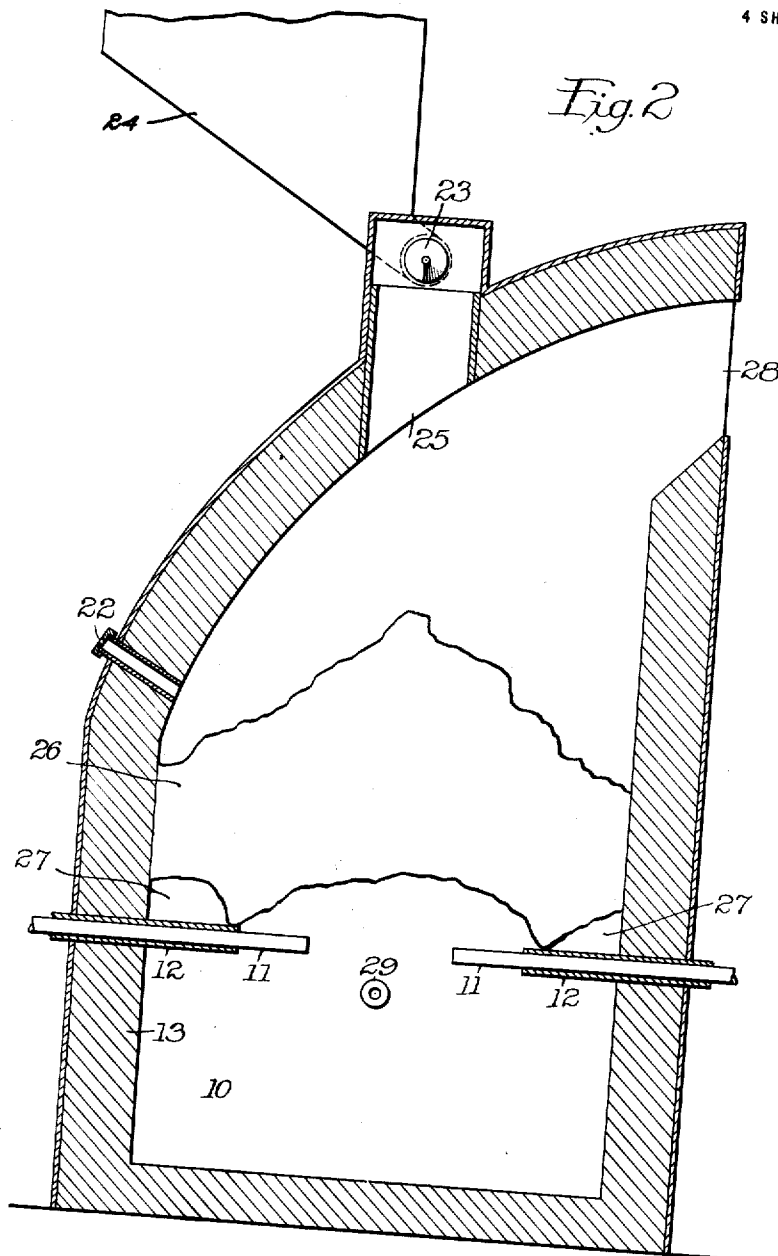


1,296,575.

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

V. M. WEAVER.
APPARATUS FOR CARRYING OUT PROCESSES OF WINNING METALS.
APPLICATION FILED AUG. 9, 1915.
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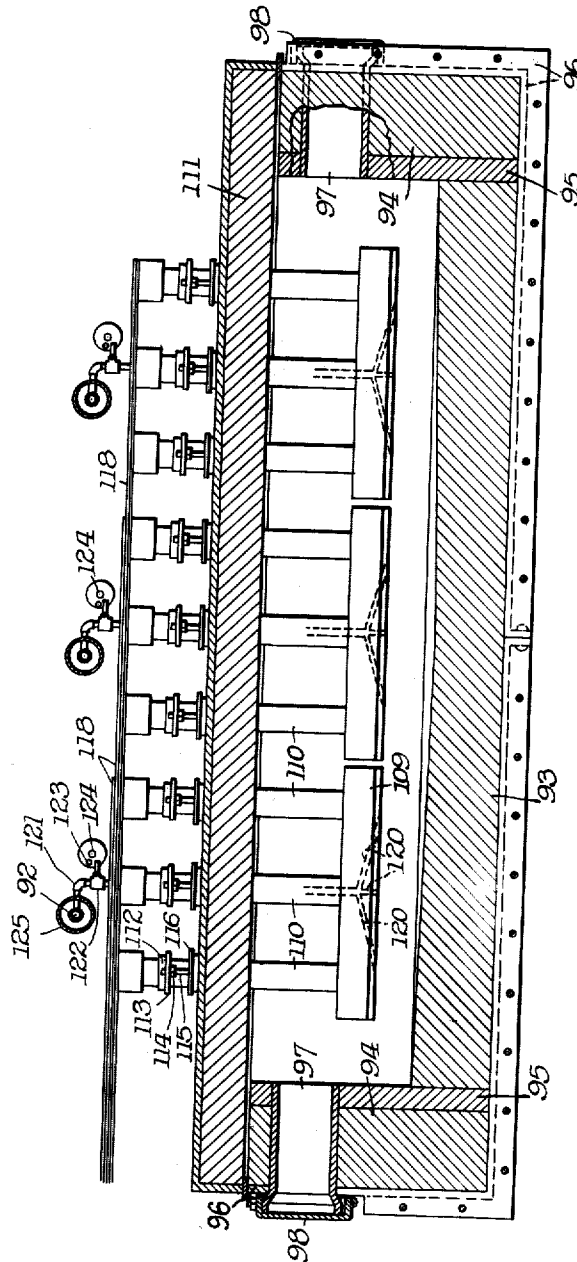
Patented Mar. 4, 1919.
4 SHEETS—SHEET 2.



Inventor
Victor M. Weaver
By *Brown, Hanson & Betts*
Attys

1,296,575.

4 SHEETS—SHEET 3.



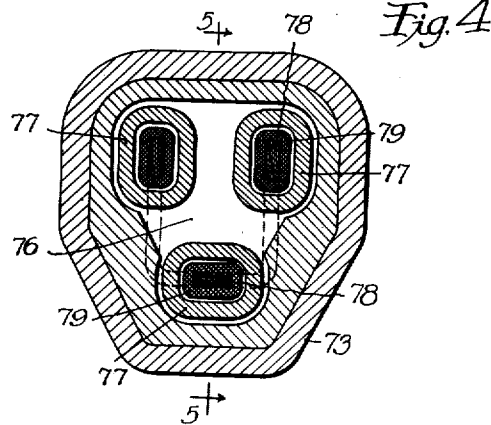
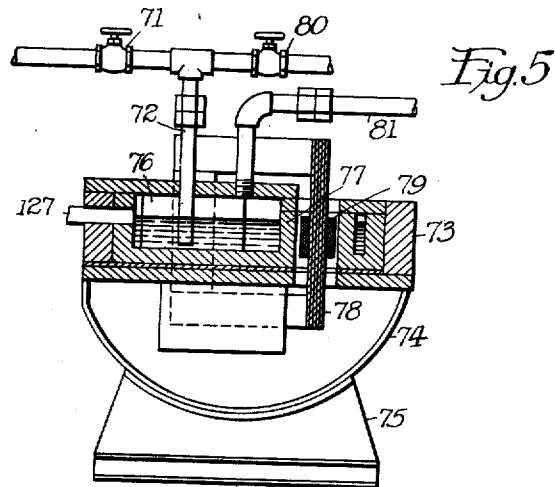
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 Att'ys

UNITED STATES PATENT OFFICE.

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

APPARATUS FOR CARRYING OUT PROCESSES OF WINNING METALS.

1,296,575.

Specification of Letters Patent.

Patented Mar. 4, 1919.

Original application filed August 22, 1914, Serial No. 858,001. Divided and this application filed August 9, 1915. Serial No. 44,517.

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 Apparatus for Carrying Out Processes of Winning Metals, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

My invention relates to apparatus for carrying out certain processes involving the chemical and physical treatment of materials.

This application is divisional from the application which resulted in my Patent No. 1,238,604, dated August 28, 1917, wherein a process of securing metals from their compounds is described. Since the apparatus employed to carry out the said process may possibly be utilized to carry on processes not covered by the claims of the parent application, the claims to the apparatus are properly in this, a separate, application.

It will be clear to those skilled in the art that my invention will admit of broader application than the specific use which I shall describe as an instance of its employment and, therefore, to simplify this description I shall describe my apparatus as employed in carrying out a process of securing aluminum and silicon from clay, or other oxygen-containing compounds of aluminum and silicon, such as bauxite in its crude form or refined.

The apparatus is such as to provide for the working of what might be termed a continuous process; that is, the operation may proceed continuously by a feed to one part thereof and withdrawals from another part thereof, as distinguished from operation which involves charging, the treatment of a consignment of material, then removal, and then recharging.

It is another feature of the apparatus of my invention that the arrangement is such as to collect, and, if desired, to utilize or reuse the reagents or their constituents, so that the continuous process can be carried on economically and conveniently.

Turning now to the specific description of my apparatus and an exemplary use, I may say briefly that 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, then separate the two chlorids and then secure the aluminum from its chlorid and the silicon from its chlorid.

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 chlorin 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 for the silicon, the silicon is released and may be removed, 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 cross-sectional view, taken on a vertical plane, of the electrolyzing vat;

Fig. 4 is a cross-sectional view, taken on a horizontal plane, of the second furnace which is employed; and

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

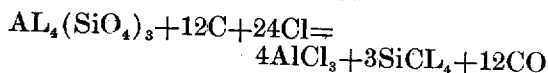
Referring first to Fig. 1, it will be seen that the chlorinizing furnace is shown at 9, and by reference to Fig. 2 it will be seen that

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 the figure, are lodged. Each of the carbon electrodes 11 is firmly mounted in a terra cotta pipe 12, which in turn is mounted in the firebrick housing 13. An electric conductor is provided for each of the carbon electrodes. A peep-hole arrangement 22 is 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 $Al_2(SiO_4)_3$ (the moisture being driven therefrom) are 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 firebrick 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 chlorine properly fed to the graphite pipe and with the current properly applied to the electrodes, the activity of the chlorine 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.

The reaction is as follows:



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. 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 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.

Where additional chlorids are formed in the chlorinizing furnace, which condense at other temperatures, as is the case when iron or titanium is present in the clay, or other ore used, the condenser may be arranged to separate these from the aluminum and silicon chlorids, and from each other, by increasing the number of elements maintained at the different temperatures which are required to separately deposit the substances.

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 also placed burners 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, and I therefore do not wish to be limited to the inclusion of this step of melting the aluminum chlorid.

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. 4 and 5. 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 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 parts 77, 77, within which the magnetic circuit frame and the primary coils 78 and 79, respectively, are disposed. The details of this furnace, except for certain features in combination with other parts of my system, do not constitute a 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 purpose 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, unless more than two condenser elements are provided at appropriate different temperatures, 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 converted 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 chlorid 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 Fig. 3, and it will be seen that it comprises a graphite hearth 93 and firebrick 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 99 is provided for a purpose that will be referred to presently, this tap being normally closed by means of the plug. A chlorin exit 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 dia-

grammatically 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 that the anode is 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 over-all 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, 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 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, 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 it is drawn from to supply the chlorinizing furnace 9, all as hereinbefore 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 removed from the Rodenhauser furnace by 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 chlorid with aluminum, in which case the silicon is removed 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.

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.

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. It is convenient to retain sufficient molten aluminum in the vat to keep the carbon cathode constantly covered.

It will appear that changes and modifications in the apparatus of my invention will be possible without departing from the spirit and scope of my invention. I have already referred to the fact that the apparatus of my invention has much wider application than for carrying out merely the process which I have cited as an instance of use, and it is to be understood that I contemplate any use to which my apparatus may be put. I desire, therefore, that the metes and bounds of my invention shall be determined by the appended claims, which I have drawn variously so as to bring out the combinations which, of themselves, and regardless of their use, are new.

I claim:

1. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, an electrolytic vat connected with said receptacle, and a gas-collecting tank connected with said vat.

2. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, an electrolytic vat connected with said receptacle, and a gas-collecting tank connected with said vat, said gas-collecting tank being connected with said furnace.

3. A closed system comprising a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, an electrolytic vat connected with said receptacle, and a gas-collecting tank connected with said vat.

4. In combination, a furnace, a condenser connected therewith, a collecting receptacle

connected with said condenser, a valve-controlled gas-outlet for said condenser, an electrolytic vat connected with said receptacle, and a gas-collecting tank connected with said vat.

5. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, a valve-controlled gas-outlet for said condenser, a receiver connected with said gas-outlet, a burner associated with said collecting receptacle and connected with said receiver, an electrolytic vat connected with said receptacle, and a gas-collecting tank connected with said vat.

6. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, a pump connected with said condenser, a scrubber connected with said pump, a receiver connected with said scrubber, a burner associated with said receptacle and connected with said receiver, an electrolytic vat connected with said receptacle, and a gas-collecting tank connected with said vat.

7. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, a valve-controlled gas-outlet for said condenser, a scrubber and a receiver connected with said gas-outlet, a burner associated with said collecting receptacle and connected with said receiver, an electrolytic vat connected with said receptacle, and a gas-collecting tank connected with said vat.

8. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, a second furnace connected with said receptacle, a second condenser connected to said second furnace, an electrolytic vat connected with said second condenser, and a gas-collecting tank connected with said vat.

9. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, a second furnace connected with said receptacle, a second condenser connected to said second furnace, an electrolytic vat connected with said second condenser, and a gas-collecting tank connected with said vat, said second furnace having a by-pass back to said first condenser.

10. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, a second furnace connected with said receptacle, a second condenser controllably connected to said second furnace, an electrolytic vat connected with said second condenser, and a gas-collecting tank connected with said vat, said second furnace having a controllable by-pass back to said first condenser.

11. In combination, a furnace, a con-

denser connected therewith, a collecting receptacle connected with said condenser, a second furnace connected with said receptacle, a second condenser connected with said second furnace, a second collecting receptacle connected to said second condenser, a reservoir connected to said second collecting receptacle, an electrolytic vat connected with said reservoir, and a gas-collecting tank connected with said vat.

12. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, a second furnace connected with said receptacle, a second condenser connected with said second furnace, a second collecting receptacle connected to second condenser, a reservoir connected to said second collecting receptacle, an electrolytic vat connected with said reservoir, and a gas-collecting tank connected with said vat, said gas-collecting tank being connected to said first-named furnace.

13. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, and an electrolytic vat connected with said receptacle.

14. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, means for heating said receptacle, an electrolytic vat connected with said receptacle, and a gas-collecting tank connected with said vat.

15. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, means for maintaining pressure above atmosphere in said receptacle, an electrolytic vat connected with said receptacle, and a gas-collecting tank connected with said vat.

16. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, means for heating said receptacle, means for maintaining pressure above atmosphere in said receptacle, an electrolytic vat connected with said receptacle, and a gas-collecting tank connected with said vat.

17. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, an electrolytic vat connected with said receptacle, a tap for said vat, and a gas-collecting tank connected with said vat.

18. In combination, a furnace, a plurality of condenser elements connected therewith, means for maintaining different temperatures in the different elements, a collecting receptacle connected with each condenser element, a second furnace, controllable connections between each of said collecting receptacles and said furnace, an electrolytic vat controllably connected with said second

furnace, and a tap for said second furnace.

19. In combination, a closed oven, a closed condenser having sealed connection therewith, a closed collecting receptacle having sealed controllable connection with said condenser, a closed crucible having sealed connection with said receptacle, a closed electrolytic vat having sealed connection with said crucible, and a gas-collecting tank connected with said vat.

20. In combination, a furnace, condensing means connected therewith, a collecting receptacle connected with said condensing means, a second furnace connected with said receptacle, condensing means being connected to said second furnace, an electrolytic vat connected with said condensing means, and a gas-collecting tank connected with said vat.

21. In combination, a furnace, condensing means connected therewith, a collecting receptacle connected with said condensing means, a second furnace connected with said receptacle, condensing means being controllably connected to said second furnace, an electrolytic vat connected with said condensing means, and a gas-collecting tank connected with said vat.

22. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, a pump connected with said condenser, a scrubber connected with said pump, a receiver connected with said scrubber, a burner associated with said receptacle and connected with said receiver, an electrolytic vat connected with said receptacle, a gas-collecting tank connected with said vat, and a gas connection leading from said tank back to said furnace.

23. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, a valve-controlled gas-outlet for said condenser, a scrubber and a receiver connected with said gas-outlet, a burner associated with said collecting receptacle and connected with said receiver, an electrolytic vat connected with said receptacle, a gas-collecting tank connected with said vat, and a gas connection leading from said tank back to said furnace.

24. In combination, a furnace, a plurality of condenser elements connected therewith, means for maintaining different temperatures in the different elements, collecting receptacles connected with the condenser elements, and electrolytic vats connected with a receptacle.

25. In combination, a furnace, a plurality of condenser elements connected therewith, means for maintaining different temperatures in the different elements, collecting receptacles connected with the condenser ele-

ments, electrolytic vats connected with a receptacle, and a gas connection from said vats back to said furnace.

26. In combination, a furnace, a plurality of condenser elements connected therewith, means for maintaining different temperatures in the different elements, collecting receptacles connected with the condenser elements, electrolytic vats connected with a receptacle, and a gas connection from said vats back to said furnace, a pump being connected in said gas connection.

27. In combination, a furnace, a plurality of condenser elements connected therewith, means for maintaining different temperatures in the different elements, collecting receptacles connected with the condenser elements, electrolytic vats connected with a receptacle, and a gas connection from said vats back to said furnace, a pump and a gas receptacle being connected in said gas connection.

28. In combination, a combining chamber, a second chamber connected with said combining chamber to receive exclusively a charge from said combining chamber, and means in said second chamber for separating two substances combined in said combining chamber.

29. In combination, a combining chamber, a second chamber connected with said combining chamber to receive exclusively a charge from said combining chamber, and means in said second chamber for releasing a gas from a compound formed in said combining chamber.

30. In combination, a combining chamber having an inlet and an outlet, a second chamber having sealed connection with the outlet of said combining chamber to receive exclusively a charge from said combining chamber, and means in said second chamber for releasing a gas from a compound.

31. In combination, a combining chamber, a second chamber connected with said combining chamber, means for conveying a compound from said combining chamber to said second chamber, means in said second chamber, for releasing a gas from a compound and means for piping the released gas back to said combining chamber.

32. In combination, a combining chamber having an inlet and an outlet, a condenser connected with said outlet, a second chamber connected with said condenser independently of said combining chamber, and means in said second chamber for releasing a gas from a compound.

33. In combination, a furnace, a condenser connected therewith, a second chamber connected with said condenser, and means in said second chamber for releasing a gas from a compound.

34. In combination, a combining chamber,

- a condenser connected therewith, a collecting receptacle connected with said condenser, a second chamber connected with said receptacle, and means in said second chamber for releasing a gas from a compound.
35. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, a chamber connected with said receptacle, and means in said chamber for releasing a gas from a compound.
36. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, a chamber connected with said receptacle, means in said chamber for separating a gas from a compound, and a gas-collecting tank connected with said chamber.
37. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, a chamber connected with said receptacle, means in said chamber for separating a gas from a compound, and a gas-collecting tank connected with said furnace.
38. A closed system comprising a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, a chamber connected with said receptacle, means in said chamber for separating a gas from a compound, and a gas-collecting tank connected with said chamber.
39. In combination, a combining chamber, a condenser connected therewith, a crucible connected to said condenser, a second chamber connected with said crucible, and means in said second chamber for releasing a gas from a compound.
40. In combination, a combining chamber, a condenser connected with said combining chamber, said condenser having two outlets, a collecting receptacle connected with each outlet, a second chamber connected with one of said receptacles, and means in said second chamber for releasing a gas from a compound.
41. In combination, a combining chamber, a second chamber to receive exclusively a charge from said combining chamber, means for conveying a compound formed in said combining chamber to said second chamber, and means in said second chamber for splitting up said compound.
42. In combination, a combining chamber, a second chamber to receive exclusively a charge from said combining chamber, means for conveying a compound formed in said combining chamber to said second chamber, and means in said second chamber for releasing a gas from said compound.
43. In combination, a combining chamber, a condenser, means for conveying material from said combining chamber to said condenser, a second chamber, means for conveying material from said condenser to said second chamber and means in said second chamber for decomposing the material fed thereto.
44. In combination, a combining chamber, a condenser, means for conveying material from said combining chamber to said condenser, a second chamber, means for conveying material from said condenser to said second chamber, and means in said second chamber for releasing a gas from a compound.
45. In combination, a furnace, a condenser, means for conveying material from said furnace to said condenser, a chamber, means for conveying material from said condenser to said chamber, and means in said chamber for releasing a gas from a compound.
46. In combination, a combining chamber, a condenser, means for conveying material from said combining chamber to said condenser, a collecting receptacle, means for conveying material from said condenser to said receptacle, a second chamber, means for conveying material from said receptacle to said second chamber, and means in said second chamber for releasing a gas from a compound.
47. In combination, a combining chamber, a condenser connected therewith, a crucible, means for conveying material from said condenser to said crucible, a second chamber, means for conveying material from said crucible to said second chamber, and means in said second chamber for releasing a gas from a compound.
48. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, and an electrolytic vat connected with said receptacle, said vat being connected back to said furnace.
49. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, a second furnace connected with said receptacle, a second condenser connected to said second furnace, and an electrolytic vat connected with said second condenser.
50. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, means for heating said receptacle, and an electrolytic vat connected with said receptacle.
51. In combination, a furnace, a condenser connected therewith, a collecting receptacle connected with said condenser, means for maintaining pressure above atmospheric in said receptacle, and an electrolytic vat connected with said receptacle.

52. In combination, a furnace, a plurality of condenser elements connected therewith, means for maintaining different temperatures in the different elements, a collecting
5 receptacle connected with each condenser element and an electrolytic vat connected with one of said receptacles.

53. In combination, a furnace, a condenser connected therewith, a collecting re-

ceptacle connected with said condenser, a 10 pump connected with said condenser, a receiver connected with said pump, a burner associated with said collecting receptacle and connected with a receiver, and an electrolytic vat connected with said receptacle. 15

In witness whereof, I hereunto subscribe my name this 3rd day of Aug., A. D. 1915.

VICTOR M. WEAVER.