Nov. 1, 1966 M. B. MELILLO 3,282,723

ELECTROLESS DEPOSITION AND METHOD OF PRODUCING SUCH ELECTROLESS DEPOSITION

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Fig. 1

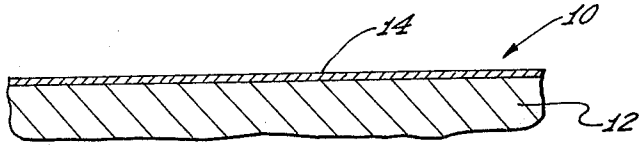


Fig. 2

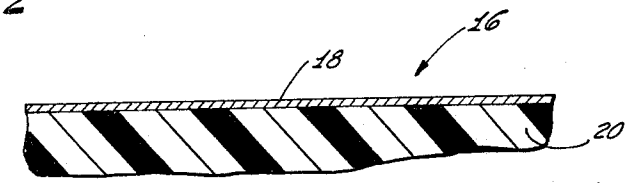


Fig. 3

Material	Grams per Liter Representative Plating Baths		
	1	2	3
Nickel Acetate $Ni(C_2H_3O_2) \cdot 4H_2O$	30	30	25
Urea $CO(NH_2)_2$	60	10	20
Sodium Hypophosphite $NaH_2PO_2 \cdot H_2O$	12	10	15
Sodium Potassium Tartrate $NaKC_4H_4O_6 \cdot 4H_2O$	50	40	30
Ferrous Sulphate $FeSO_4 \cdot 7H_2O$	10	15	12
Ammonium Hydroxide NH_4OH as required for pH 8 to 10			
Sodium Citrate $Na_3C_6H_5O_7 \cdot 2H_2O$		80	60

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ELECTROLESS DEPOSITION AND METHOD OF PRODUCING SUCH ELECTROLESS DEPOSITION

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This invention relates to articles produced by the electroless deposition of metals on a surface. More particularly, this invention relates to articles produced by the electroless deposition of iron and other metals, such as cobalt or nickel, on a surface to provide a magnetic member for the recording and reproduction of information. The invention is especially concerned with the deposition of iron and another magnetic material, such as nickel or cobalt, on a thin sheet of material to produce a tape having optimum properties of obtaining the recording and reproduction of information. The invention also relates to methods of producing such articles of manufacture.

The electroless deposition of such materials as cobalt and nickel on a surface has been known for a period of time in the order of approximately fifteen (15) years. Materials have been deposited on an electroless basis during this time by using a chemical bath in which the chemicals react without using electrical poles to attract or repel ions in the bath in accordance with the charge of the ions and the charge of the poles. Since no electrical poles have been used in electroless depositions, the reaction of the chemicals in electroless baths has proceeded entirely on a chemical basis.

The electroless deposition of such metals as cobalt and nickel on a surface was originally developed to provide a coating for surfaces such as steel so as to prevent corrosion of such surfaces. Some work has also recently been performed to produce magnetic depositions by electroless techniques. This work has not been altogether successful since iron has apparently not been able to be deposited, either alone or with other magnetic materials such as cobalt or nickel. The deposition of iron is desirable since it tends to enhance the magnetic properties of the magnetic material, especially when it is used in combination with other materials such as nickel or cobalt in certain percentages.

This invention relates to articles having magnetic depositions of iron and other magnetic materials, such as cobalt and nickel, where such depositions are produced by electroless techniques. For example, a magnetic deposition included within this invention can be produced with approximately eighty percent (80%) of nickel by weight and approximately twenty percent (20%) of iron by weight. Such a deposition is desirable because it includes magnetic materials similar to those included in the magnetic material designated by the trademark "Permalloy" and includes such materials in the same percentages as those used in the magnetic material designated as "Permalloy."

The invention also relates to methods of producing the novel depositions constituting this invention. The methods of producing such materials are particularly novel because they include a bath in which a sequestering agent, such as urea, is used to prevent the iron in the bath from reacting with other chemical materials in the bath and from precipitating out of the bath as a result of such chemical reactions. By maintaining the iron in the bath through the use of a sequestering agent, the iron is available to become deposited with the other magnetic materials in the bath, such as nickel or cobalt, on a prepared surface of a metal or a tape to form a magnetic member.

The articles of manufacture and the methods constituting this invention are especially important because they

cause a magnetic tape with optimum properties to be produced. This results in part from the fact that the magnetic materials have been successfully deposited by this invention on a polyester strip or sheet designated by the trademark "Mylar." Such a polyester is especially advantageous for use as the backing for a magnetic tape since it retains stable operating properties through a wide range of temperatures. Stability of a magnetic tape through a wide range of temperatures is particularly desirable since magnetic tapes tend to become heated because of hysteresis and eddy current losses in the magnetic deposition on the tape and because of friction between the tape and the magnetic heads when the heads are disposed in adjacent relationship to the tape. By using a polyester as the backing for the tape, the disadvantages of employing cellulose acetates as the backing are eliminated, cellulose acetate generally constituting the backings in the tapes now in use.

In the drawings:

FIG. 1 is a fragmentary sectional view of a magnetic member formed by a deposition of magnetic materials on the surface of a suitable metal, such as copper;

FIG. 2 is a fragmentary sectional view of a magnetic member formed by a deposition of magnetic materials on a thin sheet, such as a polyester, to form a magnetic tape; and

FIG. 3 is a table illustrating representative plating baths which have been used to produce the magnetic members illustrated in FIGS. 1 and 2.

As a first step in the preparation of a metallic surface such as copper for the deposition of the magnetic material, the surface is degreased. This may be accomplished in a number of different ways. One preferential method is to apply tri-chlorethylene at room temperature (70° F.) or slightly above room temperature to the surface of the metal for a suitable period of time, such as one (1) or two (2) minutes. The surface of the metal is then rinsed in water to remove the tri-chlorethylene from the metallic surface. The surface may also be dried by subjecting the surface to a blast of hot air.

The surface of the copper may then be further degreased as by applying commercial alkali to the surface of the copper at room temperature (70° F.) or slightly above room temperature. Such commercial alkali may comprise sodium hydroxide (NaOH) mixed in water to have a concentration of approximately five percent (5%) by weight. A material designated by the trademark "Oakite" may also be used.

After the surface of the metal, such as copper, has been treated in the manner set forth above, the surface of the metal is immersed in a solution of nitric acid (HNO_3) until an etching of the surface is obtained. Preferably the concentration of the nitric acid in the solution is less than twenty-five percent (25%). The surface of the metal is immersed in the solution of nitric acid until the surface of the metal changes to a color paler than its previous color. This may result from the removal of the first molecular layer on the copper surface to increase the chemical reactivity of the newly exposed layer.

A test may be made as to the operation of the nitric acid in removing the molecular layer of copper at every position along the surface of the copper. This test may be made by running water over the newly exposed surface of the copper. If the water runs over the surface of the copper without any breaks, the removal of grease at every position on the surface of the copper is indicated.

After the surface of the metal, such as copper, is treated with the solution of nitric acid, the surface is rinsed in water to remove the nitric acid. The surface of the metal, such as copper, is then treated with a solution of palladium ions. This solution may be obtained by mixing approximately 0.1 gram of palladium chloride

($PdCl_2$) per liter of water and adding a sufficient amount of hydrochloric acid to obtain a pH between 3 and 4, preferably in the order of 3.5. The resultant solution is heated to approximately 70° C., and the surface of the metal such as copper is immersed in the heated solution for approximately one (1) minute. The surface of the copper then becomes covered with a grayish-blue layer of palladium as a result of the replacement of the copper ions by the palladium ions.

It will be appreciated that the time of immersion of the surface of the copper in the palladium solution may be varied by changing the temperature of the solution. The prepared surface of the metal such as copper may be rinsed lightly or may be immersed directly in the plating bath, which will be described in detail subsequently. The deposit of palladium on the prepared surface of the metal such as copper acts as a catalyst in obtaining the deposition of the magnetic materials, such as iron and nickel, on this surface.

When the surface for receiving the deposition constitutes a tape having a suitable composition, such as a polyester or a cellulose acetate, the surface of the tape may be prepared by some of the steps described above and by some additional steps. For example, the surface of the tape may be cleaned and degreased by applying a vapor blast to the surface of the tape. The vapor blast also acts to roughen the surface of the tape.

The surface of the tape is further degreased by applying a suitable material, such as the solution of the trichlorethylene set forth above. The surface of the tape is subsequently rinsed in water and etched by applying a solution of sodium hydroxide in a maner similar to that set forth above. After the application of the solution of sodium hydroxide, the surface of the tape is rinsed again in water.

As a next step, a reducing agent is applied to the surface of the tape. One suitable reducing agent is obtained from a solution of ten (10) grams per liter of sodium hypophosphite. This solution is applied to the surface of the tape at ambient temperatures of approximately 70° F. for a suitable period of time, such as a period of at least one (1) minute. The surface of the tape may then be lightly rinsed to retain some of the sodium hypophosphite on the surface or may not be rinsed at all. The solution of palladium chloride is then applied to the surface of the tape, such that the palladium ions in the solution become reduced by the sodium hypophosphite to molecules of palladium, which become deposited on the surface of the tape. The surface of the tape is subsequently immersed in a plating bath which may be produced in a manner similar to that set forth in detail subsequently. The palladium ions on the surface of the tape act as a catalyst to obtain the proper chemical reactions in the plating bath.

Instead of using a solution of sodium hypophosphite as described in the previous paragraph, a solution of stannous chloride may be used as the reducing agent. The stannous ions become oxidized by the palladium ions to the stannic ions and the palladium ions become reduced by the stannous ions to the molecules of palladium. The molecules of palladium become deposited on the surface of the tape to provide a catalyst for the deposition of the magnetic materials, such as the nickel and iron, on the surface of the tape. This deposition of the magnetic materials, such as iron and nickel, is obtained by employing a plating bath such as will be described in detail subsequently.

It will be appreciated that materials, such as tape, are treated with a solution containing stannous ions before the material is treated with the solution containing palladium ions. However, metals such as copper are not necessarily treated with the solution of stannous ions before the solution of palladium ions. The reason is that the ions of metals such as copper are fairly active and,

accordingly, tend to move into the solution containing the palladium and to be replaced by the palladium ions.

After the surface of the metal such as copper or the surface of the tape has been prepared in the manner set forth above, the surface is subjected to a plating bath. This bath contains certain ingredients, including magnetic materials, to obtain the deposition of the magnetic materials on the prepared surface. For example, the bath includes ions of the magnetic materials such as ions of nickel and iron to obtain the deposition of the nickel and iron on the prepared surface of the tape. The nickel and iron may be obtained from suitable salts, such as nickel acetate ($Ni(C_2H_3O_2)_2.4H_2O$) and iron sulfate ($FeSO_4\cdot 7H_2O$). The nickel and iron ions are preferably in the form of nickelous and ferrous ions, respectively.

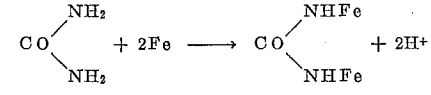
A suitable material is also included in the bath to reduce the ions of the magnetic materials to molecules for deposition of the molecules of the magnetic materials on the prepared surface of the tape. Preferably, this reducing agent is a hypophosphite such as sodium hypophosphite ($NaH_2PO_2.H_2O$).

A complexing agent is also included in the bath to prevent hydroxides of the metals, such as the hydroxides of nickel, from precipitating out of the bath. Because of the action of the complexing agent, the nickel ions are retained in the solution for reaction with the reducing agent such as the hypophosphite to obtain a deposition of molecules of the nickel on the prepared surface of the tape. The tartrate ion, such as in the form of sodium potassium tartrate ($NaKC_4H_4O_6.4H_2O$), has been used successfully as the complexing agent. Sodium potassium tartrate is well known and commercially available as Rochelle Salt. However, other ions such as the citrate ions may also be used. As will be apparent, both the tartrate and citrate ions constitute the negative ions of weak acids.

A buffer is also included to maintain the pH of the plating bath within certain desired limits. For example, ammonium hydroxide may be added as required to the bath to maintain the pH of the bath within certain limits, such as within a range of 8 to 10. The complexing and sequestering agents may also be at least partially effective in preventing the pH of the plating bath from changing rapidly. The temperature of the bath is also maintained within particular limits, such as a range of 158° F. to 194° F. corresponding to 70° C. to 90° C.

In addition to the above materials in the plating bath, an additional material is included in the bath as an important feature of the invention. This additional material constitutes a sequestering agent to prevent the iron ions in the bath from precipitating out of the bath as iron hydroxides or from being oxidized by atmospheric oxygen to iron oxide. Urea ($CO(NH_2)_2$) has been used successfully as such a sequestering agent, especially when it has been desired to stabilize in the plating bath the metallic ions having the lowest valence state, such as the nickelous and ferrous states.

When urea is used as the sequestering agent for the iron ions in the plating agent, the urea may react with the iron ions in the following manner:



Since the iron now becomes bound into the urea molecules, the iron cannot react with the ammonium hydroxide (NH_4OH) to produce iron hydroxide, which would precipitate. It will be appreciated, however, that the particular action of the urea in obtaining a deposition of the iron with the nickel on the prepared surface of the tape is not entirely certain, although the theory set forth above seems quite plausible. It will also be appreciated that the complexing agent, such as the tartrate radical, may also be partially effective in preventing the iron from precipitating out of the plating bath as iron hydroxide,

especially when the tartrate radical is combined with the sequestering agent, such as urea. However, the tartrate radical is not effective without the sequestering agent, such as urea, in preventing the iron from precipitating out of the plating bath as iron hydroxide.

As Brenner has indicated in his papers relating to electroless depositions, the reactions of the various materials with nickel in the plating bath are as follows:

$$Ni(C_2H_3O_2)_2 \cdot 4H_2O + NaH_2PO_2 \rightarrow$$
$$Ni + 2HC_2H_3O_2 + NaH_2PO_3 + 3H_2O$$

By analogy, the reaction of the various materials with iron in the plating bath is as follows:

$$FeSO_4 \cdot 7H_2O + NaH_2PO_2 \rightarrow$$
$$Fe + H_2SO_4 + NaH_2PO_3 + 6H_2O$$

Since acids are produced by the reactions set forth above, they have to be neutralized by the addition of ammonium hydroxide (NH_4OH) to maintain the pH of the plating bath within the desired limits of 8 to 10.

A magnetic member produced by the deposition of magnetic materials on a non-magnetic metallic surface is indicated somewhat schematically in FIG. 1. As will be seen, the magnetic member is generally indicated at **10** and is formed from a metallic member **12** and a magnetic deposition **14** on the surface of the member **12**. Similarly, a magnetic member generally indicated at **16** in FIG. 2 is illustrated as being formed by a magnetic deposition **18** on a non-metallic sheet **20**.

Various plating baths have been employed by deposit, by electroless techniques, magnetic materials including iron and an additional telement such as cobalt and nickel. For example, representative plating baths are listed below in FIG. 3. As will be seen, the amount of the nickel salt relative to the amount of the iron salt in each of the second and third representative baths in FIG. 3 is in the ratio of approximately 2:1, whereas the ratio of the nickel and iron salts in the first representative bath in FIG. 3 is in the ratio of approximately 3:1. This causes the relative amounts of nickel and iron in the depositions produced from each of the second and third representative plating baths in FIG. 3 to be substantially constant.

A spectrographic analysis of magnetic films obtained from the first representative plating bath in FIG. 3 has shown the following elements to be present:

Element:	Percentage of element by weight
Nickel	82.65
Iron	10.25
Palladium	2.60
Phosphorus	2.00
Total traces of other elements	2.50

The other elements in the depositions in the form of traces may include silicon, calcium, magnesium, tin, copper, silver, gold, boron, manganese, lead, aluminum, zinc, titanium, and chromium. Practically all of these elements have a concentration of less than 0.75% by weight in the deposition. They may result from impurities in the materials included in the plating bath.

It should be appreciated that the amount of iron in the deposition may be varied by providing corresponding variations in the amount of the ferrous salt in the plating bath. For example, by employing a ratio of approximately 2:1 between the nickelous and iron ions, as in the second and third representative plating bath in FIG. 3, the iron content becomes increased so that the amount of nickel constitutes approximately eighty percent (80%) by weight and the amount of iron constitutes approximately twenty percent (20%) by weight of the magnetic material and the magnetic material constitutes approximately ninety-three percent (93%) of the magnetic deposition by weight. Such a composition corresponds to that designated by the trade mark "Permalloy." This composition is known to exhibit a hysteresis loop with rectangular characteristics. A magnetic material is said to exhibit a hysteresis loop with rectangular characteristics when the magnetic field required to drive the material from a flux staturation of one polarity to a flux saturation of an opposite polarity remains substantially constant at successive positions along the hysteresis curve.

It will be appreciated that other materials than nickel may be used in the plating bath with the iron ions. For example, the nickel salt in the plating bath may be replaced by an equivalent amount of the cobalt salt to obtain a cobalt-iron deposition. Such depositions may be desired under certain circumstances. By way of further illustration, depositions of nickel, cobalt and iron may also be produced for certain special purposes, and depositions including manganese with iron and other magnetic materials may also be produced.

The depositions produced by this invention are especially advantageous since they are applied in a chemically and physically adherent relationship to a variety of different surfaces, including metals and plastic materials. The depositions are even applied in an adherent relationship to such chemically inert surfaces as polyesters. Such polyesters have been designated by E. I. du Pont de Nemours of Wilmington, Delaware, as "Mylar." The use of thin sheets of polyesters as tapes is especially advantageous because the characteristics of the sheets remain substantially contant through a wide range of temperatures. This is important because tapes tend to heat as a result of friction between the tape and magnetic heads which are disposed in contiguous relationship to the tape.

Magnetic tapes produced by electroless depositions tend to retain the magnetic materials on the tape even when the tape rubs against a magnetic head as it moves past the head. This is also true of magnetic depositions produced on metals such as copper by electroless techniques. Furthermore, the magnetic heads do not tend to wear even though they rub against the magnetic depositions as the depositions move past the heads. These advtantages are obtained because the magnetic depositions produced by electroless techniques are quite smooth and uniform in thickness and have particles of small size. Such advantages are not obtained from the magnetic members such as tapes now available on a commercial basis.

The thickness of the magnetic deposition on the prepared surface, such as on the surface of a polyester tape, is dependent upon the magnetic characteristics desired. For example, the rectangular characteristics of the hysteresis loop tend to increase with decreases in the thickness of the magnetic deposition on the prepared surface. The thickness of the magnetic deposition on the prepared surface is also dependent upon the parameters of the plating bath, such parameters including the temperature of the plating bath and the time of application of the plating bath to the prepared surface. For example, the thickness of the deposition initially increases at a rate of approximately 0.2 mil to 0.3 mil per hour at a temperature of approximately 70° C. for the plating bath. Similarly, the thickness of the deposition initially increases at a rate of approximately 1.0 mil to 1.5 mils per hour at a temperature of approximately 90° C. Furthermore, the rate of deposition increases with increases in the size of the bath and upon the agitation of the bath. It will be appreciated that the rate of deposition tends to decrease somewhat as the plating bath continues to be applied to the prepared surface, such as the surface of the tape. When the tape is to be used as a memory in a computer, the polyester sheet may have a thickness in the order of 0.0005 to 0.001 inch and the deposition on the sheet may have a thickness in the order of approximately 0.000004 to 0.000050 inch.

It is to be understood that the form of the invention herein described is the preferred embodiment, and that various changes in the materials used and method steps, and in the shape, size and construction of the resulting products may be resorted to without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. A magnetic tape, including,
a thin sheet having at least a first surface and made from a polyester;
a thin layer of palladium directly bonded to the first surface of the thin sheet; and
a magnetic material firmly and directly bonded to at least the thin layer of palladium on the sheet and consisting of a deposition of iron and an additional element from a group consisting of cobalt and nickel where such additional element has magnetic properties when included with iron and is in larger proportion than iron, said iron constituting at least 10% of the magnetic material.

2. The combination as set forth in claim 1 in which the magnetic material is firmly and directly bonded to the thin layer of palladium on the sheet along the entire first surface of the sheet.

3. A method of electrolessly depositing on a surface a magnetic material including the element of iron and a second element selected from the group consisting of cobalt and nickel, including the steps of:
cleaning the surface to prepare the surface for the deposition of the magnetic material including the iron;
sensitizing the surface by applying to the surface a bath containing palladium ions; and
immersing the sensitized surface in a bath including ions of iron and the second element, including a reducing agent to reduce the ions of iron and the second element, a complexing agent to prevent the precipitation of the second element from the bath and including urea as a sequestering agent to prevent the precipitation of the iron from the bath and for a sufficient length of time to provide for a controlled deposition on the prepared surface of the magnetic material including the iron and the second element.

4. The method set forth in claim 3 in which the complexing agent is obtained from a group consisting of tartrates and citrates and in which the reducing agent is a hypophosphite.

5. A method of electrolessly depositing on a surface magnetic materials including iron and a second element selected from a group consisting of cobalt and nickel, including the steps of:
chemically cleaning the surface to prepare the surface for the deposition of the magnetic materials;
sensitizing the surface by applying to the surface a bath containing palladium ions; and
applying to the sensitized surface, for a sufficient period of time to obtain the deposition of the magnetic materials including iron on the prepared surface, a bath including ions of the magnetic materials including iron, a reducing agent to reduce the ions of the magnetic materials to molecules for the deposition of the molecules on the prepared surface and urea as a sequestering agent to prevent the precipitation of the iron from the bath and a complexing agent to maintain the concentration of the magnetic ions in the bath.

6. The method set forth in claim 5 in which the complexing agent is obtained from a group consisting of tartrates and citrates and in which the reducing agent is a hypophosphite.

7. A magnetic article including:
a non-magnetic member having a first surface for receiving a magnetic layer;
a thin layer of palladium directly bonded on the first surface of the thin sheet; and
a magnetic material firmly and directly bonded on the layer of palladium on the non-magnetic member along the entire area of the first surface of the non-magnetic member and consisting of a deposition of the elements of iron and at least one additional element from a group consisting of cobalt and nickel where the additional element has magnetic properties when included with iron and is in greater proportion than iron, said iron constituting at least 10% of the magnetic material.

8. The magnetic member set forth in claim 7 in which the non-magnetic member is a metal.

9. A method of electrolessly depositing on a surface a magnetic composition including the element of iron and including an additional material selected from a group consisting of cobalt and nickel, including the steps of:
cleaning the surface to prepare the surface for the deposition of the magnetic composition;
sensitizing the surface by applying to the surface a bath containing palladium ions; and
disposing the sensitized surface in a bath, for a sufficient period of time to obtain the disposition of the magnetic composition including the element of iron and the element of the additional material on the prepared surface, including ions of the additional material in the range of 8 to 10 grams per liter, ions of iron in the range of 10 to 15 grams per liter, urea in the range of 10 to 60 grams per liter, a complexing agent in the range of 50 to 120 grams per liter to prevent precipitation of the additional element from the bath and ions of hypophosphite in the range of 10 to 15 grams per liter where the urea operates to prevent the precipitation of the iron from the bath.

10. A method of electrolessly depositing on a surface a magnetic composition including iron and including an additional material selected from a group consisting of cobalt and nickel, including the steps of:
cleaning the surface to prepare the surface for the deposition of the magnetic composition;
applying a reducing agent to the surface;
applying a solution of approximately 0.1 gram of a palladium salt per liter of water to the surface to obtain a reduction of the palladium ions to molecules of palladium on the surface and to obtain a deposit of palladium ions on the surface; and
disposing the surface, for a sufficient period of time to obtain a deposition on the surface of the magnetic composition including iron and the additional material, in a bath including ferrous ions in the range of approximately 10 to 15 grams per liter, ions of elements selected from a group consisting of cobalt and nickel in the range of approximately 8 to 10 grams per liter, ions of hypophosphite in the range of approximately 10 to 15 grams per liter, urea in the range of approximately 10 to 60 grams per liter and complexing agents from a group consisting of tartrates and citrates in the range of approximately 50 to 120 grams per liter.

11. The method set forth in claim 10 in which a sufficient amount of ammonium hydroxide is included in the bath to obtain a pH between approximately 8 and 10.

12. A method of electrolessly depositing on a surface a magnetic composition including iron and including additional material from a group consisting of cobalt and nickel, including the steps of:
cleaning the surface to prepare the surface for the deposition of the magnetic composition;
applying ions of hypophosphites to the surface;
applying a solution of approximately 0.1 gram of a palladium salt per liter of water to the surface to obtain a reduction of palladium ions to molecules of palladium on the surface and to obtain a deposit of palladium ions on the surface; and
disposing the surface, at a temperature in the range of approximately 70° to 90° centigrade and for a sufficient period of time to obtain a deposition on the surface of the magnetic composition including iron and the group consisting of cobalt and nickel, in a bath including ferrous ions in the range of approximately 10 to 15 grams per liter, ions of elements selected from the group consisting of manganese, cobalt and nickel in the range of approximately 25 to 30 grams per liter, ions of hypophosphite in the range

of approximately 10 to 15 grams per liter, urea in the range of approximately 10 to 60 grams per liter and a complexing agent from a group consisting of citrates and tartrates in the range of approximately 50 to 120 grams per liter.

13. The method set forth in claim 12 in which a sufficient amount of ammonium hydroxide is included in the bath to maintain the pH of the bath within a range of approximately eight (8) to ten (10).

14. A magnetic tape, including:

a thin sheet having at least a first surface and made from a polyester;

a thin layer of palladium bonded to the first surface of the thin sheet; and

a magnetic material firmly bonded to the thin layer of palladium on the sheet and consisting of a deposition of the element of iron in the range of approximately ten percent (10%) to nineteen percent (19%) by weight, an additional element from a group consisting of cobalt and nickel in the range of approximately seventy-five percent (75%) to eighty-three percent (83%) by weight, palladium in the order of approximately 2.6 percent (2.6%) by weight and phosphorus in the order of approximately two percent (2%) by weight.

15. A magnetic article, including:

a non-magnetic member having a first surface for receiving a magnetic material;

a thin layer of palladium directly bonded to the first surface of the thin sheet; and

a magnetic material firmly bonded to the thin layer of palladium on the non-magnetic member and comprising an alloy consisting of the element of iron in the range of approximately ten percent (10%) to nineteen percent (19%) by weight, an additional element from a group consisting of cobalt and nickel in the range of approximately seventy-five percent (75%) to eighty-three percent (83%) by weight where the additional element has magnetic properties when included with iron, palladium in the order of approximately 2.6 percent (2.6%) by weight and other elements from a group consisting of silicon, calcium, magnesium, tin, copper, silver, gold, boron, lead, aluminum, zinc, titanium and chromium in the order of approximately 2.5 percent (2.5%) by weight.

16. A magnetic tape, including:

a thin sheet having at least a first surface and made from a polyester;

a thin layer of palladium directly bonded to the first surface of the thin sheet; and

a thin layer of magnetic material uniformly deposited on the polyester sheet in firmly bonded relationship

to at least the thin layer of palladium on the sheet and consisting of a substantial proportion of iron nad an even larger proportion of an additional element from a group consisting of nickel and cobalt where the additional element has magnetic properties when included with iron, said iron constituting at least 10% of the magnetic material.

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