Sept. 28, 1954 G. GUTZEIT ET AL 2,690,401

CHEMICAL NICKEL PLATING ON NONMETALLIC MATERIALS

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Fig. 2

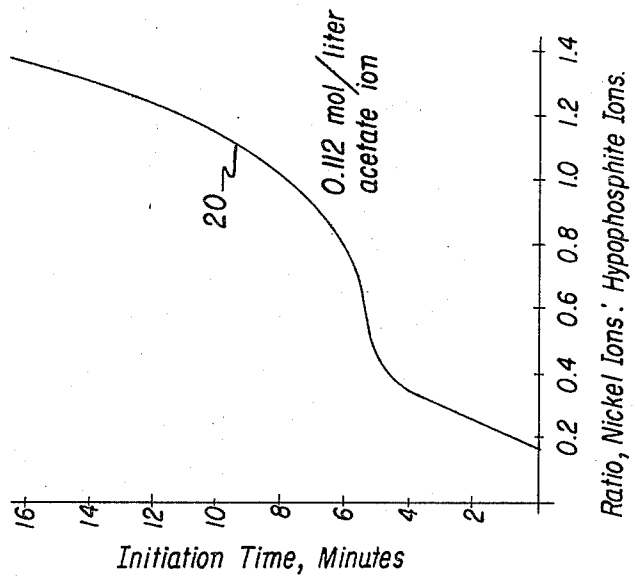
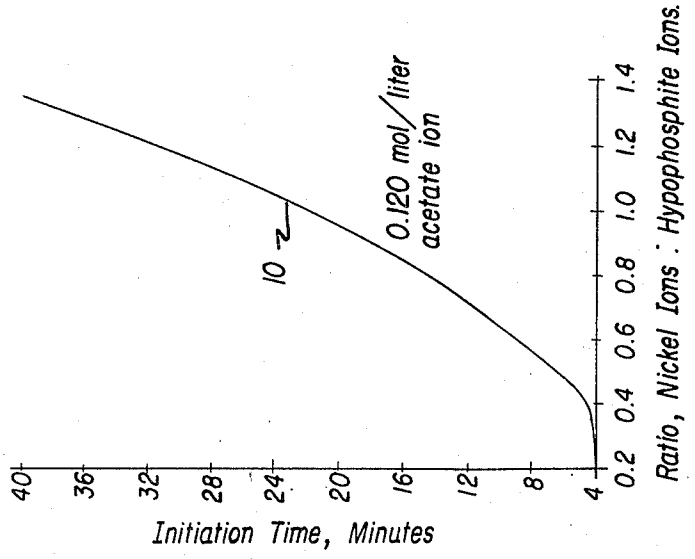


Fig. 1



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CHEMICAL NICKEL PLATING ON NON-METALLIC MATERIALS

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9 Claims. (Cl. 117—47)

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The present invention relates to processes of chemical nickel plating of non-conductive and non-catalytic solid materials and to methods of preparing the surfaces of such materials so that a homogeneous and adherent film of nickel may be chemically deposited thereon.

In the copending application of Gregoire Gutzeit and Abraham Krieg, Serial No. 194,656, filed November 8, 1950, now Patent No. 2,658,841, granted November 10, 1953, there is disclosed a process of chemically plating with nickel, metals and other catalytic materials, by contacting the materials with an acid bath containing nickel ions and hypophosphite ions and a buffer. This process is carried on under certain optimum conditions, which are as follows:

The ratio between nickel ions and hypophosphite ions in the bath, expressed in molar concentrations, is within the range from 0.25 to 0.60; the absolute concentration of hypophosphite ions in the bath expressed in mole/liter, is within the range from 0.15 to 0.35; the absolute concentration of the buffer in the bath is approximately equivalent to two carboxyl groups for every nickel ion that can be deposited, for instance, in the case of sodium acetate, 0.120 mole/liter of acetate ion; the initial pH of the bath is within the approximate range from 4.5 to 5.6; the temperature of the bath is slightly below the boiling point thereof, about 98° centigrade; and the ratio between the volume of the bath, expressed in cubic centimetres ($cm.^3$), and the surface area of the material that is to be plated expressed in square centimetres ($cm.^2$), (V/A), is not greater than 10. The buffers mentioned in that application and employed in the tests therein referred to are soluble salts of simple short chain aliphatic monocarboxylic acids with an ionization constant pKa, higher than 4.7; such as, acetic acid, butyric acid, propionic acid, etc.

In the copending application of Gregoire Gutzeit and Ernest J. Ramirez, Serial No. 204,424, filed January 4, 1951, now Patent No. 2,658,842, granted November 10, 1953, there is disclosed a process of chemically plating with nickel, metals and other catalytic materials, by contacting the materials with an acid bath containing nickel ions and hypophosphite ions and an exaltant. This process is carried on under certain optimum conditions, which are as follows:

The ratio between nickel ions and hypophosphite ions in the bath, expressed in molar concentrations, is within the range from 0.25 to 1.60; the absolute concentration of hypophosphite ions in the bath, expressed in moles/liter, is within the

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range 0.15 to 1.20; the absolute concentration of the exaltant in the bath is approximately equivalent to two carboxyl groups for every nickel ion that can be deposited, for instance, in the case of sodium succinate, at least 0.05 mole/liter of succinate ion; the initial pH of the bath is within the approximate range 4.3 to 6.8; the temperature of the bath is slightly below the boiling point thereof, about 99° centigrade; and the ratio between the volume of the bath, expressed in $cm.^3$, and the surface area of the material that is to be plated, expressed in $cm.^2$, (V/A), is not greater than 10. The exaltants mentioned in this last mentioned application and employed in the tests therein referred to are soluble salts of simple short chain aliphatic dicarboxylic acids with an ionization constant pK_2 higher than 5.4; such as malonic acid, succinic acid, glutaric acid, etc.

In the applications referred to, it was pointed out that the catalytic materials that could be plated with nickel employing the baths and processes set forth were materials which cause the plating reaction:

(1)
$$2(H_2PO_2)^- + 2HOH + Ni^{++} \xrightarrow[\text{surf.}]{\text{cat.}} 2(HPO_3)^{--} + Ni^\circ + H_2\uparrow$$

For instance, using nickel chloride to provide the nickel ion and sodium hypophosphite to provide the hypophosphite ion:

(2)
$$2Na(H_2PO_2) + 2H_2O + NiCl_2 \xrightarrow[\text{surf.}]{\text{cat.}} 2NaH(HPO_3) + Ni + 2HCl + H_2\uparrow$$

In other words, materials that catalyze the oxidation of the hypophosphite ion to the phosphite ion, while reducing water to atomic hydrogen, and, at the same time, promoting the formation of molecular hydrogen comprise catalytic materials. This reaction can be ascertained by observing and measuring the volume of hydrogen gas evolved in an aqueous solution of a soluble hypophosphite upon addition of the catalytic material, preferably at the highest possible temperature below the boiling point of the solution. The following elements are catalytic: Cu, Ag, Au, Be, B, Ge, Al, Tl, Si, C, V, Mo, W, Cr, Se, Te, Ti, Fe, Co, Ni, Pd and Pt; and the following elements are definitely noncatalytic: Bi, Cd, Sn, Pb and Mn.

Nonconductive and noncatalytic materials, such as plastics, hard rubber, wood, ceramics, etc,, do not cause the plating reactions (1) and (2); and thus cannot be plated with nickel directly in accordance with the processes set forth in the applications mentioned.

Accordingly, it is the general object of the present invention to provide a process of chemical plating with nickel the surfaces of non-conductive and non-catalytic materials, such as plastics, hard rubber, wood, ceramics, etc.

Another object of the invention is to provide a method of preparing the surface of a non-conductive and non-catalytic material of the character mentioned so that it may be chemically plated with nickel.

A further object of the invention is to provide a method of preparing the surface of a non-conductive and non-catalytic material so that it may be chemically plated with nickel employing substantially the improved processes described in the applications mentioned above.

These and other objects and advantages of the present invention will be understood from the foregoing and the following description taken with the accompanying drawings, in which:

Figure 1 shows the variations in the initiation time interval of nickel plating upon prepared non-catalytic samples with variations in ratios of nickel ions to hypophosphite ions in the chemical nickel plating baths containing sodium salts; and

Fig. 2 shows the variations in the initiation time interval of nickel plating upon prepared non-catalytic samples with variations in ratios of nickel ions to hypophosphite ions in chemical nickel plating baths containing calcium salts.

In accordance with the present invention, in order to obtain nickel chemical plating of non-conductive and non-catalytic materials, such as plastics, hard rubber, wood, ceramics, etc., it is necessary first to prepare or condition the surface of the material prior to contacting it with the chemical nickel plating bath. More particularly, the surface of the material is modified so as to form thereon firmly anchored growth nuclei. It is not necessary to achieve a complete coverage of the surface of the material with the growth nuclei, as the nickel plating will spread for a certain distance from each growth nucleus in the two dimensions along the surface of the material as it builds up in the third dimension upon the growth nucleus, thereby obtaining ultimately a complete and homogeneous coating of nickel upon the surface of the material. Also, the surface of the material is modified to eliminate polarization of the areas between the growth nuclei by effecting the presentation in these areas of a fresh surface.

In one form of the method, the surface of a nonconductive and noncatalytic material of the character referred to may be prepared for chemical nickel plating by freshening and contaminating it with traces of a catalyst in such a manner that the catalytic particles are securely anchored in place upon the freshened surface. By simply dusting the surface with a finely divided catalytic powder, such as aluminum, carbon, etc., a coating is provided so that nonconductive and noncatalytic material of the character mentioned is prepared for chemical nickel plating. However, in order to obtain good adhesion of the subsequently deposited nickel to the material, the catalyst must be firmly anchored to the surface of the material and the surface of the material must be fresh; whereby as many growth nuclei as possible are securely anchored to the surface of the material, and the noncatalytic areas on the surface of the material are not polarized. These conditions may ordinarily be obtained by removing the surface skin of the material as the catalyst is embebbed in the freshly presented surface of the material. While the catalytic powder may take the form of any one or combination of the catalytic elements previously mentioned, from a practical standpoint nickel, copper, cobalt, carbon and aluminum, as well as the alloys brass and bronze, have been found to be most useful. Specifically, beryllium cannot be used in the presence of an acetate buffer in the nickel plating bath as an insoluble acetate is formed; iron has a tendency to rust rapidly, gold and silver are too expensive, etc.

In another form of the method where an artificial or compounded non-conductive and non-catalytic material is produced by forming, molding or casting, the catalyst may be mixed with the basic material prior to forming, etc. As only the amount of catalyst present at the surface of the formed material is useful, enough catalyst should be added to the basic material initially to provide adequate growth nuclei at the boundary or surface of the formed material. The formed material is subsequently prepared by sanding, blasting, brushing, tumbling, chemical etching, etc., to expose a fresh surface thereon prior to being subjected to the nickel plating bath. For instance, by compounding a thermosetting plastic molding powder (e. g. Bakelite), with 5% aluminum powder, by weight, molding the compound under heat and pressure, then subjecting the article thus formed of the compound to a fine abrading action by liquid honing in order to prepare the surface thereof, and, finally, chemically nickel plating the prepared surface of the article, an excellent adherent and continuous nickel coating may be obtained.

A further form of the method is generally applicable to most non-conductive and non-catalytic materials, and comprises employing mechanical pressure to incorporate the catalyst into the surface of the material while simultaneously freshening the surface of the material. This can be achieved by such operations as wet or dry blasting, buffing, tumbling, sanding, wire wheel brushing, and the like, using a mixture of abrasive and catalyst materials, or alternatively, using a hard catalyst itself as the abrasive. Thus, for instance, liquid honing with "Vapor Blast" equipment using Novaculite 325 or 1250 mesh abrasive mixed with 10% aluminum powder has been found to be excellent in the preparation of the surfaces of materials for chemical nickel plating. Also, dry blasting with 325 mesh emery powder and 5% of chemically reduced nickel has been found to be useful in the preparation of the surfaces of the materials; the same is true with activated sanded surfaces obtained by powdering the sand belt with a catalyst, such as chemically reduced nickel in powder form.

In a still further form of the method, the surface of a non-conductive and non-catalytic material may be prepared for chemical nickel plating by freshening the surface of the material by mechanically employing one of the abrasive techniques mentioned and then by contaminating the freshened surface with a non-catalytic substance in powdered form to provide the growth nuclei on the freshened surface of the material, the non-catalytic substance constituting a non-catalytic metal whose solution potential is greater than that of nickel, such, for example, as manganese, zinc, magnesium and cadmium. In other words, by depositing on the freshened surface of the non-conductive and non-catalyst material, fine particles or a thin film of a metal less noble than nickel, an ion replacement occurs

in the chemical nickel plating bath between the nickel ions and the atoms of the less noble metal, whereby the nickel replaces the less noble metal and then acts as a catalyst. In the plating reactions (1) and (2), the advantage of this form of the method resides in the fact that soft less noble metals, such as zinc and cadmium, are easy to apply since these metals with low melting points can be flame-sprayed upon the freshened surface of the material. On the other hand, the more brittle, less noble metals, such as manganese, are more amenable to dusting upon the freshened surface of the material. The solution potential of nickel is about 0.25; and the following less noble metals have higher solution potentials: Mg, Al, Mn, Zn, Cr, Ga, Fe and Cd. The elements Al, Cr, Ga, and Fe are catalytic themselves, and the solution potentials of the other elements are: Mg, 2.34, Mn, 1.05, Zn, 0.76, and Cd, 0.40.

The following tests show the application of this form of the method. Bakelite samples were cut to the dimensions of 2 inches x ¾ inches and activated, i. e., the glossy surface skin was removed by means of fine emery paper which had been rubbed, respectively, with solid pieces of zinc, magnesium and cadmium. In the case of manganese, the plastic samples, after freshening, were dusted with the metal powder and rubbed by hand. Each of these samples was then placed in 50 cubic centimeters of a chemical nickel plating bath containing 0.07 mole/liter of nickel chloride, 0.225 mole/liter of sodium hypophosphite and 0.02 mole/liter of sodium succinate. The initial pH of the bath was adjusted to 5.1 with HCl and the bath was heated to 93° C. The time necessary to initiate nickel plating for Mn, Zn, Mg, and Cd were respectively 0, 6 minutes, 8 minutes and 30 minutes. Two of the samples, after 60 minutes, in the cases of Zn and Mn, had good uniform nickel platings on the surfaces thereof; and the samples after 60 minutes, in the cases of Mg and Cd, had fair nickel platings on the surfaces thereof. Thus, it may be concluded that manganese and zinc give optimum results when employing this form of the method.

In the preparation of the surface of the nonconductive and noncatalytic material, it is usually advisable just preceding the transfer of the material to the chemical nickel plating bath to subject the surface thereof to a standard cleaning operation, using techniques familiar to the metal working trade which will not deactivate the surface, such for instance as spray washing with a detergent, vapor degreasing, etc. This final standard cleaning step is unnecessary and may be omitted when the surface of the material is prepared or activated by certain of the steps described above, including liquid honing and steam blasting, since these steps will usually affect the necessary standard cleaning or degreasing simultaneously with the activation or preparation of the surface of the material.

In accordance with the process of the present invention, after the surface of the non-conductive and non-catalytic material has been activated or prepared in accordance with the method described above, the material is transferred to the chemical nickel plating bath in order that the plating of the nickel on the surface thereof is first initiated and then continued. The chemical nickel plating bath employed may be that disclosed in either of the previously noted applications; however, in employing either of these baths, it is advantageous to use a bath composition having a nickel ion to hypophosphite ion ratio toward the lower extremity of the range set forth, as it has been discovered that such lower $Ni^{++}/(H_2PO_2)^-$ ratio baths initiate the nickel plating upon the previously activated or prepared surface of the non-conductive and non-catalytic material in an appreciably shorter time interval than do the higher $Ni^{++}/(H_2PO_2)^-$ ratio baths.

In this connection, it will be apparent that once nickel plating on the surface of the material has been initiated, i. e., proceeded to a point where the surface thereof is covered with a continuous film of nickel, even a monomolecular layer, the conditions with respect to continued nickel plating become identical to those prevailing in the plating of catalytic materials as disclosed in the said applications previously mentioned. In other words, a different state exists only at the beginning of the chemical nickel plating reaction in the case of a non-conductive and non-catalytic material having a previously prepared or activated surface. Moreover, it has been discovered that the best conditions for obtaining a first uniform and continuous "flash" of nickel plating upon the previously prepared or activated surface of the non-conductive and non-catalytic material are somewhat different from the best conditions for obtaining continued nickel plating of the surface after the "flash" layer of metallic nickel has been obtained. Thus, it will be understood that after the "flash" coating of nickel upon the surface of the material has been obtained, the material may be transferred to one of the previously mentioned baths having a higher $Ni^{++}/(H_2PO_2)^-$ ratio, in order to continue the plating of the nickel upon the "flash" coating of nickel deposited upon the surface of the material, although this transfer is not essential and is suggested only when it is desired to obtain a rather thick nickel coating in a minimum time interval.

Accordingly, it will be understood that the following considerations pertain to the composition of chemical nickel plating baths that are provided specifically for the purpose of initiating the nickel plating upon the previously prepared and activated surface of a non-conductive and non-catalytic material, it being desirable to initiate the "flash" coating of nickel in the minimum time, time intervals of ten minutes, or less, being preferable

In a general way, it can be stated that the less stable the chemical nickel plating bath is, the faster it will initiate the nickel plating of the previously prepared or activated surface of the non-conductive and non-catalytic material. In other words, the more the chemical nickel plating bath tends toward chemical non-selective random reduction of nickel ions, as shown by thermal decomposition tests or by the early appearance of black precipitate during plating, the faster the chemical nickel plating bath will initiate. However, the presence of black precipitate ordinarily causes a rough deposit of metallic nickel upon the material undergoing the plating operation, as well as a rapid depletion of nickel ions in the bath by autocatalytic decomposition. Therefore, it is necessary to obtain in the chemical nickel plating bath that is employed for initiating the "flash" deposit of the nickel upon the material, a compromise between stability and the time interval lag to achieve the initiation mentioned.

Considering first a bath of the general char-

acter of that disclosed in the previously mentioned application of Gutzeit and Krieg, when alkali compounds are used as reagents, the buffer being a salt of a short chain aliphatic monocarboxylic acid, such as sodium acetate, the optimum concentration of the hypophosphite ions derived from alkali hypophosphite is again between 0.15 and 0.35 mole/liter. The initiation time is practically a straight line function of the ratio of nickel ions to hypophosphite ions, but relatively large amounts of black precipitate are formed at the lowest $Ni^{++}/(H_2PO_2)^-$ ratios, although the quality of the plating is still good within the optimum range of $Ni^{++}/(H_2PO_2)^-$ of 0.25 to 0.60. The following tabulation summarizes tests run in 50 cc. of chemical nickel plating bath at a V/A ratio of 2.5 on aluminum activated "general purpose" Bakelite samples; the absolute concentration of hypophosphite ions derived from sodium hypophosphite was 0.224 mole/liter; the buffer was sodium acetate and its concentration in acetate ions was 0.120 mole/liter; and the initial pH was adjusted to 4.85:

Table I

$Ni^{++}/(H_2PO_2)^-$ ratio	Initial pH	Initiation time, min.	Plating time, min.	Sample appearance (coverage)	Black precipitate at completion
.179	5.01	4	50	very good	Fair amount.
.268	5.00	4	50	do	Mirror.
.357	5.01	4	50	good	Do.
.433	5.01	4	50	fair	Fair amount.
.670	5.00	11	50	do	Do.
1.340	4.90	39	110	do	Do.

The results of these tests are illustrated by the curve 10 in Fig. 1; and it will be observed that the amount of nickel reduced chemically at random (as opposed to catalytic plating) is largest at the lower $Ni^{++}/(H_2PO_2)^-$ ratios, while initiation time and coverage are best with these lower ratios.

Considering another chemical nickel plating bath of the general character of that disclosed in the previously mentionad application of Gutzeit and Krieg, when alkaline earth compounds are used as reagents, the buffer being a salt of a short chain aliphatic monocarboxylic acid, such as calcium acetate, the optimum concentration of the hypophosphite ions derived from alkaline earth hypophosphites is again between 0.15 and 0.35 mole/liter. The initiation time is much shorter, although it is still a function of the $Ni^{++}/(H_2PO_2)^-$ ratio. The following tabulation summarizes tests run in 50 cc. of chemical nickel plating bath at a V/A ratio of 2.5 on aluminum activated "general purpose" Bakelite samples; the absolute concentration of hypophosphite ions derived from calcium hypophosphite was 0.224 mole/liter; the buffer was calcium acetate and its concentration in acetate ions was 0.112 mole/liter; and the initial pH was adjusted to 4.85. In these tests, the nickel plating was carried on for 180 minutes after initiation; and the results were as follows:

Table II

$Ni^{++}/(H_2PO_2)^-$ ratio	Initial pH	Initiation time, min.	Plating time, hrs.	Sample appearance	Black precipitate at completion
.179	4.86	0	3	No good (crust)	Considerable.
.268	4.86	2	3	Very good	Do.
.357	4.85	4	3	Good to fair	Trace.
.433	4.83	5	3	Very good	Do.
.670	4.84	5½	3	Good	Do.
1.34	4.71	15	3	Fair	Small amounts.

When using alkaline earth salts both as a buffer and as a source of hypophosphite ions, it is possible to obtain good nickel plating and small amounts of black precipitate by selecting the optimum ratio of $Ni^{++}/(H_2PO_2)^-$ at the proper initial pH. The results of these tests are illustrated by the curve **20** in Fig. 2; and it will be observed that the plating results were excellent at a nickel ion to hypophosphite ion ratio of 0.433, with an initiation time of only 5 minutes, and that only a mere trace of black precipitate was formed during the nickel plating operation. In referring to alkaline earths, we include magnesium.

Finally, considering a chemical nickel plating bath of the general character of that disclosed in the previously mentioned application of Gutzeit and Ramirez, the bath containing an exaltant in the form of a salt of a short chain aliphatic dicarboxylic acid, such as sodium succinate, the bath is extremely stable, and will initiate nickel plating upon an activated or prepared nonconductive and noncatalytic material only after a long period of time. The following tabulation summarizes tests run in 50 cc. of chemical nickel plating bath at a V/A ratio of 2.5 on aluminum activated "general purpose" Bakelite samples; the absolute concentration of hypophosphite ions was 0.225 mole/liter; the exaltant was sodium succinate and its concentration in succinate ions was 0.06 mole/liter; the ratio of $Ni^{++}/(H_2PO_2)^-$ was 0.4; and the tests were continued for 60 minutes after initiation of plating occurred. The results were as follows:

Table III

Initial pH	Initiation time, min.	Black precip.	Rate after initiation	Sample appearance after completion
6.30	20	after 50 min.	very fast	very good coverage, slight roughness.
5.00	20	after 90 min.	fast	fair coverage, rough.
4.00	4	none	fair	spotty coverage.

In order to obtain faster initiation of the plating process and better coverage by the nickel plating at low pH values with a bath of the character of that disclosed in the previously mentioned application of Gutzeit and Ramirez, a slight modification is suggested. This consists in

the use of a lower $Ni^{++}/(H_2PO_2)^-$ ratio in the bath, in the range 0.25 to 0.3.

The herein disclosed process of producing an intimately bonded and continuous layer of nickel upon the surface of a solid non-metallic body involving exposing a fresh non-polarized surface of the body having incorporated therein and exposed thereon dispersed growth nuclei minute carbon particles is disclosed and claimed in the copending divisional application of Gregoire Gutzeit, William J. Crehan and Abraham Krieg, Serial No. 370,142, filed July 24, 1953.

From the foregoing, it is apparent that a process has been provided for the plating with nickel of nonconductive and noncatalytic material, such as plastics, hard rubber, wood, ceramics, etc., that involves the preliminary activation or preparation of the surface of the material employing the present method so as to provide thereon firmly anchored growth nuclei and nonpolarized areas accommodating the initiation of the flash nickel coating on the material. Moreover, in carrying out the process of the present invention after activation or preparation of the surface of the material in accordance with the method of the present invention, an intimately bonded and uniform layer of nickel may be obtained upon the surface of the material having any desired thickness. It will be understood that the invention is not limited except as defined by the appended claims.

We claim:

1. The process of producing an intimately bonded and continuous layer of nickel upon the surface of a solid non-metallic body, which comprises exposing a fresh non-polarized surface of said body having incorporated therein and exposed thereon dispersed growth nuclei minute particles essentially comprising an element selected from the group consisting of iron, cobalt, nickel, aluminum, copper, silver, gold, palladium and platinum, and immersing said body in a bath consisting essentially of an aqueous solution of a nickel salt and a hypophosphite during a sufficient time interval to cause initial nickel plating upon said growth nuclei and subsequent growth of the nickel plating into a continuous nickel layer upon the fresh non-polarized surface of said body.

2. The process of producing an intimately bonded and continuous layer of nickel upon the surface of a solid non-metallic body, which comprises exposing a fresh non-polarized surface of said body, securing to the fresh non-polarized surface of said body dispersed growth nuclei minute particles essentially comprising an element selected from the group consisting of iron, cobalt, nickel, aluminum, copper, silver, gold, palladium and platinum, and immersing said body in a bath consisting essentially of an aqueous solution of a nickel salt and a hypophosphite during a sufficient time interval to cause initial nickel plating upon said growth nuclei and subsequent growth of the nickel plating into a continuous nickel layer upon the fresh non-polarized surface of said body.

3. The process of producing an intimately bonded and continuous layer of nickel upon the surface of a solid non-metallic body, which comprises abrading the surface of said body to expose a fresh non-polarized surface thereof, securing to the fresh non-polarized surface of said body dispersed growth nuclei minute particles essentially comprising an element selected from the group consisting of iron, cobalt, nickel, aluminum, copper, silver, gold, palladium and platinum, and immersing said body in a bath consisting essentially of an aqueous solution of a nickel salt and a hypophosphite during a sufficient time interval to cause initial nickel plating upon said growth nuclei and subsequent growth of the nickel plating into a continuous nickel layer upon the fresh non-polarized surface of said body.

4. The process of producing an intimately bonded and continuous layer of nickel upon the surface of a solid non-metallic body, which comprises abrading the surface of said body with an abrasive material having dispersed therein minute particles essentially comprising an element selected from the group consisting of iron, cobalt, nickel, aluminum, copper, silver, gold, palladium and platinum as both to expose a fresh non-polarized surface of said body and to embed in dispersed relation therein said minute particles as growth nuclei, and immersing said body in a bath consisting essentially of an aqueous solution of a nickel salt and a hypophosphite during a sufficient time interval to cause initial nickel plating upon said growth nuclei and subsequent growth of the nickel plating into a continuous nickel layer upon the fresh non-polarized surface of said body.

5. The process of producing an intimately bonded and continuous layer of nickel upon the surface of a solid non-metallic body, which comprises abrading the surface of said body with minute nickel particles so as both to expose a fresh non-polarized surface of said body and to embed in dispersed relation therein said minute nickel particles as growth nuclei, and immersing said body in a bath consisting essentially of an aqueous solution of a nickel salt and a hypophosphite during a sufficient time interval to cause initial nickel plating upon said growth nuclei and subsequent growth of the nickel plating into a continuous nickel layer upon the fresh non-polarized surface of said body.

6. The process of producing an intimately bonded and continuous layer of nickel upon the surface of a solid non-metallic body, which comprises exposing a fresh non-polarized surface of said body, securing to the fresh non-polarized surface of said body dispersed growth nuclei minute particles essentially comprising an element that is less noble than nickel, and immersing said body in a bath consisting essentially of an aqueous solution of a nickel salt and a hypophosphite during a sufficient time interval to cause initial nickel plating by displacement with respect to said growth nuclei and subsequent growth of the nickel plating into a continuous nickel layer upon the fresh non-polarized surface of said body.

7. The process of producing an intimately bonded and continuous layer of nickel upon the surface of a solid non-metallic body, which comprises exposing a fresh-non-polarized surface of said body, securing to the fresh non-polarized surface of said body dispersed growth nuclei minute particles essentially comprising an element selected from the group consisting of manganese, zinc, magnesium and cadmium, and immersing said body in a bath consisting essentially of an aqueous solution of a nickel salt and a hypophosphite during a sufficient time interval to cause initial nickel plating by displacement with respect to said growth nuclei and subsequent growth of the nickel plating into a continuous nickel layer upon the fresh non-polarized surface of said body.

8. The process of producing a composite solid body of non-metallic material having an intimately bonded and continuous layer of nickel upon the surface thereof, which comprises compounding with said non-metallic material an element selected from the group consisting of iron, cobalt, nickel, aluminum, copper, silver, gold, palladium and platinum, fabricating said body of said compounded non-metallic material and said element, exposing a fresh non-polarized surface of said body so that said element is dispersed as growth nuclei minute particles at the fresh non-polarized surface thereof, and immersing said body in a bath consisting essentially of an aqueous solution of a nickel salt and a hypophosphite during a sufficient time interval to cause initial nickel plating upon said growth nuclei and subsequent growth of the nickel plating into a continuous nickel layer upon the fresh non-polarized surface of said body.

9. The process of producing a composite solid body of synthetic plastic material having an intimately bonded and continuous layer of nickel upon the surface thereof, which comprises compounding with said synthetic plastic material an element selected from the group consisting of iron, cobalt, nickel, aluminum, copper, silver, gold, palladium and platinum, fabricating said body of said compounded synthetic plastic material and said element, exposing a fresh non-polarized surface of said body so that said element is dispersed as growth nuclei minute particles at the fresh non-polarized surface thereof, and immersing said body in a bath consisting essentially of an aqueous solution of a nickel salt and a hypophosphite during a sufficient time interval to cause initial nickel plating upon said growth nuclei and subsequent growth of the nickel plating into a continuous nickel layer upon the fresh non-polarized surface of said body.

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