No. 691,949. Patented Jan. 28, 1902.

H. W. LEONARD.

SUPPORT FOR ELECTRIC CONDUCTORS AND RESISTANCES.

(Application filed Jan. 10, 1901.)

(No Model.) 2 Sheets—Sheet I.

Fig. 1

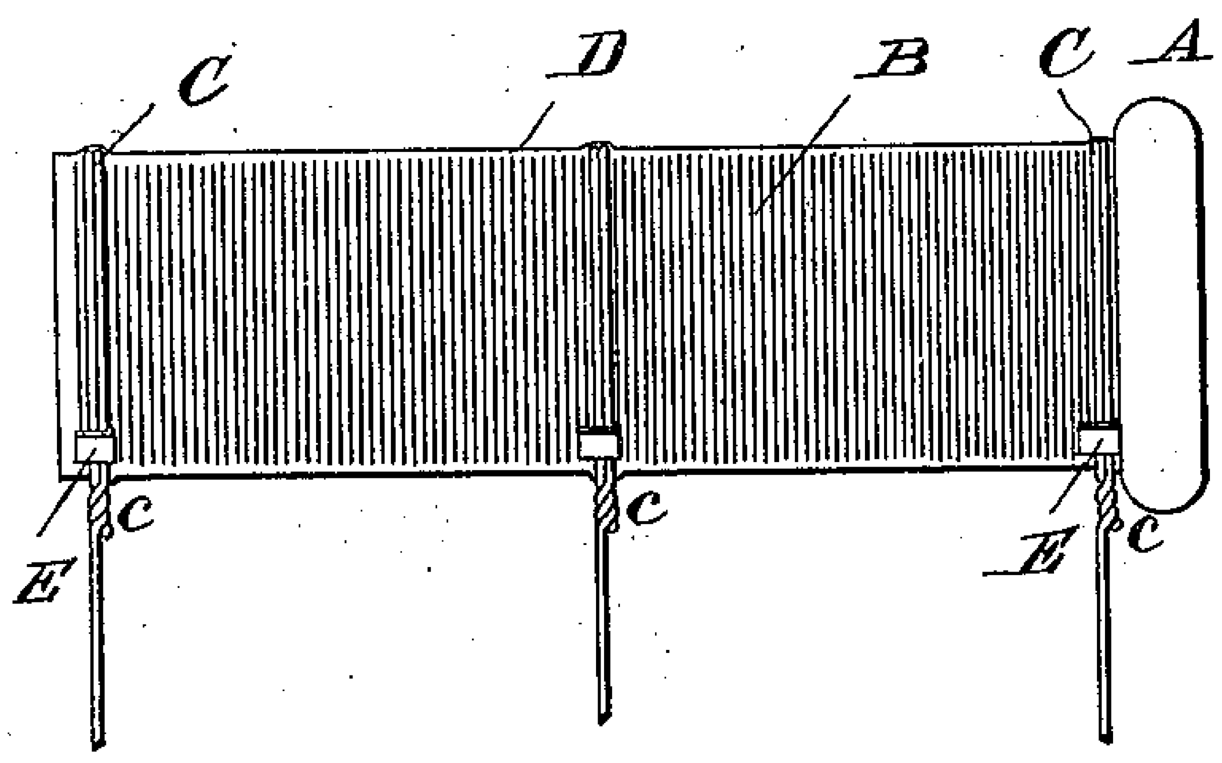


Fig. 2

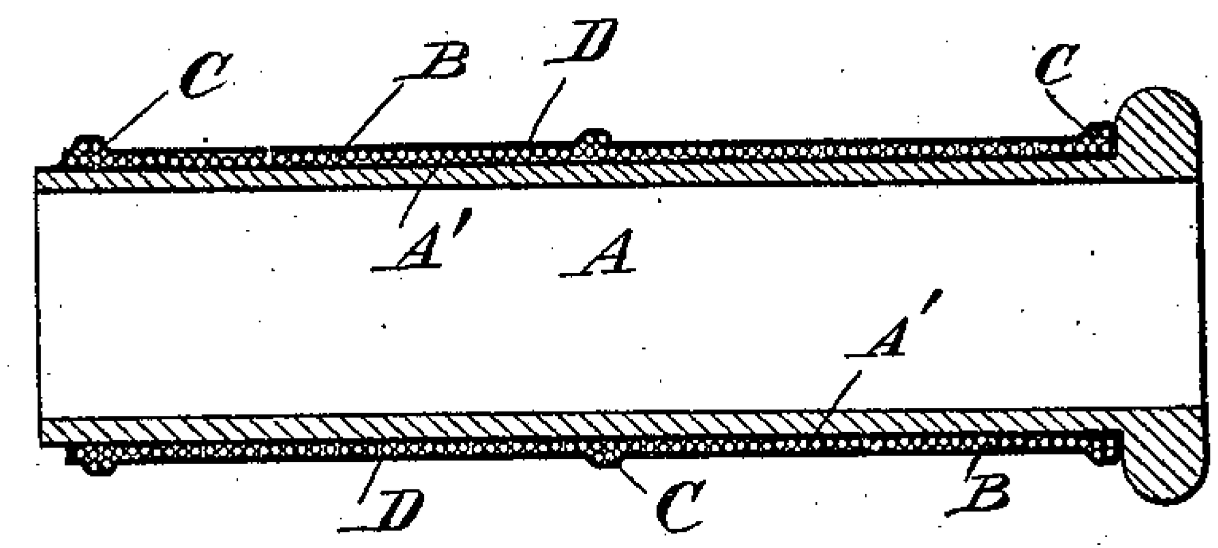


Fig. 3

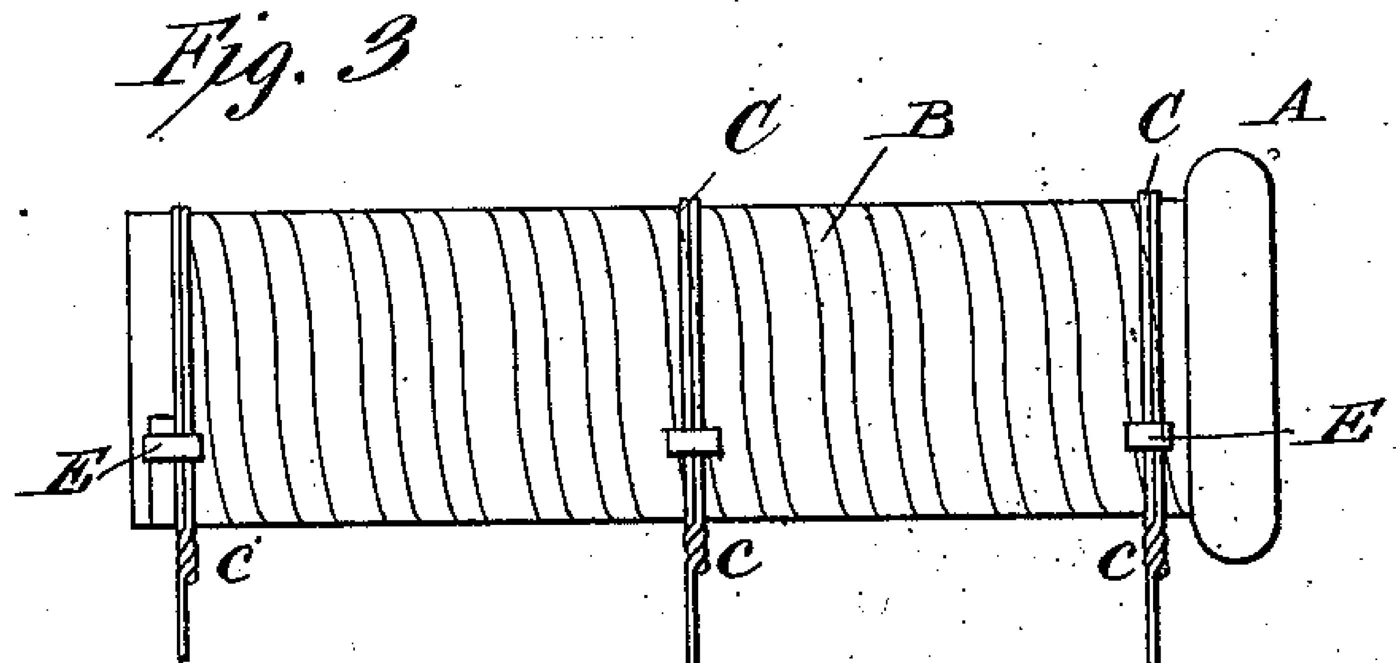


Fig. 4

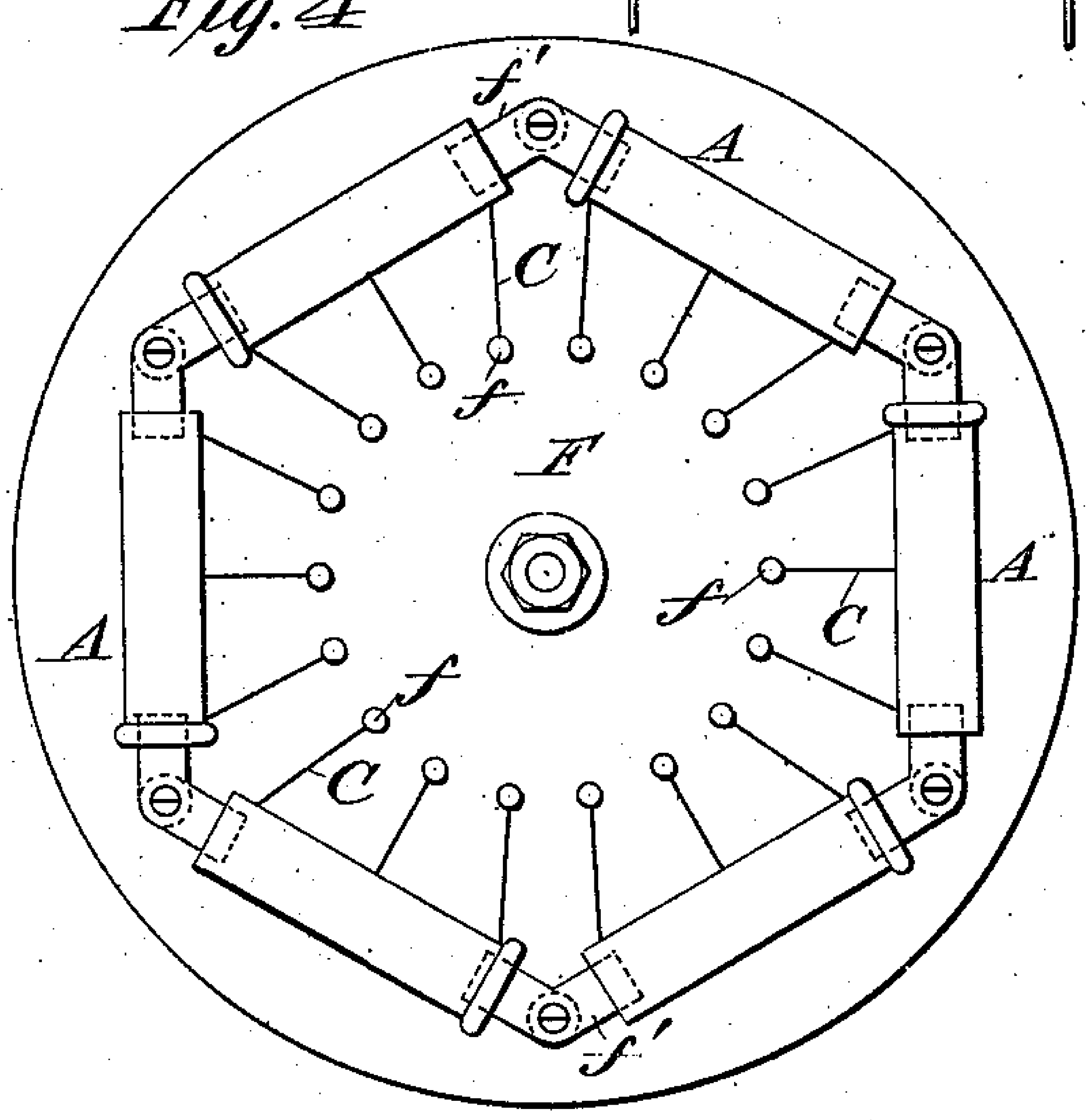
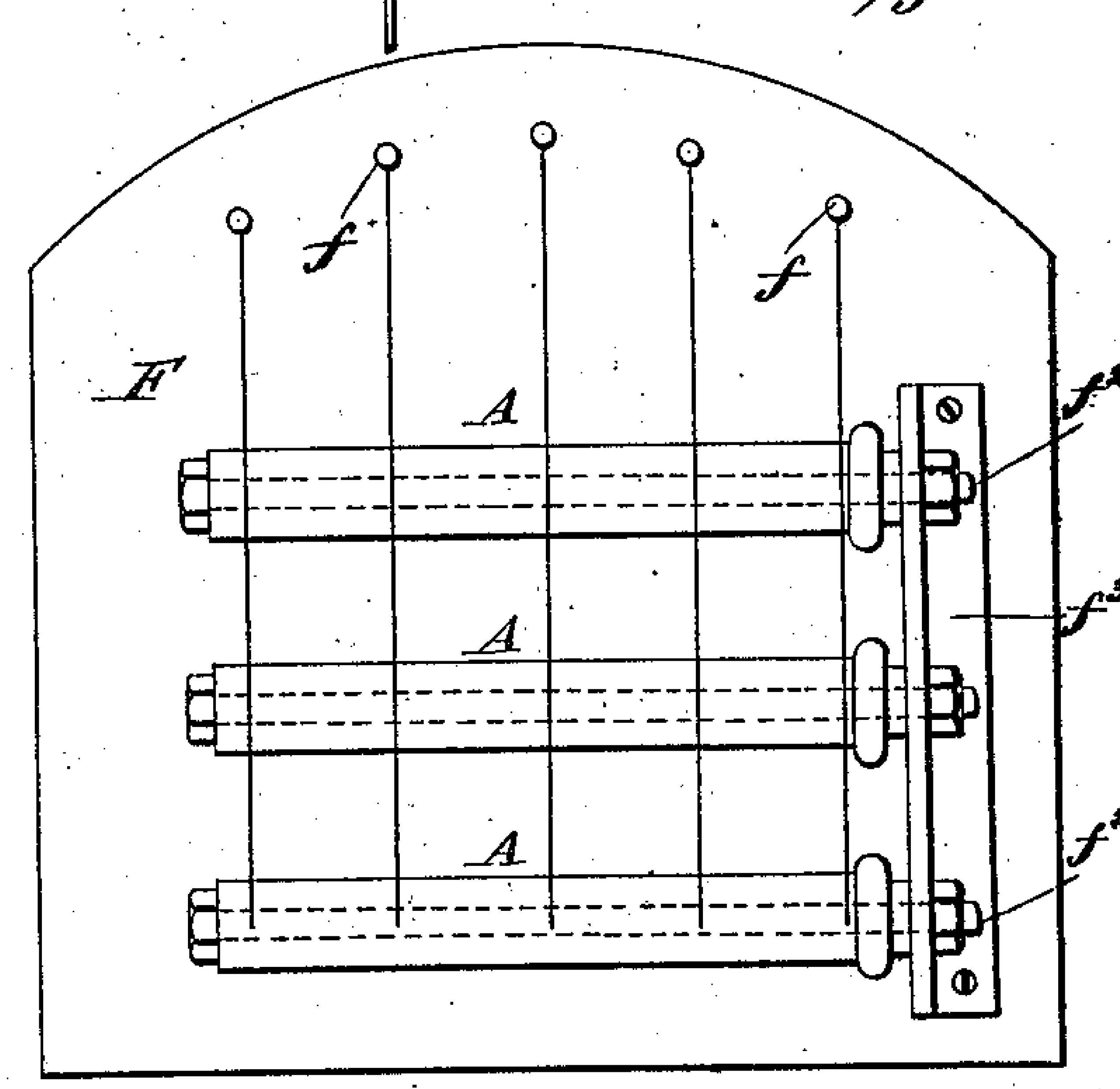


Fig. 5



Witnesses:

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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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Fig. 6

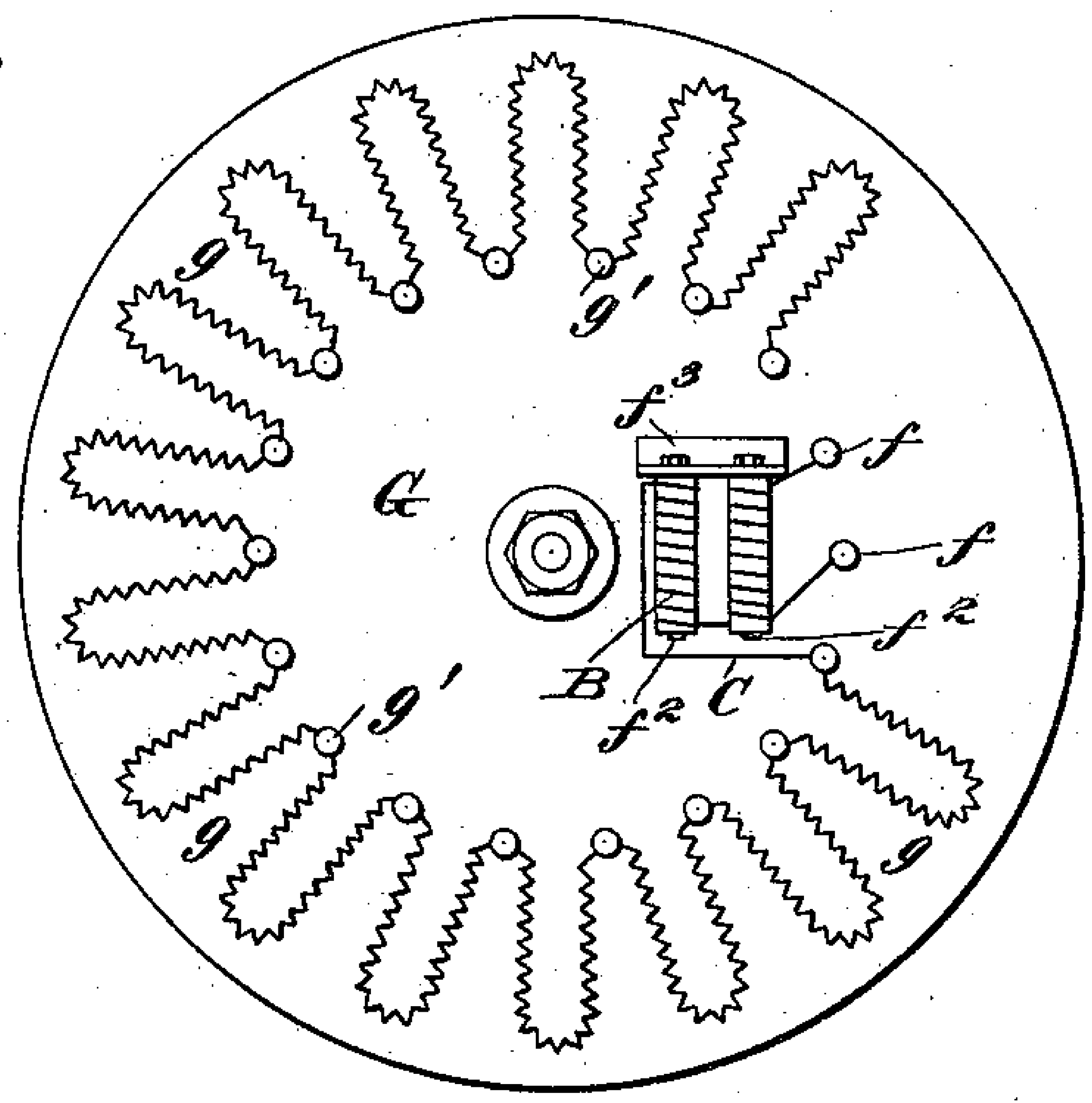


Fig. 7

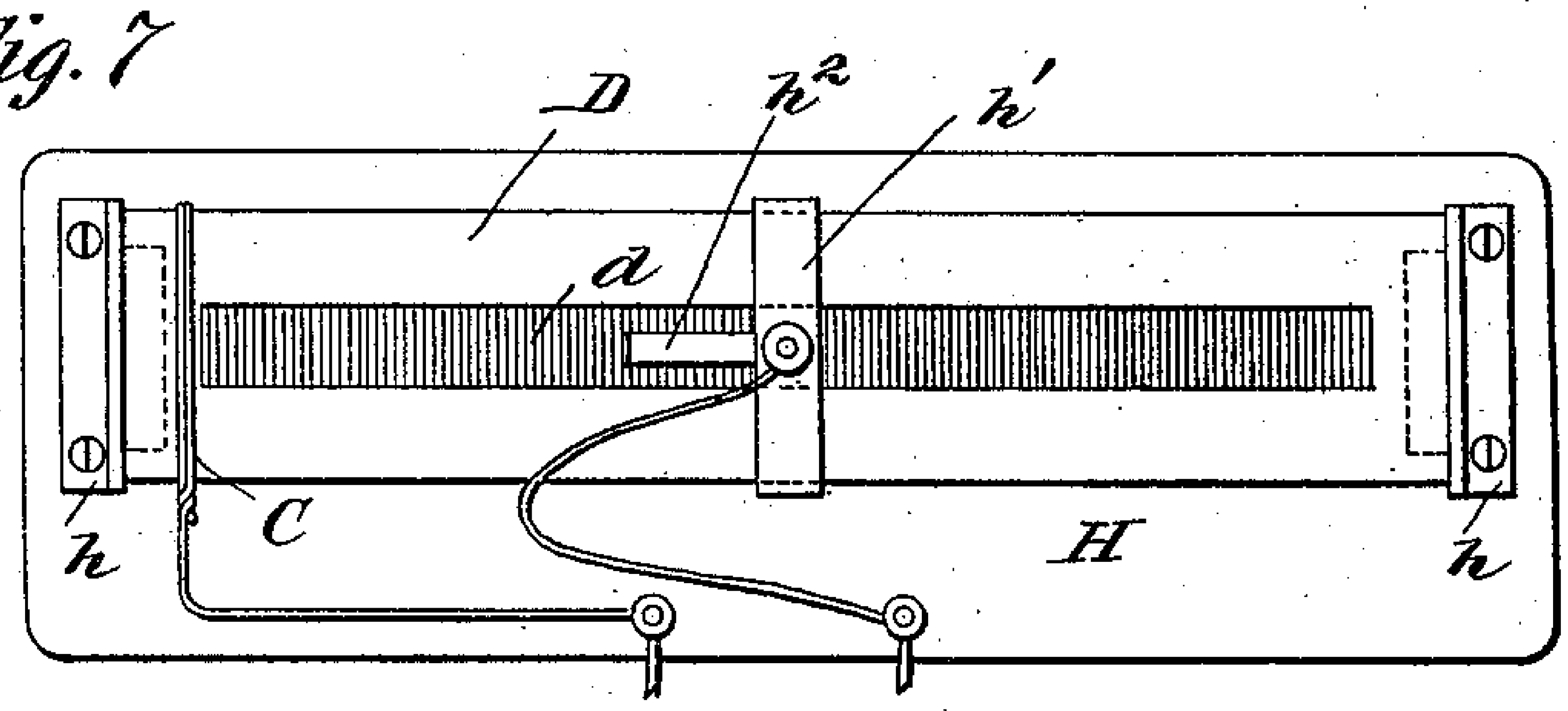


Fig. 8

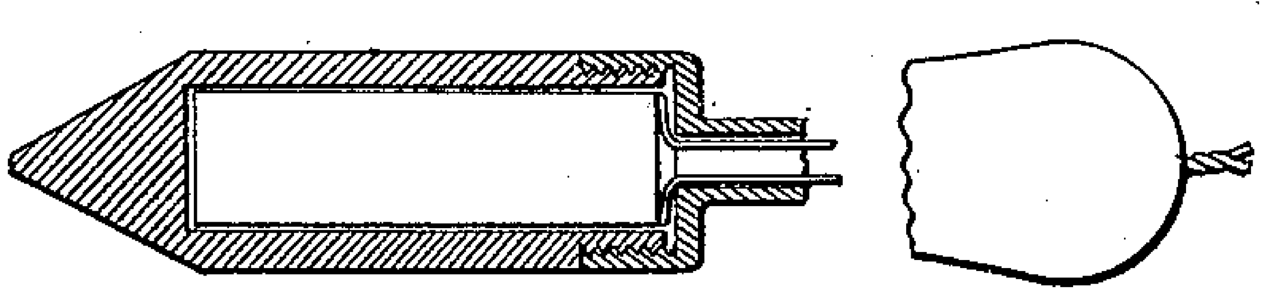


Fig. 9

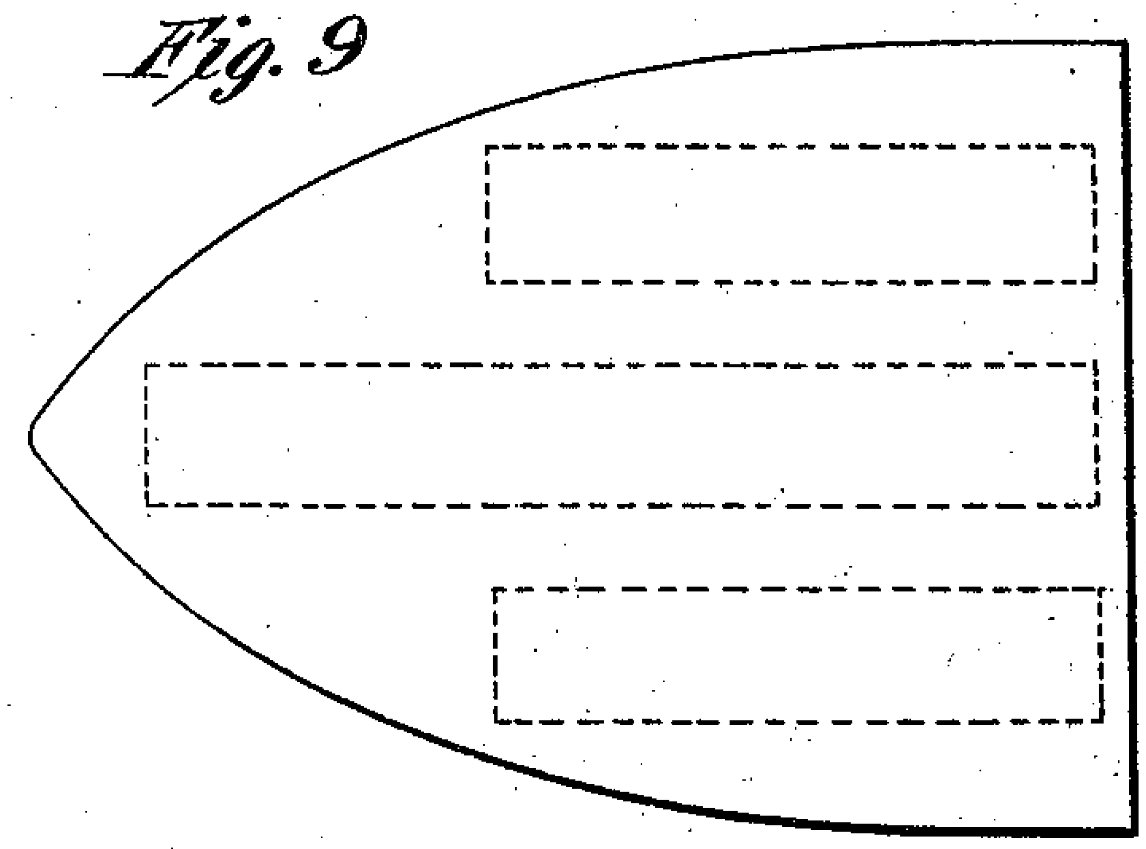
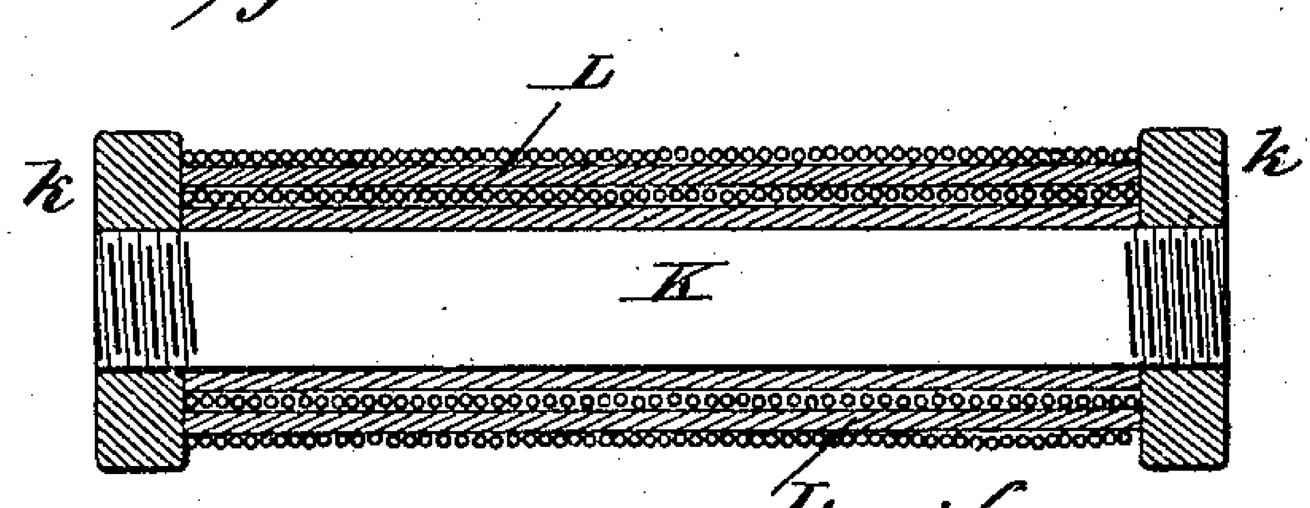


Fig. 10



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UNITED STATES PATENT OFFICE.

HARRY WARD LEONARD, OF NEW YORK, N. Y.

SUPPORT FOR ELECTRIC CONDUCTORS AND RESISTANCES.

SPECIFICATION forming part of Letters Patent No. 691,949, dated January 28, 1902.

Application filed January 10, 1901. Serial No. 42,753. (No model.)

To all whom it may concern:

Be it known that I, HARRY WARD LEONARD, a citizen of the United States, and a resident of the borough of Manhattan, in the city of New York, county and State of New York, have invented a certain new and useful Improvement in Supports for Electric Conductors and Resistances, of which the following is a specification.

This invention relates to improvements in devices in which electric energy is converted into heat not only when such conversion is intentional, as in rheostats, heaters, &c., but also relates to apparatus in which the development of heat is merely an essential but objectionable feature of the apparatus, as in the case of electromagnets.

In carrying my invention into effect I employ a tube, cylinder, or block made of earthy mineral material, preferably pottery, as the support for the conductor or resistance, the same being held in place and coated to insulate the sections by a coating of insulating material, such as enamel. I have used soapstone, lava, slate, glass, porcelain, brick, terra cotta, and a great many other materials for the support; but for most applications I prefer pottery in tubular form.

I am aware that it has heretofore been proposed to attach by means of enamel upon a support made of pottery or similar material the coils or sections of a resistance designed for use in rheostats or electric heaters, (see patent to J. H. Delaney, No. 535,321;) but in such devices perfect results could not be obtained on account of the wide difference in the coefficient of expansion of the pottery or similar base and the conductor and the high heat required to fuse the attaching material.

In employing enamel having a relatively high fusing-point, as heretofore used in the arts, I found that it was entirely impracticable to secure a conductor, particularly one of very small cross-section, to a pottery or similar tube by fusing such enamel over the surface. Enamel as ordinarily used has a melting-point of about 1,500° Fahrenheit or higher, and at this very high temperature the expansion of the conductor is very great relative to that of the pottery tube, with the result that while the enamel is in the fused state the conductor will become distorted and the adjacent sections or convolutions will come into contact with each other and become set in such position by the hardening of the coating, causing short-circuiting points when the device is used, which defect renders the device absolutely useless for the purpose for which it is designed. I overcome this difficulty by employing a vitreous glazing or enamel having a comparatively low fusing-point, the melting-point of the preferred enamel or glaze being approximately only half as high as that of ordinary enamel, or, in other words, about 750° Fahrenheit. I prefer that the glaze should entirely cover the conductor, so as to protect it from exposure to mechanical or chemical depreciation. I prefer to use a pottery tube rather than a china or porcelain tube, as the pottery tube is tougher and can be heated and cooled rapidly without danger of cracking. In practice I also prefer to have the pottery tube glazed by an ordinary glazing before the resistance is wound upon it, and after the resistance is wound upon the tube the soft glaze is applied and fixed by heat in any suitable manner. This soft glaze I prefer to apply in the form of a thick liquid, the material of the glaze or enamel being in a finely ground or pulverized state mixed with a fluid to obtain the desired consistency. After the protecting and attaching glaze is applied in this form the coating is dried and then heated until the soft glaze melts. The device is then allowed to cool and the soft glaze in hardening produces a thin and fairly uniform coating over the entire surface and around the conductor.

I attach especial importance to the tube form of support. In the commercial manufacture of these articles it is necessary to have a great many varieties, both as regards length, diameter, and the resistance in ohms. In order to make the article commercially—*i. e.*, low enough in price—it is necessary to place the tubes, with the conductor and glazing material thereon, directly into a muffle-furnace, when the soft enamel melts in a few minutes. They are then taken out directly into the outer air. By making the support in the form of a tube and by limiting the heat to about 750° Fahrenheit I have been able to accomplish this when I employ pottery or equivalent material as the support. A solid rod or other large mass of pottery-like material if heated and cooled so quickly would be too fragile to be commercially useful, and if the heat were 1,500° and upward, as usually required for enameling, the resulting article would be even more fragile. The expansion of the metal conductor would be about twice as much at 1,500° as at 750°, while the pottery would not expand very much, so that at 1,500° and upward the wire would become so loose and distorted on the tube that good results could not be obtained. I obviate all of these difficulties by using the support in the form of a tube and using a tough material like pottery rather than porcelain and by using a glaze of very low fusing-point. The tubular form also makes it possible to wind the wire upon the cylindrical surface in a lathe in a very uniform manner and very cheaply, and it is readily possible to wind any desired number of threads to the inch within very wide limits. The tubular form is also a very good form so far as mounting the resistance is concerned, as it can be placed upon a metal rod and detachably secured in position in a simple and inexpensive manner.

From the foregoing it will be seen that by employing a protecting or an attaching glaze having a comparatively low fusing-point I am also enabled to employ wires of a material and fineness heretofore entirely impracticable, because the degree of heat required does not injuriously affect even fine wires.

My invention is of especial applicability in resistances requiring a very high resistance in a very small space. It is also of especial value where extremely fine wires or other conductors are desired for carrying the current to be controlled. By my invention I can readily place upon a tube four inches long and one inch in diameter a wire having a resistance of three thousand ohms, and I have found in practice that such a resistance can be connected directly across a circuit of six hundred volts and kept there continuously without any depreciation. The wire which I prefer to employ for such work is about three-thousandths of an inch in diameter and is composed of a very high resistance alloy, having about fifty times the resistance of copper at ordinary temperature. When such an extremely fine wire can be employed, the cost of the resistance material becomes extremely low. The importance of being able to obtain such high resistances in permanent form and which can be subjected to high temperatures is well known to those acquainted with the electric art. With the methods of construction heretofore employed a resistance having the capacity just described would be very large and very expensive in comparison with my improved resistance.

In the construction of many kinds of rheostats and other devices it is desirable to have an extremely high resistance to be used for reducing the current to a very small amount before opening the circuit. By adding to the device in question one or more of my resistance-tubes I can furnish at very slight expense and in very small space this high auxiliary resistance. For example, take a generator field-rheostat in which a certain number of ohms are required, which will be so arranged as to give a very gradual regulation of the current when the generator is operating at about its full electromotive force, but when the field-circuit is to be reduced to zero and opened a very high resistance which can be inserted into the field - circuit, so as to greatly reduce the current, is very desirable. It is not necessary that this resistance should have a large number of steps, because a very fine step-by-step regulation of the generator with such a small field-current is not a requirement of practice. Heretofore the space occupied by the portion of the total resistance which is thus used for cutting down the current, in contradistinction to operative regulation of the field-current, and also the cost of such resistance was very high, and by my invention I very greatly reduce the space and cost and make the apparatus very much more effective.

In many forms of apparatus the resistance is divided into a number of steps of gradually-tapering current capacity—for example, field-rheostats, theater-dimmers, rheostats for controlling the speed of motors driving ventilating-fans, centrifugal pumps, &c. In such instances my pottery-tube resistances can be employed to good advantage. The tubes for such use are wound so that each will have the proper ohms and ampere capacity for each step, and when assembled into a rheostat, with proper contact-buttons and switch, constitute a very compact, cheap, and easily-repaired apparatus and one which can be readily modified in case modification should prove desirable.

For some uses it is desirable to have a resistance which can be varied by imperceptible increments. For such cases I provide a resistance-tube in which each convolution of the conductor is exposed for a short length—say one quarter of an inch—the exposed portions being in a straight line and with which a sliding contact coöperates to obtain the gradual changes in the current. Such a rheostat is desirable for use in cataphoresis and similar work and in many forms of laboratory and testing apparatus, and I still retain the compact form of the rheostat, low cost, positive holding of the conductor in place, and the ability of the apparatus to withstand high heat without depreciation in any way.

My pottery resistance-tube makes an extremely compact and economical form of resistance for carrying a current continuously and dissipating the heat so produced. Therefore it is extremely good for motor-speed-regulating rheostats, especially for motors of high electromotive force and small power. It is also very economical for regulating the field-current of high-electromotive-force motors, a practice rapidly growing more common and the rheostats for which are very expensive when made with a reflexed wire attached by enamel to a metal plate, which has been the best form heretofore obtainable. By my invention I can readily place two hundred ohms within a square inch of surface, while with the reflexed wire enameled upon an iron plate about twenty ohms per square inch is the maximum. As a consequence I am able to supply such rheostats having my pottery-tube resistance at a small fraction of the cost of rheostats having the reflexed-wire resistance enameled to plates and am able to make them very much more compact.

There are a great many forms of electric heating devices—such as soldering-irons, curling-irons, and flat-irons—in which the heat developed in the conductor must be conducted to a heated surface, and my pottery-tube resistance is of great value for such applications. For example, I can readily make by means of my invention a soldering-iron which will operate directly across two hundred and fifty volts with an expenditure of only about one hundred watts. For soldering-irons I employ a head having a cylindrical hole adapted to receive the tube and arranged for attachment to a suitable handle. The ease and simplicity of repairs in such a construction is apparent, and by providing a number of interchangeable tubes wound for different electromotive forces the same soldering-iron could be employed on almost any commercial circuit. Similarly I can readily make by means of my invention a small electric flat-iron which will operate directly across a five-hundred-volt circuit, which has heretofore been commercially impracticable.

High resistances are in many instances of great value to take up inductive discharges which might otherwise prove destructive to very expensive apparatus, and the insulation of such high resistances must be such as to withstand high-electromotive-force strains without being pierced. For such uses my invention is extremely well adapted in every way. In some instances the winding should be highly inductive and in others it should be non-inductive, and the well-known methods of winding for these results can be readily used in connection with my invention.

In many instances it is important to have magnetism developed under conditions such that the winding is necessarily exposed to high heat. For such cases my method of insulating and protecting the coil will often be of great value when ordinary methods of insulating the wire would be insufficient.

There are many other useful applications of my invention; but the above instances are a sufficient indication of its wide range of applicability.

I call attention to the fact that I can produce by means of my invention extremely high resistances, which will practically have a temperature coefficient of zero. Extremely high resistances have heretofore been made by means of electrolytes or by means of mixing carbon or metallic particles with non-conducting material, such as clay; but all high resistances of such types have a high temperature coefficient.

Instead of a round-wire conductor or resistance I may use a metal tape to form the helix. This method of manufacture enables me to make a very low resistance tube and yet retain the advantages of having a thin coating of glaze. Metal braid can also be employed for the conductor, the braid being composed of several strands of wire. The enamel holds the braid well in position, and the wavy form of the individual strands causes a certain amount of yielding in the conductors of large cross-section when heated and cooled, which is an advantage. A narrow strip of metal gauze may also be employed. This is wound on the surface like a tape. The enamel when fused works between the openings of the gauze and when hard holds the conductor firmly. Each particular conductor being relatively small in diameter, the expansion does not affect the enamel, as would be the case if the metal were all in one solid piece.

There is no tendency for the glaze to flake off from the tube, no matter how quickly it is heated. It is very superior to and very different in its action in this regard from the enamel upon metal. This is no doubt due to the close similarity in composition between the pottery tube and the glaze as compared with the metal and its enamel.

If very fine wires are enameled upon plates or tubes with ordinary enamel requiring about 1,500° or more to fuse it, the wires will often have open circuits, this being probably due to the difference in the expansion and contraction of the enamel, the support, and the wire, causing a strain on the wire which ruptures it. By my invention I can apply the finest wires procurable with perfect results and without subsequent failure in use, as is met with in the case of very fine wires in ordinary enamel. The very great economy of using a very fine wire has not heretofore been fully appreciated. If the diameters can be reduced to one-tenth of what has been heretofore necessary, the cross-section of the wire will be one one-hundredth and the resistance per foot one hundred times as much, and the weight will be one one-hundredth, and hence the ohms per pound will be ten thousand times as much with the fine wire as with the wire having ten times the diameter. Since the material is sold by the pound, the economy which my invention makes possible is very great. In fact, the cost of the resistance material even when I use the highest grade, which sells for many dollars per pound, becomes an insignificant portion of the cost of very high resistances, while heretofore it has been the principal item of the cost.

So far as I am aware resistances (and particularly resistance-wires made of the usual metallic alloys having low temperature coefficients) carried by supports made of any of the materials above named and secured by a glaze or enamel having a relatively high fusing-point have never been introduced into successful commercial use, and not until the tubes or supports having the resistances or conductors secured by a glazing or enamel having a relatively low fusing-point made by me did this form of resistance become a commercial article, and since the introduction of this device many thousands have been sold and their applications are rapidly increasing.

In the accompanying drawings, Figure 1 is a view of a pottery tube with a conductor or resistance wound and secured thereon in accordance with my invention. Fig. 2 is a longitudinal section of device shown in Fig. 1. Fig. 3 is a view similar to Fig. 1, showing a tape, braid, or gauze conductor in lieu of a round-wire conductor. Figs. 4, 5, and 6 are rear views of rheostats provided with resistance-tubes like those of Fig. 1. Fig. 7 is a plan view of another form of rheostat embodying my invention. Fig. 8 is a sectional view of a soldering-iron provided with my improved resistance or heating tube. Fig. 9 is a plan view of a flat-iron provided with a series of resistance or heating tubes, and Fig. 10 is a sectional view of an electromagnet having its coils carried by two pottery tubes embodying my invention.

Referring to Fig. 1 of the drawings, A represents a tube or solid support made of any of the materials above named, but preferably made of pottery. In practice I prefer to coat the tube or support in any suitable manner with a vitreous glazing A′ of high fusing-point, and upon this coating I wind or otherwise arrange the conductor or resistance B of any desired cross-section. This conductor is held in place by a binding-wire C, which is wound around the tubes or support in mechanical and electrical contact with conductor B and its ends twisted or otherwise secured together, as shown at *c*. One end of this binding-wire is left quite long, so as to be of service as a terminal or lead wire for connection to binding-posts or to other wires, as in rheostats. Similar terminal or lead wires are provided when the resistance B is to be divided into steps or sections, as shown in Fig. 1. The device so far formed is then coated with a layer of vitreous glazing D of relatively low fusing-point, the fusing-point being preferably not over 750° Fahrenheit. This glazing secures the conductor B and binder C to the support and also covers the same, thus insulating and protecting them against chemical or mechanical depreciation. A glazing having the desired low fusing-point contains oxid of lead and borax in equal proportions, and in practice I prefer to apply the glass or enamel to the supports in a finely-ground state mixed with water or other suitable liquid to form a thick paste-like mass, which after application is dried and heated to the proper degree to fuse it. When, as is usualy the case, the resistance-wire B is operated at a high heat in practice, it becomes necessary to provide a terminal or lead C of much greater conductivity, so that connection can be readily made by a substantial wire which is not heated very much. I prefer to use a copper wire for this terminal or lead. It is very important to have a good joint between the resistance-wire and this lead-wire. This joint must be maintained good when repeatedly heated and cooled to a temperature which often is as high as and sometimes higher than 600° Fahrenheit. I accomplish this by forming a metallic clamp E, which holds both the resistance-wire and the lead-wire under pressure, and then protect this joint from movement and from oxidation by covering it with the enamel. I prefer to make the clamp by folding upon itself a piece of sheet-copper of about No. 20 Brown & Sharpe and placing both the resistance-wire B and the lead-wire C, preferably twisted together, in the fold and then hammer the sheet-copper clamp upon the wires, compressing the two sides of the sheet-copper firmly upon the two wires. This makes a very good joint, and when embedded in the enamel it is firmly held mechanically against movement and is protected against oxidation. The copper wire C is then wound firmly around the tube, and the two ends of the copper wire are fastened together by twisting or otherwise, the copper wire being long enough so that it can be readily connected as desired in practice. The resistance-wire B is harder than copper. Hence when the copper clamp E is compressed upon the terminal lead (preferably a wire of copper) and the resistance-wire the resistance-wire is embedded into the copper wire, making very perfect contact between the two, and good contact is also made between the sheet-copper clamp and the terminal lead.

In the device shown in Fig. 3 the conductor B is in the form of a thin metallic ribbon or tape, metal or wire gauze, or wire braid, the width and thickness being controlled by the uses to which it is to be put. In this form it is sometimes unnecessary to provide the binding-wire or clamp; but these may be provided to give additional security to the conductor.

In Fig. 4 I show a series of my improved resistance-tubes mounted upon the back of a rheostat-plate F, made of slate or other suitable material. The tubes for this purpose will have as many sections as desired, each section being formed by a binding-wire or lead C, adapted to be connected to binding-posts or clips *f*, which are secured or connected with the usual contact-plates on the front side of the rheostat. The resistance-tubes are held in place by brackets f', made of metal or other material.

In Fig. 5 I show another form of rheostat having a support F, of slate or other material, and a series of long resistance-tubes mounted on rods f^2, carried by an angle-iron f^3. In this form the sections of the resistance are connected in multiple to five binding-posts f, which connect with the usual contact-plates on the front of the support F. Any desired number of contact-plates may be employed, the sections on the tubes being divided or arranged accordingly.

In Fig 6 I have shown a field-rheostat having the usual reflexed graduated resistance-sections g, secured to a suitable support G by enamel or otherwise and connected to binding-posts g', connected to contact-plates on the front of the support, as usual. For greatly reducing the current before opening the circuit I provide one or more of my resistance-tubes carried on rods f^2, secured to an angle-iron f^3, as in the form shown in Fig. 5. The resistance on these tubes may be divided into any desired number of sections or steps; but two steps are all that are generally employed, and these are preferably arranged, as shown, one step on each tube connected to binding-posts $f f$. In Fig. 7 I have shown a rheostat for varying the current in almost imperceptible increments. In this form I support a tube between the brackets h, secured to a base H. The tube for this rheostat has the material of the glazing D removed at d, as shown, in any suitable manner, so as to expose the resistance. Arranged on the tube is a collar h', having a contact-finger h^2 for making contact with the coils on the tube as the collar is moved along. Contact h^2 is electrically connected with a binding-post on the collar, from which extends a flexible conductor, as usual in this style of rheostat.

In Fig. 8 I have illustrated in section a soldering-iron which may be of any desired construction, the form shown having a removable hollow head containing one of my resistance-tubes connected to the usual conductors extending through the handle.

In Fig. 9 I have shown a flat-iron having any desired number of holes formed therein to receive my improved resistance-tubes, which may be connected in circuit in any desired manner.

Fig. 10 illustrates my invention applied to electromagnets. In this device K is the magnet-core, having pole-pieces k k screwed or otherwise secured thereon. The core carries one or more pottery tubes L, as shown, the number of tubes or their length depending upon the number of ampere-turns required. The tubes for this purpose will be of the minimum thickness and made with more care than is necessary in the manufacture of resistance-tubes.

What I claim is—

1. As a new article of manufacture, a metallic conductor arranged upon a support of mineral insulating material, said conductor being secured to the support by means of a vitreous glaze having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

2. As a new article of manufacture, a metallic conductor arranged upon a support of mineral insulating material and provided with one or more terminals or leads, said conductor being secured to the support by means of a vitreous glaze having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

3. As a new article of manufacture, a metallic conductor arranged upon a support of mineral insulating material and having one or more terminals or leads in electrical connection therewith and secured to the support, said conductor being secured to the support by a vitreous glaze having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

4. As a new article of manufacture, a metallic conductor arranged upon a support of mineral insulating material and having one or more terminals or leads in electrical connection therewith and secured to the support, said conductor being secured to the support by a vitreous glaze which covers the connection with the leads, and said glazing having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

5. As a new article of manufacture, the combination of a metallic conductor arranged upon a support of mineral insulating material, one or more terminals or leads, a metal plate for maintaining electrical connection between the conductor and each lead, and a vitreous glazing by means of which the conductor is secured to the support, said glazing having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

6. As a new article of manufacture, a metallic conductor arranged upon a support of mineral insulating material and having one or more terminals or leads connected therewith and secured by metal plates, said conductor being secured to the support by means of a vitreous glaze having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so

loose on the support as to materially change its position thereon.

7. As a new article of manufacture, a metallic conductor arranged upon a support of mineral insulating material and having one or more terminals or leads connected therewith and secured by metal plates, said conductor and metal plates being secured to the support by a vitreous glaze which covers the connection with the leads, and said glazing having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

8. As a new article of manufacture, a metallic conductor of very small cross-section arranged upon a support of mineral insulating material, said conductor being secured to the support by means of a vitreous glaze having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

9. As a new article of manufacture, a metallic conductor of very small cross-section arranged upon a support of mineral insulating material and having one or more terminals or leads in electrical connection therewith and secured to the support, said conductor being secured to the support by a vitreous glaze having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

10. As a new article of manufacture, a metallic conductor of very small cross-section arranged upon a support of mineral insulating material and having one or more terminals or leads in electrical connection therewith and secured to the support, said conductor being secured to the support by a vitreous glaze which covers the connection with the leads, and said glazing having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

11. As a new article of manufacture, the combination of a metallic conductor of very small cross-section arranged upon a support of mineral insulating material, one or more terminals or leads, a metal plate for maintaining electrical connection between the conductor and each lead, and a vitreous glazing by means of which the conductor is secured to the support, said glazing having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

12. As a new article of manufacture, a metallic conductor of very small cross-section arranged upon a support of mineral insulating material and having one or more terminals or leads connected therewith and secured by metal plates, said conductor and metal plates being secured to the support by a vitreous glaze which covers the connection with the leads, and said glazing having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

13. As a new article of manufacture, a metallic conductor arranged upon a tubular support of mineral insulating material, said conductor being secured to the support by means of a vitreous glaze having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

14. As a new article of manufacture, a metallic conductor of very small cross-section arranged upon a tubular support of mineral insulating material, said conductor being secured to the support by means of a vitreous glaze having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

15. As a new article of manufacture, a metallic conductor arranged upon a tubular support of mineral insulating material and having one or more terminals or leads in electrical connection therewith and secured to the support, said conductor being secured to the support by a vitreous glaze having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

16. As a new article of manufacture, a metallic conductor arranged upon a tubular support of mineral insulating material and having one or more terminals or leads in electrical connection therewith and secured to the support, said conductor being secured to the support by a vitreous glaze which covers the connection with the leads, and said glazing having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

17. As a new article of manufacture, the combination of a metallic conductor arranged upon a tubular support of mineral insulating material, one or more terminals or leads, a metal plate for maintaining electrical connection between the conductor and each lead, and a vitreous glazing by means of which the conductor is secured to the support, said glaz-

ing having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

18. As a new article of manufacture, a metallic conductor arranged upon a tubular support of mineral insulating material and having one or more terminals or leads connected therewith and secured by metal plates, said conductor and metal plates being secured to the support by a vitreous glaze which covers the connection with the leads, and said glazing having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

19. As a new article of manufacture, a metallic conductor of very small cross-section arranged upon a tubular support of mineral insulating material and having one or more terminals or leads in electrical connection therewith and secured to the support, said conductor being secured to the support by a vitreous glaze having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

20. As a new article of manufacture, the combination of a metallic conductor of very small cross-section arranged upon a tubular support of mineral insulating material, one or more terminals or leads, a metal plate for maintaining electrical connection between the conductor and each lead, and a vitreous glazing by means of which the conductor is secured to the support, said glazing having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

21. As a new article of manufacture, a metallic conductor of very small cross-section arranged upon a tubular support of mineral insulating material and having one or more terminals or leads connected therewith and secured by metal plates, said conductor and metal plates being secured to the support by a vitreous glaze which covers the connection with the leads, and said glazing having a fusing-point so low that it melts before the difference between the expansion of the conductor and the support causes the conductor to become so loose on the support as to materially change its position thereon.

22. As a new article of manufacture, a metallic conductor arranged upon a pottery tube, said conductor being secured to said tube by means of a vitreous glaze having a fusing-point so low that it melts before the difference between the expansion of the conductor and the tube causes the conductor to become so loose on the tube as to materially change its position thereon.

23. As a new article of manufacture, a metallic conductor of very small cross-section arranged upon a pottery tube, said conductor being secured to the tube by means of a vitreous glaze having a fusing-point so low that it melts before the difference between the expansion of the conductor and the tube causes the conductor to become so loose on the tube as to materially change its position thereon.

24. As a new article of manufacture, a metallic conductor of very small cross-section arranged upon a pottery tube and having one or more terminals or leads in electrical connection therewith and secured to the tube, said conductor being secured to the tube by a vitreous glaze which covers the connection with the leads, and said glazing having a fusing-point so low that it melts before the difference between the expansion of the conductor and the tube causes the conductor to become so loose on the tube as to materially change its position thereon.

25. As a new article of manufacture, a metallic conductor of very small cross-section arranged upon a pottery tube and having one or more terminals or leads connected therewith and secured by metal plates, said conductor and metal plates being secured to the tube by a vitreous glaze which covers the connection with the leads, and said glazing having a fusing-point so low that it melts before the difference between the expansion of the conductor and the tube causes the conductor to become so loose on the tube as to materially change its position thereon.

26. As a new article of manufacture, a conductor arranged upon a support of mineral insulating material, terminals or leads in electrical connection with each end of the conductor and securing the ends of the conductor in position, one or more intermediate terminals or leads in electrical connection with the conductor and dividing it into steps or sections, and said conductor being secured to the support by a vitreous glaze of low fusing-point.

27. As a new article of manufacture, a conductor arranged upon a tubular support of mineral insulating material, terminals or leads in electrical connection with each end of the conductor and securing the ends of the conductor in position, one or more intermediate terminals or leads dividing the conductor into steps or sections, said intermediate terminals or leads being bent around the conductor in electrical contact therewith, and said conductor being secured to the support by a vitreous glaze of low fusing-point.

28. The combination with a rheostat having a resistance arranged in steps or sections for regulating the current, of one or more high resistances adapted to be inserted in the circuit to greatly reduce the current, said resistances being composed of fine wire carried

by a support made of mineral insulating material and having the conductor attached by a vitreous glaze of low fusing-point.

29. The combination with a rheostat having a reflexed wire resistance arranged in steps or sections enameled to a support, of one or more high resistances adapted to be inserted in the circuit to greatly reduce the current, said resistances being composed of fine wire carried by a support made of mineral insulating material and having the conductor attached by a vitreous glaze of low fusing-point.

30. A support of mineral insulating material, a conductor carried thereby, one or more lead-wires for said conductor, a small folded metal plate for each lead-wire, between the folds of which the conductor and lead-wire are placed or clamped, and a vitreous glaze of low fusing-point attaching said conductor, leads and plate to the support.

31. A support of mineral insulating material, a conductor carried thereby, one or more lead-wires for said conductor bent around the support and secured by twisting the ends together, a small folded metal plate for each lead-wire, between the folds of which the conductor and lead-wire are placed or clamped, and a vitreous glaze of low fusing-point attaching said conductor, leads and plate to the support.

32. A pottery tube, a conductor carried thereby, one or more lead-wires for said conductor, a small folded metal plate for each lead-wire, between the folds of which the conductor and lead-wire are placed or clamped, and a vitreous glaze of low fusing-point attaching said conductor, leads and plate to the support.

33. A pottery tube, a conductor carried thereby, one or more lead-wires for said conductor bent around the support and secured by twisting the ends together, a small folded metal plate for each lead-wire, between the folds of which the conductor and lead-wire are placed or clamped, and a vitreous glaze of low fusing-point attaching said conductor, leads and plate to the support.

This specification signed and witnessed this 31st day of December, 1900.

H. WARD LEONARD.

Witnesses:

WM. PELZER,

JNO. R. TAYLOR.