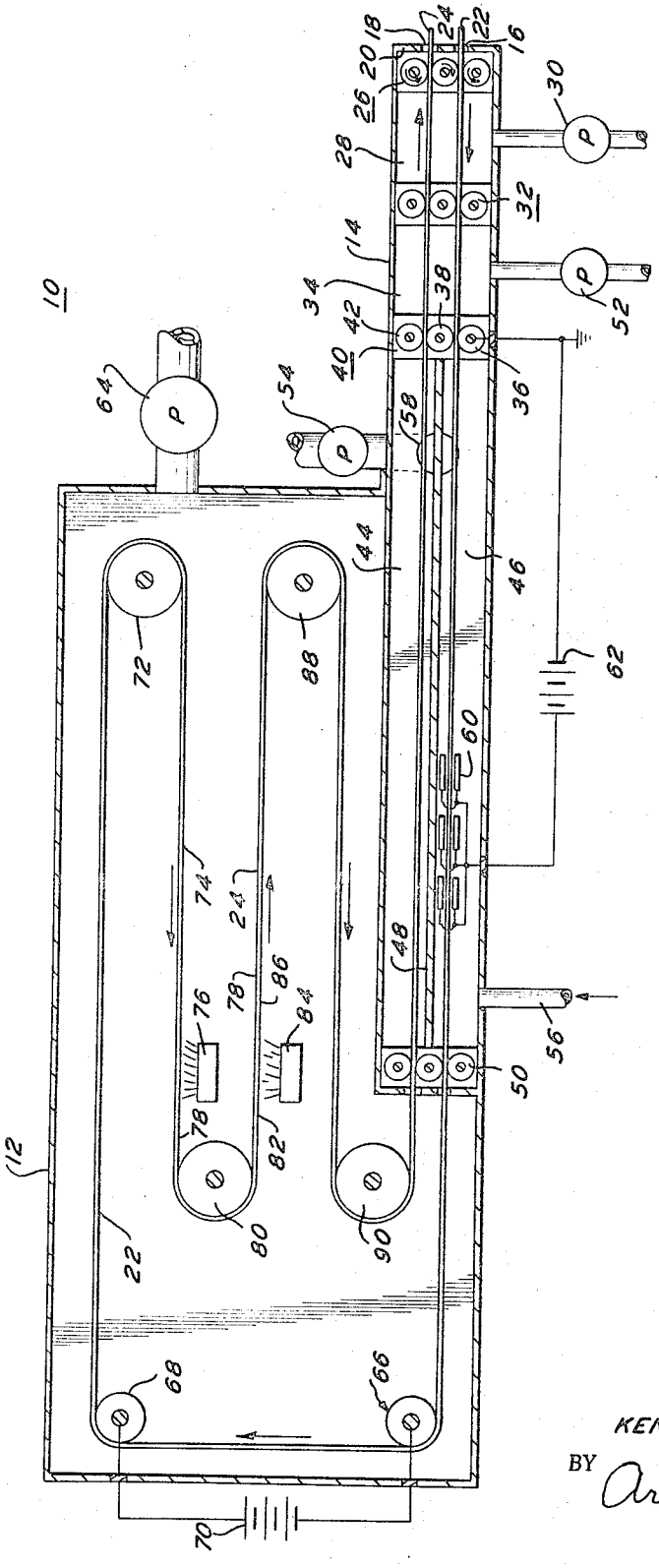
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METAL VAPOR COATING APPARATUS

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METAL VAPOR COATING APPARATUS

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This invention relates to a new and improved method of and apparatus for coating metals and/or other conducting substrates and more particularly to the coating of both sides of a metal strip with different thicknesses for the coatings on each side.

In the past, metal such as iron has been galvanized by immersing the metal in a bath of zinc, covered with a flux, at a temperature of 425 to 500° C. This process had the limitation that equal thicknesses were deposited on both sides of the metal.

Further, the hot dipping process discussed above was only continuous for thicknesses above .001 inch. When the desired thickness was less than .001 inch, the coating became discontinuous. Further, it was necessary to allow for the action of the fluxes for control of the zinc iron interface and for thickness control so that the speed of the galvanizing line was limited to three to four hundred feet per minute. Further, it was not economically feasible to differentially coat the metal.

Differential coating of metal is desirable as a commercial solution to the automation of resistance welding. Thus, in resistance welding, the zinc which comes in contact with the copper electrodes of the resistance welder should be minimized. The zinc attacks these electrodes. Thus, only 8% of the copper electrode life is realized when a typical hot dipped galvanized coating of one ounce per square foot per side is resistance welded to another such sheet. Further, galvanizing by the hot dipping method gives a roughened surface so that it becomes difficult to paint thereover.

The galvanizing of iron with zinc by electrodeposition from cold sulfate solutions has the same faults as the hot dipping process mentioned above. In either the electrodeposition or the hot dipping processes, the only way differential coating is presently feasible is by masking one side and coating the other and then reversing the process. Such processes are at a cost premium compared to the present invention.

Therefore, it is the general object of this invention to provide a new and improved method of coating metal vapors to an electrically conducting substrate.

Still another object of this invention is the provision of a new and better coating apparatus capable of speeds up to two thousand feet per minute.

A further object of this invention is the provision of a new and better coating apparatus which will coat a metal substrate with a coating less than .001 inch.

Other objects will appear hereinafter.

For the purpose of illustrating the invention, there is shown in the drawings a form which is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

In the drawing, there is shown a cross sectional view of the coating apparatus of the present invention generally designated by the numeral **10**.

The apparatus **10** includes a main coating housing **12** and an entrance and exit housing **14** integral therewith. It will be understood that the main housing **12** and the entrance and exit housing **14** may be vertically disposed and opposed to the horizontal disposition shown in the drawing. The entrance and exit housing **14** has a delivery opening **16** and an exit opening **18** on one wall **20** thereof.

A sheet **22** of conducting material such as iron or steel which is to form the substrate of a finished product **24** coated on both sides thereof is supplied through the delivery opening **16** to the housing **14**. The finished product **24** leaves the coating apparatus **10** of the present invention through the exit opening **18**.

The sheet **22** and finished product **24** pass through a suitable first rotary seal **26** which isolates a first vacuum chamber **28** within the housing **14** from the atmosphere. A pump **30** evacuates the first vacuum chamber **28**. A second rotary seal **32** through which the sheet **22** and finished product **24** pass separates the first vacuum chamber **28** from a second vacuum chamber **34** which still further reduces the pressure within the chamber **14**.

The sheet **22** passes between a lowermost roll **36** and a center roll **38** of a third rotary seal **40**. The finished product **24** passes between the uppermost roll **42** of the rotary seal **40** and the center roll **38** thereof. It should be noted that the rotary seals **26**, **32** and **40** are exactly similar in their sealing operation in that the rolls are all moving in the direction of the sheet **22** and the finished product **24** at the points of contact therewith.

The rotary seal between rollers **42** and **38** separates vacuum chamber **34** from a finished product vacuum chamber **44** through which passes the finished product **24**. The rollers **38** and **36** separate second vacuum chamber **34** from a sheet cleaning chamber **46**. The finished product vacuum chamber **44** and sheet cleaning chamber **46** are separated by a suitable barrier **48** and are closed at the end opposite from rotary seal **40** by a fourth rotary seal **50**. The finished product **24** and sheet **22** pass through the rotary seal **50** in the same manner as was discussed with respect to third rotary seal **40**.

The second vacuum chamber **34** is evacuated by a second pump **52**.

A suitable reducing gas such as hydrogen is supplied to the sheet cleaning chamber **46** through a conduit **56** spaced adjacent the fourth rotary seal **50**. The finished product vacuum chamber **44** and sheet cleaning chamber **46** have a common opening **58** connected to a vacuum pump **54** for evacuating the chamber **44** and maintaining the pressure within the sheet cleaning chamber **46** at a low value. The opening **58** is near the third seal **40** so that the flow of the reducing gas entering through conduit **56** is away from the fourth seal **50** thus aiding in maintaining low vacuum in the main housing **12**.

A plurality of plates **60** are provided on opposite sides of the sheet **22** and equally spaced therefrom for cleaning the sheet **22** in a manner to be discussed below.

The plates **60** are connected to the positive terminal of a battery **62** whose negative terminal is connected to the grounded lowermost roll **36** of third rotary seal **40**. Roll **36** is in continuous electrical contact with the sheet **22**. Thus, sheet **22** acts as a cathode as it passes between the plates **60**. Battery **62** may range in voltage between 100 and 3000 volts in accordance with the spacing of the plates **60**.

The sheet **22** of metal may have a layer of metal oxide and/or organic contaminates thereon. It is essential for good coating of the sheet that these layers be cleaned from the sheet on both sides thereof. The plates **60** with the voltage placed thereon by battery **62** creates a glow discharge between the plates **60** and the sheet **22** on opposite sides thereof. The sheet **22** will act as a cathode and there will be electron flow from the cathodic sheet **22** to the plates **60**. In the reducing atmosphere of hydrogen within the sheet cleaning chamber **46**, the oxide coating is thereby removed. The water vapor produced by the reaction of the hydrogen with the oxides will be removed through the opening **58** by third vacuum pump **54**.

Further, the ions which will flow from the anodes or plates **60** to the cathodic sheet **22** will physically bombard the sheet **22** in a manner which will loosen and thus remove any organic contaminates on the sheet **22**. In this manner, the oxide coating and the organic contaminates on sheet **22** are removed from both sides thereof in a simple and easy manner. Since the roll **36** is grounded, there is no danger of shock to persons coming in contact with components of the apparatus **10**. The cleaned sheet **22** then passes into main housing **12** which is evacuated by a suitable fourth vacuum pump **64**.

The sheet **22** passes over two spaced conducting rolls **66** and **68** which are electrically connected to a battery **70**. The battery **70** will act to supply high current through the sheet **22** which will resistance heat the sheet to a predetermined temperature. This step of preheating the sheet to a temperature such as between 350° and 600° F. is necessary if the sheet **22** is to be coated with a metal whose thickness is one mill or greater. Other factors affecting preheating are degree of cleanliness of sheet **22** and surface adhesion coefficient or other characteristic of the coating material.

The now preheated sheet **22** passes over a feed roller **72**. One exposed side **74** of the sheet **22** then passes over a coating metal vaporizing boat **76**.

While the conducting substrate sheet **22** of the present invention is preferably strip steel, it will be understood that other metals may be utilized therefor. Further, the present invention in its preferred form utilizes zinc as the material within the boat **76**. However, chromium, nickel, tin, or other metals might also be utilized by the process of the present invention. The strip **22** passes over the boat **76** in a horizontal plane so as to insure constant spacing of the side **74** from the boat **76**. In a preferred embodiment of the present invention, the boat **76** was spaced ten inches from the downwardly facing side **74**.

The boat **76** is heated to the temperature at which the zinc evaporates at the pressure within the main chamber **12**. The zinc will be heated above the vaporization temperature for the pressure of the chamber **12**. For example, zinc vaporizes at a temperature of 343° C. to 405° C. over a pressure range of .01 millimeter of mercury to .1 millimeter of mercury respectively. At such pressure, the zinc would be superheated to temperatures in excess of 405° C. It will be understood that the side **74** of the sheet **22** must be at a temperature less than the vaporization temperature of the zinc coating material in order to achieve vapor deposition thereon. The amount of material deposited on the side **74** can be varied by varying the temperature in the boat **76**, the size of the surface of the zinc in the boat **76** exposed to the side **74**, or by the provision of a mask spaced from the boat **76** to limit the exposed surface of the side **74**. However, the step of controlling the amount of coating material which is deposited on the side **74** of the sheet **22** as it passes over the boat **76** is considered a part of the present invention. The sheet **22** with its coating **78** on one side **72** thereof then passes over a roller **80** so that the other side **82** of the sheet **22** is then horizontally disposed over a second coating metal vaporizing boat **84** which will deposit a coating **86** on the side **82**. The boat **84** is similar to the boat **76** but may be differently controlled from the boat **76** so as to achieve a different coating **86** on the side **82** than the coating **78** achieved on the side **72** of the sheet **22**. Thus, the sheet **22** after it leaves the boat **84** will have become the finished product **24** which has two coatings **78** and **86** on opposite sides thereof which coatings may be different in thickness and/or material. The now coated sheet **22** (finished product **24**) passes around rollers **88** and **90** and through rotary seal **50** into the finished product vacuum chamber **44**. The finished product **24** continues out of the apparatus **10** through third rotary seal **40**, second vacuum chamber **34**, second rotary seal **32**, first vacuum chamber **28**, first rotary seal **26** and exit opening **18**.

Thus, the objects of the present invention have been achieved by the provision of a method for an apparatus of coating a metal substrate with a metal vapor wherein the coating may have different thicknesses on opposite sides thereof, and the coating can be less than 1 mil (.001 inch). Further, this can be achieved at a speed of two thousand feet per minute. The metal substrate is cleaned prior to the coating, and may be preheated if necessray.

It is within the scope of the present invention to have the housing **12** upright as opposed to the horizontal disposition illustrated. In that case, the portions of sheet **22** and product **24** between rollers **68**, **72**, **80**, **88** and **90** would be vertically disposed. In such an arrangement, it is easier to control the tension in sheet **22** and deflector plates will be provided above boats **76** and **84**.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

I claim:

1. Coating apparatus comprising first and second vacuum chambers, a controlled vapor deposition means in said first chamber for vapor depositing a coating on at least one side of the stripe, said second vacuum chamber having first seal means for passing a strip into said second vacuum chamber and a second seal means for passing the strip in said second vacuum chamber into said first vacuum chamber, cleaning means in said second vacuum chamber for cleaning at least one side of said strip prior to passage of the strip through said second seal means, said cleaning means including electrically conducting plates spaced from opposite sides of said strip as said strip passes through said second vacuum chamber, and means for applying an electric potential to said electrically conducting plates to thereby provide a glow discharge between opposite sides of said strip and said electrically conducting plates, said cleaning means further including means for supplying a reducing gas into said second vacuum chamber and means for removing said reducing gas from said vacuum chamber to maintain low pressure in said vacuum chamber, said first seal means including a rotary seal, means for connecting said rotary seal to said electric potential means, said rotary seal being in electrically conducting relation with the strip as it passes into said second vacuum chamber, said means for supplying a reducing gas to said second vacuum chamber being mounted adjacent said second seal means, and said means for evacuating said second vacuum chamber being mounted adjacent said rotary seal.

2. Coating apparatus in accordance with claim **1** wherein said first and second seal means each comprises three vertically disposed rollers, said strip passing between a first roller and a central roller of each seal when passing into said second vacuum chamber and said first vacuum chamber, and between a second roller and the central roller of each seal when passing out of said first vacuum chamber and said second vacuum chamber.

3. Coating apparatus comprising first and second vacuum chambers, a controlled vapor deposition means in said first chamber for vapor depositing a coating on at least one side of a strip, said second vacuum chamber having first seal means for passing a strip into said second vacuum chamber and a second seal means for passing the strip in said second vacuum chamber into said first vacuum chamber, cleaning means in said second vacuum chamber for cleaning at least one side of said strip prior to passage of the strip through said second seal means, said cleaning means including electrically conducting plates spaced from opposite sides of said strip as said strip passes through said second vacuum chamber, and means for applying an electric potential to said electrically conducting plates to thereby provide a glow discharge between opposite sides of said strip and said electrically conducting plates, said cleaning means further including

means for supplying a reducing gas into said second vacuum chamber and means for removing said reducing gas from said vacuum chamber to maintain low pressure in said vacuum chamber, said first seal means including a rotary seal, means for connecting said rotary seal to an electric potential means, said rotary seal being in electrically conducting relation with the strip as it passes into said second vacuum chamber.

4. Coating apparatus in accordance with claim 3 wherein said first and second seal means each comprises three vertically disposed rollers, said strip passing between a first roller and a central roller of each seal when passing into said second vacuum chamber and said first vacuum chamber, and between a second roller and the central roller of each seal when passing out of said first vacuum chamber and said second vacuum chamber.

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