

# UNITED STATES PATENT OFFICE.

EMIL WOHLWILL, OF HAMBURG, GERMANY.

## PRODUCTION OF CHEMICALLY-PURE GOLD BY ELECTROLYSIS.

SPECIFICATION forming part of Letters Patent No. 625,864, dated May 30, 1899.

Application filed August 29, 1896. Serial No. 604,306. (No specimens.)

*To all whom it may concern:*

Be it known that I, EMIL WOHLWILL, a subject of the German Emperor, residing at Hamburg, Germany, have invented Improvements in the Production of Chemically-Pure Gold by Electrolysis from Fine Gold and Alloys Rich in Gold; and I do hereby declare the following to be a full, clear, and exact description of the invention.

This invention has relation to the electrolytic production of chemically-pure gold from impure gold or gold alloys.

In my application for Letters Patent of the United States filed on or about June 4, 1896, Serial No. 549,339, describing a process which has also for its object the electrolytic purification of gold from impure gold or auriferous alloys—that is to say, the electrolytic production of pure gold from impure gold or from auriferous alloys—I have stated that when the electrolytic extraction is carried out with an electrolyte containing chlorid of gold and under conditions that give rise to the evolution and liberation of gaseous chlorin at the anode an amount of anode gold or gold compound proportionate to or corresponding with the amount of gaseous chlorin so liberated will remain unaffected by the electrolytic action, and in my said application I have conclusively shown the correctness of my said statement and given ample reasons in support thereof. I have also described in the aforementioned application my discovery that the liberation of the gaseous chlorin at the anode can be absolutely prevented and the whole of the chlorin generated by the action of the electric current utilized in the dissolution of the anode gold or compounds thereof by binding the chlorin; that this can be done by means of hydrochloric acid introduced into the electrolyte in sufficient quantity; that at a given temperature the maximum current density at which the whole of the chlorin evolved at the anode is bound corresponds with the quantity of hydrochloric acid present in the electrolyte, or vice versa; that this maximum of current density can be increased in proportion as the hydrochloric acid contained in the electrolyte is increased, or with an electrolyte containing an amount of hydrochloric acid corresponding with a given current density the latter can be increased by merely raising the temperature of the electrolyte, or by doing

this and increasing the proportion of hydrochloric acid therein, the quantity of anode gold dissolved depending, therefore, upon the intensity of the electric current, the proportion of hydrochloric acid in the electrolyte, and the temperature of the latter. In my said application for patent I have, furthermore, described the application of the process to the extraction of chemically pure gold from alloys of such, particularly from alloys containing metals of the platinum group, as well as from argentiferous and plumbiferous alloys, all of which will, therefore, not require further description herein. In further experimenting on the lines above set forth I have discovered that the hydrochloric acid described in my said application as being used in the electrolyte in such quantities as to prevent liberation of gaseous chlorin at the anode can be replaced either *in toto* or in part by another chlorin compound—as, for instance, by a chlorid that will form a double salt with the chlorid of gold—and obtain the same satisfactory results in that I also prevent thereby the evolution and escape of free chlorin at the anode, the continuity of the process of extraction of chemically pure gold being likewise insured.

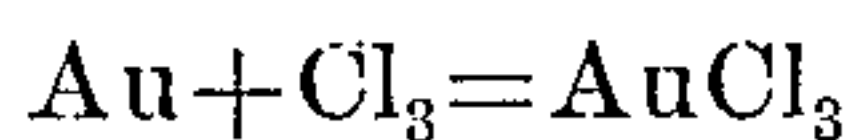
In carrying out the process which forms the subject-matter of this invention I therefore substitute for the whole or part of the hydrochloric acid an equivalent quantity of a chlorid that will form a double salt with the gold chlorid—as, for instance, sodium or potassium chlorid. Thus, for instance, if the electrolyte contains from twenty-five to thirty grams of gold chlorid per liter and if the electrolysis is to be carried out at a temperature of from 60° to 70° centigrade instead of adding to such electrolyte from thirty to fifty cubic centimeters of fuming hydrochloric acid of a specific gravity of 1.19 I add an equivalent of another chlorid, as sodium or potassium chlorid, that will form a double salt with the gold chlorid, or from 21.3 to 35.5 grams of the sodium or potassium chlorid per liter; but when operating at low temperatures or with currents of a higher density than five hundred amperes per square meter this quantity of sodium chlorid must be greatly increased, in fact doubled.

In the use of the chlorin compounds referred to in lieu of hydrochloric acid the amount of said compounds should be limited,

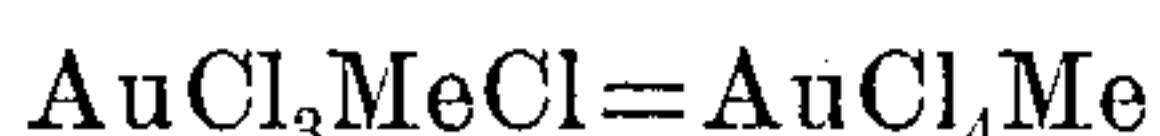


so as not to exceed, for instance, one hundred grams per liter of electrolyte. As is well known, all impure gold contains more or less silver, which is converted by the electrolytic action into a chlorid, and as this chlorid is soluble in alkali-chlorid solutions the greater the saturation of such solution the greater the amount of chlorid of silver dissolved thereby, which would, of course, be deposited at the cathode with the gold, and thus defeat the object in view, this being avoided by restricting the amount of chlorin compound in the electrolyte to that which will suffice to bind the chlorin evolved at the cathode. The action of the chlorin compound in the electrolyte is precisely the same as that of hydrochloric acid, in that both prevent the liberation of gaseous chlorin at the anode, all the chlorin evolved being utilized in the dissolution of the anode gold.

The action of the chlorid of a metal of the alkalies is as follows: Chlorination of gold according to the following equation



taking place only at temperatures of about 200° centigrade (see *Julius Thomsen Thermochemische Untersuchungen*, Vol. 3, p. 382, et seq., Leipzig, 1883) cannot take place in an aqueous solution. For this reason the chlorin evolved at the gold anode in an aqueous solution of gold chlorid escapes in a gaseous state; but when said solution contains also free chlorin (NaCl) or an equivalent chlorin compound a soluble double salt is formed corresponding to the schematic formula



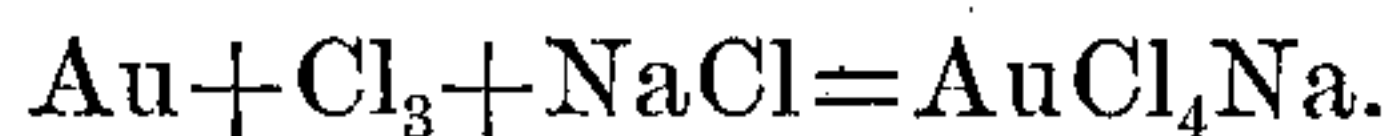
(Me=metal) is readily formed. Hence if in an aqueous solution of gold chlorid containing sodium chlorid or an equivalent chlorin compound chlorin is separated at the gold anode the chlorin will be bound and the anode gold dissolved according to the equation



or, generally,

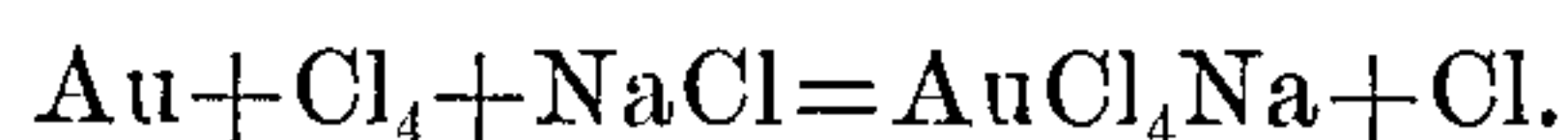


Indeed, Hittorf has proven (*Poggendorff's Annalen der Physik und Chemie*, Vol. 106, p. 522, et seq.) that in an aqueous solution of the double salt of gold chlorid and sodium gold is contained exclusively in the form of the complex anion  $\text{AuCl}_4$ , sodium being the cation. From this it will be readily understood that gold is dissolved at the anode if the formation of  $\text{AuCl}_4$  is made possible—that is to say, if the electrolyte contains, besides chlorin, a chlorid capable of forming with gold and chlorin the combinations of the group  $\text{AuCl}_4$ , as in the following equations:

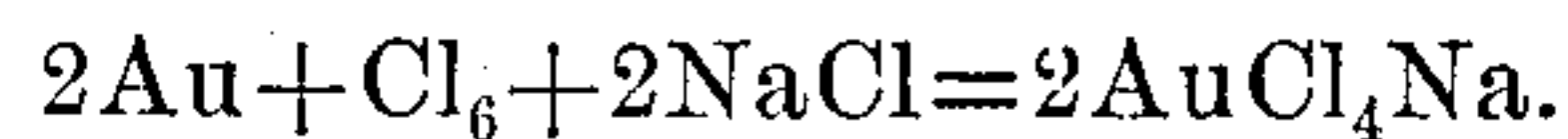
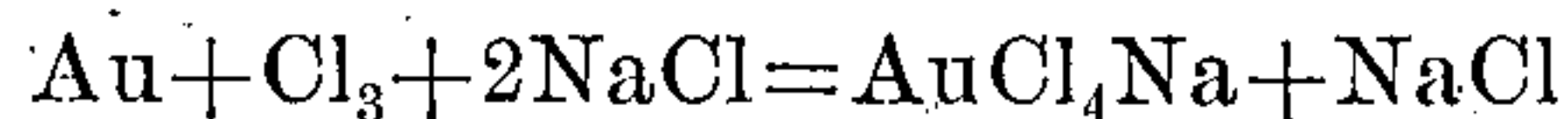


The latter equation also shows the proportions of the constituents necessary to the dis-

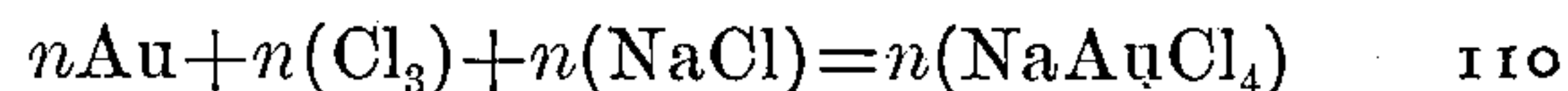
solution of anode gold. It further shows that the escape of free chlorin at the anode can be fully prevented by the addition to the electrolyte of sodium chlorid if the amount of chlorin in said chlorid which is in direct contact with the anode gold is at least equal to one-third of the chlorin electrolytically separated at said anode. From the same equation it is clear that a portion of the chlorin escapes whenever the amount of chlorin in the sodium chlorid is less than one-third of the free chlorin. Thus, for instance, if the proportion of chlorin in the sodium chlorid is equal to one-fourth of the chlorin electrolytically-separated one atom of chlorin must escape, as will be seen from the following equation:



When, however, undecomposed sodium chlorid in sufficient quantity is present, so that the proportion of chlorin therein is greater than one-third of the chlorin electrolytically separated, it becomes possible with a current of higher density—that is to say, under a more copious evolution of chlorin at the anode per second—to bind the whole of it—i. e., to utilize it in the dissolution of anode gold:



In a like manner it follows quite naturally that with an increasing current density—hence, with an increase in the quantity of chlorin electrolytically separated within a unit of time upon a unit of anode-surface—a corresponding increase in the quantity of sodium chlorid will be necessary in order that all the chlorin electrolytically separated may be bound and that the uninterrupted dissolution of anode gold may take place



generally,



where Me signifies any metal whose chlorid is capable of forming a double salt with gold chlorid.

In the treatment of gold containing platinum care must be taken that the chlorid employed does not, like potassium chlorid and ammonium chlorid, form with platinum chlorid a double salt that is soluble with difficulty. In this case, for instance, chlorid of sodium is to be recommended.

Having thus described my invention, what I claim as new therein, and desire to secure by Letters Patent, is—

1. The herein-described process of obtaining pure gold, which consists in passing an electric current from an anode of impure gold or of an auriferous alloy to a suitable cathode through a gold-chlorid solution and maintaining in said solution at all times during the passage of such current another chlorin compound in such quantity as to prevent the lib-



eration of gaseous chlorin at the anode and so as not to dissolve the silver that may be contained in said anode, for the purpose set forth.

5 2. The herein-described process of obtaining pure gold, which consists in passing an electric current from an anode of impure gold or of an auriferous alloy to a suitable cathode through a heated gold-chlorid solution and  
10 maintaining in said solution at all times during the passage of such current another chlorin compound in such quantity as to prevent the liberation of gaseous chlorin at the anode and so as not to dissolve the silver that may  
15 be contained in said anode, for the purpose set forth.

3. The herein-described process of obtaining pure gold, which consists in passing an electric current from an anode of impure gold  
20 or of an auriferous alloy to a suitable cathode through a heated gold-chlorid solution, and maintaining in said solution at all times during the passage of such current another chlorin compound, capable of forming a double  
25 salt with the gold in said solution, in such quantity as to prevent the liberation of gaseous chlorin at the anode, and so as not to dissolve the silver that may be contained in said anode, for the purpose set forth.

30 4. The herein-described process of obtaining pure gold, which consists in passing an electric current from an anode of impure gold

or of an auriferous alloy to a suitable cathode through a heated solution of gold chlorid, and maintaining in said solution at all times during the passage of such current hydrochloric  
35 acid and another chlorin compound, capable of forming a double salt with the gold in the solution in such quantity as to prevent the liberation of gaseous chlorin at the anode, and  
40 so as not to dissolve the silver that may be contained in said anode, for the purpose set forth.

5. The herein-described process of obtaining pure gold, which consists in passing an  
45 electric current of high density, as five hundred amperes per square meter or higher, from an anode of impure gold or of an auriferous alloy to a suitable cathode through a gold-chlorid solution, and maintaining in said  
50 solution at all times during the passage of such current another chlorin compound in such quantity as to prevent the liberation of gaseous chlorin at the anode and so as not to dissolve the silver that may be contained in  
55 said anode, for the purpose set forth.

In testimony that I claim the foregoing as my invention I have signed my name in presence of two subscribing witnesses.

EMIL WOHLWILL.

Witnesses:

ADOLPH BENON,  
SAUL SLAAS.