V. M. WEAVER.

PROCESS OF WINNING METALS.

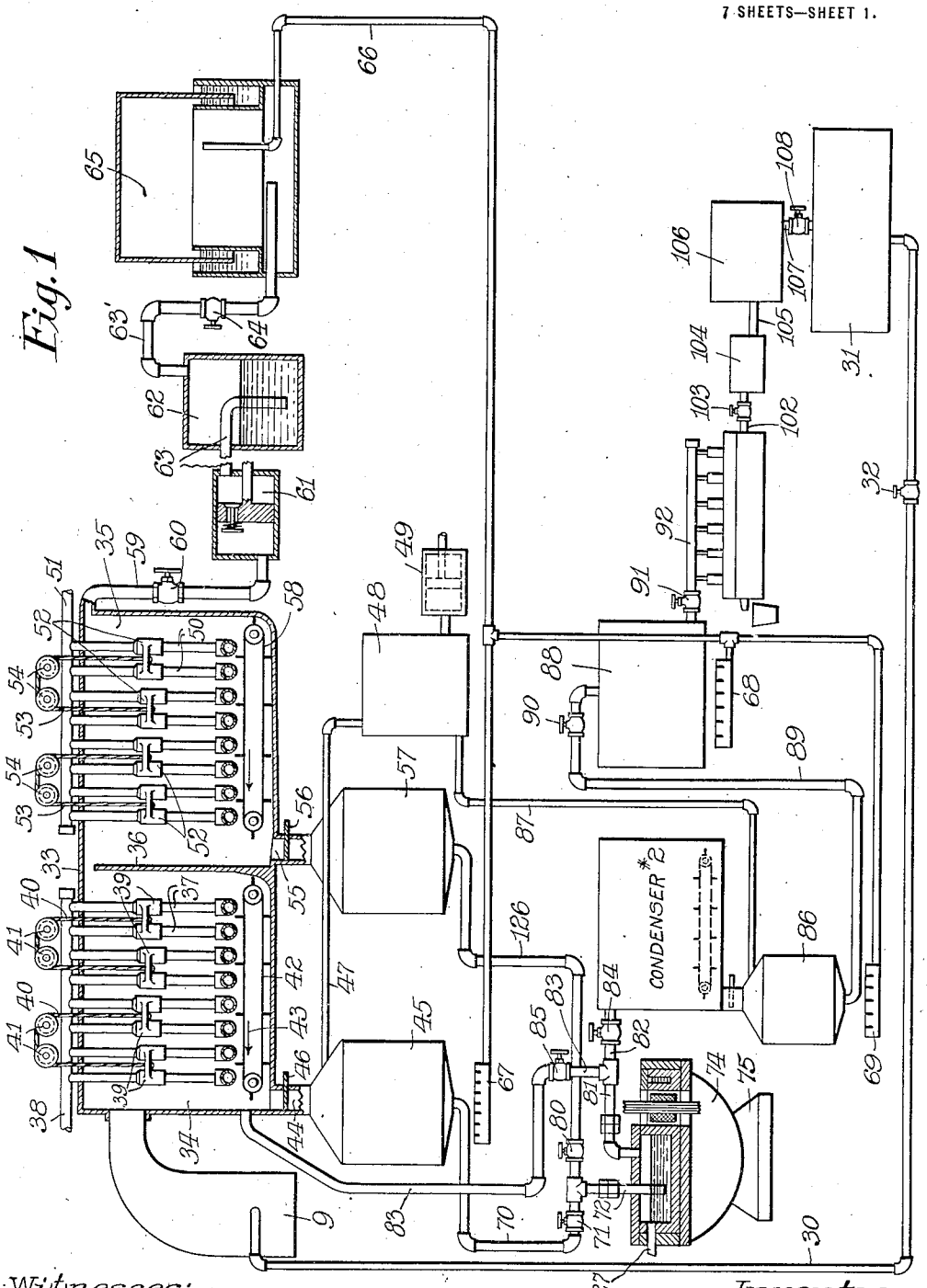
APPLICATION FILED AUG. 22, 1914.

1,238,604.

Patented Aug. 28, 1917.

7 SHEETS—SHEET 1.

Fig. 1



Witnesses:
Leonard W. Novander.
Cameron A. Whitcomb

Inventor
Victor M. Weaver
By Brown, Hanson & Boettcher
Att'ys

V. M. WEAVER.

PROCESS OF WINNING METALS.

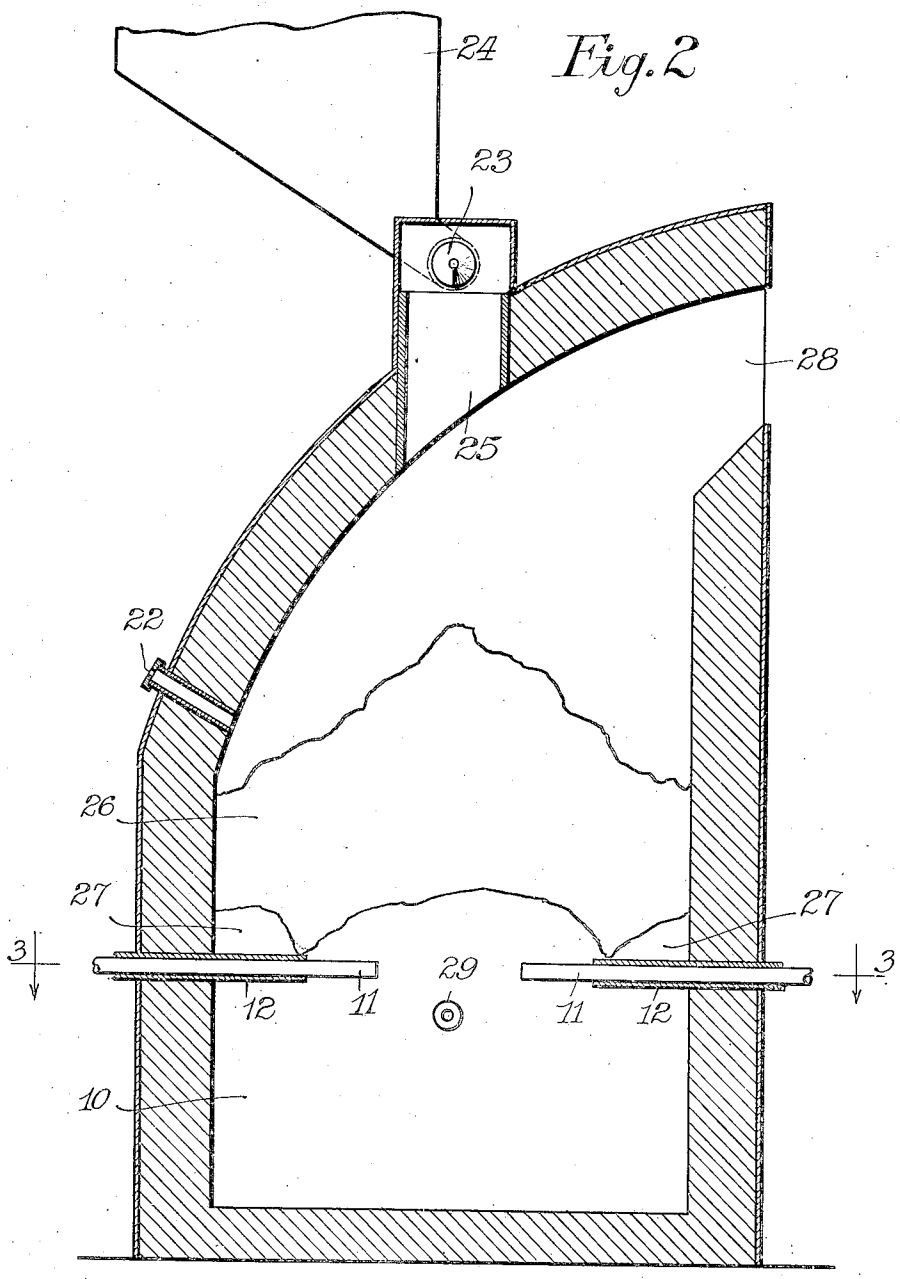
APPLICATION FILED AUG. 22, 1914.

1,238,604.

Patented Aug. 28, 1917.

7 SHEETS—SHEET 2.

Fig. 2



Witnesses:
Cameron A. Whitsett
Leonard W. Novander

Inventor
Victor M. Weaver
By Brown, Hanson & Boettcher
Att'ys

V. M. WEAVER.

PROCESS OF WINNING METALS.

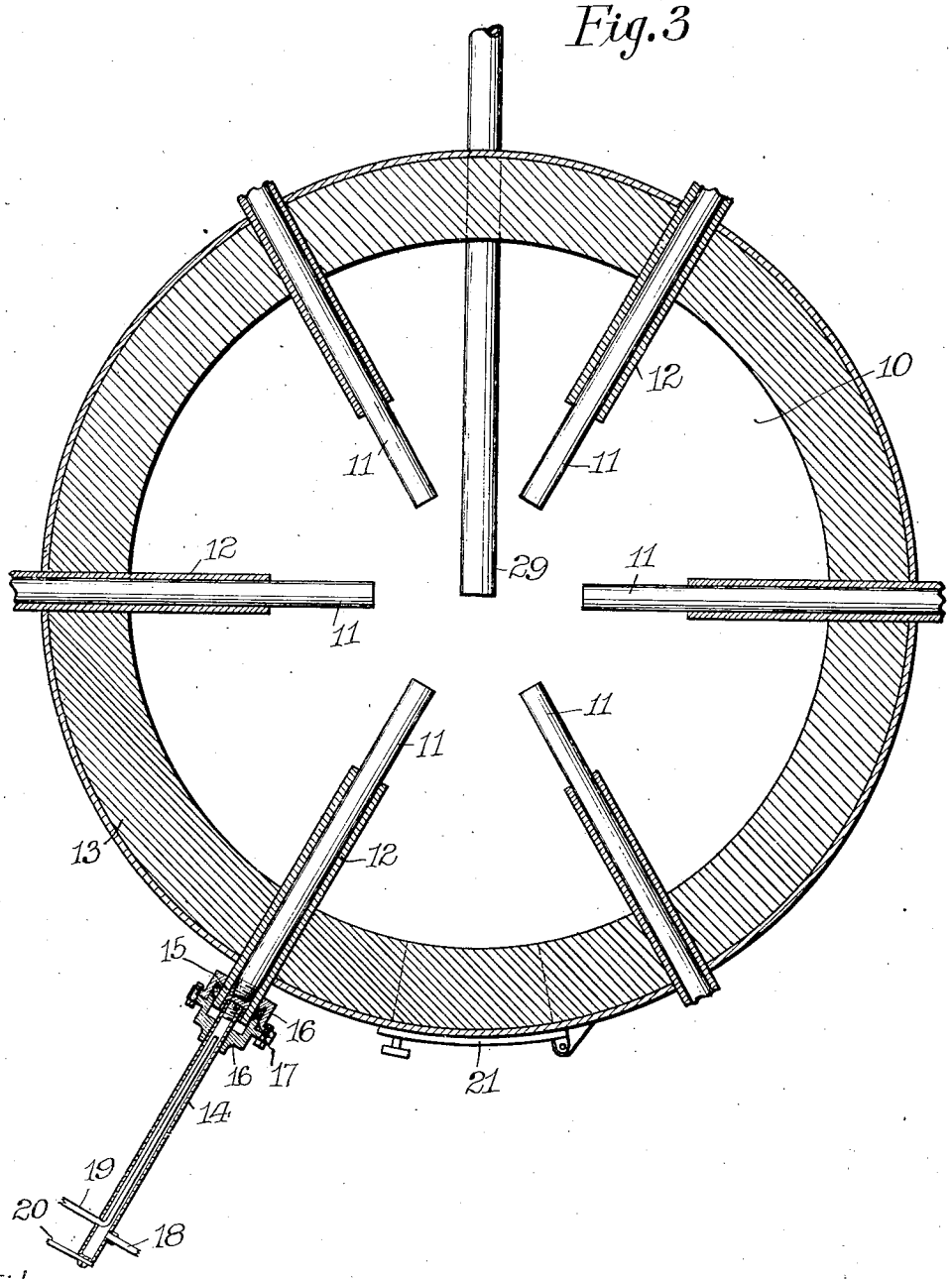
APPLICATION FILED AUG. 22, 1914.

1,238,604.

Patented Aug. 28, 1917.

7 SHEETS—SHEET 3.

Fig. 3



Witnesses:
Leonard W. Novander
Cameron A. Whitsett

Inventor
Victor M. Weaver
By Brown, Hanson & Boettcher
Attys

V. M. WEAVER.

PROCESS OF WINNING METALS.

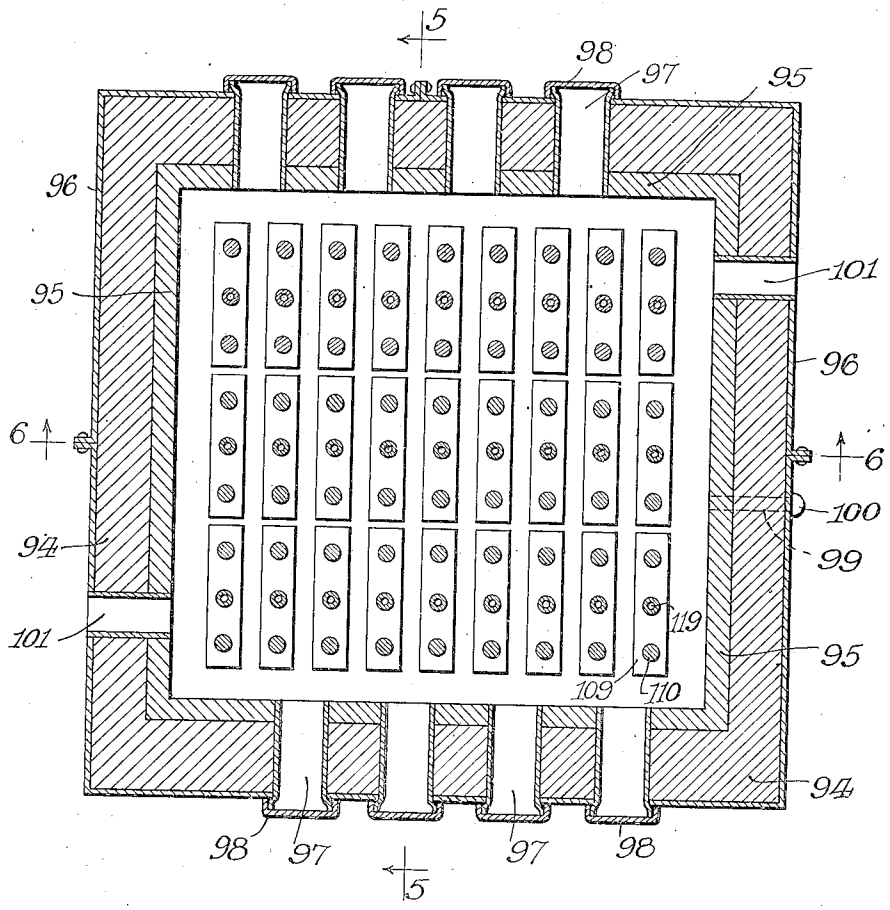
APPLICATION FILED AUG. 22, 1914.

1,238,604.

Patented Aug. 28, 1917.

7 SHEETS—SHEET 4.

Fig. 4



Witnesses:
Leonard W. Novander
Cameron A. Whitsett

Inventor
Victor M. Weaver
By Brown, Hanson & Boettcher
Attys

V. M. WEAVER.

PROCESS OF WINNING METALS.

APPLICATION FILED AUG. 22, 1914.

1,238,604.

Patented Aug. 28, 1917.

7 SHEETS—SHEET 5.

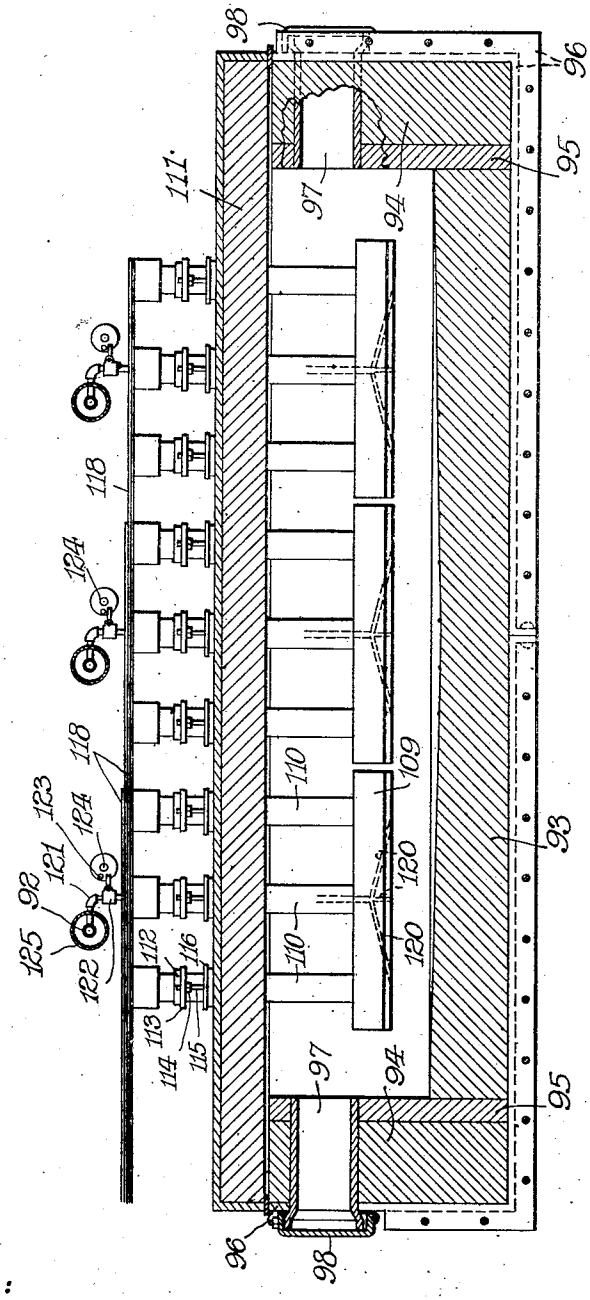


Fig. 5

Witnesses:
Leonard W. Novander
Cameron A. Whitsett

Inventor
Victor M. Weaver
By Brown, Hanson & Bottler
Att'ys

V. M. WEAVER.

PROCESS OF WINNING METALS.

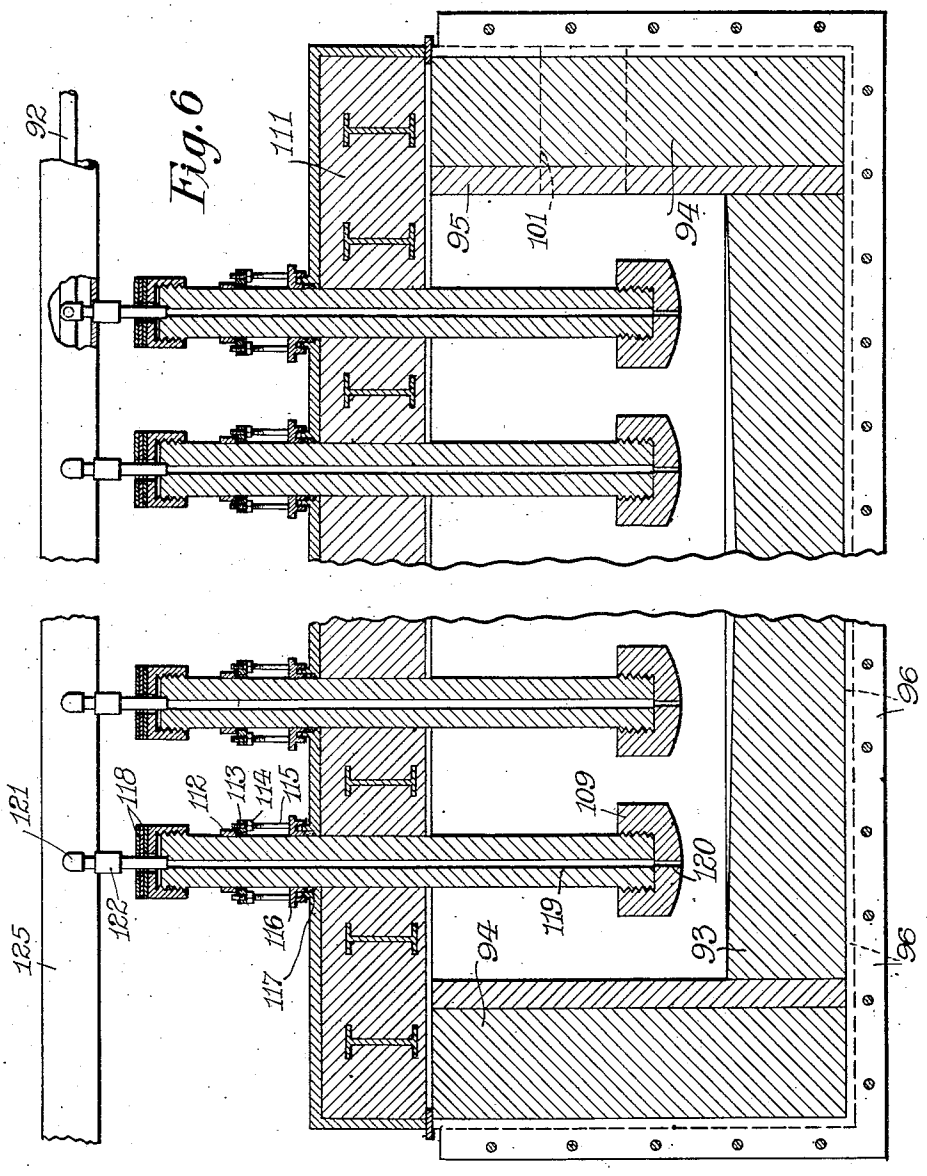
APPLICATION FILED AUG. 22, 1914.

1,238,604.

Patented Aug. 28, 1917.

7 SHEETS—SHEET 6.

Fig. 6



Witnesses:
Leonard W. Novander
Cameron A. Whitsett

Inventor
Victor M. Weaver
By Brown, Hanson & Boettcher
Attys

V. M. WEAVER.

PROCESS OF WINNING METALS.

APPLICATION FILED AUG. 22, 1914.

1,238,604.

Patented Aug. 28, 1917.

7 SHEETS—SHEET 7.

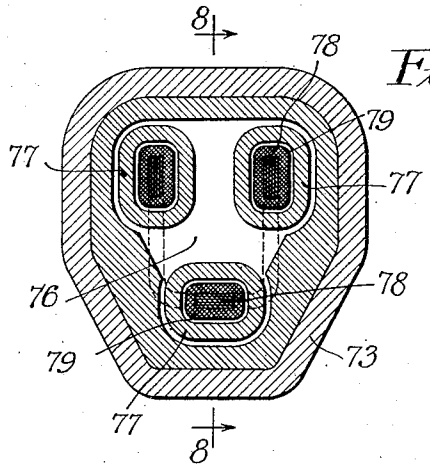


Fig. 7

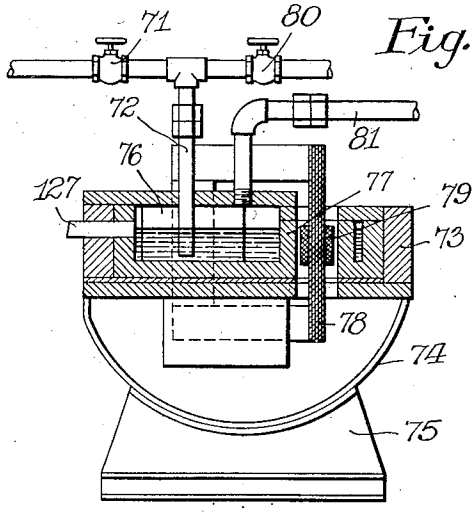


Fig. 8

Witnesses:
Leonard W. Novander
Cameron A. Whitsett

Inventor
Victor M. Weaver
By Brown, Hanson & Boettcher
Att'ys

UNITED STATES PATENT OFFICE.

VICTOR M. WEAVER, OF HARRISBURG, PENNSYLVANIA, ASSIGNOR TO WEAVER COMPANY, A CORPORATION OF WISCONSIN.

PROCESS OF WINNING METALS.

1,238,604. Specification of Letters Patent. Patented Aug. 28, 1917.

Application filed August 22, 1914. Serial No. 858,001.

To all whom it may concern:

Be it known that I, VICTOR M. WEAVER, a citizen of the United States, residing at Harrisburg, in the county of Dauphin and State of Pennsylvania, have invented a certain new and useful Improvement in Processes of Winning Metals, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

My invention relates to processes of winning metals and is concerned particularly with a process of securing metals from their oxids.

It will appear to those skilled in the art that my invention may be variously employed in order to secure various metals from their various compounds and that certain steps in the process of my invention and certain parts of the apparatus which I employ may be usefully engaged in various pursuits, and while I shall define the metes and bounds of my invention by the appended claims I shall refer specifically in this disclosure to a certain process and to certain apparatus for the recovery of aluminum and silicon, respectively, from clay, this being the embodiment of my invention with which I have experimented most thoroughly and which I regard as of special importance. This description of my process as utilized to secure aluminum and silicon in their respective elemental states from clay will enable those skilled in the art to understand and appreciate my invention, and it will be understood that the process and apparatus which I herein set forth is an example of the carrying out and use of my invention so that those skilled in the art may be duly advised. In my process of securing aluminum and silicon from clay I have devised numerous refinements which are peculiarly adapted to this particular embodiment of my invention and I make these refinements the subject matter of the more limited of the appended claims. It will appear also that there is novelty not only in the combination of steps which I employ in my process but that the steps *per se* are novel, the steps *per se* being claimed in my copending applications, Serial No. 919, filed January 7, 1915, Serial No. 1559, filed January 11, 1915, Serial No. 2234, filed January 14, 1915, Serial No. 44,518, filed August 9, 1915.

I shall now proceed with a specific description of my invention as embodied in my process of and apparatus for recovering aluminum and silicon from clay, and I shall refer to and describe the various parts of the apparatus and the various steps in the process in detail in order to instruct those skilled in the art.

In the treatment of clay I break up the compound by the use of chlorin gas so as to produce aluminum chlorid and silicon tetrachlorid, this action being carried on under special restrictions and conditions, as will later be more fully described. I then subject the chlorids which are thus formed to condensing temperatures and the process here divides into two branches, one of which is concerned with the production of aluminum in its elemental state and the other of which is directed toward the production of silicon in its elemental state. In order to separate the aluminum from the chlorin I charge the aluminum chlorid into an electrolyzing vat preferably containing melted sodium chlorid and the consequent electrolysis separates the aluminum from the chlorin so that the former may be tapped away from the sodium chlorid while the latter may be conducted to a storage tank for further use. In this connection I may point out that my process is continuous in the sense that it permits of the constant feeding of clay at one point in the process with the corresponding production of aluminum and silicon at other points in the process and the reacting agents may be used and reused and may require replenishing only because of any unavoidable leaks which may occur in the system.

The silicon tetrachlorid is fed into a chamber containing molten aluminum and by reason of the greater affinity of the chlorin for the aluminum than the silicon, the silicon is released and may be tapped off, with aluminum chlorid remaining. This aluminum chlorid, like the aluminum chlorid obtained from the condenser elements, may be subjected to electrolysis, as above described, in order to free the chlorin and secure the aluminum therefrom.

My invention will be more readily understood by reference to the accompanying drawings, in which—

Figure 1 is a more or less diagrammatic representation of the entire system of apparatus;

Fig. 2 is a vertical sectional view of the chlorinizing furnace;

Fig. 3 is a horizontal sectional view of the chlorinizing furnace taken on the plane of the line 3—3 of Fig. 2 and looking in the direction indicated by the arrows;

Fig. 4 is a sectional view, taken on a horizontal plane, of the electrolyzing vat;

Fig. 5 is a vertical sectional view taken on the plane of the line 5—5 of Fig. 4 and looking in the direction indicated by the arrows;

Fig. 6 is a sectional view drawn on a larger scale, taken on the plane of the line 6—6 of Fig. 4 and looking in the direction indicated by the arrows;

Fig. 7 is a sectional view, taken on a horizontal plane, of the second furnace which is employed; and

Fig. 8 is a sectional view taken on the plane of the line 8—8, Fig. 7, and looking in the direction indicated by the arrows.

Referring first to Fig. 1, it will be seen that the chlorinizing furnace is shown at 9, and by reference to Figs. 2 and 3 it will be seen that this chlorinizing furnace is of the closed type and provides for a bed of coke 10, in which a plurality of electrodes 11—11, extending inwardly through the circular housing, as illustrated in Fig. 3, are lodged. Each of the carbon electrodes 11 is firmly mounted in a terra cotta pipe 12, which in turn is mounted in the fire brick housing 13. An electric conductor 14 is provided for each of the carbon electrodes and this conductor is in the form of a pipe which is connected with the electrode at 15 and which is supported in position by means of a union 16 packed at 17. The pipe 14 is kept cool by a flow of water introduced through the entry pipe 18, and, after circulation, passed through the return pipe 19. The usual insulated electric conductor 20 may be attached to the end of the pipe 14, as illustrated, and at this distance from the furnace housing the conductor and its insulation will not be injuriously affected by the heat. The reference character 21 indicates a clean-out door which may be provided, and a peep hole arrangement 22 may also be provided.

The charge is introduced into the chlorinizing furnace by way of a screw conveyer, indicated at 23 at the bottom of a hopper bin 24, this screw conveyer leading the charge to the passage 25, through which the charge may drop on to the bed of coke which has already been referred to.

The charge is indicated at 26 and the bed is preferably so arranged that the coke exposed in the middle is surrounded by packed clay, as illustrated at 27, 27. The charge may be any clay but I have found that the higher grades of clay, such as kaolin, of the formula $Al_4(SiO_4)_3$—(the moisture being driven therefrom) is especially desirable. It will be noted that the furnace has only the outlet 28 and it will be noted as this description proceeds that the entire system is closed as this furnace is. It will be noted that a graphite pipe 29 extends through the fire brick housing of the furnace and terminates in the heart of the coke bed. This pipe 29 is fed through a pipe 30 (Fig. 1) from a storage tank 31, the connection being controlled by a valve 32. It will now be noted that with the chlorin properly fed to the graphite pipe and with the current properly applied to the electrodes the activity of the chlorin gas and the heat immediately effects the disintegration of the kaolin, the formation of aluminum chlorid and silicon tetrachlorid, and, by the combination of the carbon and the oxygen liberated from the kaolin, the formation of carbon monoxid. So far as the degree of heat is concerned, those skilled in the art will, of course, be guided by the fact that such a degree of heat as effects reaction between the chlorin and the aluminum and silicon is required, the effective temperatures being well known in the art. I might add, for what further assistance it may give, that I have found that temperatures between 900° and 1200° centigrade are most efficient.

The reaction is as follows:

$$Al_4(SiO_4)_3+12C+24Cl=4AlCl_3+3SiCl_4+12CO$$

The three gases thus formed naturally rise and pass out of the outlet opening 28, and, as illustrated in Fig. 1, are conducted to the condenser 33. This condenser is in the form of a double closed chamber providing the compartment 34 and the compartment 35 separated by a partition 36. The compartment 34 is provided with a system of cooling pipes 37, 37, which extend downwardly through and from the top of the chamber and which are distributed throughout the entire space of this particular compartment in order to get complete temperature control. The pipes 37, 37 are joined at the upper ends outside of the chamber by means of the header pipe 38 and circulation is secured in any desirable manner. In this particular condenser element the system of pipes is connected to a cold water supply and the result is that as the three gases which have been referred to enter and pass through the compartment 34 the aluminum chlorid gas, which condenses at a higher temperature than the silicon tetrachlorid gas, is condensed and deposits itself as a white powder upon the pipes 37, 37. The temperatures at

which these respective gases condense are, of course, well known in the art. It might be mentioned here that it is possible that in the action in the chlorinizing furnace some other chlorid of silicon might incidentally be formed, a chlorid such as hexachlorid (Si_2Cl_6), but I find that conditions are such that it is only the silicon tetrachlorid which plays any considerable part.

Since the temperature which is produced by the circulation of mere cold water in the cooling pipes 37, 37 is not sufficiently low to condense silicon tetrachlorid, this gas, together with the carbon monoxid, passes on to the next compartment 35 of the condenser. Thus the first condenser element 34 is devoted to the condensation of the aluminum chlorid and the white powder to which it is reduced is removed from the pipes upon which it is deposited by means of the scrapers 39, 39, which by means of pulley cords 40 passing over suitable pulleys 41, 41 on the outside of the condenser are drawn up and down on the pipes to scrape them, in an obvious manner. The powder is thus thrown down on to the conveyer 42, the upper run of which passes in the direction of the arrow 43, and thus the condensed aluminum chlorid is brought to the end of the condenser element where the outlet 44 leading to a tank 45 is provided. This outlet may be controlled by a valve 46. It will be noted that this tank is connected by means of a pipe 47 with a compressed air tank 48, which is fed through the air compressor 49. It is important, as before indicated, that the system be a closed system and that various actions be carried on under pressure, and I speak of it particularly at this time because of the fact that the aluminum chlorid to which I have just referred is extremely deliquescent and must be kept free from moisture in order to avoid decomposition and the formation of hydrochloric acid. When the system is closed, however, such a result is not possible, and the pressure has a purpose to be referred to later.

Leaving the aluminum chlorid, which has been deposited in the tank 45, for the present, I shall follow the course of the silicon tetrachlorid gas and the carbon monoxid through the second element of the condenser. The condenser element 35 is provided with a system of cooling pipes 50 like the pipes 37, these pipes having the outside header 51 and being provided with the scrapers 52, 52 hung from the pulley cords 53, 53, passing over the pulleys 54, 54. Instead of being supplied with mere cold water, however, the cooling pipes 50 are supplied with a freezing mixture of ice water and salt, and the temperature in the condenser element 35 is therefore considerably lower than the temperature in the condenser element 34. The lower temperature is sufficient to condense the silicon tetrachlorid which comes down as a colorless liquid, except for any impurities which may discolor it. This liquid silicon tetrachlorid passes down the sloping bottom of the condenser element 35 and passes through the outlet 55, controlled by the valve 56 which leads to the tank 57. The condenser element 35 is provided with scrapers as the condenser element 34 is, because it is possible that the aluminum chlorid not entirely condensed in its passage through the condenser element 34 may condense upon the pipes 50 of the condenser element 35, and it is therefore desirable periodically to operate the scrapers 52 in order to remove this condensation. The scrapers 39 of the other condenser element are operated during all the time that the system is being worked. The condenser element 35 is provided with a conveyer 58.

The carbon monoxid passes out of the condenser element 35 through a pipe 59, past a valve 60 and to a closed gas pump 61, and is then carried to a scrubber 62 by means of a pipe 63, this scrubber being in the form of a tank containing lime water and having an outlet pipe 63′ leading therefrom. This outlet pipe is provided with a valve 64 and leads to a telescoping gas tank 65 so that pressure may be kept upon the carbon monoxid which finds its way to this tank and so that the carbon monoxid may be fed by way of a pipe 66 to any number of burners 67, 68 and 69, which are used for heating purposes in certain other steps in the process which will hereinafter be referred to.

Returning now to the aluminum chlorid which has been deposited in the form of a powder in the tank 45 (this powder being white unless discolored by impurities), it will be noted that I have placed the burner 67 under this tank, and I may mention here that I surround the tank in practice with a suitable fire wall so that I can subject the tank to a high degree of heat. With the valve 46 closed, the material in the tank 45 can be placed under high pressure from the tank 48, and this pressure, together with the heat from the carbon monoxid burner, melts the aluminum chlorid, after which step the aluminum chlorid is much more stable and much more easily handled, due to its physical condition, and desirably so in view of the steps which are to follow and which will presently be described. I desire to state, however, that it is entirely feasible to conduct the aluminum chlorid to the farther parts of the system in its dry, unfused state.

A pipe 70 leads from the tank 45 to a valve 71, which in turn is connected with a pipe 72 leading into a furnace, preferably of the Rodenhauser-three-phase type, this furnace being shown in detail in Figs. 7 and 8. This furnace comprises a heavy outer housing 73, which is provided with a round bottom 74

mounted in a correspondingly shaped base 75, the idea being that when the connecting pipes are temporarily detached, the furnace can be tilted in order to tap off molten metal, as will be pointed out a little later. The lining of the furnace provides a closed cavity 76 for the molten metal which is formed between and around tubular casing parts 77, 77, within which the magnetic circuit frame and the primary coils 78 and 79, respectively, are disposed. The details of this furnace *per se* do not constitute part of my present invention, but I refer to them because it is a type of furnace well adapted for use as part of my system. For the purposes of the present description, I shall assume that the valve 80 is closed, and I shall refer to this valve later. With this assumption, it will be seen that when the valve 71 is opened, the liquid aluminum chlorid is conducted to the working chamber of the Rodenhauser furnace. The reason for this step in the process is as follows:

In the first condensation of the aluminum chlorid in the condenser element 34, there are likely to be impurities, principally iron, and it is the object of the step in the process now under description to eliminate this iron and to secure pure aluminum chlorid. Therefore, preliminarily, the Rodenhauser furnace is charged with aluminum, and the molten bath, as illustrated, is formed, when, as before stated, the valve 71 is opened and the liquid aluminum chlorid is fed into this bath of molten aluminum near the bottom thereof, the aluminum chlorid is immediately reconverted into a gas due to the release of pressure and heat of bath, and passes up through the molten aluminum. Due to the greater affinity of the chlorin for the aluminum than for the iron, or other impurity for that matter, the chlorin releases the iron and takes on the proper share of aluminum. The result is that the refined aluminum chlorid will leave the bath of aluminum and will pass out of the furnace through the pipe 81. It will be noted that the pipe 81 divides into the pipes 82 and 83, which are provided with valves 84 and 85, respectively. If the refined aluminum chlorid is to be further purified, the valve 84 is kept closed and the valve 85 is opened, so that the aluminum-chlorid gas may pass up the pipe 83 and be passed back into the condenser element 34 for condensation purposes, and in its refined state it will be recharged into the Rodenhauser furnace, as has been described, and this process may be repeated until the required degree of purity has been attained. At this point, the valve 85 is closed and the valve 84 is opened, so that the substantially pure aluminum chlorid may be passed into what may be termed "condenser #2", as indicated. This condenser is of the same structure as the condenser element 34, and the condensed aluminum chlorid in the form of a white powder is brought down into the tank 86. In this tank 86 the aluminum chlorid may be put under pressure by way of the pipe 87 leading from the compressed-air tank 48, and may also be subjected to heat from a flame at the burner 69, preferably confined within fire-walls. This again melts the aluminum chlorid, which may then be conducted to a storage tank 88 through a pipe 89 controlled by a valve 90, the pure aluminum chlorid being heated by a carbon monoxid flame at the burner 68 so as to be kept in a liquid condition.

From this storage tank 88 the liquid aluminum chlorid is conducted through a valve 91 and a pipe 92 to the electrolytic vat, which is also sealed. The electrolytic vat is illustrated in detail in Figs. 4, 5 and 6, and it will be seen that it comprises a graphite hearth 93 and fire-brick surrounding walls 94, 94, with magnesite linings 95, 95, the entire vat being surrounded by sustaining plates 96. Along opposite sides of the vat are access openings 97, 97, which are normally sealed by means of covers 98, 98, and a tap hole 99 is provided for a purpose that will be referred to presently, this tap hole being normally closed by means of the plug 100. A chlorin exit 101 is provided, and, as indicated in Fig. 1, this exit is connected by means of a pipe 102, in which there is a valve 103, with a chlorin compressor 104, which in turn is connected by a pipe 105 with a chlorin cooler 106, these two elements being merely diagrammatically shown. The cooler 106 is connected by means of a pipe 107 with the liquid chlorin tank 31, which has already been referred to, and the connecting pipe 107 is provided with a valve 108

Returning to the detailed showing of the electrolytic vat, it will be seen, from Figs. 5 and 6 particularly, that the anodes are in the form of graphite blocks 109, to each of which three stems 110, 110 are secured, the stems being firmly lodged in a reinforced fire-brick seal cover 111. Each of the anodes is provided with a collar 112, which is engaged by a loose collar 113 which may be moved up and down by means of nuts 114 on bolt rods 115 extending upwardly from a packing-box cover 116, which surrounds the anode stem and packs it at 117. By this arrangement the electrode stems may be adjusted vertically so that the proper overall adjustment may be secured within the vat. Copper bus bars 118, 118 connect the tops of the electrode stems 110, and in this way the current is conveyed to the bath, the graphite hearth acting as the opposite electrode. The center one of each set of three anode stems is drilled axially, as indicated

at 119, and this bore is connected to distributing passageways 120, 120 in the corresponding graphite block. Each of these bores is connected by means of a pipe 121 with the supply pipe 92, which has been hereinbefore referred to, and a valve 122 is disposed in each pipe 121 and is intermittently operated for feeding purposes by a traveler 123 which is mounted upon a rotating shaft 124. Thus, when the various rotating shafts 124 are put into operation, and, as before stated, the valve 91 is opened to permit the passage of the liquid aluminum chlorid, a constant feed is afforded down through the passageways 119 and into the vat.

The liquid aluminum chlorid is kept at a high temperature, about 200° centigrade, and at about a pressure of two and a half atmospheres. The heated material from the storage tank is transmitted through hot-oil baths in pipes 125 which surround the supply pipes 92, and thus it is insured that the aluminum chlorid be fed into the vat at the proper temperature. The electrolyte is a bath of melted sodium chlorid at a high temperature which is primarily induced by external means, but which is maintained by the application of the current, the heat being due to the resistance of the bath. The aluminum chlorid is fed to the bath at such a rate as to keep the bath saturated. The action which takes place in the electrolytic vat separates the aluminum from the chlorin and leaves the sodium chlorid. Due to the difference in specific gravity between the pure aluminum which is thus obtained and the melted sodium chlorid, it is a simple matter to tap off the molten aluminum by removing the plug 100, and in this way the first ultimate object of my process is obtained—the securing of aluminum in its elemental state from clay. Since the action is secured leaving sodium chlorid, the electrolyte may go on indefinitely. The chlorin which is freed is passed to the chlorin compressor 104, then to the cooler, and then to the storage tank, where is is drawn from to supply the chlorinizing furnace 9, all as hereinberore described.

Returning now to the silicon chlorid which has been collected in the tank 57 in liquid condition, it will be seen that the pipe 126 leads to the valve 80, which has hereinbefore been referred to, and at the time when the silicon chlorid is to be split up the valve 71 is closed and the valve 80 is opened, so that the silicon chlorid may be conducted to the bath of molten aluminum in the Rodenhauser furnace. As the silicon chlorid strikes the molten aluminum it is reconverted into a gas and it rises through the molten aluminum, and chemical action is immediately begun, due to the greater affinity of the chlorin for the aluminum than for the silicon. In this way the aluminum displaces the silicon in the chlorid and free silicon and aluminum-chlorid gas are formed. The free silicon is tapped from the Rodenhauser furnace my way of the spout 127, and the aluminum-chlorid gas is passed either to the condenser element 34, if it is to be further refined, or to the condenser #2, if it is to be immediately condensed and passed on to the electrolytic vat to be split up into the elements aluminum and chlorin.

Thus the Rodenhauser furnace has the double function of displacing the iron or other impurities in the impure aluminum chlorid with aluminum, in which case the impurities are cleaned out of the furnace and a new charge of pure aluminum provided, and of displacing the silicon in silicon tetrachlorid with aluminum, in which case the silicon is tapped off, to secure the other important object of this process, and a new charge of aluminum is provided whenever necessary. It will be seen that the process is uniquely continuous, and that the chlorin which is freed in the electrolytic vat may be used over and over again in the chlorinizing furnace, while the carbon monoxid which is formed by the oxygen liberated from the clay and the coke which is introduced is used for burner purposes. It is important that the system be a closed system, as described, to exclude the moisture and to protect the active chlorids, particularly the aluminum chlorid.

An important feature in the matter of the operation of my system is found in the feeding of the melted aluminum chlorid to the electrolytic vat. It is an important feature of my invention that the electrolytic bath is fed with the melted aluminum chlorid in such a way as to keep it saturated.

It will be apparent to those skilled in the art that various modifications might be made in this system without departing from the spirit or scope thereof. For instance, one might use fused zinc, instead of fused aluminum, for the breaking up of the silicon chlorid, or one might use a different electrolyte; so far as structure is concerned, it will be seen that any kind of furnace might be used, but I have attempted to refer to those which are particularly adaptable, and, so far as certain refinements are concerned, necessary. In heating the pipes which maintain the aluminum chlorid in its melted condition while being fed to the electrolytic bath, it might be better practice in some instances to use electric heating coils than to use an oil bath, and it might be well to heat the aluminum-chlorid containers in a manner other than by the carbon monoxid flame. With the closed system which has

been described, I have the particular advantage that there is no electrode consumption, and therefore when the electrodes are adjusted they will remain adjusted, and economic service is secured.

In charging the chlorinizing furnace, it is good practice to mix calcined clay and coke breeze to the right proportions before feeding it into the furnace, and to drop the mixture through the roof. I also use a deep fire and run the pile at a white heat. I contemplate the use of other reducing agents than that specifically mentioned and I have taken care of this in some of the appended claims. Where, in the claims, I speak of a reducing agent "inert" toward the reagent, I mean, of course, inert under the circumstances of the process set forth. For instance carbon, which I mention specifically, does react with chlorin under certain circumstances, but not under the conditions of the process described. I may state here, for what further assistance it may give, that carbon monoxid is a perfectly feasible reducing agent for use in my process. In the appended claims where the formation of an oxygen compound is specified it is assumed that it may or may not be separated from both halogen or chlorin compounds, it being preferable, however, to do so, as is the case in the specific description above. The essential thing is that the halogen or chlorin compounds are separated.

I desire to call attention to the fact that it is possible to treat the clay with chlorin in some other way than to feed the chlorin gas to the chlorinizing furnace, as has been described. I contemplate the use of compounds of chlorin to secure reactions, in order to produce the chlorids. For instance, I might use carbon tetrachlorid and feed this carbon tetrachlorid, which is a colorless mobile liquid, into the chlorinizing furnace with the clay and carbon, or into the mixture of clay and carbon already fed into the furnace.

Referring to the electrolytic vat, I may mention here that the hearth is the cathode and the graphite blocks constitute the anode, and I may also state that, so far as I have been able to observe, the action of the vat is a reduction process. The aluminum forms globules varying in size from mere specks to considerably larger particles. The chlorin is liberated and streams away with great rapidity. The aluminum which is thus formed is heavier and settles to the bottom, and the particles of aluminum as formed above the bottom frequently join to form larger particles. As the process continues, the bottom is covered by drops of aluminum, and, as described, is tapped out from the vat.

It is pertinent here to suggest that the method which has been described, as to the securing of aluminum from aluminum chlorid by electrolysis, is applicable in the winning of other metals; for instance, zinc can be secured from zinc chlorid by this process. Although I have entitled my invention "Process of winning metals" it will be understood that it is not necessarily limited strictly to metals but includes other substances which partake of the nature of metals in the reactions entailed. For instance, I secure silicon and, while strictly speaking, it is not a metal, its response in the process is analogous to that of a metal.

While I have already referred to the fact that the broad conception of my invention has to do with the winning of any adaptable metal from any adaptable compound, I desire to point out that my process is particularly useful in the winning of metals from compounds containing those metals and oxygen and in this respect I have particularly in mind bauxite, which, so far as some of the broader features of my invention are concerned, would be regarded as the equivalent of clay. However, I have directed my attention merely to the treatment of clay, and the more specific aspects of my invention will be seen to be directed to this end.

The various suggestions of changes and the suggestions as to explanations of the action are presented in closing this description so that those skilled in the art may be as fully advised as possible, and so that it may be clear that my invention is to be measured in its broader aspects as set forth in the broader of the appended claims, and in its more limited aspects as set forth in the more specific claims.

I claim as new and desire to secure by Letters Patent:

1. The process of securing a metal from a substance containing it and silicon, which comprises treating the substance with a halogen to form a compound of the metal and the halogen and a compound of silicon and the halogen, then separating the two halogen compounds, and then separating the metal from the halogen.

2. The process of securing a metal from a substance containing it and silicon and oxygen, which comprises treating the substance with a halogen in the presence of a reducing agent inert toward the halogen to form a compound of the metal and the halogen, a compound of silicon and the halogen and a compound of oxygen and the reducing agent, then separating the two halogen compounds, and then separating the metal from the halogen.

3. The process of securing aluminum from a substance containing it and silicon, which comprises treating the substance with a halogen to form a compound of aluminum and the halogen and a compound of silicon and the halogen, then separating the two halogen compounds, and then separating the

aluminum from the halogen, all the steps being performed in a moisture free atmosphere.

4. The process of securing aluminum and silicon from clay which comprises in treating the clay with chlorin in the presence of carbon to form aluminum chlorid, silicon tetrachlorid and carbon monoxid, then separating the two chlorids, then separating each of the desired elements from the chlorin, and then utilizing the chlorin for treating fresh charges of clay.

5. The process of securing aluminum from a substance containing it and silicon, which comprises treating the substance with a halogen to form a compound of aluminum and the halogen and a compond of silicon and the halogen, then separating the halogen compounds, and then separating the aluminum from the halogen.

6. The process of securing aluminum from a substance containing it and silicon and oxygen which comprises treating the substance with a halogen in the presence of a reducing agent inert toward the halogen to form a compound of aluminum and the halogen, a compound of silicon and the halogen and a compound of oxygen and the reducing agent, then separating the two halogen compounds, and then separating the aluminum from the halogen.

7. The process of securing aluminum and silicon from clay which comprises treating the clay with a halogen in the presence of a reducing agent inert toward the halogen to form a compound of aluminum and the halogen, a compound of silicon and the halogen and a compound of oxygen and the reducing agent, then separating the two halogen compounds, and then separating the desired elements from the halogens.

8. The process of securing aluminum from a substance containing it and silicon, which comprises treating the substance with chlorin to form aluminum chlorid and silicon tetra-chlorid, then separating the two chlorids, and then separating the aluminum from the chlorin.

9. The process of securing aluminum from a substance containing it and silicon and oxygen, which comprises treating the substance with chlorin in the presence of a reducing agent inert toward chlorin to form aluminum chlorid and silicon tetrachlorid, then separating the two chlorids, and then separating the aluminum from the chlorin.

10. The process of securing aluminum from a substance containing it and silicon, which comprises treating the substance with chlorin to form aluminum chlorid and silicon tetra-chlorid, then separating the two chlorids, and then separating the aluminum from the chlorin, all the steps being performed in a moisture free atmosphere.

11. The process of securing aluminum from clay which comprises treating the clay with chlorin in the presence of carbon to form aluminum chlorid, silicon tetrachlorid and carbon monoxid, then separating the two chlorids and the carbon monoxid, and then separating the aluminum from the chlorin.

12. The process of securing aluminum and silicon from a substance containing them, which comprises treating the substance with chlorin to form aluminum chlorid and silicon tetrachlorid, then separating the two chlorids, and then separating each of the desired elements from the chlorin.

13. The process of securing aluminum and silicon from a substance containing them and oxygen, which comprises treating the substance with chlorin to form aluminum chlorid and silicon tetrachlorid, then separating the two chlorids, and then separating each of the desired elements from the chlorin.

14. The process of securing aluminum and silicon from a substance containing them and oxygen, which comprises treating the substance with chlorin in the presence of a reducing agent inert toward chlorin to form aluminum chlorid and silcon tetrachlorid, then separating the two chlorids, and then separating each of the desired elements from the chlorin.

15. The process of securing aluminum and silicon from clay which comprises treating the clay with chlorin in the presence of a reducing agent inert toward chlorin to form aluminum chlorid, silicon tetrachlorid and a compound formed by the reducing agent and oxygen released from the clay, then separating the two chlorids, and then separating each of the desired elements from the chlorin.

16. The process of securing aluminum and silicon from a substance containing them, which comprises treating the substance with chlorin to form aluminum chlorid and silicon tetrachlorid, then separating the two clorids and then separating each of the desired elements from the chlorin, all the steps being performed in a moisture free atmosphere.

17. The process of securing silicon from a substance containing it and a metal, which comprises treating the substance with a halogen to form a compound of silicon and the halogen and a compound of the metal and the halogen, then separating the two halogen compounds, and then separating the silicon from the halogen.

18. The process of securing a metal from a substance containing it and oxygen and another material, which comprises treating the substance with a halogen in the presence of a reducing agent inert toward the halogen to form a compound of the metal and the

halogen, a compound of oxygen and the reducing agent and a compound of the other material and the halogen, then separating the two halogen compounds, and then separating the metal from the halogen.

19. The process of securing aluminum from a substance containing it and another material, which comprises treating the substance with a halogen to form a compound of aluminum and the halogen and a compound of the other material and the halogen, then separating the two halogen compounds, and then separating the aluminum from the halogen.

20. The process of securing aluminum from a substance containing it and oxygen and another material, which comprises treating the substance with a halogen in the presence of a reducing agent inert toward the halogen to form a compound of aluminum and the halogen, a compound of oxygen and the reducing agent and a compound of the other material and the halogen, then separating the two halogen compounds, and then separating the aluminum from the halogen.

In witness whereof, I hereunto subscribe my name this 17th day of August, A. D. 1914.

VICTOR M. WEAVER.

Witnesses:
NOAH I. HEISEY,
EDWARD J. DUNLAP.