PHOSPHATE BONDED MICA MAKES NEW ELECTRICAL INSULATION*

by

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The bonded mica board called Mica-Ramic is one of many products developed during searches for sheet mica substitutes. The unique properties of sheet mica ideally suit it to certain electrical and electronic applications. Its place of distinction is shown by the fact that the government pays as much as $70 a pound for strategic grades. Because of the value of this material the search for replacements has been relentless.

The first substitute to enter the market was built-up mica which was invented in 1892. This flexible material, made by pasting mica splittings together with varnish and other organics, has been substituted for sheet mica in many electrical applications. The inherent disadvantages of built-up mica are high cost and poor heat resistance.

Various ceramic materials have also been developed for use as electrical and electronic insulators, and have replaced sheet mica in certain cases. Among the best known of these ceramics are steatite and Mycalex, or glass-bonded mica.

The most direct attempts to replace natural sheet mica are projects on mica synthesis. At least nine organizations in this country, led by the Bureau of Mines at Norris, are developing and evaluating various synthetic micas and reconstituted synthetic micas. Although a substitute for strategic natural mica has not been found, interest is being shown in several types of reconstituted synthetic mica.

During recent years at least four reconstituted natural mica products have also been developed and have been placed on the market. Three of these,

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Mica Mat, Integrated Mica and Isomica or Samica, are formed from extremely thin mica flakes by paper making techniques. The unadulterated paper has a few uses, but normally it must be strengthened by addition of a small amount of organic binder, which limits the usefulness of the product. The fourth product is Mica-Ramic, an inorganically-bonded mica board, which is the subject of this report.

Mica-Ramic was developed in 1952 by the North Carolina State College Minerals Research Laboratory under the sponsorship of Farnam Manufacturing Company. It consists of aluminum phosphate-bonded mica flakes. As early as 1926 Dawes and Boughton obtained a patent on phosphate bonding of fine mica, but apparently their products had soluble constituents and therefore were not satisfactory for electrical insulation. Aluminum phosphate, which is an excellent bonding agent, was described in U. S. Patent No. 1,828,211 in 1931. However, no attempt to make an electrical insulator from flake mica and aluminum phosphate is known prior to the development of Mica-Ramic. On the basis of an article on aluminum phosphates by H. H. Greger in the August 1950 Brick and Clay Record, it was decided that this should be the first binder investigated in the Farnam project. From the unusual properties of the first sheet produced it was obvious that this material had potentialities not only as a substitute but as a new insulating material. A process development program was therefore started immediately.

The first problems to be approached were (1) type of mica to use, (2) how to incorporate the mono aluminum phosphate with the mica and (3) how to form a uniform sheet. It was decided to use ground mica, slurry it with a water solution of the phosphate and pour onto a buchner funnel with filter paper for retaining medium. A slight rotary motion was given to the slurry while applying vacuum. This procedure was successful and was used for all the early testing.

Early in the investigation two articles on properties of aluminum phosphates by W. D. Kingery[1] were studied. A most important property of mono aluminum phosphate was found. At a temperature of approximately 250° C it forms a material which is not soluble in water and is essentially non-hygroscopic. The cycle adopted therefore was to dry the material at 110° C in an oven and then in a muffler furnace at 250° C or over.

As the investigation proceeded, it rapidly became apparent that a new material with good electrical properties, but only limited flexibility was being developed. With the acceptance of this fact, experiments were directed toward developing the strongest possible material. Tests were made to study (1) type of mica to use, (2) type and rate of drying, (3) amount of mono aluminum phosphate, (4) method of firing, (5) use of additives and (6) other raw materials. The results of the tests indicated that the optimum conditions for the best product were to use ground delaminated mica and concentrated mono aluminum phosphate solution, dry slowly under infra red light and press-fire at 250° C or more for at least 30 minutes.

With the construction of a shaking box and a heated press, larger scale tests were begun and samples for market evaluation made. Studies were started on a continuous process similar to paper making. During this phase two major problems were encountered. They were the tendency of the sheet to bloat if dried too fast and to stick to the dividers in the press. The bloating problems were intensified when very highly delaminated mica was used. As a result the process developed to a point where hammer mill ground minus 20 mesh mica from shop scrap was used and sheets were dried slowly by infra red. Aluminum foil was placed between sheets of dried board and the dividers before

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(1) "Fundamental Studies of Phosphate Bonding in Refractories"
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placing in the press. Many experiments were made to find a suitable substitute for the aluminum foil, however, they met with limited success.

The mica-mono aluminum phosphate sheet has a most remarkable property when partially dried. At a critical moisture content the material has considerable strength and is soft and pliable. Tests were made to try to roll the material while in this state and to form it into various shapes. This area provides one of the major possibilities for future expansion into additional new products.

The next step was to develop the process to a production level. Some of the Laboratory problems have been resolved and some remain. However, commercial production has been in operation for five years under the trade name of Mica-Ramic and protected by U. S. Patent 2,760,879. Briefly the plant flowsheet is as follows: grind scrap mica in hammer mill to -20 mesh, mix with mono aluminum phosphate solution, pump to vacuum box with nylon filter cloth, apply vacuum, remove sheet, dry under infra red until hard, place between dividers and aluminum foil and press fire at 250° C or above for 30 minutes or more. The material is cooled and aluminum foil is stripped from the sheets.

The product which comes out of these operations is a greyish-white, semi-rigid board or shaped part of inorganic composition. It is capable of being worked in many ways. It can be punched, sawed, sheared, drilled, tapped, and machined.

The dielectric strength of 300 volts/mil of thickness is adequate for electrical appliances, and unlike organics, its dielectric strength does not diminish appreciably at elevated temperature - neither does its insulation resistance.

Thermal shock has little effect on Mica-Ramic. It stands repeated heat-cool cycling in its operating temperature range.

A product with these qualities is suited particularly for those uses where heat and electricity are both present. Some of these places are in thermostat stacks, waffle irons, toasters, electric irons, electric heating elements, hand dryers, hair dryers, and other similar applications.

Mica-Ramic heating elements are a patented development of Farnam Manufacturing Company. These elements combine both the heating medium and insulation in one body. Where required, metal sheaths may be added. In air or space heating finned sheaths are used to make heat transfer more efficient. Finned elements are ideally suited to electric baseboard heaters and can be mounted in banks for forced air heaters. The non-finned type may also be used in these applications but these are better suited to heating applications wherein the element is clamped tightly to the surface to be heated. This type of element has many applications from melting butter for popcorn machines, to heat sealing plastics, to heating platen presses.

In the immediate future the baseboard heating element promises to be the best sales outlet. Other phases which will probably develop in the future are tablet pressing and also molding of intricate shapes from pliable, uncured material. It may also be possible to take advantage of this flexible condition in a pre-pressing or densifying operation which would increase final strength of the board.

Experiments with a small Fourdrinier type paper machine have demonstrated the feasibility of producing uncured Mica-Ramic sheets by a continuous process. This operation will be perfected and used when warranted by sales volume.