

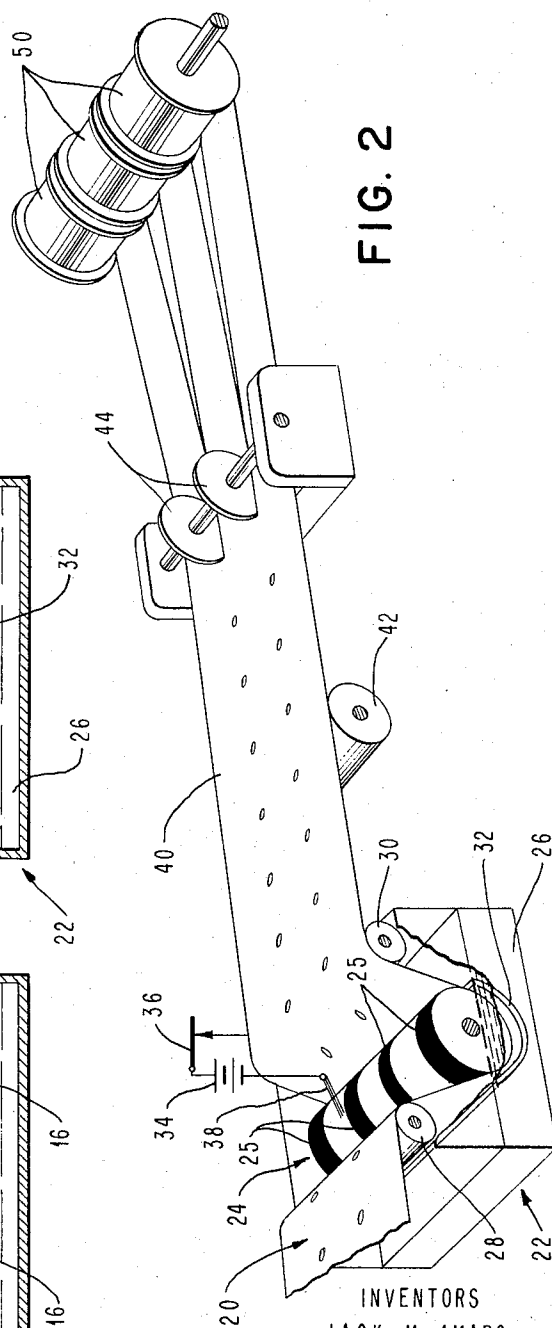
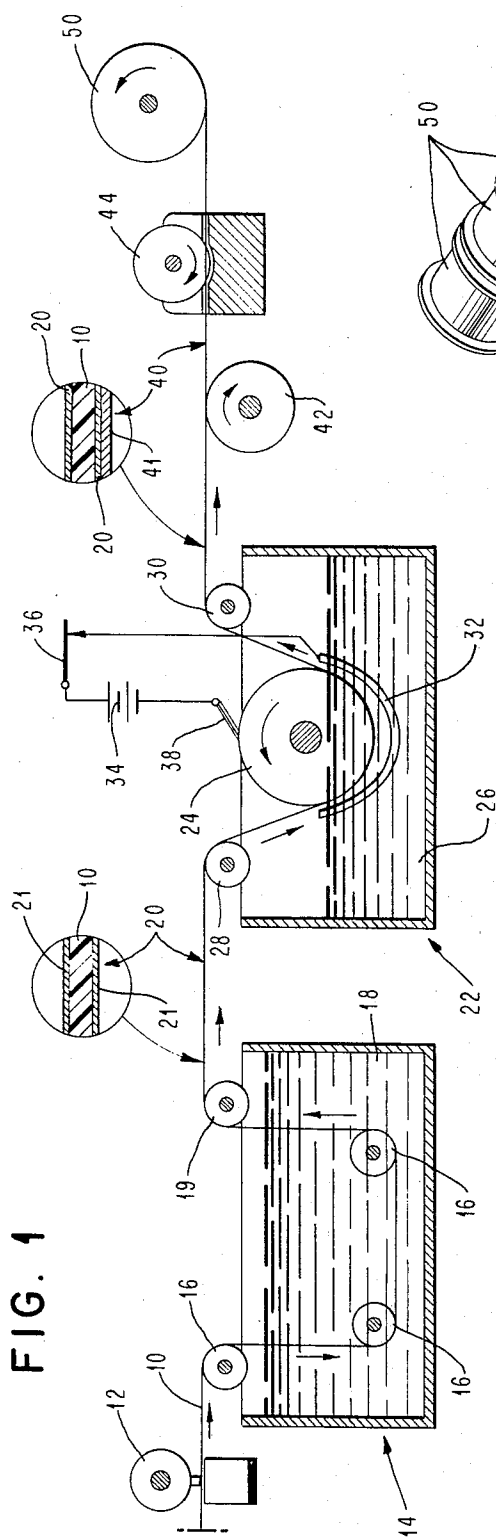
Jan. 9, 1968

J. M. AMARO ET AL  
METHOD AND APPARATUS FOR THE HIGH SPEED  
PRODUCTION OF MAGNETIC FILMS

3,362,893

Filed April 27, 1964

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 3

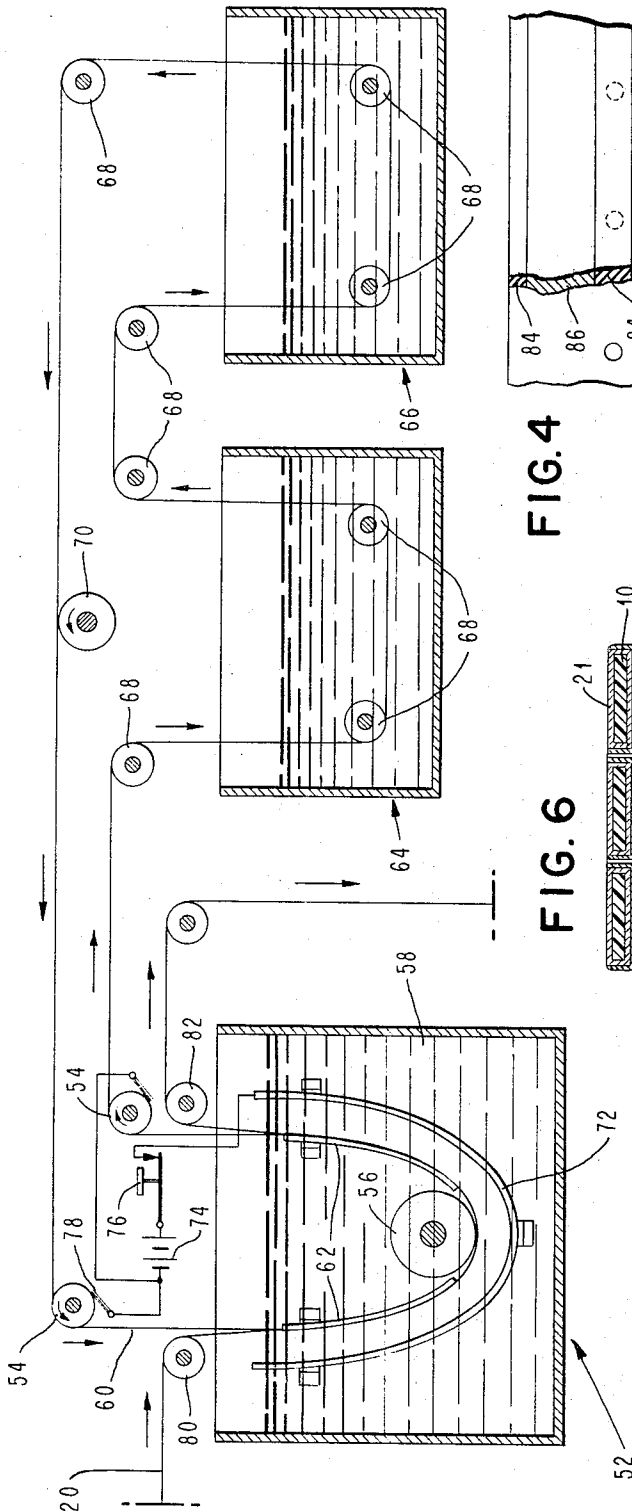


FIG. 4

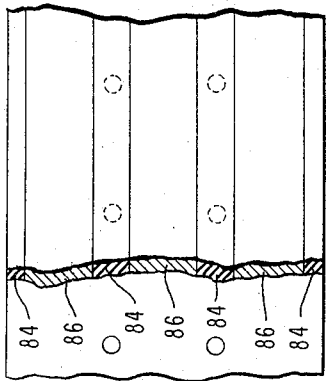


FIG. 6

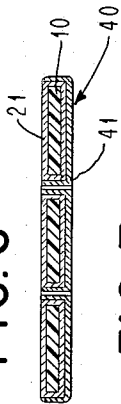


FIG. 7

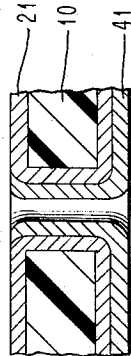
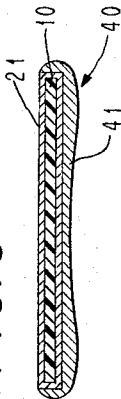


FIG. 5



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3,362,893

## METHOD AND APPARATUS FOR THE HIGH SPEED PRODUCTION OF MAGNETIC FILMS

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14 Claims. (Cl. 204—15)

This invention relates to methods and apparatuses for the deposition of a layer of metal onto the surface of a resistive article. The invention is more particularly concerned with techniques for electrodepositing at high speeds a metal layer having uniform magnetic properties onto one side of a resistive article.

The electrodeposition of a metallic coating onto an article which is resistive presents problems which are not present in the electrodeposition onto conductive metal articles. A typical article of this resistive class would include a substantially dielectric or nonconductive portion having thereover a thin film of conductive metal. The metallic coating is so thin that it is effectively resistive to the passage of an electric current in comparison to an all-metallic article of the same metal. When the resistive article is connected as the cathode of an electroplating cell, the electroplating current density will rapidly decrease from a peak current density at the power source to a value less than limiting current density of the metal ion to be electroplated due to the resistive nature of the thin metal coating.

The current carrying capacity of the conductive film on the surface of the resistive article is limited by the resistive heating of the resistive article. Resistive heating causes a degradation of the dielectric substance, particularly when the dielectric substrate is composed of a plastic material such as polyethylene terephthalate. The resistive heating also can cause a poor electrodeposit.

Prior art methods and apparatuses for electrodepositing a metallic film onto a high resistive article used exclusively cathodic contacts external to the electroplating bath. A difficulty encountered with these prior art apparatuses and methods is that the external contact produces a nonuniform current density distribution upon the resistive work piece. The current density distribution goes from a high value at the electroplating surface to a value where no significant electrodeposition can be accomplished in only a few centimeters below the bath surface. Therefore, in the case of an elongated, continuously moving article, there is no electrodeposit being applied to the surface of the work piece during most of the resistive article's path through the electroplating bath. To increase the amount of electrodeposit the speed at which the continuously moving resistive article is moved through the bath is maintained at a low value. In this way the time in which the article is in the region of significant current density is increased. However, to obtain sufficient thicknesses of electrodeposit, a series of electroplating stages is required through which the resistive article to be electroplated is passed.

An electrodeposit of a magnetic coating onto a resistive article further complicates the already difficult problem. It is, however, particularly desirable to be able to apply a thin magnetic electrodeposit to a long length of high resistive web composed, for example, of a thermoplastic base having a thin metallic coating. Such a structure could provide a superior magnetic recording tape. The tape would have an extremely low inertia and be flexible enough to travel at high speeds around bearing members such as capstans or the like. The thin magnetic layer is sufficiently thin to insure recording densities and magnetic properties substantially superior to the

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present day magnetic oxide tapes. A highly conductive metallic web cannot be successfully used as a support for the magnetic layer in a magnetic recording tape because such a web lacks the required low inertia and high flexibility properties. The alternate support then is a flexible thermoplastic web having a conductive coating on its surfaces. This initial conductive film on the thermoplastic web is very thin. The thicker this film is, the greater will be the inertia of the tape, and if made too thick it will be brittle and tend to crack. However, the thinner the film is the more resistive it is to the current flow and the more nonuniform will be the electroplating current densities where, as in the prior art, an external cathodic contact is used.

The control of the crystal size of the deposited magnetic metal is necessary to produce a magnetic recording tape having acceptable magnetic properties. The crystal size in the electrodeposit is important because the important magnetic properties of the tape, such as coercivity, are dependent thereon. The coercivity of the magnetic layer, for example, increases as the electrodeposit's crystal size decreases. Unfortunately, the electrodeposit's crystal size is dependent upon the current density. Because increased current density decreases the electrodeposit's crystal size, control and uniformity of the current density are again prime requirements. Using the prior art external cathodic contacts the current density distribution on the conductive film of the resistive web cannot be successfully controlled. Therefore, the magnetic properties of the electrodeposit are, in turn, difficult to control.

The prior art apparatuses necessarily produce magnetic layers on both sides of the resistive web. When the magnetic recording tape is used, only one side of the tape is used for recording of information. The other side of the recording tape is the surface which contacts all driving means. Therefore, there is no reason to apply a magnetic coating to more than one side of the resistive web. Further, it has been found that the magnetic coating on the back side of the magnetic tape in fact is detrimental. Over periods of time, this magnetic layer tends to wear due to its constant contact with the driving means in the start-and-stop operation of the tape. In the wear process metallic particles in the form of a dust come off of the magnetic tape and sometimes find their way onto the magnetic head or the front side surface of the magnetic tape. These dust particles can in these places cause scratching of the tape and errors in the recording of bits of information on the magnetic layer.

It is thus an object of this invention to provide a method and apparatus for depositing a metallic coating onto one side of a dielectric article.

It is another object of this invention to provide an apparatus for the high speed electroplating of a resistive article which is several times faster than prior art electroplating apparatuses.

It is another object of this invention to provide an apparatus for depositing a uniform electrodeposit onto one conductive surface of a continuously moving resistive length of article which includes a dielectric body having a conductive film thereon, wherein an electrodeposit thickness may be obtained in one electroplating stage which required three or more electroplating stages using prior art apparatuses.

It is a further object of this invention to provide an apparatus for the high speed electrodeposition of a magnetic coating onto a continuously moving resistive web having uniform and reproducible magnetic properties.

It is a further object of this invention to provide novel, economical and efficient methods and apparatuses for electrodepositing a magnetic film onto a web having a plastic base with a thin conductive coating thereover for

a magnetic recording impulse memory device, which is to be utilized in a very high-speed, high-capacity data processing system.

It is a still further object to provide methods and apparatuses for continuously electroplating a magnetic recording tape surface wherein the plating current density can be precisely controlled with the resultant improvement and reproducibility of the magnetic and physical properties of the magnetic coating.

These and other objects are accomplished in accordance with the broad aspects of the present invention by providing apparatus for depositing an electrodeposit which includes a cathodic contact which is at least partially submerged in the electroplating bath and maintaining the resistive article to be electroplated in tight contact with the submerged contact to establish electrical contact between the article and itself. An electroplating cell is used which contains an appropriate electroplating solution for depositing the desired metal coating. The one side of the resistive article is supported in tight contact to the cathodic contact for two purposes. First, to make electrical contact between the resistive article and the cathodic contact. The second purpose is to seal the electrolyte from between the article and the contact so that no electroplating can occur on the cathodic contact side of the article.

The cathodic current path is from the cathodic contact to the conductive film on the side of the resistive article pressed against the cathodic contact, around the conductive film edges of the resistive article and to the opposite side of the article which is not in contact with the cathodic contact. An anode is positioned in the electrolyte. Means are provided for causing a current to pass between the anode and the cathode and the resulting electrodeposit is deposited onto only the side of the resistive article which is not in contact with the submerged cathodic contact means.

The cathodic contact covers a large area of the resistive article and therefore a large and uniform current can be applied to the article. Since the contact is submerged within the electroplating bath, the electroplating bath will tend to cool the heat-up of the resistive article due to current flow therein. A thick electrodeposit can be deposited because of the high and uniform current density on the resistive article surface opposite to the cathodic contact. This uniform electroplating current density improves the magnetic and physical properties of the electrodeposit over prior art techniques. Also, a single electroplating stage can be used to produce the desired coating product thickness. An electrodeposit is deposited on only one side of the resistive article because the cathodic contact together with the supporting means which tightly supports the resistive article against the cathodic contact prevents the electrolyte from coming into contact with the one side of the resistive article. Should it be desired that an electrodeposit be applied to both sides of the article, the electrodeposit can readily be applied to one side at a time in the electroplating apparatus of the present invention.

The foregoing and other objects, features and advantages of the present invention will be apparent from the following more particular description of the preferred embodiments of the invention as illustrated in the accompanying drawings:

In the drawings:

FIGURE 1 is a schematic illustration of the coating apparatus of the present invention;

FIGURE 2 is a perspective view of the electroplating and slitting portions of the FIGURE 1 embodiment of the coating apparatus of the present invention;

FIGURE 3 is a schematic illustration of a second embodiment of the electroplating apparatus portion of the coating apparatus of the present invention;

FIGURE 4 is a schematic illustration partially in section, illustrating the location of the holes in the resistive

article in relation to the insulated and conductive portions of the continuous cathodic belt contact used in the FIGURE 3 embodiment of the present invention;

FIGURE 5 is a greatly enlarged sectional illustration of the one-sided electroplated product of the present invention;

FIGURE 6 is a greatly enlarged sectional illustration of another one-sided electroplated product of the present invention; and

FIGURE 7 is a greatly enlarged sectional illustration of a hole portion of the FIGURE 6 product and the hole's effect upon the electrodeposit.

Referring now more particularly to FIGURES 1 and 2, there is shown a first embodiment of the coating apparatus of the present invention. The apparatus is capable of depositing an electrodeposit onto one side of a resistive article. The invention is illustrated using a continuously moving web of resistive material, however, the invention would be equally applicable to a stationary resistive article of material. A dielectric or nonconducting web 10 passes through means 12 for making holes in the dielectric web. The hole making means 12 can be any conventional means which preferably allows continuous, rather than intermittent, movement of the web 10. The dielectric web 10 having holes therein is passed through a conditioning treatment (not shown) where necessary. In the case of a polyethylene terephthalate web a conditioning treatment is necessary to make the surface of the web receptive to the electroless deposition. The preferred treatment is described in U.S. patent application Ser. No. 138,609, filed Sept. 18, 1961, or Ser. No. 153,187, filed Nov. 17, 1961, both of which are assigned to the assignee of the present invention. The conditioning operation is not herein described in detail since it is merely incidental to the present invention. The conditioned web then passes through a means 14 for electrolessly depositing a conductive metal film 20 onto all exposed surfaces of the dielectric web, including the sides of the holes in the web. The means 14 for electrolessly depositing the conductive film includes idler rollers 16 for supporting the web on its path through the electroless plating bath 18 and a drive means 19 for pulling the web through the plating bath at the desired speed.

The electroless plating bath 18 includes chemicals which allow the plating of a conductive metal onto the nonconductive substrate by means of an autocatalytic chemical reduction reaction. This chemical or electroless plating process does not depend on the presence of a couple between galvanically dissimilar metals. Instead, the mechanism of the reaction is based on a chemical added to the plating solution which acts as a reducing agent for the metal being plated. In electroless plating, the metal ion in solution is reducing to the corresponding metal by gaining the required number of electrons. The source of these electrons is the oxidation of the reducing agent which generally in the art is the hypophosphite ion.

The web 20 leaving the means 14 for electrolessly depositing a conductive film is resistive in nature. The web 20 shown in magnified cross section is resistive because the electrolessly deposited conductive film 21 is so thin. This conductive film 21 completely covers all exposed surfaces of the dielectric body of the web 10, including the sides of the holes provided in the web by means 12.

The resistive web 20 is then passed into the means 22 for electrodepositing a metallic layer onto one side of the resistive web. The resistive web is passed around the at least partially submerged conductive member, such as conductive drum 24, within an appropriate electrolyte 26. Means, such as idler rollers 28 and 30, continuously guide the resistive web 20 around and in tight contact to the conductive drum 24. A shaped anode 32 having a curvature similar to the conductive drum 24 and spaced therefrom is positioned in the electrolyte 26. A current source, which is generally illustrated as battery 34 in the drawing, has its positive side connected to the anode 32

through switch 36. The negative side of the current source 34 is connected to the conductive drum 24 by means of a brush 38. The idler roller means 28 and 30 guide and support the resistive web in tight contact with the conductive drum 24 to establish electrical contact between the conductive film 20 and the conductive drum 24. Further, this tight contact effectively seals the electrolyte from between the resistive article and the drum.

The drum 24 preferably has continuous insulated surface areas 25 around its periphery. The areas 25 are located at the side edges of the drum and wherever a column of holes in a resistive web passes over the drum, the remaining surface areas of the drum are conductive. These insulated areas deter electroplating onto the surface of drum 24.

The current path is from the positive terminal of current source 34 through the lead to the shaped anode 32 through the electroplating bath 26, through the conductive film on the side of the web opposite end to the submerged conductive member 24. The current path continues through the conductive film around the edges of and through the holes in the resistive web to the conductive film on the side of the resistive web adjacent to the cathodic drum 24. The current path proceeds from the conductive film to the cathodic drum contact 24, across the brush contact 38 and to the negative side of the current source 34.

A large and uniform current density is applied to the conductive film 21 of the web 20 by means of the conductive drum 24 because of the large area of electrical contact between the drum and the conductive film, and the cooling effect of the bath in reducing resistive heat-up of the web 20. The higher current density, in turn, allows a faster electroplating rate than the prior art external cathodic contact had. The uniformity of current density produces a vastly superior magnetic coating in physical characteristics, such as smoothness, brightness, hardness, toughness and ductility. This is especially advantageous when electroplating an alloy because current density affects the alloy composition. The variation of the alloy along the length of the electrodeposit is, of course, very undesirable because it affects the magnetic properties along the length of the article.

An electrodeposit 41 is deposited onto only one side of the resistive web 20 in the electroplating means 22 to produce the metal coated web 40, shown in magnified cross section. The web is pulled through the bath by drive means 42 which is driven in unison with the drive means 19. The web 40 is then moved through the slitter means 44 wherein the electroplated web is cut along its length to the desired widths. Conveniently, the slitting operation can be used to eliminate all traces of the holes used in the web for maintaining the uniformity of current density during electroplating. To to this the originally punched holes are positioned along the line through which the slitting means 44 is intended to pass. The holes would thereby be cut out during the slitting operation. The cut widths of web are then rolled up on spool members 50.

FIGURE 3 illustrates the preferred embodiment of the electrodepositing apparatus for depositing a metallic layer onto one side of a resistive web 20. The electroplating means 52 in this embodiment differs from the electroplating means 22 in the first embodiment principally in the form of the cathodic contact means. The cathodic contact means includes cathodic contact rollers 54, a submerged dielectric roller 56 in a suitable electrolyte 58 and a continuous belt 60 composed of a conductive metal. The conductive contact belt 60 is continuously guided around the dielectric roller 56 and guides 62, which are preferably composed of a polytetrafluoroethylene polymer such as Teflon. It is also preferred, although not absolutely necessary, to guide the conductive belt through a stripping bath 64, followed by a rinsing bath 66. The stripping bath acts to remove electrodeposits

which tend to form on the belt's surfaces. The conductive belt 60 passes through these baths over idler rollers 68 and is moved along its path through the stripping bath, rinsing bath and back to the electroplating apparatus by means of drive roller 70. A shaped anode 72 is provided within the electroplating bath. The shape of the anode is similar to that of the conductive belt 60 as it passes in its prescribed path within the electrolyte 58.

A current source, illustrated as battery 74, has its positive side connected through switch 76 to the anode 72. The battery has its negative side connected through brush means 78 to the current contact roller 54. The resistive film is guided over the conductive belt by means, illustrated as rollers 80 and 82, for continuously guiding it around and in tight contact to the conductive belt member 60 to establish electrical contact between the conductive film on the web and effectively seal the electrolyte from the surface of the belt.

The conductive belt means is preferably constructed of a plurality of alternate conductive and dielectric belts as illustrated in FIGURE 4 when the resistive web contains holes for increasing the uniformity of the electrodeposit. However, a single belt with appropriately positioned dielectric areas could equally serve the purpose of the plurality of belts, but would be more difficult to construct. In order to counteract the action of the electrolyte touching the conductive belt through the holes, insulated belts are positioned in the areas where the holes in the resistive web would strike the belt and at the edges of the resistive web. The belt 60 would then be composed, as shown in FIGURE 4, of dielectric or nonconducting belts 84 and conductive belts 86. A series of brushes 78 would contact each of the conductive belts 86 to thereby connect the negative side of the current source 74 to the cathodic contact belt 60.

The purpose of providing holes in the dielectric web prior to electrolessly depositing a conductive film over the external surface of the web can be more readily understood by references to FIGURES 5, 6 and 7. The cathodic contact for electroplating onto the conductive film is on one side of the web. The conductive film 20 is resistive in nature, therefore the current density will be reduced proportionately as it progresses from the source of current. The region of highest current density is where the greatest electroplating occurs. This is brought out in FIGURE 5. At the corners of the web 40 the greatest amount of electrodeposit 41 is found and in the center of the electrodeposit on the web there is found the least amount of electrodeposit. The use of conductive holes is the novel solution proposed by this invention to remove this non-uniformity of current density which in turn causes a non-uniformity of electrodeposit.

FIGURES 6 and 7 show that uniformity of electrodeposit is obtained by use of conductive holes. The conductive layer 20 covers the entire external surface of the dielectric article 10, including the sides of the holes. The holes form shortened current paths to the side of the resistive web upon which an electrodeposited layer is deposited. The current paths around the edges of and through the holes in the resistive article allow the uniformity of current density with the improvement in electrodeposit.

The following examples are included merely to aid in the understanding of the invention, and variations may be made by one skilled in the art without departing from the spirit of the invention.

#### EXAMPLE 1

An elongated, polyethylene terephthalate web was first conditioned according to the treatment of U.S. patent application Ser. No. 153,187, referred to above, and then was sensitized by successive exposure to a stannous chloride solution and a palladium chloride solution with water rinsing after each exposure. The stannous chloride solution included 30 grams/liter of stannous chloride, 10 milliliters/liter hydrochloric acid and the balance water. The

palladium chloride solution included 0.1 gram/liter palladium chloride, 10 milliliters/liter hydrochloric acid and the balance water. The sensitized web at this time had a thin coating of palladium on its surface.

The sensitized web was drawn through an electroless plating bath wherein a thin film of approximately 5 to 10 micro-inches of metal was deposited onto the sensitized

This bath composition differs from the Example 1 bath composition in the addition of saccharin to the bath as a stress removing ingredient to prevent the "cupping" of the one-sided electroplated web.

Electroplating of the web was accomplished for each Example using the before mentioned electrolyte and according to the conditions below:

| Ex. | Current Density in amps. per sq. ft. | Time in Bath in sec. | Web Speed in feet/min. | Temp., °C. | Amps. | pH  | Coercivity H <sub>c</sub> in Oersteds | Remanent Magnetization in e.m.u. |
|-----|--------------------------------------|----------------------|------------------------|------------|-------|-----|---------------------------------------|----------------------------------|
| 2   | 25                                   | 12                   | 6.2                    | 53         | 2.8   | 3.4 | 750                                   | 4.3×10 <sup>-2</sup>             |
| 3   | 50                                   | 6                    | 13.3                   | 70         | 5.5   | 3.4 | 640                                   | 5.5×10 <sup>-2</sup>             |
| 4   | 75                                   | 4½                   | 18.3                   | 70         | 8.2   | 3.4 | 750                                   | 5.0×10 <sup>-2</sup>             |
| 5   | 100                                  | 3                    | 25                     | 70         | 11.0  | 3.4 | 750                                   | 5.3×10 <sup>-2</sup>             |
| 6   | 150                                  | 2                    | 37                     | 70         | 16.5  | 3.4 | 770                                   | 4.6×10 <sup>-2</sup>             |

surface. The electroless bath had the following composition and operating conditions:

|                                                                                                                |             |         |
|----------------------------------------------------------------------------------------------------------------|-------------|---------|
| Nickel sulfate hexahydrate (NiSO <sub>4</sub> ·6H <sub>2</sub> O)                                              | Grams/liter | 18.4    |
| Sodium hypophosphite monohydrate (NaH <sub>2</sub> PO <sub>2</sub> ·H <sub>2</sub> O)                          | do          | 24.4    |
| Acetic acid (CH <sub>3</sub> COOH)                                                                             | do          | 3.6     |
| Sodium acetate (NaC <sub>2</sub> H <sub>3</sub> O <sub>2</sub> )                                               | do          | 4.8     |
| Lactic acid (85%) Sp. Gr.=1.2 (CH <sub>3</sub> CHOHCOOH)                                                       | do          | 31      |
| Sodium succinate hexahydrate (Na <sub>2</sub> C <sub>4</sub> H <sub>4</sub> O <sub>4</sub> ·6H <sub>2</sub> O) | do          | 16.2    |
| Lead ion (Pb <sup>++</sup> )                                                                                   | p.p.m.      | 5       |
| pH (adjusted with sodium hydroxide NaOH)                                                                       |             | 5.2±0.6 |
| Temperature                                                                                                    | ° F.        | 180-210 |

The web was drawn from the electroless plating tank and rinsed with water.

The electroplating set-up included four electroplating cells through which the nickel coated web was drawn. Just prior to the entrance of the resistive nickel coated web into each of the electroplating cells, the web passed over a cathodic contact roller. Each electroplating cell included an electrolyte having the following composition and operating conditions:

|                                                                           |             |     |
|---------------------------------------------------------------------------|-------------|-----|
| Cobalt sulfate (CoSO <sub>4</sub> ·7H <sub>2</sub> O)                     | Grams/liter | 60  |
| Nickel sulfate (NiSO <sub>4</sub> ·6H <sub>2</sub> O)                     | do          | 40  |
| Sodium hypophosphite (NaH <sub>2</sub> PO <sub>2</sub> ·H <sub>2</sub> O) | do          | 1.0 |
| Ammonium chloride (NH <sub>4</sub> Cl)                                    | do          | 70  |
| Temperature                                                               | ° C.        | 53  |
| pH                                                                        |             | 3.4 |

The web could be effectively electroplated only a short distance from the external cathodic contact roll and the depth of immersion of the web in the electrolyte is adjusted accordingly. The current at the first electroplating station was approximately 0.5 to 2.0 amps.; at the second plating station the current was 1 to 3 amps.; at the third station the current was 1.5 to 3.5 amps.; and the current at the fourth station was between 2.0 and 4.0 amps. The resulting electroplated web had a coercivity of 600 oersteds and an M<sub>r</sub> of 7.0. The web was drawn through the electroplating baths at a speed of 10 feet per minute.

#### EXAMPLES 2, 3, 4, 5 AND 6

Polyethylene terephthalate webs were conditioned, sensitized and electrolessly plated according to the procedure of the Example 1. The FIGURE 3 electroplating apparatus was used except for the stripping and rinsing baths for the conductive belt. The electrolyte composition was as follows:

|                                                                           |             |     |
|---------------------------------------------------------------------------|-------------|-----|
| Cobalt sulfate (CoSO <sub>4</sub> ·7H <sub>2</sub> O)                     | Grams/liter | 60  |
| Nickel sulfate (NiSO <sub>4</sub> ·6H <sub>2</sub> O)                     | do          | 40  |
| Sodium hypophosphite (NaH <sub>2</sub> PO <sub>2</sub> ·H <sub>2</sub> O) | do          | 1.0 |
| Ammonium chloride (NH <sub>4</sub> Cl)                                    | do          | 70  |
| Saccharin                                                                 | do          | 2   |

The electrodeposits were on one side of the resistive web. The deposits were bright, smooth and continuous. The squareness ratios and coercivities of all examples were good.

The remanent magnetization, M<sub>r</sub>, value is a thickness measuring tool for thin magnetic layers. Using the remanent magnetization values as a guide an evaluation of the thickness of the magnetic layer electrodeposited can be made. The Example 1 apparatus required four electroplating stations to get up above the minimum value of 5.0×10<sup>-2</sup> e.m.u. for use as a magnetic record member. Examples 3, 4 and 5 obtained electrodeposits having M<sub>r</sub> values of above 5.0×10<sup>-2</sup> e.m.u. in a single electroplating station using plating speeds of up to 2½ times faster speed than the Example 1 apparatus. Examples 2 and 6 were only slightly below the minimum M<sub>r</sub> value.

The invention thus provides an apparatus and a method for substantially increasing the speed of coating a plastic article with a metallic layer over prior methods and apparatuses. Prior art apparatus required three or four electroplating operations to produce a thickness of metallic coating on a resistive article equal to what the applicant accomplishes in one electroplating operation with his novel method and apparatus. Further, the speed of electroplating has been increased from two to three or more times the prior art procedure. Another important advantage of the applicant's apparatus over the prior art apparatuses is in the elimination of the drying effect of the electrodeposit as the article passes between each electroplating cell. This drying between the cells produces a final product which is composed of layers rather than a single thickness of electroplate. The precisely controlled current densities obtained using the techniques of the present invention allow an improvement in the physical properties of the electrodeposit.

Any metal capable of being electroplated can be electrodeposited onto a high resistive article according to the methods and apparatuses of this invention. Alloys of these metals, of course, can be codeposited when suitable electrolytes known to the art are used. The ferromagnetic metals, iron, nickel and cobalt, have been very successfully codeposited from aqueous electrolytes using the techniques of the present invention.

Although the described embodiments presented are one-stage electroplating apparatuses and methods, it is obvious to one skilled in the art that more than one electroplating stage can be used. Such a multistage process allows the electrodeposit of even thicker total electrodeposits, or an electrodeposition onto each side of the resistive article, if desired. Also layers of different metals may thereby be applied one on top of another.

While the invention as been particularly shown and described with reference to the preferred embodiment thereof, it will be understood by those skilled in the art that the foregoing and other advantages in form and de-

tails may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. Apparatus for depositing an electrodeposit onto one surface of a dielectric length of article, including means arranged to guide said article through a plurality of treatment means in sequence, as follows:

means for producing holes through said dielectric length of article;

means for depositing a conductive film onto all exposed surfaces of said dielectric article having holes therein to form a resistive article; and

means for electrodepositing a metallic layer onto one side of said article, including electroplating cell means adapted to contain an appropriate electrolyte for depositing said metallic layer, electrical contact means within said cell means over which said resistive article may be guided and supported to establish electrical contact while forming a fluid tight seal between said contact means and said article, electrode means within said cell means spaced apart from said contact means, a current source having a negative side and a positive side, means for connecting the negative side of said current source to said electrical contact means and the positive side of said current source to said electrode means, thus making the electrical contact means and said resistive article in electrical contact therewith a cathode and the electrode means an anode of the electrodepositing means, whereby said electrodeposit is deposited onto only the side of said article opposite to the electrical contact means by virtue of the cathodic current path established through the said conductive film in contact with said contact means, around the edges of and through the said holes in said article, and to said opposite side.

2. The apparatus of claim 1 in which the article is a web and in which there is means for continuously moving said web through the plurality of treatment means.

3. The apparatus of claim 2 wherein the holes are made in columns along the length of said web and the contact means has non-conductive areas where the said holes in the said web are in contact with said contact means.

4. The apparatus of claim 1 in which the electrical contact means is a drum and the surface of the electrode means nearest said drum has a curvature similar to said drum.

5. The apparatus of claim 4 by which the resulting plated article is a magnetic recording media having a uniform magnetic electroplated coating.

6. The apparatus of claim 3 in which there are means for slitting said electroplated web along the column of holes.

7. Apparatus for depositing an electrodeposit onto one surface of a dielectric length of article including holes therein, including means arranged to guide said article through a plurality of treatment means in sequence, as follows:

means for depositing a conductive film onto all exposed surfaces of said dielectric article having holes therein to form a resistive article; and

means for electrodepositing a metallic layer onto one side of said article, including electroplating cell means adapted to contain an appropriate electrolyte for depositing said metallic layer, electrical contact means within said cell means over which said resistive article may be guided and supported to establish electrical contact while forming a fluid tight seal between said contact means and said article, electrode means within said cell means and spaced apart from said contact means, a current source having a negative side and a positive side, means for connecting the negative side of said current source to said electrical contact means and the positive side of said current source to said electrode means, thus

making the electrical contact means and said resistive article in electrical contact therewith a cathode and the electrode means an anode of the electrodepositing means, whereby said electrodeposit is deposited onto only the side of said article opposite to the electrical contact means by virtue of the cathodic current path established through the said conductive film in contact with said contact means, around the edges of and through said holes in said article, and to said opposite sides.

8. Apparatus for depositing an electrodeposit onto one surface of a dielectric length of article, including means arranged to guide said article through a plurality of treatment means in sequence, as follows:

means for producing holes through said dielectric length of article;

means for depositing a conductive film onto all exposed surfaces of said dielectric article having holes therein to form a resistive article; and

means for electrodepositing a metallic layer onto one side of said article, including electroplating cell means adapted to contain an appropriate electrolyte for depositing said metallic layer, stripper containing means separate from said cell means and adapted to contain a stripping bath, a dielectric roller in said cell means, electrical contact roller means outside of said cell means, a continuous belt composed of conductive material continuously guided through said cell means around said dielectric roller and in electrical contact with said contact roller and through said stripper containing means, a shaped electrode residing in the cell means and having a curvature similar to the path of the conductive belt through the cell means and spaced therefrom, means for continuously guiding said resistive article around and in fluid tight electrical contact with said conductive belt member within said cell means, a current source having a negative side and a positive side, means for connecting the negative side of said current source to said electrical contact roller and thereby to said conductive belt member and the positive side of said current source to said shaped electrode, whereby said electrodeposit is uniformly deposited onto only the side of said article opposite to said belt by virtue of the cathodic current path established through the said conductive film in contact with said belt, around the edges and through the said holes in said article and to said opposite side.

9. The apparatus of claim 8 in which the resulting plated article is a magnetic recording media having a uniform magnetic electroplated coating.

10. The apparatus of claim 8 wherein the holes are made in columns and there are means for slitting the plated article along the columns of holes.

11. The apparatus of claim 8 wherein the conductive belt has at least one continuous insulated area around its peripheral length and its remaining peripheral surfaces being composed of conductive material and there are guide means for positioning the column of holes in the article over said insulated portion of the belt.

12. A method for uniformly electroplating a dielectric substrate comprising:

providing holes through the dielectric body;

depositing a conductive film onto all exposed surfaces of said body having holes therein to produce a resistive substrate;

placing said resistive substrate in a suitable electrolyte;

providing an anode in said electrolyte;

applying a cathodic contact to one side of said substrate;

passing an electroplating current between said anode and said conductive film whereby a uniform current density is established on the side of the web opposite

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to said cathodic contact by virtue of the current paths established through the said holes and which allows a uniform electrodeposit thereon.

13. The method of claim 12 whereby magnetic recording media is produced, the holes are punched in columns, and the plated substrate is slit along the said column of holes.

14. The method of claim 13 wherein the cathodic contact is a conductive belt which is continuously moved through the plating solution, a deplating solution, and a rinsing solution to provide a cathodic belt which is free of surface impurities at all times.

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