GENERAL ELECTRIC

Research Laboratory

A CEMENT FOR USE IN VACUUM DEVICES

by

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A CEMENT FOR USE IN VACUUM DEVICES

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ABSTRACT

A versatile inorganic cement that can be used inside the vacuum envelope of electron devices has been developed. The cement will adhere to glass and certain metals. Its composition can be controlled to produce a wide variety of ceramic-like products. Fusion heat is not required to mature the body.

A CEMENT FOR USE IN VACUUM DEVICES

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The need often arises for a cement that can be used inside the envelope of electron tubes or other vacuum devices. The stringent requirements of such a cement immediately exclude all organic materials. For electron-tube uses, the ideal cement must have:

(1) Fast drying or hardening characteristics.

(2) Good adherence to both glass and metals.

(3) Resistance to deterioration under bake-out and out-gassing procedures.

(4) Resistance to electron bombardment.

(5) Freedom from gas evolution during operation of the device.

(6) Freedom from cathode contaminating elements.

(7) A controllable or particular thermal coefficient of expansion.

A recent urgent request for a cement having these properties, plus the additional condition that it be electrically conductive, initiated a program to discover or develop such a material.

A literature survey disclosed that the bulk of the inorganic cements were made from a soluble silicate, usually sodium silicate, and a suitable filler, such as asbestos fiber. Although these silicate cements are excellent adhesives, they are difficult to out-gas in vacuum, they evolve water vapor when bombarded with electrons, they set very slowly, and they shrink during setting, so that glass to which they are stuck will often crack or spall. Numerous experiments were run in an effort to overcome these defects. Inasmuch as these appeared to be an inherent property of the silicates alone, the soluble silicates were abandoned in favor of other compositions.

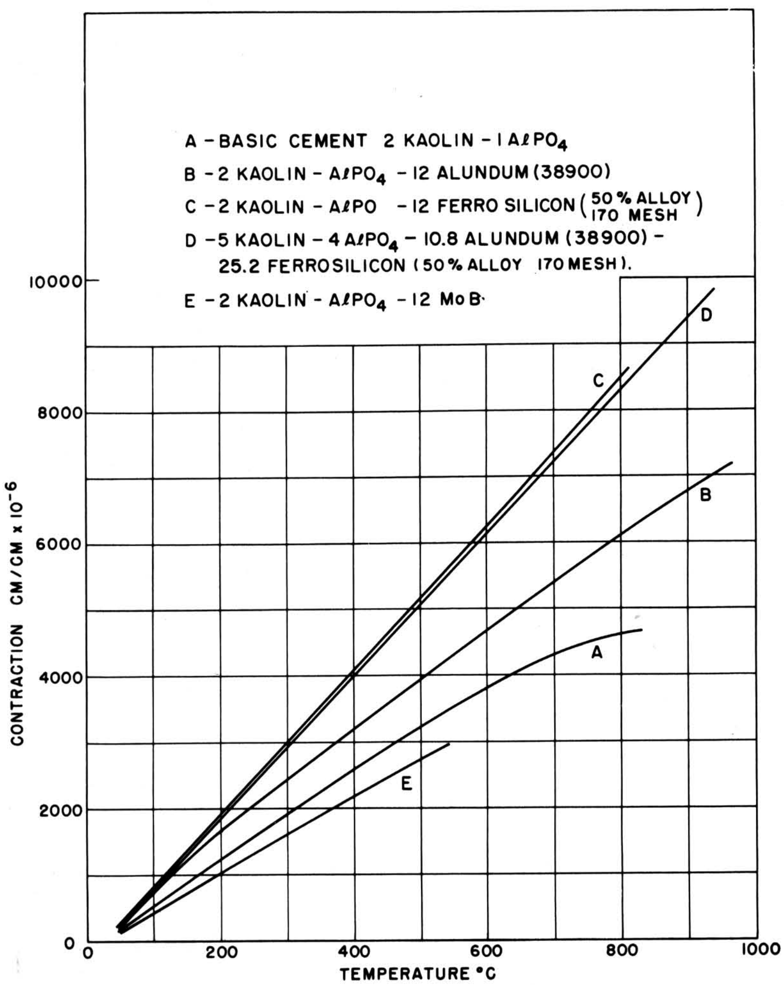

Fig. 1 Expansion curves for phosphate cement with several fillers.

Other cements referred to in the literature include the magnesium oxy chlorides and the dental cements, such as the zinc oxy chlorides. These are undesirable because of their chlorine content and their low decomposition temperature.

After testing over 250 compositions and variations, a cement was developed that appears to fulfill the seemingly impossible list of requirements and, in addition, offers new possibilities as a vacuum-tube material. One preferred composition is a mixture of two parts of aluminum silicate, one part of freshly calcined aluminum phosphate, and enough dilute phosphoric acid to give the desired viscosity.

While this mixture alone will harden into a stone-like mass when warmed to 125°C, it is most useful when mixed with a suitable filler or aggregate. The aggregates then largely determine the physical property of the cement.

To make an electrically conductive cement, fillers such as 50 per cent ferrosilicon alloy, manganese dioxide, or molybdenum boride can be added. By controlling the grain size as well as the quantity, the conductivity can be varied over wide limits. The ferrosilicon alloy will yield a product with a resistance ranging from a few hundred ohms to several megohms per centimeter cubed. Molybdenum boride gives a cement with resistance comparable to metals. Manganese dioxide produces a material with a very high negative temperature coefficient of resistance.

Insulating aggregate, such as aluminum oxide, can be used to control the thermal coefficient of expansion of the cement. It was found that Georgia kaolin could be substituted for the C. P. aluminum silicate. The attached curves are the thermal expansion characteristics of a kaolin base cement with various filler materials added.

Probably the most unique feature of this cement is its ability to yield a vitreous type insulator without resorting to high-temperature fusion. Tube spacers and complex shapes pressed from a moist mixture do not undergo dimensional changes during hardening or curing. Insulators will also withstand temperatures of over 1000°C in vacuum. However, hydrogen atmospheres decompose the body.

Other suggested uses, some of which are only partially explored, include:

(a) high-temperature basing cement;

(b) attenuators for traveling-wave tubes;

(c) ceramic heaters for electron tubes, and

(d) a wide variety of insulating bodies.

It must be pointed out that there is no preferred composition that satisfies all applications. Each individual case must be carefully explored if the maximum utility of cement is to be attained.

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TECHNICAL INFORMATION SERIES

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CONCLUSIONS

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