

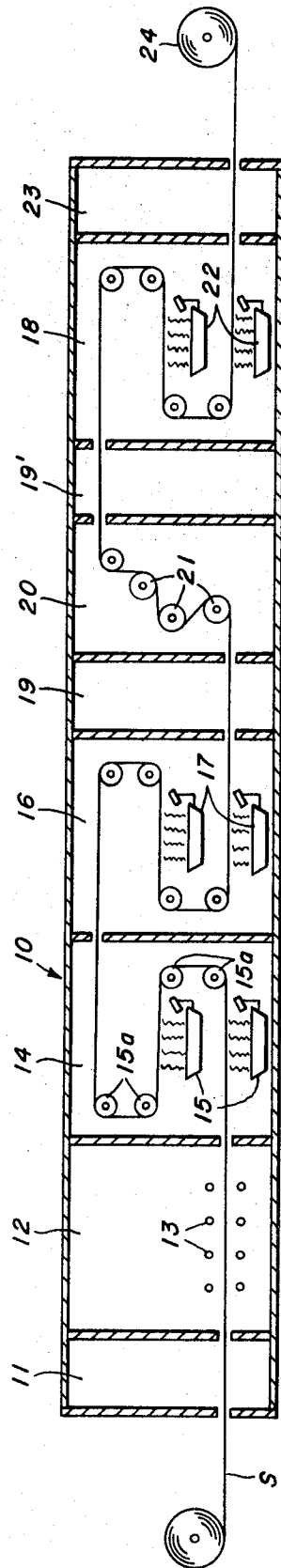
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3,594,214

METHOD OF APPLYING A ZINC COATING TO A SHEET-STEEL BASE

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3,594,214

## METHOD OF APPLYING A ZINC COATING TO A SHEET-STEEL BASE

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Continuation-in-part of abandoned application Ser. No. 561,807, June 30, 1966. This application Apr. 4, 1969, Ser. No. 822,805

Int. Cl. C23c 13/02

U.S. Cl. 117—71

1 Claim

### ABSTRACT OF THE DISCLOSURE

Low-carbon steel strip is continuously coated with a thin layer of iron by vapor deposition while at a temperature of at least 350° F. under an atmospheric pressure of not more than  $10^{-4}$  torr. The iron-coated strip is then subjected to a flash coating of zinc by vapor deposition under similar conditions. The strip is then cooled, to remove the heat adsorbed by condensation of metal vapor thereon, and a further coating of zinc applied thereto by any desired method conveniently under the same or increased atmospheric pressure, the total thickness of zinc applied being limited to less than .001".

This invention relates to a method for coating low-carbon sheet steel with a protective metal such as zinc and, in particular, to a process of coating by vapor deposition in a vacuum.

### CROSS REFERENCE TO RELATED APPLICATION

This is in part a continuation of our application Ser. No. 561,807, filed June 30, 1966, now abandoned.

### BACKGROUND OF THE INVENTION

The coating of various materials with metal by vapor deposition in a vacuum is well known. Drummond Patent 2,970,068, furthermore, discloses a refinement of such process, utilizing an intermediate bonding metal layer between the base metal or substrate and the surface layer of protective metal. When the protective layer is zinc, it must be deposited while the strip is at a temperature of 350° F. or higher to avoid failure by cracking when the composite material is subjected to the 180° bend test. At such temperature, the deposited zinc tends to re-evaporate and the strip cannot be efficiently cooled in a high vacuum to prevent this.

### SUMMARY OF THE INVENTION

We have discovered an improvement on the process of the Drummond patent whereby we apply to the substrate after deposition of the initial bonding layer, e.g., iron, a flash coating of zinc under substantially the same conditions as those under which the iron layer was deposited, i.e., a vacuum of about  $10^{-4}$  torr and a strip temperature of at least 350° F. We then apply a further coating of zinc to the substrate under different conditions, e.g., a higher atmospheric pressure ( $10^{-4}$  to  $10^{-2}$  torr) and at a temperature below 350° F., but limit the total thickness of zinc applied to less than .001".

### BRIEF DESCRIPTION OF THE DRAWING

A complete understanding of the invention may be obtained by referring to the following detailed description of the preferred practice which is illustrated diagrammatically in the annexed drawing which is a longitudinal

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vertical section through one form of apparatus by which our method may be carried out.

### DETAILED DESCRIPTION OF THE PREFERRED PRACTICE

Referring now in detail to the drawing, our method contemplates, as the preferred practice, the progressive or continuous treatment of thin, low-carbon, steel strip, e.g., black plate, in gages of, say from .005" to .030", which has been properly cleaned, in a series or group of successive chambers generally indicated at 10. Strip S is unwound from a coil and fed through a suitably sealed introductory chamber 11, evacuated to an intermediate pressure such as 10 torr. Thence the strip advances into a preheat chamber 12 provided with heating coils 13 or other suitable means effective to raise the strip temperature to at least 350° F. and preferably higher. Chamber 12 is evacuated to a pressure of not more than  $10^{-4}$  torr. There will, of course, be a certain unavoidable minimum leakage of air into chambers 11 and 12 but the pressures indicated may easily be maintained by known vacuum pumps because of the staged decrease in pressure from one chamber to the next.

The strip next passes through chamber 14 containing iron-vaporizing crucibles 15, over guide rolls 15a disposed to effect coating of both strip sides with a thin coating of iron by vapor condensation on passing over the crucibles successively. The pressure in chamber 14 is maintained at not greater than  $10^{-4}$  torr and the strip temperature as it passes over the crucibles should not be less than 350° F. If the iron is applied at a pressure of  $10^{-3}$  torr, it will oxidize and be totally ineffective as a bonding layer. The crucibles or their contents may be heated by any convenient means to the temperature necessary to insure adequate evolution of iron vapor. An example of heating means is the electron-beam gun, arranged to heat by bombardment the surface of the metal in the crucible.

On leaving chamber 14, the strip passes through chamber 16 wherein it is given a flash coating of zinc by vapor condensation vaporized from crucibles 17 similar to those shown at 15. The temperature of the strip and the pressure of the atmosphere in chamber 16 are maintained substantially the same as those in chamber 14.

After the flash coating of zinc has been applied in chamber 16 the balance of desired amount of protective metal is applied in a similar chamber 18 separated from chamber 16 by intermediate or spacing chambers 19 and 19' and a cooling chamber 20 provided with contact cooling drums 21. It is not necessary that chamber 18 be highly evacuated although some reduction of full atmospheric pressure facilitates vaporization from crucibles 22 therein. Chamber 20 may be at any pressure desired, up to full atmospheric, to facilitate strip cooling.

The total thickness of zinc coating applied, including both the flash coating and the final coating should be less than .001" otherwise the coating will not have the necessary adherence. Coatings between 0.0001 and 0.00075 have been found satisfactory.

After final coating in chamber 18, the strip is drawn through a final-stage vacuum chamber 23 and recoiled at 24 or otherwise disposed of.

Our invention affords a simple, easily performed method for obtaining highly adherent coatings of a wide range of protective metals on steel strip at low cost.

Vacuum-deposited zinc top coats 0.5 mil thick over the vacuum-deposited layers of each of these materials have been found to be adherent in "Scotch"-tape adhesion tests, whereas zinc deposited directly on a steel substrate easily peels off. In the reverse bend adhesion tests (in which four channels 3 to 4 mm. deep are formed in the test specimen, two channels with the coating on the concave surface

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and two with the coating on the convex surface, with both concave and convex channels intersecting and crossing each other) no loss or cracking of a 0.5 mil zinc coating was observed.

We claim:

1. A method of coating sheet steel with zinc which comprises heating the steel to at least 350° F., passing it through a vacuum chamber at a pressure not greater than  $10^{-4}$  torr containing vaporized iron to form an iron layer then cooling the strip below 350° F. and vapor containing zinc vapor to form a zinc layer over the iron layer then cooling the strip below 350° F. and vapor depositing thereto a further zinc coating aggregating with said zinc layer less than 0.001" in thickness.

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## References Cited

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U.S. Cl. X.R.

29—196.1, 196.5; 117—107

UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,594,214

Dated July 20, 1971

Inventor(s) Lawrence E. Helwig et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 47, "seperated" should read -- separated --.  
Column 3, line 10, "then cooling the strip below 350°F and vapor" should read -- thereon, then through a second vacuum chamber --.

Signed and sealed this 29th day of August 1972.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.  
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Commissioner of Patents