

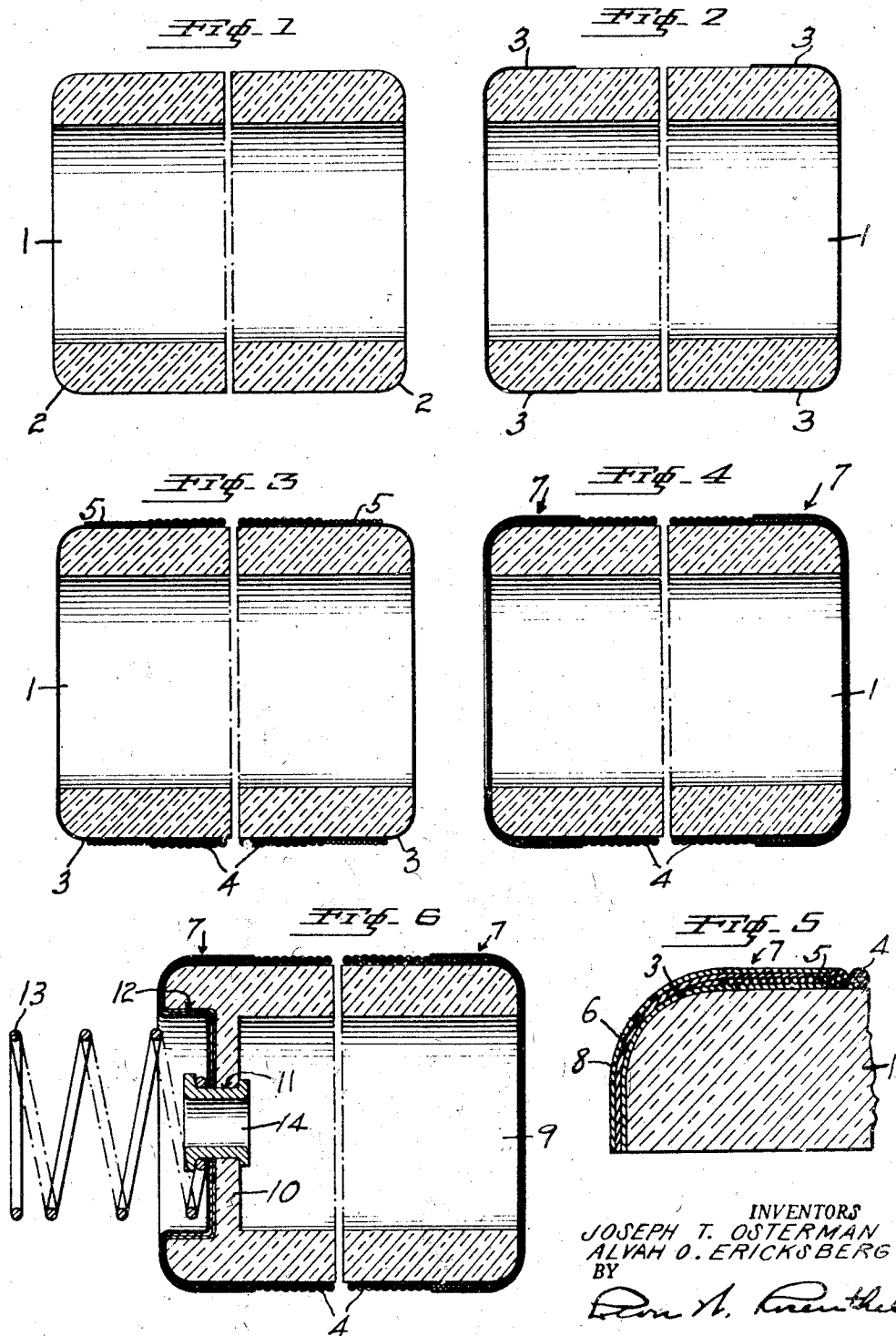
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METHOD OF MAKING ELECTRIC COILS

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METHOD OF MAKING ELECTRIC COILS

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1 The present invention relates to methods of making electric coils on heat-resistant coil forms with wire terminals rigidly fastening the coil winding to the form, by bonding the end turns of the winding to separated conducting areas baked on the form. Such coils employ relatively fine wire and are used generally as for instance in sparkplugs in ignition systems of the capacitor discharge type, electrical instruments, and radio and other high frequency devices.

Heretofore it was customary to solder the ends of the coil winding to conducting areas or bands sometimes baked on coil forms to produce the coil terminals, but this subjected the form to heat shocks of such nature as often fractured it particularly if silver solder was used, or set up such stresses and strains as resulted in unduly fragile forms which broke upon ordinary mechanical shock or vibration. Also, the electric contact between the wire and the conducting areas occurred at spots only, and the surface of the wire at the joints often corroded in soldering and sometimes further thereafter so as to be faulty and non-uniform in resistance upon completion besides deteriorating during service. Also the solder sometimes formed lumps and otherwise lacked uniformity in dimensions, which detracted from the smooth and regular dimensions of the terminal in such wise as to prevent reliable contact therewith in electrical devices and circuits. Furthermore, in application to sparkplugs in which the coils were impregnated in place at comparatively high temperature and also in service reached a comparatively high temperature at the location of the coil, the solder would sometimes melt and thereupon interrupt the electrical circuit at one or both terminals of the coil.

In accordance with our invention, the foregoing difficulties are obviated by bonding the bare end turns of the coil winding to the conducting areas on the coil form by baking adherent metallic material spread over at least a substantial part of the contacting surfaces of the winding while the end turns thereof are held against the conducting areas. In order to wind closely, insulated wire is used preferably, and to withstand the baking and operating temperatures this insulation is of the heat-resistant type. Preferably the bonding operation, and also the operation of baking the conducting areas on the coil form, are accomplished by gradually heating the coil form to the necessary temperature and thereafter gradually cooling it to room temperature, thereby avoiding the subjection of the coil form to heat shocks and to excessive stresses and

2 strains. Preferably also the conducting areas on the coil form constitute end bands of such width as will be covered by a number of turns of bare wire of the size used, so as to secure rigid terminals of uniform and permanent electrical character. Preferably also the same metallic material is used for producing the conducting areas on the form and for bonding the winding to those areas, since such subsequent bonding may then be accomplished at a temperature lower than is required to produce the conducting areas with the metallic material then penetrating the coil form. After the winding is bonded to the conducting areas to form the coil terminals, it is preferable to adherently coat the terminals with highly conducting material to thereby increase the electric conductivity thereof.

In such coils, the coil form is preferably cylindrical so as to take advantage of the reduced cost of cutting the forms into lengths from a long tube. However, in case a spring terminal is required at one end of the coil to compensate for changes in dimensions in the device incorporating the coil, the form may have an integral cross wall to which the spring is riveted. In this latter case the outer face of the cross wall is likewise coated with adherent metallic material at the time the conducting areas are formed on the outer surface of the form, and the cross wall is likewise coated with the highly conductive material, to thereby produce a good electrical connection between the end of the coil winding and the spring.

Accordingly, one object of the invention is to provide methods of producing electric coils having rigid terminals which are smooth and of substantially uniform dimensions and of uniform and permanent electrical characteristics.

Another object is to provide such methods as are applicable to the rapid and uniform production in quantity of inexpensive coils of this kind.

These and other objects and advantages of the invention will be understood from the following description of two embodiments herein, using as examples ceramic coil forms and insulated wire, taken in conjunction with the accompanying drawings of which each is a central longitudinal section partly broken away near its middle portion. In the drawings:

Fig. 1 shows a cylindrical coil form; Fig. 2 shows the coil form of Fig. 1 after conducting bands of adherent metallic material are baked on each of its ends; Fig. 3 shows the coil form of Fig. 2 after there is wound thereon a coil of wire having an appropriate number of its turns

at each end bared for bonding to the conducting bands; Fig. 4 shows the coil of Fig. 3 after its completion, the end turns of the winding being connected to the conducting bands by means of adherent metallic material appropriately baked to mechanically and electrically secure the winding to the conducting bands to form rigid terminals therewith, and the terminals being covered with a layer of copper applied thereto by electrolytic deposition or spraying; Fig. 5 is an enlarged detail of a completed terminal of Fig. 4; and Fig. 6 shows a modified form of coil of this type provided with a spring terminal.

Referring to the embodiment of Figs. 1-5, the tubular coil form 1 consists preferably of suitable ceramic material as porcelain, such as that used in sparkplug insulators. Preferably, in order to reduce their cost, the forms are cut from long tubes while plastic before firing, the corners at 2 of each form being rounded off by turning or grinding. After the fired coil form, as shown in Fig. 1, is thoroughly cleansed with carbon tetrachloride to remove oil, grease and other foreign material therefrom, each of its ends is coated by stenciling or in any other suitable way, with a band of commercial metallic paint consisting of 90% silver and 10% platinum. Each band is of sufficient width to underlie about 10-15 turns of wire subsequently wound on the coil form almost from end to end thereof. These bands are then baked on the coil form by gradually raising its temperature in a furnace to a value between 1000° F. and 1100° F. during a period of about 3 to 5 minutes. Then the coil form is gradually cooled to room temperature. Thus in these steps of processing, the coil form is not subjected to such heat shock, either while the temperature is being increased or decreased, as might crack or break it or might produce such stresses and strains therein as would cause its fracture upon ordinary mechanical shocks or vibration, and the paint is baked into the exterior pores of the ceramic and completely around the coil form, and if desired around its end surfaces also, in sharply defined bands 3 of continuously conducting metal of substantially uniform width and thickness.

Instead of using porcelain, other heat-resistant coil forms, as steatite or glass-bonded mica may be used. Furthermore, the metallic band may be in the form of a paste and may contain pure silver or pure platinum or pure gold or other suitable adherent metallic materials including admixtures thereof such that after the baking operation there is no formation of metal oxide having a relatively high electrical resistance.

Having the finished coil form with conducting end bands thereon, as shown in Fig. 2, relatively small copper wire 4 of a B and S gage between No. 30 and No. 42 having a bare diameter of about 10 mils down to about 2.5 mils, is wound thereon substantially from end to end of the coil form as shown in Fig. 3. Preferably the wire is covered with a well known insulation which is a ceramic (inorganic) insulating coating on copper, nickel and other types of wire and which may contain resin and which is heat-resistant capable of withstanding without change a temperature of at least 600° F. Other insulation materials having suitable heat resisting characteristics may be used if desired. About 10 to 15 turns at each end of the winding 4 depending upon the size of wire making up about the width of the bands 3, are bared of its insulation in any suitable way as by scraping. The bare end turns 5 are then given a coating of paint, preferably

of the same composition as the adherent metallic material of the end bands 3. While these coated turns are held down tightly against the bands 3 by spring clips or tape, and the winding 4 on that portion of the coil form therebetween maintained tight, the wire-wound coil form is baked in a furnace at a gradually increasing temperature up to about 500° F. during a period of 3 to 5 minutes, and then gradually cooled, to bond the end turns 5 of the winding to the bands 3. The spring clips or tapes are then removed. This temperature of about 500° F., instead of the baking temperature of between 1000° F. and 1100° F. for the bands 3, suffices for the bonding operation between the end turns 5 and bands 3 because the first coating of paint requires a higher temperature for penetration of the ceramic while the second coating of paint does not require such penetration but merely a bond between two contact surfaces. Either before or after the wound coil form has its temperature from the second baking operation gradually reduced to the room temperature, a second and heavier coating 6 of the same paint may preferably be baked over the bonded end turns at a gradually rising temperature finally reaching about 500° F. after a period of 2 to 2½ hours. This additional coating assists in producing a terminal 7 in which the end turns are rigidly secured to the band in a bond of comparatively low electrical resistance capable of withstanding a temperature in service of at least 600° F. Whether or not the additional coating is applied, the terminals may then, if desired, be further covered by electrolytically plating them with copper, silver or other highly conducting metal 8 which does not melt at the temperature to which the coil is subjected in service, or by spraying them with suitable metal, to thereby further reduce the electrical resistance of the terminals. Whether or not the step of electrolytic deposition or spraying is used, each of the terminals 7 so produced is smooth all around its outer surface and of uniform dimensions, comprising a substantially continuous bond between 10-15 short-circuited end turns of the winding. Also, such terminals and windings made in quantity have substantially uniform electrical resistance and result in coils of substantially uniform distributed inductance and capacity. Also the terminals are mechanically rigid and not only are non-corroded when completed but do not corrode thereafter in such wise as would materially change the electrical resistance thereof. Furthermore, due to the gradual application of heat and gradual reduction in temperature, the coil form is not so apt to be cracked or broken under stresses and strains such as may result in fracture under ordinary mechanical shock or vibration in handling or service.

In the modification shown in Fig. 6, the coil form 9 has near one end an integral cross wall 10 which is perforated at 11, whereas the remainder of the coil form is tubular as before. The bond between the bared end turns of the winding and the end bands or conducting areas are formed as before, but the initial coating of adherent metallic material is extended over the inner surface at 12 of the coil form and also over the outer surface of the cross wall 10, to form a continuous conducting area at that end of the coil form. The spring 13 is electrically fastened to the coil form, preferably after the winding is secured in place, with its ends connected to the conducting area on the cross wall by a brass rivet 14. Such a coil, with a spring electrically connected to one

terminal thereof, is useful in mounting in devices, such as sparkplugs, having mounting dimensions which are variable within the compensation afforded by the spring 13. Obviously, this electric coil has the mechanical and electrical characteristics of the embodiment of Figs. 1-5.

It will be apparent that in either of the embodiments of Figs. 1-5 or Fig. 6, the wire of the coil may be bare instead of insulated, the turns then being maintained in spaced relation in the well known way as by forming in the coil form a helical groove in which the wire is wound. This and other changes and modifications may be made without departing from the spirit of the invention as embodied within the broad terms of the appended claims.

Having thus described our invention, what we claim is:

1. The method of making an electric coil having terminals and a heat-resistant inorganic coil form, which consists in spreading an adherent metallic material on separated areas on the coil form, heating the metallic material to a temperature at which it is baked on the coil form to produce conducting areas thereon, winding wire on the coil form over the conducting areas and the portion therebetween, covering at least a part of the surface of the bare end turns of the winding with a coating of an adherent metallic material, and baking the metallic material on the end turns while in contact with the conducting areas to thereby bond the metallic materials into coil terminals rigidly fastening the winding to the coil form.

2. The method of making an electric coil having terminals and a heat-resistant inorganic coil form, which consists in spreading an adherent metallic material on separated areas on the coil form, heating the metallic material to a temperature at which it is baked on the coil form to produce conducting areas thereon, winding wire on the coil form over the conducting areas and the portion therebetween, covering at least a part of the surface of the bare end turns of the winding with a coating of an adherent metallic material, baking the metallic material on the end turns while in contact with the conducting areas to thereby bond the metallic materials into coil terminals, spreading a layer of adherent metallic material over the coil terminals to embed the end turns, and baking said layer to bond it onto the terminals.

3. The method of making an electric coil having terminals and a heat-resistant inorganic form, which consists in forming bands of an adherent metallic material at the ends of the coil form, heating the metallic material to a temperature at which it is baked on the coil form to produce conducting bands thereon, winding wire on the coil form over the end bands and the portion therebetween, covering the entire surface of the bare end turns of the winding with a coating of an adherent metallic material, and baking the metallic material on the end turns while in contact with the conducting bands to thereby bond the metallic materials into coil terminals rigidly fastening the coil to the coil form.

4. The method of making an electric coil having terminals and a heat-resistant inorganic coil form, which consists in coating an adherent metallic material on separated areas on the coil form, heating the metallic material to a temperature at which it is baked on the coil form to produce conducting areas thereon, winding wire on the coil form over the conducting areas

and the portion therebetween, covering at least a part of the surface of the bare end turns of the winding with a coating of the same kind of adherent metallic material, and baking at a temperature substantially lower than the previous baking temperature the metallic material on the end turns while in contact with the conducting areas to thereby bond the metallic materials into heat-resistant non-corroded coil terminals rigidly fastening the coil to the coil form.

5. The method of making an electric coil having terminals and a heat-resistant inorganic coil form, which consists in spreading platinum-silver paint on separated areas on the coil form, heating the paint to a temperature between substantially 1000° F. and 1100° F. during a period of about 3 to 5 minutes to bake the paint on the coil form and produce conducting areas thereon, winding wire on the coil form over the conducting areas and the portion therebetween, covering at least a part of the surface of the bare end turns of the winding with a coating of platinum-silver paint, and baking the paint on the end turns while in contact with the conducting areas at a temperature of substantially 500° F. to thereby bond the metallic materials on the end turns and the conducting areas into coil terminals rigidly fastening the coil to the coil form.

6. The method of making an electric coil having terminals and a heat-resistant inorganic coil form, which consists in spreading platinum-silver paint on separate areas on the coil form, heating the paint to a temperature between substantially 1000° F. and 1100° F. during a period of about 3 to 5 minutes to bake the paint on the coil form and produce conducting areas thereon, winding wire on the coil form over the conducting areas and the portion therebetween, covering at least a part of the surface of the bare end turns of the winding with a coating of platinum-silver paint, baking the paint on the end turns while in contacts with the conducting areas at a temperature of substantially 500° F. during a period of about 3 to 5 minutes to thereby bond the metallic materials of the paint into coil terminals, spreading a layer of platinum-silver paint over the terminals, baking said layer at a temperature of substantially 500° F. for a period of about 2 to 2½ hours, and thereafter cooling the coil to thereby rigidly fasten the winding to the coil terminals.

7. The method of making an electric coil having terminals and a heat-resistant inorganic coil form, which consists in spreading an adherent metallic material on separated areas on the coil form, heating the metallic material to a temperature at which it is baked on the coil form to produce conducting areas thereon, winding wire on the coil form over the conducting areas and the portion therebetween covering at least a part of the surface of the bare end turns of the winding with a coating of an adherent metallic material, baking the metallic material on the end turns while in contact with the conducting areas to thereby bond the metallic material into terminals rigidly fastening the winding to the coil form, and adherently coating a layer of highly conductive material on the terminals to increase the conductivity thereof.

8. The method of making an electric coil having terminals and a heat-resistant inorganic coil form, which consists in forming bands of an adherent metallic material near the ends of the coil form, heating the metallic material to a temperature at which it is baked on the coil form to

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produce conducting bands thereon, winding heat-resistant insulated wire on the coil form over the conducting bands and the portion therebetween, baring the end turns of the winding of the insulation thereon, covering at least a part of the surface of the bare end turns of the coil with an adherent metallic material, baking the metallic material on the end turns while in contact with the conducting bands to thereby bond the metallic materials into coil terminals rigidly fastening the coil to the coil form, and depositing a coating of conducting material thereover by electrolytically plating the terminals with high conductive material to increase the conductivity thereof.

9. The method of making an electric coil having one rigid terminal and one resilient terminal and also having a heat-resistant inorganic coil form of tubular section with an inner cross wall, which consists in spreading an adherent metallic material near one end of the coil form and also spreading adherent metallic material in a continuous mass over the other end of the coil form and over the cross wall, heating the metallic material to a temperature at which it is baked

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on the coil form to produce conducting areas thereon, winding wire over the outer surface of the coil form and over the conducting areas and the portion therebetween, covering at least a part of the surface of the bare end turns of the winding with a coating of an adherent metallic material, baking the metallic material on the end turns while in contact with the conducting areas to thereby bond the metallic materials into coil terminals rigidly fastening the coil to the coil form, and fastening a resilient terminal to the cross wall in contact with the conducting area thereon.

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