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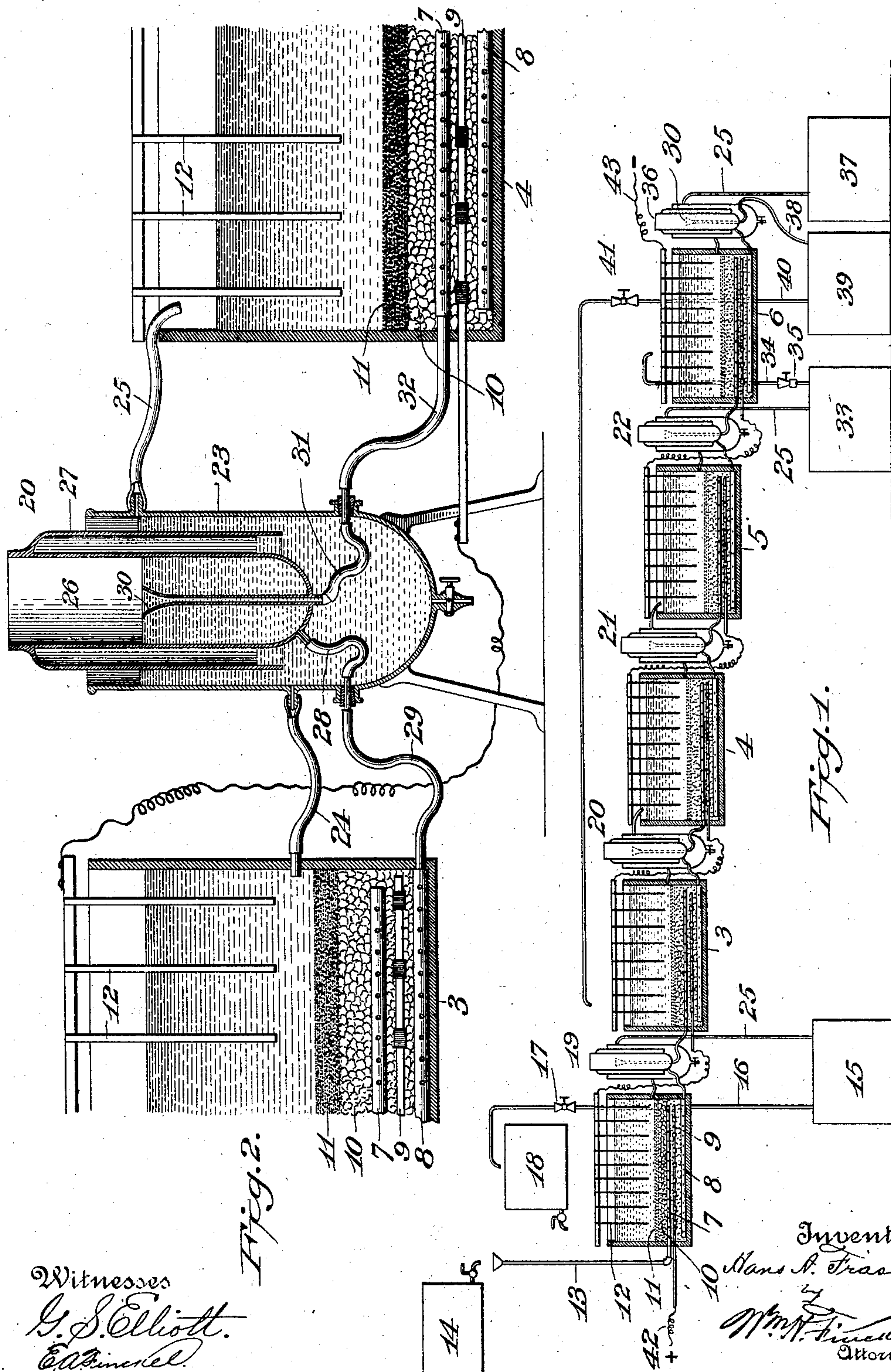
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PROCESS OF RECOVERING AND SEPARATING METALS FROM THEIR ORES.

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NO MODEL.



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# UNITED STATES PATENT OFFICE.

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PROCESS OF RECOVERING AND SEPARATING METALS FROM THEIR ORES.

SPECIFICATION forming part of Letters Patent No. 720,235, dated February 10, 1903.

Application filed November 2, 1900. Serial No. 35,260. (No specimens.)

*To all whom it may concern:*

Be it known that I, HANS A. FRASCH, a citizen of the United States, residing at Hamilton, in the county of Wentworth and Province of Ontario, Canada, have invented a certain new and useful Improvement in Processes of Recovering and Separating Metals from Their Ores and Concentrates Thereof, of which the following is a full, clear, and exact description.

10 This invention relates to an electrolytic process of recovering and separating metals from bodies of greater or less complexity, and more especially such as complex ores, matte, slags, &c.

15 The object of my invention is to bring the metals represented in ore, matte, and other metal-bearing mineral substances into solution and at the same time deposit from an independent electrolyte certain metals upon cathodes, transmitting the solvent ions to whatever ore or other mineral substance is used for anode, and thereby producing constantly a fresh electrolyte at the anode, which electrolyte may be of entirely different composition from the electrolyte acted upon by the cathode, so that by my invention I am enabled to exhaust an electrolyte in the cathode-compartment entirely from all metallic contents and produce at the anode an amount of metallic salts equivalent to the amount which originally was present in the electrolyte of the cathode.

I am aware that soluble anodes have been used for resaturating an electrolyte; but the methods heretofore employed have not permitted the production of an electrolyte at the anode independent of and yet in contact with the contents of the cathode-compartment, so that, for instance, the chlorid of one metal could be electrolyzed, the metal deposited at the cathode, and the chlorin recovered at the anode as the chlorid of another metal without either of the electrolytes contaminating each other. By my invention I accomplish this purpose, and while electrolyzing a solution of one or several metals contained in an electrolyte I may produce at the same time another electrolyte of entirely different composition in proportional quantities to the solvent ions liberated by the anodes, and I may remove the electrolyte from the anode and constantly supply the cathode with an electrolyte other

than what the anode produces and from an outside source.

In carrying out my invention I take the body containing the metals to be extracted, and whether such body contains only those metals or others, and utilize it in the form of an anode as part of an electrolytic bath or a number of baths. The cathodes may consist of any usually-employed substance, and I prefer to use cathodes consisting of the same kind of metal as will be deposited upon them.

My invention is particularly applicable in the treatment of copper-nickel ore or matte. To treat such ore or matte and bring the metals contained therein into solution, I use such ore or matte as the anode in an electrolytic bath, in which a solution of a salt of an alkali—such as sodium chlorid, (common salt,) for instance, or any other salt of an alkali—forms the electrolyte, ordinary carbon or copper cathodes being employed. By electrolysis I obtain caustic alkali or soda at the cathode, while the chlorin combines with the metals represented in the anode, producing the corresponding salts of the metals. Sulfur, silica, and all non-metallic ingredients contained in the anode remain as residuum. While I prefer to do so, I do not limit my invention to producing this initial solution in the manner described, and the solution may be obtained by chemical or any other processes. To enrich the metallic solutions and bring them to a high state of concentration, I pass the chlorid solution successively through similar anodes of any desired number of baths, or I may return the metallic solution to the anode of the same bath, keeping up a constant circulation through the anode only until the solution has obtained a sufficiently high degree of concentration. At the same time I circulate an electrolyte consisting of a solution of the salt of an alkali through the cathode-compartment. This solution I may also pass through a series of cathode-compartments or, as in the instance of the anode, circulate the solution through the cathode-compartment of the same bath until it is sufficiently enriched in alkali to be concentrated and disposed of. Again, I may equip a series of electrolytic baths in such manner that a solution of sodium chlorid or any other salt of an alkali



may be allowed to flow through the anode of any desired number of baths, while a second flow of saline solution is maintained through the cathode-compartments, so that at the last  
 5 of the series of baths I obtain in concentrated form a solution of the metals represented in the different anodes and a solution of alkali from the cathodes. In the same manner one  
 10 or more baths may be utilized to produce alkali at the cathode and metallic solutions at the anode, and the anode electrolyte may be allowed to pass on through a further number of baths, while the alkali may be drawn off  
 15 at any one of the baths, and solutions of different metals may be circulated in the cathodes of the remainder of the baths.

In the accompanying drawings, illustrating my invention, in the two figures of which like parts are similarly designated, Figure 1 is a  
 20 vertical longitudinal section of one form of plant by which my invention may be carried out. Fig. 2 is a similar section, on a larger scale, more fully illustrating the regulator and its application between adjacent baths.

25 The electrolytic plant may comprise any number of baths, as 2, 3, 4, 5, and 6, arranged at progressively lower levels from inlet to outlet. Each bath has in its bottom a perforated feed-pipe 7 and discharge-pipe 8, an electric conductor 9, surrounded by an anode  
 30 of a mineral substance containing the metal or metals to be extracted and used in comminuted or disintegrated or divided form—such as ore, matte, slag, concentrates, &c.—  
 35 and also a diaphragm 11, preferably of granular chemically inert or neutral substance, such as sand, spread over the anode, and the cathode-plates 12, suspended in the upper portion of the bath. Bath 2 has an inlet-  
 40 pipe 13, which is fed with salt brine from tank 14, and said bath overflows into tank 15, and the contents of said tank 15 may be raised through pipe 16 by the lifting or forcing apparatus 17 into tank 18, whence it is returned  
 45 to the bath 2. Between each bath is an automatic regulator, (designated, respectively, 19 20 21 22,) each of which regulators is constructed as follows: There is an outside boot 23 of non-corrosive material connected by a  
 50 tube 24 at its bottom or lower portion with the cathode-section of bath 2 and overflowing or discharging from its upper portion through tube 25. Within this boot is a float 26, buoyed by a surrounding air-chamber 27 in the fluid  
 55 contents of the boot. This float is supplied with a flexible connection 28, communicating by pipe 29 with the anode-section of one bath, whereby said float receives the electrolytic fluid from said section, and it is also supplied  
 60 with an overflow 30, connected by a flexible tube 31 with a pipe 32, leading to the anode-section of the next bath or to a discharge-tank. This regulator serves to adjust the overflow of the two electrolytes by means of  
 65 their relative gravity. The overflow-level in the boots being of constant height establishes the level of the liquid in the baths. This reg-

ulator, operating in connection with the electrolytic baths—say bath 2—where alkali is produced at the cathodes in the cathode or up- 70 per section of the bath and metallic chlorid solutions in the anode or lower section of the bath, allows the alkaline solution to overflow through pipe 24, through the boot, and out through the overflow 25 of the boot, while the 75 metallic chlorid solution leaves the bath 2 through pipe 29, enters the float 26 through pipe 28, and passes out through overflow 30 and pipe 31 to outlet 32. As the density of the alkaline solutions contained in the upper part 80 of the bath 2 increases the float 26 rises, and thereby balances the overflow in accordance with the difference in specific gravity between the chlorid solution and the alkaline solution. On the other hand, if the metallic chlo- 85 rid solution becomes heavier the float sinks, thereby lowering the overflow 30 and again balancing the outflow of the chlorid solution with the overflow 25 by reason of the specific gravity of the chlorid solution contained in 90 float 26. In adjusting the levels between the chlorid and the alkaline solution overflow a perfect and constant circulation of two different streams of liquids of different specific gravities is possible through one and the same 95 vessel without intermixing. I wish to observe in passing that while I may employ this regulator in this instance for maintaining the circulation of the two electrolytes in the different baths I do not wish to limit this part 100 of the invention to this specific purpose. The overflow 25 of the regulator 19 discharges into tank 15, while the similar overflows of regulators 20 and 21 discharge into baths 4 and 5, respectively. The overflow 25 of regu- 105 lator 22 discharges into a tank 33, whence the fluid may be conveyed to bath 6 by means of pipe 34 and any suitable forcing or lifting apparatus 35. The last bath 6 in the series has a similar regulator 36, the overflow 25 of 110 which discharges into a tank 37 and the overflow 30 of which discharges through pipe 38 into a tank 39, whence the fluid is withdrawn through pipe 40 and any suitable forcing or lifting apparatus 41 and returned to bath 3 115 or any other bath in the series.

Illustrating one form of the invention, if the process should be applied to the extraction and recovery of metals contained in copper-nickel matte each of the baths (indicated 120 in Fig. 1 as 2 to 6) is provided with a quantity of coarsely-disintegrated matte, which forms the individual anodes. This matte is covered with a diaphragm or, as I prefer, with a thin layer of sand or other chemically-inert 125 granular material. Tank 14, containing salt brine of a strength of about 20° Baumé, supplies bath 2 with salt brine until it overflows through pipe 25 into tank 15. The electric current is then turned on, when chlorine is 130 evolved with the mass of the anode, while a corresponding quantity of caustic soda is produced at the cathode. When bath 2 is filled to the level of overflow 25 of the regulator 19,



a proportional quantity of salt brine from tank 18 is permitted to flow into the cathode-compartment of bath 2, and circulation through the cathode-compartment is then maintained by the forcing or lifting apparatus 17, while the chlorid solution formed in the anode-compartment leaves bath 2 through pipe 29 and regulator 19, passing on through pipe 32, through the anode of bath 3, and so on through regulators 20, 21, and 22, through the anodes of baths 5 and 6, and from the last bath it flows into tank 39. The forcing or lifting device 41, which may be of porcelain or other suitable material, delivers the metallic solution, which may have been previously acidulated to increase its electric conductivity, from tank 39 through pipe 40 into the cathode-compartment of bath 3, the baths 3, 4, 5, and 6 having previously been filled with either salt brine or metallic salt solution from previous operations. The electric current is now closed between the poles 42 and 43, so that the whole series of baths is in one circuit when the least positive of the metals contained in the solution coming from tank 39 (in this instance silver) is deposited upon the cathodes of bath 3, the supply of the cathode electrolyte from tank 39 being adjusted so as to exhaust of silver the electrolyte in said bath 3. From the cathode-compartment of bath 3 the electrolyte flows through regulator 20 into the cathode-compartment of bath 4. Here the next positive metal (in this instance copper) is deposited, and the electrolyte flows again through the regulator 21 into bath 5 or as many baths as are required to remove all the copper, when the electrolyte is allowed to flow through regulator 22 into tank 33, where it is treated with oxidizing agents and carbonate of lime for the purpose of removing the iron contained therein. After removal of the iron the electrolyte is delivered by the forcing or lifting device 35, through pipe 34, into the cathode-compartment of bath 6, where the nickel is deposited upon the cathode. The electrolyte from bath 6 is caused to flow through the cathode-compartments of as many electrolytic baths as are required to remove the nickel, and finally through the regulator of the last bath of the series into tank 37, whence it may be returned to tank 14 and used over again for circulation through the anodes of the whole series of baths and re-saturation. Whenever this electrolyte, after the removal of the copper, iron, or nickel, contains enough cobalt or other metals more electropositive than nickel, the latter may be removed in the same manner as the copper and nickel in an additional number of similar baths.

Instead of having only one bath for the initial chlorination as conducted in bath 2 any number of baths necessary to produce a sufficient quantity of electrolyte may be used, and these baths may be connected in multiple or series with the system. The same may

be done at every station where a different operation is conducted in the cathode-compartment to balance the electric-current density required by each individual metal to be deposited.

By this method I electrolyze individually in one and the same operation and under one circuit the solutions of the chlorids of sodium, silver, copper, nickel, cobalt, and as many metals as are contained in the matte, (anodes,) recovering in every instance the chlorine or other solvent agent in the anode-compartments by producing constantly the chlorids or other salts of the metals contained in the anodes. I can also at any point in the series of baths disconnect the overflows of the regulators and remove the electrolyte produced at the anode, so that one part of the system may be charged with copper nickel matte and the rest of the system may be charged with any other metal-bearing substance, and while I electrolyze at all the cathodes the solutions obtained from the anodes of the copper-nickel matte sections I may produce the chlorids of whatever ores are contained in the other sections and remove them for commercial purposes, resupplying the chlorine thus abstracted from the system by an increased production of alkali in the first section of the series of baths. For instance, the anodes of baths 2, 3, 4, and 5 may consist of copper-nickel matte, and in bath 6 of zinc ore, salt brine being allowed to circulate between the tank 15 and the cathode-compartment of bath 2, while the salt brine or other electrolyte supplied from tank 14 is allowed to pass on through the overflows of the series of baths to bath 5, the overflow of said bath 5 being connected with tank 33. The anode-section of bath 5 is supplied with salt brine or a solution of chlorid of zinc by the same means as bath 2, which is allowed to flow through the anode of bath 6 to the vessel 39, the electrolyte collected in tank 33 being delivered to the cathodes of bath 3 and thence allowed to circulate through all the baths 4, 5, and 6 to tank 37, whence it may be returned to the anode of bath 3 by suitable means and circulated again. In this instance a solution of alkali is obtained in bath 2, an electrolyte consisting of a solution of the metals contained in the matte is obtained in baths 3, 4, and 5, and a solution of chlorid of zinc is obtained in bath 6, while on the cathodes of all the baths from 3 to 6 the metals contained in the electrolyte of tank 33 are deposited.

What I claim is—

1. The method of separating, by electrolysis, metals from their ores, which consists in providing an electrolytic bath with a soluble anode composed of comminuted ore bearing the metals to be obtained, circulating successively through a series of such anodes an electrolyte capable of dissolving the metals contained therein, and simultaneously circulating the electrolyte obtained from the whole series of anodes past the cathodes of one or



more baths and thereupon depositing the least positive metal, keeping the other metals in solution.

2. The method of recovering copper and separating nickel and cobalt from matte or ore, by electrolysis, which consists in providing a number of electrolytic baths with anodes composed of the matte or ore to be treated, electrolyzing the salt of an alkali whose radical will combine with the metals contained in the anode in the first of the series of baths and circulating the metal-bearing electrolyte obtained at the anodes through the cathode-compartments of any desired number of the series of baths and electrodepositing the copper, retaining the nickel and cobalt in solution.

3. The method of recovering copper and separating nickel and cobalt from matte or ore by electrolysis, which consists in providing a system of electrolytic baths with anodes composed of the matte or ore to be treated, supplying the anodes of any desired number of the system of baths with a solution of a salt of an alkali whose acid or halogen radical is capable of combining with the metal represented in the anode, and circulating the electrolyte obtained at the anodes of these baths through the cathode-compartments of another number of the system of baths, and electrodepositing the copper, while retaining the nickel and cobalt in solution.

4. The method of recovering copper and separating nickel and cobalt from matte or ore by electrolysis, which consists in providing a system of electrolytic baths with soluble anodes composed of the matte or ore to be treated, supplying the anodes of any desired number of the system of baths with a solution of a salt of an alkali whose acid or halogen radical is capable of combining with the metal represented in the anodes, supplying the cathodes with a catholyte of different specific gravity, and regulating the overflow of the anolyte and catholyte by means of their difference in specific gravity.

5. The method of recovering copper and separating nickel, cobalt and other metals from matte or ore by electrolysis, which consists in providing a system of electrolytic baths with anodes composed of the material to be treated, electrolyzing the salt of an alkali

whose acid or halogen radical is capable of combining with the metal represented in the anode in a part of the system of baths, and circulating the metal-bearing electrolyte thereby obtained at the anodes successively through the anodes of the bath next in series, returning the electrolyte to the cathode-compartments of these baths, and electrodepositing the copper, then returning the exhausted electrolyte to the anode of the first bath, and repassing it successively through the anodes of all the baths, thereby resaturating the electrolyte and enriching it constantly with nickel, cobalt and other metals than copper.

6. The method of exhausting an electrolyte composed of the salts of a number of metals, of an individual less electropositive metal contained therein, and enriching the electrolyte with the more electropositive metals, consisting in passing an electrolyte first through the anodes of a series of baths containing the metals represented in the electrolyte, then through the cathodes and depositing the least positive metal thereon, returning the electrolyte to the anode of the first bath in series and passing it again through the series of anodes and thereby constantly enriching the electrolyte with the more electropositive metals.

7. The method of recovering nickel from nickel-bearing mineral substances, consisting in providing a series of electrolytic baths with anodes composed of the comminuted nickel-bearing substance to be treated, electrolyzing the salt of an alkali in the first section of the series of baths, electrodepositing the copper from the electrolyte thereby obtained in the next section of the series of baths, removing by suitable means the iron contained in the electrolyte derived from the whole series of baths after removal of the copper, and finally depositing the nickel upon suitable cathodes in the last section of the series of baths, and constantly producing fresh nickel-bearing electrolyte from the anodes of the whole series of baths.

In testimony whereof I have hereunto set my hand this 19th day of October, A. D. 1900.

HANS A. FRASCH.

Witnesses:

C. A. NEALE,  
WM. H. FINCKEL.