No. 787,047. PATENTED APR. 11, 1905.

H. W. LEONARD.

ELECTRIC RESISTANCE.

APPLICATION FILED DEC. 8, 1904.

Fig. 1

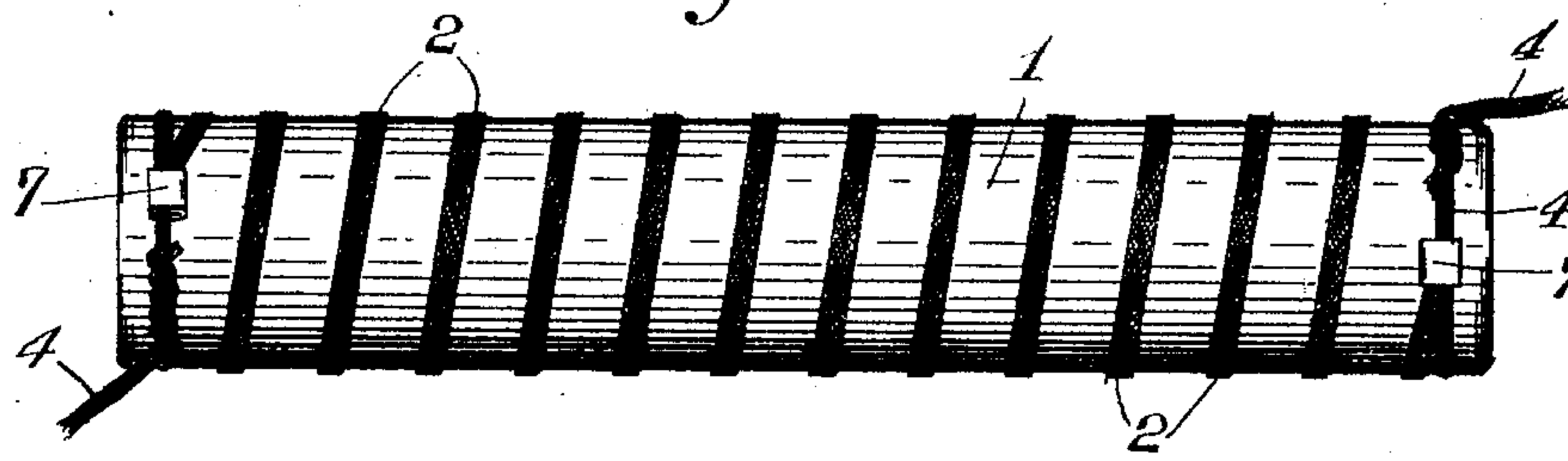


Fig. 2

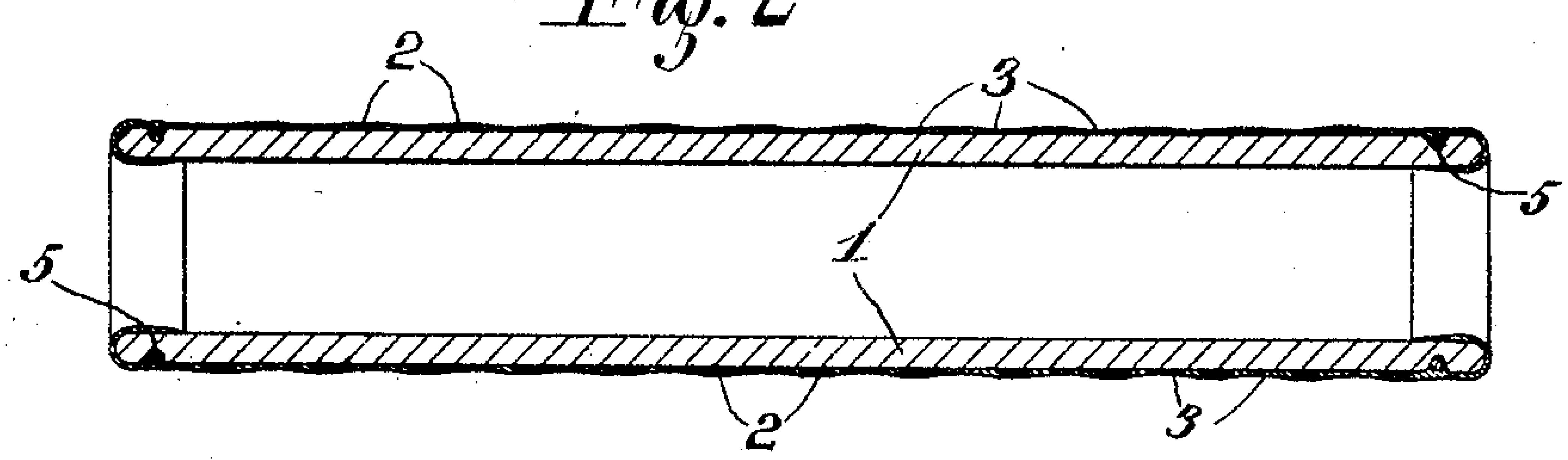


Fig. 3

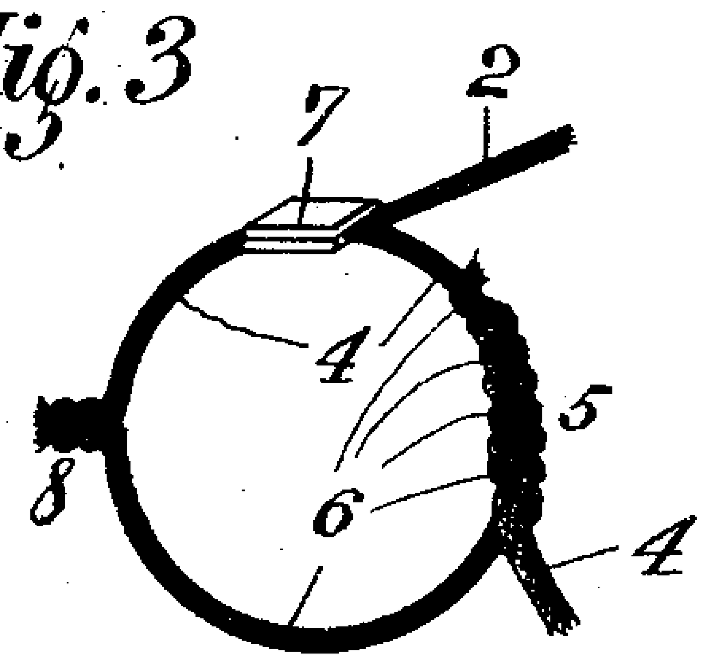


Fig. 4

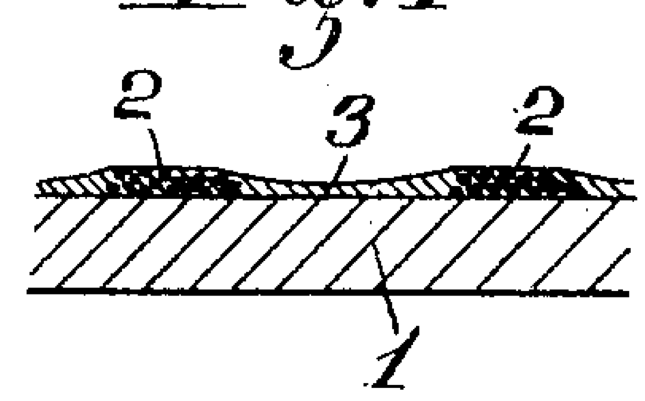


Fig. 5

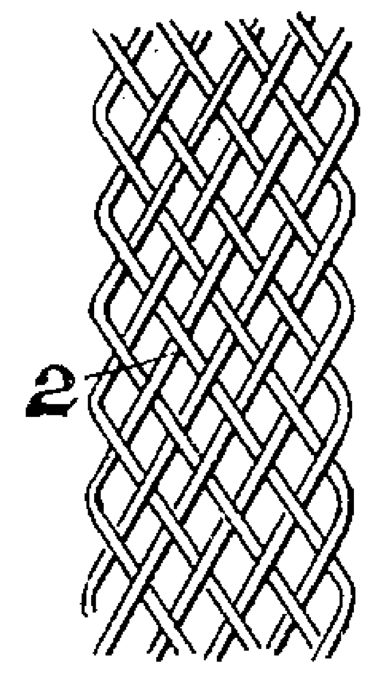
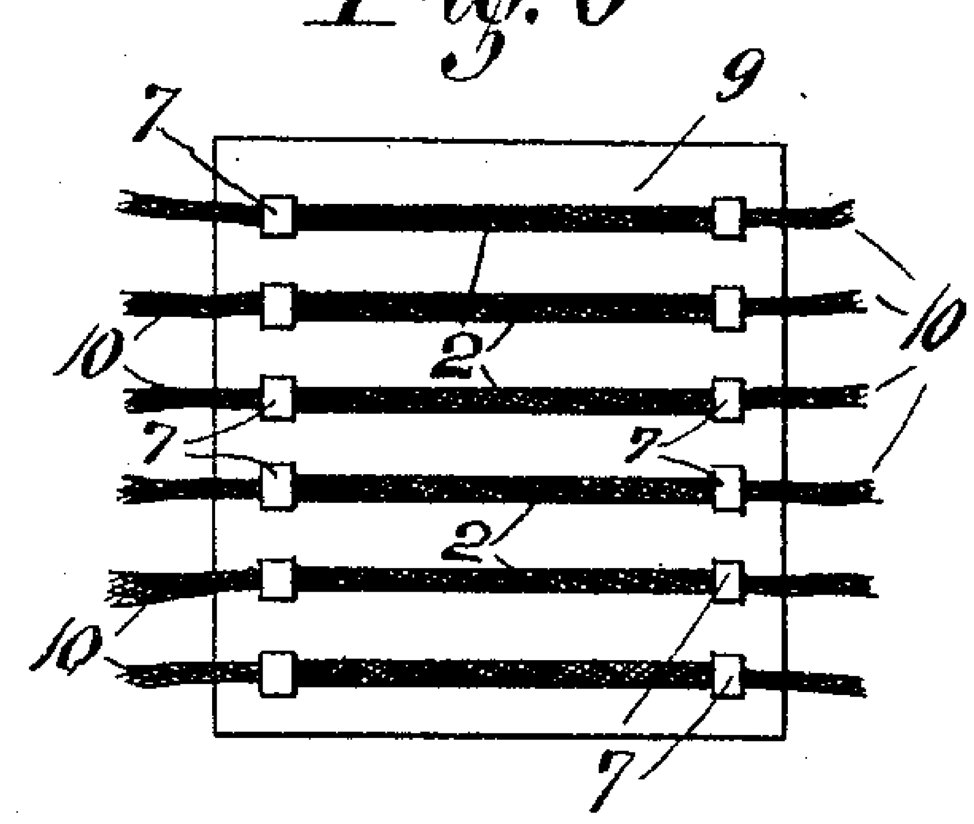


Fig. 6



Witnesses

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No. 787,047. Patented April 11, 1905.

UNITED STATES PATENT OFFICE.

HARRY WARD LEONARD, OF BRONXVILLE, NEW YORK.

ELECTRIC RESISTANCE.

SPECIFICATION forming part of Letters Patent No. 787,047, dated April 11, 1905.

Application filed December 8, 1904. Serial No. 235,930.

To all whom it may concern:

Be it known that I, HARRY WARD LEONARD, a citizen of the United States, residing at Bronxville, in the county of Westchester and State of New York, have invented certain new and useful Improvements in Electric Resistances, of which the following is a full, clear, and exact specification.

My invention relates to improvements in resistances, especially such as are heated by electric currents in apparatus such as rheostats, electric heaters, &c. My invention, however, has many other uses, as will be apparent from the description later herein.

There are now in use many forms of resistances in which the resistance is embedded either wholly or partially in some insulating material which closely surrounds the resistive conductor. Examples of such resistances are shown and described in the following United States patents: No. 447,023, to Carpenter; No. 477,247, to Cummings, and Nos. 691,949 and 707,244, to myself. In all such cases it is difficult to use a single resistive conductor of large cross-section such as would be suitable for carrying a large current—such as fifty amperes, for example—because the mechanical strains developed in the insulating material contiguous to this resistive conductor would be so great as to have a tendency to crack or otherwise impair the perfection of the mechanical contact or the electrical insulation, or both.

I have found that certain resistive alloys which are very satisfactory if used so as to be free to expand and contract, as is usually the case, will be very troublesome when, for example, they are to be enameled upon the surface of a porcelain tube or other similar surface, especially when the wire is wound around the outside surface and when the material of the support has a low coefficient of expansion. For example, I have found by suitable tests that there is such a great difference in the expanson of various metallic alloys which I customarily use in making rheostats that I frequently have difficulty in making satisfactorily an enameled resistance-tube such as I have described in my Patent No. 691,949, because the specific expansion of the material of the resistive conductor is so high relative to that of the material of the desired support that the wire becomes very loose and distorted when subjected to the heat of manufacture in a muffle-furnace. Also after this resistance-tube is made there is a strong tendency for the enamel to crack off above the wire and for the wire to become loose on the tube when the wire is a large one and the material of the conductor has a high specific expansion. Of course when the wire becomes exposed and loose it is not so good commercially as it would be if the coating of enamel should remain practically unaffected by the expansion of the heated conductor. These difficulties I have overcome by my present invention, and some of the advantageous results thereof will be understood from the following description.

Referring to the accompanying drawings, which show the preferred form of my invention, Figure 1 is a side view of a resistance unit embodying my invention, no insulating-coating being shown, however. Fig. 2 is a longitudinal section of the completed article. Fig. 3 is a detail showing the form of terminal connection. Fig. 4 is an enlarged view of a portion of Fig. 2. Fig. 5 is an enlarged view of the resistive conductor, and Fig. 6 is a plan view of a modified form of construction with the insulating coating removed.

A tube of porcelain or other suitable material is indicated at 1. Upon this is located the resistive conductor 2, wound spirally. This conductor is composed of reflexed strands and preferably in the form of a flat braid having a loose open mesh. I prefer to make the conductor of alloy and composed largely of copper and nickel or some other form of resistance having a temperature coefficient as low as practical. The conductor is embedded in the insulating, heat-resisting, and protective coating 3 of material having the desired properties and which serves to conduct heat from the conductor and dissipate this heat. These properties are to be found in various solid mineral insulating materials, and I therefore prefer to use such materials. Glass enamel is preferable and serves to hermetically seal the conductor and adhesively engages the support. This coating 3 does not merely cover the braided or stranded conductor, but is worked all through the loose mesh thereof and practically incloses each individual strand. Any one of a large number of different insulating-coatings may be used. Also after it has been manufactured it can be subjected to alternate heatings and coolings by passing a current through the conductor and the perfection of the coating is not affected in any way. I can use conductors of even the highest specific expansion embedded in coatings of a very brittle nature upon supports having an extremely different specific expansion from that of the resistive conductor. I have used conductors having the highest specific expansion and supports having the lowest specific expansion, and vice versa, and in every case I have obtained a perfectly satisfactory result. The reason for this is no doubt that the mechanical strain of each individual strand is so slight and the several strands are so distributed through the coating that the strain developed by heating the conductor is not sufficient to be troublesome.

Another important result obtained by my invention is that whereas heretofore I was obliged to use for large currents material of relatively high temperature coefficient I can by practicing my invention use resistive conductors of practically no temperature coefficient even when the currents are very large.

In explanation I can say that the commercial resistive conductors which have the lowest temperature coefficient have invariably, so far as I know, a high specific resistance or resistivity. One of the best alloys as regards low temperature coefficient, high fusion temperature, non-oxidizing qualities, tensile strength, ductility, hardness, and other desirable qualities for use in enamel-coated resistances, such as I often desire to employ it for, is an alloy composed essentially of nickel and copper in substantially the proportions of sixty copper and forty nickel; but this alloy has relatively a much higher specific expansion than others I might employ if I could disregard the importance of the above-cited qualities. It also has a high resistivity, its resistivity at ordinary temperatures being about thirty times that of copper. It will be apparent that a single wire of this material capable of carrying, say, fifty, amperes is necessarily very large in cross-section relative to copper, for example.

The smaller copper wire might be successfully enameled upon an insulating-support; but it would be objected to because of its high temperature coefficient.

The copper-nickel-alloy wire would be so large in order to carry fifty amperes satisfactorily as regards possible fusion by the current that its expansion when heated in practice would cause a destructive strain. One way of overcoming some of these difficulties is to use a reflexed metallic ribbon, attached edgewise by the enamel to the surface of the tube, as patented to me in United States Patent No. 707,244; but this form is not always desirable, because the conductor is exposed to the air, and it is extremely delicate and liable to be injured if the resistance has to be packed, shipped, or handled, especially if it has to be handled by inexperienced parties, as is often the case. By my new resistance-conductor in the form of a wide loose flat braid I overcome all of these difficulties and obtain all of the most desirable qualities—such as high insulation, low temperature coefficient, freedom from depreciation of the conductor by oxidation or other chemical action, freedom from depreciation of the insulating coating due to the heating strains, compactness, and low cost.

Another very important advantage is that due to greatly-reduced fire risk, which is explained as follows: Of course every such resistance-tube can be burned out if sufficiently large currents be passed through it, and in practice it must be expected that improper usage or failure of other allied devices may result in burning out the resistance. When such a burn out does occur, it is of the greatest importance in many instances that the arc shall be reduced to the minimum, that it shall be extinguished as promptly as possible, and that it shall be kept below the surface of the insulating-coating as much as possible. In many instances, such as in uses on board of naval ships, this quality of burning out without risk of igniting explosive or inflammable material in the vicinity is of the first importance. It is essential for such cases that the conductor be of the inclosed type—that is, surrounded by solid insulating material—and glass enamel is the most desirable material thus far employed; but a large single wire fused by excessive current on an enameled tube makes an arc which is sometimes quite disruptive in character and throws off molten pellets that are a serious risk. By means of my invention I greatly reduce this risk. When the stranded conductor is fused by excessive current, a large number of different divided arcs of much correspondingly smaller energy result, and the well-known extinguishing effect due to dividing an arc into a number of smaller ones and subjecting each to the cooling effect of having it surrounded by its own inclosing mass of material is very beneficial and results in a practical freedom from all fire risk. Each small strand acts, in fact, like a small inclosed type-fuse.

The flat form of braid of course enables me to perfectly cover a conductor of high ampere capacity with a thin layer of enamel, and this again results in a much tougher coat of enamel than could be obtained with a thicker coat. All that I have said as to the advantages I obtain when using glass enamel apply equally well to other forms of insulating-coating, and it will be apparent that there are many advantages in using my invention for uses not described by me or uses in which only a few of the qualities I have named as desirable may be of especial importance.

Sometimes I use my stranded resistive conductor in sheet-glass or other similar solid glass insulation. Sometimes I mold the insulating material about the conductor and then subject the insulating material to the usual processes of its manufacture.

In some cases my new form of resistive conductor will have advantages even when it is not embedded in or attached by adhesive insulating material.

Although the cost of the same weight of wire will be greater when stranded than when in a single wire, there are several reasons why I am able to reduce the cost of manufacture by using the stranded conductor. The first reason is that the surface of the conductor from which the heat is enameled is greatly increased relative to that of a single wire of the same cross-section and weight per foot. Therefore to dissipate the same energy from the surface of the conductor I can use a much smaller weight per foot. This increases the ohms per foot, and hence enables me to reduce the number of feet to obtain the desired resistance. This reduction of total cross-section and reduction of length results in such a great saving in weight that the stranded conductor is materially cheaper for a certain duty than a single wire would be.

Another reduction of cost of manufacture is that due to the much greater ease in securing a perfect coating of enamel. With large wires thick coats of enamel are needed. These are much more expensive both as regards material and labor, and they require longer time in the furnace and usually require more coats and firings than the flat braided conductor requires. Also there is a smaller percentage of defective pieces which are wasted in manufacture and few defects develop in usage.

Another important feature of my invention is the form of the terminal lead-wires. Heretofore it has been universally customary to use a single solid lead for such rheostats, electric heaters, &c., the material being copper. I now use a braided copper terminal lead, preferably a round braid. This is shown at 4 on the drawings and part encircles the tube and lodges in the groove 5, formed at the end thereof. By providing this groove or other depression in the support for the location of the terminal lead I secure very desirable results. It prevents the shifting of the terminal. The lead and joint, with the resistive conductor, may be easily and thoroughly covered with the insulating-coating. It permits the use of a very thin coating along the rest of the tube, while having a thick coating within which the joint and terminal lead may lie. It reduces the diametrical dimension at the ends of the unit, where it would otherwise be greatest, and secures additional protection of the lead and joint. It aids in manufacture by giving a definite distance between the end of the tube and the terminal and between the two terminals and insures that the terminal lead and joint will be perfectly attached and protected by the coating. The principal objects of using stranded, reflexed, copper terminal wire are to secure the greatest possible flexibility, to reduce to a minimum the strain which may be brought upon the wire under the enamel and in the enamel itself when the terminal lead-wire is bent back and forth, as it frequently must be in connecting up the resistance, disconnecting it and handling it otherwise, also to reduce to a minimum the liability of the terminal lead-wire breaking off, due to bending or vibration or other strain. This desirability of the braided or otherwise stranded copper terminal lead-wire is especially pronounced in apparatus in which the copper wire has during the course of manufacture been subjected to such a heat as that of a muffle-furnace and then allowed to cool in the air. A copper wire which will stand repeated bending without breaking off when it is in the condition as received from the maker of the copper wire, especially when it has been properly soft-annealed or otherwise treated to make it as ductile as possible, will alter greatly as to this quality of withstanding bending if it be subject to a muffle-furnace heat, as indicated. After such heating the wire is very apt to break off if it be bent back and forth in a way which would have no appreciable effect upon it before it was so heated. The solid terminal lead formerly in use would oftentimes break off when the purchaser or user was bending the terminal lead. Usually this break would be just where the copper wire entered the enamel. This would render the resistance worthless. Even when the wire did not break off at the place where it entered the enamel it would often subject the enamel at that point to such a strain as to rupture the enamel, and thus cause a depreciation of the resistance, which often led to a burning out of the resistance-wire at that point. Sometimes the strain due to the too rigid terminal lead-wire would rupture the very fine resistance-wire even before the current was applied. There was formerly also this difficulty. The simplest and cheapest way of connecting the lead was to wind it around the tube and fasten to it, by means of a hammered joint, to the smaller resistance-wire. When the resistance unit was one for, say, fifty amperes, the copper terminal lead-wires were necessarily rather large and difficulty was met with on account of the rigidity of the wire in making it lie close to the tube at all places. At the place where the joint was made there was a tendency for the wire to stand away from the surface, and this made it difficult to get this part well enameled. Also the solid wire when heated in the muffle-furnace expanded so strongly as to crack the coating of the dried enamel powder, which had previously been applied in the form of a viscous paste. Such a small crack as this would tend to follow any wire of considerable size, and when finally the higher heat fused the enamel powder into a glass coating the coating would pull apart at the edges of such cracks. This would necessitate additional coatings and firings, entailing additional expense and resulting in an inferior article. There was also difficulty in making a good hammered joint between the large single copper wire and the resistance-wire of different size and material. All of these difficulties I overcome by using the stranded copper terminal lead-wire. It is very superior as regards resisting repeated bends without breaking. It reduces to a minimum any strain upon the terminal lead or the enamel where the terminal lead enters the enamel. When wound around the tube, it hugs the surface perfectly. When heated, it does not produce sufficient strain by its expansion to crack the dried enamel-powder coating, as there is a flexibility endwise along the axis of the conductor due to its braided form, as there always is in a reflexed wire relative to a straight one. The braided wire is practically reflexed in every plane instead of one plane only. The several strands laid over the resistance-wire enable me to secure a very perfect hammered joint.

Fig. 3 shows my preferred form of terminal connection. The lead 4 has wrapped around it at 5 a short piece of similar braided round copper wire 6. The connection is made between the resistive conductor and lead 4 by the clip 7, which is hammered over the union of the lead and conductor. The parts are tightened about the tube by twisting together the ends of the lead 4 and the piece 6, as shown at 8. It will be noted that the piece 6 is wrapped around the lead 4 at 5, so that one end of piece 6 is toward the joint 7. Consequently when the parts are tightened up by twisting the ends together at 8 the union at 5 will closely engage the surface of the tube. Also on account of the flexibility of the terminal connection the parts encircling the tube will closely engage its surface. The only joint in the parts which conduct the current is that at 7, the lead 4 making direct connection with the conductor 2 at the joint 7. This joint is some distance away from the union at 5 and is entirely free from injurious strains due to movement of the outside portion of lead 4.

Sometimes I use a plurality of conductors in multiple between the terminal, each being preferably wound as a thread on a cylindrical surface and there being two, three, or more such threads parallel to each other.

Sometimes I make a tubular braid and then put inside of it a cylinder as a support, and I then sometimes attach this braid to the surface of the cylindrical support by an insulating-coating.

In some cases I use a tubular braid with an open mesh as the resistive conductor of a rheostat without any support inside of it. The tubular shape makes it self-supporting, and there is a very large surface well exposed to the air.

Sometimes I make such a tubular braid or a flat braid or other form of stranded resistive conductor and place it in a heat-absorptive insulating material, such as sand or oil or any suitable material which makes good contact with the heat-emitting surface of the resistive conductor.

Sometimes I mount the resistive conductor upon a support having a flat surface, and I may divide the conductor into a number of parts. Fig. 6 shows a form of construction in which the flat-braided conductor 2 is mounted upon a support 9, having a flat surface instead of the form of a cylinder. The several conductors 2 are united to the lead-wires 10 by the clips 7 in the form of a hammered joint. The leads 10 are of copper and in the form of a round-braided wire. The insulating-coating, such as glass enamel, is not indicated in this figure; but it will be understood that the resistive conductors, joints, and portions of the terminal leads are embedded in such a coating, as previously explained. This form of construction is very desirable where it is desired to vary the resistance of the unit or to adjust its resistance to an amount desired to meet certain conditions. Six resistive conductors are shown, and by means of the leads 10 they all may be connected in multiple, giving the lowest resistance and maximum current capacity. They may be connected three in multiple and the two sets of three in series, giving an increased resistance and decreased current capacity. They may be connected two in multiple and the three sets of two in series, giving a further increase in resistance and a further decrease in current capacity, and finally they may all be connected in series, giving maximum resistance and lowest current capacity. The leads 10 are made extra long to permit the various connections desired.

As my invention is susceptible of many modifications, I do not intend or wish my invention to be limited except as expressed by the following claims.

Having thus described my invention, I declare that what I claim as new, and desire to secure by Letters Patent, is—

1. In a device in which electric energy is intentionally converted into heat, a stranded resistive conductor, the individual strands of said conductor composed of a material having a relatively low temperature coefficient.

2. In a device in which electric energy is intentionally converted into heat, a stranded re-

sistive conductor, the individual strands of said conductor composed of a material having a relatively low temperature coefficient and a relatively high specific resistance.

3. In a device in which electric energy is intentionally converted into heat, a stranded resistive conductor, the individual strands of said conductor composed of a material having a relatively low temperature coefficient and a relatively high specific resistance and coefficient of expansion.

4. The combination of a stranded conductor having interstices between the strands, means for supporting said conductor, and a heat-resisting insulating material within said interstices.

5. The combination of a stranded conductor of high specific resistance and low temperature coefficient, means for supporting said conductor, and an insulating heat-resisting material embedding and surrounding said conductor.

6. The combination of a stranded conductor of high specific resistance and low temperature coefficient, a support for said conductor, and an insulating heat-resisting material embedding and surrounding said conductor and fixing the same in position upon said support.

7. The combination of a stranded conductor of high specific resistance and low temperature coefficient, a support for said conductor composed of insulating material, and an insulating heat-resisting material embedding and surrounding said conductor and securing the same in position upon said support.

8. The combination of a conductor in the form of a flat braid, means for supporting said conductor, and a mineral insulating material embedding and surrounding said conductor.

9. The combination of a conductor in the form of a flat braid having interstices between the strands, means for supporting said conductor, and a heat-resisting insulating material filled within said interstices and surrounding said conductor, said material serving to conduct and dissipate heat from said conductor.

10. The combination of a stranded resistive conductor, said conductor composed of an alloy, means for supporting said conductor, and a copper terminal lead-wire electrically connected to said conductor.

11. The combination of a stranded resistive conductor, said conductor composed of an alloy, means for supporting said conductor, and a copper-stranded terminal lead-wire electrically connected to said conductor.

12. The combination of a braided resistive conductor, said conductor composed of an alloy, means for supporting said conductor, and a copper-braided terminal lead electrically connected to said conductor.

13. In a rheostat or electric heater, the combination with the resistive conductor, of a stranded copper lead electrically connected to said conductor.

14. In a rheostat or electric heater, the combination with the resistive conductor, of a copper lead composed of strands braided together and electrically connected to said conductor.

15. In a rheostat or electric heater, the combination with the resistive conductor, of a copper lead electrically connected with said conductor, said lead composed of a plurality of copper conductors.

16. In a rheostat or electric heater, the combination with the resistive conductor, of a lead electrically connected to said conductor, said lead composed of reflexed copper wires.

17. The combination of a resistive conductor, means for supporting said conductor, solid insulating material surrounding said conductor, and a stranded copper terminal lead electrically connected to said conductor.

18. The combination of a stranded conductor of high specific resistance and low temperature coefficient, means for supporting said conductor, an insulating heat-resisting material embedding and surrounding said conductor, and a stranded copper terminal lead-wire electrically connected to said conductor.

19. The combination of a stranded conductor, said conductor composed of an alloy containing nickel, means for supporting said conductor, an insulating heat-resisting material embedding and surrounding said conductor, and a stranded terminal lead-wire electrically connected to said conductor.

20. The combination of a stranded conductor, said conductor composed of an alloy containing nickel and copper, means for supporting said conductor, an insulating heat-resisting material embedding and surrounding said conductor, and a stranded copper terminal lead-wire electrically connected to said conductor.

21. The combination of a conductor in the form of a flat braid, means for supporting said conductor, a mineral insulating material embedding and surrounding said conductor, and a braided copper terminal lead electrically connected to said conductor.

22. The combination of a conductor in the form of a flat braid, means for supporting said conductor, a mineral insulating material embedding and surrounding said conductor, and a braided copper terminal lead electrically connected to said conductor, said connection being formed by a hammered joint.

23. The combination of a resistive conductor having a relatively high specific expansion, said conductor being subdivided and reflexed, a support having a relatively low specific expansion, and an adhesive coating embedding said conductor and adhesively engaging said support.

24. The combination of a resistive conductor composed of a plurality of reflexed wires, the material of said conductor being an alloy having a relatively high coefficient of expansion, a high specific resistance and low temperature

coefficient, a support of relatively low specific expansion, and an adhesive coating embedding said conductor and adhesively engaging said support.

25. The combination of a resistive conductor composed of a plurality of reflexed wires, the material of said conductor being an alloy having a relatively high coefficient of expansion, a high specific resistance and low temperature coefficient, a support of relatively low specific expansion, and an adhesive coating embedding said conductor and hermetically sealing the same, and adhesively engaging said support.

26. As a new article of manufacture, a stranded conductor having interstices between the strands, said conductor composed of an alloy.

27. As a new article of manufacture, a stranded conductor, said conductor composed of a metallic alloy having a high specific resistance.

28. As a new article of manufacture, a stranded conductor, said conductor composed of a metallic alloy having a high specific resistance and a low temperature coefficient.

29. As a new article of manufacture, a resistive conductor composed of an alloy and in the form of a flat braid.

30. As a new article of manufacture, a resistive conductor composed of an alloy and in the form of a flat braid, said alloy having designedly relatively low temperature coefficient.

31. As a new article of manufacture, a resistive conductor composed of an alloy and in the form of a flat braid, said alloy containing nickel and having designedly a low temperature coefficient.

32. As a new article of manufacture, a resistive conductor composed of an alloy and in the form of a flat braid, said alloy containing nickel and copper and having designedly a low temperature coefficient.

33. As a new article of manufacture, a resistive conductor composed of an alloy and in the form of a flat braid, said alloy containing nickel and copper as the principal ingredients, and having designedly a low temperature coefficient.

34. The combination of a resistive conductor, a support for said conductor, a terminal lead electrically connected to said conductor, said connection being some distance from one end of said lead, and means for securing said lead to said support comprising a wire, one end of said wire being twisted to one end of said lead, and the other end of said wire being twisted upon said lead above said connection.

35. The combination of a resistive conductor, a support for said conductor, a terminal lead electrically connected to said conductor, said connection being some distance from one end of said lead, and means for securing said lead to said support comprising a wire, one end of said wire being twisted to one end of said lead and the other end of said wire being twisted upon said lead above said connection and in such a direction along said lead as to closely engage said support.

36. The method of preventing detrimental strains in the insulating material in which a conductor is embedded, which consists in dividing the conductor into a plurality of strands, embedding said strands in an insulating medium, and dividing the current in multiple between the several strands.

37. The method of preventing detrimental strains in an insulating medium in which a conductor is embedded, which consists in embedding the conductor in an insulating medium, dividing the current between a plurality of strands composing the resistive conductor, and subdividing and distributing the total strain.

38. The combination of a stranded conductor having interstices between the strands, and a heat-resisting insulating material within said interstices.

39. The combination of a stranded conductor of high specific resistance and low temperature coefficient, and an insulating heat-resisting material embedding and surrounding said conductor.

40. The combination of a conductor in the form of a flat braid, and a mineral insulating material embedding and surrounding said conductor.

41. The combination of a resistive conductor, solid insulating material surrounding said conductor, and a stranded copper terminal lead electrically connected to said conductor.

42. The combination of a stranded conductor of high specific resistance and low temperature coefficient, an insulating heat-resisting material embedding and surrounding said conductor, and a stranded copper terminal lead-wire electrically connected to said conductor.

43. The combination of a stranded conductor, said conductor composed of an alloy containing nickel, an insulating heat-resisting material embedding and surrounding said conductor, and a stranded terminal lead-wire electrically connected to said conductor.

44. The combination of a stranded conductor, said conductor composed of an alloy containing nickel and copper, an insulating heat-resisting material embedding and surrounding said conductor, and a stranded copper terminal lead-wire electrically connected to said conductor.

45. The combination of a conductor in the form of a flat braid, a mineral insulating material embedding and surrounding said conductor, and a braided copper terminal lead electrically connected to said conductor.

46. The combination of stranded resistive conductors, an insulating heat-resisting ma-

terial embedding said conductors, and means electrically connected to said conductors for connecting them in series or in parallel.

47. The combination of stranded resistive conductors, an insulating heat-resisting material embedding said conductors, and stranded terminal leads electrically connected to said conductors.

48. The combination of a support having a flat surface, stranded resistive conductors, an insulating heat-resisting material embedding said conductors, and stranded terminal leads electrically connected to said conductors.

49. The combination of a support having a flat surface, resistive conductors in the form of a flat braid, said conductors composed of an alloy having a low temperature coefficient, and stranded copper terminal leads electrically connected to said conductors.

50. In a rheostat or electric heater, the combination of a resistive conductor composed of an alloy containing nickel and copper and having a relatively high coefficient of expansion, a relatively high specific resistance and a relatively low temperature coefficient, a support of insulating heat-resisting material for said conductor having a relatively low coefficient of expansion, an exposed terminal forming an electrical joint with said resistive conductor, a coating of insulating heat-resisting material covering and surrounding said resistive conductor and said joint, the said conductor being reflexed, whereby destructive strains in the coating is prevented when the resistive conductor is heated by the current.

51. The combination of a resistive conductor, a support for said conductor, said support having a depression, and a terminal lead electrically connected to said conductor and partly seated in said depression.

52. The combination of a resistive conductor, a support for said conductor, said support having a depression, and a terminal lead forming an electrical joint with said conductor, the joint and part of said lead being seated in said depression.

53. The combination of a resistive conductor, a support having a depression, a terminal lead forming an electrical joint with said conductor, the joint and part of said lead seated in said depression, and a coating of insulating material covering said resistive conductor and said joint.

54. In a rheostat or electric heater, the combination with the resistive conductor, of a stranded lead electrically connected to said conductor.

55. In a rheostat or electric heater, the combination with the resistive conductor, of a lead composed of strands braided together and electrically connected to said conductor.

56. In a rheostat or electric heater, the combination with the resistive conductor, of a lead electrically connected to said conductor, said lead composed of a plurality of reflexed wires.

57. The combination of a resistive conductor, means for supporting said conductor, solid insulating material surrounding said conductor, and a stranded terminal lead electrically connected to said conductor.

58. The combination of a stranded conductor of high specific resistance and low temperature coefficient, means for supporting said conductor, an insulating heat-resisting material embedding and surrounding said conductor, and a stranded terminal lead-wire electrically connected to said conductor.

In testimony whereof I affix my signature in presence of two witnesses.

H. WARD LEONARD.

Witnesses:
L. K. Sager,
Julian S. Wooster.