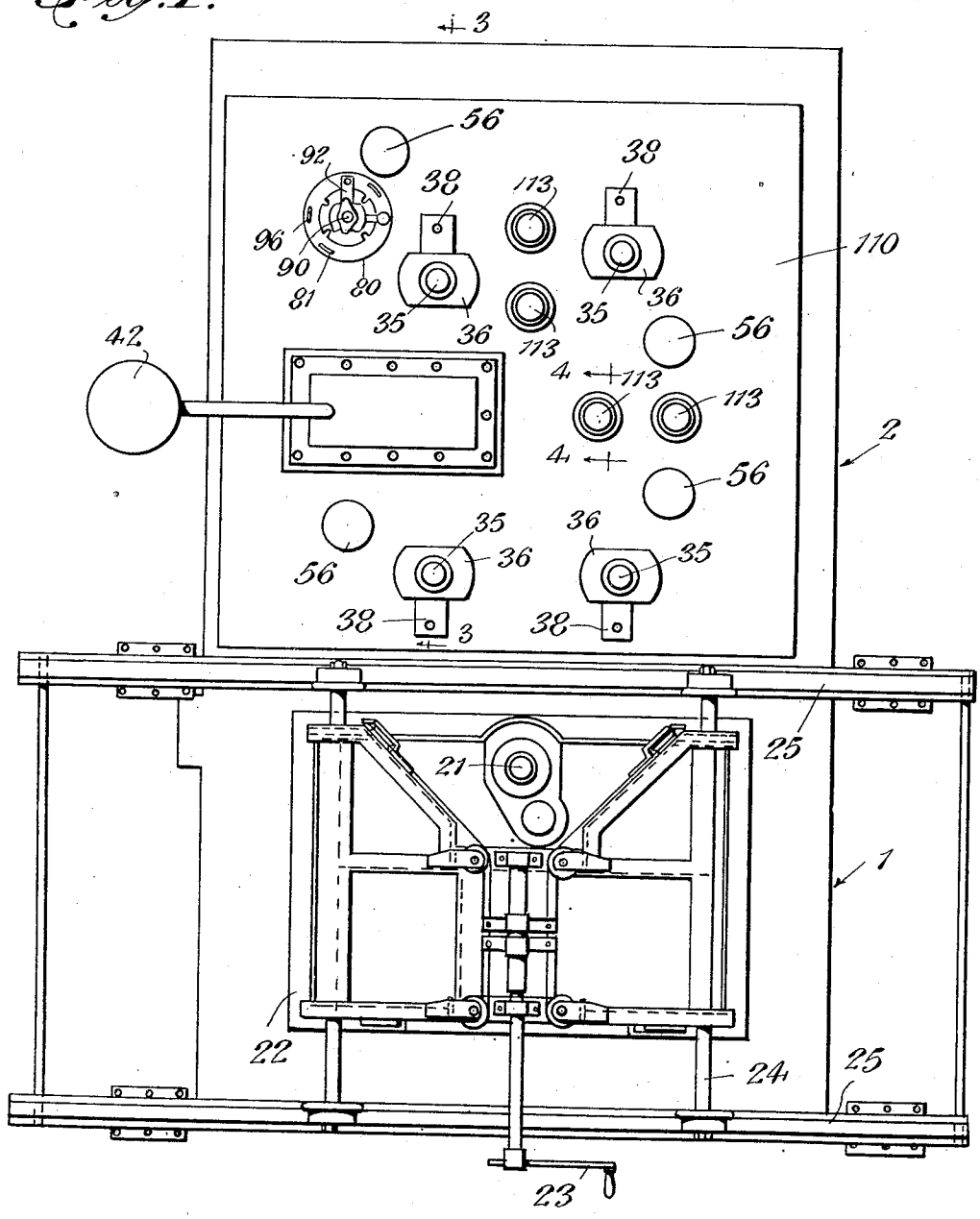
Oct. 19, 1948. A. F. JOHNSON 2,451,492

METHOD AND APPARATUS FOR ENRICHING THE ALUMINA CONTENT OF CRYOLITE FUSIONS IN ALUMINUM PRODUCTION

Filed Jan. 31, 1946 6 Sheets-Sheet 1

Fig. 1.



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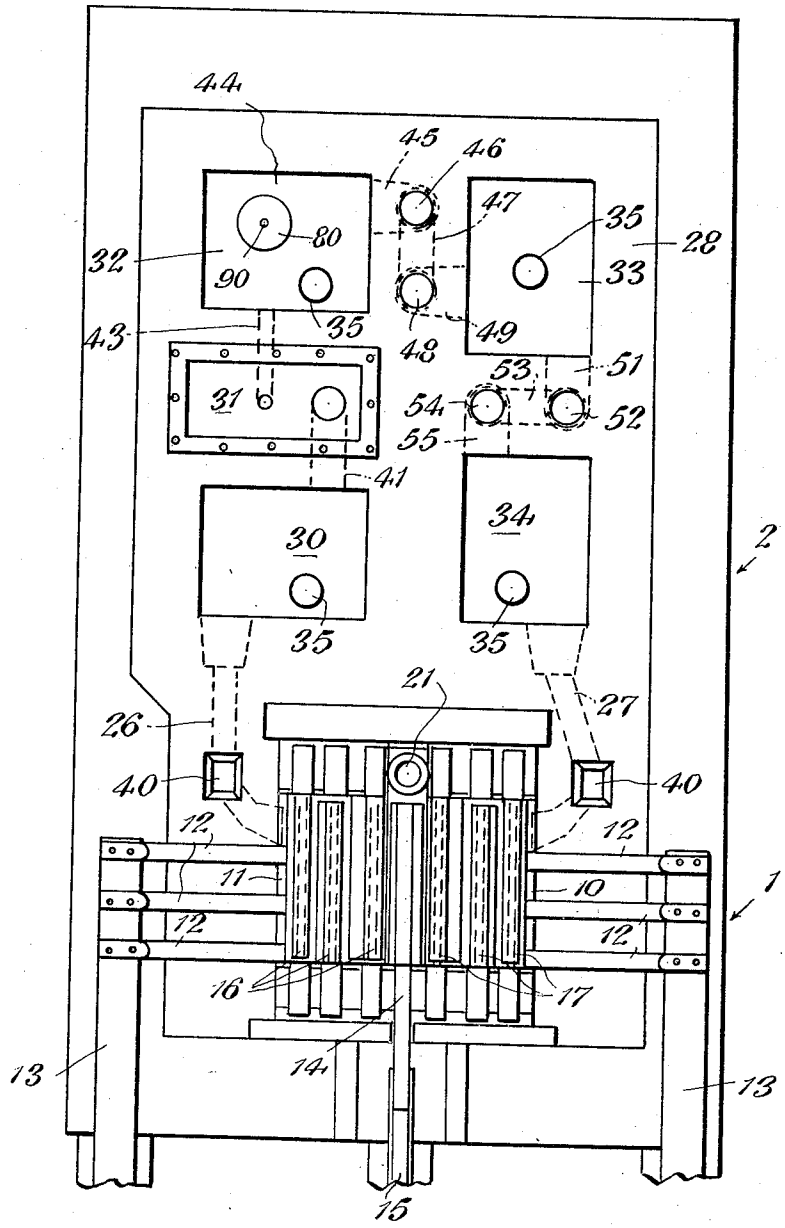
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METHOD AND APPARATUS FOR ENRICHING THE ALUMINA CONTENT OF CRYOLITE FUSIONS IN ALUMINUM PRODUCTION

Filed Jan. 31, 1946 6 Sheets-Sheet 2

Fig. 2.



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METHOD AND APPARATUS FOR ENRICHING THE ALUMINA CONTENT OF CRYOLITE FUSIONS IN ALUMINUM PRODUCTION

Filed Jan. 31, 1946 6 Sheets-Sheet 3

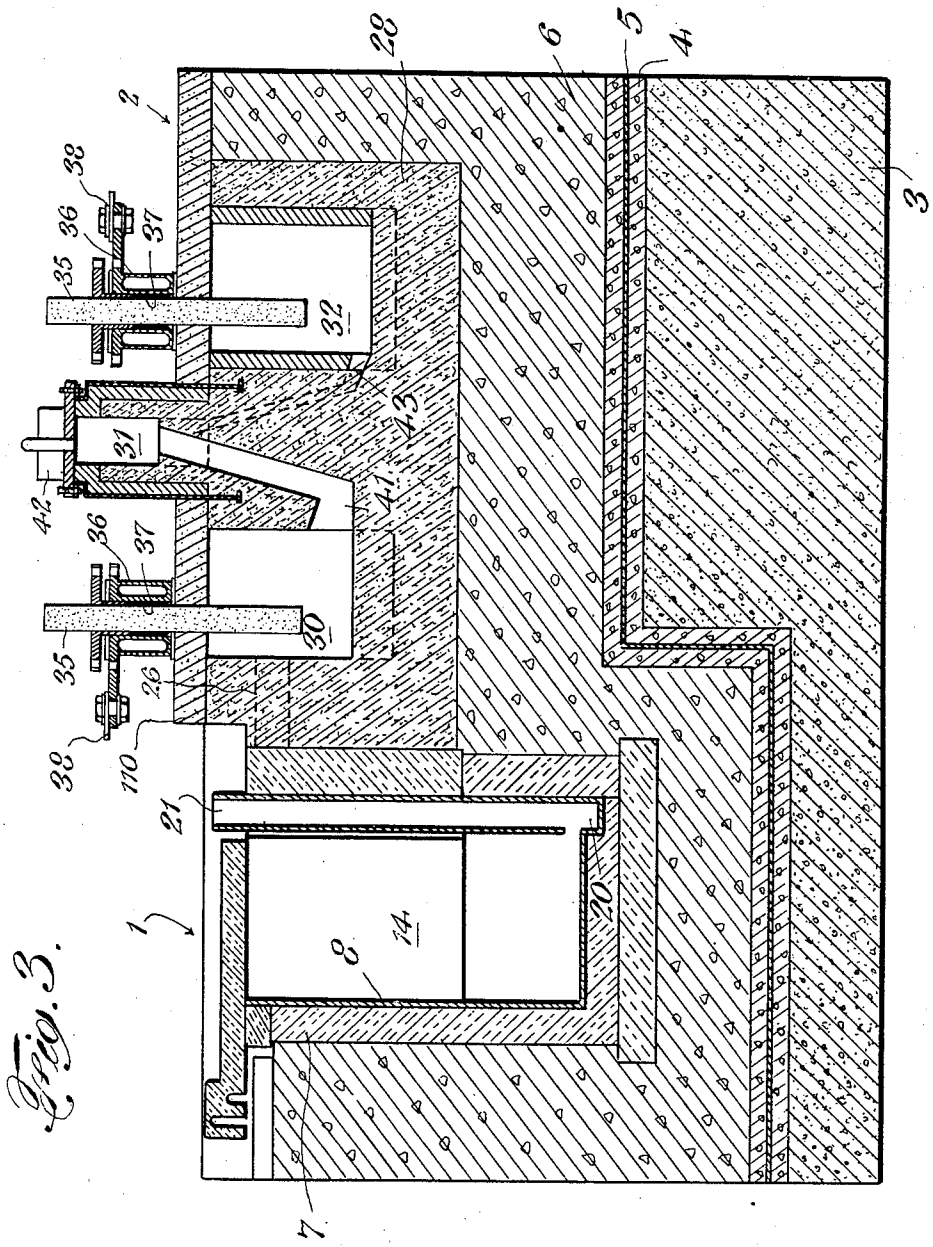


Fig. 3.

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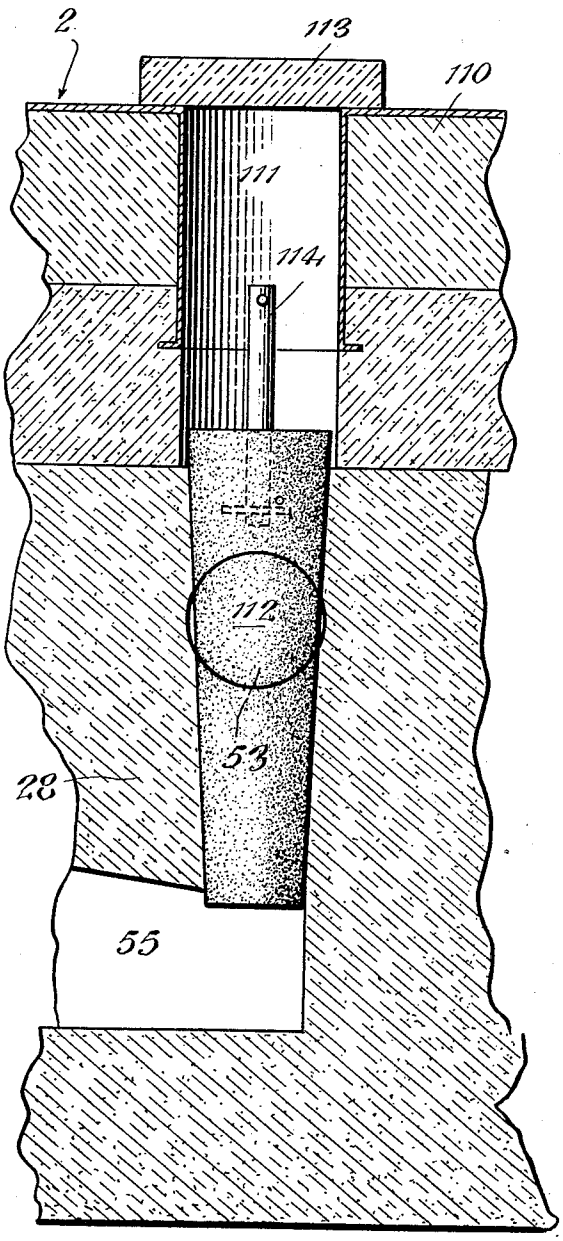
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Oct. 19, 1948. A. F. JOHNSON 2,451,492

METHOD AND APPARATUS FOR ENRICHING THE ALUMINA CONTENT OF CRYOLITE FUSIONS IN ALUMINUM PRODUCTION

Filed Jan. 31, 1946 6 Sheets-Sheet 4

Fig. 4.



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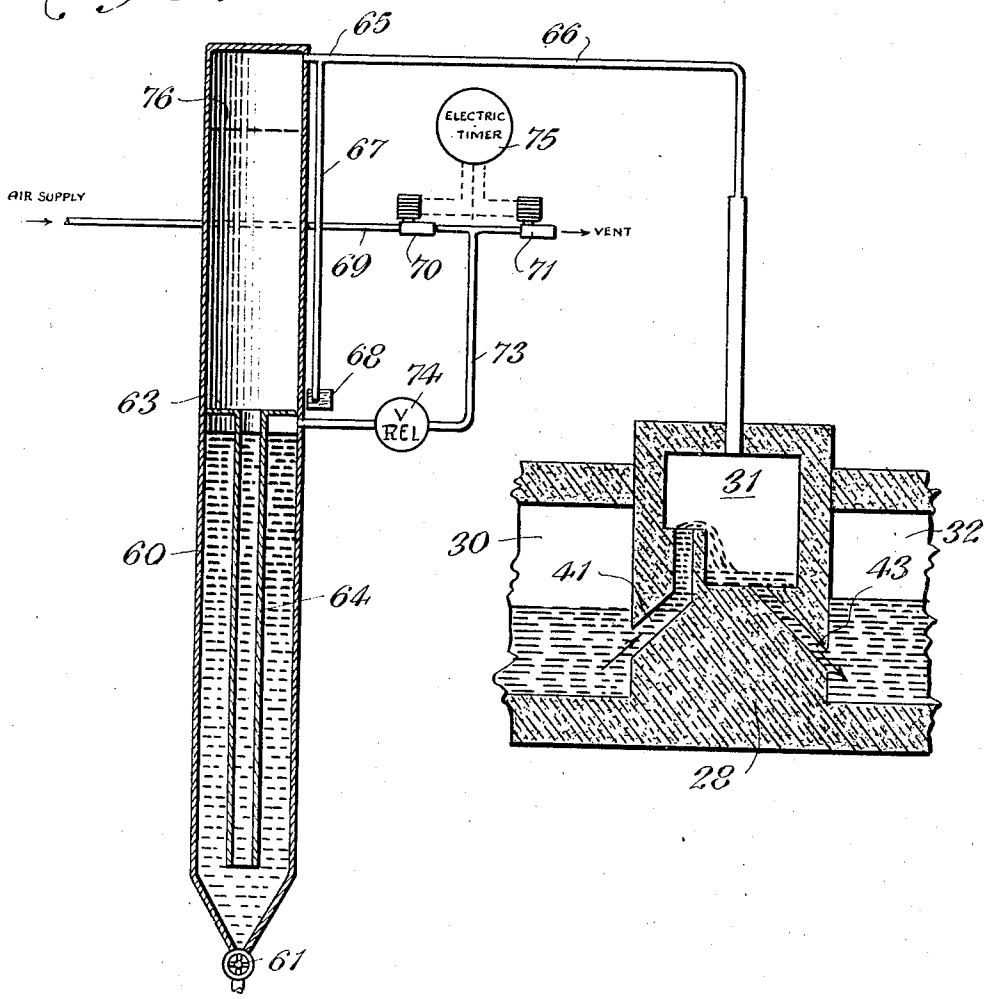
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METHOD AND APPARATUS FOR ENRICHING THE ALUMINA CONTENT OF CRYOLITE FUSIONS IN ALUMINUM PRODUCTION

Filed Jan. 31, 1946 6 Sheets-Sheet 5

Fig. 5.



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METHOD AND APPARATUS FOR ENRICHING THE ALUMINA CONTENT OF CRYOLITE FUSIONS IN ALUMINUM PRODUCTION

Filed Jan. 31, 1946 6 Sheets-Sheet 6

Fig. 6.

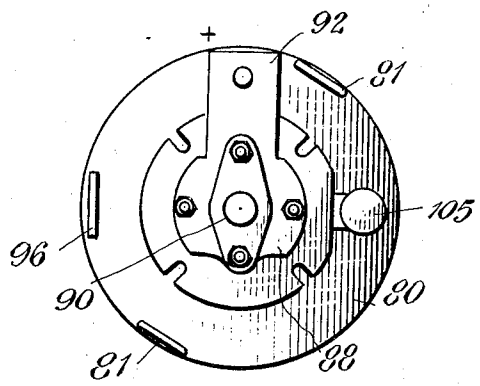
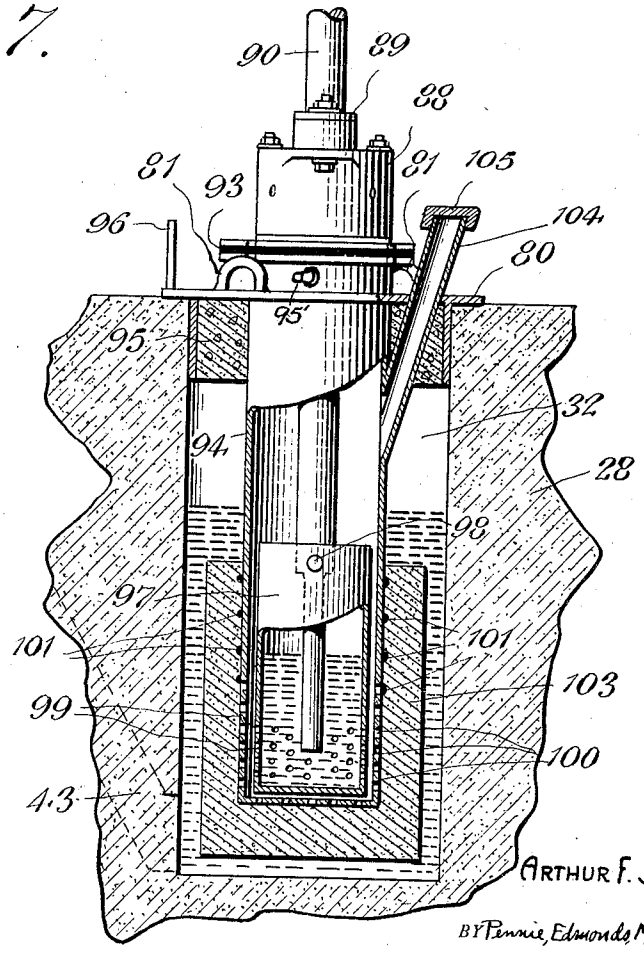


Fig. 7.



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Patented Oct. 19, 1948

2,451,492

UNITED STATES PATENT OFFICE

2,451,492

METHOD AND APPARATUS FOR ENRICHING THE ALUMINA CONTENT OF CRYOLITE FUSIONS IN ALUMINUM PRODUCTION

Arthur F. Johnson, Cambridge, Mass., assignor to Reynolds Metals Company, Richmond, Va., a corporation of Delaware

Application January 31, 1946, Serial No. 644,562

4 Claims. (Cl. 204—67)

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This invention relates to the electrolytic production of aluminum from aluminiferous fusions. The invention is especially concerned with the electrolytic reduction of fusions of alumina dissolved in cryolite and provides an improved apparatus and method for refining impure fusions such as fusions of bauxite in cryolite for use in the electrolytic production of aluminum. The invention, in one of its aspects, comprises the purification of impure alumina-containing materials, especially bauxite ores containing reducible oxidic impurities, such as Fe_2O_3, SiO_2, and TiO_2, in combination with the electrolytic reduction of the alumina of the purified fusion to aluminum.

In a more complete embodiment, my invention provides a method of enriching alumina-depleted cryolite fusions with alumina-containing material having oxidic impurities in which the oxidic impurities are reduced, the reduced metals are separated from the fusion, and the fusion enriched in alumina is passed into an electrolytic reduction cell. In an advantageous embodiment of the invention, I circulate the fusion more or less continuously through chemical reduction and filtering stages and through an electrolytic reduction cell, and I replenish the depleted alumina by suitable additions to the circulating fusion of the raw impure alumina-bearing material, usually calcined bauxite ore, along with a reducing agent. The feed of impure ore is preferably subjected to a preliminary reduction in the fusion for the more or less selective reduction of Fe_2O_3, SiO_2 and TiO_2 with separation of the reduced metals. I reduce the oxidic impurities largely by chemical reduction, and to this end, I admix with the feed of impure dry ore a sufficient quantity of carbon, for example, crushed coke, and aluminum, preferably powdered scrap aluminum or ferro aluminum, when the amounts of SiO_2 and TiO_2 require aluminum additions. I prefer to add the carbon alone to the initial feed material so that the iron oxide will be reduced with the relatively inexpensive carbon and then to add the expensive aluminum for the reduction of the SiO_2 and TiO_2. A small amount of cryolite is usually included in the feed as make-up. The cryolite has a very pronounced effect upon the reduction of the oxides, acting as a catalyst. I have found that a mixture of say 80% cryolite and 20% calcium fluoride is even more effective than straight cryolite and

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when I refer to cryolite fusion I include those containing a salt such as calcium fluoride. In the purification treatment, temperatures of around 1050° C. to 1100° C. are preferably used although higher temperatures may be used at the place of most intense reduction. The cryolite dissolves the alumina leaving the oxidic impurities in condition for efficient reduction, the iron being especially susceptible to reduction with carbon. Metallic iron may be added to one or more stages to act as a solvent collector for the impurities silicon and titanium and to precipitate and collect any vapors of aluminum which may be present. I prefer to separate the bulk of the reduced metals by settling and then circulate the alumina enriched fusion through one or more heating and filtering stages to reduce to a very low percentage the residual oxidic impurities before transferring the fusion into the electrolytic reduction cells.

One of the important features of my invention is the flowing of the fusion, heated to reduction temperature, through heated carbon filters to reduce the oxide that escaped reduction in the initial or preliminary reduction stage, and the separation of the thus reduced metals from the fusion. I may flow the fusion through filters packed with granular carbon, such as coke, or through porous blocks or bodies of carbon, and therein effect a reduction of the oxide and a trapping of the metal in the carbon filters. The carbon of the filters, when metal laden, may be pulverized if necessary and mixed with the ore feed to consume the carbon and recover the metal.

I have found it advantageous to use a pump to circulate the fusion through the system and a number of electrodes, preferably A. C., to add whatever heat is necessary to keep the fusion at the proper reacting temperatures.

One feature of my invention is the employment in the circuit of a feed stage in which the gas liberated in reduction is used to effect a pulsating and intermixing of the fused feed with the cryolite fusion and the filtering out of the reduced metals. In this aspect of the invention, I prefer to subject the fusion, enriched by addition of bauxite ore, to electrolysis to heat the mass to reduction temperatures and generate gas which is used to effect the pulsating flow of fusion through the filter and into the circulating fusion.

My invention provides a reduction and puri-

fication apparatus comprising a plurality of heating and filtering stages, together with pumping means, preferably an intermittent vacuum system which eliminates the contacting of the fusion with mechanical elements, and an electrolytic reduction cell in combination. The apparatus provides a flow circuit for the fusion through the reduction cell and several stages of heating and filtering together with means to replenish the consumed alumina with alumina from impure ore or the like, which is purified by reduction of the reducible oxides before the enriched fusion reaches the electrolytic cell.

In one of the stages of the heating and purification circuit, I provide a device that I shall hereinafter call a "breather cell" into which I introduce a mixture of dry ore, carbon and aluminum to reduce the reducible oxides. The breather cell comprises a reduction chamber positioned within a body of the circulating fusion into which the feed mixture is introduced. An anode and a cathode are provided in the reduction chamber to effect a reduction of a part of the oxidic impurities by electrolysis with the liberation of sufficient heat to effect a chemical reduction of the impurities by the carbon and aluminum mixed with the ore. Most of the reduced metals are settled out and the enriched fusion is forced through a carbon filter. While I may use suitable pulverized carbon as a filter, I have found it advantageous to use a mass of formed porous carbon through which the fusion is forced to flow to effect a scavenging reduction and a trapping of the metals in the pores. I utilize the pressure of the gas formed by reduction of the oxides in the reduction chamber to force the fusion out of the chamber through the carbon filter and into the fusion circuit. I provide a tapered anode in the reduction chamber and as the level of the fusion is depressed by the generation of gas, the "anode effect" shuts off the flow of current. The reduction chamber is opened for feeding more of the mixture and the alumina-depleted fusion of the circuit in the space surrounding the reduction chamber flows back in until the large part of the anode is contacted at which time the electric circuit is reestablished with a repetition of the cycle. The breather cell for the introduction of feed materials including bauxite, carbon, aluminum and some cryolite is a means not only to effect a reduction and filtering out of the reduced oxidic impurities, but an intermingling of the alumina-rich fusion with the alumina-depleted fusion. The breather cell is described more fully and claimed in my copending application Serial Number 647,179, filed February 12, 1946.

In the combination of my invention, I employ an electrolytic reduction cell of the type described and claimed in my copending application Serial No. 634,903, filed December 14, 1945. Briefly, such reduction cells comprise a cathode and an anode with one or more intermediate electrodes suspended in the electrolyte between the anode and the cathode. The electrolytic cell is provided with an electrically non-conducting lining and the current is passed through the electrodes in series.

These and other novel features of the invention will be better understood after considering the following discussion taken in conjunction with the accompanying drawings, in which:

Fig. 1 is the plan view of an apparatus embodying the invention;

Fig. 2 is a plan view of the apparatus of Fig. 1 with covers removed;

Fig. 3 is a sectional view along line 3—3 of Fig. 1;

Fig. 4 is a fragmentary enlarged sectional view along line 4—4 of Fig. 1;

Fig. 5 is a sectional side view of a fusion pump of the invention;

Fig. 6 is a plan view, and

Fig. 7 is a side view, with parts in section, of a breather cell of the invention.

The apparatus illustrated in Figs. 1 to 4 comprises two distinct interconnected parts, an electrolytic cell part 1, and a purification part 2. The entire apparatus in combination is preferably constructed in the earth, with the top at floor level, in the manner of a soaking pit and, as shown, is built upon a cinder fill 3 which is covered with a layer of concrete 4 having an interior sheet of steel 5 to prevent moisture passing into the heat insulating refractory 6, preferably formed of rammed alumina.

The electrolytic cell part has a receptacle for the purified fusion within the lining 7 formed of fused alumina, the interior surface of which is covered with a thin layer of aluminum nitride 8. The fused alumina is electrolytically non-conducting and the aluminum nitride is substantially impervious to the cryolite fusions and protects the fused alumina. Within the receptacle are two cathodes 10 and 11 electrically connected by the bars 12 to the negative power lines 13. The anode 14 positioned in the center is connected to the power line 15. Three intermediate electrodes 16 are mounted between the cathode 11 and the anode 14 and three intermediate electrodes 17 are mounted between the cathode 10 and the anode 14. The anode, cathodes and intermediate electrodes may be formed of graphite or other suitable form of carbon. The aluminum reduced in this type of cell falls to the bottom and flows into the collecting sump 20 from which it may be pumped out through the upright duct 21. This cell is preferably provided with a removable cover 22, as best shown in Fig. 1. By means of the crank 23, the cover may be raised and lowered and when raised may be moved laterally by rolling the carriage 24 on which it is mounted along the rails 25.

The purification part of the apparatus is more or less integrally connected to the electrolytic part so far as the supporting and heat insulating refractories are concerned. The two parts are actually connected for the circulation of the fusion by the delivery duct 26 by means of which the alumina-depleted fusion flows out of the electrolytic cell and by the return duct 27 by means of which the alumina-enriched and purified fusion is returned to the electrolytic cell.

Within the purification apparatus there are several chambers 30, 31, 32, 33 and 34, all interconnected in series by channels or ducts formed within a body of carbon pot lining 28. In other words, the entire circuit for the flow of fusion from and to the electrolytic cell including all of the chambers 30 to 34, inclusive, are lined with carbon pot lining. In each of the compartments 30, 32, 33 and 34, a graphite heating electrode 35 is mounted. As shown, these are single phase heating electrodes, the current flowing through the fusion in which they dip and the pot lining to one of the other electrodes. In larger cells three of these may be mounted in each position on a three-phase system. As best shown in Figs. 1 and 3, the electrodes are mounted in an electrode holder 36 having a gas-tight packing gland 37. The electricity is supplied to each of these

holders by power lines connected to the terminal bars 38. These electrodes may be controlled to provide the desired temperature in the particular chamber in which they are mounted.

The chamber 30 is connected near its top to the duct 26 through which the fusion flows from the electrolytic cell. Ducts 26 and 27 have removable covers 40 for inspection purposes. The chamber 30 is merely a heating chamber and the heated fusion flows out through duct 41 into chamber 31 by pumping action due to the fluctuating pressure therein by the suction pump 42. The operation of this pump will be described fully in connection with Fig. 5. The fusion flows by gravity through duct 43 into chamber 32. Within chamber 32 is mounted the breather cell 44 which will be described more fully in connection with the description of Figs. 6 and 7. The raw feed material, usually in the form of calcined bauxite and a reducting agent, is introduced into the breather cell and from there is forced out into chamber 32 from which it flows by gravity through duct 45, carbon filter 46, duct 47, carbon filter 48, and duct 49 into chamber 33. From chamber 33, the fusion flows through duct 51, carbon filter 52, duct 53, carbon filter 54, duct 55, and into chamber 34. From chamber 34, the fusion flows through duct 27 into the electrolytic cell.

As best shown in Fig. 1, the chambers 30, 32, 33 and 34 have removable small covers 56 by means of which the chambers may be inspected from time to time. Various temperature recording devices (not shown) are inserted in the fusion in the various chambers.

The flow pump 42, together with a part of the chamber 31, is illustrated more or less diagrammatically in Fig. 5 and comprises an upright pressure member 60, the upper end of which is closed by a plate and the lower end of which is closed by the drainage valve 61. Near its center the pressure member is closed with a partition 63 having a central opening to which is connected the depending pipe 64 reaching almost to the bottom. The upper part of member 60 is connected to pipe 65 having a branch 66 which enters chamber 31 and a branch 67 which enters the oil pot 68 serving as a pressure limiting device. Pipe 69 connects to a source of air under pressure and electrically operated valves 70 and 71. These valves are connected to pipe 73 which leads through the relief valve 74 to the space below the wall 63. Valves 70 and 71 are connected to the electric timer 75 which operates at a uniform speed opening and closing a circuit in such order that, when valve 70 is closed, valve 71 is opened and vice versa. This pump is described and claimed in my copending application Serial No. 644,252, filed January 30, 1946.

In operating the pump for the circulation of the fusion, pressure member 60 is filled with oil or other suitable liquid, as shown in heavy lines. Valve 70 is opened and valve 71 is closed. Air under pressure flows through pipe 73, valve 74 and forces the oil to flow upward through pipe 64 to the position shown in broken lines at 76. If the pressure should be excessive, the relief valve opens and allows the pressure to escape. While the oil is rising, a slight pressure is imposed upon chamber 31, but before this can not reach any appreciable amount, as the gas begins to blow through the oil in pot 68. The electric timer is set so that by the time the oil reaches the level 76 the switch closes valve 70 and opens valve 71 which is vented to the atmosphere. The air escapes as the oil falls to the original position. This creates a partial vacuum in the upper part of pressure member 60 and in chamber 31.

As shown in Fig. 5, duct 41 is considerably larger in diameter than duct 43 and opens into the chamber 31 at a materially higher elevation. As a result of the decreased pressure in chamber 31, the fusion in chambers 30 and 32 is sucked upward. Since, however, duct 41 is considerably larger than duct 43 much more of the fusion will flow through duct 41 than through duct 43. As a consequence, while the vacuum is in effect, receptacle 31 fills with fusion, and after the vacuum is broken, the accumulated fusion is free to flow through duct 43 into chamber 32. This operation is repeated continuously and causes the flow of fusion through the entire circuit.

In compartment 32, the breather cell, as best shown in Figs. 6 and 7, is mounted. Duct 43 connects to that part of chamber 32 surrounding the breather cell. The breather cell is in the form of a removable unit supported by the horizontal plate 80 which rests on the refractory lining surrounding chamber 32. By means of the rings 81, the unit may be removed or placed in the position shown with a crane. The electrode holder 88 has a metallic packing gland 89 which grips the anode 90 forming a gas-tight connection through which the electricity flows from the positive electrical terminal 92. The holder is electrically insulated by the layer of asbestos insulation 93 from the cover 80 and integrally connected cylindrical reduction chamber 94 into which the anode is inserted. The under portion of the cover is protected with a layer of carbon pot lining 95. The chamber 94 serves as the cathode and the bar 96 is the cathode connection to the power line.

Inside the chamber 94 and surrounding the anode, a steel bucket 97 is suspended in spaced relation on the bolts 98 which connect to the chamber. The sides of the bucket are perforated with many small holes 99 such as $\frac{3}{16}$ inch drill holes at ½ inch centers. The lower portion of the chamber 94 has a large number of holes 100 approximately ¾ inch in diameter and several weld beads 101 are formed on the exterior to effect an engagement with the body of porous carbon 103 which is pressed over and then baked on the exterior. The entire lower under portion of the vessel 94 with the surrounding porous carbon filter is suspended inside the chamber 32 and the fusion which flows therethrough is in contact with the exterior.

The feed material, preferably comprising a pulverulent mixture of dry bauxite such as Haitian bauxite, and carbon is charged into the reaction chamber 94 through the feed pipe 104. I prefer to add the carbon to reduce the iron oxide and later on to add metallic aluminum to reduce the SiO_2 and TiO_2. This material may also include a small amount of make-up cryolite and calcium fluoride, and some soda ash if required to increase the alkalinity of the fusion. The charged admixture of the materials falls into the bucket 97 wherein electrolysis takes place by the current flowing from the anode to the cathode. Since the feed pipe is tightly closed by the cover 105, the gas formed in the reduction creates a pressure and forces the fusion inside the chamber 94 outward through the holes 99 and 100 and through the porous carbon filter 103 into the surrounding fusion in chamber 32. It will be noted that the lower part of the anode is rather small in diameter, having been eaten

away by the oxygen from the oxides, and when the level of the bath in the bucket 97 approaches the lower end, the "anode effect" chokes off the flow of current interrupting the operation. The bleeder valve 95' is set to permit the gas to escape gradually from the chamber 94 and the pressure to return to atmospheric pressure, at which time part of the fusion, depleted in alumina, flows back through the porous carbon into the chamber 94. Additional feed material is charged into the depleted fusion through pipe 104. When the level of the fusion approaches the top of bucket 97 where the anode is large in diameter, the current is reestablished and the operation is repeated.

Fig. 4 shows on an enlarged scale a fragmentary cross section through filter 54. The cover 110 for part 2 has a hole 111 for each filter which extends into the pot lining 28 and into which the conically shaped block of porous carbon 112 is inserted. The holes 111 have removable lids 113. The downwardly tapered carbon filter 112 may easily be removed by pulling it upward with the metal handle 114, the lower end of which is embedded in the carbon. The fusion flows through the ducts or channels in the pot lining, as shown channel 53, through the pores in the carbon block 112 and into channel 55. Carbon block 112 is similar to the other carbon filters and in the fusion circuit. These filters are heated by the A. C. current flowing through the electrodes 35, the pot lining and the fusion to a temperature of around 1000 to 1200° C.

In carrying out an operation of the invention in apparatus of the type illustrated in the drawings, the electrolytic cell, chambers and connecting passageways are provided with a fusion consisting of alumina dissolved in cryolite. A certain amount of calcium fluoride may be included in the fusion if desired. In the electrolytic cell, the current flows from the anode 14 through the intermediate electrodes 16 and 17 to the cathodes 10 and 11. The reduced aluminum settles to the bottom and flows into the sump 20 from which it may be removed from time to time by inserting a pump connection through the duct 21. As a result of the decomposition of the alumina, the fusion flowing out of the cell from the duct 26 may contain anywhere from 1% to 6% of alumina. With relatively high rates of circulation, however, the alumina content may be only slightly lower than the usual fusion containing around 8% to 10% of alumina. The fusion enters chamber 30 in which its temperature is increased by the A. C. current. By reason of the pulsating vacuum in the chamber 31 caused by the operation of pump 42, the fusion is elevated and caused to flow through the duct 43 into the chamber 32. From this chamber, the fusion flows into duct 45. While in chamber 32, however, the fusion undergoes a churning or intermixing by reason of the intermittent surging of fusion through the porous carbon 103. The materials charged through pipe 104 into chamber 94 comprise raw dried impure bauxite, or other form of impure alumina, in suitable pulverulent admixture with carbon undergo both electrolytic reduction and chemical reduction in the reaction chamber. A certain amount of the oxides are reduced by electrolysis, but by reason of the high temperature, which may be in the neighborhood of 1200° to 1300° C., chemical reduction takes place. As a result of this action, a large percentage of the Fe_2O_3 is reduced with carbon while SiO_2 and TiO_2 are reduced with the aluminum. An appreciable portion of the iron and iron which has collected silicon and titanium settle to the bottom of the bucket 97 where they remain. As a result of the pressure of the generated gas, the alumina enriched fusion with a certain amount of entrained fine particles of reduced metals flow through the holes 99 and 100 and through the pores of the carbon filter 103. A portion of particles of metal suspended in the fusion are trapped in the pores while the unreduced oxides that escaped reduction in the reduction chamber are reduced by the heated porous carbon. This is effectively accomplished by reason of the large carbon surface presented to the remaining oxides. I may add the powdered aluminum or ferro-aluminum to the fusion in the chamber 32 to reduce the SiO_2 and TiO_2. Most of the iron oxide was reduced with carbon and only a small amount of aluminum is required. The ferro-aluminum performs the important function of dissolving silicon and titanium to form a saturated alloy.

From time to time the feeding of material is interrupted and the entire breather cell is removed from its position by a crane and the bucket 97 is removed to recover the reduced metals. The porous body of carbon 103 becomes fouled with metals, at which time it is broken, removed, and preferably pulverized to recover the metal. The pulverized carbon may be admixed with the impure bauxite and charged back into the system through pipe 104, thereby recovering both the carbon and its contained metals.

At any stage along in the circuit, for example, in chamber 32, a small amount of soda ash may be added to make the fusion alkaline. The bauxite is preferably added in an amount sufficient to raise the alumina content to around 11% and the calcium fluoride may be added in an amount preferably not exceeding 20%. Higher amounts of calcium fluoride result in a poor separation of the reduced metals. A small amount of barium fluoride, say 2% to 5%, may also be used with cryolite. The following analysis is typical of a type of calcined bauxite which may be effectively treated in accordance with the invention:

Al_2O_3	61.59
Fe_2O_3	27.71
TiO_2	4.01
SiO_2	4.55
Ignition loss	1.70

The following is the complete analysis of metal recovered in one of the operations resulting from the reduction of impurities:

Si	6.59
Ti	3.13
Al	13.72
Fe	53.30
C	0.73
P	0.29
Mn	0.38
Cr	0.38
V	0.27
Cu	3.02
Balance	Bath

It is sometimes avantageous to add powdered iron along with the pulverulent materials charged through pipe 104 because I have found that the iron absorbs silicon, titanium, and any vapors of aluminum that may be present in the bath.

The fusion leaving cell 32 through duct 45 flows

through the carbon filter 46, duct 47, carbon filter 48, duct 49, and into chamber 33. In this part of the apparatus, the A. C. current flowing through the electrode 35 is regulated to provide a temperature around 1150° to 1200° C. to impart the desired fluidity to the fusion and render the carbon filters reactive. Some powdered aluminum or ferro-aluminum may be added to the fusion in chamber 33 if necessary and the fusion may also be agitated, for example, with a breather cell or other pumping means. In both chambers 32 and 33 most of the reduced and alloyed metal settles to the bottom from which it may be removed by dredging. The fusion flows out of chamber 33 through duct 51, through carbon filter 52, duct 53, carbon filter 54, and duct 55 into chamber 34. The filters 52 and 54 may be operated at a slightly lower temperature than the filters 46 and 48. While I prefer to use the formed tapered bodies of porous carbon 112 shown in Fig. 4, I may pack the space through which the fusion flows with granular coke. The granular coke does not present such effective filtering or reacting contact with the remaining oxidic impurities and is more difficult to handle than a molded body of porous carbon. By the time the alumina enriched fusion flows through the last carbon filter, the reducible oxidic impurities are substantially eliminated. Moreover, the reduced metals are easily recoverable.

In chamber 34 the temperature is preferably permitted to decrease, say, to around 1050° C. so that the enriched fusion flowing through duct 27 into the electrolytic cell is not too hot for efficient electrolytic reduction.

I claim:

1. In the electrolytic production of aluminum from alumina dissolved in a fluoride fusion, the improvement which comprises circulating an alumina-containing fluoride fusion through an electrolytic cell having several stages of electrolysis in series in which it is subjected to electrolysis resulting in a diminution of the alumina content of the fusion and in liberation of fused metallic aluminum, transferring the fluoride fusion depleted in alumina from the cell to an alumina-replenishing zone and in said zone dissolving alumina in the alumina-depleted fusion by bringing said fusion into contact with a charge of impure alumina-containing feed material having oxidic impurities, including the oxides of iron, silicon and titanium, and carbon and aluminum as reducing agents, heating the feed material and reducing agents to reduce the oxides of iron, silicon and titanium, separating the reduced metals from the alumina-enriched fusion, flowing the alumina-enriched fusion from which the reduced metals were separated through at least one carbon filter heated to a temperature of about 1000° C. to 1200° C. to remove metallic impurities, and flowing the enriched and purified fusion back into and through the electrolytic cell.

2. In the electrolytic production of aluminum from alumina dissolved in a fluoride fusion, the improvement which comprises circulating an alumina-containing fluoride fusion through an electrolytic cell in which it is subjected to electrolysis resulting in a diminution of the alumina content of the fusion and in liberation of fused metallic aluminum, transferring the fluoride fusion depleted in alumina from the cell to an alumina-replenishing zone and in said zone dissolving alumina in the alumina-depleted fusion in an amount sufficient to produce a fusion containing alumina in a concentration of approximately 11%

by bringing said fusion into contact with a charge of impure alumina-containing feed material having oxidic impurities, including the oxides of iron, silicon and titanium, and carbon and aluminum as reducing agents, heating the feed material and reducing agents to reduce the oxides of iron, silicon and titanium, separating the reduced metals from the alumina-enriched fusion, flowing the alumina-enriched fusion from which the reduced metals were separated through at least one carbon filter heated to a temperature of about 1000° C. to 1200° C. to remove metallic impurities, and flowing the enriched and purified fusion back into and through the cell.

3. In the electrolytic production of aluminum from alumina dissolved in a fluoride fusion, the improvement which comprises circulating an alumina-containing fluoride fusion through an electrolytic cell having several stages of electrolysis in series in which it is subjected to electrolysis resulting in a diminution of the alumina content of the fusion and in liberation of fused metallic aluminum, pumping the fluoride fusion depleted in alumina from the cell to an elevated alumina-replenishing zone and in said zone dissolving alumina in the alumina-depleted fusion by bringing said fusion into contact with a charge of impure alumina-containing feed material having oxidic impurities, including the oxides of iron, silicon and titanium, and a reducing agent comprising carbon, heating the feed material and the reducing agent to reduce the iron oxide, then adding alumina to the alumina-enriched fusion to reduce the oxides of silicon and titanium, separating the reduced metals from the alumina-enriched fusion, flowing the alumina-enriched fusion from which the reduced metals were separated by gravity through at least one carbon filter heated to a temperature of about 1000° C. to 1200° C. to remove metallic impurities, and flowing the enriched and purified fusion by gravity back into and through the electrolytic cell.

4. Apparatus for the production of aluminum from alumina dissolved in a fluoride fusion comprising an electrolytic cell in which the alumina-containing fluoride fusion is subjected to electrolysis resulting in a diminution of the alumina content of the fusion and in liberation of fused metallic aluminum, an alumina-replenishing chamber outside of said cell and elevated with respect thereto, said chamber being connected to the cell for the passage to said chamber of fusion depleted in alumina, pumping means for pumping the alumina-depleted fusion to said chamber, means for heating the alumina-depleted fusion transferred from said cell to said chamber, means whereby alumina-containing feed material having oxidic impurities containing iron, silicon and titanium, and a reducing agent may be added to the alumina-depleted fusion in said chamber for the dissolving of alumina therefrom by said fusion, a heating chamber, a passageway connecting the alumina-replenishing chamber and said heating chamber for the transfer of alumina-enriched fusion from the former to the latter, carbon filter means in said passage, means for raising the temperature of the filtered and alumina-enriched fusion in said heating chamber, and a passageway from said heating chamber to the electrolytic cell for the transfer of alumina-enriched fusion from the heating chamber to said cell, and carbon filter means in said last-named passageway, said heating chamber being at an elevation intermediate the alumina-replenishing chamber and said cell, whereby alumina-enriched

fusion will flow by gravity serially from the alumina-replenishing chamber through said first carbon filtering means, said heating chamber and the second carbon filtering means to said cell.

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