

UNITED STATES PATENT OFFICE

1,936,792

METHOD OF MAKING COPPER OXIDE RECTIFIERS FOR HIGH VOLTAGE APPLICATION

Herbert Kahler, Kensington, Md., assignor to Westinghouse Electric & Manufacturing Company, a corporation of Pennsylvania

No Drawing. Application February 6, 1929
Serial No. 338,053

7 Claims. (Cl. 175—366)

My invention relates to rectifiers and particularly to rectifiers depending upon the uni-lateral electrical conductivity which exists between a body of copper and a layer of oxide formed on the surface thereof.

One object of my invention is to provide a method of heat treatment for a rectifier comprising a copper base coated with an oxide layer.

Another object of my invention is to provide a method of producing an oxidized copper rectifier which shall be capable of withstanding higher impressed voltages than rectifiers of the same general type in the prior art.

It is now well known that the junction between certain metals, for example, copper, and an oxide layer formed thereon possesses a uni-lateral electrical conductivity; that is to say, electrons apparently flow much more readily from the copper to the oxidized layer than in the reverse direction. By proper methods of manufacture, the resistance in the highly-conductive direction can be made less than 1000th of the resistance in the non-conductive direction of current flow. Such a rectifier accordingly produces nearly a pure uni-directional current when an alternating voltage is impressed upon it; and by properly combining two or more such units in well-known circuit connections, a continuous current output may be obtained.

However, it is found that as the alternating voltage impressed between the underlying metal and the oxide layer is increased above a certain critical value, the current flow in the non-conductive direction increases very rapidly much more than current in the conductive direction. Since current flow in a non-conductive direction represents a clear loss of power it has been found advisable hitherto to limit the alternating voltage impressed between an oxide layer and its underlying metal to about 3 volts. When it was desired to rectify larger voltages than the foregoing, it has been necessary to employ a sufficient number of rectifier units in series, so that each unit has impressed upon it only 3 volts.

For many purposes, the foregoing limitation as to voltage per rectifier unit has made it necessary to employ an undesirably large number of units in series; and this, even in the case of rectifiers in which the current output required was very low, such for example, as B-battery eliminators for radio sets. Such rectifiers have accordingly had a bulk and cost which was excessive in view of the small power output which they were called upon to supply.

It is one of the features of my invention that

I have discovered a certain method of forming oxidized metal rectifier discs which produces units capable of withstanding as high as 20 volts per disc; and accordingly, resulting in a great decrease in the number of units which it is necessary to employ in series when it is desired to rectify relatively high voltages.

One of the features of the process which I have devised comprises a particular series of steps of heat treatment to which the oxidized discs are subjected.

In accordance with the foregoing objects and principles, a metallic disc, which is preferably of copper, but which may alternatively comprise an alloy of copper with another metal or metals such as zinc, is heated to a temperature just below its melting point in contact with an oxidizing atmosphere for a predetermined period. In the case of copper, the temperature is preferably between 1000 and 1025 degrees C. and the heating may be continued for approximately 8 minutes. The unit is then gradually cooled, during a period of several hours duration, to room temperature. The cooling is preferably at a uniform rate for approximately 4 hours.

After the unit just described has reached room temperature, the oxide may be removed from a portion of its surface and contact made to the underlying metal for the terminal of an electric circuit. Another portion of the oxidized surface may be reduced to the metallic state by contact with a reducing liquid or gas, such as ethyl alcohol, and contact made to the reduced surface for another terminal of the electric circuit. It is preferred not to reheat the unit in performing these last-mentioned steps. The resulting unit possesses a uni-lateral electrical conductivity and may be combined in circuit arrangements which are well-known in the rectifier art.

Instead of reducing the surface of the oxide layer, contact for the electrical circuit may be made therewith by firmly pressing a contact disc of some impressible metal such as lead or tin into contact therewith. Such a unit may also be employed in standard rectifier connections which are too well-known to require extended description.

For certain purposes, it will be found desirable to have a rectifier unit with a lower resistance in the conductive direction than that made in accordance with the process just described, even though it is necessary to sacrifice somewhat of the capacity for withstanding high impressed voltages. When rectifiers of the latter type are desired, discs of the character already described

may be heated in contact with an oxidizing agent to a temperature of approximately 1005° C. for about eight minutes. The foregoing figures are those which I now consider preferable, but it will be understood that departures from them may be found desirable in certain instances, and that my invention is not limited to the employment of the precise temperatures thus stated. After being maintained at the aforesaid temperature for approximately eight minutes, the discs are transferred to an environment, such as air, at a temperature of about one-half the foregoing figure, the exact temperature which I have previously found preferable being 490° C. The discs are maintained in this environment for about two and one-half minutes and then cooled off in air for from two to three minutes. The units are then quenched in water at room temperature. It will be recognized that the foregoing figures are given as a specific example of what has been found desirable for certain purposes, but that it may in certain instances be found desirable to vary them, and even to omit such steps as the cooling in air or the quenching.

Contact may be made with the underlying metal and with the outside of the oxide layer in the same manner as that described in the case of units made by the process first described. Rectifier units made in accordance with the process last described will be found capable of withstanding impressed alternating voltages of approximately 10 volts per unit. They may be connected in series and in multiple in accordance with the standard rectifier connections.

While I have given precise figures for temperatures and times of application applicable to copper discs, it will be recognized that similar process steps may be applied to copper alloys or to other metals with such modifications as are necessitated by the variance of their melting points from that of copper.

In accordance with the patent statutes, I have given detailed examples of the application of my invention but the principles thereof are broadly applicable and various modifications will be evident to those skilled in the art. I accordingly desire that the appended claims be given the broadest interpretation which their terms admit in view of the prior art.

I claim as my invention:

1. A process of forming rectifying devices comprising the steps of subjecting a metal containing copper to a temperature of 1000 to 1025° C. for

several minutes in an oxidizing atmosphere and gradually cooling during a period of several hours the resultant product to substantially room temperature.

2. In a method of forming a rectifying device, the steps of subjecting a metal containing copper to a temperature between 1000° C. and 1025° C. for several minutes in an oxidizing atmosphere, and maintaining said unit in an environment having a temperature of approximately 490° C. for several minutes and then cooling said unit to room temperature.

3. The method of forming elements having a uni-directional electrical conductivity which comprises the steps of subjecting metallic copper to a temperature just below its melting point for a period of several minutes in an oxidizing atmosphere and then gradually cooling said copper during a period of several hours to substantially room temperature.

4. In a method of producing rectifier elements, the steps of heating metallic copper to a temperature between 1000° C. and 1025° for a period of several minutes in an oxidizing medium, cooling said copper over a period of several minutes to substantially 490° C. and then cooling said copper at room temperature.

5. In a method of producing rectifier elements, the steps of heating metallic copper to a temperature between 1000° C. and 1025° C. for a period of several minutes in an oxidizing atmosphere, cooling said copper over a period of several minutes to substantially 490° C., cooling said copper at room temperature for a period of several minutes and then quenching said copper in a liquid at substantially room temperature.

6. In a method of producing rectifier elements, the steps of heating a metal containing copper to a temperature not far below its melting point for several minutes in an oxidizing medium, cooling said metal for several minutes in an environment which is at a temperature of substantially 490° C. cooling said metal at room temperature for several minutes and then quenching it in water.

7. In a method of producing devices having a uni-lateral electrical conductivity, the steps of heating a metal containing copper to a temperature not far below its melting point for several minutes in an oxidizing medium, gradually cooling said metal during a period of several minutes to a temperature of substantially 490° C. and quenching said metal in a liquid near room temperature.

HERBERT KAHLER.

55

130

60

135

65

140

70

145

75

150