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ELECTROLYTIC BATH FOR USE IN ELECTRODEPOSITION OF FERROMAGNETIC COMPOSITIONS

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This invention relates generally to the manufacture of ferromagnetic memory elements such as coated wires, bobbin and toroidal shaped cores, and the like, for use in present day electronic computers and data processors, and more specifically relates to new and improved electrolytic baths for use in the manufacturing of such elements which possess greatly improved magnetic and other characteristics than heretofore possible.

In most electronic computer and data processor applications, it is generally highly desirable that the magnetic memory elements be relatively small in size, require negligible expenditure of time and effort in order to be electrically connected in circuit, be physically sturdy and economical to manufacture utilizing mass production techniques, possess relatively high magnetic remanence and relatively low magnetic coercivity properties, be readily adaptable to fast switching operations measured in microseconds or less, and additionally, possess substantially rectangular hysteresis characteristics resulting in a substantially high signal-to-noise ratio.

Various attempts have heretofore been made to produce such magnetic memory elements for information storage purposes by providing an electrically conductive carrier with a relatively thin coating of an alloy having magnetic properties. Even though the use of present day electroplating techniques possess practically unlimited potentialities in the manufacture of such elements, to date however, to the knowledge of applicants, there is yet to be produced thereby any memory element which possesses the above-mentioned characteristics.

Consequently, the primary object of the present invention is to devise a new and improved aqueous electrolytic bath for utilization in the process of electrodeposition of a ferromagnetic coating onto an electrically conductive substrate whereby magnetic memory elements are produced which possess all of the above-mentioned characteristics.

Briefly, in accordance with the present invention, there has been devised a new and improved aqueous electrolytic bath for use in the process of deposition of a ferromagnetic coating on an electrically conductive substrate, in which process the substrate is subjected as a cathode to electrolytic action in the bath. Such a bath includes as essential constituents iron ions in a concentration in the range of .7 to 16 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, and a complexing agent, the bath having a pH in the range of 7.5 to 9.5.

More specifically, the plating bath preferably contains simple salts of iron and nickel in complexed form wherein iron is initially added as either a ferrous salt such as ferrous chloride ($FeCl_2 \cdot 4H_2O$), and/or as a ferric salt such as ferric chloride ($FeCl_3 \cdot 6H_2O$); nickel is preferably added to the plating bath as a simple nickel chloride salt ($NiCl_2 \cdot 6H_2O$). From the standpoint of economic availability, the chlorides are preferred, however, any salt of iron and nickel may be used provided the anion does not cause precipitation in the overall system. However, following the addition, several iron and nickel species may appear such as hydrated ions, amine complexes, metal chelates, and addition agent

complexes. The form in which nickel and iron exists in a given system depends upon many factors such as the bath pH, temperature, constituent concentrations therein of nickel, iron, ammonium, and chelating, addition, and complexing agents. It is by varying these factors that a wide range of magnetic properties is obtained. The nickel and iron species in the bulk of the solution are not necessarily the same as those species occurring in the so-called "double layer" at the cathode. It is the latter species from which deposition actually occurs and which is the ultimate importance in determining the magnetic properties of the deposit. However, the species present in the bulk of the plating solution, are instrumental in determining the nature and concentration of the species present in the cathode double-layer.

Due to the fact that the hydrated oxides of iron begin to precipitate even in acid solutions, it is necessary to utilize a complexing agent to maintain the plating bath in solution. The preferred complexing agent for this purpose is ammonium citrate $(NH_4)_2HC_6H_5O_7$. However, any material which forms a complex with the iron ions of sufficient solubility and stability is a suitable complexing agent. For example, complexing agents which may be used with equal success are sodium citrate $(Na_3C_6H_5O_7 \cdot 2H_2O)$, and potassium citrate

$$(K_3C_6H_5O_7 \cdot 2H_2O)$$

Various acids such as citric acid ($H_3C_6H_5O_7$), glycolic acid ($C_2H_4O_3$), aspartic acid ($C_4H_7O_4N$), and the sodium salt of ethylenediaminetetraacetic acid

$$(C_{10}H_{12}O_8N_2Na_4)$$

etc. may be used, provided there is no electrolytic breakdown of the complex, for example due to the occurrence of anodic oxidation during the plating process which might form oxidation products at the anode thus modifying the plating bath and, consequently, modifying the magnetic properties of the cathode deposit.

In the present invention, it is believed that the essential function of the complexing agent is to provide a soluble reservoir of iron and nickel ions from which are formed, through dynamic equilibria, the species from which the deposition actually occurs. The complexing agent must be of a concentration in the bath to supply the iron and nickel species rapidly enough through equilibria to provide a suitable concentration of species for deposition, and yet, not rapidly enough to form an appreciable amount of other species whose solubility limits are exceeded to cause precipitation in the bath. Since the complexing agent partially determines the concentration of the reactive species present in the plating bath, the choice of the particular complexing agent has an effect on the composition and structure, and consequently the magnetic properties of the cathode deposit, which influence may be modified by the other constituents of the plating system. In the preferred plating baths, it is desirable that a minimum of a molar ratio of 1 to 1 be maintained between the relative citrate and iron ion concentrations.

Ammonia is preferably added to the plating bath in the form of ammonium hydroxide (NH_4OH) to control the pH thereof. Even though it is possible to utilize the plating baths in accordance with the present invention, to prepare cathode deposits having magnetic properties without the addition of ammonia, it is desirable that the baths have a pH within the range of 7.5 to 9.5, preferably 8.5. Ammonia, aside from controlling the pH, is believed to modify the bath through complex formations and to be part of the reservoir complexes from which deposition occurs. Amines have been found to be less suitable than ammonia for controlling the bath pH, however, non-complexing bases such as sodium hydroxide (NaOH) and

potassium hydroxide (KOH) may be used with equal success, provided the amounts added to the citrate baths are of insufficient quantity to cause precipitation therein. As the plating bath is preferably operated at a temperature in the order of 90° C., the ammonia concentration is depleted due to vaporization and, consequently, it is necessary to continuously replenish the bath with ammonium hydroxide to maintain the pH thereof at the preferred 8.5 value.

Ammonium is preferably added to the plating bath in the form of ammonium chloride (NH_4Cl). As the ammonium ions exert a common ion effect on the ammonia complexes, they are believed to influence the concentration of the ionic species present in the system and thereby effect the structure and consequently the magnetic properties of the electrodeposit. Other ammonium salts i.e. ammonium sulfate $(NH_4)_2SO_4$, may be used with equal success provided precipitation does not occur in the bath as a result of the addition.

It has been found that when very small quantities of certain addition agents are added to the just described complexed type of plating bath, considerable changes take place in the crystal orientation of the deposit, which in turn, results in a corresponding change in the magnetic properties of the electrodeposit. For example, it has been discovered that selective addition of thiourea (CN_2H_4S) to the bath lowers the magnetic coercivity of the electrodeposit. The thiourea addition agent is believed to be adsorbed at the cathode and/or react with the depositing species to form ionic complexes thereof which are also readily adsorbed at the cathode. The addition of thiourea has been found, by electron microscopy, to cause a (111) crystal orientation in the electrodeposit; when no thiourea is added to the bath, a randomly oriented deposit is formed. The addition of thiourea also alters the ratio of iron to nickel in the deposit.

The simultaneous deposition of iron and nickel in the presence of the addition agent occurs at a lower deposition potential than in the simultaneous deposition of iron and nickel in the absence of the addition agent. The complex between the addition agent and the original depositing species may be detected by a shift in the polarographic half-wave potential, whereas, the adsorption of the addition agent may be determined by a lowering of the polarographic maximum. Thus, it is concluded that any addition agent which forms complexes with the originally deposited species which are readily adsorbed at the cathode and forms complexes with the originally depositing species is suitable for use as an addition agent in the complexed type of plating bath.

Other compounds suitable for use as addition agents with equal success for the above mentioned purposes are other soluble substituted thioureas such as 1-1-diphenyl-2-thiourea, 1-3-diphenyl-2-thiourea ($C_{13}H_{12}N_2S$), allylthiourea ($C_4H_8N_2S$), ethylthiourea ($C_3H_8N_2S$) etc., soluble thioamides such as thioacetamide (C_2H_5NS), soluble thiocyanates such as potassium thiocyanate (KSCN), and soluble thiosulfates such as sodium thiosulfate ($Na_2S_2O_3$) etc.

The amount of addition agent required, depends on the concentrations of the other constituents in the bath, on the conditions of deposition, and on the specific magnetic properties desired. For example, in a given bath, at higher current densities it is usually necessary to employ larger amounts of addition agents to obtain the same set of magnetic properties as before. Therefore, it is to be appreciated that the concentration of addition agent in the bath is critical for a given set of bath conditions.

Shown below in charts #1 through #6 are new and improved aqueous electrolytic baths having preferred constituent compositions in accordance with the teachings of the present invention. It is to be noted, in the upper half of each chart is given the concentration of each compound in the actual bath measured in grams per liter of aqueous solution; in the lower half of each chart, is

the concentration given in grams per liter of aqueous solution of each constituent present in solution as contributed by each compound. In each instance, the minimum, optimum, and maximum concentrations for each compound and constituent are given in tabular form. However, it is to be appreciated, of course, that the upper and lower concentration limits of each compound and constituent of the bath are not critical in that they specifically define limits above and below which is a definite zone of demarcation of all useful magnetic properties possessed by the cathode deposit.

I

Plating Bath #1 Compounds	Min.	Opt.	Max.
Ferrous Chloride ($FeCl_2 \cdot 4H_2O$) g./l.	45	50	55
Nickel Chloride ($NiCl_2 \cdot 6H_2O$) g./l.	10	20	40
Ammonium Citrate $[(NH_4)_2HC_6H_5O_7]$ g./l.	105	125	135
Ammonium Chloride (NH_4Cl) g./l.	35	50	100
pH (Ammonium Hydroxide Addition)	7.5	8.5	9.5
Plating Bath #1 Constituents	**Min.**	**Opt.**	**Max.**
Ferrous Ion g./l.	12	14	16
Nickel Ion g./l.	3	5	10
Citrate Ion g./l.	88	104	113
Ammonium Ion g./l.	12	17	34

II

Plating Bath #2 Compounds	Min.	Opt.	Max.
Ferrous Chloride ($FeCl_2 \cdot 4H_2O$) g./l.	45	50	55
Nickel Chloride ($NiCl_2 \cdot 6H_2O$) g./l.	10	20	40
Ammonium Citrate $[(NH_4)_2HC_6H_5O_7]$ g./l.	105	125	135
Ammonium Chloride (NH_4Cl) g./l.	35	50	100
Thiourea (CN_2H_4S) g./l.	.002	.02	1
pH (Ammonium Hydroxide Addition)	7.5	8.5	9.5
Plating Bath #2 Constituents	**Min.**	**Opt.**	**Max.**
Ferrous Ion g./l.	12	14	16
Nickel Ion g./l.	3	5	10
Citrate Ion g./l.	88	104	113
Ammonium Ion g./l.	12	17	34
Thiourea g./l.	.002	.02	1

III

Plating Bath #3 Compounds	Min.	Opt.	Max.
Ferric Chloride ($FeCl_3 \cdot 6H_2O$) g./l.	4	6	15
Nickel Chloride ($NiCl_2 \cdot 6H_2O$) g./l.	10	20	40
Ammonium Citrate $[(NH_4)_2HC_6H_5O_7]$ g./l.	40	50	125
Ammonium Chloride (NH_4Cl) g./l.	25	50	75
pH (Ammonium Hydroxide Addition)	7.5	8.5	9.5
Plating Bath #3 Constituents	**Min.**	**Opt.**	**Max.**
Ferric Ion g./l.	.7	1	3
Nickel Ion g./l.	3	5	10
Citrate Ion g./l.	33	42	104
Ammonium Ion g./l.	8	17	25

IV

Plating Bath #4 Compounds	Min.	Opt.	Max.
Ferric Chloride ($FeCl_3 \cdot 6H_2O$) g./l.	4	6	15
Nickel Chloride ($NiCl_2 \cdot 6H_2O$) g./l.	10	20	40
Ammonium Citrate $[(NH_4)_2HC_6H_5O_7]$ g./l.	40	50	125
Ammonium Chloride (NH_4Cl) g./l.	25	50	75
Thiorea (CN_2H_4S) g./l.	.002	.02	1
pH (Ammonium Hydroxide Addition)	7.5	8.5	9.5
Plating Bath #4 Constituents	**Min.**	**Opt.**	**Max.**
Ferric Ion g./l.	.7	1	3
Nickel Ion g./l.	3	5	10
Citrate Ion g./l.	33	42	104
Ammonium Ion g./l.	8	17	25
Thiourea g./l.	.002	.02	1

V

Plating Bath #5 Compounds	Min.	Opt.	Max.
Ferric Chloride ($FeCl_3 \cdot 6H_2O$)---g./l.	13	15	17
Ferrous Chloride ($FeCl_2 \cdot 4H_2O$)---g./l.	32	35	38
Nickel Chloride ($NiCl_2 \cdot 6H_2O$)---g./l.	10	20	40
Ammonium Citrate [$(NH_4)_2HC_6H_5O_7$]---g./l.	105	125	135
Ammonium Chloride (NH_4Cl)---g./l.	35	50	100
pH (Ammonium Hydroxide Addition)----	7.5	8.5	9.5

Plating Bath #5 Constituents	Min.	Opt.	Max.
Ferric Ion---g./l.	3	4	5
Ferrous Ion---g./l.	9	10	11
Nickel Ion---g./l.	3	5	10
Citrate Ion---g./l.	88	104	113
Ammonium Ion---g./l.	12	17	34

VI

Plating Bath #6 Compounds	Min.	Opt.	Max.
Ferric Chloride ($FeCl_3 \cdot 6H_2O$)---g./l.	13	15	17
Ferrous Chloride ($FeCl_2 \cdot 4H_2O$)---g./l.	32	35	38
Nickel Chloride ($NiCl_2 \cdot 6H_2O$)---g./l.	10	20	40
Ammonium Citrate [$(NH_4)_2HC_6H_5O_7$]---g./l.	105	125	135
Ammonium Chloride (NH_4Cl)---g./l.	35	50	100
Thiourea (CN_2H_4S)---g./l.	.002	.02	1
pH (Ammonium Hydroxide Addition)----	7.5	8.5	9.5

Plating Bath #6 Constituents	Min.	Opt.	Max.
Ferric Ion---g./l.	3	4	5
Ferrous Ion---g./l.	9	10	11
Nickel Ion---g./l.	3	5	10
Citrate Ion---g./l.	88	104	113
Ammonium Ion---g./l.	12	17	34
Thiourea---g./l.	.002	.02	1

Even though each of the just tabulated electrolytic baths find utility in a great many of the numerous present day electroplating processes, a preferred process will now be described which utilizes the novel baths of the present invention to fabricate new and improved magnetic data storage devices of the "twistor" type as shown and described in copending application Serial No. 696,987, by J. R. Anderson et al., filed November 18, 1957, and assigned to the present assignee.

After each of the just described electrolytic baths has been prepared having preferred constituent concentrations in accordance with either of tabulated baths #1 thru #6, the pH thereof is adjusted to a value in the range of 7.5 to 9.5, preferably 8.5, by the addition thereto of a suitable amount of ammonium hydroxide (NH_4OH). Even though the bath may successfully be operated at ordinary room temperature, the temperature thereof is nevertheless adjusted to a value in the range of 80° C. to 95° C., preferably 90° C. and then introduced into a conventional rubber-lined steel plating tank, or an equivalent glass or inert plastic container. The substrate, onto which the electrodeposit is to be formed, may be composed of any of a variety of electrically conductive materials such as copper, aluminum, silver, brass, bronze or alloys thereof. The physical shape of the substrate is not critical and even may be an extremely thin electrically conductive film which is mechanically supported by an insulating material such as glass, plastic, ceramic or the like. However, it is preferred that the substrate be in the form of a phosphor-bronze wire having a diameter of approximately 9 mils. It is, of course, necessary that the metallic substrate be cleaned in a conventional manner before plating, through the use of any of the well known alkaline-acid-water methods as used by present day plating industries.

As in the aforementioned copending application, it is herein desirable to secure on the substrate a relatively thin ferromagnetic deposit having a thickness in the order of one ten-thousandth of an inch so as to maintain eddy current losses therein at a minimum and yet be thick enough to insure adequate "readout" voltages during operation

of the device as a memory element. Consequently, it is necessary that the substrate be exposed as a cathode to electrolytic action in the bath for only a short period of time, preferably in the order of 1 minute, depending upon of course the particular value of cathode current density chosen to be used in the plating process. To accomplish this, the process is made a continuous one whereby the wire substrate is moved through the bath at a constant speed, by any well known means, with electrical contact at all times being maintained with the substrate to supply the plating current thereto. It is also preferred that the substrate be centrally encompassed at all times, while in the bath, by a helical shaped anode having a coil diameter of approximately one inch and composed of an electrically conductive wire of approximately 50 mils in diameter.

The choice of anode material may not be arbitrarily made, however anodes of iron, nickel and tungsten, and alloys thereof may be successfully used provided any sludge formations originating at the anode do not enter the bath solution. One of the important factors associated with the choice of anode material, is oxidation in the system. Consequently, inert anodes such as platinum, or the like, may be used provided they do not lead to excessive system oxidation. An iron-nickel anode is used in baths #5 and #6 as it tends to replenish the bath with iron and nickel ions, however, it is usually necessary to continually add iron and nickel solutions to the plating bath in order to maintain the concentrations thereof constant at their respective values during the plating process; in baths #1, #3 and #4, a platinum anode is used, whereas, in bath #2 a tungsten anode is used.

In baths using thiourea as an addition agent, a tungsten anode may be used since the addition agent prevents the deposition of tungsten at the cathode.

The current density involved in the deposition process is not critical and may range, for example, from 50 to 500 amperes per square foot of substrate surface area exposed in baths #5 and #6, however, a current density of 380 amperes per square foot is preferred. In baths #1 thru #4, the current density may range from 250 to 1000 amperes per square foot, however a current density of 500 amperes per square foot is preferred. The current density primarily determines the rate of deposition of the metallic ions onto the cathode and also affects the rate of diffusion into the cathode film which influences the amount of depositing species which must be in equilibrium with the reservoir complexes. Consequently, the bath constituents and current density of the process must be compatible, and the current density may not be arbitrarily chosen. As the current density is one of the prime factors which determine the structure of the deposit, it is generally necessary to modify the plating system to permit the use of a specific current density.

On emergence from the plating bath, the ferromagnetic element is rinsed and dried and is then ready to be incorporated into the electrical circuitry of present day electronic computers and data processors and operated as a coincident current memory element in the following manner:

The core, and the ferromagnetic coating disposed thereon, are both simultaneously twisted and the ends thereof maintained in a fixed position during operation of the device. As a direct result of the applied twisting action, the easy direction of magnetization of the magnetic coating is oriented in a helical direction throughout the entire core length, similar to the threads of a screw. Such a ferromagnetic coating has been found to possess a substantially high positive and negative magnetic remanence and a substantially rectangular hysteresis characteristic. Consequently, selected length portions of the coating, in the direction of twist, are allowed to attain one or the other of two stable conditions, respectively characterized by a positive or negative magnetic remanence. Thus, a magnetic field of $\pm H$ oersteds, along the direction of

twist, switches the length portions from one magnetic state to another, whereas, a field of $\pm H/2$ oersteds, produces only negligible changes in the magnetic remanence of the coating. Consequently, a plurality of similar coils are separately wound about the coated substrate and are positioned in a spaced side-by-side relationship with respect to one another, to encompass and thereby define a corresponding plurality of helical-path length portions of ferromagnetic material. Storage of binary information in a selected length portion of the coating is accomplished by sending a current impulse of "half-select" magnitude into the conductive wire of the common core and simultaneously sending a current impulse of "half-select" magnitude into the selected coil in such directions that the vector summation of the magnetic fields produced by both of the coincident half-select currents is at least equal in magnitude to $\pm H$ oersteds and is additionally oriented in the same direction as the essy magnetization of the coating.

During "reading" of a selected length portion of the coating, either the core or the corresponding coil is pulsed with a current impulse of "full-select" magnitude to individually develop a magnetic field of at least $\pm H$ oersteds in the opposite direction from the magnetic field developed during storage of the function. In response to the "read" impulse, an electrical signal is or is not available across the ends of the core, or the corresponding coil depending upon which one was pulsed, according to whether the binary information (1) or (0) had previously been established in that length portion of the coating encompassed by that particular coil, as represented by its positive or negative magnetic remanence.

Listed below in chart form, are the electrical operational characteristics of the magnetic data storage devices fabricated from each of baths #1 thru #6. In the chart (Ir) represents the "half-select" current impulse applied across the ends of the ferromagnetic element during storage of the function; (Is) represents the "half-select" current impulse applied across the ends of the coil during storage of the function, the coil being circumferentially wound about the ferromagnetic element in the same manner and for the same purposes as previously described; (Is') represents the "full-select" current impulse applied across the ends of the coil during reading of the function; (uV1) represents the instantaneous readout potential appearing across the ends of the ferromagnetic element indicative of any reversal of the magnetic remanence of the element, i.e. due to previous binary 1 storage; and (uV1/dV_z) represents the operational signal to noise ratio of the storage element.

	Bath #1 Element	Bath #2 Element	Bath #3 Element	Bath #4 Element	Bath #5 Element	Bath #6 Element
Ir	310 ma.	120 ma.	100 ma.	100 ma.	340 ma.	165 ma.
Is	340 ma.	92 ma.	60 ma.	33 ma.	220 ma.	50 ma.
Is'	500 ma.	500 ma.	500 ma.	500 ma.	500 ma.	500 ma.
uV1	152 mv.	50 mv.	100 mv.	144 mv.	36 mv.	18 mv.
uV1/dV_z	Approx. 13.	10	100	144	18	3.
Turns of Coil	50	20	20	50	20	20.
Coil Wire Size	#36	#36	#36	#36	#36	#36.
Element Wire Size	9 mil	9 mil	9 mil	9 mil	9 mil	9 mil.
Switching Time	1.5 μsec.	1.0 μsec.	.3μsec.	.3 μsec.	.3 μsec.	.3 μsec.
Coercivity	5 oersteds.	5 oersteds.	5 oersteds.	5 oersteds.	5 oersteds.	5 oersteds.
Hysteresis Squareness	Approx. .99.	Approx. .99.	Approx. .99.	Approx. .99.	Approx. .99.	Approx. .99.
Amt. of Twist	90°/in.	65°/in.	10°/in.	75°/in.	360°/in.	60°/in.

From the foregoing, it is now evident that in accordance with the present invention, there has been devised new and improved aqueous electrolytic baths for use in present day electrodeposition processes whereby novel magnetic data storage devices are economically fabricated by mass production techniques, possess greatly improved magnetic and other characteristics than heretofore possible and are readily adaptable for incorporation in present day electronic computers and data processors.

While particular embodiments of the invention have been shown and described, it will be obvious to those skilled in the art of electrodeposition of ferromagnetic materials, that changes and modifications may be made without departing from the invention in its broadest aspects, and therefore, the aim of the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 and including as essential constituents iron ions in a concentration in the range of .7 to 16 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, and a complexing agent capable of forming soluble iron and nickel complexes and being of sufficient concentration to prevent precipitation of said iron and nickel ions; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

2. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 and including as essential constituents ferrous ions in a concentration in the range of 12 to 16 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, and a complexing agent capable of forming soluble ferrous and nickel complexes and being of sufficient concentration to prevent precipitation of said ferrous and nickel ions; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

3. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 and including as essential constituents ferric ions in a concentration in the range of 3 to 5 grams per liter, ferrous ions in a concentration in the range of 9 to 11 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, and a complexing agent capable of forming soluble ferric, ferrous, and nickel complexes and being of sufficient concentration to prevent precipitation of said ferric, ferrous, and nickel ions; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient

to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

4. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 and including as essential constituents ferric ions in a concentration in the range of .7 to 3 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, and a complexing agent capable of forming soluble ferric and nickel complexes and being of sufficient concentration to prevent precipitation of said ferric and nickel ions; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

5. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 and including as essential constituents iron ions in a concentration in the range of .7 to 16 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, a complexing agent capable of forming soluble iron and nickel complexes and being of sufficient concentration to prevent precipitation of said iron and nickel ions, and an addition agent taken from the class comprising soluble substituted thioureas, thioamides, thiocyanates, and thiosulfates; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

6. A process in accordance with claim 5 in which the addition agent is capable of being adsorbed at said cathode and of reacting at said cathode with the original depositing species to form complexes thereof.

7. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electroyltic bath having a pH in the range of 7.5 to 9.5 and including as essential constituents ferrous ions in a concentration in the range of 12 to 16 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, a complexing agent capable of forming soluble ferrous and nickel complexes and being of sufficient concentration to prevent precipitation of said ferrous and nickel ions, and in addition agent taken from the class comprising soluble substituted thioureas, thioamides, thiocyanates, and thiosulfates; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

8. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 and including as essential constituents ferric ions in a concentration in the range of 3 to 5 grams per liter, ferrous ions in a concentration in the range of 9 to 11 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, a complexing agent capable of forming soluble ferric, ferrous, and nickel complexes and being of sufficient concentration to prevent precipitation of said ferric, ferrous, and nickel ions, and an addition agent taken from the class comprising soluble substituted thioureas, thioamides, thiocyanates, and thiosulfates; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

9. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 and including as essential constituents ferric ions in a concentration in the range .7 to 3 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, a complexing agent capable of forming soluble ferric and nickel complexes and being of sufficient concentration to prevent precipitation of said ferric and nickel ions, and an addition agent taken from the class comprising soluble substituted thioureas, thioamides, thiocyanates, and thiosulfates; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

10. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 and including as essential constituents ferrous ions in a concentration in the range of 12 to 16 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, and a complexing agent comprising citrate ions in a concentration in the range of 88 to 113 grams per liter; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

11. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 and including as esesntial constituents ferric ions in a concentration in the range of 3 to 5 grams per liter, ferrous ions in a concentration in the range of 9 to 11 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, and a complexing agent comprising citrate ions in a concentration in the range of 88 to 113 grams per liter; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said lonigtudinal axis.

12. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 and including as esesntial constituents ferric ions in a concentration in the range of .7 to 3 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per ltier, and a complexing agent comprising citrate ions in a concentration in the range of 33 to 104 grams per liter; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

13. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 and including as essential constituents ferrous ions in a concentration in the range of 12 to 16 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, a complexing agent comprising citrate ions in a concentration in the range of 88 to 113 grams per liter, and an additional agent taken from the class comprising soluble substituted thioureas, thioamides, thiocyanates, and thiosulfates; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a lonigtudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

14. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 and including as essential constituents ferric ions in a concentration in the range of 3 to 5 grams per liter, ferrous ions in a concentration in the range of 9 to 11 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, a complexing agent comprising citrate ions in a concentration in the range of 88 to 113 grams per liter, and an addition agent taken from the class comprising soluble substitued thioureas, thioamides, thiocyanates, and thiosulfates; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

15. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 and including as essential constituents ferric ions in a concentration in the range of .7 to 3 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, a complexing agent comprising citrate ions in a concentration in the range of 33 to 104 grams per liter, and an addition agent taken from the class comprising soluble substituted thioureas, thioamides, thiocyanates, and thiosulfates; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

16. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 and including as essential constituents iron ions in a concentration in the range of .7 to 16 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, a complexing agent capable of forming soluble iron and nickel complexes and being of sufficient concentration to prevent precipitation of said iron and nickel ions, and an addition agent comprising a concentration in the range of .002 to 1 gram per liter of a soluble substituted thiourea; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

17. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 and including as essential constituents ferrous ions in a concentration in the range of 12 to 16 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, a complexing agent capable of forming soluble ferrous and nickel complexes and being of sufficient concentration to prevent precipitation of said ferrous and nickel ions, and an addition agent comprising a concentration in the range of .002 to 1 gram per liter of a soluble substituted thiourea; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

18. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 and including as essential constituents ferric ions in a concentration in the range of 3 to 5 grams per liter, ferrous ions in a concentration in the range of 9 to 11 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, a complexing agent capable of forming soluble ferric, ferrous, and nickel complexes and being of sufficient concentration to prevent precipitation of said ferric, ferrous, and nickel ions, and an addition agent comprising a concentration in the range of .002 to 1 gram per liter of a soluble substituted thiourea; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

19. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 and including as essential constituents ferric ions in a con-

centration in the range of .7 to 3 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, a complexing agent capable of forming soluble ferric and nickel complexes and being of sufficient concentration to prevent precipitation of said ferric and nickel ions, and an addition agent comprising a concentration in the range of .002 to 1 gram per liter of a soluble substituted thiourea; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

20. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 by the addition of ammonium hydroxide and including as essential constituents ferrous ions in a concentration in the range of 12 to 16 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, ammonium ions in a concentration in the range of 12 to 34 grams per liter, and a complexing agent capable of forming soluble ferrous and nickel complexes and being of sufficient concentration to prevent precipitation of said ferrous and nickel ions; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

21. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 by the addition of ammonium hydroxide and including as essential constituents ferric ions in a concentration in the range of 3 to 5 grams per liter, ferrous ions in a concentration in the range of 9 to 11 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per per liter, ammonium ions in a concentration in the range of 12 to 34 grams per liter, and a complexing agent capable of forming soluble ferric, ferrous, and nickel complexes and being of sufficient concentration to prevent precipitation of said ferric, ferrous, and nickel ions; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

22. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 by the addition of ammonium hydroxide and including as essential constituents ferric ions in a concentration in the range of .7 to 3 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, ammonium ions in a concentration in the range of 8 to 25 grams per liter, and a complexing agent capable of forming soluble ferric and nickel complexes and being of sufficient concentration to prevent precipitation of said ferric and nickel ions; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

23. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 by the addition of ammonium hydroxide and including as essential constituents ferrous ions in a concentration in the range of 12 to 16 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, ammonium ions in a concentration in the range of 12 to 34 grams per liter, a complexing agent capable of forming soluble ferrous and nickel complexes and being of sufficient concentration to prevent precipitation of said ferrous and nickel ions, and an addition agent taken from the class comprising soluble substituted thioureas, thioamides, thiocyanates, and thiosulfates; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

24. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 by the addition of ammonium hydroxide and including as essential constituents ferric ions in a concentration in the range of 3 to 5 grams per liter, ferrous ions in a concentration in the range of 9 to 11 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, ammonium ions in a concentration in the range of 12 to 34 grams per liter, a complexing agent capable of forming soluble ferric, ferrous, and nickel complexes and being of sufficient concentration to prevent precipitation of said ferric, ferrous, and nickel ions, and an addition agent taken from the class comprising soluble substituted thioureas, thioamides, thiocyanates, and thiosulfates; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

25. A process for fabricating magnetic computing devices comprising the steps of: providing an aqueous electrolytic bath having a pH in the range of 7.5 to 9.5 by the addition of ammonium hydroxide and including as essential constituents ferric ions in a concentration in the range of .7 to 3 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, ammonium ions in a concentration in the range of 8 to 25 grams per liter, a complexing agent capable of forming soluble ferric and nickel complexes and being of sufficient concentration to prevent precipitation of said ferric and nickel ions, and an addition agent taken from the class comprising soluble substituted thioureas, thioamides, thiocyanates, and thiosulfates; subjecting an elongated electrically conductive carrier as a cathode to electrolytic action in said bath for a time sufficient to effect the deposition thereon of a ferromagnetic coating which has the

property of providing a particularly oriented easy direction of magnetization when stressed; and applying a torsional stress to said coating, relative to a longitudinal axis of said carrier, by an amount sufficient to establish in said coating an easy direction of magnetization which is oriented at an angle with respect to said longitudinal axis.

26. An aqueous electrolytic bath for use in the process of deposition of a ferromagnetic coating on an electrically conductive substrate, in which process said substrate is subjected as a cathode to electrolytic action in said bath, said bath having a pH in the range of 7.5 to 9.5 and including as essential constituents ferrous ions in a concentration in the range of 12 to 16 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, and a complexing agent capable of forming soluble ferrous and nickel complexes and being of sufficient concentration to prevent precipitation of said ferrous and nickel ions.

27. An aqueous electrolytic bath for use in the process of deposition of a ferromagnetic coating on an electrically conductive substrate, in which process said substrate is subjected as a cathode to electrolytic action in said bath, said bath having a pH in the range of 7.5 to 9.5 and including as essential constituents ferric ions in a concentration in the range of .7 to 3 grams per liter, nickel ions in a concentration in the range of 3 to 10 grams per liter, and a complexing agent capable of forming soluble ferric and nickel complexes and being of sufficient concentration to prevent precipitation of said ferric and nickel ions.

28. An aqueous electrolytic bath for use in the process of deposition of a ferromagnetic coating on an electrically conductive substrate, in which process said substrate is subjected as a cathode to electrolytic action in said bath, said bath having a pH of approximately 8.5 by the addition of ammonium hydroxide and including as essential constituents ferrous chloride in a concentration approximately 50 grams per liter, nickel chloride in a concentration approximately 20 grams per liter, ammonium chloride in a concentration approximately 50 grams per liter, and a complexing agent comprising ammonium citrate in a concentration approximately 125 grams per liter.

29. An aqueous electrolytic bath for use in the process of deposition of a ferromagnetic coating on an electrically conductive substrate, in which process said substrate is subjected as a cathode to electrolytic action in said bath, said bath having a pH of approximately 8.5 by the addition of ammonium hydroxide and including as essential constituents ferric chloride in a concentration approximately 6 grams per liter, nickel chloride in a concentration approximately 20 grams per liter, ammonium chloride in a concentration approximately 50 grams per liter, and a complexing agent comprising ammonium citrate in a concentration approximately 50 grams per liter.

30. An aqueous electrolytic bath for use in the process of deposition of a ferromagnetic coating on an electrically conductive substrate, in which process said substrate is subjected as a cathode to electrolytic action in said bath, said bath having a pH of approximately 8.5 by the addition of ammonium hydroxide and including as essential constituents ferric chloride in a concentration approximately 15 grams per liter, ferrous chloride in a concentration approximately 35 grams per liter, nickel chloride in a concentration approximately 20 grams per liter, ammonium chloride in a concentration approximately 50 grams per liter, and a complexing agent comprising ammonium citrate in a concentration approximately 125 grams per liter.

31. An aqueous electrolytic bath for use in the process of deposition of a ferromagnetic coating on an electrically conductive substrate, in which process said substrate is subjected as a cathode to electrolytic action in said bath, said bath having a pH of approximately 8.5 by the addition of ammonium hydroxide and including as essential constituents ferrous chloride in a concentration approximately 50 grams per liter, nickel chloride in a concentration approximately 20 grams per liter, ammonium chloride in a concentration approximately 50 grams per liter, a complexing agent comprising ammonium citrate in a concentration approximately 125 grams per liter, and an addition agent comprising thiourea in a concentration approximately .02 gram per liter.

32. An aqueous electrolytic bath for use in the process of deposition of a ferromagnetic coating on an electrically conductive substrate, in which process said substrate is subjected as a cathode to electrolytic action in said bath, said bath having a pH of approximately 8.5 by the addition of ammonium hydroxide and including as essential constituents ferric chloride in a concentration approximately 6 grams per liter, nickel chloride in a concentration approximately 20 grams per liter, ammonium chloride in a concentration approximately 50 grams per liter, a complexing agent comprising ammonium citrate in a concentration approximately 50 grams per liter, and an addition agent comprising thiourea in a concentration approximately .02 gram per liter.

33. An aqueous electrolytic bath for use in the process of deposition of a ferromagnetic coating on an electrically conductive substrate, in which process said substrate is subjected as a cathode to electrolytic action in said bath, said bath having a pH of approximately 8.5 by the addition of ammonium hydroxide and including as essential constituents ferric chloride in a concentration approximately 15 grams per liter, ferrous chloride in a concentration approximately 35 grams per liter, nickel chloride in a concentration approximately 20 grams per liter, ammonium chloride in a concentration approximately 50 grams per liter, a complexing agent comprising ammonium citrate in a concentration approximately 125 grams per liter, and an addition agent comprising thiourea in a concentration approximately .02 gram per liter.

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UNITED STATES PATENT OFFICE

CERTIFICATION OF CORRECTION

Patent No. 3,032,486 May 1, 1962

Jerome S. Sallo et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 47, for "deposited" read -- depositing --; line 48, after "cathode" insert -- , or is adsorbed at the cathode --; column 4, charts III and IV, column 1, line 4 thereof, for "g./.", each occurrence, read -- g./l --; chart IV, column 1, line 5 thereof, for "Thiorea" read -- Thiourea --; columns 7 and 8, in the chart, column 2, line 4 thereof, for "152 mv" read -- 52 mv --; column 9, line 57, for "in" read -- an --; column 10, line 35, after "coating" insert a comma; column 11, line 27, for "additional" read -- addition --; column 13, line 48, strike out "per", first occurrence.

Signed and sealed this 11th day of September 1962.

(SEAL)

Attest:

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Attesting Officer

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