Feb. 5, 1946. C. C. HEIN 2,394,056

REDUCTION OF LEAKAGE CURRENT IN CUPROUS-OXIDE RECTIFIERS

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Fig. 1.

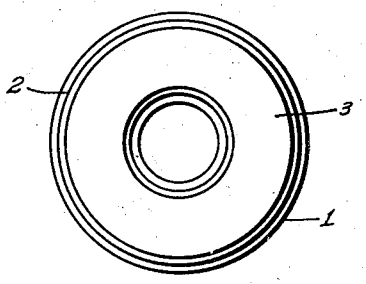
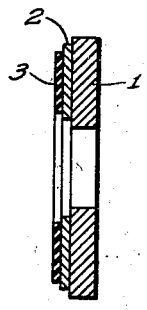


Fig. 2.



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REDUCTION OF LEAKAGE CURRENT IN CUPROUS-OXIDE RECTIFIERS

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4 Claims. (Cl. 175—366)

My invention relates to copper oxide rectifiers and, in particular, relates to an improved form of such rectifiers.

Rectifiers of the copper oxide type are described in Grondahl Patent No. 1,640,335, assigned to the Union Switch & Signal Company of Swissvale, Pennsylvania. In accordance with the Grondahl patent, plates or discs of metallic copper are heated to a temperature not far below their melting point in air, thereby coating at least a portion of their surface area with oxide. Operating contacts are then made, respectively, to the copper metal and to the outer surface of the oxide. For most purposes, it has been found advantageous to obtain contact to the copper metal by maintaining a substantial area of one side of the plate free from oxide, for example, by masking it from contact with the air while the other side is being oxidized.

While copper oxide rectifiers made in general accordance with the Grondahl patent are much more highly conductive to electron flow from the copper to the oxide than they are to current flow in the opposite direction and, consequently, constitute good electrical rectifiers of alternating voltage, there is still a residual leakage current, sometimes called a "reverse current," flow in their nominally non-conductive direction. This "reverse current" is undesirable; for one thing because it represents a waste of energy and raises the temperature of the disc during operation, and thereby limits the maximum voltage which may be rectified safely by a single disc. I have found that the portions of the oxide immediately adjacent the periphery of the disc are apparently much more conductive to this leakage current than are other portions of the oxide surface. In accordance with my invention, I remove the oxide from a strip or area about the perimeter of the disc or plate and also about the perimeter of any openings therein. I have found that such a procedure materially reduces the amount of leakage or "reverse current" exhibited by the disc under operating conditions.

My invention will be more fully described in connection with the drawing, in which:

Figure 1 is a plan view; and

Fig. 2 is a view in section of completed rectifier disc made in accordance with my invention.

Referring to the drawing, a copper disc 1, which may be of annular form, is treated in accordance with the process outlined in the above-mentioned Grondahl patent by oxidizing one of its faces at a temperature just below its melting point, the other face of the disc being preferably masked to prevent free access to it of the atmospheric oxygen. This produces a unit in which the right-hand face, as it appears in Fig. 2, is substantially free from oxide, but in which an oxide coating is formed on the left-hand face of the disc and extends well over the outer edge and also the inner edge of the central hole.

Having formed a plurality of discs in the manner just described, I provide a set of rubber gaskets or annular rings of such diameter as to cover the major portion of each face of the disc, but to leave uncovered the edges, together with a narrow strip along each edge heaving a width which may, for example, be one-tenth of the radius of the disc. I then stack a plurality of discs with washers sandwiched between them and sand blast the uncovered areas of the oxide preferably with 150 mesh silicon carbide powder, using air pressure of 50 to 60 pounds. After the oxide has been completely removed from the exposed edges of the elements, the copper oxide discs are given an acid etch in a water solution containing 2% sulphuric acid, plus 0.1% hydrochloric acid operated at 80° C., the etch continuing for approximately two minutes. Thereafter the discs are quickly dipped in concentrated nitric acid and thoroughly rinsed in water. A coating of aquadag is then placed on the remaining oxide surface 3, and the rectifier units are then ready for assembly which may be carried out, for example, in the manner described by the above-mentioned Grondahl patent.

Copper oxide rectifiers as heretofore made have shown an increase in leakage or "reverse current" during the course of their operating life, this rate of increase being comparatively rapid at first and gradually attaining a low rate, the rapid portion of the change being over in a time of the order of forty or fifty hours. I have found that while discs made in accordance with the above-described process also show an increase of leakage current with time, both the initial value of the leakage current and the value at which it is approaching stability are much less than those of copper oxide elements made in accordance with the prior art. For example, after a period of the order of forty hours, discs made in accordance with the above-described process show a leakage current of the order of one-third to one-fourth that of discs produced by a process identical except that the oxide strip at the edge of the discs was not removed.

I have further discovered that discs made in accordance with the above-described procedure show a substantially less increase of resistance in

the conductive direction of current flow during operating life of the discs. It has been found that the resistance of copper oxide rectifiers in their conductive direction undergoes an increase during their operating life which is rapid at first and which attains a relatively lower rate of increase after some twenty or thirty hours of operation. I have found that discs made in accordance with the above-described process, while showing an increase of resistance in their conductive direction in the course of time, exhibit an increase which is only of the order of one-half to two-thirds of that shown by discs made by a process identical except that the strip along their edges is not removed.

Experiments have shown that the improvement due to removal of the edge strip of oxide takes place in the case of rectifiers made by the "vacuum treatment" process described in my application Serial No. 286,613, filed July 26, 1939, now Patent No. 2,304,090, and assigned to the assignee of the present application, as well as in rectifiers made by the process described in the above-mentioned Grondahl patent.

Figs. 1 and 2 show the form of the finished rectifier disc, the oxide coating being represented by the reference numeral 2 and the aquadag contact to the surface thereof being represented by the reference numeral 3.

It is possible to produce the same effect as described above by the use of an acid etch alone. The method described above is more readily adaptable to commercial manufacture than the method employing solely chemical etching methods. It is to be understood that I wish the chemical method to be included in my invention.

I claim as my invention:

1. The method of forming elements of a copper oxide rectifier which comprises oxidizing one surface of a copper plate at a temperature not far below the melting point of the copper, heat treating the elements at a temperature of the order of 500° C. to 575° C. for a period of the order of fifteen minutes, quenching the elements in water, removing the oxide from an area comprising the edges of the element and a strip having a width of the order of one-tenth of the radius of the element along said edge, acid dipping the element for a period of the order of two minutes, water rinsing it and imposing a contact layer on the remaining surface of the oxide.

2. The method of forming elements of a copper oxide rectifier which comprises oxidizing one surface of a copper plate at a temperature not far below the melting point of the copper, heat treating the elements at a temperature of the order of 575° C for a period of the order of fifteen minutes, quenching the elements in water, abrading with silicon carbide powder of about 150 mesh operating under an air pressure of 50 to 60 pounds the oxide from an area comprising the edges of the element and a strip having a width of the order of one-tenth of the radius of the element along said edge, acid dipping the element for a period of the order of two minutes, water rinsing it and imposing a contact layer on the remaining surface of the oxide.

3. The method of forming elements of a copper oxide rectifier which comprises oxidizing one surface of a copper plate at a temperature not far below the melting point of the copper, heat treating the elements at a temperature of the order of 500° C. to 575° C. for a period of the order of fifteen minutes, quenching the elements in a non-reducing medium, removing the oxide from an area comprising the edges of the element and a strip having a width of the order of one-tenth of the radius of the element along said edge, acid dipping the element for a period of the order of two minutes, water rinsing it and imposing a contact layer on the remaining surface of the oxide.

4. The method of forming elements of a copper oxide rectifier which comprises oxidizing one surface of a copper plate at a temperature not far below the melting point of the copper, heat treating the elements at a temperature of the order of 575° C. for a period of the order of fifteen minutes, quenching the elements in a non-reducing medium, abrading with silicon carbide powder of about 150 mesh operating under an air pressure of 50 to 60 pounds the oxide from an area comprising the edges of the element and a strip having a width of the order of one-tenth of the radius of the element along said edge, acid dipping the element for a period of the order of two minutes, water rinsing it and imposing a contact layer on the remaining surface of the oxide.

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