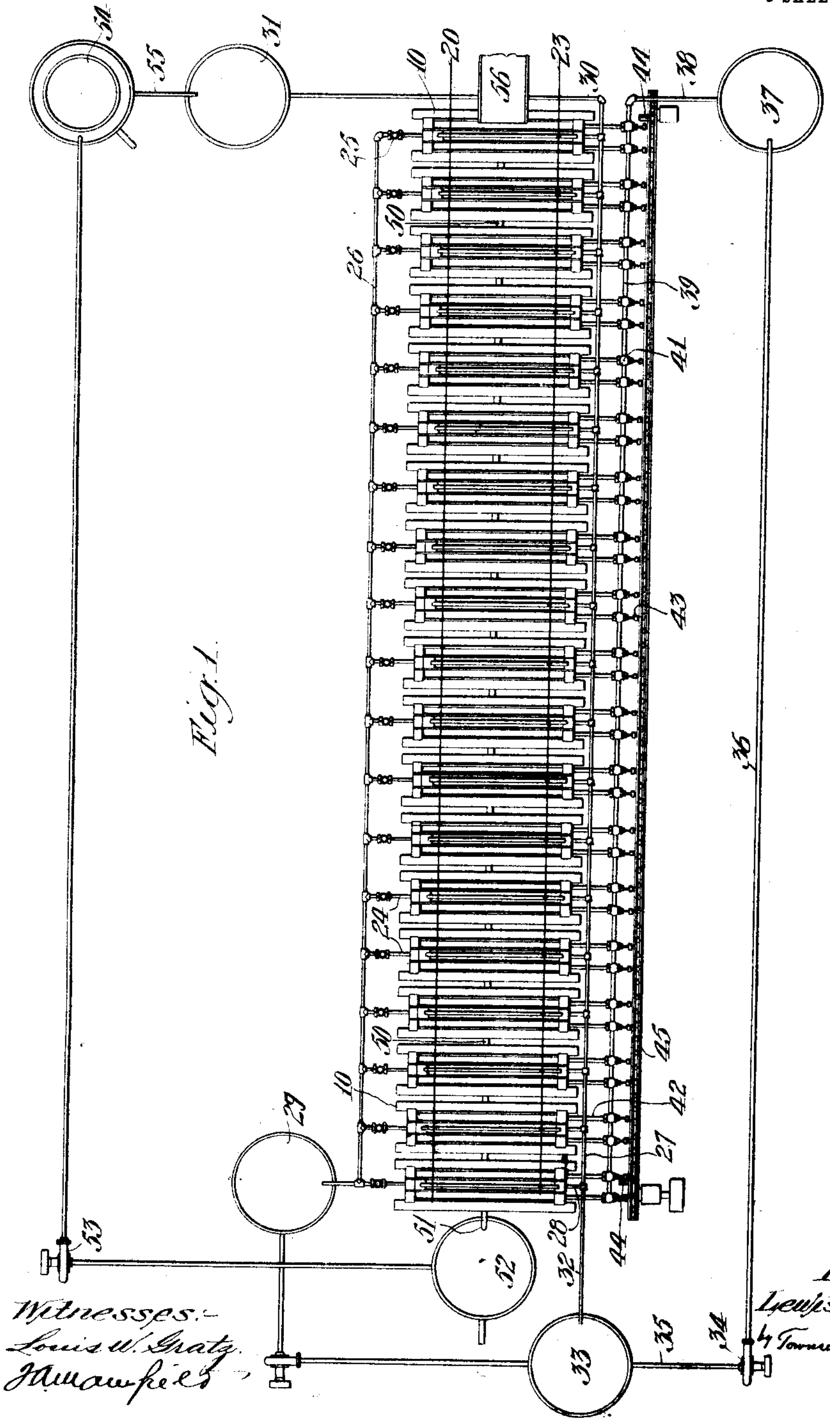
L. E. PORTER.

PROCESS AND APPARATUS FOR TREATING ORES.

APPLICATION FILED AUG. 27, 1914.

1,136,483. Patented Apr. 20, 1915.

3 SHEETS—SHEET 1.



Witnesses:—
Louis W. Gratz
[illegible]

Inventor
Lewis E. Porter
by Townsend & Graham
his Attys.

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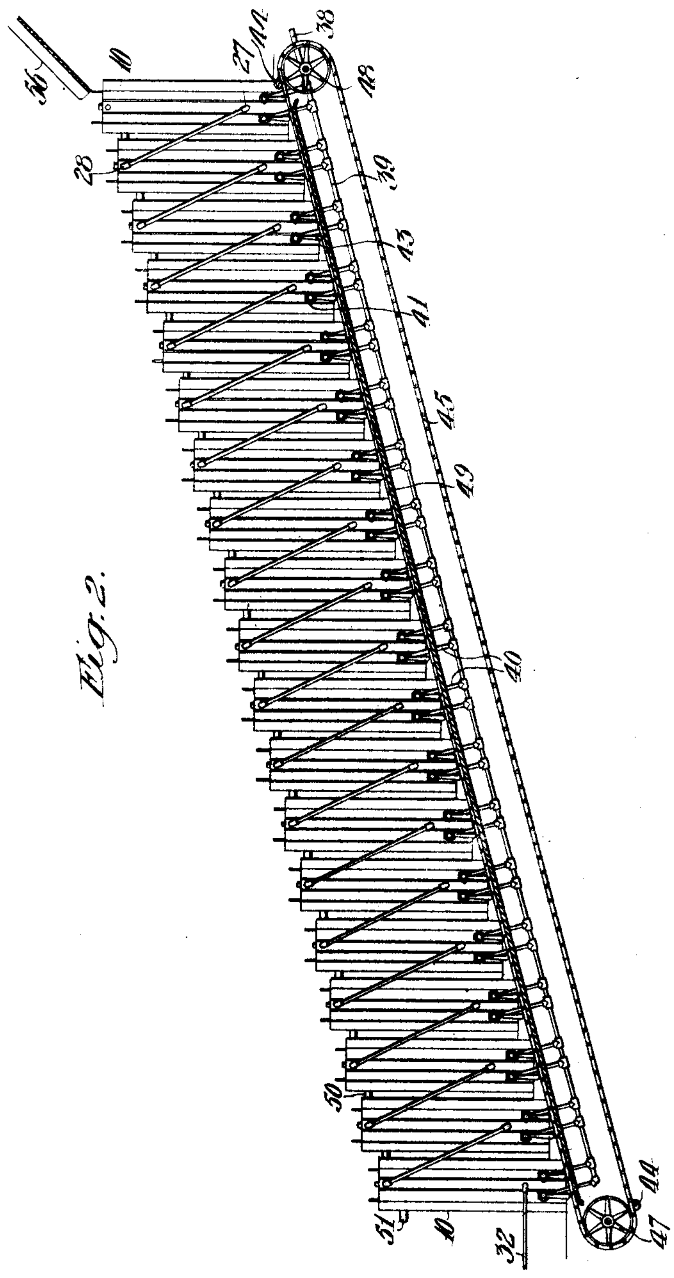
3 SHEETS—SHEET 2.

Fig. 2.



Witnesses:—
Louis W. Gratz
J. W. Mansfield

Inventor
Lewis E. Porter
by Townsend & Graham
his attys.

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3 SHEETS—SHEET 3.

Fig. 3.

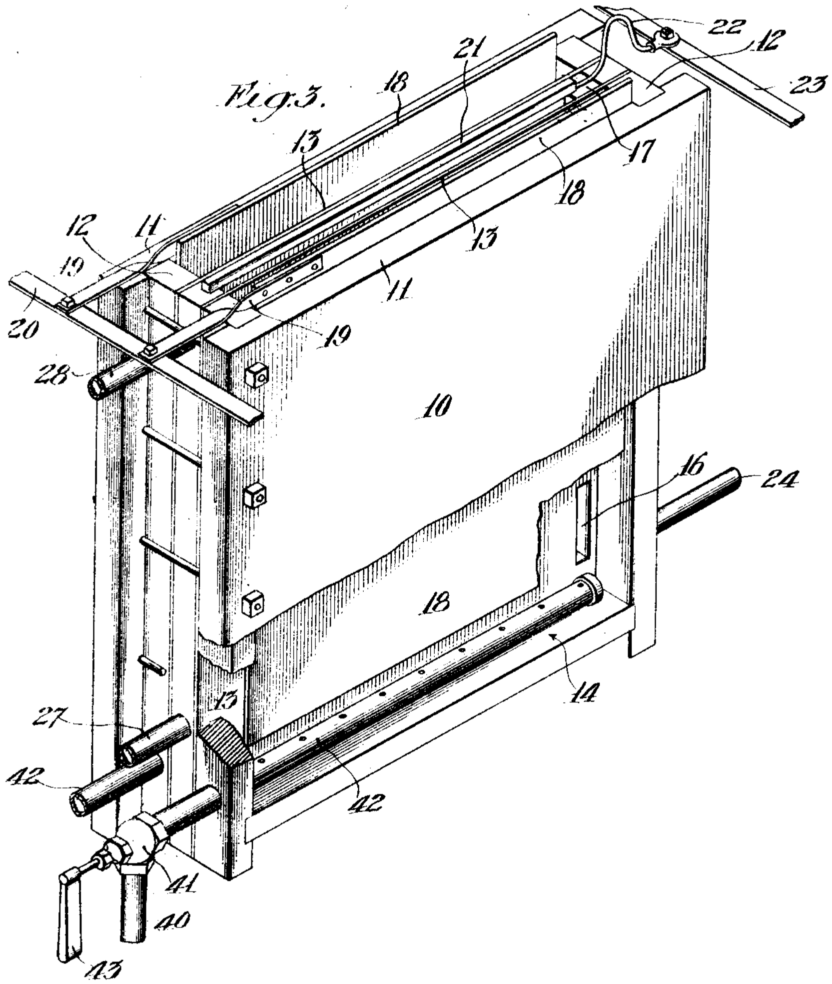
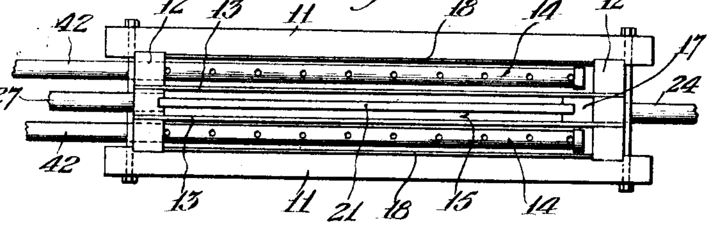


Fig. 4.



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UNITED STATES PATENT OFFICE.

LEWIS E. PORTER, OF LOS ANGELES, CALIFORNIA, ASSIGNOR OF ONE-HALF TO HUGH STOCK, OF CASPER, WYOMING.

PROCESS AND APPARATUS FOR TREATING ORES.

1,136,483. Specification of Letters Patent. Patented Apr. 20, 1915.

Application filed August 27, 1914. Serial No. 858,955.

To all whom it may concern:

Be it known that I, LEWIS E. PORTER, a citizen of the United States, residing at Los Angeles, in the county of Los Angeles, State of California, have invented a new and useful Process and Apparatus for Treating Ores, of which the following is a specification.

The process and apparatus relate to systems of ore treatment and particularly to systems which are adapted to the recovery of copper zinc, and other metals, directly from their ores, and especially from sulfid ores. The system is further adapted for the recovery of zinc and copper from complex ores containing various metals.

The usual process of treating sulfid ores is to roast and leach such ores for the purpose of changing the sulfids into sulfates, oxids, or chlorids, the sulfates, oxids, and chlorids yielding readily to various treatments.

In my invention I dispense with all preliminary treatment passing the raw ore directly into an electrolytic cell where it is agitated and pulsated in the electrolyte in the anode chamber. Metallic salts are formed from the ore and the gases released by electrolytic action, and these metallic salts are held in solution in the electrolyte and the metal is deposited therefrom as the electrolyte is circulated through the cathode chambers.

The principal object of my invention is to provide such a process in which metal is directly deposited from an electrolyte which is formed and maintained at saturated strength, from ore held in suspension, in the same cells in which the deposition takes place.

A further object of my invention is to provide electrolytic cells in which the area of the electric path will be large and the length of path will be small thus providing for a maximum of efficiency by reducing the electrical resistance and the C^2R losses due to such resistance. I have found that where filter diaphragms are used to separate the anode and cathode compartments of such a cell that there is a great tendency for such diaphragms to clog up due to the collection of slimes thereon, and a further object of my invention is to agitate and pulsate the ore in the anode chamber in such a manner as to continuously scrub the diaphragm by the action of the pulverized ore on the same.

The process illustrated and described herein is an improvement on the process disclosed in my application, Serial No. 837,939, filed in the United States Patent Office May 11, 1914, for an electrolytic cell.

While the invention is applicable to various ores containing copper, zinc, or similar metals, the chemical action taking place in treating such ores will vary with different kinds of ore, and for the purpose of illustration only the chemical action in treating a copper sulfid will be described herein.

Further objects and advantages will be evident hereinafter.

For the purpose of accomplishing the above named objects I have devised not only the new process, but have also devised a new type of apparatus as will hereinafter be more particularly described.

Referring to the drawings, which are for illustrative purposes only, and which show one embodiment of my invention: Figure 1 is a plan view in which the apparatus involved is shown diagrammatically. Fig. 2 is an elevation of a portion of the apparatus. Fig. 3 is a perspective view of one of the electrolytic agitators. Fig. 4 is a plan view of such an agitator.

In these drawings, a series of electrolytic cells 10, which are also agitators or mixers, are located in a single row on a definite gradient so that a circulation of electrolyte and ore can take place successively, therethrough under the action of gravity. The method of construction of these agitators is illustrated in Figs. 3 and 4, the agitators being made up of sides 11 and ends 12 which may be conveniently formed of wood or similar material. Porous diaphragms 13 are tightly secured in the ends 12, dividing each of the agitators into anode compartments 14 and cathode compartments 15. The anode compartments 14 are in open communication with each other through an opening 16 formed in a block of wood 17 set in the cathode compartment 15. Insoluble anodes 18, which are preferably formed of carbon or magnetite, are permanently secured against the sides 11 of the agitator in the anode compartments 14, being connected by means of straps 19 with a longitudinal bus bar 20 running the whole length of the series of agitators and connected to any convenient source of electrical supply. A metallic cathode 21 is removably mounted in the center of the cathode chamber 15 being preferably formed of a thin sheet of copper, each of these sheets being connected through a flexible connection 22 with a longitudinal bus bar 23 running the whole length of the series of agitators and connected to the source of electrical energy. To prevent confusion the bus bars 20 and 23 are shown diagrammatically in Fig. 7, and entirely omitted in Fig. 2. The anodes and cathodes do not extend to the extreme bottom of the agitator, a considerable space being left below them.

Opening into one end of each of the cathode chambers 15, at the extreme bottom thereof, is a deposit outlet pipe 24, these deposit outlet pipes being connected through valves 25 with a longitudinal pipe 26 which discharges in a copper washing tank 29, the valves 25 being normally closed as will be explained under the method of operation. Opening into each of the cathode chambers 15, at a point somewhat higher than the pipes 24, is a solution outlet pipe 27 which is carried diagonally upward, entering the next agitator through a pipe 28 communicating with the top of the cathode chamber of this next agitator. The first of the anode chambers is fed through the pipe 30 communicating with the pipe 28 of that agitator from a clear saturated solution tank 31 located above the first of the agitators, the flow therefrom being regulated so that there is a continual supply of clear saturated solution fed into the first of the cathode chambers. The pipe 30 has been omitted for the sake of clearness. The last of the cathode chambers communicates through a pipe 32, in open communication with the solution outlet 27, with a weak electrolyte tank 33 located below the last of the agitators so that the solution is readily carried away to this tank under the action of gravity. A force pump 34 is provided which takes the weak electrolyte from the tank 33 through a pipe 35, forcing it through a pipe 36 into a head weak electrolyte tank 37 located considerably above the first of the agitators. A pipe 38 carries the weak electrolyte to a longitudinal pipe 39 which runs along beside the agitators. A series of pipes 40 connect with the pipe 39, valves 41 being placed therein, these valves being normally closed and connecting the pipes 40 with perforated pipes 42 which extend across the agitators at the extreme bottom of each of the anode chambers 14. The valves 41 are provided with weighted operating levers 43 which extend downwardly and are engaged by projections 44 carried on a chain 45 which is driven by a sprocket 47, the chain 45 also passing over a sprocket 48. A guide 49 is provided for the chain 45 and is so located that the projections 44 are forced to strike against the levers 43 in successive order as the chain is moved, thereby opening the valves 41 and injecting the weak electrolyte, under some pressure, into the bottom of the anode chambers causing the pulsation and agitation of the pulp and circulation of solution through the pulp.

An anode outlet pipe 50 is provided opening into the anode chamber 14 of each agitator considerably below the top thereof and discharging into the top of the anode chamber of the next succeeding agitator, the outlet 50 opening from the anode chamber on one side of the agitator and discharging into the anode chamber on the other side of the next succeeding agitator, so that a circulation of the solution takes place downwardly through one anode chamber, through the opening 16, and upwardly through the other anode chamber of each agitator. The speed of the chain 45 is made such, and the pressure under which the solution is delivered to the pipe 39 is such, that the injection of solution into the anode chambers is under considerable force and is maintained for a sufficient period to completely fill the agitator in spite of the overflow pipes 50. This results in a pulsation in the agitator, the level of the liquid in the anode chambers being raised by the injection of fresh liquid through the valves 41, this level thereafter being lowered by the gradual action of the overflow pipes 50 during the time that the valves 31 are closed. This movement of the ore in the anode chamber continuously scrubs the diaphragm which is preferably formed of a thin slice of yucca wood, thereby preventing the adhesion of slimes from clogging this diaphragm. The last anode chamber communicates through an overflow pipe 51 with a tailings tank 52 from which the solution is forced by a pump 53 into a slime tank 54. Clear saturated solution is removed from this slime tank by means of a pipe 55, being carried into the clear saturated solution tank 31 from which it passes through the pipe 30, previously described, into the first of the cathode chambers. An ore chute 56 is provided through which finely pulverized ore is fed at a uniform rate from a crusher or other convenient means, this stream of ore being regulated to suit the number and capacity of agitators used.

The method of operation is as follows: The treatment of a copper sulfid ore being chosen as an example, the ore held in suspension in an electrolyte consisting of a solution of copper sulfate is successively circulated through the anode chambers of the agitators, the cathode chambers being also kept filled with a solution of copper sulfate. Electric current is then passed through the electrolyte liberating copper at the cathode and SO_4 at the anode. This SO_4 unites with the copper of the ore to form copper sulfate, free sulfur being liberated. Under some conditions other chemical reactions may occur but the above action is that depended on. It will be seen that there is a continual impoverishment of the electrolyte in the cathode compartment and a continual enrichment of the electrolyte in the anode compartment.

The practical method of operating the apparatus is as follows: Pulverized ore is fed through the chute 56 into the anode chamber 14 of the first of the electrolytic agitators. The anode chambers are filled with weak electrolyte which has been introduced through the pipes 42 and the electrolyte and suspended ore are agitated by the periodic injection of more weak electrolyte through the pipes 42. The ore and electrolyte pass through the openings 16 into the corresponding anode chamber on the other side of the agitator being reagitated therein by the periodic introduction of more weak electrolyte through the pipe 42. The ore and electrolyte then pass through the pipe 50 into the succeeding agitator where more weak electrolyte is added, the ore being held in suspension by the agitation produced thereby. This continues through the succeeding agitators, the copper being removed from the ore by combination with the SO_4 liberated at the anode, $CUSO_4$ being added to the electrolyte. Free sulfur is liberated from the sulfid ore forming a valuable by-product. The porous diaphragms 15 prevent the ore from passing into the cathode chamber 15 at the same time allowing the electric current to pass freely therethrough.

When the mixture of ore and solution passes into the tailings tank 52 through the overflow pipe 51 the solution is a saturated solution of copper sulfate. The rate of flow of material through the agitators is such that the ore has been thoroughly treated before the mixture enters the tailings tank 52 and the solid material entering this tank is practically free from copper, all the copper having passed into solution as copper sulfate. The solid material settling in the bottom of the tailings tank 52 is removed and washed for the purpose of recovering various materials therefrom.

The saturated solution from the tailings tank 52 is forced into the slime tank 54 through which it is filtered, a clear saturated solution of copper sulfate being taken from this tank and delivered to the clear saturated solution tank 31. This clear saturated solution of copper sulfate is fed through the pipe 30 into the first of the cathode chambers, passing downwardly therethrough and being taken off through the solution outlet 27 and passed into the top of the cathode chamber of the next succeeding agitator. Copper is deposited from the saturated solution upon the cathode 21 by the action of the electric current. I prefer to make my current value such that this deposit does not adhere permanently to the cathode, falling into the bottom of the cathode chamber after it has accumulated on the cathode in sufficient amounts. This deposited copper is removed at intervals through the deposit outlets 24 being passed through the pipe 26 into the copper washing tank 27 in which it is washed, it being thereafter melted into suitable bars. A solid metallic deposit can be formed on the cathode 21 if desired.

The electrolyte having passed through the successive cathode chambers is slightly impoverished and passes into the tank 33 through the pipe 32 being then forced into the tank 37 by the pump 34. From this tank 37 it passes through the pipe 38 into the pipe 39, being injected therefrom into the anode chambers through the pipes 42 as previously described.

It is to be understood, while I have described the path followed by a single particle of solution, that all the operations described herein are simultaneous, the solution flowing in a continuous path through the apparatus described so that ore is continuously flowing through the anode chambers, and copper sulfate solution is continuously flowing through the cathode chambers, electrolytic action taking place simultaneously in these chambers.

I claim as my invention:

1. An electrolytic cell and agitator comprising a containing vessel, porous diaphragms dividing the interior of said vessel into anode and cathode compartments, an anode in each anode compartment, a cathode in each cathode compartment, an anode compartment outlet pipe located in the side of said vessel in open communication with the anode compartment at some distance from the top of said compartment, and means for intermittently injecting solution into said anode compartment.

2. An electrolytic cell and agitator comprising a containing vessel, porous diaphragms dividing the interior of said vessel into anode and cathode compartments, an anode in each anode compartment, a cathode in each cathode compartment, an anode compartment outlet pipe located in the side of said vessel in open communication with the anode compartment at some distance from the top of said compartment, and means for intermittently injecting solution into said anode chamber at a rate considerably faster than the discharge rate through said outlet pipe, so that the level of the electrolyte in the anode chamber rises during the time of injection and falls during the intervals between said injection.

3. An electrolytic cell and agitator com-

prising a containing vessel, porous diaphragms dividing the interior of said vessel into anode and cathode compartments, an anode in each anode compartment, a cathode in each cathode compartment, an anode compartment outlet pipe located in the side of said vessel in open communication with the anode compartment at some distance from the top of said compartment, and perforated pipes located at the bottom of said anode chamber for intermittently injecting solution into said anode chamber at a rate considerably faster than the discharge rate through said outlet pipe, so that the level of the electrolyte in the anode chamber rises during the time of injection and falls during the intervals between said injection.

4. An electrolytic apparatus comprising a cell divided by a porous diaphragm into anode and cathode compartments each having suitable electrodes, means by which an ore in suspension in an electrolyte is flowed through the anode compartment, and means whereby an electrolyte containing the values extracted in the anode compartment is flowed through the cathode compartment.

5. An electrolytic apparatus comprising a cell divided by a porous diaphragm into anode and cathode compartments each having suitable electrodes, means by which an ore in suspension in an electrolyte is flowed through the anode compartment, means for pulsating the ore and the electrolyte in the cathode compartment, and means whereby an electrolyte containing the values extracted in the anode compartment is flowed through the cathode compartment.

6. An electrolytic apparatus comprising a cell divided by a porous diaphragm into anode and cathode compartments each having suitable electrodes, means by which an ore in suspension in an electrolyte is flowed through the anode compartment, means for injecting poor electrolyte into the anode compartments, and means whereby an electrolyte containing the values extracted in the anode compartment is flowed through the cathode compartment.

7. An electrolytic apparatus comprising a cell divided by a porous diaphragm into anode and cathode compartments each having suitable electrodes, means by which an ore in suspension in an electrolyte is flowed through the anode compartment, means for intermittently injecting poor electrolyte into the anode compartments, and means whereby an electrolyte containing the values extracted in the anode compartment is flowed through the cathode compartment.

8. An electrolytic apparatus comprising a cell divided by a porous diaphragm into anode and cathode compartments each having suitable electrodes, means by which an ore in suspension in an electrolyte is flowed through the anode compartment, a valve through which poor electrolyte may be introduced into the anode compartment, means for intermittently opening said valve, and means whereby an electrolyte containing the values extracted in the anode compartment is flowed through the cathode compartment.

9. An electrolytic apparatus comprising a cell divided by a porous diaphragm into anode and cathode compartments each having suitable electrodes, means by which an ore in suspension in an electrolyte is flowed through the anode compartment, means for removing from the cell any deposited metal that falls to the bottom of the cathode compartment, and means whereby an electrolyte containing the values extracted in the anode compartment is flowed through the cathode compartment.

10. An electrolytic apparatus comprising a cell divided by a porous diaphragm into anode and cathode compartments each having suitable electrodes, means by which an ore in suspension in an electrolyte is flowed through the anode compartment, means for removing from the cell any deposited metal that falls to the bottom of the cathode compartment, means for pulsating the ore and the electrolyte in the cathode compartment, and means whereby an electrolyte containing the values extracted in the anode compartment is flowed through the cathode compartment.

11. An electrolytic apparatus comprising a cell divided by a porous diaphragm into anode and cathode compartments each having suitable electrodes, means by which an ore in suspension in an electrolyte is flowed through the anode compartment, means for removing from the cell any deposited metal that falls to the bottom of the cathode compartment, and means for injecting into the cathode compartment electrolyte containing the values extracted in the anode chamber.

12. An electrolytic apparatus comprising a cell divided by a porous diaphragm into anode and cathode compartments each having suitable electrodes, means by which an ore in suspension in an electrolyte is flowed through the anode compartment, means for removing from the cell any deposited metal that falls to the bottom of the cathode compartment, means for injecting poor electrolyte into the anode compartments, and means whereby an electrolyte containing the values extracted in the anode compartment is flowed through the cathode compartment.

13. An electrolytic apparatus comprising a cell divided by a porous diaphragm into anode and cathode compartments each having suitable electrodes, means by which an ore in suspension in an electrolyte is flowed through the anode compartment, means for removing from the cell any deposited metal that falls to the bottom of the cathode compartment, means for intermittently inject-

ing poor electrolyte into the anode compartments, and means whereby an electrolyte containing the values extracted in the anode compartment is flowed through the cathode compartment.

14. An electrolytic apparatus comprising a cell divided by a porous diaphragm into anode and cathode compartments each having suitable electrodes, means by which an ore in suspension in an electrolyte is flowed through the anode compartment, means for removing from the cell any deposited metal that falls to the bottom of the cathode compartment, a valve through which poor electrolyte may be introduced into the anode compartment, means for intermittently opening said valve, and means whereby an electrolyte containing the values extracted in the anode compartment is flowed through the cathode compartment.

15. An electrolytic apparatus comprising a plurality of cells, each cell being divided by a porous diaphragm into anode and cathode compartments, suitable electrodes in said compartments, means for causing an ore in solution in an electrolyte to flow successively through the anode compartments for the purpose of extracting the values to form a rich electrolyte, means for separating the gangue from the rich electrolyte, and means for circulating the rich electrolyte through the cathode compartments.

16. An electrolytic apparatus comprising a plurality of cells, each cell being divided by a porous diaphragm into anode and cathode compartments, suitable electrodes in said compartments, means for causing an ore in solution in an electrolyte to flow successively through the anode compartments for the purpose of extracting the values to form a rich electrolyte, means for successively passing said rich electrolyte through the cathode compartments so that the values are partially extracted therefrom to form a poor electrolyte, and means for injecting said poor electrolyte into the anode compartments.

In testimony whereof, I have hereunto set my hand at Los Angeles, California, this 20th day of August, 1914.

LEWIS E. PORTER.

In presence of—

Ford W. Hanis,

Fred A. Mansfield.