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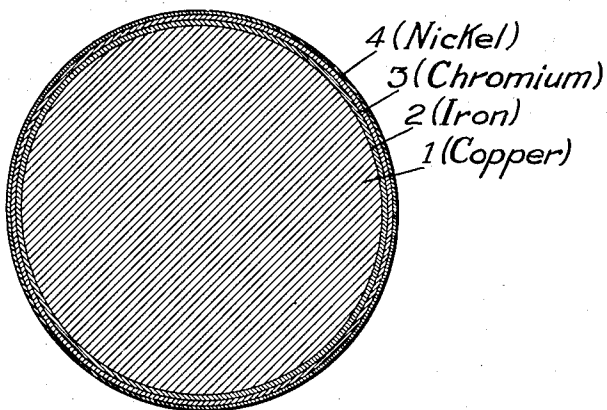
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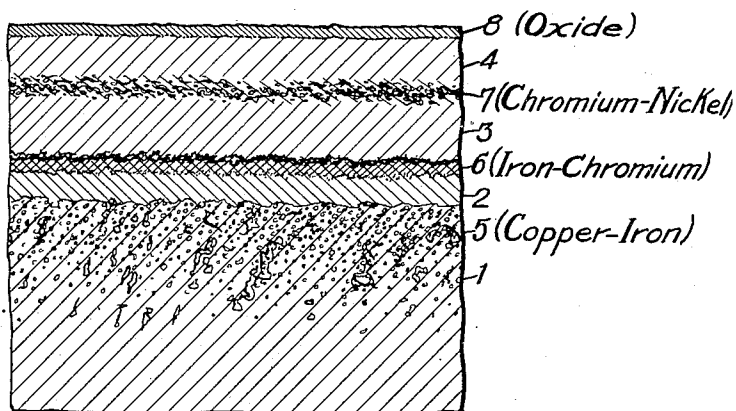
PROTECTION OF CUPROUS METALS

Filed March 6, 1925

**Fig. 1.**



**Fig. 2.**



**Fig. 3.**



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By His Attorney

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# UNITED STATES PATENT OFFICE

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## PROTECTION OF CUPROUS METALS

Application filed March 6, 1925. Serial No. 13,504.

In a certain previous application No. 722,462, filed June 6, 1924 (Patent No. 1,578,254, granted March 30, 1926) and No. 3,720, filed January 21, 1925, I have described a method of protecting ferrous metals against corrosion at high temperatures and against acids by applying thereto a coating of chromium and applying nickel over the chromium and heating the article to cause the alloying of the iron and chromium and of the chromium and nickel and to form on the outside an adherent oxide coating.

I have discovered also that copper, brass and other cuprous metals can be protected by similar methods, using coatings of various metals such for example as iron or other ferrous metal, chromium, nickel and aluminum.

The accompanying drawings illustrate an embodiment of the invention.

Fig. 1 is a cross-section of a copper rod with a compound coating of several metals applied thereto;

Fig. 2 is a section of the same after heating, taken from a photomicrograph, magnified five hundred diameters.

Fig. 3 is a plan of a treated fuse strip.

In the example illustrated a copper rod 1 is coated by plating with iron 2. A second coating of chromium 3 is plated on the iron and a third coating 4 of nickel is similarly applied. The article thus produced may be used as a finished product and subjected to the high temperature involved in such use; in which case the conditions of use will fix the coatings by the oxidizing and alloying effects referred to below.

Or the article produced by the successive coatings may be heated before use. For this purpose it is preferable to use an oxidizing atmosphere which will form an oxide coating which contributes materially to the success of the process. A suitable method of heating is to expose the article to a temperature of 850 degrees C. for four hours and to a further temperature of 1000 degrees C. for another four hours. In this heating operation there is a diffusion of the metals into each other and the formation of layers of alloys and metals as indicated in Fig. 2.

In this figure the copper base is indicated at 1. Surrounding this is a layer of a copper-iron alloy 5, then a layer of iron 2, a layer of iron-chromium alloy 6, a layer of chromium 3, a layer of chromium-nickel alloy 7 and a layer of nickel 4, outside of which is a thin film of extremely adherent nickel oxide 8 which is very dense and non-porous. Or, instead of being a straight nickel oxide, it may be a mixture of nickel-oxide and chromium-oxide intimately dispersed and of low oxygen solubility.

I prefer to use the several metals described and in the order stated because the iron combines readily with the copper, the chromium with the iron and the nickel with the chromium. The invention may be applied, however, with coatings which contain the said metals even though they do not consist entirely of such metals. Also there may be several layers of any one or more of the metals, deposited alternately; and other metals may be added to those above referred to. Also, though I have found electro-plating a convenient method of applying the metals, yet they may be applied in other known or suitable ways.

As an example of the method of depositing the iron on copper, the following solution of iron may be used.

FeSO <sub>4</sub> .7H <sub>2</sub> O	-----	200 grams.	
NH <sub>4</sub> Cl	-----	40 grams.	
Water	-----	to make solution of	
		one liter.	
Temperature	-----	20-30 deg. C.	85
Current density per square foot	-----	10 amperes.	

As an example of the method of depositing the chromium, a bath used may be of the following composition:

Chromic acid	-----	200-250 grams.	
Chromius sulphate	-----	4 grams.	
Water	-----	1000 cc.	
Anode of chromium or of lead,			95
Cathode of steel,			
Cathode current density per square foot	-----	100 amperes.	
Solution E. M. F.	-----	2-3 volts.	100

I have found that two hours in such a bath will give a satisfactory deposit.

An example of the method of depositing the nickel involves the use of the following bath:

5	Boric acid.....	15 gm.
	Nickel-ammonium sulphate.....	75 gm.
	Ammonium chloride.....	15 gm.
	Water .....	1000 cc.
10	Anode of nickel,	
	Cathode of chromium deposited on steel,	
	Cathode current density (amperes per square ft.).....	2-3
15	Solution E. M. F. ....	1.5 volts.

Two hours in this bath gives a satisfactory deposit.

The corrosion resisting properties of the treated copper make it valuable particularly for the fins used on boiler tubes as described in my previous applications above referred to. The tubes are protected by the cooling effect of the water which they carry, but the fins have very little protection from this source and are intended to be subjected to the radiant heat of the furnace so that, even where they are of copper, it is important to protect them as far as possible by coatings of a character herein described. The product is valuable also in laboratories or work shops where strong acids are employed or where, because of the corrosive fumes present, it would be impossible to use untreated copper.

The invention may be applied also to the making up of a composite piece of metal throughout its thickness by this process; that is, starting with a small core or base and building up a rod, sheet or bar with successive coatings to the desired size.

In certain tests which I have made, coatings of chromium and nickel in succession on a copper base gave a product which looked well and showed little oxidation after heating to 1500 or 1600 degrees F. for four hours. On heating for an additional four hours at 1830 degrees F., which is about 150 degrees F. below the melting point of copper, the sample was wrinkled in appearance and the outer coat was loose so as to give no substantial protection to the copper.

On the other hand, a sample coated in succession with iron, chromium and nickel as first above described, was subjected to the same treatment and was still in very good shape at the end of the second heating.

A similar sample of copper coated with iron, chromium and nickel and finally with aluminum applied as a paint showed even better results.

We conclude that the chromium-nickel coating offers a considerable protection against oxidation of copper at high temperatures, but that the use of the intermediate

coating of iron improves the product. The iron coat acts as a common bond between the copper and the chromium and is advisable wherever temperatures above 1600 degrees F. are apt to be encountered. I have found an improved result to follow the use of an outside aluminum coating with either of the schemes described above.

In all of these cases it is to be understood that the adjacent metals are diffused into each other in the solid state by the high temperature to which they are subjected preliminarily or in actual use, such diffusion resulting in the formation of alloys or series of alloys that are extremely resistant to oxidation and to the action of acids.

A single heating may be used instead of the duplex heating above described; and, in fact, various other methods of heating will serve to secure the desired diffusion of the metals into each other.

The condition shown in Fig. 2 is not necessarily permanent, the extent of the diffusion and alloying depending on the temperatures to which the product is exposed and the periods of such exposure. Actual equilibrium or permanent conditions may never be reached during the life of the product.

The invention may be applied with advantage also to such articles as electrical fuses. Fig. 3 illustrates an ordinary fuse strip to which the invention has been applied. In such articles it is important to avoid oxidation under service conditions, because it would change the rating of the fuse. Though copper is highly desirable for fuses, the common practice is to use other metals because of their greater resistance to oxidation in service. By the present invention copper is made available without fear of such damaging oxidation.

Various other devices for carrying electric current may be made of copper and advantageously treated in accordance with this invention. Such, for example, are copper electrodes used in welding by the Murray and other welding processes. These are at present expensive to maintain. They are heated by the current and there is a serious abrasion and wearing away of the edges. There is also some wear due to pieces of flash (metal extruded from the joint of the work pieces) from a preceding weld remaining in the electrode and causing a cutting action when the new workpieces are inserted. There is also some loss of copper if workpieces improperly cleaned are inserted in the electrodes, causing arcing due to bad contact. If the edges and surfaces subject to wear are coated as described, their life is prolonged. Chromium is a metal of great wear-resisting properties and is also a fair conductor of electricity. It is also possible to renew electrodes by replating or building up, and par-

particularly is this so where inserts are used along the clamping faces of the electrodes.

Though I have described with great particularity of detail certain embodiments of my invention, yet it is not to be understood therefrom that the invention is restricted to the embodiments described. Various modifications thereof may be made by those skilled in the art without departing from the invention as defined in the following claims.

What I claim is:

1. The method of protecting the surface of cuprous metal against corrosion at high temperatures and against acids which consists in applying iron thereto and applying chromium over the iron and nickel over the chromium.

2. The method of protecting the surface of cuprous metal against corrosion at high temperatures and against acids which consists in applying iron thereto and applying chromium over the iron and nickel over the chromium and heating the article to cause the alloying of the copper and iron, the iron and chromium and the chromium and nickel.

3. The herein described product adapted to resist corrosion at high temperatures and to resist acids comprising a base of cuprous metal coated with protective layers the first containing iron, the second containing chromium and the third containing nickel.

In witness whereof, I have hereunto signed my name.

IRVING T. BENNETT.

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