

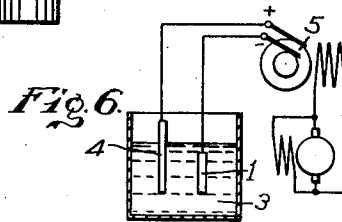
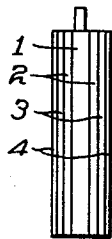
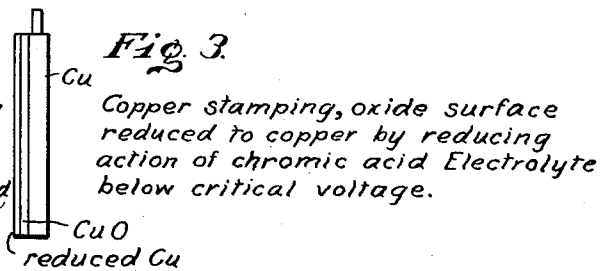
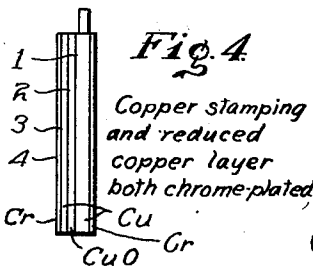
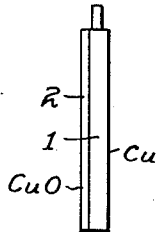
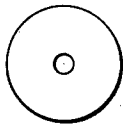
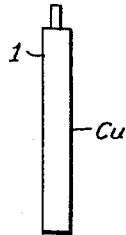
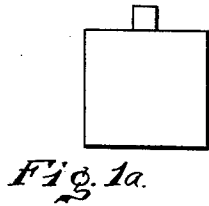
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R. J. PIERSOL

1,746,867

UNDIRECTIONAL CURRENT CONDUCTING DEVICE

Filed Aug. 25, 1928



INVENTOR
Robert J. Piersol
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UNITED STATES PATENT OFFICE

ROBERT J. PIERSOL, OF PITTSBURGH, PENNSYLVANIA

UNIDIRECTIONAL CURRENT-CONDUCTING DEVICE

Application filed August 25, 1928. Serial No. 301,998.

My invention relates to unidirectional current-carrying devices of the type described in U. S. Patent 1,640,335 issued August 23, 1927, to Lars Q. Grandahl and assigned to the Union Switch and Signal Co. of Swissvale, Pa., and it relates particularly to an improved device of that type and a novel method of manufacturing it.

Among the objects of my invention are to provide 1, a simple and inexpensive method of manufacturing copper-copper oxide rectifiers; 2, a simple method of providing a good contact surface with the copper-oxide film; 3, a simple and inexpensive method of reducing the surface of the copper-oxide film at a low temperature; 4, a method of hermetically sealing the oxide layer to prevent undue influence to chemical action by the constituents of the atmosphere.

Copper-oxide rectifiers of the type described in the Grandahl patent referred to above, are manufactured with the oxide on substantially one side only. Contact with the oxidized surface is established by a lead washer under heavy pressure. When the rectifier unit and the washer become heated due to current flow, the washer becomes softened, and, due to the pressure impressed upon it, tends to flow, thereby varying the pressure between the washer and the oxide surface. Under such conditions of changing pressures, the rectifying action becomes unstable.

Moreover, variation in pressure between the lead washers and the rectifier unit permits the constituents of the surrounding atmosphere greater access to the surfaces of the rectifying unit when heated, with a resultant greater chemical activity. Such activity further contributes to the instability of the rectifier unit.

The purpose of my invention is to modify the design of the rectifying unit to obviate the necessity of pressure contact washers, and to prevent access of the atmospheric constituents.

In making a rectifying unit according to my invention, I utilize the critical actions of a chromic acid solution as an electrolyte.

When current at less than a predetermined

voltage is passed through the solution, hydrogen is evolved and renders the solution reductive. If a metal electrode having an oxidized surface is disposed in the solution to constitute the cathode, the hydrogen will be evolved at the surface of that electrode and will reduce the oxidized surface to the plain metal. If the layer of oxide is of substantial thickness, the surface layer of the oxide will be reduced to the plain metal and will remain in intimate contact with the remainder of the oxide layer, and if the layer of reduced metal is one that is not attacked by chromic acid, that layer will protect the oxide layer below from further influence by the acid solution.

In the case of a copper base with copper oxide on its surface, when the oxide is reduced the resulting copper layer provides a temporary bar against further reduction. Since the copper goes into solution in chromic acid, the unreduced layer of oxide may be uncovered if the metal is left in the solution. If desired, the entire layer of oxide may thus be reduced.

Thus, after the surface of the oxide layer has been removed by the reducing action of the hydrogen at low voltage, an electrolytically cleaned surface is available as the cathode surface.

If the voltage across the solution is then raised above the critical voltage, a plating action takes place and chromium is electrolytically deposited upon the reduced cathode surface.

The chromium is therefore in close intimate homogeneous contact with the reduced layer of copper, which in turn, is in intimate contact with the layer of cuprous oxide.

Since chromium is unaffected by the constituents of the atmosphere, the layer of chromium constitutes a relatively permanent contact surface whose current-conducting character is permanent, and does not vary under atmospheric influence. Moreover, chromium will withstand higher temperatures than copper itself, and thus eliminates the necessity for, and trouble due to overheating of the lead washers engaging the surface of the oxide layer, as used at present.

A rectifier constructed according to my invention therefore constitutes in itself a complete and entire unit with proper contactive surfaces free from influence by the chemical action of the atmosphere.

The method of manufacturing a rectifier according to my invention and the construction of the rectifier will be understood from the illustrations, in the accompanying drawings, in which

Fig. 1 is a sectional view of a copper base, which may be a sheet, strip or washer, which is to be built into a rectifier unit; Figs. 1^a and 1^b respectively, showing a strip and a washer type;

Fig. 2 is a sectional view of the copper base in Fig. 1 after it has been oxidized on one surface;

Fig. 3 is a sectional view of the copper base after the outer surface layer of the oxide has been reduced to metallic copper; and

Fig. 4 is a sectional view of the copper base after a layer of chromium has been deposited upon the reduced layer of copper.

Fig. 5 is a sectional view of a unit of the strip type, as shown in Fig. 1^a, which has been treated on both sides to provide a double rectifying unit.

Fig. 6 is a diagram of the plating circuit. In the manufacture of rectifier units of the type herein considered, a copper base 1 is first made in the form of a copper sheet stamping or copper washer, that may be readily handled, and then oxidized on one side or on both sides as may be desired, by being subjected to a relatively high temperature in an atmosphere containing oxygen to form a cuprous oxide 2. The rectifying action occurs between the metal base and the oxide at the surface of contact.

The outer surface of the oxide is in itself unsatisfactory for good electrical contact whereby a connection may be made to an external circuit. In the rectifiers now made according to Grandahl's patent, previously referred to, a lead washer is employed in contact with the oxide surface, under pressure. Such construction has the disadvantage that the pressure varies when the unit becomes heated, and tends to change the rectification character of the unit. Moreover, the lead washers tend to flow under the pressure forces when heated and thus further affect the stability of the unit. If the variation in pressure or the flow becomes sufficient, the atmosphere is admitted to the various surfaces of contact and chemical action results, causing variations in the action of the unit. Such variations may be due to modification of the rectifying action itself, or to changes in the nature of the contactive surfaces, that cause the resistance of the circuit to vary in which the unit is included.

In order to obviate such variations, I reduce the outer oxide surface to metallic cop-

per whereby good contact may be obtained without resort to pressure. The reduction of the oxide surface may be effected in a reducing atmosphere at high temperature, but such method is expensive due to the heat required.

As an inexpensive method of reducing the oxide surface at normal temperatures, I utilize the reducing character of a chromic acid solution when electrolyzed by a current of less than plating voltage.

The copper base 1 is first oxidized by subsection to high temperature or by any other suitable process. It is then immersed in the chromic acid solution 3 and connected to constitute the cathode of a circuit including the solution 3, an anode 4 and a direct-current generator 5. The solution may be any well-known chromic acid solution, such as, for example, Sargent's bath, described in Technologic Papers of the Bureau of Standards, No. 346. The voltage of the generator should be adjusted so that the voltage across the solution will be less than plating voltage, which for a normal solution, may be as low as 3.0 volts.

The action for evolving the hydrogen is substantially merely the decomposition of the water of the solution and requires merely a decomposition voltage. Since evolution of hydrogen without decomposition of the chromic acid (and resultant plating) is desired, the voltage should be less than critical plating voltage.

The hydrogen will be evolved at the surface of the cathode, in this case the oxide surface 6 of the copper base. The hydrogen will attack the oxide surface 6 and reduce it to metallic copper 7. A clean surface is then available upon which chromium may be deposited.

The voltage impressed upon the solution is then increased to, or above, the critical plating voltage, and a layer of chromium 8 is deposited upon the copper surface 7. The chromium provides a hard non-tarnishing metallic surface whereby a good surface contact may be obtained with the oxide layer for connection to an external circuit.

I have illustrated the copper base as of rectangular (1^a) or washer (1^b) form. It may, obviously, be made of any form or outline, as may be desired.

Although illustrated as oxidized on only one side, it may be oxidized on both sides to provide a double rectifier unit. The reduction on both sides may be simultaneously accomplished by two anodes or a double anode. If desired, the oxide layer may be put on one side only and the reduced layer of copper, and the other original surface, may be plated.

The action between the original copper base 1 and the oxide is such as to permit current flow in the direction from the oxide to the base. That action lends itself to the re-

duction and plating since the current for the latter operations must pass to the unit as a cathode.

An important feature of the reduction of the oxide at low temperature is that the oxide structure is not expanded to admit and absorb the reducing hydrogen. When the oxide layer of the rectifier is reduced at high temperature, as is the practice in the present manufacture of one of the present commercial types of such rectifiers, the hydrogen permeates the expanded crystalline structure of the oxide layer. The hydrogen so occluded weakens the oxide structure and hastens the deterioration of the oxide layer by the active constituents of the atmosphere.

By effecting reduction of the oxide surface at low temperature, the activity of the hydrogen is confined substantially to the outer surface and the permeation or occlusion of the hydrogen is prevented.

Moreover, if the original structure of the oxide layer could be permanently maintained, the effective operation of the rectifier would be unimpaired. The gradual breakdown of the rectifier is caused by the gradual deterioration or modification of the original structure of the oxide layer, in response to the effect of the active constituents of the atmosphere.

By covering the reduced layer of copper by the inactive chromium, access of the atmosphere to the oxide is prevented and the oxide structure is maintained. Consequently the rectifying character of rectifier unit is unimpaired and remains constant.

My invention thus comprehends the improved rectifier unit wherein the oxide layer is reduced at low temperatures and inexpensively, and is then covered with an integral metallic surface whereby good electrical contact may be directly established, and the original character of the rectifier maintained. My invention also comprehends the method of producing or establishing the conditions whereby the improved rectifier may be made.

My invention is not limited to the particular rectifier described but may be applied to any rectifier of the metal-metal-oxide type which introduces a difficulty in establishing contact with the oxide, or in which the oxide is affected by the atmosphere, and may be otherwise modified without departing from its spirit and scope, as expressed in the appended claims.

I claim as my invention:

1. A rectifier unit comprising in combination, a copper base having a copper oxide formed thereon, a layer of copper on the oxide formed by reduction of the oxide surface and a layer of chromium on the copper layer.

2. In combination, copper having cuprous oxide formed thereon, said combination constituting in and of itself a unidirectional current-carrying device, and means for making

intimate contact with the cuprous oxide to establish an electric circuit through said combination, said means comprising a layer of copper reduced from the oxide and a layer of chromium deposited upon the copper layer.

3. A rectifier unit comprising in combination a copper base having a copper oxide formed thereon, a copper layer integral with the oxide and formed by reduction of the oxide, and an electrolytically deposited layer of chromium on the copper layer and integral therewith.

In testimony whereof, I have hereunto subscribed my name this 20th day of August, 1928.

ROBERT J. PIERSOL.