the pieces which have already been fired do not undergo nearly such a large amount of shrinkage and there is almost no tendency for the composite piece to crack.

While the invention has been described in connection with a process in which the faces of two plates are cemented together, it will be understood that the invention is suitable for many other types of cementing operations. Thus large bowls or cylinders may be constructed from small pieces of fired ceramic transducer material by cementing the pieces together in accordance with the teachings of the present invention.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. The method of cementing together two faces of fired ceramic transducer material which is comprised almost wholly of barium titanate which comprises: placing on at least one of said faces a thin layer of a cementing material comprising at least 88 percent but less than 98 percent by weight of barium titanate and less than 12 percent and at least 2% by weight of one of the silicates from the group consisting of aluminum silicate and sodium silicate; placing the other of said faces in contact with said layer and said one face; and heating said material while said faces are in engagement to a temperature within the range of 1300 to 1400 degrees centigrade.

2. The method of cementing together two faces of fired ceramic transducer material which is comprised almost wholly of barium titanate which comprises: placing on at least one of said faces a thin layer of a cementing material comprising at least 88 percent but less than 98 percent by weight of barium titanate and less than 12 percent and at least 2 percent by weight of aluminum silicate; placing the other of said faces in contact with said layer and said one face; and heating said material while said faces are in engagement to a temperature within the range of 1300 to 1400 degrees centigrade.

3. The method of cementing together two faces of fired ceramic transducer material which is comprised almost wholly of barium titanate which comprises: placing on at least one of said faces a thin layer of a cementing material comprising at least 88 percent but less than 98 percent by weight of barium titanate and less than 12 percent and at least 2 percent by weight of sodium

silicate; placing the other of said faces in contact with said layer and said one face; and heating said material while said faces are in engagement to a temperature within the range of 1300 to 1400 degrees centigrade.

4. The method of cementing together two faces of fired ceramic transducer material which is comprised almost wholly of barium titanate which comprises: placing on at least one of said faces a thin layer of a cementing material comprising approximately 96 percent by weight of barium titanate and approximately 4 percent by weight of aluminum silicate; placing the other of said faces in contact with said layer and said one face; and heating said material while said faces are in engagement to a temperature within the range of 1300 to 1400 degrees centigrade.

5. The method of cementing together two faces of fired ceramic transducer material which is comprised almost wholly of barium titanate which comprises: placing on at least one of said faces a thin layer of a cementing material comprising approximately 96 percent by weight of barium titanate and approximately 4 percent by weight of sodium silicate; placing the other of said faces in contact with said layer and said one face; and heating said material while said faces are in engagement to a temperature within the range of 1300 to 1400 degrees centigrade.

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