

1

3,000,756

HOT DIP ALUMINUM COATING

John E. Logan, Pittsburgh, Pa., assignor to The Wean Engineering Company, Inc., Warren, Ohio, a corporation of Ohio
No Drawing. Filed Aug. 9, 1957, Ser. No. 677,214
18 Claims. (Cl. 117—51)

This invention relates to the coating of metallic objects with an adherent ductile coating of aluminum. It is particularly useful in coating steel wire, steel strip and the like with aluminum.

It has long been customary to coat steel and other base metals with coating metals for the purpose of protecting the base metal against corrosion or to provide other surface qualities not inherent in the base metal. Such metals have been applied by hot dip processes, by electrolytic plating, or by rolling slabs of different metals together. To the best of my knowledge, all present methods of coating a base metal, such as steel, with aluminum have marked disadvantages in that they require a protective atmosphere as well as the installation of expensive equipment. Hot dip processes have been employed to deposit aluminum on steel, but even in the presence of various fluxes, they have been only partially successful. The coatings heretofore produced by the hot dipping of metallic objects in aluminum have produced coatings which are brittle. Some, for example, adhere satisfactorily only after passing the coated metal through a rolling mill. Such coatings do not adhere satisfactorily to wire. In many instances, the fluxes which have been employed for hot dipping in aluminum are poisonous, corrosive, or otherwise extremely difficult to handle.

I provide a flux selected from the group comprising phosphorus and compounds of phosphorus with sulphur. It is essential that the flux not contain oxygen in order to produce satisfactory results. I prefer to employ phosphorus free of oxygen but find that compounds of phosphorus and sulphur also produce satisfactory results.

A few examples will serve to illustrate my invention. Red phosphorus was applied to various steel specimens. For example, the phosphorus was reduced to a fine powder and then suspended in water. The phosphorus and water were then sprayed on the specimens. Upon evaporation of the water, a fine coating of phosphorus remained adhering to the metal. After application of the phosphorus, the metal was dipped in a pot of molten aluminum for a preferred time of two or three seconds under the following conditions:

Example	Flux	Temperature of Al, ° F.	Dipping Time, seconds
1.....	Powdered P ₄ in hot water sprayed on steel strip.	1,290	5
2.....	Powdered P ₄ in cold water sprayed on steel strip.	1,290	3
3.....	Powdered P ₄ in hot water sprayed on steel strip.	1,290	3

Alternatively, finely divided phosphorus may be suspended in an organic carrying agent such as alcohol.

Example	Flux	Temperature of Al, ° F.	Dipping Time, seconds
4.....	Powdered P ₄ in alcohol sprayed on steel strip.	1,330	5
5.....	Powdered P ₄ in alcohol sprayed on steel strip.	1,330	3
6.....	Powdered P ₄ in alcohol sprayed on steel strip.	1,260	1
7.....	Powdered P ₄ in alcohol sprayed on steel strip.	1,290	3

2

All of the above examples produced a product on which the aluminum coating tightly adhered to the steel underneath. It was noted that where the temperature and immersion time are both increased, the coating may tend to scale or flake off. This apparently results from the formation of an iron-aluminum alloy layer.

Alternatively, the phosphorus may be applied directly to the strip as a powder by rubbing it on with a cloth. The following tests were performed in this manner.

Example	Flux	Temperature of Al, ° F.	Dipping Time, seconds
8.....	Powdered P ₄ rubbed on steel strip with a cloth.	1,260	3
9.....	Powdered P ₄ rubbed on steel wire with a cloth.	1,290	3

When phosphorus is applied to clean mild steel in the manner described, a ductile and highly adherent coating of aluminum is produced. For example, when ordinary steel wire is coated in accordance with the invention herein, repeated flexing of the wire will not break or separate the aluminum coating from the steel until the steel itself is at the point of rupture from work hardening resulting from the repeated flexure. As noted above, the coating is apparently less ductile if the temperature of the aluminum bath and the dipping time are increased.

Compounds of phosphorus with sulphur have also been employed as fluxes with satisfactory results. For example, phosphorus pentasulfide, P₂S₅, has been employed in the same manner described for red phosphorus and has produced a satisfactory coating. The following examples are illustrative.

Example	Flux	Temperature of Al, ° F.	Dipping Time, seconds
10.....	Powdered P ₂ S ₅ in methylene chloride sprayed on steel strip.	1,260	3
11.....	Steel strip dipped in carbon disulfide suspending P ₂ S ₅ .	1,330	3
12.....	P ₂ S ₅ rubbed on steel strip with a cloth.	1,290	3
13.....	Powdered P ₂ S ₅ rubbed on steel wire with a cloth dipped in carbon disulfide.	1,290	6

In the same manner, phosphorus trisulfide, P₄S₃, has been employed to produce a useful product. The coating has, however, been less satisfactory than that produced using red phosphorus or phosphorus pentasulfide. The following example is noted as producing a reasonably satisfactory coating.

Example	Flux	Temperature of Al, ° F.	Dipping Time, seconds
14.....	Steel strip dipped in carbon disulfide in which powdered P ₄ S ₃ was suspended.	1,310	

The use of a flux containing oxygen should be avoided. Some of the phosphates, for example, may be used as fluxes, but they are quite unsatisfactory when compared to the fluxes described above.

While I have described certain present preferred embodiments of my invention, it is to be understood that I do not limit myself thereto and that my invention may be otherwise variously practiced within the scope of the following claims.

I claim:
1. The method of coating a metal with aluminum which comprises fluxing the metal with a member selected

3

from the group consisting of phosphorus and compounds of phosphorus with sulphur, and then immersing the metal in molten aluminum.

2. The product of the process of claim 1.

3. The method of coating a ferrous metal with aluminum which comprises fluxing the metal with a member selected from the group consisting of phosphorus and compounds of phosphorus with sulphur, and then immersing the metal in molten aluminum.

4. The method of coating a ferrous metal with aluminum which comprises fluxing the metal with red phosphorus, and then immersing the metal in molten aluminum.

5. The product of the process of claim 4.

6. The method of coating a ferrous metal with aluminum which comprises fluxing the metal with P_2S_5 , and then immersing the metal in molten aluminum.

7. The product of the process of claim 6.

8. The method of coating a ferrous metal with aluminum which comprises fluxing the metal with P_4S_3 , and then immersing the metal in molten aluminum.

9. The product of the process of claim 8.

10. The method of coating a metal with aluminum which comprises cleaning the metal, coating the surface of the metal with a flux selected from the group consisting of phosphorus and compounds of phosphorus with sulphur, immersing the metal in a bath of molten aluminum and then withdrawing it therefrom.

11. The method of coating a ferrous metal with aluminum which comprises cleaning the ferrous metal, coating the surface of the metal with a flux of red phosphorus, immersing the metal in a bath of molten aluminum and then withdrawing it therefrom.

12. The product of the process of claim 11.

13. The method of coating a ferrous metal with aluminum which comprises cleaning the ferrous metal, coating the surface of the metal with a flux of P_2S_5 , immersing the metal in a bath of molten aluminum and then withdrawing it therefrom.

14. The method of coating a ferrous metal with alu-

4

minum which comprises cleaning the ferrous metal, coating the surface of the metal with a flux of P_4S_3 , immersing the metal in a bath of molten aluminum and then withdrawing it therefrom.

15. The method of coating a metal with aluminum which comprises mixing a liquid with a flux selected from the group consisting of phosphorus and compounds of phosphorus with sulphur, spraying the mixture on said metal, allowing the liquid to evaporate and then immersing the metal in a bath molten aluminum and withdrawing it therefrom.

16. The method of coating a metal with aluminum which comprises mixing water and a flux selected from the group consisting of phosphorus and compounds of phosphorus with sulphur, spraying the mixture on said metal, allowing the water to evaporate and then immersing the metal in a bath of molten aluminum and withdrawing it therefrom.

17. The method of coating a metal with aluminum which comprises mixing alcohol and a flux selected from the group consisting of phosphorus and compounds of phosphorus with sulphur, spraying the mixture on said metal, allowing the alcohol to evaporate and then immersing the metal in a bath of molten aluminum and withdrawing it therefrom.

18. The method of coating a ferrous metal with aluminum which comprises mixing water and a flux of powdered red phosphorus, spraying the mixture on the metal, allowing the water to evaporate and then immersing the metal in a bath of molten aluminum and withdrawing it therefrom.

References Cited in the file of this patent

UNITED STATES PATENTS

750,511	Wherry	Jan. 26, 1904
750,512	Wherry	Jan. 26, 1904
1,456,274	Keep	May 22, 1923
1,501,293	Staack	July 15, 1924
1,910,385	Fisher et al.	May 23, 1933

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,000,756

September 19, 196

John E. Logan

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 2, third table thereof, column 3, line 1 thereof, insert -- 3 --; column 4, line 10, after "bath" insert -- of --.

Signed and sealed this 13th day of February 1962.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

DAVID L. LADD

Commissioner of Patents