United States Patent

[11] 3,595,985

[72] Inventor Walter G. Zelley
Lower Burrell, Pa.

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[73] Assignee Aluminum Company of America
Pittsburgh, Pa.

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[54] **CONVERSION COATED ALUMINUM CONDUCTOR AND METHOD FOR PREPARATION THEREOF**

8 Claims, 2 Drawing Figs.

[52] U.S. Cl. ..... 174/119 R, 29/191.6, 148/6.2, 148/31.5, 174/110 FC, 174/126 C
[51] Int. Cl. H01b 7/28
[50] Field of Search 174/110.6, 119, 126.2, 128; 29/191.6; 148/6.2, 31.5

[56] References Cited

UNITED STATES PATENTS

3,116,176	12/1963	Fuchs	148/6.2
3,256,071	6/1966	Singleton	29/191.6

FOREIGN PATENTS

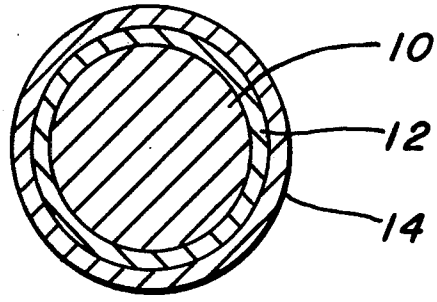
217,784	10/1958	Australia	174/126 (.2)
921,453	3/1963	Great Britain	174/110 (.6)

OTHER REFERENCES

Bellino, How To Select A Multiconductor Cable In Insulation, 12/67 pp. 64— 65

Primary Examiner—E. A. Goldberg
Attorney—Abram W. Hatcher

ABSTRACT: Preparation of aluminum conductor material and insulated multistrand cable made therefrom by zinc treatment of aluminum followed by chromate conversion coating of the thus treated aluminum and forming same into the insulated cable.



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FIG. 1.

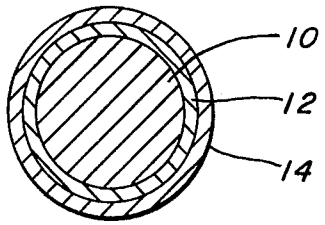
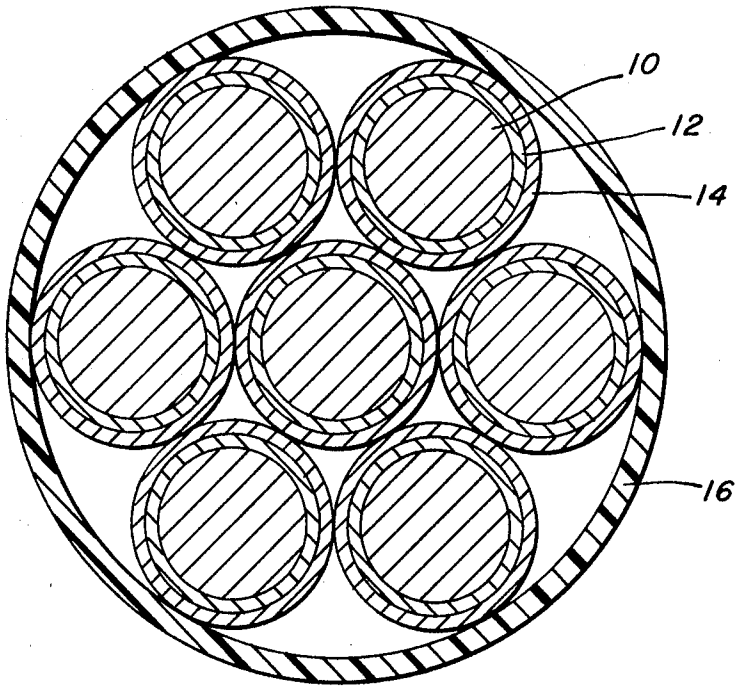


FIG. 2.



INVENTOR.
WALTER G. ZELLEY
By
Abram W. Hatcher
Attorney

CONVERSION COATED ALUMINUM CONDUCTOR AND METHOD FOR PREPARATION THEREOF

BACKGROUND OF THE INVENTION

This invention involves treatment of aluminum so as to decrease the electrical contact resistance and increase the corrosion resistance thereof. More particularly, it involves a multistrand aluminum conductor cable prepared by treatment of aluminum and the formation of a plurality of strands of the treated aluminum into an insulated cable.

U.S. Pat. Nos. 2,569,030 and 3,156,763 dealt with applying a zincate, zinciferous or zinc immersion coating to aluminum wire. The term "aluminum" as used herein and in the appended claims encompasses substantially pure aluminum, for example, commercially pure electrical conductor (EC) grade aluminum, and also commercially employed aluminum base alloys in which the elemental metal aluminum is present in amounts of at least 50 percent by weight. The purpose of this zinc treatment was to cause the aluminum to exhibit the property of a high electrical conductivity which would be retained over long periods. U.S. Pat. Nos. 2,563,430, 3,007,818 and 3,053,691 teach treating of a zinc surface or the surface of some other metal or alloy, such as steel, with a chromate conversion coating, that is, a coating containing $Cr0_3$ and sometimes a fluoride radical, to improve the corrosion resistance of the electrical equipment or like products thus treated made therefrom. U.S. Pat. No. 3,404,046 discloses treatment of a zinc or aluminum surface with a chromate conversion coating containing hexavalent chromium, sulfate and zinc ions to give it good corrosion resistance and paint bonding qualities. Despite the teaching of these patents, however, production of aluminum which has a low surface or electrical contact resistance and at the same time possesses the required high corrosion or salt-spray resistance, plus maintenance of the low surface resistance over prolonged periods of use, has not yet been achieved. This has probably been principally due to the fact that the aforementioned U.S. Pat. Nos. 2,569,030 and 3,156,763 have taught the necessity of removing the zinc coating by acid stripping and the fact that it has heretofore been taught that use of a chromate conversion coating on aluminum would necessarily lower its electrical conductivity and increase its surface resistance to such an extent that it would no longer be useful in preparation of conductor material or multistrand conductor cable. Accordingly, production of corrosion-resistant aluminum of prolonged low resistance which can be formed into a highly efficient conductor represents a highly desirable result.

SUMMARY OF THE INVENTION

It is therefore one object of this invention to provide corrosion-resistant aluminum of low surface resistance. Another object is to provide a multistrand conductor cable the aluminum wires of which have both high-corrosion resistance and low surface or electrical contact resistance. A further object is to provide a method for treating aluminum in such a manner as to impart thereto a combination of lasting low surface resistance and high-corrosion resistance as well as a method for using the resultant treated aluminum in insulated multistrand conductors or the like. Other objects will be apparent from the description and claims which follow.

In its broader aspects my invention involves zinc-coated aluminum with a chromate conversion coating formed thereon. While I do not wish to be bound by any particular theory as to how the chromate conversion coating is formed, it appears that the chromate reacts in some way with at least some of the zinc and/or aluminum so as to form a film. The zinc coating may be applied in a well-known manner, for example, by zinc plating, or by a zinc immersion treatment such as described in the aforementioned U.S. Pat. Nos. 2,569,030 and 3,156,763. The chromate conversion coating results from treatment of the zinc-coated aluminum by use of a chromate conversion coating solution, preferably one containing $Cr0_3$ and a fluoride radical. The fluoride radical in this instance may be supplied by any appropriate fluorine containing ion, for example, fluotitanate $(TiF_6)^{12}$, fluoborate $(BF_4)^1$, fluosilicate $(SiF_6)^1$, or fluoaluminate $(A1F_6)^{13}$, as well as the simple fluoride ion F^1. The $Cr0_3$ may be supplied in any known appropriate form such as, for example, chromic acid, or a chromate or bichromate. Further information as to types of chromate conversion coating solutions which may be used to treat zinc-coated aluminum according to my invention may be found in the aforementioned U.S. Pat. Nos. 3,053,691, 3,404,046 and 2,563,430.

For best results according to my invention the chromate conversion coating contains from about 0.05 to about 2.50 g./l. $Cr0_3$ and from about 0.01 to about 0.50 g./1. F^1. The preferred pH of the solution is from about 2 to about 4 and the preferred temperature of treatment from about 120° to about 200° F. It is especially desirable that the surface resistance after treatment according to the invention not exceed about 10 microhms. Especially good results are obtained by treating the zinc-coated aluminum by using a chromate conversion coating solution for from about 15 to about 60 seconds. While this is our preferred treating time it is also possible according to my invention to employ shorter or longer treatment times.

DESCRIPTION OF THE DRAWING

A further understanding of my invention may be had from an examination of the drawing which forms a part hereof.

In the drawing,

FIG. **1** is a schematic representation of a cross section of a single strand of aluminum wire containing representative zinc and chromate coatings, respectively, from the inside out, according to the instant invention.

FIG. **2** is a schematic cross section of an insulated conductor or cable made up of a plurality of strands of aluminum wire coated as in FIG. **1** circumferentially surrounding a center or axial strand, and having an insulation layer surrounding the plurality of strands of aluminum wire externally and circumferentially.

In FIGS. **1** and **2** of the drawing, the aluminum wires **10** are represented as being coated first by a zinc layer **12** and then on the outside by a chromate conversion coating **14**. The external insulation of the wires as shown stranded in cable form in FIG. **2** is represented by insulation layer **16**.

The zinc and chromate conversion coated aluminum strands such as those shown in FIG. **1** may be fashioned into the insulated aluminum conductor or cable of FIG. **2** by any appropriate known fabrication procedure, and the insulation layer, for example, polytetrafluoroethylene, applied by any appropriate known process.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following table provides examples representative of materials which may be treated according to the invention.

In these examples 6061–T6 alloy (Aluminum Association designation) may be used in the form of aluminum aircraft circuitry wire which is treated in the following manner and subsequently wound in strands into a seven-strand conductor insulated with polytetrafluoroethylene.

1. Clean for 1 minute at 160° F. in a borax-pyrophosphate nonetching cleaner.
2. Water rinse.
3. Immerse for 1 minute at 80° F. in the zinc immersion solution of U.S. Pat. 2,569,030. [100 g. of zinc oxide (Zn0) and 400 g. of caustic soda (Na0H) per liter of bath, the balance being substantially all water]
4. Water rinse.
5. Immerse for 1 minute at 160° F. in 1 percent by volume of the indicated chromate conversion coating solution.
6. Water rinse.

The following table summarizes the composition, pH, and effectiveness of various concentrations of chromate conversion coating solutions used for treating the zinc-coated 6061

alloy samples. The fluoride radical (here F^1) was added as HF and the CrO_3 by chromic acid. Substantially the same results are obtained by using NH_4HF_2 or NH_4F to supply the fluoride ion. The electrical contact resistance for the various samples in the table was measured with 0.5 inch diameter copper electrodes at 1,000-lb. pressure, using a Kelvin bridge The weight loss figures confirm the desired minimum attack on the zinc film caused by the chromate conversion coating treatment following the zincate treatment step according to my invention. The salt spray resistance was obtained by a procedure conducted substantially as follows:

The selected specimens were subjected to a 5 percent continuous salt spray test in accordance with Method 6061 of Federal Test Method Standard No. 141, with the significant surface inclined approximately 6° from the vertical. Specimens were exposed for 48 hours as required in the electrical industry. After exposure, the specimens were cleaned in running water and blown dry with clean air. When treated according to this invention the specimens were essentially free from any corrosion attack.

TABLE I.—SURFACE RESISTANCE MEASUREMENTS
(Zincated 6061-T6 sheet)

Example	Concentration of chromate conversion coating solution (percent by volume)	Composition (g./l.) CrO_3	Composition (g./l.) F^-	pH	Temp. (° F.)	Time (sec.)	Surface resistance (microhms)	Weight loss (percent)
1	0.1	0.05	0.01	3.7	160	60	2	[4]
2	0.5	0.25	0.05	2.9	160	60	2	[4]
3	1.0	0.50	0.10	2.7	120	15	2	----
4	1.0	0.50	0.10	2.7	120	30	2	----
5	1.0	0.50	0.10	2.7	120	60	2	----
6	1.0	0.50	0.10	2.7	160	15	2	----
7	1.0	0.50	0.10	2.7	160	30	2	----
8	1.0	0.50	0.10	2.7	160	60	2	13.5
9	1.0	0.50	0.10	2.7	200	15	2	----
10	1.0	0.50	0.10	2.7	200	30	2	----
11	1.0	0.50	0.10	2.7	200	60	2	----
12	5.0	2.50	0.50	2.5	120	15	4	----
13	5.0	2.50	0.50	2.5	120	30	4	----
14	5.0	2.50	0.50	2.5	120	60	6	----
15	5.0	2.50	0.50	2.5	160	15	4	----
16	5.0	2.50	0.50	2.5	160	30	5	----
17	5.0	2.50	0.50	2.5	160	60	11	18.0
18	5.0	2.50	0.50	2.5	200	15	6	----
19	5.0	2.50	0.50	2.5	200	30	7	----
20	5.0	2.50	0.50	2.5	200	60	10	----
21	10.0	5.00	1.00	1.7	120	15	16	----
22	10.0	5.00	1.00	1.7	120	30	14	----
23	10.0	5.00	1.00	1.7	120	60	25	----
24	10.0	5.00	1.00	1.7	160	15	8	----
25	10.0	5.00	1.00	1.7	160	30	14	----
26	10.0	5.00	1.00	1.7	160	60	18	18.5
27	10.0	5.00	1.00	1.7	200	15	10	----
28	10.0	5.00	1.00	1.7	200	30	18	----
29	10.0	5.00	1.00	1.7	200	60	20	----
30	[1]	0.50	0.05	2.7	160	60	2	----
31	[2]	0.50	0.10	2.7	160	60	3	----
32	[3]	0.50	0.10	2.9	160	60	2	----

[1] 0.5 g./l. CrO_3, 0.1 g./l. 48% HF.
[2] 0.5 g./l. CrO_3, 0.15 g./l. NH_4HF_2.
[3] 0.5 g./l. CrO_3, 0.2 g./l. NH_4F.
[4] No measured change.

Table II, which follows, demonstrates the capability of aluminum treated first with a zinc immersion coating and then with a chromate conversion coating according to my invention for retaining a low surface resistance during longterm usage, as compared to the lack of such capability for the same material given representative prior art treatments. To obtain the final resistance figures, the indicated samples (treated as in table I), after measurements of the original surface resistance, were again measured for surface resistance after exposure to 90 percent relative humidity at 100° F. for a 16-week period.

TABLE II.—EFFECT OF 90% R.H. AT 100° F. ON SURFACE RESISTANCE

Treatment	Resistance as prepared, microhms	Resistance, 16 weeks exposure, microhms
Deoxidized only	22	228
Deoxidized plus Zn immersion only	1	225
Deoxidized plus Zn immersion plus HNO_3 strip	16	165
Deoxidized plus chromate conversion coating	8	71
Deoxidized plus Zn immersion plus chromate conversion coating	1	2
Deoxidized plus Zn immersion plus HNO_3 plus chromate conversion coating	4	29

While the invention has been described and several practices for the employment thereof have been set forth, it will be obvious to those skilled in the art that many modifications of the invention are possible without departing from the scope thereof.

Having thus described my invention and certain embodiments thereof, I claim:

1. Aluminum adapted for conductor usage having as a base coating thereon zinc substantially covered by a chromate conversion coating.

2. Aluminum wire adapted for stranded conductor usage, said wire having as a base coating thereon a zinc film with a chromate conversion coating thereover.

3. A multistrand conductor comprising a plurality of wound strands of the wire of claim 2 surrounded with insulation.

4. The conductor of claim 3 wherein the insulation is polytetrafluoroethylene.

5. A process for decreasing the electrical contact resistance and increasing the corrosion resistance of aluminum which comprises first applying a film to the aluminum by zinc immersion treatment and then forming a chromate conversion coating thereover.

6. The process of claim 5 wherein the zinc coating is a zinc immersion coating.

7. The process of claim 5 wherein the chromate conversion coating is formed by a solution containing CrO_3 and a fluoride radical supplying F^1.

8. The process of claim 5 wherein the chromate conversion coating is applied from a solution containing from about 0.05 to about 2.50 g./l. CrO_3 and from about 0.01 to about 0.50 g./1. F^1, at a pH of from about 2 to about 4, at a temperature of from about 120° to 200° F., and for a period of from about 15 to about 60 seconds.

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,595,985 Dated July 27, 1971

Inventor(s) Walter G. Zelley

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

Col. 2, line 3	Change "12" to -- $^{-2}$ --.
Col. 2, line 3	Change "$(BF_4)^1$" to --$(BF_4)^-$ --.
Col. 2, line 4	Change "1" to -- $^{-2}$ --.
Col. 2, line 4	Change "13" to -- $^{-3}$ --.
Col. 2, line 5	Change "F^1" to -- F^- --.
Col. 2, line 14	Change "F^1" to -- F^- --.
Col. 3, line 1	Change "F^1" to -- F^- --.
Col. 4, line 58	Change "F^1" to -- F^- --.
Col. 4, line 62	Change "F^1" to -- F^- --.

Signed and sealed this 25th day of January 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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