US008187450B2

(12) **United States Patent**
Sandoval et al.

(10) **Patent No.: US 8,187,450 B2**
(45) **Date of Patent: May 29, 2012**

(54) **METHOD AND APPARATUS FOR ELECTROWINNING COPPER USING FERROUS/FERRIC ANODE REACTION**

(75) Inventors: **Scot Philip Sandoval**, Morenci, AZ (US); **Timothy George Robinson**, Scottsdale, AZ (US); **Paul Richard Cook**, Morenci, AZ (US)

(73) Assignee: **Freeport-McMoran Corporation**, Phoenix, AZ (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 87 days.

(21) Appl. No.: **12/752,933**

(22) Filed: **Apr. 1, 2010**

(65) **Prior Publication Data**

US 2010/0187125 A1 Jul. 29, 2010

Related U.S. Application Data

(60) Continuation of application No. 12/126,552, filed on May 23, 2008, now Pat. No. 7,704,354, which is a division of application No. 10/629,497, filed on Jul. 28, 2003, now Pat. No. 7,378,011.

(51) **Int. Cl.**
C25C 1/12 (2006.01)

(52) **U.S. Cl.** **205/576**; 205/586; 205/574

(58) **Field of Classification Search** ..... None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,792,342 A * 5/1957 Tuwiner 205/577
5,492,608 A * 2/1996 Sandoval et al. 204/237

OTHER PUBLICATIONS

"Manifold", accessed at http://dictionary.reference.com/browse/manifold. access date: Feb. 10, 2012.*

* cited by examiner

Primary Examiner — Harry D Wilkins, III
(74) *Attorney, Agent, or Firm* — Snell & Wilmer L.L.P.

(57) **ABSTRACT**

The present invention relates, generally, to a method and apparatus for electrowinning metals, and more particularly to a method and apparatus for copper electrowinning using the ferrous/ferric anode reaction. In general, the use of a flow-through anode—coupled with an effective electrolyte circulation system—enables the efficient and cost-effective operation of a copper electrowinning system employing the ferrous/ferric anode reaction at a total cell voltage of less than about 1.5 V and at current densities of greater than about 26 Amps per square foot (about 280 A/m^2), and reduces acid mist generation. Furthermore, the use of such a system permits the use of low ferrous iron concentrations and optimized electrolyte flow rates as compared to prior art systems while producing high quality, commercially saleable product (i.e., LME Grade A copper cathode or equivalent), which is advantageous.

5 Claims, 3 Drawing Sheets