June 3, 1924. 1,496,440

V. M. WEAVER

ELECTRIC FURNACE

Original Filed March 11, 1918 4 Sheets-Sheet 1

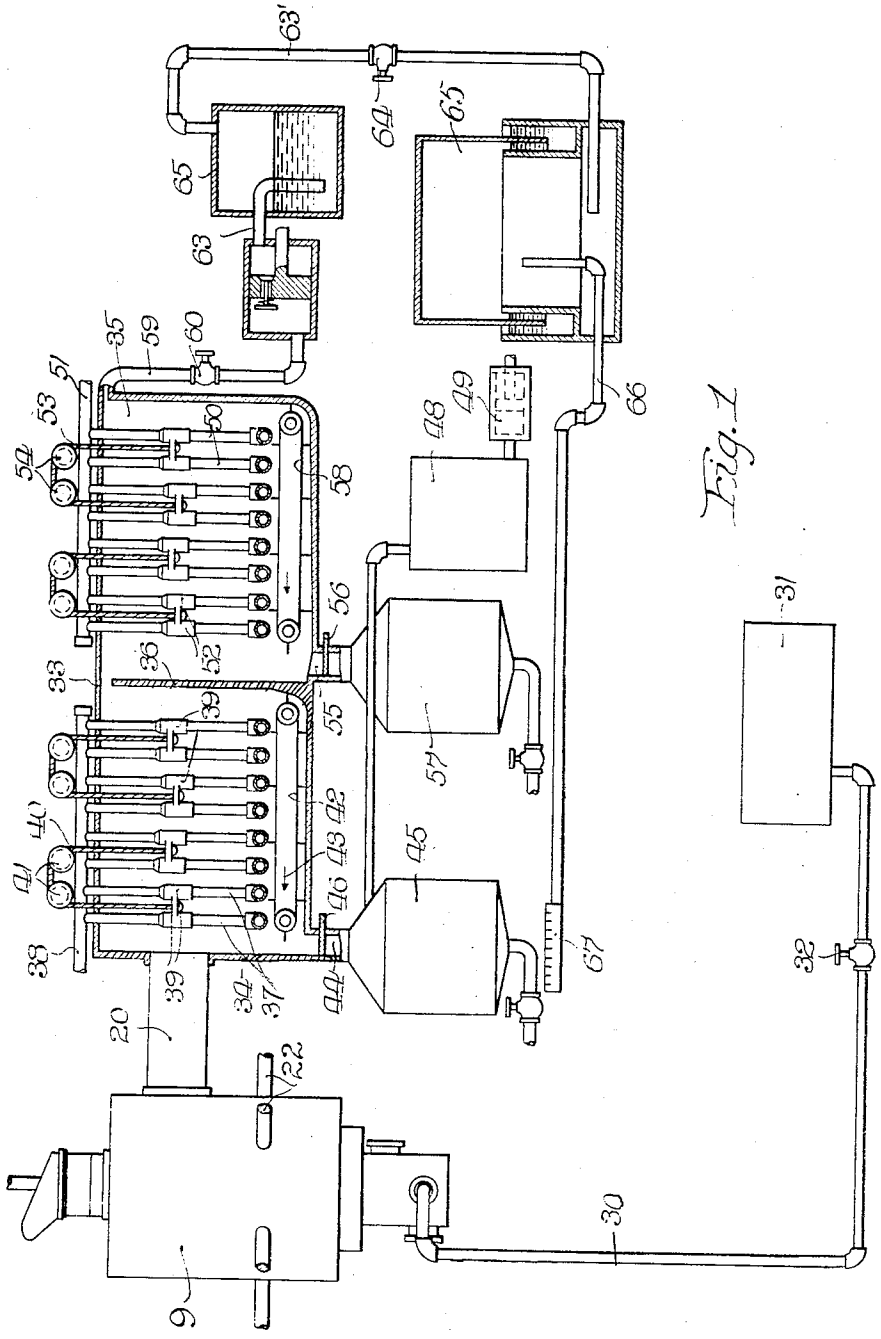


Fig. 1

Inventor
Victor M. Weaver
By Brown, Hanson & Whittemore
Attorneys

June 3, 1924.

1,496,440

V. M. WEAVER

ELECTRIC FURNACE

Original Filed March 11, 1918 4 Sheets-Sheet 2

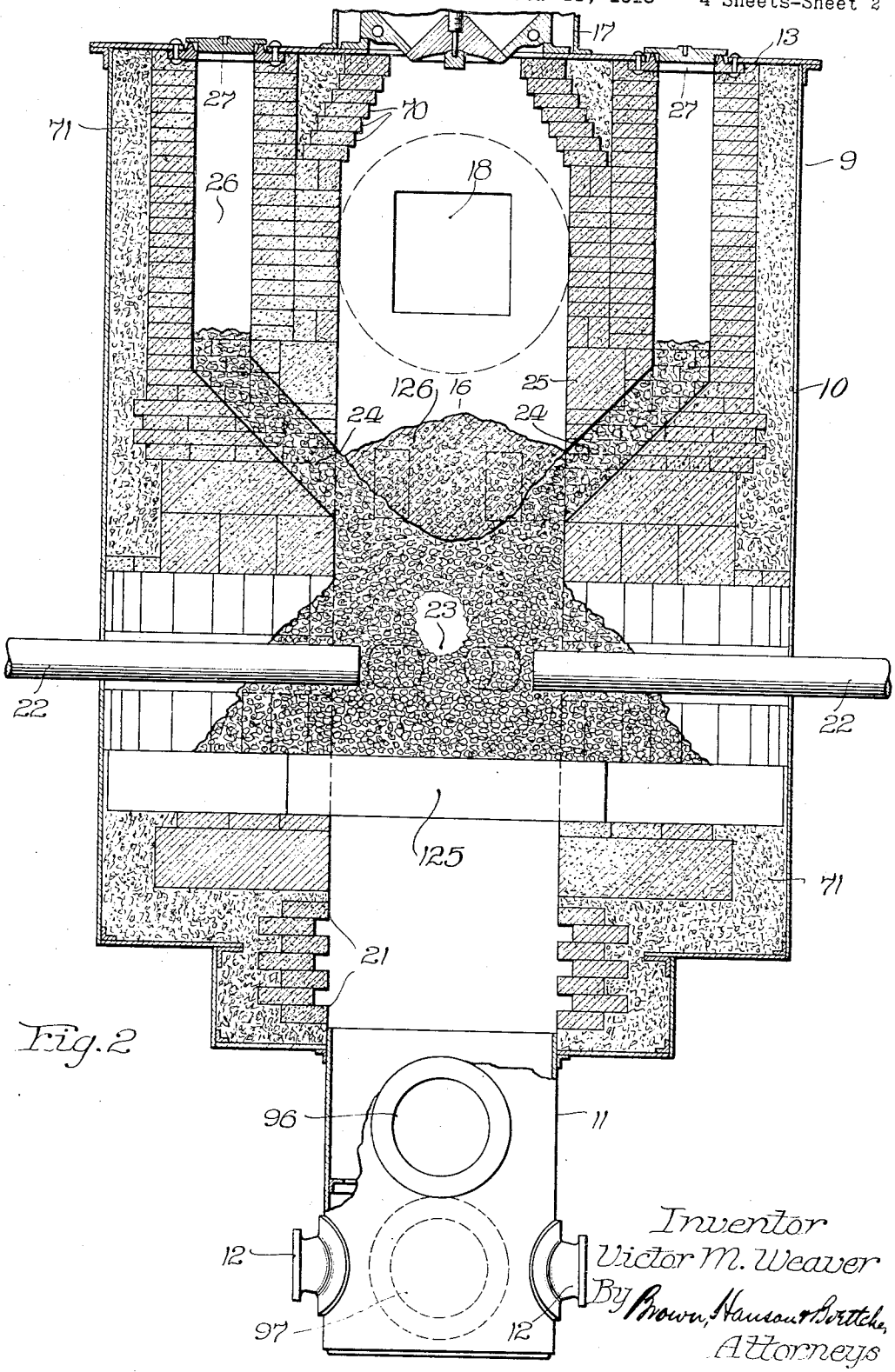


Fig. 2

Inventor
Victor M. Weaver
By Brown, Hanson & Bottcher,
Attorneys

June 3, 1924. 1,496,440

V. M. WEAVER

ELECTRIC FURNACE

Original Filed March 11, 1918 4 Sheets-Sheet 3

Fig. 3

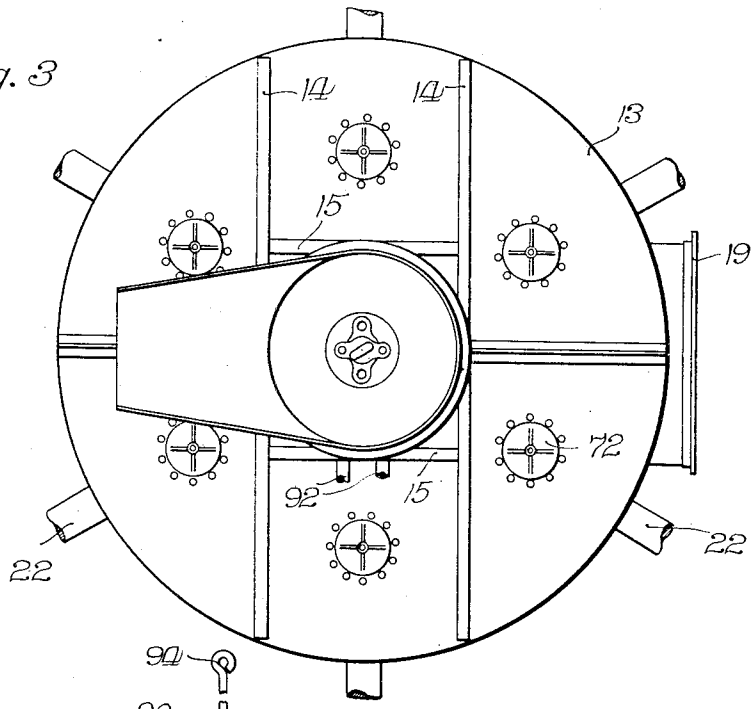


Fig. 4

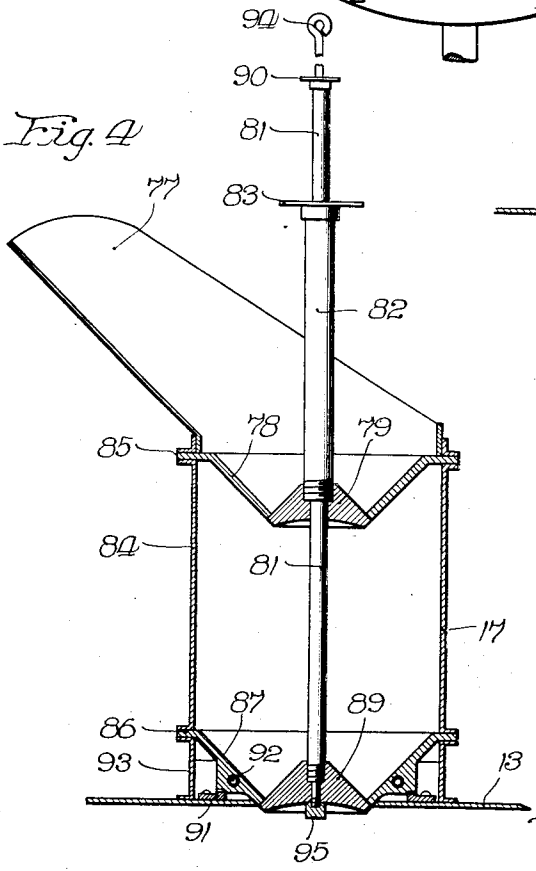
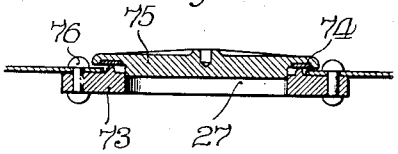


Fig. 5



Inventor
Victor M. Weaver
By Brown Hanson & Bottcher
Attorneys.

June 3, 1924. 1,496,440

V. M. WEAVER

ELECTRIC FURNACE

Original Filed March 11, 1918 4 Sheets-Sheet 4

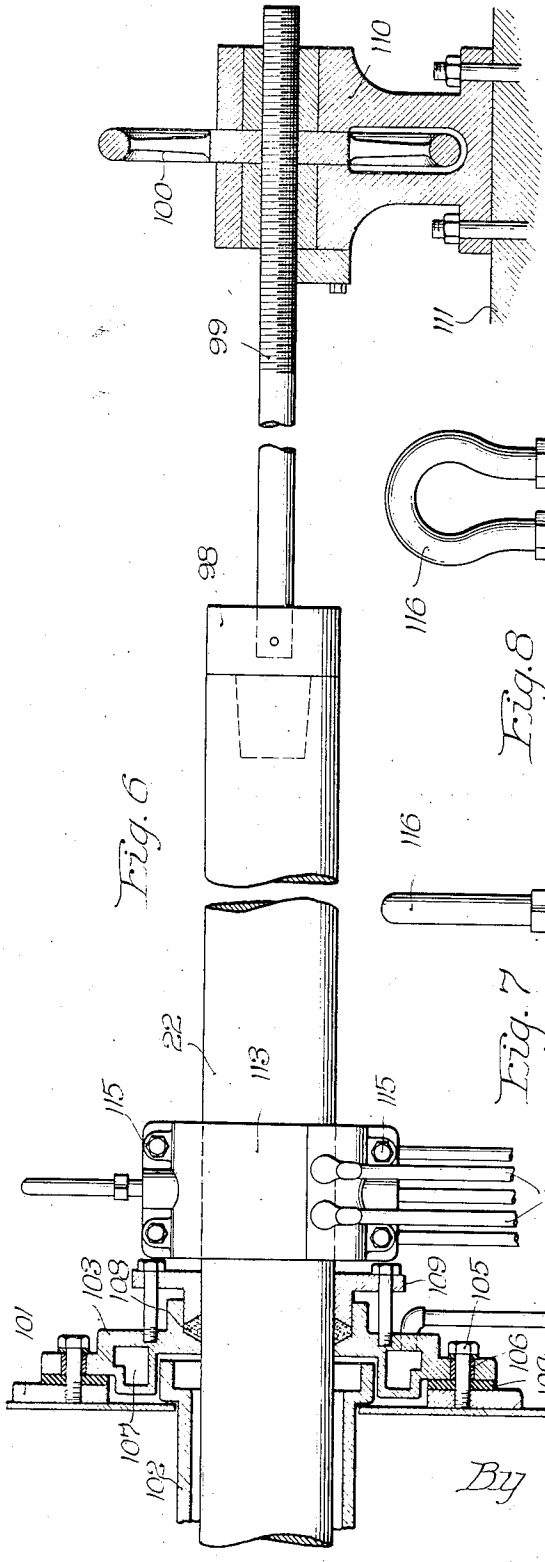


Fig. 6

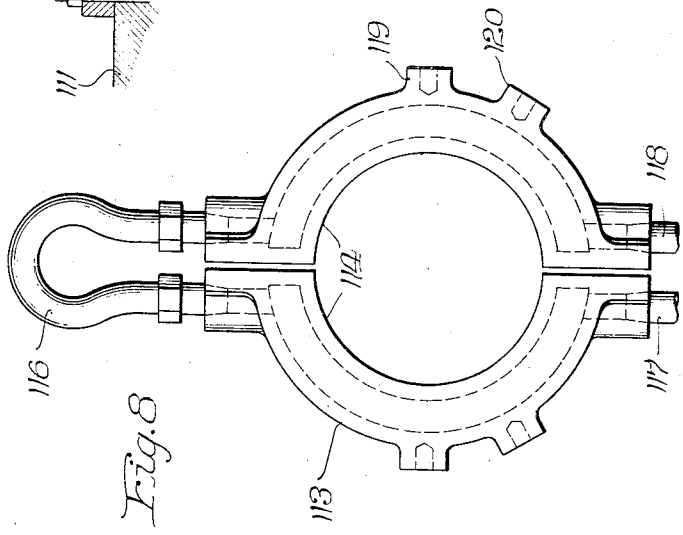


Fig. 8

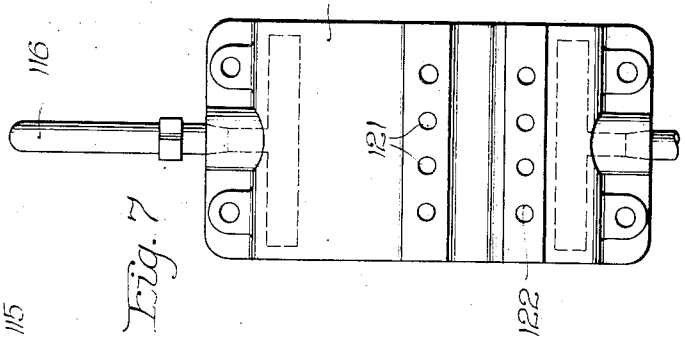


Fig. 7

Inventor
Victor M. Weaver
By Brown, Hanson & Bottcher
Attorneys.

Patented June 3, 1924. 1,496,440

UNITED STATES PATENT OFFICE.

VICTOR M. WEAVER, OF THOROLD, ONTARIO, CANADA, ASSIGNOR TO WEAVER COMPANY, OF MILWAUKEE, WISCONSIN, A CORPORATION OF WISCONSIN.

ELECTRIC FURNACE.

Application filed March 11, 1918, Serial No. 221,630. Renewed January 21, 1921. Serial No. 439,049.

To all whom it may concern:

Be it known that I, VICTOR M. WEAVER, a citizen of the United States, residing at Thorold, Ontario, Canada, have invented a certain new and useful Improvement in Electric Furnaces, 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 the art of forming desired chemical combinations and has to do particularly with processes wherein it is necessary to maintain a reducing atmosphere for the purposes of decomposition preliminary to combination.

I am concerned particularly with the formation of halides by the treatment of a charge, such as an ore, which contains considerable oxygen, with a halogen gas and it is my purpose to provide for a mode of operation which at all times insures the formation of a monoxide gas instead of a dioxide gas. It will be clear to those skilled in the art that my invention is applicable, in its broader sense, to any procedure wherein it is necessary or desirable to secure a monoxide gas rather than a dioxide gas and it will be noted that the broader of the appended claims are accordingly drawn. More specifically, I find special utility and characteristic adaptability of this broad idea to the formation of halides, still more particularly chlorides, in which cases new functions are performed. Accordingly it will be seen that I also make more specific claims drawn to these more particular features which, in actual practice, I have found to be extremely important.

As a specific instance of the desirability of insuring a monoxide gas instead of a dioxide gas, for certain purposes, I make reference to my United States Letters Patent 1,238,604, issued August 28th 1917, wherein a process of winning metals is described. There the teaching is to secure a monoxide gas and my present invention contemplates a new, effective and "automatic" way of insuring it.

In a specific process described in that patent aluminum chloride, silicon tetrachloride and carbon monoxide are formed by the action of chlorine gas upon kaolin, in the presence of carbon, in a suitable furnace. I shall use this specific process as an example in this description for instruction to those skilled in the art. If the amount of carbon were sufficiently limited, so that carbon dioxide would be formed instead of carbon monoxide, a different result, involving the production of carbonyl chloride (phosgene) would result. This is all clearly set forth in my copending application, Serial No. 210,609, filed January 7, 1918. When, however, carbon monoxide is to be formed instead of carbon dioxide, as taught in my patent above referred to, it is obviously necessary to provide an excess rather than a deficiency of carbon, and my present invention, as before stated, is directed to this end.

My invention contemplates a carbon lined furnace, the carbon lining comprising an inside part composed of closely united carbon in slabs or bricks or one large piece of closely united carbon formed and baked in place, and an outside or surrounding part composed of crushed or finely divided carbon not cemented together. Such a lining has the properties of being infusible and of freely distributing the heat over the inside part of the lining and of preventing the loss of heat from the furnace through the outside part of the lining, and also provides at all times carbon in contact with the gases after they have passed through the charge. It is also has the property of being inert with respect to the halides.

Owing to the carbon being inert with respect to the halides, I may use carbon grate bars which are placed in such position with relation to the heating zone that they will be maintained at a red heat.

A carbon hearth of crushed coke or the like is provided over the grate bars to support the charge and as a resistor for the electric current, thereby causing a heating effect beneath the charge and in the path of the incoming gases.

To prevent excessive erosion of the inner carbon wall at the portions touched by the charge, provision is made for furnishing additional carbon in the form of coal or coke in the side chutes, which has the effect of maintaining a supply of carbon around the walls, and thereby protects them from the erosion above referred to.

In the specific process above referred to

the charge, such as kaolin, is fed into the furnace with an adequate charge of carbon, whereupon chlorine gas is admitted and the action, under heat, proceeds. It is proposed that the same procedure shall follow with the use of my present furnace, but it will be seen that as my present furnace is constructed the adequate charge of carbon is always insured. If, perchance, the amount of loose carbon introduced with the kaolin should be insufficient to form carbon monoxide the carbon parts of the furnace themselves will be attacked so as to insure the formation of the monoxide—an omnipresent safety device to avoid upsetting the intended chemical procedure.

So far as the process phase of my present invention is concerned, it consists of insuring an excess of reducer by the constant presence of a redhot reducer element, in addition to the calculated charge and preferably in different physical form. It is conceivable that it may also differ chemically.

So far as the apparatus phase of my invention is concerned, it lies in the construction of the furnace, providing, broadly, inherent carbon elements and, specifically, carbon lining, hearth and grate bars, or any of them.

I shall now refer to the accompanying drawings, in which—

Figure 1 illustrates diagrammatically the apparatus by means of which the process is carried out;

Figure 2 is a vertical longitudinal section partly diagrammatic of the furnace employed for carrying out the invention;

Figure 3 is a plan view of the same on a reduced scale;

Figure 4 is a vertical longitudinal section of the charging hopper;

Figure 5 is a sectional detail view showing the covers for the coal chutes;

Figure 6 is an elevational view partly in section showing the electrodes, the adjusting mechanism for the same and the electrode clamps;

Figure 7 is a side elevation on a larger scale of a modified form of electrode clamp; and

Figure 8 is an end elevation of the same.

Figure 1, which is a diagrammatic outlay of a system for carrying out the process of my invention, shows the chlorinizing furnace at 9. This furnace, in which the reaction between the clay and carbon of the charge with the chlorine occurs, is of the closed type.

The structure of the furnace and its electrodes is shown in Figures 2 to 8 inclusive.

The furnace 9 comprises an outer shell or casing of sheet metal 10 generally cylindrical in form having a smaller cylindrical shell of sheet metal of considerably less diameter, as shown at 11, attached to the lower end where the chlorine is introduced at one of the nozzles 12. The top of the casing 10 is covered by a reinforced sheet metal top or cover 13 which has the braces of angle and channel iron 14—15 for stiffening and supporting the same.

The interior of the furnace comprises a central bore 16, communicating at its upper end with a charging hopper 17 and having a side outlet 18 for discharging the gaseous products of the chemical combination carried on within the furnace. The discharge opening 18 leads out by way of a flanged nozzle 19 which communicates by way of the discharge pipe 20 with the double chamber 33, to be referred to later.

The entire inner facing of the furnace is composed of carbon. The wall or shaft of the furnace is constructed of carbon bricks or blocks laid in courses from bottom to near the top of the furnace.

The hearth 23 is composed of a bed of coke, or other porous mass of carbon supported on the carbon grate bars 125. The charge 126 which in this case comprises kaolin and crushed coke, both freed of moisture, rests upon the hearth 23.

Electrodes 22 project into the bore of the furnace a short distance above the grate bars 125. The hearth 23 forms a resistor between said electrodes 22 and is maintained at a red heat by the passage of current between the electrodes. The charge 126 is thus supported upon a hot mass of carbon directly in the path of the incoming gases.

Above the hearth of the furnace 23 a plurality of coal feeding chutes 24 are formed in the carbon walls 25. These chutes comprise a lower diagonal portion converging into the main bore 16 and upper vertical portions 26 communicating at their upper ends with the filling openings 27 formed in the cover plate 13 of the furnace. These cover plates may be left free to lift and act as relief valves in case of gas explosions.

The upper end of the main bore 16 is reduced by means of the upper courses of carbon blocks or bricks 70 which extend inward to provide an opening suitable for the discharge opening of the charging hopper 17. The space between the carbon blocks or bricks and the metallic or sheet metal shell 10 is filled with crushed carbon. The central carbon lining is thus heat-insulated at the sides, top and bottom.

The top plate 17 is provided with a number of charging openings 27 in line with the vertical charging chutes 26. These charging openings 27 are normally closed by a cover plate 72 seated upon annular rings 73, as illustrated in detail in Figure 5. The closure between the cover 72 and the rings 73 is made by a lead gasket or other suitable material. The ring 73 is suitably fastened as by means of rivets 76 to the cover plate

13. In the particular embodiment that I have illustrated, six of these charging openings and six of the charging chutes are employed. The six electrodes 22 pass into the hearth of the furnace, being supported upon the sheet iron body 10 by the mechanism shown in Figure 6, which will be described in detail later. These electrodes and the charging chutes are spaced equally about the circumference of the furnace.

While the furnace as shown provides for bringing in the electric current by means of horizontal graphite or plain carbon electrodes I contemplate the use of vertical or inclined electrodes in cases where this is deemed more desirable.

The charging hopper 17 comprises an upper receiving spout 77 which is adapted to receive the material of the charge, and which is closed by a hopper bottom 78 generally conical or funnel-shaped in contour, and having its bottom opening normally closed by means of the charging bell 89. The upper bell 79 is apertured at the center to permit the passage therethrough of a pipe 81 and is threaded to receive the end of the larger pipe 82, which pipe 82 is the stem of the bell 79. The stem 82 is secured to a flange member 83 which flange member is in turn connected by suitable operating mechanism for raising and lowering the bell 79 to open the hopper bottom 78, or to close the same. A cylindrical barrel portion 84 is secured to the flange 85 of the hopper bottom 78 and extends downward to engage the flange 86 of the second hopper bottom 87, which is of the general contour of the hopper bottom 78, previously described. A bell 89 closes the hopper bottom 87, this bell having as a stem the pipe 81 which extends through and above the pipe 82 that forms the stem of the bell 79. At its upper end the pipe 81 has a flange 90, to which suitable operating cables are connected for manipulating the bell 89.

The hopper bottom 87 provides a water cooled valve seat for the bell 89 as these parts face the interior of the furnace. The hopper bottom 87 rests upon a ring 91 secured to the top 17 of the furnace. An enlargement is formed in the hopper bottom at this portion to provide the necessary seating surface for the ring 91 and also to provide room for the pipe 92 to be imbedded in the walls of the hopper bottom which forms the valve seat. The pipe 92 which extends outside of the valve seat, as shown in Figure 3, is adapted to be connected to a source of cooling water or other medium. This pipe is imbedded in the valve seat by casting the metal about the same. The flange of the hopper bottom 87 is connected by a short cylindrical section 93 with the top plate 13 to form a tight joint between these parts.

A sounding or feeling rod 94 passes down through the pipe 81 and through the valve member 89, having a knob 95 at its lower end for protecting the end of the rod and for closing off the hole in the bell member 89. To this end the top of the knob 95 is made conical and is adapted to seat around the conical edge of the hole formed through the bell so as to close off any leakage around the rod 94. This rod 94 is connected to suitable lowering and raising mechanism so that the rod may be let down to feel the height of the charge in the furnace.

The bottom section 11 of the furnace is provided with a pair of manholes 96 and 97. These manholes are of a suitable size to permit cleaning of the furnace after a run or for making repairs, or inspection or the like.

The electrodes 22 are made of graphite and are provided at their outer end with metal caps 98 which in turn are connected by means of an adjusting rod 99 threaded at the outer end for feeding the electrode as by means of the hand-wheel 100. The details of this construction are shown in Figure 6. A cast metal flange or ring 101 is secured about the opening in the shell 10 through which the electrode 22 passes. A flanged sleeve 102 made of insulation preferably vitrified pipe surrounds the electrode 22 and serves to insulate it from the shell and lining of the furnace. A water cooled guiding plate 103 is supported on but insulated from the ring 101 and serves to guide the electrode 22 into the insulating sleeve 102.

A layer of suitable insulation 104 is interposed between the flange of the guiding plate 103 and the supporting ring 101. The bolts 105 which secure these parts together are carefully insulated by means of washers and collars of insulation 106. The guiding plate is cored out as shown at 107 to provide water cooling space for water-cooling the cover plate and the electrode. A stuffing box 108 adapted to receive suitable packing is provided in the guiding plate 103 and the stuffing box gland 109 co-operates with the stuffing box to maintain a tight packing about the electrode 22.

The adjusting mechanism which comprises the threaded hand wheel and the threaded stem 99 permits the electrodes to be fed into the furnace as they are consumed. The hand wheel 100 is mounted in a suitable pedestal 110 mounted on a foundation 111, which may in this case be a floor or gallery about the furnace.

The electrodes 22 are connected to the electric cables which supply the necessary current by clamps such as shown at 113. These clamps preferably comprise two semi-circular parts 114, substantially similar in all respects, these semi-circular parts being adapted to be clamped upon opposite sides of the electrodes 22 by means of the

bolts 115. The interior of each half of the clamp is cored out to provide water jacket space and the two halves are put into communication with each other by means of a flexible metallic hose 116, which is preferably bent into U-shape as shown in Figure 8.

A suitable inlet and outlet pipe 117 and 118 are provided at the bottom of the halves of the clamp.

The electrical conductors 112 are preferably clamped by means of bolts or studs to the metallic side walls of the clamp members, being thereby put into direct metallic contact with the same. Suitable ridges 119 and 120, provided with screw sockets 121 and 122 may be provided to facilitate such attachment of the electrical conductors.

The operation of the furnace in connection with the other apparatus will now be described. The bore of the furnace is first charged with loose carbon, preferably in the form of coke to substantially the height of the hearth. The charge of material—in this case, clay, preferably in the form of kaolin of the approximate formula, $Al_4(SiO_4)_3$ is first given a preliminary heating to drive off all of the moisture, being heated for this purpose to a high temperature. The hot kaolin is then mixed with dried carbon such as crushed coke and conveyed in dump cars to the dumping spout 77 where it is received in the hopper 78, from thence discharged by way of the bell in the hopper bottom into the interior of the hopper 17. The bell 79 is then closed and the bell 89 is opened to discharge the clay into the bore of the furnace. The coal chutes are charged with crushed anthracite coal by opening the cover plate 72 and filling the chutes substantially full of loose coal in such position that it will tend to settle down into the bore or hearth of the furnace as space is made therefor. There is thus a composite mass of kaolin and coal or carbon deposited on the hearth of the furnace.

The kaolin and coal or coke are charged into the furnace in proper proportions, so that the oxygen of the charge will be taken up by the coal and coke thus introduced; but the carbon in the coal chutes is provided to protect the side walls in contact with the charge in case all of the oxygen in these parts of the charge is not taken up by the coal or coke provided as a part of the charge.

The nozzles 12 are connected by way of a pipe 30 with a suitable source of chlorine gas as indicated by the tank 31 the admission of chlorine being controlled by the valve 32. The chlorine gas is adapted to enter by way of the lower section 11 and pass up through the loose bed of coke into the zone of activity at the hearth when the furnace is operating. Assuming that the current is now turned on and that the chlorine gas is discharged into the active zone the disintegration of the kaolin with the formation of aluminum chloride and silicon tetrachloride is accomplished. This is due to the heat, the carbon, and the chlorine, which effect the reaction. The oxygen liberated from the kaolin unites with the excess of carbon to form carbon monoxide. 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 chlorine 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 18, and, as illustrated in Figure 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 chloride gas, which condenses at a higher temperature than the silicon tetrachloride 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 chloride of silicon might incidentally be formed, a chloride such as hexachloride (Si_2Cl_6), but I find that conditions are such that it is only the silicon tetrachloride which plays any considerable part.

Where the clay contains oxide of titanium or other metals, the process of chloridization will make the chlorides of titanium and other metals and carbon monoxide.

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 tetrachloride, this gas, together with the carbon monoxide, passes on to the next compartment 35 of the condenser. Thus the first condenser element 34 is devoted to the condensation of the aluminum chloride 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 the conveyor 42, the upper run of which passes in the direction of the arrow 43, and thus the condensed aluminum chloride 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 chloride 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 clear 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 conveyor 58.

The carbon monoxide 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 monoxide which finds its way to this tank and so that the carbon monoxide may be fed by way of a pipe 66 to a burner which may be used for heating.

It will now be seen that there will always be an excess of carbon to insure the formation of carbon monoxide, rather than carbon dioxide, as above pointed out, it being clear that should the loose carbon introduced prove insufficient, the carbon elements of the furnace itself will respond. Beyond this the fact that carbon is used for the purpose specified is important because of the characteristics of carbon already pointed out.

As before indicated, my furnace and process may be employed, in broader sense, in connection with the production in any halide from oxygen bearing ores, compounds or mixtures, and, in fact, in a still broader sense, is applicable to any process wherein a reducing atmosphere, particularly an excessive one, must be maintained.

I claim:

1. A furnace having hearth supporting grate bars of carbon.

2. A furnace having a lining of carbon and hearth supporting grate bars of carbon.

3. A furnace having grate bars of carbon and a hearth of carbon supported thereon.

4. A furnace having a lining of carbon, grate bars of carbon, and a hearth of carbon supported on said grate bars.

5. A furnace comprising an interior carbon wall forming a chamber, a charge entry for said chamber, an entry for solid reducer for said chamber, a separate gas exit for said chamber, and means for heating said chamber.

6. A furnace comprising an interior carbon wall forming a chamber, a charge entry for said chamber, an entry for solid reducer for said chamber, a gas exit for said chamber and electrical means for heating said chamber.

7. A furnace comprising an interior carbon wall forming a chamber, a charge entry

for said chamber, an entry for solid reducer for said chamber, a gas exit for said chamber, means for heating said chamber and a surrounding metal housing and top for said wall.

8. A furnace comprising an interior carbon wall forming a chamber, a charge entry for said chamber, a reducer entry for said chamber, a gas exit for said chamber, means for heating said chamber, a surrounding metal housing and top for said wall, and a packing of heat insulating material between said wall and said housing.

9. A furnace for heating an oxygen bearing charge, comprising an interior bore of carbon brickwork, a surrounding housing and a filling of charcoal between said brickwork and said housing.

In witness whereof, I hereunto subscribe my name this 28th day of February A. D. 1918.

VICTOR M. WEAVER.