

(No Model.)

H. W. LEONARD.  
RHEOSTAT.

No. 576,202.

Patented Feb. 2, 1897.

Fig. 1.

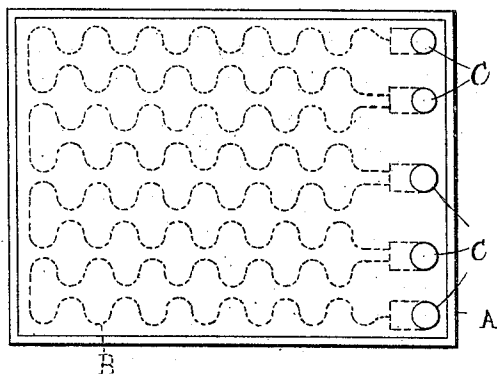


Fig. 2.

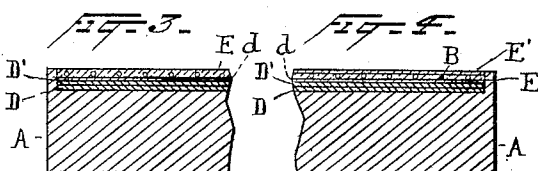
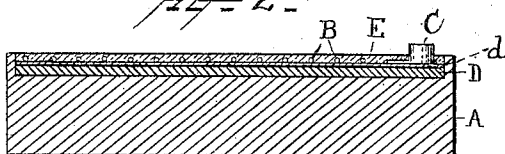
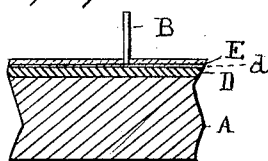


Fig. 5.



Witnesses  
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# UNITED STATES PATENT OFFICE.

HARRY WARD LEONARD, OF EAST ORANGE, NEW JERSEY.

## RHEOSTAT.

SPECIFICATION forming part of Letters Patent No. 576,202, dated February 2, 1897.

Application filed July 30, 1896. Serial No. 601,020. (No model.)

*To all whom it may concern:*

Be it known that I, HARRY WARD LEONARD, a citizen of the United States, residing at East Orange, in the county of Essex and State of New Jersey, have invented a certain new and useful Improvement in Rheostats, of which the following is a specification.

My invention relates to apparatus in which an electric conductor is insulated from a support, and especially to instances in which a conductor is heated to a comparatively high degree by the passage of a current, as in rheostats, electric heaters, electric tools, &c.

The object of my invention is to simplify the manufacture and improve the quality of such apparatus.

I have found that the best results are obtained when the support is given two insulating-coatings of quite different materials. The lower or ground coat should be pottery-like in nature, that is, it should become a hard and coherent mass when subjected to the heat of a muffle-furnace, and it should not become soft or viscous even at the highest commercial heat of a muffle-furnace. It should be somewhat porous, that is, somewhat brick-like, so that it will have to the greatest degree the qualities of toughness in resisting strains and so that it will have the least tendency to crack. The material for this ground coat should contain a very high percentage of silica or other equivalent infusible material. The ground coat preferably should be a mixture of a material which at the heat of a muffle-furnace is practically inert and infusible, such as clay, and a material which will fuse at the heat of the muffle-furnace, such as a low-fusing glass. This mixture of inert material and low-fusing glass before being applied to the support is finely ground and intimately mixed. When this fine mixture is heated, the glass becomes fused and acts as a binder for the inert material, producing a coherent mass, and also adhesively attaches the coating to the support. The mixture for the ground coat is applied either as a dry powder or as a wet powder, in which case the mixture will be in the form of a paste. In either case the layer is caused by heat to become a solid layer adherent to the support.

In speaking of "powder" I mean material

in a finely-divided state, whether it be dry or mixed with a fluid, so as to be paste-like or cement-like, or whether it be suspended in a liquid, so as to be paint-like.

I prefer to apply the ground-coat powder in the form of a paste. That is, I "flow" the ground coat over the surface of the support in the form of a liquid mass having about the consistency of thick cream. This forms a thin layer of the powder, and when it is dried a thin coat of the powder remains on the support. If now the object having this coat be heated in a muffle-furnace, the minute particles become bound together by the softening of the glass particles and form a layer of solid material, and the glass particles also cause the layer to adhere to the surface of the support. That is, there is in the material fusible matter enough to cause the particles to become bound or welded together at the heat of the muffle, although not enough to cause the mass as a whole to become soft or viscous, as ordinary glass or enamel would become. This ground coat when removed from the furnace at a bright-red heat is preferably so hard that a hard implement pressed lightly against the surface makes no impression therein. For the purposes of this description I shall call this material "infusible."

In the manufacture of electrical apparatus, such as rheostats, I prefer to use a cast-iron plate for the support. It becomes important to have the insulation of the conductor from the iron plate as high as possible. This means not only material of high specific insulation for the ground coat, but as great a thickness as possible consistent with good results. Now if a thick layer of the ground-coat paste is applied at one operation I find that many difficulties develop, especially the development of cracks in the ground coat either before, during, or after the firing. Hence in cases where I wish to obtain extremely high insulation, especially when high electromotive-force static discharges are met with or when one pole of the electric circuit is grounded, as in electric-railway rheostats, I apply successive layers of the ground-coat powder and fire them independently. It is important that the ingredients of the ground coat be almost inert chemically, so as not to combine

except slightly with the metal in contact therewith when the whole is subjected to the heat of the muffle in subsequent steps of manufacture. Any tendency on the part of the ground  
5 coat to form a slag with the metal would injuriously affect the insulation between the conductor and the support.

I find that cast-iron is especially troublesome to make use of, because it contains carbon, because its surface oxidizes so readily, and because of the chemical nature of the so-called "skin" of cast-iron, and because of its coefficient of expansion. Hence with cast-iron it becomes of especial importance to use  
15 a material for the first coat which is chemically almost inert. If the material used for the ground coat on cast-iron is one which at the heat of the muffle-furnace becomes molten, the result is a strong chemical action between  
20 the cast-iron and the molten vitreous material, resulting in bubbles, blisters, &c., and also resulting in poor insulation. For this reason my invention is of especial importance for cast-iron. In the case of copper, silver,  
25 gold, wrought-iron, low-grade steel, &c., such as are ordinarily covered with vitreous coatings in the arts, this difficulty is not met with to a troublesome degree.

I prefer to use cast-iron for rheostats, heaters, &c., on account of the facility in making the support in any shape desired by casting and the use of machine-tools and because of its cheapness. I also prefer to use iron rather than other materials for rheostats, because of  
35 its high specific capacity for heat.

I have found that by my invention I can use glass for attaching the conductor to the ground coat. On account of the cheapness and general use and availability of glass this  
40 is very desirable. I prefer to use a low-fusing glass, and I find lead-glass very satisfactory. I sometimes make my own glass from any of the materials well known in the arts, in order to obtain glass which is uniform in  
45 nature, free from bubbles and undesirable particles, and which has the properties of toughness and high insulation. Before making use of this glass I grind it into a very fine powder, preferably 100 mesh. In some cases,  
50 when a glassy surface impervious to moisture is not essential, as is the case in some apparatus, I dispense with the glass altogether and cause the conductor to adhere to the infusible layer by a second pottery-like layer  
55 applied in powdered form, but which after firing is more or less moisture-absorbent. This pottery-like-finish coat has advantages in some cases, as it is tougher in resisting strains due to the heating of the conductor and  
60 does not unite with the conductor chemically to the degree that glass does. Certain metals used for the conductor will oxidize in the furnace, and if we use glass for the finish coat it will combine, forming bubbles, pinholes, &c. This is avoided by the use of the infusible material for the finish coat. By "pottery-like" I mean semivitreous, that is, con-

taining vitreous material mixed with non-vitreous material, and which when heated forms a solid coherent mass.

Before applying the conductor to the ground coat I prefer to glaze the surface of the ground coat by a thin layer of glass. This glazing is applied, preferably, after the ground coat has been made into a hard continuous  
75 layer by the heat of the muffle-furnace, and is preferably applied in powdered form while the plate is still hot. The plate is then returned to the muffle without allowing it to cool and is subjected to a temperature sufficient to cause the surface of the powdered glass, which before firing has a dull non-reflecting surface, to become glassy, smooth, and free from imperfections. This glaze is not moisture-absorbent and protects the  
85 ground coat against the absorption of moisture, which would of course affect the insulating qualities. If the first application of the powdered glass upon the ground coat does not produce a perfect glazing, an additional  
90 layer or layers may be applied by successive firings. By glazing the surface of the ground coat I am enabled to very greatly increase the insulation between the conductor and the metal support. For example, one thousand  
95 volts alternating would readily pierce a certain thickness of the porous ground coat, but this ground coat after being glazed, as above described, would readily stand a very much higher electromotive force without being  
100 pierced. After the ground coat is glazed the plate is allowed to cool, and the conductor is then placed in position and the finish or glass coat is applied in the form of powdered glass, and the whole is then returned to the muffle-  
105 furnace to fuse the glass coat, which coat upon cooling forms a solid coherent layer impervious to moisture and is adhesively attached to the glazing of the ground coat and secures the conductor in position.

I attach the greatest importance to the application of both the infusible or ground coat and the glass or finish coat in powdered form and consider my process limited to the use of powdered material.

I am aware that heretofore it was the practice to apply two coatings or layers in attaching and insulating a conductor from a metal support, but in that process the two layers were both "enamel," and hence became soft  
120 at the heat of the muffle-furnace. The soft enamel in contact with a metal support, especially cast-iron, causes the development of bubbles, blisters, pinholes, &c., and results in poor insulation, and while the enamel is soft the conductor often sinks through the enamel into close proximity with the metal support, and hence causes defective insulation.

I sometimes mix with the powdered infusible material for the ground coat and with the powdered glass such materials as are well known in the art to hold the powder in suspension in a liquid, to prevent crazing in dry-

ing, to prevent oxidation of the metal support, to cause better adherence to the support, &c., but none of these are essential features of my invention.

5 My infusible or ground coat is not enamel. It is practically infusible at the heat of the muffle-furnace, is somewhat porous, somewhat absorbent of moisture, has a non-reflecting or poor-reflecting surface, and, unlike  
10 enamel, it does not combine freely with the oxidized-metal surfaces to form low-fusing silicates. In fact, it has almost none of the characteristic features of enamel. My vitreous or finish coat is glass, and has no prop-  
15 erty other than that of ordinary low-fusing glass.

By a "vitreous material" I mean a mineral composition having a glassy or reflecting surface impervious to moisture and one which  
20 gradually softens and becomes more and more fluid when subjected to the heat of a muffle-furnace.

My invention is illustrated in the accompanying drawings.

25 Figure 1 is a plan view showing a metal support A, having a conductor B and metal terminals C, adhesively attached thereto. Fig. 2 is a sectional view showing the metal support A, with an infusible or ground coat D,  
30 glazed by a thin layer of glass *d*, and a glass coat E, in which the conductor B and terminals C are embedded. Fig. 3 shows the support A, having two infusible coats D and D', the second layer having a glazing *d*. Fig. 4  
35 shows two infusible coats D and D', a glazing *d*, a glass coat E, in which the conductor is embedded, and an additional glass coat E' for correcting imperfections in the coat E; and  
40 Fig. 5 shows a metal support having a glazed ground coat and a ribbon-like conductor held edgewise thereto by a glass coat, the greater portion of the conductor being exposed.

What I claim is—

1. The method of making apparatus in  
45 which an electrical conductor is applied to a metal surface, which consists in coating the metal surface with a layer of infusible insulating material applied as a powder and made by heat into a coherent layer adhesive to the  
50 metal support, and placing the conductor upon said layer, substantially as set forth.

2. The method of making apparatus in which an electrical conductor is applied to a metal surface, which consists in coating the  
55 metal surface with a layer of infusible insulating material applied as a powder and made by heat into a coherent layer adhesive to the metal support, glazing said layer with a coating of glass, and placing the conductor upon  
60 said layer, substantially as set forth.

3. The method of making apparatus in which an electrical conductor is applied to a metal surface, which consists in coating the  
65 metal surface with a layer of infusible insulating material applied as a powder and made by heat into a coherent layer adhesive to the metal support, and then attaching the con-

ductor to the infusible layer by means of glass applied in powdered form and made adherent to the conductor and infusible layer by heat, 70 substantially as set forth.

4. The method of making apparatus in which an electrical conductor is applied to a metal surface, which consists in coating the  
75 metal surface with a layer of infusible insulating material applied as a powder and made by heat into a coherent layer adhesive to the metal support, glazing said layer with a coating of glass, and then attaching the conduc-  
80 tor to the infusible layer by means of glass applied in powdered form and made adherent to the conductor and infusible layer by heat, substantially as set forth.

5. The method of insulating electrical con-  
85 ductors from supports, which consists in applying to the support by successive firings several coatings of powdered material, which coatings become at a red heat, hard, coherent, insulating and pottery-like, and placing the  
90 conductor in contact with the thick coating so formed, substantially as set forth.

6. The method of insulating electrical con-  
ductors from supports, which consists in ap-  
95 plying to the support by successive firings several coatings of powdered material, which coatings become at a red heat, hard, coherent, insulating and pottery-like, glazing the sur-  
100 face of the last coating, and placing the conductor in contact with the thick coating so formed, substantially as set forth.

7. The method of insulating electrical con-  
ductors from supports, which consists in ap-  
plying to the support by successive firings  
105 several coatings of powdered material, which coatings become at a red heat, hard, coherent, insulating and pottery-like, and then attach-  
110 ing the conductor to the pottery-like material by means of glass applied in powdered form and made adherent to the conductor and the pottery-like layer by heat, substantially as  
115 set forth.

8. The method of insulating electrical con-  
ductors from supports, which consists in ap-  
plying to the support by successive firings  
115 several coatings of powdered material, which coatings become at a red heat, hard, coherent, insulating and pottery-like, glazing the sur-  
120 face of the last coating, and then attaching the conductor to the pottery-like material by means of glass applied in powdered form and made adherent to the conductor and the pot-  
tery-like layer by heat, substantially as set forth.

9. The method of insulating conductors  
125 from metallic supports while attaching them thereto, which consists in first forming upon the support an adherent, solid layer of non-vitreous insulating material, and then attach-  
130 ing the conductor to the non-vitreous layer by means of a layer of vitreous material made by heat adherent to the first layer, substantially as set forth.

10. The method of insulating conductors from metallic supports while attaching them

- thereto, which consists in first forming upon the support an adherent solid layer of non-vitreous insulating material, glazing the surface of said non-vitreous layer by a thin layer of vitreous material, and then attaching the conductor to the glazed non-vitreous layer by means of a layer of vitreous material made by heat adherent to the first layer, substantially as set forth.
11. The method of making apparatus in which an electrical conductor is applied to a metal surface, which consists in applying a ground coat, placing powdered glass on said coat while hot to produce a glaze thereon, allowing the metal and said coatings to cool, then placing the conductor upon the glazed ground coat and applying a glass coat, and fusing the glass to cause the same to adhere to the glazed ground coat and to adhesively secure the conductor in position, substantially as set forth.
12. The combination of a metallic support, covered by a layer of infusible insulating material applied as a powder and made by heat into a coherent adhesive layer, and a conductor attached to said infusible layer by glass applied as a powder and made by heat adhesive to said infusible layer, substantially as set forth.
13. The combination of a metallic support, covered by a layer of infusible insulating material applied as a powder and made by heat into a coherent adhesive layer, a glazing of glass on said infusible layer, and a conductor attached to said glazed infusible layer by glass applied as a powder and made by heat adhesive to said infusible layer, substantially as set forth.
14. The combination of a metallic support, covered by a layer of infusible non-vitreous insulating material applied as a powder and made by heat into a coherent adhesive layer, a glazing of glass on said infusible layer, and a conductor attached to said glazed infusible layer by glass applied as a powder and made by heat adhesive to said infusible layer, substantially as set forth.
15. The combination of a cast-iron support, a conductor, and a layer of infusible material and a layer of glass, the whole forming a coherent mass, substantially as set forth.
16. The combination of a cast-iron support, a conductor, and a layer of non-vitreous infusible material and a layer of glass between said support and conductor, the whole forming a coherent mass, substantially as set forth.
17. The combination of a cast-iron support, a layer of infusible material thereon applied as a powder and made by heat into a solid coherent adhesive layer, a conductor placed thereon, and a layer of glass applied as a powder and made by heat into a solid layer adhesive to the infusible layer and securing the conductor in position, substantially as set forth.
18. The combination of a cast-iron support, a layer of infusible material thereon applied as a powder and made by heat into a solid coherent adhesive layer, a glazing of glass on said layer, a conductor placed thereon, and a layer of glass applied as a powder and made by heat into a solid layer adhesive to the glazed infusible layer and securing the conductor in position, substantially as set forth.
19. The combination of a cast-iron support, a layer of infusible material thereon applied as a powder and made by heat into a solid coherent adhesive layer, a conductor placed thereon, and a layer of glass applied as a powder and made by heat into a solid layer adhesive to the infusible layer and securing the conductor in position, substantially as set forth.
20. The combination of a cast-iron support, a layer of infusible non-vitreous material thereon applied as a powder and made by heat into a solid coherent adhesive layer, a glazing of glass on said layer, a conductor placed thereon, and a layer of glass applied as a powder and made by heat into a solid layer adhesive to the glazed infusible layer and securing the conductor in position, substantially as set forth.
21. In a rheostat, the combination of a cast-iron plate or support, a layer of infusible material thereon, a conductor, and a layer of insulating material adherent to the infusible layer and securing the conductor in position, substantially as set forth.
22. In a rheostat, the combination of a cast-iron plate or support, a layer of pottery-like material adherent thereto, a conductor thereon, and a layer of glass adherent to the pottery-like layer, and securing the conductor in position, substantially as set forth.
23. In a rheostat, the combination of a cast-iron plate or support, a layer of infusible material thereon, and a conductor embedded in a layer of glass adherent to the infusible layer, substantially as set forth.
24. In a rheostat, the combination of a cast-iron plate or support, a layer of infusible material thereon, a glazing of glass thereon, and a conductor embedded in a layer of glass adherent to the glazed infusible layer, substantially as set forth.
25. In a rheostat, the combination of a cast-iron plate or support, a layer of infusible insulating material adherent to said support, and a conductor partially embedded in a layer of glass which attaches the conductor to the infusible layer, substantially as set forth.
26. In a rheostat, the combination of a cast-iron plate or support, a layer of infusible insulating material adherent to said support, and a ribbon-like conductor partially embedded in a layer of glass which attaches the conductor to the infusible layer, substantially as set forth.
27. The method of insulating two metal bodies from each other consisting in applying to the surface of one of the bodies a layer of powdered material which by heat is caused to become a solid body of insulating material

and to adhere to the metal surface, glazing said material with a layer of insulating material, and placing the other metal body upon said glazed surface, substantially as set forth.

5 28. The method of insulating two metal bodies from each other consisting in applying to the surface of one of the bodies a layer of powdered material which by heat is caused to become a solid body of insulating material and to adhere to the metal surface, glazing  
10 said material with a layer of insulating material, and attaching the other metal body thereto by a layer of glassy material, whereby the two metal bodies are secured together but  
15 insulated from each other, substantially as set forth.

29. The combination of a metal body, a layer of infusible insulating material applied there-

to and made by heat into a coherent, adhesive layer, a glazing of glass on said layer, and a 20 metal body placed upon said glazed surface, substantially as set forth.

30. The combination of a metal body, a layer of infusible insulating material applied there-  
to and made by heat into a coherent, adhesive 25 layer, a glazing of glass on said layer, and a metal body placed upon said glazed surface and attached thereto by glass made adhesive by heat, substantially as set forth.

This specification signed and witnessed this 30 27th day of July, 1896.

HARRY WARD LEONARD.

Witnesses:

W. PELZER,

EUGENE CONRAN.