

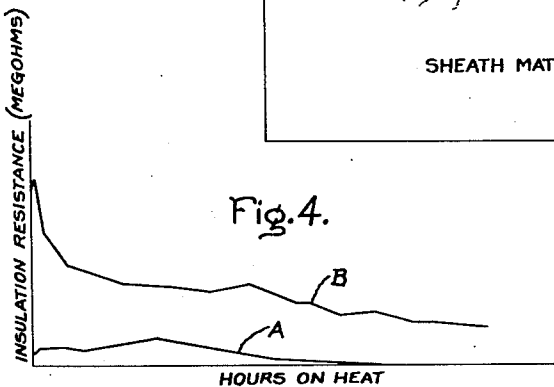
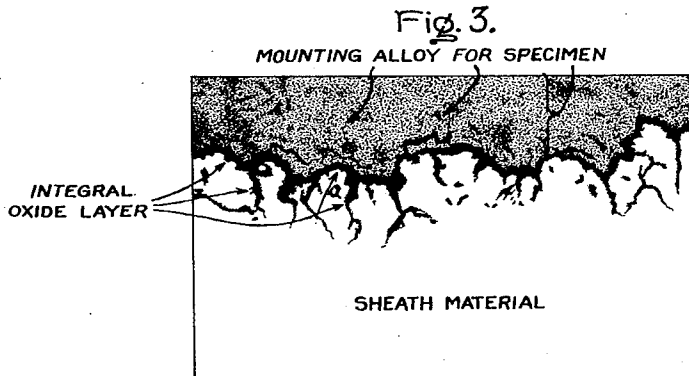
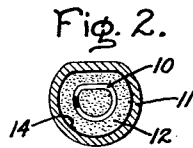
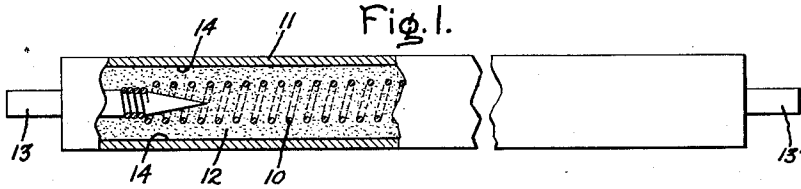
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2,233,182

ELECTRIC HEATER

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UNITED STATES PATENT OFFICE

2,233,182

ELECTRIC HEATER

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10 Claims. (Cl. 201—67)

This invention relates to electric heaters, and more particularly to electric heaters of the sheathed type and has for its object an improvement in heaters of this character.

5 The invention has particular application to electric heaters of the sheathed type such as described and claimed in United States patent to C. C. Abbott No. 1,367,341, dated February 1, 1921. Briefly, heaters of this type comprise a heating
10 element enclosed in a metallic sheath and embedded in and supported in spaced relation with respect to the sheath by a densely packed layer of electrically insulating, heat conducting, refractory material, such as magnesium oxide. It is
15 to be understood, however, that this invention is not limited to this specific type of heater but has general application in electric heaters having a resistance conductor encased in a metallic sheath.

It has been found in heaters of the above-mentioned type that the insulation resistance thereof
20 decreases during life. In some instances the insulation resistance has decreased to 1% of its initial value in about 1200 hours of heating.

In one of its aspects therefore this invention
25 contemplates the provision of an electric heater of the sheathed type having a higher and more permanent insulation resistance.

It has been found that if the inner surface of the metallic sheath is provided with an integral
30 or intimately bonded layer of oxide the value and life of the insulation resistance are considerably improved. The oxide layer may consist of an integral layer of the oxides of the metals present in the sheath itself or it may be in the form of a
35 layer of applied refractory oxides such as aluminum oxide, beryllium oxide, thorium oxide, magnesium oxide, silica, zirconium oxide, chromium oxide, or any other similar material either individually or in combination. The essential requirement with the last-mentioned materials is
40 that the material be intimately bonded to the internal surface of the metallic sheath and be formed in a relatively thick and smooth coat.

45 It is therefore an object of this invention to provide an oxide layer on the inner surface of the sheath of an electric heater so as to increase and maintain the insulation resistance of the heater element during its life.

50 It is a more specific object of this invention to provide an electric heater of the sheathed type in which the inner surface of the sheath is provided with a developed integral oxide layer or intimately bonded applied layer of oxide.

55 A further more specific object of this invention

is to provide methods by which the inner surface of the sheath of a sheathed type resistance element may be oxidized quickly and economically.

In the preferred embodiment of this invention a developed metallic oxide layer consisting of an
5 integral layer of oxides of the metals which are alloyed in the sheath is provided on the inner surface of the sheath. The sheath may consist of any type of alloy suitable for heating elements operating at temperatures above 1200° F., but a
10 metallic sheath having a composition within the range described and claimed in United States patent to J. C. Sharp No. 2,034,539, dated March 17, 1936, is preferred. The developed integral metallic
15 oxide layer is formed on such sheath material by preliminarily preparing the inner surface of the sheath, for example by sandblasting, and then heating it for a limited time at some predetermined high temperature while subjecting it to an
20 oxygen atmosphere. In order to prevent oxidation and scaling of the outside surface of the tube, the tube may be placed in a reducing or neutral atmosphere during the heating operation. It has
25 been found that the depth of oxide coating depends upon the temperature to which the sheath is subjected, the pressure of the oxygen, and the length of time of the treatment. An integral
30 layer of oxide of any thickness substantially uniformly formed on the inner surface of the metallic sheath will produce beneficial results but it is preferable that a coating of oxide corresponding to a minimum gain in weight of the sheath of one
35 tenth per cent (0.1%) shall be formed. It has been found that such a coating is sufficient to maintain the insulation resistance well above the value of that of unoxidized sheaths.

For a more complete understanding of this invention, reference should be had to the accompanying drawing in which Fig. 1 is a fragmentary
40 view in elevation of an electric heater embodying this invention, portions of the heater being shown in section to illustrate structural details; Fig. 2 is a cross-section of the heater element shown in Fig. 1; Fig. 3 is a reproduction of a photomicro-
45 graph of a specimen of sheath material showing the structure of the developed or integral layer of oxide; and Fig. 4 is a curve showing the improvement in insulation resistance of oxidized units as compared with similar but unoxidized units.

50 Referring to Fig. 1, this invention has been shown in one form as applied to an electric heater of the type described and claimed in the above-mentioned Abbott Patent No. 1,367,341, as modified and improved in the United States patent to
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Oliver G. Vogel No. 2,094,480, dated September 28, 1937. Briefly, this heater comprises a helical resistance conductor 10 mounted within and centrally of a tubular metallic sheath 11. Conductor 10 preferably will be formed of a nickel chromium alloy having a nickel content of approximately 80% and a chromium content of about 20%. The resistance conductor 10 is embedded in and supported in spaced relation with respect to sheath 11 by a densely compacted layer of a suitable heat conducting, heat refractory, and electrically insulating material 12, such as powdered magnesium oxide. The insulating material 12 may be compacted to a hard, dense mass in any suitable manner, such as reducing the diameter of the sheath after the unit has been assembled. This may be accomplished by either swaging or rolling. As described in the aforementioned Vogel patent, the characteristics of the heater element may be further improved by flattening the sheath on at least one side as shown in Fig. 2.

The resistance conductor 10 has its ends secured to terminals 13, 13', which project from the ends of the sheath and which have their inner ends embedded in the insulating material 12 so as to be supported in spaced relation with respect to the sheath 11.

As previously explained, the sheath 12 may be composed of any suitable alloy capable of withstanding temperatures of 1200° F. or more for a sustained period. It is preferred to use an alloy the constituents of which fall within the range described and claimed in the aforementioned Sharp Patent No. 2,034,539. One specific composition which has been found satisfactory is an alloy consisting of 79% nickel, 13% chromium, and approximately 8% iron.

An oxide layer 14 is provided on the inner surface of the metallic sheath 11. In the preferred embodiment of this invention the layer 14 consists of an integral layer of the oxides of the metals of which the sheath is composed which may be termed a developed metallic oxide layer. The method of oxidizing the sheath itself may be varied to a considerable extent depending on the thickness of oxide layer desired and permissible production costs.

It has been found that a satisfactory coating of oxide could be formed on the sheath in the following manner. The tubular sheath is first sandblasted on its inner surface to remove any protective scale formed thereon or foreign material such as dust, oil, etc. It is then oxidized by passing oxygen at atmospheric pressure there-through for from three to five minutes while maintaining the tube at a temperature of 2200° F. If it is so desired, the outer surface of the tubular sheath may be protected from oxidation during the heating by providing an inert or reducing atmosphere on the outside of the tube. The tube may be heated in any satisfactory manner, but it has been found that the temperature may be controlled to a greater degree by passing current directly through the metallic sheath. This method has produced a coating of oxide which materially improves the insulation characteristics of the heater element. In addition, the method described does not produce any detrimental scaling of the sheath element. While the oxidation might be carried on at a different temperature, either higher or lower, the above-indicated oxidation temperature is preferred from the standpoint of speed of oxidation and ease of control.

It has been found that the thickness of the oxide layer is proportional to the pressure of the oxygen used in the oxidation step. Carrying on the oxidation with the oxygen under a pressure of two atmospheres greatly facilitates the obtaining of a heavy oxide layer in a relatively short time.

Tests have indicated that additional improved results might also be obtained by subjecting the sheath to a pickling or hydrogen sulphide gas treatment prior to oxidizing. Such preliminary treatment of the sheath is particularly desirable when heater elements of the type described in the aforementioned Abbott patent are used in place of the improved heater element described in the aforementioned Vogel patent. This is due to the fact that the heater element of the Abbott patent has inherently lower insulation resistance characteristics than the flattened type of heater element described in the Vogel patent and hence the improved results due to such preliminary treatment are more pronounced when heater elements of the Abbott type are employed. The pickling in one case was carried out in a 50% solution of hydrochloric acid to which approximately 3% hydrofluoric acid was added. The solution was maintained at about 180° F. and the tubing treated for approximately one-half hour, after which it was bright-dipped in hot concentrated nitric acid. With the hydrogen sulphide gas treatment, the tubing, after sandblasting, was treated with hydrogen sulphide gas for five minutes at about 1100° F., followed by oxidation with oxygen for five minutes at 2200° F.

In Fig. 3 is shown a reproduction of a photomicrograph of a portion of a tubular sheath pickled and oxidized as stated above. In this figure the unshaded portion represents the sheath material and the light mottled portion represents the alloy upon which the specimen was mounted. The dark portion between the mounting alloy and the sheath material is the developed or integral coating of oxide formed on the sheath.

With tubes oxidized in the manner indicated above, it has been found that such units after the first thousand hours of life test maintain an insulation resistance at least twenty times higher than that of untreated units. The results obtained are shown graphically in Fig. 4. In obtaining these results the units tested were the same except that those giving the results shown in curve A were not oxidized, and those giving the results shown in curve B were oxidized. It is readily apparent from these curves that oxidizing the inner surface of the sheath gives higher and more permanent values of insulation resistance.

It is not known exactly why this improvement results. Several theories have been advanced but none have been established as controlling. One theory is based upon micrographic studies. As shown in Fig. 3, it appears that an oxide film covers the surface of the metallic sheath and also penetrates into the grain boundaries to a certain extent. It is possible, therefore, that this oxide film or layer acts as a protective layer preventing diffusion of deleterious gases or vapors from the metal into the insulation during life.

Another possible explanation is that the materials added to the sheath by oxidation can react with the magnesium oxide refractory material. In this way a bond between the metal and the insulation is formed, thus assuring better thermal

contact and restricting migration of impurities from the metal into the magnesium oxide.

Neither of these theories is a complete explanation of the results obtained, but is substantiated by tests that the oxidation of the inner surface of the tubular sheath gives higher and more permanent values of insulation resistance throughout the life of the heater. As previously stated, an intimately united layer of oxide of any thickness substantially uniformly formed on the inner surface will produce the aforementioned beneficial results but it is preferred that a coating of oxide corresponding to a minimum gain in weight of the sheath of 0.1% be formed on the sheath. With a sheath composed of an alloy the constituents of which fall within the range described and claimed in the aforementioned Sharp Patent No. 2,034,539 and particularly the preferred specific composition referred to above a gain in weight of 0.1% corresponds to a coating of oxide of approximately 4.6 milligrams per square inch of area.

While in the preferred embodiment the oxide layer is formed from the metals of the sheath itself, it has also been found, as previously stated, that beneficial results may be obtained by using an applied refractory oxide coating or layer of various other oxides, such as aluminum oxide, beryllium oxide, thorium oxide, magnesium oxide, silica, zirconium oxide, chromium oxide, or similar materials, either individually or in compounds. These are applied to the inner surface of the tubular sheath in any suitable manner so as to bond intimately the refractory oxide to the metal and thereafter provide a coating which tightly adheres to the metal surface.

In the case of alumina, for example, the tubular sheath is first sandblasted in order to clean the surface thereof and provide an extended surface area. It is then coated with fired, finely ground alumina which is suspended in a suitable carrier. The particular solution employed was a mixture of 68% alumina suspended in an organic material. After this solution is applied to the sheath it is air dried and then heated in an oven from room temperature to about 250° F., at which temperature it is held for about one hour. It is then heated to about 400° F. and held at this temperature for another hour. The tubes are then heated to about 2200° F. and maintained at this temperature for approximately twenty minutes.

The method for applying beryllium oxide is substantially the same as that used in applying a refractive coating of alumina except that a solution comprising about 54% beryllium oxide suspended in an organic carrier is employed. In each of these methods the application of the refractory coating may be facilitated by passing oxygen through the tubing during the final heating step of the method.

By employing either of the methods just described it was found that an evenly distributed refractory coating could be intimately bonded to the inner surface of the metallic sheath and that sheaths so coated when used in electric heater elements would produce units having higher insulation resistance.

While particular embodiments of this invention have been shown and described, modifications thereof will be apparent to those skilled in the art. It is desired, therefore that this invention should not be limited to the particular constructions and methods shown and described, and it is intended in the appended claims to

cover all modifications within the spirit and scope of this invention.

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

1. In a sheathed type electric heater, a coiled resistance unit embedded in a compacted mass of electrically insulating, heat conducting refractory material, a metallic sheath encasing said element and said refractory material, and a refractory oxide coating intimately united to the inner surface of said sheath and engaged by said refractory material.

2. A sheathed type electric heater comprising a coiled resistance unit embedded in a compacted mass of electrically insulating, heat conducting refractory material, a metallic sheath encasing said element and said refractory material, and a developed metallic oxide layer integrally formed on the inner surface of said sheath and adapted to be engaged by said refractory material.

3. A sheathed type electric heater comprising a coiled resistance unit embedded in a compacted mass of electrically insulating, heat conducting refractory material, a metallic sheath encasing said element and said refractory material, and an applied refractory oxide coating intimately bonded to the inner surface of said sheath and adapted to engage said refractory material.

4. A sheathed type electric heater comprising a tubular sheath the inner surface of which is provided with a tightly adhering refractory oxide coating, a resistance element within said sheath, and an electrically insulating heat conducting mass compacted between the oxide coating of said sheath and said heating element.

5. In an electric heater of the sheathed type, a coiled resistance element, a partially flattened metallic sheath formed of alloyed metals encasing said resistance element, a developed layer of the oxides of said alloyed metals integrally formed with the inside surface thereof, and a mass of heat conducting electrically insulating material compacted between said sheath and said resistance element and embedding said resistance element.

6. An electric heater of the sheathed type comprising a metallic sheath, an electric resistance element arranged centrally of said sheath, a tightly compacted mass of insulating material embedding said resistance element, and a layer of applied refractory oxide arranged between said insulating material and said sheath and intimately bonded to the inner surface of said sheath.

7. An electric heater element of the sheath type comprising a metallic sheath, an integral covering of oxide on the inner surface of said sheath, said oxide covering comprising oxides of the metals of which the sheath is composed, a resistance element within said sheath and embedded in a tightly compacted mass of electrically insulating heat conducting refractory material.

8. A metallic sheath for an electric heater adapted to encase a resistance element embedded in an electrically insulating heat conducting mass, said sheath being composed of an alloy comprising approximately 79% nickel, 13% chromium, and 8% iron, and having developed on its inner surface an oxide coating comprising oxides of nickel, chromium, and iron.

9. In an electric heater of the sheathed type, a metallic sheath, an integrally formed oxide coating on the inner surface of said sheath, a

resistance element within said sheath, and a mass of refractory material compacted between said resistance element and said oxide coating whereby an electric heating unit having high insulation resistance is provided.

5 10. A sheathed type electric heater having high insulation resistance comprising a tubular sheath the inner surface of which is provided with an intimately bonded layer of applied refractory

oxide, a coiled resistance element within said sheath, and a compact mass of electrically insulating heat conducting refractory material within said sheath embedding said resistance element.

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