

1

3,466,232

## ELECTROPLATING PROCESS

Peter S. Francis, Minneapolis, Minn., and Leslie D. McGraw, Weirton, W. Va., assignors, by mesne assignments, to Carlen Industries, Inc., Minneapolis, Minn., a corporation of Minnesota

No Drawing. Filed Oct. 23, 1965, Ser. No. 504,188

Int. Cl. C23b 5/60, 3/02

U.S. Cl. 204—30

15 Claims

### ABSTRACT OF THE DISCLOSURE

The process of plating a plastic with a metal which involves using a plastic in which is dispersed at least one etchable material, etching a surface of the plastic after the plastic has first been molded into the desired shape, and thereafter plating the etched surface with a metal. The etching produces a large number of small pockets in the surface of the plastic article. These pockets are substantially filled with metal during plating to thereby provide a strong mechanical bond between the metal film and the plastic article.

This invention pertains to a new process for electroplating plastics and more particular to a new process for electroplating plastics in which the plastics themselves are modified to greatly increase the bond between the surface of the plastic and the metal plated thereon.

In general, plastics and other non-conductors are electroplated in the following manner. The surface of the plastic which it is desired to electroplate is first roughened in some manner such as sandblasting or tumbling with pumice. In some cases the material may be treated chemically to etch or swell the surface to make it rough. The surface is completely cleaned after mechanical roughening or before chemical roughening and the surface is rinsed with clean water before and after each of the following steps.

After roughening and cleaning the surface a sensitizer solution is applied by dipping, spraying, or swabbing. A number of different solutions are utilized for sensitizing, however, various tests have proven that stannous chloride is better than most. The solution generally consists of  $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$  or  $\text{SnCl}_2$  in the recommended ranges from 0.7 to 150 g./l. Also, this solution is either acidic or alkaline depending upon the material being sensitized. It is generally believed that stannous ions from the sensitizing solution are strongly adsorbed on the surface of the material being sensitized.

In the next step the surface is treated with an activating or "seeding" solution. The activating solution consists of a dilute acidic solution of the chloride of a noble metal, such as platinum, gold, palladium, etc. The surface is treated by immersion or the like in the activator for a period of generally several minutes. While again this industry is not certain what chemical reaction actually takes place, it is believed that the noble metal forms an invisible film on the surface of the plastic. It is further believed that the ions adsorbed by the plastic from the sensitizing solution reduce the noble metal chloride to the metallic noble metal which then adheres to or becomes part of the surface of the plastic. This noble metal acts as a catalyst and accelerates the formation of, for example, metallic copper from a coppering solution. Copper plated in this manner is referred to as electroless copper.

After the surface of the plastic is activated an electroless copper or other electrically conducting metal is plated on the surface of the plastic in the form of a thin film. This film is produced chemically by a reduction of Fehling's Solution, or some similar but improved solu-

2

tion, by means of a formaldehyde or hydrazine sulfite reducing agent. In some instances it is preferable to use a thin film of silver or nickel in place of the copper in which case the various chemicals and procedures are basically the same.

The final step is the electroplating of a metal on the surface of the chemically deposited metal. The most common metal which is electroplated onto the plastic is copper, however, nickel and, in some cases, silver may also be plated thereon. The electroplated film of metal is produced by placing the plastic having the thin film of chemically deposited metal thereon in a solution containing ions of the metal it is desired to electroplate. An electrical current is then passed through the solution and the thin film of metal which results in the deposition of the new metal and forms a film having the desired thickness. It should be understood that all of the steps set forth thus far are well known in the art and that there are many variations as to chemicals, methods of application, times, etc.

In all of the prior art, while it is possible to plate a film of metal on practically any plastic, it is impossible to provide any substantial amount of adherence between the film of metal and the plastic. That is, in nearly every case the metal film is readily peeled from the surface of the plastic by using a very unsubstantial amount of force and in some instances the metal film actually falls off of the surface of the plastic in the electroplating solution. This lack of adhesion is partially due to the fact that in all prior roughening methods the material at the surface of the plastic is damaged and weakened. Thus, even though a good mechanical bond is obtained, the surface of the plastic easily breaks away, thereby, greatly lowering the force required to peel the metal film from the plastic surface. In some instances and by utilizing a specific plastic, some relatively good adherence has been obtained, however, this adherence is very unpredictable and in no case has the method been broadened to include any other plastics.

It is an object of the present invention to provide a new and improved method of electroplating plastics.

It is a further object of the present invention to provide a process for electroplating substantially any desired plastic.

It is a further object of the present invention to provide a method for electroplating substantially any plastic with a metal which adheres to the surface of the plastic so that a substantial force is required to peel it therefrom.

These and other objects of this invention will become apparent to those skilled in the art upon consideration of the accompanying specification and claims.

In essence this invention comprises a method for effecting the electro-deposition of a metal on substantially any desirable plastic. However, the following explanation will be limited to the deposition of copper on certain specific plastics. It should further be understood that the following procedures and chemicals are set forth simply for explanation and are not intended to limit this invention in any way.

Specifically, to practice the present invention, a polyblend or multiphase plastic having the desired characteristics is produced. A polyblend or multiphase plastic is a plastic having a first phase or base which is composed of a polymeric plastic and a second or dispersed phase which is composed of some etchable material. The base plastic may be a homopolymer or a copolymer or any compatible combination thereof. The base plastic can be chosen, for example, from any of a group of polymers including but not limited by the following: polystyrene, polyethylene, polyacetal, polyamide, polypropylene, and phenolics.

It is preferable that the base plastic have some resiliency since a resilient plastic greatly increases the force

required to peel the plated metal film from the surface thereof. This can be seen by noting that two stiff sheets of material which are bonded together have a tendency to separate along a geometric line, lying in the plane of the sheets but perpendicular to the direction of separation, which progresses down the junction between the two sheets, similar to a zipper action, as the two sheets are separated. All of the separating forces are concentrated in this geometric line, which produces the zipper action, and consequently a relatively small force will separate the two sheets. If one, and preferably both, of the sheets (the plastic and the plated metal) is resilient, the separating force is distributed over a larger area and the amount of force required to separate the two sheets is greatly increased.

A plastic or other material which will blend with the base plastic and which can be etched by some material that does not etch the base material is then chosen. It should be noted that the etchant might have some effect on the base plastic but it should be substantially slower than the effect on the etchable material. Also, the etchable material is chosen so that separate particles have a preferred size and shape when the etchable material is blended with the base plastic. If the size of the particles of the etchable material are too large, the final metal film deposited on the surface will be rough and will not have good adhesion. If the etchable material and the base plastic are too compatible, they can become molecularly dispersed and the polyblend plastic will react similar to a copolymer plastic without an etchable material therein. Typical materials which may be utilized are latex, which may be a cross linked polybutadiene latex and/or bulk rubber or the like, powdered zinc oxide, any combination of these or any other material which will be preferentially etched and which corresponds to the requirements already described.

The following procedure sets forth one method of producing desirable polyblends. It should be understood that the following procedure is for use in a laboratory preparation and might vary considerably in commercial production. A desired base plastic in the molding powder state is chosen and the molding powder is pulverized. When the pulverized powder is in the desired state, a latex dispersion is added and thoroughly mixed therewith. An oxidation stabilizer, (antioxidant) N-phenyl- $\beta$ -naphthylamine, has to be added in some cases at a level amounting to 1% of the dry latex. The plastic-latex-antioxidant system is then dried and lumps are broken down into fine particles.

After the plastic-latex-antioxidant is broken down into sufficiently fine particles it is introduced into a pre-heated mixing bowl while the mixer is operating at approximately 25 r.p.m. The mixture coalesces rapidly into a viscous melt after which the mixer speed is increased to between 50 and 125 r.p.m. for approximately two to five minutes. The mixing bowl is then opened and the molten polyblend is rapidly removed and allowed to solidify. The solid polyblend is then repulverized after which it is ready for molding into the desirable shapes. It was found desirable to pulverize the polyblend a final time because of certain surface characteristics, due primarily to air oxidation. Specimens molded from unpulverized polyblends had very blotchy and irregular surfaces while the final pulverizing of the polyblend resulted in a product which when molded had a uniform surface. Temperatures utilized for heating the polyblends in the mixing bowl varied from approximately 170° C. for polyethylene to approximately 280° C. for the polyamides.

After the polyblend plastic is molded into the desirable shape the surface to be electroplated is treated with an alkaline cleaner. This cleaner removes any surface contamination such as greasy or oily films which may be present due to handling, etc. The cleaner need not usually be strongly alkaline and may be one of a number of commercially available mild proprietary cleaners commonly used for soak cleaning of non-ferrous metals and

the like. While the present alkaline cleaner was generally operated at temperatures near 200° F., it should be noted that excessive temperatures may cause distortion of the plastic materials, especially those of the thermoplastic type. After the surface is cleaned any excess alkaline cleaner is removed by rinsing in clean water, such as flowing tap water or the like.

After the polyblend plastic article is cleaned, it is treated to neutralize any mold release agents that might be present. It should be understood that this step is not essential and, in the event that the user is sure that no mold release agents are present, this step may be eliminated. During experiments conducted to perfect the present invention, polyblend plastics containing such base plastics as polystyrene, polyethylene, and polypropylene were treated with an alkaline methyl alcohol solution, containing approximately 10% sodium hydroxide by volume, for approximately 30 minutes. In addition, some of the polyblend plastics were treated with chloroform for periods ranging from one-half minute to several minutes. It is believed that the chloroform aided in neutralizing or removing some of the mold release agents and in some cases it was utilized to swell the latex used in the dispersed phase so that particles adjacent the surface would break through the surface skin and actually be available for exterior agents to operate on them. While this step is not necessary it did prove highly desirable in some cases. Thereafter, the excess material is rinsed in clean water to prepare the polyblend plastic article for the next step.

As a next step the dispersed phase or etchable material adjacent to the surface to be electroplated is etched or leached away to leave a surface having a large number of small holes or pockets therein. Because of the size and shape of the dispersed phase and because of the manner in which the dispersed phase and the base plastic are blended, these pockets will in general be somewhat larger than hemispherical. In other words, the opening into the pocket at the surface of the polyblend plastic article will have a diameter which is somewhat smaller than the diameter of the spherical pocket. Thus, these pockets will differ greatly from pockets produced by sandblasting or the like in that they will be dispersed about the surface of the polyblend plastic article in a substantially uniform arrangement and, in general, each pocket will have a somewhat ridgelike structure internally around the opening. Another major advantage of the present process over sandblasting and other roughening procedures is that the present process does not weaken the surface material or structure.

In general, the etchant varies with the material used as the dispersed phase and the material used as the dispersed phase varies with the base plastic. Thus, an acid etch may preferentially etch some dispersed phase material while in alkaline etch would be required to preferentially etch other dispersed phase material. While a great many different acid or alkaline etches may be provided by one skilled in the art, an acid etch composed of 93% by volume of concentrated sulfuric acid and 7% by volume of 50 weight percent  $\text{CrO}_3$  solution and an alkaline etch composed of 5%  $\text{KMnO}_4$  in 10% sodium hydroxide solution were used successfully. Depending upon the effect which the etchant has on the base plastic of the polyblend plastic article, the time which the article is subjected to the etchant may be important. In general, the etchant should have sufficient time to etch out all of the dispersed phase adjacent the surface to be electroplated. Thus, the pockets in the surface of the polyblend plastic article have a maximum ridge about the opening therein. After the etchant is rinsed from the surface of the polyblend plastic article by fresh water, the article is ready for the next step.

After the dispersed phase is etched from the surface of the polyblend plastic article, the next step toward preparing the article for electroplating is to treat the surface

with a sensitizer and activator, as described for the prior art. In general the sensitizer utilized in the present invention is composed of 38 grams of  $\text{SnCl}_2 \cdot \text{H}_2\text{O}$ , 190 milliliters of concentrated HCl and sufficient water to bring the solution to one gallon. The sensitizer is applied for approximately two minutes. The activator is comprised of approximately 5 grams of  $\text{PdCl}_2$ , 10 milliliters of concentrated HCl and water sufficient to bring the solution to one gallon. The activator is applied for a period of approximately one to two minutes. In general, it was found during experimentation that a double run through the sensitizer-activator steps was preferable. It is believed that a double run of the polyblend plastic article through the sensitizer-activator steps produces a more uniform distribution of the stannous and palladium ions along the surfaces of the pockets.

After each of the sensitizing and activating steps the polyblend plastic article is rinsed in fresh water in preparation for the next step. After the final activating and rinsing step, the surface of the article is coated with a thin film of electroless copper, as described in conjunction with the prior art. As stated previously, the thin film applied to the surface of the article may be any metal which is a relatively good electrical conductor and which can be chemically plated on the surface. After the thin film of copper is chemically plated on the surface of the polyblend plastic article, the surface is rinsed in deionized water. In some cases, it was found that allowing the electroless copper thin film to cure for a substantial period of time, which in general was a period of approximately two days, greatly strengthened the bond between the final electroplated metal film and the polyblend plastic article. While experiments have proven that an increase in strength is provided by allowing the electroless copper thin film to cure for a substantial period of time in some cases, the exact reason for this increase in strength is not known at the present time. However, it is believed that the curing of the electroless copper in air results in a chemical bonding between the electroless copper and the plastic molecules at the surface of the polyblend plastic article and especially in the pockets therein.

Once the conducting film has been chemically plated on the surface of the polyblend plastic article, the electroplating proceeds in the manner common to the prior art. The electroplated metal combines with the chemically plated metal to form a solid film of metal over the surface of the polyblend plastic article. This solid film of metal substantially fills the pockets in the surface of the article which provides an extremely strong mechanical bond between the metal film and the plastic article. Because of the configuration of the pockets in the surface of the plastic article, when these pockets are filled with copper which is an integral portion of the copper film covering the surface of the article, the copper film is actually locked onto the plastic. This interlocking of the copper film and the plastic is so firm that to peel the copper film from the plastic article, the outer plastic portions adjacent the surface of the article must break away from the article. In fact, it was found during experimentation that care must be used when etching the dispersed phase from the surface of the plastic article so that the base plastic is not weakened. If the base plastic is weakened, it will break or separate adjacent the surface and reduce the amount of force required to peel the final copper film from the surface of the article.

The following are some specific examples of processes utilized to successfully plate a metal film on the surface of plastic articles, which film had relatively high adhesion. These examples further illustrate the invention. Those skilled in the art will readily appreciate that modifications and changes can be made in these examples without departing from the spirit and scope of the invention.

## EXAMPLE 1

A polyblend plastic is provided by pulverizing polystyrene molding powder, which was purchased commercially under the trade name Styron, type 666-72-71, and adding a latex dispersion in the amount of approximately 25% by volume of dry latex. The latex utilized was a polybutadiene latex purchased commercially. An oxidation stabilizer (antioxidant), N-phenyl- $\beta$ -naphthylamine, is added at a level amounting to 1% of the dry latex. The plastic-latex-antioxidant system is then dried and, after drying, lumps are broken down into fine particles. A mixing bowl is then heated to approximately 190° C. and the plastic-latex-antioxidant is slowly introduced to the mixing bowl while the mixer is running at approximately 25 r.p.m. When the mixture coalesces into a viscous melt the speed of the mixer is raised to between 50 to 125 r.p.m. for two to five minutes. The molten plastic is then removed and allowed to solidify. Once the plastic has cooled sufficiently it is again pulverized after which it is ready for molding. The pulverized plastic is molded into a desired shape in a compression mold by heating to approximately 190° C.

In the preplating treatments the surface of the plastic article is cleaned with an alkaline cleaner for ten minutes after which it is rinsed and treated with an alkaline methyl alcohol solution (10% NaOH) for thirty minutes. The plastic article is again rinsed and treated with an acid etch composed of 93 volume percent concentrated sulfuric acid and 7 volume percent 50 weight percent  $\text{CrO}_3$  solution for thirty minutes. After the acid etch the article is again rinsed and a sensitizer consisting of 38 grams of  $\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$ , 190 milliliters of concentrated HCl and water sufficient to bring the solution to one gallon, is used to treat the surface for two minutes. The article is again rinsed and the surface is treated for one to two minutes with an activator consisting of 5 grams of  $\text{PdCl}_2$ , 10 milliliters of concentrated HCl and water sufficient to bring the solution to one gallon. After rinsing, the surface of the article is again treated with a sensitizer, as described above, rinsed, treated with an activator, as described above, and rinsed. A thin film of electroless copper is then applied to the surface by treating the surface with a commercially purchased solution for ten to fifteen minutes. After a sufficient film of electroless copper is deposited on the surface the plastic article is rinsed in deionized water. The electroless copper film should be allowed to cure for approximately 48 hours before proceeding with the electroplating.

## EXAMPLE 2

A polyblend plastic consisting of 75% by volume of polyethylene purchased commercially under the trade name Hifax, type 1600, and 25% by volume of dry latex is provided in a manner similar to that described for polystyrene, in Example 1, except that the melting temperatures utilized are approximately 170° C. and molded into a desired article.

In the preplating treatments of this polyblend plastic article, all of the steps are exactly similar to those described for polystyrene except that the surface of the plastic article should be treated with chloroform for one minute after it is cleaned. However, this step as well as the alkaline methyl alcohol solution treatment immediately following, is optional and, while somewhat better results are produced by utilizing these steps, they are not necessary.

## EXAMPLE 3

75% by volume of polyacetal, purchased commercially under the trade name Delrin, type 500, is mixed with 25% by volume of dry latex in a manner similar to that described for polystyrene in Example 1, except that the melting temperature is 210° C.

In the preplating treatments the surface of the polyblend plastic article is treated with chloroform for one-

half minute after which it is rinsed and treated with an alkaline cleaner for ten minutes. The surface is again rinsed and the dispersed phase adjacent the surface is etched by treating the surface with a solution of 5%  $\text{KMnO}_4$  in a 10%  $\text{NaOH}$  solution for sixty minutes. The surface is again rinsed and treated twice with the sensitizer and activator as explained in Example 1. In this example, curing of the electroless film is not required to obtain a good adherent plate.

#### EXAMPLE 4

In this example, 75% by volume of polyamide, or nylon, is blended with 25% zinc oxide in a manner similar to that set forth in Example 1, except that the powdered zinc oxide was incorporated dry and no oxidation stabilizer is added.

In the preplating treatment the surface of the polyblend plastic article is treated with an alkaline cleaner for one to five seconds after which it is rinsed and treated with the acid etch described in Example 1 for one to two seconds. After the acid etch, the surface of the polyblend plastic article is rinsed and treated with an alkaline solution containing 30%  $\text{NaOH}$  for thirty minutes and again rinsed. The surface of the article is then treated with a sensitizer and activator twice as described in Example 1, except that the sensitizer is alkaline rather than acidic. In this example, a satisfactory adherence of the plated film can be obtained without curing the electroless copper film.

#### EXAMPLE 5

A polyblend plastic containing 75% by volume of polypropylene, type 1016, and 25% by volume of dry latex is provided in a manner similar to that explained in Example 1.

The preplating treatments for this polyblend plastic article are similar to those set forth in Example 1 except that the surface is treated with chloroform for one minute after it is cleaned and rinsed.

In each of the above 5 examples peel strength tests were made on the resulting electroplated product. Comparative peel strength tests were made on similar articles constructed from each of the base plastics (polystyrene, polyethylene, polyacetal, polyamide, polypropylene and phenolic compound) and treated in a fashion similar to the articles constructed from a polyblend plastic. In general the peel strength was so great for the polyblend plastic articles that a sufficient amount of electroplated metal could not be raised on which to gain a purchase. The peel strength of the base plastics alone was so low it could not be effectively measured and was considered substantially zero.

This invention has been practiced as herein before disclosed, and has been found to accomplish all of the aforementioned objectives and advantages. It will be obvious to those skilled in the art that this invention may be modified in many respects without departing from the essence thereof; and therefore, we intend to be limited solely by the scope of the appended claims.

What is claimed is:

1. The process of plating a plastic with a metal which comprises the steps of:

- (a) using as said plastic a blended plastic comprised of a plastic having dispersed therein at least one etchable material;
- (b) etching a surface of said blended plastic after the blended plastic has been molded into a desired shape, thereby removing etchable material from said surface to produce a large number of small pockets having openings in said surface which are smaller in diameter than the largest diameter through their respective pockets; and
- (c) thereafter plating said surface with a metal.

2. Processes of claim 1 wherein the metal which is plated on the etched surface of said blended plastic sub-

stantially fills said pockets and forms a solid film of metal over said surface, thereby mechanically interlocking said metal film and said plastic.

3. Processes of claim 2 wherein the etchable material is a second plastic.

4. Processes of claim 2 wherein the etchable material is a polybutadiene latex or powdered zinc oxide.

5. Processes of claim 2 wherein the first plastic is a polystyrene, polyethylene, polyacetal, polyamide, polypropylene or phenolic plastic, and wherein said metal is electroplated on said surface.

6. Processes of claim 5 wherein the etchable material is a polybutadiene latex.

7. Processes of claim 6 wherein the molded plastic is cleaned and treated with chloroform prior to etching.

8. Processes of claim 2 wherein said plating is an electroplating process which includes at least one set of sensitizing and activating steps, followed by the chemical deposition on said etched surface of a thin film of metal, and the subsequent electroplating of metal over said chemically deposited metal.

9. Processes of claim 8 wherein said chemically deposited metal is copper.

10. Processes of claim 9 wherein said copper is permitted to age for a substantial period of time before metal is electroplated over said copper.

11. An electroplating process comprising the steps of:

- (a) providing a multiphase plastic to be electroplated consisting essentially of polystyrene in the range of approximately 85% to 70% of the total plastic by volume and latex in the range of approximately 15% to 30% of the total plastic by volume;
- (b) cleaning the surface of the multiphase plastic which it is desired to plate;
- (c) etching said latex adjacent said surface of said multiphase plastic with an acid composition containing approximately 93% by volume concentrated sulfuric acid and 7% by volume of 50 weight percent  $\text{CrO}_3$  solution;
- (d) applying an acid sensitizer to said surface of said multiphase plastic;
- (e) applying an activator to said surface of said multiphase plastic;
- (f) reapplying an acid sensitizer to said surface of said multiphase plastic;
- (g) reapplying an activator to said surface of said multiphase plastic;
- (h) chemically plating a thin film of electrically conducting metal on said surface of said multiphase plastic;
- (i) allowing said chemically plated film to cure for a substantial period of time; and
- (j) electroplating a metal on said surface of said multiphase plastic.

12. An electroplating process comprising the steps of:

- (a) providing a multiphase plastic to be electroplated consisting essentially of polyethylene in the range of approximately 85% to 70% of the total plastic by volume and latex in the range of approximately 15% to 30% of the total plastic by volume;
- (b) cleaning the surface of the multiphase plastic which it is desired to plate;
- (c) etching said latex adjacent said surface with an acid composition containing approximately 93% by volume concentrated sulfuric acid and 7% by volume of 50 weight percent  $\text{CrO}_3$  solution for approximately 30 minutes;
- (d) applying an acid sensitizer to said surface;
- (e) applying an activator to said surface;
- (f) reapplying an acid sensitizer to said surface;
- (g) reapplying an activator to said surface;
- (h) chemically plating a thin film of electrically conducting metal on said surface;
- (i) allowing said chemically plated film to cure for a substantial period of time; and

- (j) electroplating a metal on said surface to the desired thickness.
13. An electroplating process comprising the steps of:
- (a) providing a multiphase plastic to be electroplated consisting essentially of polyacetal in the range of approximately 85% to 70% of the total plastic by volume and latex in the range of approximately 15% to 30% of the total plastic by volume;
  - (b) cleaning the surface of the multiphase plastic which it is desired to plate;
  - (c) etching said latex adjacent said surface with an alkaline composition containing approximately 5%  $\text{KMnO}_4$  in 10% NaOH solution for approximately 60 minutes;
  - (d) applying an acid sensitizer to said surface;
  - (e) applying an activator to said surface;
  - (f) reapplying an acid sensitizer to said surface;
  - (g) reapplying an activator to said surface;
  - (h) chemically plating a thin film of electrically conducting metal on said surface; and
  - (i) electroplating a metal on said surface to the desired thickness.
14. An electroplating process comprising the steps of:
- (a) providing a multiphase plastic to be electroplated consisting essentially of polyamide in the range of approximately 85% to 70% of the total plastic by volume and ZnO in the range of approximately 15% to 30% of the total plastic by volume;
  - (b) cleaning the surface of the multiphase plastic which it is desired to plate;
  - (c) etching said ZnO adjacent said surface with an acid composition containing approximately 93% by volume concentrated sulfuric acid and 7% by volume of 50 weight percent  $\text{CrO}_3$  solution for approximately 1 to 2 seconds followed by an alkaline composition containing approximately 30% NaOH for approximately 30 minutes;
  - (d) applying an alkaline sensitizer to said surface;
  - (e) applying an activator to said surface;
  - (f) reapplying an alkaline sensitizer to said surface;
  - (g) reapplying an activator to said surface;
  - (h) chemically plating a thin film of electrically conducting metal on said surface; and

- (i) electroplating a metal on said surface to the desired thickness.
15. An electroplating process comprising the steps of:
- (a) providing a multiphase plastic to be electroplated consisting essentially of polypropylene in the range of approximately 85% to 70% of the total plastic by volume and latex in the range of approximately 15% to 30% of the total plastic by volume;
  - (b) cleaning the surface of the multiphase plastic which it is desired to plate;
  - (c) etching said latex adjacent said surface with an acid composition containing approximately 93% by volume concentrated sulfuric acid and 7% by volume of 50 weight percent  $\text{CrO}_3$  solution for approximately 30 minutes;
  - (d) applying an acid sensitizer to said surface;
  - (e) applying an activator to said surface;
  - (f) reapplying an acid sensitizer to said surface;
  - (g) reapplying an activator to said surface;
  - (h) chemically plating a thin film of electrically conducting metal on said surface;
  - (i) allowing said chemically plated film to cure for a substantial period of time; and
  - (j) electroplating a metal on said surface to the desired thickness.

## References Cited

## UNITED STATES PATENTS

|           |         |                      |          |
|-----------|---------|----------------------|----------|
| 2,663,663 | 12/1953 | Weltman et al. ....  | 204—30   |
| 2,921,246 | 1/1960  | Peck et al. ....     | 317—260  |
| 2,944,917 | 7/1960  | Cahne .....          | 156—2 XR |
| 3,116,170 | 12/1963 | Williams et al. .... | 136—86   |
| 3,222,218 | 7/1965  | Beltzer et al. ....  | 117—213  |
| 3,305,460 | 2/1967  | Lacy .....           | 204—20   |
| 3,235,473 | 2/1966  | LeDuc .....          | 204—30   |

JOHN H. MACK, Primary Examiner

W. B. VANSISE, Assistant Examiner

U.S. Cl. X.R.

204—20; 156—2; 117—47