July 26, 1938. D. MACKENZIE 2,125,075

ELECTRICAL HEATING ELEMENT

Filed Oct. 12, 1935

Fig. 1.

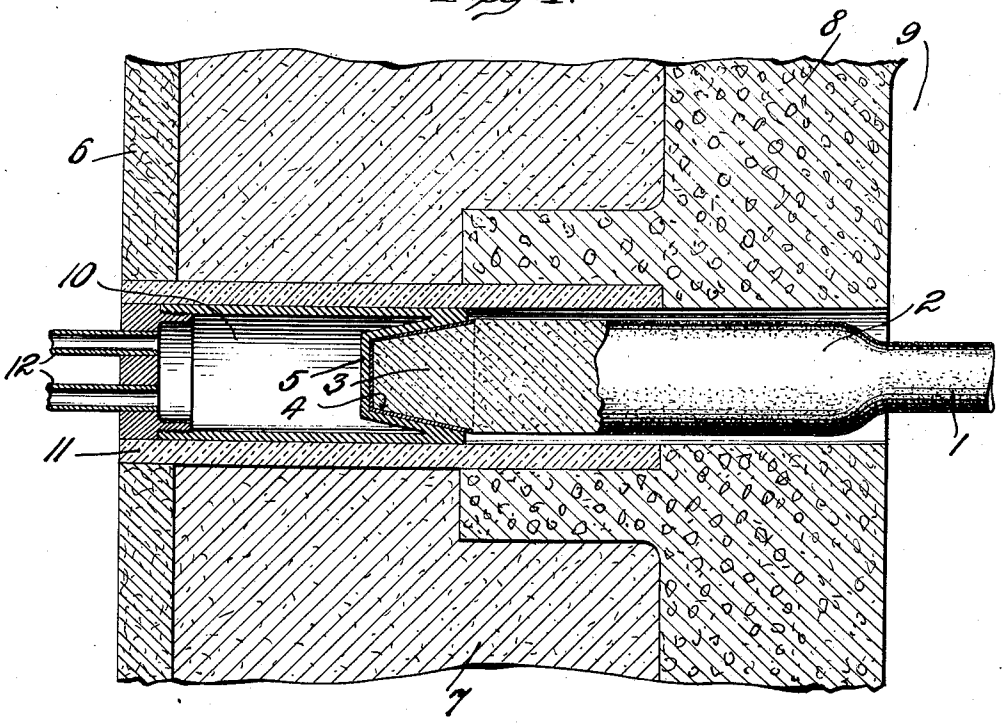
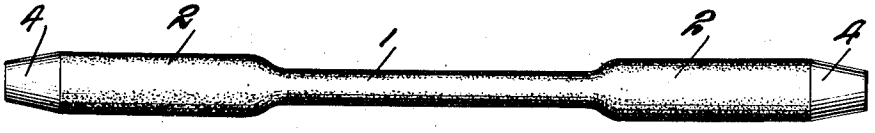


Fig. 2.



INVENTOR
DUNCAN MACKENZIE
BY Sager & Malcolm
ATTORNEYS

Patented July 26, 1938 2,125,075

UNITED STATES PATENT OFFICE

2,125,075

ELECTRICAL HEATING ELEMENT

Duncan Mackenzie, Cream Ridge, N. J.

Application October 12, 1935, Serial No. 44,639

2 Claims. (Cl. 201—76)

This invention relates to electrical heating elements of the type employed in high temperature electrical resistance furnaces and its object is to provide a refractory heating element which is more efficient in operation and is capable of withstanding considerably higher temperatures over much longer periods of time than previous devices of this type.

Ordinary metallic heating elements composed of molybdenum, nickel-chromium alloys, etc., are used successfully in household and commercial electrical appliances in which temperatures of less than 2000° F. are encountered; but at higher temperatures, such as are employed in electrical resistance furnaces, it is necessary to use non-metallic heating elements composed of silicon carbide or various other refractory compositions which are readily obtainable on the market. It is to this latter class of non-metallic heating elements that the present invention relates.

Non-metallic heating elements heretofore obtainable on the market are ineffective at temperatures exceeding 2600° F., either failing completely around 2600° F. or being incapable of sustained operation at such high temperatures. This is due in large measure to the impossibility of establishing and maintaining an effective contact between the heating element and its cooperating terminals, as all heating elements of this type contain countless small voids causing arcing and resulting pitting which impairs electrical conductivitity and soon renders the element unfit for further service. Another disadvantage of these heating elements as heretofore constructed is that the passage of sufficient current through the central heating zone always causes excessive heating of the end portions of the element, which not only hastens the destruction of the terminals but also has a deleterious effect on the furnace itself.

My invention provides an improved electrical heating element comprising a rod or bar composed of non-metallic refractory material having a portion composed of metal embedded in and coating the surface adjacent an end of the element for connecting same to an electrical terminal. The metal coating is deposited in such a way, as by being sprayed on the element under great pressure, that the metal completely fills in the small voids in the underlying surface of the non-metallic refractory material. After the metal coating is applied, it is smoothed down as by grinding to a finish and fit suitable to the seat of the cooperating electrical terminal. The smooth metal surface thus intimately combined with the non-metallic refractory material provides a larger and more constant contact between the heating element and its terminal than has been obtainable heretofore, thereby preventing loss of conductivity and danger of arcing such as is experienced with all previous heating elements of this general type. Heating elements employed in electrical resistance furnaces require terminal connections at both ends, and in the case of such elements it is understood that I provide two embedded metal contacts as hereinafter described.

Another feature of my invention resides in the construction of a refractory non-metallic heating element or rod with a relatively narrow body portion and an end or ends of enlarged cross-sectional area, which enlarged end or ends may be coated with embedded metal contact surfaces as previously described. One advantage of this construction is that it permits more current to pass through the enlarged ends of the rods to the reduced central heating section thereof without undue heating of the metal contacts and terminal connections, acting as a baffle which protects the insulation as well as the exterior portions of the furnace from excessive heat. Furthermore, the enlargement at the ends of the rod makes it possible to keep the end portions much cooler than the central heating section as it increases the available heat conducting surface which may be cooled by suitable water-jacketing of the furnace terminal connections.

My invention also provides an improved refractory heating element for electrical furnaces and the like, composed essentially of a mixture of flint and coke. This heating element preferably comprises a mixture of flint and coke particles of substantially uniform size, molded to shape with the aid of a binder, and heat treated to burn out the binder as well as all other foreign matter. The resulting product is extremely hard and resistant to fracture and is much more efficient and durable in use than non-metallic heating elements of ordinary construction.

These and other features and advantages of the invention will be apparent from the following description taken in connection with one specific embodiment shown in the accompanying drawing, wherein:

Fig. 1 is a fragmentary sectional view of the heating element, showing the usual method of mounting same in an electrical resistance furnace; and

Fig. 2 is a plan view of the heating element.

The heating element shown in the drawing

comprises a non-metallic refractory rod of circular cross-section having a relatively narrow body portion 1 and opposite end portions 2 of enlarged cross-sectional area. In the form shown, the extremities of end portions 2 are tapered outwardly at 3, in the form of a truncated cone, and these conical portions are coated at 4 with a layer of copper, nickel or any other suitable metal having satisfactory electrical conductivity.

The metal coating 4 is preferably sprayed on the tapered portions 3 of the rod in a molten state, as by means of a spray gun which bombards the exposed surface of the rod with a fine stream of molten metal under great pressure, completely filling in the tiny voids in the surface of the tapered portions of the rod and building up a coating of any desired thickness, say from a sixty-fourth to an eighth of an inch thick. The coating thus formed is then ground smoothly to fit the complementary terminals 5 of the electrical furnace shown in Fig. 1. I prefer to apply the metal coating 4 to the flat ends of the rod as well as to the conical peripheral portions thereof, and I have illustrated such embodiment of the invention in Fig. 1, but the ends need not be treated in this manner, nor is the invention limited to the conical contact surfaces which are disclosed here for purposes of illustration only.

The electrical resistance furnace shown diagrammatically in Fig. 1 comprises a housing 6 of asbestos board containing suitable insulation 7 such as "Sil-O-Cel" and a molded muffle 8 surrounding the heating chamber 9. In the embodiment illustrated, the conical cup-like terminals 5 at opposite sides of the heating chamber are integral with brass tubes 10 which are mounted in porcelain sleeves 11 extending through the walls of the furnace. The terminals are connected to a source of electrical current in any suitable manner. In operation, cold water may be circulated through tubes 10 as by means of pipes 12 for the purpose of cooling the terminal ends of the heating element. The smooth metal surface 4 embedded in and intimately combined with the non-metallic refractory material at each end of the heating element contacts snugly with its complementary terminal 5, preventing loss of conductivity and eliminating danger of arcing such as is always experienced when direct contact is made between the terminal and the natural pitted surface of the heating element itself. Also, due to the special shape of the heating element, with a relatively narrow body portion 1 and end portions 2 of enlarged cross-sectional area, more current will pass through end portions 2 to the central heating zone without excessive heating of the metal contacts and terminal connections, the enlarged end portions also being cooled more effectively than has heretofore been possible. While the dimensions of the electrical heating element may vary widely as occasion requires, I prefer to make the central heating section 1 relatively long and the enlarged end portion 2 relatively short in order to minimize the absorption of heat at the ends outside the heating chamber of the furnace.

A molded refractory composition of matter which I have used with very satisfactory results in the construction of the foregoing heating element is one composed of a specially treated mixture of flint and coke. Preferably, I take approximately 63 parts by weight of flint to 26 parts by weight of coke, both in a finely divided or powdered state, and mix same thoroughly. These proportions may vary anywhere from equal parts of flint and coke to 72 parts flint and 18 parts coke, but I find that the best results are obtained with a mixture containing 63 parts flint and 26 parts coke, all of the stated proportions being by weight. This thorough mixture is then heated, for example by packing same in a box of sufficient size to hold the batch and embedding in the center of the mixture a carbon or graphite hairpin resistor. The terminals of the resistor may then be connected to a standard 240 volt line and the current turned on. This resistor can reach a temperature of approximately 4500° F., it being possible to build up such a temperature since the mixture under treatment has excellent heat insulating properties. The current is preferably left on until a temperature of approximately 3500 to 4500° F. is reached, after which the current is turned off and the mix allowed to cool as by standing over night. The resulting product is a mixture of greenish colored particles of powdered form which, when the above mentioned starting proportions of 63 parts flint and 26 parts coke are employed, analyzes: silicon 65.80%, iron oxide .87%, alumina 2.25%, magnesia .59%, and total carbon 29.90%. I sift this material to obtain granules of uniform size and then heat the mixture, for example by placing same in a graphite crucible which I place in an electrical induction furnace, thoroughly sealing the top of the crucible before turning on the current. In a short time a temperature of approximately 4500° F. is reached, and I hold this temperature until all the gases are burned out of the mixture, after which the current is turned off and the batch allowed to cool over night. The resulting material, which is in fine granular form contains silicon 61.76%, iron oxide .92%, alumina 5.10%, total carbon 31.85%, and a trace of magnesia. It will thus be seen that this second heat treatment not only burns out certain undesirable gases, but also effects a marked change in the chemical composition of the material.

The grains produced by the above treatment are mixed with a suitable binder such as pitch or tar, in proportions suitable for molding, and heated to a temperature high enough to melt the binder and make a plastic mix. This plastic mixture is then placed in compression dies and molded to the shape of the resistance elements. After the molded elements are removed from the die, I place them in a container and cover them with carborundum to exclude air. The container is then placed in an electric furnace and heated to a temperature of approximately 300° to 400° F., which is done to burn out the binder. After the binder is burned out of the elements, I take a number of them, for example from one to a dozen, and lay them across a carbon or graphite hairpin resistor, cover them completely with a mixture composed of flint and coke in the proportions of the original mix described above, and bring the temperature of the furnace to approximately 4500° F., holding this temperature for about three hours, after which the current is turned off and the elements allowed to cool over night. In the morning the rods are cold and in such shape that they can be handled without fear of breakage. The final product, free of gases, binder and other foreign matter, contains silicon 52.70%, iron oxide 7.70%, alumina 4.20%, magnesia .41% and total carbon 34.80%. These proportions and all others given herein are by weight.

The rods produced as described above are ground, for example in a universal grinder, to the desired shape or cone-fit on the ends, after

which they are ready for the application of the metal coating 4. After this metal coating is applied, preferably by spraying as described above, the metal ends are ground to fit the terminals 5 into which they make perfect contact. I find that, because of the composition of the heating elements, the use of uniformly sized particles of refractory material therein, and the elimination of the binder and other foreign matter therefrom, these heating elements are far superior to any other non-metallic heating elements heretofore produced.

From tests performed on various standard silicon carbide heating elements, under conditions of actual commercial use, I have found that they invariably fail due to pitting and destruction of the terminals at approximately 2600° F. My heating elements, employing metal contact terminals as described above, will run almost indefinitely at a temperature of 2600° F. and will withstand temperatures in excess of 3000° F. without noticeable deterioration.

It will be evident that my invention is capable of various modifications and adaptations not specifically described but included within the scope of the appended claims.

The invention claimed is:

1. Method of making a refractory heating element for electrical furnaces and the like, which comprises mixing finely divided flint and coke in the proportions of from equal parts of flint and coke to 72 parts flint and 18 parts coke by weight, heating the mixture to a temperature of approximately 3500 to 4500° F., cooling the resulting mixture and sifting same to obtain granules of substantially uniform size, heating such uniform granules to expel gases, mixing the resulting gas-free granules with a plastic binder and molding to shape, and heating the plastic element in the absence of air to burn out the binder.

2. Method of making a refractory heating element for electrical furnaces and the like, which comprises mixing finely divided flint and coke in substantially the proportions of 63 parts flint to 26 parts coke by weight, heating the mixture to a temperature of approximately 3500 to 4500° F., cooling the resulting mixture and sifting same to obtain granules of substantially uniform size, heating such uniform granules to a temperature of approximately 4500° F. until all gases are expelled, mixing the resulting gas-free granules with a plastic binder and molding to shape, heating the plastic element in the absence of air to burn out the binder, then covering said element with a mixture of finely divided flint and coke in substantially the proportions of the original mix, and then heating to a temperature of approximately 4500° F. for about three hours.

DUNCAN MACKENZIE.