

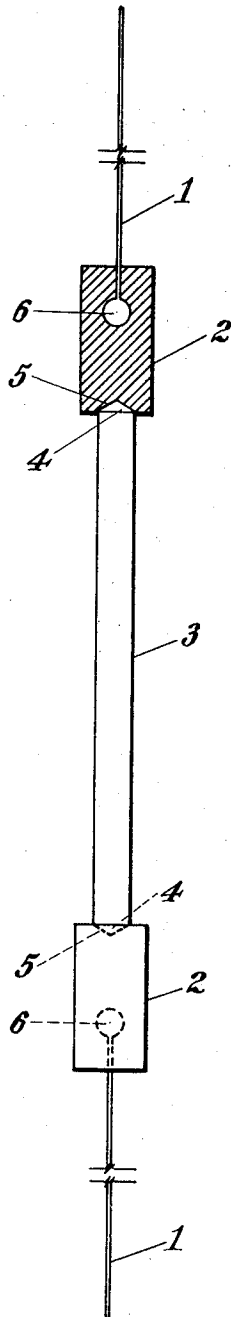
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HEATING UNIT

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HEATING UNIT

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Commerce

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This invention relates to producing and maintaining controllable temperatures which may be in excess of 1600° C. in a furnace atmosphere which may contain free oxygen. The attaining of these high temperatures, and especially those above about 1800° C., under conditions which can be controlled satisfactorily, as for the maturing of preformed shapes as practiced in the ceramic art, for example, has in general, been accomplished only with a reducing atmosphere. While the electric arc is available for high temperature work, and with it reducing conditions can be avoided, neither the electric arc nor a source of heat such as the oxyhydrogen and oxyacetylene flames, has been found sufficiently controllable to be suitable for heat treatments, such as the heating of preformed articles.

Research laboratories have long needed equipment in which investigations, such as phase-equilibria studies, could be carried above the 1600° C., which is the approximate upper limit of platinum-rhodium wire-wound furnaces. Increasingly higher temperatures, at present approaching 1800° C., are being used in the manufacture of special ceramics, and it is to be expected that furnaces producing from 1800° to 2000° C. will soon find industrial application. Tungsten and molybdenum wire-wound furnaces have been used in the laboratory; but here again the furnace atmosphere must be free from oxygen, and the cost of the wire would make such an installation impracticable for industrial purposes.

The present invention provides for meeting the need for a furnace in which material such as ceramic specimens, for example, can be heated on a definite schedule and in an oxidizing atmosphere, and at temperatures in excess of 1800° C. For these purposes the invention provides a heating unit which may be used advantageously in industrial installations as well as in laboratory equipment. This heating unit is in the form of an oxide resistor having a composition of the Nernst filament type and one or more of these units may be used as desired, depending upon the size and design of the furnace as will be understood by those skilled in this art.

Oxide resistors having a composition of the Nernst filament type have been provided heretofore in the form of a tube or cylinder, the interior of which constituted the heating chamber of the furnace. These prior resistors have been unsatisfactory. It appears that difficulty was experienced in maintaining contact between the resistor and the electrical lead-in wires, and also in obtaining a resistor sufficiently uniform and

free from cracks to conduct the current satisfactorily. The cracks are caused by the large decrease in volume which takes place when the resistors become conducting for the first time and are heated to a temperature well above that at which they are heated preparatory to use. Furthermore, the size of the heating chamber within a tubular resistor is necessarily small because of fabrication difficulties in the forming of the tube.

Important objects of the invention are to provide for overcoming disadvantages of the kind just mentioned and to provide an improved heating unit of the class described; to improve the efficiency and the construction of a heating unit of the class described; to provide a heating unit capable of attaining and maintaining controlled temperatures under oxidizing conditions and greatly in excess of temperatures now practically maintainable and controllable in laboratory or industrial furnaces for the heating of preformed ceramic articles under oxidizing conditions; to improve the electrical contact between the lead-in wires or electrodes and the heating unit; to provide for maintaining a suitable temperature gradient between the resistor proper and the metal lead-in wires or electrodes so as to prevent the fusion of the latter; to provide a heating unit comprising a resistor of the class described which is of a compact, solid construction so that one of these units may be used alone or any desired number of the units may be arranged in spaced relation about the heating chamber of a furnace; to provide for varying the composition of a heating unit of the class described to give it the desired conductivity; and also to provide a heating unit of the class described which may be operated at relatively low amperage and thus, to provide for reducing the size and the expense of the metal electrical connections. Other objects and advantages of the invention will appear as the description proceeds.

In the accompanying drawing the single figure is an elevation of a heating unit with the upper contact block shown in section.

In the embodiment selected for illustration, the heating unit comprises lead-in wires or electrodes 1, contact blocks 2 and a resistor 3, which may be in the form of a round rod or bar having pointed or conical ends 4 which fit in complementary recesses 5 in end blocks 2.

In accordance with this invention the composition of the resistor and of the contact blocks may be varied to give the desired conductivity and also to provide a temperature gradient across each contact block from the resistor to the lead-

in wires or electrodes so as to protect the latter from the high temperatures which prevail in the resistor and which otherwise would cause the lead-in wires or electrodes to fuse. Suitable compositions cover a considerable range. For the contact blocks, mixtures of zirconia with scandia or yttria or lanthia or ceria are preferred, except for very high temperatures as will be hereinafter explained. For example, the contact blocks may be formed of mixtures of from about 80% to 99% by weight of zirconia and about 20% to 1% by weight of scandia or yttria or lanthia or ceria. Within this range an increase in the proportion of zirconia in the mixture will result in a higher resistivity. Preferably these contact blocks are

parts of thorium to one of zirconia to seventeen parts of thorium to one of zirconia. The principal ingredient of these resistors may constitute about 80% to 95% by weight of the total mixture, the remainder of the mixture being composed of yttria, scandia, lanthia or ceria, either singly or in combinations. For resistors for producing temperatures from about 1000° C. to above about 1850° C. where the principal ingredient consists of thorium, this ingredient should form about 80% to 95% by weight of the total mixture, the remainder being yttria, scandia, lanthia or ceria either singly or in combinations. Examples of suitable compositions for the resistor and their relative conductivity are given in the following table:

No.	Composition, weight per cent	Conductivity at (°C.)							
		1300°	1400°	1500°	1600°	1700°	1800°	1900°	2000°
2	85 ZrO ₂ , 15 Y ₂ O ₃	Mho	Mho	Mho	Mho	Mho	Mho	Mho	Mho
4	85 ThO ₂ , 15 CeO ₂		0.021	0.044	0.16				
6	80 ThO ₂ , 10 Y ₂ O ₃ , 10 CeO ₂		.001	.010	.024	0.043	0.074	0.11	0.16
8	80 ThO ₂ , 15 Y ₂ O ₃ , 5 CeO ₂		.001	.006	.020	.050	.10	.19	
12	80 ThO ₂ , 10 ZrO ₂ , 10 Y ₂ O ₃		.003	.010	.030	.050	.085	.14	
21	90 ThO ₂ , 10 Y ₂ O ₃	0.010	.014	.030	.064	.11	.23	.41	
22	95 ThO ₂ , 5 Y ₂ O ₃	.038	.050	.076	.12	.18	.25	.35	.45
		.015	.030	.042	.078	.11	.14	.19	

formed of mixtures of about 85% to 90% of zirconia and about 15% to 10% of scandia or yttria or lanthia or ceria as these compositions have been found best suited for use with the preferred resistor compositions. Of course if so desired, the percentages given above for either scandia or yttria or lanthia or ceria may be made up of mixtures of these oxides, as for example instead of 15% scandia, 5% scandia and 5% yttria and 5% lanthia could be used, but this is not necessary.

The composition of the resistor proper, as resistor 3, should be mainly thorium and/or zirconia with minor portions of yttria, scandia, lanthia or ceria either singly or in combination. When zirconia is used alone as the principal ingredient of the mixture good results can be obtained for temperatures from about 1000° C. up to about 1700° C. For temperatures from about 1000° C. to about 1850° C. good results can be obtained with thorium alone as the principal ingredient, or with thorium and minor additions of zirconia as the principal ingredient. For higher temperatures thorium should be used alone as the principal ingredient of the resistor. As previously pointed out herein with reference to the contact blocks, the greater the proportion of thorium or zirconia in the mixture, the higher will be the resistivity and the temperature to which the resistor must be heated before it becomes conducting. It has been found that for best results the proportion of thorium and/or zirconia should not exceed 95% by weight of the mixture, the remainder of the mixture being yttria, scandia, lanthia or ceria either singly or in combinations. In general, the proportion of thorium and/or zirconia used will be determined by the resistance to deformation at high temperatures and by the conductivity desired for the resistor.

Compositions of about 80% to 95% by weight of thorium and/or zirconia and about 20% to 5% by weight of yttria, scandia, lanthia or ceria either singly or in combinations are preferred for temperatures from about 1000° C. to about 1700° C. In resistors for producing temperatures from about 1000° C. to about 1850° C., where the principal ingredient consists of thorium with minor additions of zirconia, the proportions by weight of thorium to zirconia therein may be varied from five

If it is desired to use a heating unit of very high resistance which is also especially adapted for very high temperatures, as for example those running above 1950° C., is highly advantageous to use a resistor composed of thorium as the principal ingredient with a minor proportion of ceria as illustrated, for example, by composition No. 4 in the table hereinabove set forth. With a resistor of this or similar composition, it is desirable to use contact blocks composed principally of thorium with minor additions of yttria, preferably within the range, as illustrated by compositions Nos. 21 and 22 in said table, in order to assure adequate resistance to deformation at such high temperatures as well as to maintain the desired lower resistivity of the contact blocks with relation to the resistivity of the resistor.

In accordance with this invention, the resistance of the resistor proper, as of resistor 3, is greater than the resistance of either of the end blocks 2, and preferably the resistivity of the resistor proper is greater than the resistivity of end blocks 2. In this way a sufficient temperature gradient may be established between the high temperatures prevailing in the resistor and the temperature at the contact with the metal electrode, as at the contact between end blocks 2 and their associated lead-in wires or electrodes 1. This temperature gradient should be such as to protect the metal electrodes from fusion and to maintain the desired conductivity of the contact blocks 2.

Another important feature of this invention as shown in the drawing resides in the improved electrical contact between contact blocks 2 and their associated metal electrodes 1. Considerable difficulty has been encountered heretofore in maintaining good electrical contact with the metal electrodes for heating units of this type. As the contact blocks are heated during the normal operation of the furnace they undergo permanent shrinkage and changes in volume and this has caused the contact with the metal electrode to be broken or impaired, when the electrode was applied to the outer surface of the heating element. The present invention provides for overcoming these disadvantages and assures the maintenance of good electrical contacts by

embedding the electrode or lead-in wire in the contact block to a sufficient depth to provide adequate contact area and to give sufficient mechanical strength to this connection. The metal electrodes may extend into the ends of the contact blocks, as shown in the drawing, or these electrodes may be brought into the sides of the contact blocks if this is desired. The embedded portion of each electrode may have formed thereon preferably at the inner end thereof a suitable enlargement 6 to assure adequate contact area. Conveniently this enlargement may be substantially globular in form as shown, or it may have any other shape adapted to furnish the desired contact area. With this improved construction, shrinkage of the contact block causes the material thereof surrounding the embedded portion of the electrode to press more firmly against the electrode so as to improve the electrical contact.

It will be seen that the invention provides a heating unit comprising a resistor in the form of a solid rod which may be and preferably is of small cross section relative to that of the space to be heated. These heating units are well adapted to be placed and spaced where they can be most efficient in producing the desired temperatures in the heating chamber. Since each resistor operates independently of the others, they may be arranged and spaced for the heating of chambers of various sizes and shapes. For instance, in the ceramic art these heating units are particularly adapted for heating either intermittent or continuous kilns and furnaces used in the maturing of preformed shapes.

By using a plurality of independently operated resistors I overcome the difficulty encountered with earlier heating devices of the oxide resistor type in which one resistor in the shape of a tube formed the wall of the heating chamber and was the source of heat energy as shown, for example, in U. S. Patents No. 652,640, No. 715,505 and No. 719,507. Resistors of the oxide type undergo considerable shrinkage on the first heating thereof and this results in objectionable cracking of tubular resistors. Furthermore, the practically unavoidable chemical and physical irregularities in the wall structure of the tubular resistor brings about an unequal distribution of the current. This results in one portion of a tubular resistor conducting a disproportionate amount of current, thereby causing such portion to become hotter than adjoining portions. This increase in temperature along the path of greatest conductivity causes this path to become still more conducting, resulting in an uneven distribution of heat in the heating chamber and eventually in the fusion of the tubular resistor along this path. By using resistors in the form of solid rods of relatively small cross section compared to that of the space to be heated, the resistors can be made sufficiently uniform in texture to assure a substantially equal distribution of the current and by independently operating these resistors any differences in electrical conductivity or in shrinkage during operation of one resistor as compared with another can be compensated for by electrical controls and mechanical adjustments, as will be understood by those skilled in this art.

Another advantage of heating units in accordance with this invention is the very small amperage required to produce a unit of heat energy compared, for example, to resistors composed essentially of graphite or of silicon carbide. This makes it possible to use relatively small and in-

expensive conductors for supplying electrical energy to the heating units.

In using heating units of the oxide type in accordance with this invention, it is, of course, understood that at ordinary temperatures the mixtures of which the heating units are composed are non-conductors and it is necessary, as a preliminary step, to supply heat from any suitable source to bring the heating units up to a temperature at which they become conducting, as is well known to those conversant with this art. For example, with a heating unit of the shape shown in the drawing in which the contact blocks were made of composition No. 2, and the resistor of composition No. 21, as shown in the table previously set forth herein, the resistor being 9 cm. long and 0.6 cm. in diameter, the heating unit became conducting at 960° C. and 540 volts.

The invention described herein, if patented, may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

It should be understood that the present disclosure is for the purpose of illustration only, and that the invention includes all modifications and equivalents which fall within the scope of the appended claims.

I claim as my invention and desire to secure by my patent:

30 1. A resistance heater for electric furnaces comprising a lower contact block, a resistance rod having one of its ends seated by gravity against said contact block, and an upper contact block seated by gravity against the opposite end of said resistance rod, each of said three elements being formed of metal oxides, and said blocks having a lesser electrical resistivity than said rod; whereby good electrical contacts between said elements are provided, the installation is made easily demountable, and extremely high incandescent temperatures of said rod may be attained without excessive heating of said contact blocks.

45 2. A resistance heater for electric furnaces comprising a lower contact block, a resistance rod having one of its ends seated by gravity against said contact block, and an upper contact block seated by gravity against the opposite end of said resistance rod, each of said three elements being formed of metal oxides, and said blocks having a lesser electrical resistivity than said rod, each of said blocks comprising a metallic conductor having a substantial terminal portion completely embedded in the material of the block, said block material being exposed relative to said terminal portion to increase its grip thereon on shrinkage of said block material at the temperature of use; whereby good electrical contacts between said elements are provided, the installation is made easily demountable, and extremely high incandescent temperatures of said rod may be attained without excessive heating of said contact blocks.

60 3. A resistance heater for electric furnaces comprising a resistance rod having conical ends and composed of thoria as the major constituent and an oxide of the class consisting of yttria, scandia, lanthia and ceria as a minor constituent, two contact blocks provided with recesses for seating the conical ends of said rod and composed of zirconia as the major constituent and an oxide of the class consisting of yttria, scandia, lanthia and ceria as the minor constituent said blocks having a lesser resistivity than said rod, whereby extremely high incandescent temperatures of said

rod may be attained without excessive heating of said contact blocks.

4. A resistance heater for electric furnaces comprising a resistance rod having tapered ends and composed of thorium as the major constituent and an oxide of the class consisting of yttria, scandia, lanthanum and ceria as a minor constituent, two contact blocks each provided with a recess for seating the tapered ends of said rod and composed of zirconia as the major constituent and an oxide of the class consisting of yttria, scandia, lanthanum and ceria as the minor constituent, said blocks having a lesser resistivity than said rod and being of a character such that when heated to a normal operating temperature of an electric furnace they undergo permanent shrinkage causing them to firmly grip an electrode terminal embedded therein.

5. An electrically heated resistor furnace comprising a plurality of resistance heaters each heater including a lower contact block provided with a tapered recess, a resistance rod having an end seated by gravity in said recess of the block, an upper recessed block seated by gravity on said resistance rod, said resistance heaters being formed of metal oxides, each block being composed of oxides which have a lesser electrical resistivity than said rod and which undergo permanent shrinkage and change in volume when heated to furnace operating temperature causing it to grip more firmly an electrode terminal embedded therein and an independent regulating means for supplying current to each of said units.

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