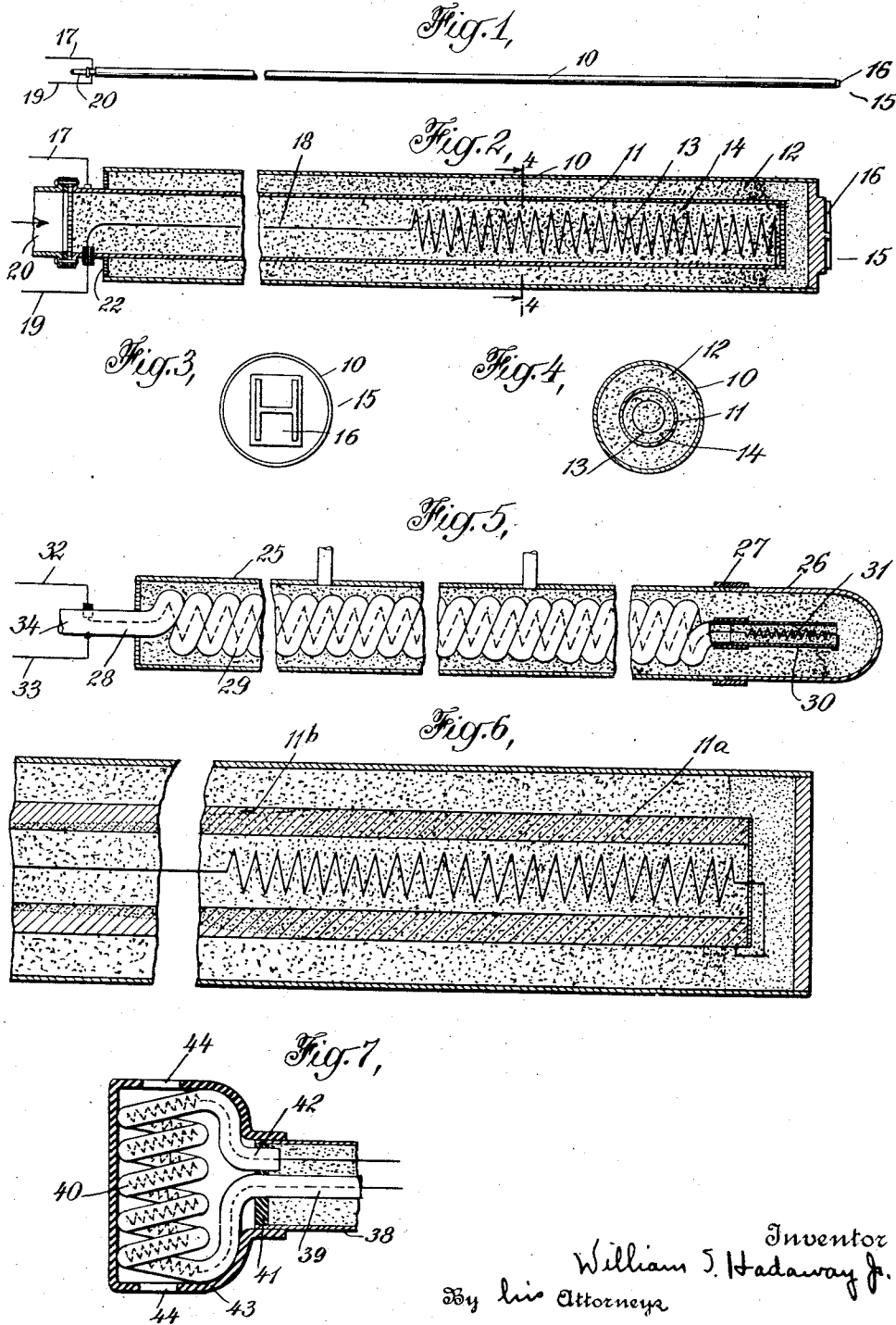


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ELECTRIC HEATER ELEMENT.

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UNITED STATES PATENT OFFICE.

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ELECTRIC HEATER ELEMENT.

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To all whom it may concern:

Be it known that I, WILLIAM S. HADAWAY, Jr., a citizen of the United States of America, and a resident of New Rochelle, Westchester County, and State of New York, have invented certain new and useful Improvements in Electric Heater Elements, of which the following is a specification, reference being had to the accompanying drawings, forming a part thereof.

My invention relates to high temperature resistors for electric heating and processes of producing the same, and it has special reference to vapor electric heating devices comprising a common conductor for electric energy and a hot vapor, and having a high temperature section or member where heat is concentrated.

One object is to provide a simple and relatively inexpensive heater of the general character above indicated, and an efficient process of producing the high temperature vapor electric heater element thereof.

Another object is to provide a heater composed of a high temperature portion having a negative temperature coefficient, i. e., its resistance to the flow of electricity diminishes as its temperature increases—and a portion having a positive temperature coefficient which serves as a ballast or regulating resistance to stabilize the operation of the device in conjunction with a heat conveying vapor which concentrates the heat at the high temperature portion and relatively cools the portion having a positive temperature coefficient.

Another object of my invention is to provide an electric heating element that shall have a gradually varying characteristic between predetermined points in its length.

Another object is to provide a process of treating a uniform iron conductor of electricity to modify its resistance characteristics in a gradually increasing degree.

Another object is to provide a high resistance coating on the surface of an iron conductor, the depth of the coating being gradually varied to produce a varying resistance characteristic throughout the conductor.

Another object is to provide a tubular conductor of electricity that shall be adapted to carry steam or other vapor and that shall be automatically changed in its composition to a predetermined depth, varying gradually from one point to another where-

by the resistance and the heat resistive qualities of the tube are increased toward the outlet end of the tube where the temperatures are greater.

Still another object is to provide a tubular heating conductor, adapted to operate at high temperatures, and assembled as a part of a complete device in a different form or composition from that to which it is transformed by the process of my invention, prior to use in the arts.

Another object is to provide a heater comprising a high temperature member of granular material, and means for supporting and maintaining the same in tubular form.

In order that my invention may be thoroughly understood I will now proceed to describe the same in the following specification, and then point out the novel features thereof in appended claims.

Referring to the drawings:

Figure 1 is an elevation of the heater element or unit constituting an embodiment of my invention.

Figure 2 is a longitudinal section of the same unit as adapted to the use of a branding tool or iron, but drawn to a relatively large scale to show the structure in detail.

Figure 3 is an end view of the tool and Figure 4 is a transverse section on the line 4-4 of Figure 2.

Figure 5 corresponds to Figure 2 but shows a modification of my invention, and Figure 6 shows a portion of the unit of Figure 2 drawn to a still larger scale to illustrate the transformation effected by the process of my invention.

Figure 7 shows another embodiment of my invention as adapted for singeing thread.

Special reference may first be had to Figures 1 to 4 inclusive, from which it appears that the unit or heater element comprises an elongated tubular casing or armor 10 of metal, an inner tubular member 11 which is substantially coextensive with the casing, and is smaller in diameter being spaced therefrom by an insulating granular mass 12 which may be composed of particles of carborundum. Within the inner tube is an electric heating coil 13 which is connected at the working end of the device to the inner tube 11 and is separated from the inner tube throughout its length by finely divided insulating particles 14 which may constitute a porous or granular mass similar to the mass 12.

The coil may extend the entire length of the structure but it may be preferable in many cases to make it somewhat shorter than the tubes and locate it adjacent to the working end of the device which is designated 15. In the structure illustrated in Figures 1 to 4, the working member is formed into a branding die 16.

The tube 11 constitutes one of the electrical terminals of the device, a supply circuit conductor 17 being connected thereto. The terminal 18 of the coil 13 constitutes the other terminal of the device and is connected to a supply circuit conductor 19. The inner tube 11 extends slightly beyond the casing and is connected to a pipe 20 through which low temperature steam or other suitable fluid is supplied to the device.

The unit, as already explained, will usually be long relative to its size and as hereinafter explained, it may be bent into any convenient form such as a helix or spiral in order that it may be more compact and better adapted for use in the arts.

The inner tubular resistor 11 is produced by the process of my invention and is composite in formation, being suitably assembled in the complete heater unit and then transferred into its final condition before the device is put into service.

As originally assembled in the unit, it is formed of iron, steel or some other suitable metallic substance which is adapted to be chemically changed as hereinafter explained.

The first step of the process is to heat the tube to a high temperature which may be accomplished by connecting the terminal conductors 17 and 19 to a suitable source of electric energy. While the tube is hot steam or other vapor capable of producing the results desired is introduced into the outer end of the tube 11 from the pipe 20.

The temperature of the steam is increased by the heat of the tube and reacts upon the tube to heat the end portion near the working member, to a high temperature. This temperature is sufficient to transform the iron tube into a granular compound of iron and hydrogen which is a particularly permanent resistor which is able to operate at high temperatures without deterioration and which has a negative temperature coefficient.

The chemical change which occurs will of course depend upon the materials used and while I prefer to use iron some other substance may be employed.

The temperature varies from the working end of the tube to the outer end where the steam enters and the change in the composition of the tube takes place to a varying degree as illustrated in Figure 6.

For example, the tube will be completely transformed in the portion near the working member designated 11^a in Figure 6 and it will merge into an adjacent portion designat-

ed 11^b which is only partially transformed into high resistance material, the outer layer being left in its original state.

The depth to which the transformation occurs varies, increasing toward the working end where the temperature is highest and when the process is complete the tubular resistor will have definite and predetermined characteristics and will be able to operate continuously at high temperatures without substantial deterioration. The temperatures employed in producing the transformation will be considerably higher than those attained when the unit is subsequently in use.

Assuming that the device is complete and that the transformation has been made as above described, when the device is in use electric energy is supplied from the conductor 17 for example, through the tube 11 in which more or less heat is generated, thence through the coil 13 in which a large proportion of the heat is generated, then through the terminal 18 to the conductor 19. The fluid supplied to the unit may be a permanent gas as air, but I prefer to utilize low pressure steam which may enter for example, at a temperature of 225° F.

This steam percolates through the porous mass 14 formed by the granular particles within the inner tube and heats the mass to its own temperature. As the steam progresses its temperature is very materially increased by taking up the heat generated in the coil 13 and in the tube 11. This heat is cumulative, the temperature of the steam being built up until it finally emerges from the working end of the inner tube into the casing at the temperature desired to produce the best working results.

The heat is given up to the work and the temperature of the steam is reduced at this point to some extent. It then flows backwardly through the porous mass 12 in the casing. This mass 12 is an insulating mass which prevents the short-circuiting of the inner tube and coil to the casing and it is heated by the steam to a relatively high temperature and hence operates very effectively in preventing loss of heat from the tube and coil in which it is generated electrically.

Steam in passing back to the casing is at a sufficiently high temperature to give up heat to the incoming steam. This heat transfer takes place to a greater extent as the steam travels away from the working member, and it will be clearly understood that a large proportion of the heat remaining in the steam as it passes through the casing is taken up by the incoming steam as it enters the inner tube. By this means the steam which finally escapes from the casing through the opening 22 is only slightly higher in temperature than the

steam which is supplied to the inner tube.

It is therefore evident that the loss of heat when the structure is in use, is very slight.

When the device is not in use the electric energy may be shut off and the steam allowed to percolate through the tool. The steam constitutes a relatively low cost source of heat and will maintain the tool at a temperature materially above that of the atmosphere and make up for the usual standby losses. In many classes of work the standby losses under ordinary conditions are relatively great when electricity is utilized as the sole source of heat.

The structure of the unit may be varied within the spirit and scope of my invention; for example, only the section or member of the tubular resistor which is adjacent to the working member may be formed of iron or like substance adapted to be chemically changed, the remainder of the tube which operates at a relatively low temperature being formed of some other suitable substance which is not changed by the process of my invention. A structure of this kind is shown in Figure 5 to which special reference may now be had.

The structure here shown is particularly adapted for small furnace work and other high temperature service, and comprises an outer casing having a metallic section designated 25 and a high temperature section 26 which may be formed of a quartz tube, a fulgarite or the like. This tube is joined in some suitable manner to one end of the metallic section 25, the sleeve 27 being indicated as a convenient means for this purpose. Within the casing is a relatively small metal tube 28 which corresponds to the tube 11 of Figure 2 and may be bent into the form of a helix 29 in order to increase its length relative to the length of the device. Within the high temperature member of the casing is a high temperature resistor tube 30 which is preferably composed of a compound of iron produced by the process of my invention. The metallic helix 29 and the high temperature resistor tube 30 may solely constitute the electric heating element of the device or they may be employed in conjunction with a resistance wire or coil 31 disposed within the tubular members 29 and 30 and connected to the high temperature member at its outer end.

The resistance coil or wire 31 is spaced from the tube within which it is disposed by means of carborundum or some other like substance into granular or porous condition to permit the flow of steam or other suitable vapor therethrough. The inner tube having the sections 29 and 30 is also supported within the casing by means of similar material. The structure may be completed in any suitable manner and it is adapted to be used as the structure shown and described in my co-

pending application Serial No. 170,359 filed May 23, 1917.

The structure is assembled complete with the high temperature tube 30 made of iron or the like, then electric energy is supplied from the terminal conductors 32 and 33 and steam is introduced through the pipe 34. The electrically generated heat is imparted to the steam so that its temperature is accumulated toward the hot end of the device and when it passes through the high temperature member 30 it transforms the metal thereof or converts it into a new chemical compound which is particularly adapted to withstand high temperature conditions and which is permanent and does not deteriorate by constant use.

In order to further illustrate the adaptability of my invention to service conditions, I have shown in Figure 7 the inner tube 39 formed into a helix 40 with its axis at right angles to the casing 38. Furthermore, the helix extends through a partition or wall 41 which prevents the escape of the steam or hot vapor, the open end of the helix which is designated 42 being arranged to extend back through the partition and to discharge into the casing 38.

The helix is surrounded by a protective covering 43 having holes 44 at its opposite ends disposed with their centers in the axis of the helix 40. The device as shown is adapted to concentrate heat at the helix 40 which may be relatively small in size and which is adapted to be used as a singeing device in the manufacture of thread.

It has been my aim to provide an electric heater capable of operating at very high temperatures and which may nevertheless be constructed of an ordinary resistance material such as iron wire. It is of course well understood that iron wire will not withstand very high temperature operation and as employed hitherto it has limited the operating temperatures of the apparatus with which it has been employed to comparatively low values. To overcome this objection relatively expensive resistance elements of special steels have been employed.

I however, do not make use of special resistance materials but construct my heater of ordinary iron tubing or wire and subject the completed appliance to a treatment such that the iron is chemically changed either in whole or in part to form a fulgarite which possesses characteristics quite unlike those of the original iron. The fulgarite is composed of an alloy of hydrogen and iron, and iron oxides, it is capable of withstanding very high temperatures without damage and it has a negative temperature coefficient.

It is therefore evident that if the resistor has originally the form of an iron tube and if heat is electrically generated therein, and steam is caused to flow through the tube, the

temperature of the steam will be greatly increased toward the outgoing end because the steam acts as a heat carrier and takes heat from the resistor near the incoming end and concentrates heat at the outgoing end.

The steam under these conditions changes the interior wall of the tube and may change the entire wall of the tube at the hot end into the aforesaid hydrogen iron alloy. The amount of electrically generated heat and temperature and rate of flow of the steam supplied to the tube are constantly changed and I prefer to treat the device under fixed conditions before it is put into commercial use. By this means a certain section of the tube is formed into a fulgarite and the adjoining section of the tube provided with an alloy coating of varying depth which tapers away from the hot end of the tube.

As above explained the fulgarite has a negative temperature coefficient, consequently the higher its temperature the greater the flow of energy tends to become and it could not be employed without some suitable ballast for preventing the indefinite building up of temperature. The remainder of the tube however is formed of iron and the temperatures are not sufficient to change it so that it retains its positive temperature coefficient characteristic and serves as a ballast. Furthermore, the hot vapor flowing through the tube serves to prevent the increase in temperature of the tube, above a definite amount at the cool end. In other words, the steam or hot vapor serves as a ballast, both alone and in conjunction with the low temperature end of the resistor, and may for convenience be termed a mobile ballast.

I am aware that the above described alloy of iron and hydrogen is not new per se, but great difficulty has been found in attempting to make the alloy and then use it as a material in the manufacture of electrical insulators or the like, but I believe I am the first to propose the manufacture of an electric resistor from ordinary iron and the conversion of the article, after it is formed and associated with other elements in a complete device, partially or wholly into a material of this kind.

My invention may be embodied in structures adapted for various purposes, and I intend that only such limitations be imposed as are indicated in the appended claims.

What I claim is:

1. An electric conductor composed of iron having a coating of varying depths formed of hydrogen in combination with the iron of the conductor.

2. An electric conductor composed partly of iron and partly of a ferro-hydrogen compound formed therefrom.

3. A tubular conductor having its inner

wall changed to a varying depth into a relatively high resistance compound of iron.

4. A tubular conductor having a relatively high temperature portion composed of a compound of iron and hydrogen, and another portion composed of iron with a high temperature coating.

5. A tubular conductor having a relatively high temperature portion composed of a compound of iron and hydrogen, and another portion composed of iron with a high temperature coating of varying depth.

6. A tubular conductor having a relatively high temperature portion composed of a compound of iron and hydrogen, and another portion composed of iron with a high temperature coating of varying depth increasing towards and merging into the high temperature portion.

7. A conductor composed of a metallic portion and a high temperature portion of unlike characteristics merging into the metallic portion.

8. A conductor composed of a high temperature portion having a negative temperature coefficient and a relatively low temperature portion merging into the high temperature portion and composed of metal with a high temperature coating of varying depth increasing toward the high temperature portion.

9. A tubular conductor having its inner wall changed to a varying depth into a compound of hydrogen and iron.

10. The process of producing electric heating resistors that consists in supporting a ferroconductor within a vapor passage, and electrically generating heat in the conductor of sufficient temperature in conjunction with the vapor in the passage, to transform the ferro-conductor into a granular high resistance heat resisting conductor.

11. The process of producing electric heating resistors that consists in supporting a ferroconductor in porous heat resisting insulation, and subjecting the ferroconductor to heat and water vapor at a sufficient temperature to transform the ferroconductor into a granular high resistance heat resisting conductor.

12. The process of producing electric heating resistors that consists in supporting a ferro conductor in porous heat resisting insulation enclosing in an outer casing and subjecting the ferro conductor to heat and water vapor at a sufficient temperature to transform the ferro conductor into a granular high resistance heat resisting conductor.

13. A process of producing a high temperature resistor that consists in forming the resistor of a ferro-conductor and subjecting it when formed to hot steam and generating heat in it electrically.

14. The process of producing electric re-

sistors that consists in assembling a metallic member having the form of the desired resistor in a porous mass of insulation, passing electric energy through the metallic member to heat the same and passing vapor through the porous mass at a temperature to transform the metallic member into a high temperature granular member.

15. The process of producing electric resistors that consists in supporting a relatively low temperature electric resistance conductor, electrically generating heat therein, and subjecting the heated conductor to hot vapor adapted to chemically change its composition into a high temperature electric resistance member.

16. The process of producing electric resistors that consists in supporting a ferro electric resistance conductor, electrically generating heat therein and subjecting the heated conductor to steam at a temperature sufficient to chemically change the conductor into a compound adapted to operate at high temperatures without substantial deterioration.

17. The process of producing electric resistors that consists in supporting a ferro electric resistance conductor, electrically generating heat therein and subjecting the heated conductor to steam at a temperature sufficient to chemically change the conductor into a compound having an unlike temperature coefficient.

18. The process of producing electric resistors that consists in supporting a relatively low temperature electric resistance conductor, electrically generating heat therein and subjecting the heated conductor to hot vapor adapted to chemically change the composition of the surface of the conductor to a variable depth at one end and of the entire conductor at the other end into a high resistance conductor.

19. The process of producing tubular electric resistors that consists in supporting an iron tube in granular insulation, electrically generating heat in the iron tube and passing steam through the tube when hot, the temperatures of the steam and of the tube being sufficient to chemically change the composition of the tube and adapt it to operate at high temperatures without deterioration.

20. A vapor electric heater comprising a resistance element having a negative temperature coefficient portion and means for causing a heat carrying vapor to flow in proximity to said portion, and constituting a ballast therefor.

21. A vapor electric heater comprising a resistance element composed of a positive temperature coefficient portion and a negative temperature coefficient portion, and means for causing a heat carrying vapor to flow in successive proximity to the said portions.

22. A vapor electric heater comprising a tubular resistance element composed of a negative temperature coefficient portion, and means for connecting a source of steam with one end of said tubular element said steam constituting a ballast therefor.

23. A vapor electric heater comprising a tubular resistance element composed of a positive temperature coefficient portion, and a negative coefficient portion, and means for connecting a source of steam with the positive temperature coefficient portion of the tubular element said steam being adapted to flow through said portions in succession and to constitute a ballast for the negative temperature coefficient portion.

24. An electric heater comprising a heating element having a positive temperature coefficient and a second heating element in series therewith having a negative temperature coefficient.

25. A heater comprising means for generating heat upon the passage of an electric current adapted to render the resistance of the heater substantially constant independent of variations in temperatures.

26. An electric heater comprising a plurality of heat generating elements having unlike temperature coefficients.

27. An electric heater comprising a plurality of heat generating elements having substantially balanced temperature coefficients.

28. An electric heater comprising a plurality of heat generating elements of unlike characteristics, and means for bringing into intimate contact with said elements successively a mobile ballasting medium adapted to regulate the temperatures of said elements.

29. An electric heater comprising a plurality of heat generating elements having unlike temperature coefficients, and means for bringing into intimate contact with said elements successively a ballasting fluid adapted to retard a rise in temperature of a desired one of said elements above a predetermined point.

In witness whereof, I have hereunto set my hand this 21st day of June, 1917.

WILLIAM S. HADAWAY, JR.