Nov. 22, 1960 H. D. EPSTEIN 2,960,757

METHOD OF MAKING ELECTRICAL HEATING ASSEMBLY

Filed May 21, 1956

Fig. 1.

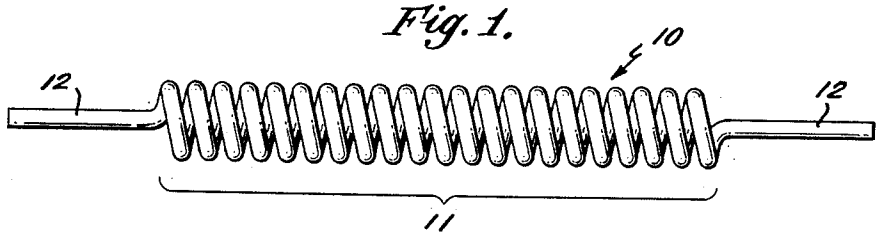


Fig. 2.

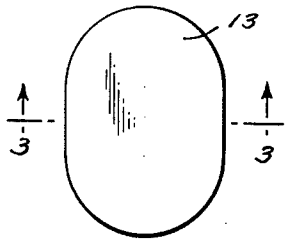


Fig. 3.

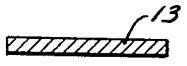


Fig. 4.

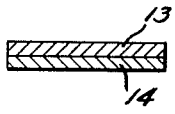


Fig. 5.

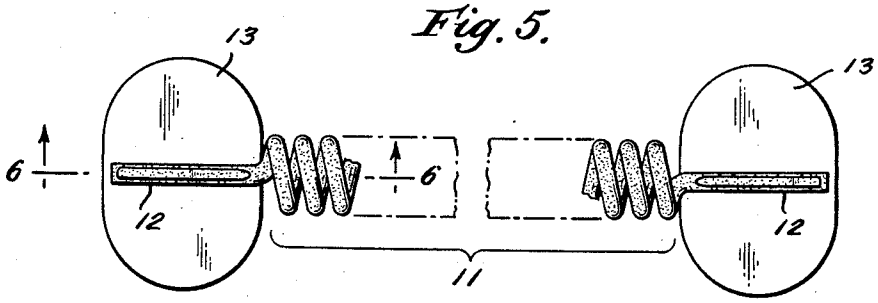


Fig. 6.

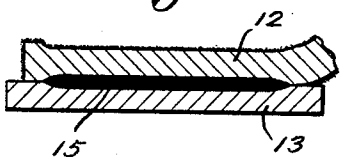
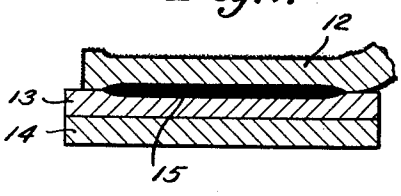


Fig. 7.



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2,960,757

METHOD OF MAKING ELECTRICAL HEATING ASSEMBLY

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8 Claims. (Cl. 29—155.71)

This invention relates to an improved method of making an electrical heater assembly.

An object of this invention is to provide an improved method of making such an assembly.

A further object of the invention is to provide a novel method for making such a heater assembly by which distortion and stretching of the heating element is materially reduced, by which the entire exposed surface of the heating element can be uniformly oxidized and by which the quality of the oxide at the exposed surface of the heating element is improved.

A further object of the present invention is to provide a novel method of forming such a heater assembly whereby all portions of the exposed surface of the heater are uniformly insulated from those adjacent thereto.

A further object of this invention is to provide a novel method whereby the entire exposed surface of a heating element is uniformly oxidized and at least a portion of the exposed surface of a terminal structure, to which the heating element is bonded, is non-oxidized.

Still another object of this invention is to provide a novel method of making such a heater assembly, which method is simple, economical, efficient, and which avoids or reduces the use of jigs or fixtures.

Other objects will be in part apparent and in part pointed out hereinafter.

The invention accordingly comprises the steps and sequence of steps and features of operation which will be exemplified in the methods hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which is illustrated one of the various possible embodiments of the invention:

Fig. 1 is a plan view of one form of electrical heating element which may be utilized by this invention;

Fig. 2 is a plan view of an electrical terminal which may be utilized by this invention;

Fig. 3 is a sectional view taken along line 3—3 in Fig. 2;

Fig. 4 is a view similar to Fig. 3 but further including a contact portion carried by the terminal;

Fig. 5 is a plan view showing an assembly whereby the heating element of Fig. 1 is bonded to two of the Fig. 2 terminals and the entire exposed surface has been uniformly oxidized as indicated by the stippling in this view;

Fig. 6 is a sectional view taken along line 6—6 of Fig. 5; and

Fig. 7 is a view similar to Fig. 6 but further including a contact carried by the terminal.

Common desiderata of an electrical heater assembly such, for example, as that set forth in the environment illustrated in Figs. 5 and 6 of United States Letters Patent 2,501,156, granted March 21, 1950, to J. D. Bolesky, are that the heating element be bonded to electrical terminal structure, that the exposed surface of the heating element be electrically insulating, and that the exposed

surface of the terminal structure be electrically conductive. Obviously, if a portion of the electrical heating element were to short out with another portion thereof or with other adjacent structure, the intended purposes and functions of the assembly would be defeated. Since such heating elements are often provided in coiled or otherwise configured forms whereby two or more portions of such elements lie closely adjacent each other, it is clear that it is highly desirable that the entire exposed surface of the heating element be uniformly electrically insulating. The terminal structure, of course, provides means for electrical connection of the heating element to its source of electrical potential, and it is oftentimes desired that the exposed surface thereof be in non-oxidized condition, for example, to facilitate soldering a lead wire thereto.

In general, a convenient method of insulating the exposed surface of an electrical conductor is to oxidize this surface. To form an electrical heating assembly wherein the surface of the heating element is oxidized and the terminal structure is not, the surface of the heating element could be separately oxidized in any suitable manner, and then the heating element could be subsequently bonded to suitable terminal structure. This procedure is expensive and time-consuming in that it requires that portions of the heating element, after they have been oxidized, be cleaned by abrading or otherwise. For example, to resistance-weld the heating element to a terminal, that portion of the heating element to be bonded to the terminal must be substantially free of oxides, and also, that portion to which the welding electrode is connected must likewise be so cleaned. Practically, it is impossible to render the entire exposed surface of the heating element in oxidized form by this procedure since the portion of the heater unit, to which the electrode is connected for the welding process, remains non-oxidized.

Another conventional procedure to provide heater assembly of this type would be first to bond the heating unit to the terminal structure and then pass an electrical current through the assembly to bring the heating element to a red heat. When the heating element is so heated in air, a substantial portion of the heating unit will be oxidized. However, a number of disadvantages accrue to this method, namely; it is expensive, time-consuming and involves a great deal of heater distortion and stretching which, in turn, requires extensive fixturing. Also, and perhaps more importantly, by this method the portions of the heating element which lie closely adjacent the terminal structure do not heat up to the same temperature as the more remote portions thereof with the result that these closely adjacent portions do not oxidize properly.

It is well known that controlled atmospheres can be provided which, depending upon a number of different variables, will be effective to oxidize or to reduce the surface of a given metal. In the main, these variables are: the components of the atmosphere or gas; the dew point of this atmosphere; the temperature to which the metal is heated in this atmosphere; and the particular metal whether it be in elemental form, in the form of an alloy, or otherwise. For a given metal and a given atmosphere, the lower the dew point of the atmosphere and the higher the temperature to which the metal is heated in the atmosphere, the greater the tendency for that atmosphere to act as a reducing atmosphere and the lesser the tendency for that atmosphere to act as an oxidizing atmosphere. An equilibrium temperature exists for each of these controlled atmospheres at a given dew point above which reduction of a given metal occurs and below which oxidation of that metal occurs. By way of example, chromium is in equilibrium with an atmosphere of hydrogen when that atmosphere has a dew point of 0° F. and the chromium is heated to a

temperature of 3000° F. If the chromium is heated to a temperature substantially above 3000° F., this atmosphere of hydrogen having a dew point of 0° F. will reduce the chromium; and if the chromium is heated to a temperature substantially below 3000° F., this same atmosphere will oxidize the chromium.

This phenomenon is utilized by this invention in a manner which will become apparent as the description proceeds.

Referring to the drawings, an electrical heating element **10** is provided which is formed of metal having a comparatively high electrical resistivity. Heating element **10** may be provided as shown in Fig. 1 whereby a portion **11** is made up of a plurality of closely adjacent coils. At each end of the heating element is an integral projecting portion **12**, **12**. By way of example, the metal of which heating element **10** is formed could be "Chromel-C" alloy, "Chromel-D" alloy, or "Alloy #732." "Chromel-C" alloy comprises 60% nickel, 16% chromium and the remainder iron. "Chromel-D" alloy comprises 35% nickel, 18.5% chromium and the remainder iron. "Alloy #732" is a variation of "Chromel-C" alloy which is vacuum-melted and contains slightly more iron than "Chromel-C" alloy; the approximate nominal analysis of "Alloy #732" is 59% nickel, 16% chrome, 24.5% iron and 0.5% of usual residuals. Each of these alloys is commercially available from Hoskins Manufacturing Company, Detroit, Michigan.

Also provided are one or more electrical terminals **13**. Each of terminals **13** is formed of metal having a substantially higher conductivity than the metal of which heating element **10** is formed. This metal may be any of a number of conventional terminal-forming metals, and preferably one which can be welded to heating elements such as described above. Examples are Monel (a trade name for an alloy comprising approximately by weight, 67% nickel, 30% copper, 1.4% iron and 1% manganese in the wrought form) and nickel. As shown in Fig. 4, terminal **13** may be provided with a contact-forming portion **14**, such as silver. Contact **14** is bonded to terminal **13** in any suitable manner.

According to this invention, heating element **10** is bonded to one or more terminals **13** as shown in Fig. 5. This bond may be conveniently formed by resistance-welding to form a weld **15** as shown in Fig. 6.

After bonding the heating element to one or more terminals, the bonded assembly is placed in a controlled atmosphere and the assembly is heated to a predetermined temperature range at which this atmosphere acts as a reducing atmosphere with respect to the metal of which the terminal is formed and as an oxidizing atmosphere with respect to the metal of which the heating element is formed. In order for this controlled atmosphere so to function as both a reducing atmosphere and an oxidizing atmosphere, the above-mentioned variables must be properly adjusted. According to one preferred adjustment of these variables, the terminal or terminals are formed of an alloy comprising substantially 60% nickel and the remainder copper, the heating element is formed of "Chromel-C" alloy, the atmosphere is provided in the form of cracked city gas having a dew point of approximately 60–70° F. (sample tests indicate that this gas comprises approximately 5–7% carbon monoxide, 12% carbon dioxide, 5–7% hydrogen and the remainder nitrogen and water vapor) and the bonded assembly is heated to a temperature of from approximately 1550° F. to approximately 1600° F. Under these conditions, this atmosphere will act as an oxidizing atmosphere with respect to the heating element whereby the entire exposed surface of the heating element will be uniformly oxidized (as indicated by the stippling in Figs. 5–7); and this atmosphere will act as a reducing atmosphere with respect to the terminals whereby the exposed surface of the terminals will be non-oxidized. In accomplishing this last step one or more of the bonded assemblies may

be merely dropped into a pan which may then be disposed in the gas-filled heating chamber of a furnace prior to heating the assemblies. Numerous other adjustments of these variables will suggest themselves in the light of this disclosure.

In the case where the electrical terminal or terminals carry a contact-forming portion of precious metal such as silver which has a melting point considerably lower than that of the other parts of the assembly, the above-mentioned variables must be adjusted so that the melting point of the metal of the contact-forming portion lies above the range to which the bonded assembly is heated in the controlled atmosphere. Since the melting point of silver is significantly above 1600° F., one or more terminals having a contact portion **14** of silver as shown in Fig. 7 may be substituted in the above-described specific example for corresponding terminals **13** as indicated in Fig. 6.

By this improved process the oxide formed on the exposed surface of the heating element is much more permanent and has a higher insulating quality than that obtained by passing a current through the heater assembly to oxidize the heating unit in air. Furthermore, by this improved method the entire surface of the heating element is uniformly oxidized in contradistinction to that formed by the previously-described methods. Since the entire surface of the heating element is uniformly oxidized by the method of this invention, the operating temperature to which the heating element may be raised is not limited by one or more portions of the element, the exposed surfaces of which would otherwise be less well oxidized. Furthermore, the heating unit, when formed by this improved method, has higher strength than that when formed by passing an electrical current through it in air since it is not as greatly annealed. Also, distortion and stretching of the heating element during the improved process is substantially reduced if not avoided altogether and therefore no fixturing or jigging is ordinarily required for the practice of this process.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As many changes could be made in the above constructions and methods without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings, shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. The method comprising the steps of providing a heating element formed of a first alloy comprising substantially 35% nickel, 18.5% chromium and the remainder iron, providing an electrical terminal having at least a part thereof formed of a metal different from that of the heating unit, providing an atmosphere in the form of cracked city gas having a dew point of approximately 60° F. to 70° F., said cracked city gas comprising 5% to 7% carbon monoxide, 12% carbon dioxide, 5% to 7% hydrogen and the remainder nitrogen and water vapor; metallurgically bonding said heating element to said terminal; and then heating said bonded assembly in said atmosphere to approximately 1550° F. to 1600° F., for a time sufficient for said atmosphere to act both as an oxidizing atmosphere with respect to the metal of said heating element and as a reducing atmosphere with respect to those portions of the metal of said electrical terminal which are oxidized, and a heater-terminal assembly is provided wherein the heating element is substantially uniformly oxidized and the electrical terminal is substantially free from contaminating oxidation.

2. The method as set forth in claim 1 and wherein said electrical terminal is formed of Monel metal.

3. The method as set forth in claim 1 and wherein said electrical terminal comprises nickel.

4. The method comprising the steps of providing a heat-

ing element formed of a first alloy comprising substantially 35% nickel, 18.5% chromium and the remainder iron; providing an electrical terminal having at least a part thereof formed of an alloy of substantially 60% nickel and the remainder copper; providing an atmosphere in the form of cracked city gas having a dew point of approximately 60° F. to 70° F., said cracked city gas having 5% to 7% carbon monoxide, 12% carbon dioxide, 5% to 7% hydrogen and the remainder nitrogen and water vapor; bonding said heating element to said terminal; and subsequently heating said bonded assembly in said atmosphere to approximately 1550° F. to 1600° F., whereby said atmosphere acts as an oxidizing atmosphere with respect to the metal of said heating element and as a reducing atmosphere with respect to those portions of the metal of said electrical terminal which are oxidized, and a heater-terminal assembly is provided wherein the heating element is substantially uniformly oxidized and the electrical terminal is substantially free from contaminating oxidation.

5. The method comprising the steps of providing a metallic heating element characterized by a substantial electrical resistivity and capable of being surface oxidized by heating thereof in a selected atmosphere within a selected temperature range; providing an electrical terminal, at least a part thereof being formed of metal different from that of the heating element and of substantial electrical conductivity, said selected atmosphere, when heated to said selected temperature range, also acting as a reducing atmosphere with respect to said part of said electrical terminal; metallurgically bonding said heating element to said terminal; and heating said bonded assembly in said selected atmosphere to said selected temperature range for a time sufficient for said atmosphere to act as an oxidizing atmosphere with respect to said heater and as a reducing atmosphere with respect to said part of said terminal.

6. The method comprising the steps of providing a metallic heating element characterized by a substantial electrical resistivity; providing an electrical terminal having at least a part thereof formed of metal different from that of the heating element and of substantial electrical conductivity, said part being formed of a precious metal having a melting point considerably lower than that of the metal of the heating element; providing a selected atmosphere which, within a selected temperature range below the melting point of said precious metal, acts as an oxidizing atmosphere with respect to the surface of the metal of said heating element and also acts as a reducing atmosphere with respect to said part of said terminal; metallurgically bonding said heating element to said part of said terminal; and heating said bonded assembly in said selected atmosphere to said selected temperature range for a time sufficient for said atmosphere to act as an oxidizing atmosphere with respect to said heater and as a reducing atmosphere with respect to said terminal.

7. The method comprising the steps of providing a heating element formed of a first alloy comprising substantially 60% nickel, 16% chromium and the remainder iron; providing an electrical terminal formed of a second alloy comprising substantially 60% nickel and the remainder copper; providing a selected atmosphere of a cracked city gas having a dew point of substantially 60° F.–70° F.; metallurgically bonding said heating element to said terminal; and heating said bonded assembly in said selected atmosphere to a temperature range of approximately 1550° F.–1600° F. for a time sufficient for said atmosphere to act as an oxidizing atmosphere with respect to said heater and as a reducing atmosphere with respect to said terminal.

8. The method comprising the steps of providing a heating element formed of a first alloy comprising substantially 60% nickel, 16% chromium and the remainder iron; providing an electrical terminal formed of a second alloy comprising substantially 60% nickel and the remainder copper, said terminal having an electrical contact connected thereto which includes a portion formed of silver; metallurgically bonding said heating element to said terminal; and heating said bonded assembly to a selected temperature range of 1550° F.–1600° F. in a selected atmosphere of a cracked city gas having a dew point of substantially 60° F.–70° F. for a time sufficient for said atmosphere to both oxidize said heater and to reduce surface portions of said terminal.

References Cited in the file of this patent

UNITED STATES PATENTS

1,360,267	Chubb	Nov. 30, 1920
1,865,208	Pilling	June 28, 1932
1,907,930	Adams	May 9, 1933
2,438,850	Fot	Mar. 30, 1948
2,461,935	Stockdale	Feb. 15, 1949
2,519,127	Fessler	Aug. 15, 1950
2,533,351	Carpenter	Dec. 12, 1950
2,565,004	Smith	Aug. 21, 1951
2,614,052	Taylor	Oct. 14, 1952