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G. GÄRTNER ET AL

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METHOD OF FORMING A METALIZED ARTICLE

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FIG. 1

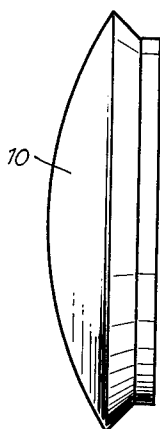


FIG. 2

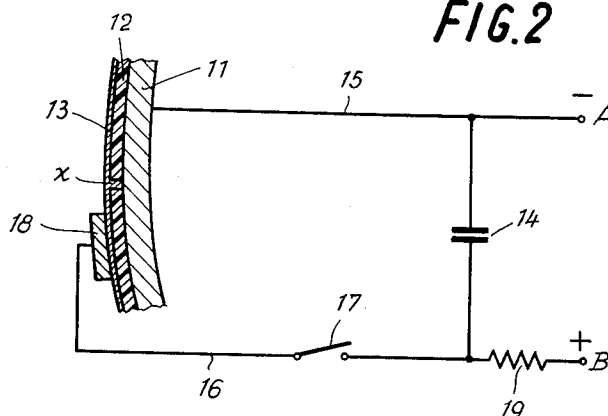
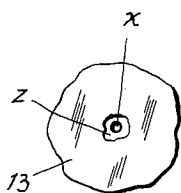


FIG. 3



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METHOD OF FORMING A METALIZED ARTICLE
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The present invention refers to forming and treating metalized articles, more particularly of such articles which essentially consist of a metal object covered by a basic insulating coating and a thin metal layer applied to the outside of such insulating coating. After forming and treating the metalized articles the outside of the thin metal layer may be covered by a protective insulating coating.

This application is a continuation-in-part of our copending application, Serial No. 733,954, filed May 8, 1958, for "Method of Forming a Metalized Article," now abandoned.

Insulating coatings of the type referred to usually consist of baked enamels or lacquers which may have a thickness of 10-20 μ and are supposed to cover or coat the entire surface of the metal article which is exposed to sight or outside influences. The thickness of the insulating layer may however be slightly below or above the just-mentioned dimensions which does not affect the method according to this invention.

Mainly for decorative purposes a thin metal layer is applied to the outside surface of this insulating coating, preferably by means of the generally known vapor deposition which process creates a layer of a thickness in the neighborhood of .1 μ but may of course vary to dimensions somewhat above and below this dimension. Metals usable for this vapor deposition process are for instance aluminum, zinc and even precious metals.

It has been found that lacquers or enamels which are usually baked at temperatures approximately between 180° and 200° C. usually do not result in a completely continuous coat. As a matter of fact, usually very small cracks or pores develop in the baked coating, also due to internal tensions the coating sometimes withdraws slightly from the edges of the particular metal object. A suitable material for these coatings are for instance melamine-alkyd-resin lacquers, also epoxy-resin lacquers and mixtures thereof. The metal object to which the above mentioned insulating coating is applied may be practically of any type, usually articles of the type to which this method refers are basically made of iron, steel, brass or similar industrial materials.

It has been found by experience, that particularly in all those cases where the outside metal layer is applied in a fine distribution of metal as for instance in the vapor deposition process small amounts of the metal of the outside layer penetrate through any existing crack or opening in the insulating layer so as to establish conductive bridges, constituting a resistance of only 0.1 ohm or even less, between the outside layer and the metal object underneath the lacquer or insulating layer. Since in most cases the metal of the outside layer will be different from that of the basic material of the metal object, and also for other reasons, a deterioration in appearance or a complete corrosion of the outside metal layer or of the metal object, or both, takes place, caused by electrical current flowing over the above mentioned small bridges connecting the outside layer with the metal object. It should be noted that in some cases the bridging connections between the outside layer and the metal object are not only due to openings in the insulating layer filled with metal of the top layer material, but sometimes small loose metal particles may be resting on the surface of

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the metal object when the insulating lacquer layer is applied so that they are imbedded in the lacquer layer and likewise constitute a conductive bridge between the outside metal layer and the metal object, resulting in the same type of corrosion effect as was described above.

It is a main object of the present invention to provide for a method of preventing such corrosion effects by suitably treating the metal article before applying the protective layer on the thin metal layer.

It is a further object of this invention to provide a method of increasing the total resistance across the cracks or pores of the insulating layer to more than 10⁷ ohms so as to eliminate the possibility of creep currents between the outer metal layer and the metal object.

It is another object of this invention to provide for a method as set forth above, which method is extremely simple and comparatively inexpensive.

With the above objects in view the method according to the present invention mainly consists in removing metallic bridges of small cross-sectional area and extending transversely across an insulating layer between a metallic layer and a metal object so as to conductively connect the latter, the method comprising the step of passing an electric current under the action of a predetermined potential between said metal layer and the metal object through the metallic bridges existing therebetween so that the metallic bridges are destroyed by the development of resistance heat therein, thus electrically separating the metal layer from the metal object, whereby corrosion of the metallic layer or of the metal object, or of both, which otherwise would be due to the existence of these bridges, is prevented.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

FIGURE 1 is a lateral elevation of a metal article for instance a hub cap for a vehicle wheel, treated according to the present method;

FIGURE 2 is a partial section through a portion of an article like the hub cap of FIGURE 1, at a larger scale, and includes a circuit diagram for illustrating the method; and

FIGURE 3 is a fractional plan view at a still larger scale showing a defective portion of the insulating layer after the treatment according to the present method.

Referring now to FIGURE 1, it may be assumed that a hub cap 10 is formed of sheet metal, for instance iron. The entire outside surface of this article has been provided by dipping with a coating layer of 15 μ thickness consisting of a melamine-alkyd-resin lacquer which has been baked, whereafter a layer of aluminum in a thickness of .1 μ has been applied to the lacquer layer by vapor deposition. In FIGURE 2 the metal object is indicated by 11, the lacquer layer by 12 and the outside metal layer by 13. It can be seen that in the lacquer layer 12 exists a small hole or gap x which has been filled with a portion of the metal constituting the outside layer 13. Thus a conductive connection is established between the metal layer 13 and the metal object 11.

In order to remove the detrimental effects of the existence of the bridging connection through the hole x and thereby to prevent future corrosion according to this invention, an electric current is caused to pass through the bridge i.e., the metallic connection between the layer 13 and the metal object 11. Since for obvious reasons the cross-section area of the bridge is very small the resistance of this bridge can be used by application of the

proper amount of current and the proper potential to develop resistance heat to a sufficient degree for destroying the bridge entirely.

For doing this the metal object 11 is connected by a conductor 15 to the terminal A, and the layer 13 is connected by a conductor 16 to a terminal B of a source of electric energy. A switch 17 may be provided for starting or terminating the operation.

There are various ways of applying the required current to the double coated article. It has been found that the best and most reliable method consists of three subsequent steps of applying currents of respectively different characteristics. However, in certain cases the third step may be omitted, particularly if it is deemed sufficient, in view of the character and intended use of the particular article treated by this method, to raise the total resistance across cracks or pores of the insulating layer to a value in the order of 10^7 ohms only.

Experiments have shown that from the outset damage to the extremely thin outer metal layer 13 (having a thickness in the order of 0.1μ) through the conductive connection thereof with the conductor 16 must be avoided in order not to affect the desired finished appearance of the article. It is obvious that a mechanical injury to the metal layer must be prevented by using utmost care and a contact member 18 of substantial contact area and substantial thermal capacity. Above all, it must be prevented that the current passing from the conductor 16 or contact member 18 burns and destroys the layer 13 itself in the contact area instead of, or in addition to, eliminating the conductive bridges between the layer 13 and the object 11.

Therefore, according to the invention, the first step consists in the application of a current of great intensity for a very brief period of time. As a contact member 18 a pad of soft metal foil having good thermal conductivity and capacity and approximately .080" thickness is pressed by any conventional means against the surface of the metal layer 13.

As illustrated by FIGURE 2, a condenser 14 is arranged between the conductors 15 and 16 and charged, while the switch 17 is in open position, to a sufficient extent so that when the switch 17 thereafter is closed a sudden discharge of the condenser 14 causes a short-timed flow of current of substantial magnitude through any bridge connection x that may exist in the lacquer layer 13 so that these bridge connections are burned and destroyed. It has been found that for instance charging the condenser having a capacity of $16\mu\text{f.}$ to a charge potential of 100 volts will result in a discharge of sufficient power for destroying most of the bridge connections in an article of the type described, at least all those bridge connections which have a comparatively large cross-sectional area and therefore a comparatively low resistance between layers 11 and 13 in the order of 0.1 ohm.

Of course, the conditions may cause the condenser capacity and its charge voltage to be chosen differently. This may depend on a variance of the resistance of the conductive bridges, the configuration or shape of the article to be treated, the surface characteristics and area of the portion 11 of the article, and the quality and thickness of the insulating layer 12. For instance, if the article to be treated is comparatively small and of simple shape, a condenser 14 of only $4\mu\text{f.}$ may be sufficient which is charged by direct current of only 50 volts, while in the case of rather large objects larger condensers having a capacity of $32\mu\text{f.}$ and charged with 120 volts may have to be used.

It can be seen that it is quite impossible to set fixed limits for the required capacity of the condenser and for its charge voltage as well as for the amperage of the current furnished by the discharge of the condenser, so as to fit all possible operating conditions. Moreover, the amperage of the discharge current does not depend solely on the charge and capacity of the condenser, but

also on the number and magnitude of the conductive bridges existing between the metal layer 13 and the object 11, as well as on the inner structure of the condenser and the inductivity of the connecting conductors 15, 16 and the like.

However, as a guide for the user of this invention, it can be stated that e.g. the use of a $16\mu\text{f.}$ condenser charged to 100 volts in this first step of the method discharge currents in the order of over 100 amperes flowing for a period of 10^{-5} seconds can be expected which are sufficient to cause evaporation of the conductive bridges between layer 13 and object 11. By all means it is necessary to arrange matters so that currents of over 100 amperes are caused to flow for a period of about 10^{-5} seconds in the first step of the method. This explains why in the first step only currents resulting from a condenser discharge can be taken into consideration.

It has been found that the metal vapor developing from the material of the conductive bridges between the metal layer 13 and the object 11 does not disappear completely from the sites of these bridges, but at least partially condenses after the end of the condenser discharge and thus forms new conductive bridges although of substantially higher resistance. Experiments have indicated that where the original resistance of the conductive bridges was up to 0.1 ohm, this resistance was increased after the first step to about 100 to 200 ohms. This is still far below the desired increase to over 10^7 ohms.

Therefore, it is possible and advisable to remove these bridges of reduced cross-section and somewhat increased resistance by applying a direct current whilst the condenser 14 is disconnected preferably across a current limiting series-resistance 19, through the circuit in which case currents from 0.1 to one ampere are caused to flow through the bridging connections while the voltage is raised for instance up to 60 volts, in which case those bridge connections having the above mentioned increased resistance are destroyed. After about 1 second maximum even at a voltage between 40 and 60 volts no current will flow any more through the circuit.

By this second step the resistance of the conductive bridges is increased to 1-10 megohm. It is to be noted that the application of a voltage of more than 60 volts in this step is not advisable because it may entail the risk of damaging the decorative metal layer 13 by providing a steady high-amperage arc between the layer 13 and the object 11. Also, it is advisable in the first and second steps of this method to connect the negative pole of the source of direct current to the object 11 because in this case, as has been found, the spots where the conductive bridges have been eliminated are even less noticeable on the outer metal layer 11 than it would be the case with reversed polarities.

Finally, in order to raise the resistance between the outside metal layer 13 and the object 11 to the optimal values over 10^7 ohms, the invention provides a third step consisting in the application of an alternating current weaker than that in the second step but at a voltage higher than that in the second step. This is done by applying a current operating at 50 to 100 cycles per second while the voltage may be 100 to 160 volts. In this case even the smallest bridge connections of highest resistance are destroyed. The current in the last mentioned case in which alternating current is applied should be limited to approximately 1 ma. or less. A duration of this current application of 1 second is usually sufficient.

Experiments have shown that after this third step the total resistance between the layer 13 and the object 11 is in the order of more than 10^7 ohms because now practically the last traces of metal have been eliminated from the insulating layer 12.

It should be noted that the above given figures are not the absolute maxima and minima but can be somewhat

reduced or increased although it has been found that

values as mentioned give most satisfactory results in ordinary cases.

Summing up it may be stated that the purpose of eliminating existing conductive bridges between an extremely thin decorative outer metal layer and a metal object, across an insulating layer therebetween can be achieved only by first destroying those conductive bridges which constitute a comparatively low resistance. This requires, if damage to the decorative layer is to be avoided, the application of a brief high-amperage condenser discharge. If, on the other hand, as a first step, instead of the condenser discharge a direct current would be passed between the layer 13 and the object 11, the layer 13 would be burned away at the area of contact with the member 18 instead of the conductive bridges because in this case the difference between the thermal capacity of the contact member 18 and that of the metal forming the bridge would not come into play favorably as is the case if a condenser discharge is used. Therefore, any application of direct current must follow only after the application of the condenser discharge.

It should be understood that the third step may be omitted when circumstances permit to terminate the process when the total resistance between layer 13 and object 11 is raised to only about 10^7 ohms. However, it would be unadvisable to follow the condenser discharge with the application of alternating current as described for the third step. This is due to the fact that by using an alternating current of the above mentioned value of about 1 ampere as specified for the second step the decorative layer would be impaired by unsightly spots because the above mentioned condition of applying negative potential to the object 11 and positive potential to the layer 13 cannot be met. However, this danger does not exist if the alternating current is applied only in the third step after the preceding first and second steps. In this manner the importance of the particular sequence of the different steps of the method according to the invention is supported by the fact that the desired result with exclusion of the above mentioned undesirable effects will be obtained only by this sequence.

For further guidance of the user of this invention the following information is furnished. The use of a 16 μ f. condenser with a charge of 100 volts has been found satisfactory for treating a hub cap of about 93 in.² metalized surface area. On the other hand, for parts having a metalized surface of only about .3 to .5 in.² a small condenser of 4 μ f. may be sufficient, because for obvious reasons in that smaller area only a smaller number of conductive bridges can be expected. The charge can in this case be reduced from 100 volts to say 50 volts. At any rate, some experimentation will be advisable in all cases for establishing the desirable and suitable values for the condenser and its charge.

Moreover, if the metalized area of the object is smooth, flat or only slightly curved, the number of conductive metallic bridges will be comparatively small. For instance, on the surface of a hub cap as described by way of example and illustrated by FIGS. 1 and 2, there may be only 3-5 such bridges because the insulating layer 12, when applied, is formed under favorable conditions. The situation is critically different if the object has sharp bends or corners in the metalized area. The surface tension in the lacquer or similar coating 12 causes at such points or edges a substantial contraction so that the layer 12 is much thinner in these areas than in the adjoining areas of the surface of the object, in extreme cases there may be practically no coating at all of such points or edges. In such cases, the total sum of conductive bridges is very great, and they may even appear as an almost continuous row along a sharp bend or edge. In such cases, the electrical data must be adjusted experimentally to the actual conditions.

FIGURE 3 illustrates the effect of the method. It can be seen that the application of electrical current of suitable

strength at a suitable predetermined potential has removed entirely the metal bridge and leaves an open hole x. At the same time usually a small portion of the outside metal layer 13 is also destroyed leaving a slightly larger opening 2 in the layer 13, surrounding the hole x. In this manner any conductive connection between the outside layer 13 and the metal object 11 is safely removed so that the corrosion effect discussed at the outset cannot take place. It should be noted that the dimensions of the holes or pores are so minute that they are not visible to the naked eye and that the general appearance of the coated and metalized article is in no way impaired by the treatment according to this method.

It is advisable to subject the finished metal article, subsequent to the above described removal of the metallic bridge connections, to an insulation test i.e., to a test establishing whether there is any conductivity left between the outside metal layer and the metal object. Finally, it is good practice to apply to the finished articles a further protective layer consisting of some transparent lacquer or the like.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of methods forming a metalized article differing from the types described above.

While the invention has been illustrated and described as embodied in a method of removing metallic bridges extending through an insulating layer between a metallic layer and a metal object, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. Method of forming a decoratively metalized article, comprising the steps of applying to the surface of a metal object an insulating coating having an undetermined number of small openings passing therethrough; applying metal to the outer face of said insulating coating so as to form a thin decorative metal layer thereon, said metal during its application penetrating said openings and forming thereby metallic conductive bridges of small cross-sectional area between said metal layer and the metal object; and passing in consecutive steps electric currents of different predetermined strengths and characteristics and under the action of respectively different predetermined potentials for respectively different predetermined periods of time through said bridges between said metal layer and the metal object in such a manner that said metallic bridges are destroyed by development of resistance heat therein, thus increasing the electrical resistance between said metal layer and the metal object to a value in the order of at least 10^7 ohms, thereby preventing subsequent corrosion of said decorative metal layer, and finishing the article by applying a protective insulating coating on the outside of the metal layer.

2. Method of removing metallic bridges having small cross-sectional area and extending between a thin decorative metallic layer and a metal object transversely across a thin insulating layer therebetween and thereby conductively connecting said metal layer and said metal object with comparatively low resistance, comprising the steps of passing sequentially electric currents of different predetermined strengths and characteristics under the action of respectively different predetermined potentials

for respectively different predetermined periods of time between said metal layer and said metal object through said metallic bridges existing therebetween in such a manner that the resistance between said metal layer and said metal object is stepwise increased to a value of the order of at least 10^5 – 10^7 ohms by destruction of said bridges through development of resistance heat therein, thus electrically separating said metal layer from said metal object whereby subsequent corrosion of said metal layer is prevented.

3. Method of removing metallic bridges having small cross-sectional area and extending between a thin decorative metallic layer and a metal object transversely across a thin insulating layer therebetween and thereby conductively connecting said metal layer and said metal object with comparatively low resistance, comprising the steps of passing between said metal layer and said metal object through said metallic bridges existing therebetween first a short-timed electrical current derived from the discharge of a condenser under action of a charge sufficient to furnish a discharge current capable of destroying said bridges to the extent that the resistance between said metal layer and said metal object is increased to values between 100 and 200 ohms; thereafter passing through said bridges between said metal layer and said metal object a direct current of between .1 and one ampere under the action of a voltage of up to 60 volts for a duration of up to 1 second for removing remnants of said bridges and for further increasing the resistance between said metal layer and said metal object to values between 1 and 10 megohms, thus electrically separating said metal layer from said metal object whereby subsequent corrosion of said metal layer is prevented.

4. A method as claimed in claim 3, wherein said insulating coating has a thickness in the order of 15μ and the resistance between said metal layer and said metal object is originally of the order of .1 ohm, and wherein said condenser discharge is derived from a condenser capacity of the order of 16 μ f. charged to a potential of the order of 100 volts resulting in the flow of a discharge current in the order of 100 amperes for a time period of about 10^{-5} seconds.

5. A method as claimed in claim 3, wherein said insulating coating has a thickness in the order of 15μ and the resistance between said metal layer and said metal object is originally of the order below 1 ohm, and wherein said condenser discharge is derived from a condenser capacity of the order of 4 μ f. charged to a potential of the order of 50 volts resulting in the flow of a discharge current in the order of 100 amperes for a time period of about 10^{-5} seconds.

6. A method as claimed in claim 3, wherein the negative polarity of the condenser potential and of the source of direct current is applied to the metal object, and the positive polarity to the metallic layer.

7. A method as claimed in claim 2, wherein a first of said passes consists in the discharge of a condenser, and a second pass consists in the flow of a direct current from a direct current source.

8. A method as claimed in claim 2, wherein the first of said passes consists in the discharge of a condenser, another pass consists in the flow of direct-current from a direct-current source, and a further pass consists in the flow of alternating current from an alternating-current source.

9. Method of forming a decoratively metalized article, comprising the steps of applying to the surface of a metal object a thin insulating coating having an undetermined number of small openings passing therethrough; applying metal to the outer face of said insulating coating so as to form a thin decorative metal layer thereon, said metal during its application penetrating said openings and forming thereby metallic conductive bridges of small cross-sectional area between said metal layer and the metal object, the resistance between said metal layer and

the metal object being comparatively low; passing between said metal layer and said metal object through said bridges first a short-timed electrical current derived from the discharge of a condenser under action of a charge sufficient to furnish a discharge current capable of destroying said bridges to the extent that the resistance between said metal layer and said metal object is increased to values between 100 and 200 ohms; thereafter passing through said bridges between said metal layer and said metal object a direct current of between .1 and 1 ampere under the action of a voltage of up to 60 volts for a duration of up to 1 second for removing remnants of said bridges and for further increasing the resistance between said metal layer and said metal object to values between 1 and 10 megohms, and subsequently passing through final remainders of said bridges an alternating current of up to 1 mamp. at a frequency of the order of 50 to 100 cycles per second at a voltage of the order of 100 to 160 volts for a period of time in the order of one second for further increasing the total resistance between the metal layer and the metal object to over 10^7 ohms, thus electrically separating said metal layer from said metal object whereby subsequent corrosion of said metal layer is prevented; and finishing the article by applying a protective insulating coating on the outside of the metal layer.

10. Method of forming a decoratively metalized article, comprising the steps of applying to the surface of a metal object a thin insulating coating having a thickness in the order of 15μ and having an undetermined number of small openings passing therethrough; applying metal to the outer face of said insulating coating so as to form a thin decorative metal layer thereon, said metal during its application penetrating said openings and forming thereby metallic conductive bridges of small cross-sectional area between said metal layer and the metal object, the resistance between said metal layer and the metal object being originally of the order of .1 ohm; passing between said metal layer and said metal object through said bridges first a short-timed electrical current derived from the discharge of a condenser having a capacity of the order of 16 μ f. under action of a charge potential of the order of 100 volts resulting in the flow of a discharge current in the order of 100 amperes for a time period of about 10^{-5} seconds capable of destroying said bridges to the extent that the resistance between said metal layer and said metal object is increased to values between 100 and 200 ohms; thereafter passing through said bridges between said metal layer and said metal object a direct current of between .1 and 1 ampere under the action of a voltage of up to 60 volts for a duration of up to 1 second for removing remnants of said bridges and for further increasing the resistance between said metal layer and said metal object to values between 1 and 10 megohms, and subsequently passing through final remainders of said bridges an alternating current of up to 1 mamp. at a frequency of the order of 50 to 100 cycles per second at a voltage of the order of 100 to 160 volts for a period of time in the order of one second for further increasing the total resistance between the metal layer and the metal object to over 10^7 ohms, thus electrically separating said metal layer from said metal object whereby subsequent corrosion of said metal layer is prevented; and finishing the article by applying a protective insulating coating on the outside of the metal layer.

11. Method of forming a decoratively metalized article, comprising the steps of applying to the surface of a metal object a thin insulating coating having a thickness in the order of 15μ and having an undetermined number of small openings passing therethrough; applying metal to the outer face of said insulating coating so as to form a thin decorative metal layer thereon, said metal during its application penetrating said openings and forming thereby metallic conductive bridges of small

cross-sectional area between said metal layer and the metal object, the resistance between said metal layer and the metal object being originally of the order of below 1 ohm; passing between said metal layer and said metal object through said bridges first a short-timed electrical current derived from the discharge of a condenser having a capacity of the order of 4 μ f. under action of a charge potential of the order of 50 volts resulting in the flow of a discharge current in the order of 100 amperes for a time period of about 10^{-5} seconds capable of destroying said bridges to the extent that the resistance between said metal layer and said metal object is increased to values between 100 and 200 ohms; thereafter passing through said bridges between said metal layer and said metal object a direct current of between .1 and 1 ampere under the action of a voltage of up to 60 volts for a duration of up to 1 second for removing remnants of said bridges and for further increasing the resistance between said metal layer and said metal object to values between 1 and 10 megohms, and subsequently passing through final remainders of said bridges an alternating current of up to 1 mamp. at a frequency of the order of 50 to 100 cycles per second at a voltage of the order of 100 to 160 volts for a period of time in the order of one second for further increasing the total resistance between the metal layer and the metal object to over 10^7 ohms, thus electrically separating said metal layer from said metal object whereby subsequent corrosion of said metal layer is prevented; and finishing the article by applying a protective insulating coating on the outside of the metal layer.

12. Method of forming a decoratively metalized article, comprising the steps of applying to the surface of a metal object a thin insulating coating having an undetermined number of small openings passing there- through; applying metal to the outer face of said insulating coating so as to form a thin decorative metal layer thereon, said metal during its application penetrating said openings and forming thereby metallic conductive bridges of small cross-sectional area between said metal layer

and the metal object, the resistance between said metal layer and the metal object being comparatively low; passing between said metal layer and said metal object through said bridges first a short-timed electrical current derived from the discharge of a condenser under action of a charge sufficient to furnish a discharge current capable of destroying said bridges to the extent that the resistance between said metal layer and said metal object is increased to values between 100 and 200 ohms, the negative condenser potential being applied to the metal object, the positive potential to the metal layer; thereafter passing through said bridges between said metal layer and said metal object a direct current of between .1 and 1 ampere under the action of a voltage of up to 60 volts for a duration of up to 1 second, with the positive potential applied to the metal layer, the negative potential to the metal object, for removing remnants of said bridges and for further increasing the resistance between said metal layer and said metal object to values between 1 and 10 megohms, and subsequently passing through final remainders of said bridges an alternating current of up to 1 mamp. at a frequency of the order of 50 to 100 cycles per second at a voltage of the order of 100 to 160 volts for a period of time in the order of one second for further increasing the total resistance between the metal layer and the metal object to over 10^7 ohms, thus electrically separating said metal layer from said metal object whereby subsequent corrosion of said metal layer is prevented; and finishing the article by applying a protective insulating coating on the outside of the metal layer.

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