UNITED STATES PATENT OFFICE.

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ART OF TREATING ORES.

No. 862,987. Specification of Letters Patent. Patented Aug. 13, 1907.

Application filed November 20, 1906. Serial No. 344,344.

To all whom it may concern:

Be it known that I, ROBERT McKNIGHT, a citizen of the United States, residing at the city of Pittsburg, in the county of Allegheny and State of Pennsylvania, have invented new and useful Improvements in the Art of Treating Ores, of which the following is a specification.

My invention has reference to a treatment of ores containing one or more of the acid forming rare metals tungsten, uranium, vanadium, molybdenum and tellurium which are weakly basic and acid forming in which I effect the separation and recovery of the rare metal or metals by mixing the ore with an alkaline chlorid, preferably much in excess of the amount required to furnish chlorin for the chloridizable constituents of the ore, and heating the resulting mixture until the alkaline chlorid and rare metal or metals have reacted and volatile and soluble chlorids or double chlorids of the alkali metal used and the rare metals in the ore have been formed.

I will describe now in detail the manner in which I practice my invented art.

Taking as a specific case an ore containing tungsten as the rare metal and using sodium chlorid as the alkaline chlorid, I treat it as follows: The ore is preferably reduced to a fine consistency, most advantageously, to about thirty (30) mesh. It is then mixed with about double the amount of ordinary commercial sodium chlorid and fed into the heating furnace, which is preferably of the revolving cylindrical type, feeding, agitating and discharging the ore automatically; or the ore and salt may be fed separately into the furnace and allowed to mix within it. As to the amount of salt to be used, the more used the quicker and better are the results obtained. In practice, however, it is found that the advantages derived from the use of a large excess of the salt, such as would be expected from the law of mass action, become after a certain point counterbalanced by the disadvantage of having to handle too large a bulk of material; and hence the optimum maximum amount of salt to be used in each case is best determined experimentally for each ore. The temperature in most cases need not exceed 700 C., which can be obtained through any available fuel. Where electricity is obtainable, a good furnace in which to carry out my invention is that described in my application for Letters Patent Ser. No. 332,403, filed August 28th, 1906. By this treatment the tungsten in the ore is converted into a volatile and soluble chlorid or double chlorid of the sodium and tungsten, what is volatilized is condensed in a suitable condenser, such as is described in U. S. Patent No. 737,003, August 25th, 1903, granted to me, and entitled "Apparatus for condensing fumes"; and the residue, preferably while hot from the furnace, is allowed to fall into water, and thus by the sudden change of the temperature quickly disintegrated and crumbled and the portion of the tungsten which has not volatilized is obtained in solution, from which its acid or the metal itself can be obtained in any suitable manner. In some cases it is found advantageous to let the ore which has passed through the furnace pass also through a suitable pulverizer, which is preferably done after the hot ore has been suddenly cooled by the water and thus disintegrated and made easy to crush. In this way the complete solution of the portion which has not volatilized is insured to be effected easily and well. I prefer also to use a limited amount of water, which I keep in circulation through all the apparatus used, including the pulverizer, by means of a suitable pump, and thus I can obtain a supersaturated solution of the metal or metals in question, which on standing is precipitated, usually as the hydrated oxid or acid, and use the filtrate from this precipitate for the recovery by spontaneous evaporation or otherwise the alkaline chlorid in solution, which can be used over again in the treatment of new ore.

In some cases I prefer to precipitate the acid of the rare metal by rendering its solution acid by means of some suitable acid, such as hydrochloric. When the latter acid is used there is obtained the additional advantage that most of the alkaline chlorid is thrown down along with the acid of the rare metal, especially when the hydrochloric acid is led into the solution in the gaseous form, on account of the decrease in the ionization by the common anion in the solution and precipitating acid; and thus it becomes a simple matter to recover and separate the alkaline chlorid used, all that is necessary being the washing with water of the mixed rare metal acid and alkaline chlorid, obtaining the latter in the filtrate and the former as the residue on the filter.

In cases where the ore contains a metal whose oxid is soluble in ammonia, such as silver, copper, nickel, zinc, etc., I prefer to use as the condensing liquid for the volatilized portion and as the solvent for the residual portion a solution containing ammonia. This avoids the partial loss of rare metal by reason of the slight solubility or insolubility of the double compounds which the oxids of the metals that are electropositive with reference to the rare metals, in some cases, apparently form with the oxids of the latter.

Representing by X the variable excess of alkaline chlorid used in the specific case of the tungsten ore described above, we may represent symbolically the principal reactions taking place as follows:

(1) $FeWO_4 \gtrless FeO + WO_3$

(2) $WO_3 + XNaCl = WO_2Cl_2.Na_2O.(X-2)NaCl$

Similarly in the case of an ore containing pitchblende the following equation represents the principal probable reaction:

$$U_3O_8 + XNaCl = UO_2Cl_2.U_2O_3.3Na_2O.(X-6)NaCl + 2Cl_2$$

Similar and analogous equations represent the prin-

cipal reaction taking place in the cases of vanadium, molybdenum and tellurium ores. Thus in the case of a vanadium ore such as vanadite, the principal reaction may be represented by the following equation:

$$PbCl_2 3Pb_3(VO_4)_2 + XNaCl = 2PbO.8PbCl_2 4VOCl_2 .16Na_2O(X—32)NaCl.2VOCl_3 2Cl_2.$$

In the case of a molybdenum ore such as wulfenite, the principal reaction may be represented by the following equation:

$$2PbMoO_4 + XNaCl = 2PbO.Mo_2Cl_{10}.(X—12)NaCl.6Na_2O + Cl_2$$

In the case of a tellurium ore such as tetradymite, the principal reaction may be represented by the following equation:

$$Bi_2Te_3 + XNaCl + 9O(\text{the atmosphere}) = 2BiOCl3TeCl_4.7Na_2O(X—14)NaCl.$$

Having now described my invention what I claim and desire to secure by Letters Patent is:

1. The art of treating ores which contain one or more of the acid forming rare metals tungsten, uranium, vanadium, molybdenum and tellurium, which consists in treating the ore with an alkali-metal chlorid and heating the resulting mixture until volatile and soluble chlorids of these metals have been formed, condensing what has been volatilized and treating the residue with an aqueous liquid, substantially as described.

2. The art of treating ores which contain one or more of the acid forming rare metals tungsten, uranium, vanadium, molybdenum and tellurium, which consists in treating the ore with a large excess of an alkali-metal chlorid and heating the resulting mixture until volatile and soluble chlorids of these metals have been formed, condensing what is volatilized and treating the residue with an aqueous liquid, substantially as described.

3. The art of treating ores which contain one or more of the acid forming rare metals tungsten, uranium, vanadium, molybdenum and tellurium, which consists in treating the ore with an alkali-metal chlorid and heating the resulting mixture until volatile and soluble chlorids of these metals have been formed, condensing what has been volatilized and passing the residual ore and the thus resulting salts while hot from the furnace into a solvent liquid, substantially as described.

4. The art of treating ores which contain one or more of the acid forming rare metals tungsten, uranium, vanadium, molybdenum and tellurium, which consists in treating the ore with an alkali-metal chlorid and heating the resulting mixture until volatile and soluble chlorids or double chlorids of these metals have been formed, condensing what is volatilized, passing the residue while hot from the furnace into water, and therefrom through a suitable pulverizer through which circulates a limited amount of the solvent for the thus resulting metallic compounds, substantially as described.

5. The art of treating ores which contain one or more of the acid forming rare metals tungsten, uranium, vanadium, molybdenum and tellurium, which consists in treating the ore with an alkali-metal chlorid and heating the resulting mixture until volatile and soluble chlorids or double chlorids of these metals have been formed, condensing what is volatilized, passing the residue while hot from the furnace into water, and thereafter through a suitable pulverizer through which circulates the solvent for the thus resulting metallic compounds, using the same solution over and over again until it becomes supersaturated and deposits the less soluble rare metal compounds, thus leaving the alkali metal chlorid in solution, which can be used in the treatment of new ore, substantially as described.

In witness whereof I affix my signature in presence of two witnesses.

ROBERT McKNIGHT.

Witnesses:
WALTER S. BUTLER,
B. C. BARTON.