Aug. 17, 1965 S. P. MITOFF 3,201,738

ELECTRICAL HEATING ELEMENT AND INSULATION THEREFOR

Filed Nov. 30, 1962

Fig. 1

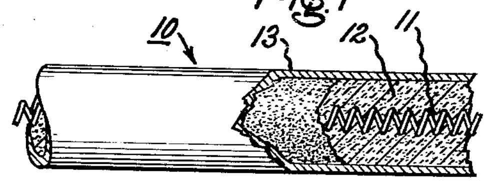


Fig. 2

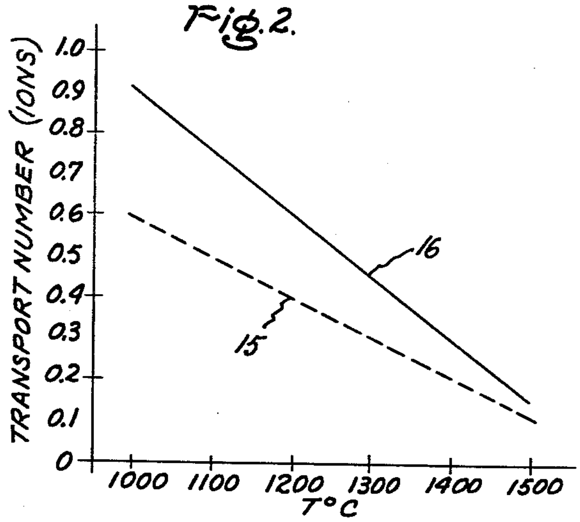
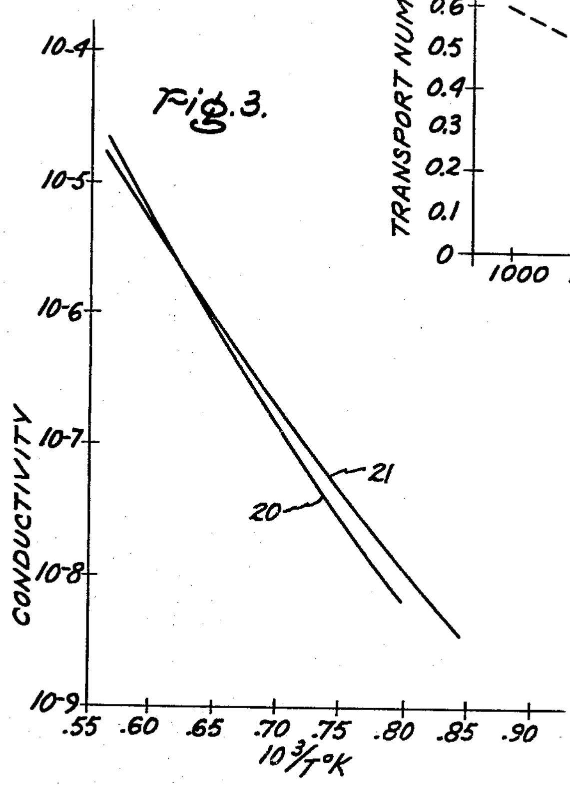


Fig. 3



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ELECTRICAL HEATING ELEMENT AND INSULATION THEREFOR

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This invention relates to electric, resistance heating elements and more particularly to those using compacted magnesia, electrical insulating material between an inner, electrically resistive heating conductor and an outer protective jacket and to the insulating magnesia composition.

Heating elements of the type comprising an inner, electrically resistive conductor, a surrounding layer of magnesia, electrical insulation and an outermost protective jacket are widely used in many industrial heating devices as well as in devices such as household ovens. This type of heating element is much more durable than, for example, exposed resistance wire. Structurally, it usually includes: (1) a coiled resistance wire composed of alloys such as those made up of 15–16 percent chromium, 59–62 percent nickel, about 24 percent iron and 0.1 percent carbon; (2) compacted magnesia powder containing minor amounts of impurities surrounding the resistance coil as an insulator; and (3) an outer protective jacket normally constructed of metals ranging from lead to high temperature alloys.

While the service life of these elements is generally good, in due time the magnesia insulation breaks down and the unit becomes useless. This breakdown occurs as a result of electrical current leakage which takes place between the resistance coil and the outer jacket which is at ground potential. Thus, the potential difference causes ion transport through the magnesia insulation with electrolytic decomposition thereof. Additionally, the upper operating temperature limit has also been dependent upon the effectiveness of the magnesia insulation.

It is a principal object of this invention to provide an electric heating element having magnesia insulation imparting longer service life and greater temperature stability to the element.

Another object of this invention is to provide a magnesium-oxide, lithium-oxide insulation material.

Other objects and advantages of this invention will be inpart obvious and in part explained by reference to the accompanying specification and drawing in which:

FIG. 1 is an enlarged elevation, partly broken away, of the type of heating element with which this invention is concerned;

FIG. 2 is a graph showing the fraction of electrolytic conductivity for doped and undoped magnesia as a function of temperature; and

FIG. 3 is a graph showing the conductivity of lithium-oxide doped and undoped magnesia specimens as a function of temperature.

Broadly, this invention is concerned with a new doped magnesia composition and specifically with the use of the composition as the insulating material surrounding the heating coil or resistive conductor in a shielded heating element or unit. The magnesia contains small but effective amounts up to the solid solubility limit of lithium-oxide, Li_2O or about 0.010 mol percent. The purpose of the lithium-oxide additions is to reduce the ionic conduction which is felt to exist between the resistive conductor and the outer metallic protective sheet or jacket through the magnesia insulating material. The ionic conduction, that is the carrying of current by ions, results in deterioration and eventual failure of the unit. The basis for saying this is that when ionic conductivity occurs in a substance it electrolyzes, much as a salt solution with two

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electrodes, and decomposition products are given off at the electrode. This statement is highly simplified, of course, but serves to illustrate the principle.

On the belief that ionic or electrolytic conductivity in magnesia results from magnesium ion transport, it has now unexpectedly been found that small amounts of lithium added to the magnesia substantially reduce the ionic electrolytic conductivity thereof at those temperatures where magnesia is predominately an ionic conductor. Specifically, ionic conduction is predominant up to about 1000° C. and then decreases as electronic conduction increases as the temperature is raised to 1500° C.

Referring to FIG. 1 of the drawing, the numeral **10** indicates the type of resistance heating device in which the insulation of this invention is most useful. Element **10** is constructed of an innermost, electrically resistive conductor **11** through which electricity flows. Normally, these conductors **11** are constructed in a spiral or helical form, as indicated, and are composed of high resistance alloys. For example, suitable alloys include those such as Nichrome, which are high resistance alloys, composed of from 15 to 16 percent chromium, 59 to 62 percent nickel, about 24 percent iron and about 0.1 percent carbon.

Surrounding the conductor **11** is a quantity of particulate magnesia **12** which is packed tightly about conductor **11**, this compaction usually being performed by a swaging operation although rolling is used occasionally. The magnesia normally is fairly low in impurity content, containing only several hundred parts per million of impurities such as calcium, aluminum, silicon and iron. The structure of the heating element is completed by an outermost metallic jacket **13** which serves to protect the elements **11** and **12** from breakage. This jacket will be constructed of some metal which is sufficiently heat-resistant to withstand the designed operating temperature of the heating device. Thus, for relatively low temperature applications, a metal such as lead can be used, whereas for higher temperature applications, a high alloy metal such as Inconel can be used. Inconel is a high nickel-chromium iron alloy which, in the wrought form, contains 79.5 percent nickel, 13 percent chromium, 6.5 percent iron, 0.25 percent manganese, 0.25 percent silicon, 0.8 percent carbon and 0.20 percent copper.

It was previously indicated that the service life of the magnesia, electrical insulation could be increased by reducing the fraction of ionic conductivity which occurs in the magnesia. It might also be stated that it is now possible to obtain an increase in the operating temperature of the heating device for a given life. To test the efficacy of the lithium-oxide additions, crystals of magnesium oxide to which about one weight percent carbonate had been added, were fused between carbon arcs. The resulting crystals were analyzed and found to contain roughly 0.010 mol percent of lithium-oxide. The relative fraction of ionic conductivity was found to be 0.5 at 1000° C. By way of comparison, control samples of magnesia containing no lithium-oxide addition were tested at 1000° C. and the relative fraction of ionic conductivity was found to be 0.9.

Referring to FIG. 2 of the drawing, curve **15** indicates the ionic conductivity of a magnesia specimen containing 0.010 mol percent dissolved lithium-oxide, whereas curve **16** illustrates the fraction of ionic conductivity of an undoped magnesia specimen. It is apparent by a comparison of the two curves that the fraction of ionic conductivity has been reduced in the material of curve **15**. It should particularly be noted that the reduction is significant at 1000° C. which is currently the upper operating limit for most of the commercial heating devices constructed similarly to that shown in FIG. 1 of the drawing. Considering the conductivity as a function of reciprocal temperature of the two specimens used to obtain curves 15 and 16 of FIG. 2, it will be seen by reference to FIG. 3 of the drawing that the magnesia, which contains the lithium-oxide addition of curve 20, has a lower conductivity than the undoped material of curve 21 at those temperatures in which the magnesia has the highest fraction of ionic conductivity.

Although the present invention has been described in connection with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and the appended claim.

What I claim as new and desire to secure by Letters Patent of the United States is:

An electrical resistance heating element comprising, an

electrically resistive conductor through which electricity flows, an insulating ceramic consisting of magnesium-oxide containing dissolved amounts of lithium-oxide up to the solid solubility limit thereof effective to give said insulating ceramic a fraction of ionic conductivity no higher than about 0.6 at 1000° C., said ceramic surrounding said resistive conductor, and a protective jacket enclosing said ceramic.

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