April 29, 1924. 1,491,960

E. MILL

APPARATUS AND PROCESS FOR REDUCING AND REFINING ORES

Filed Sept. 28, 1920

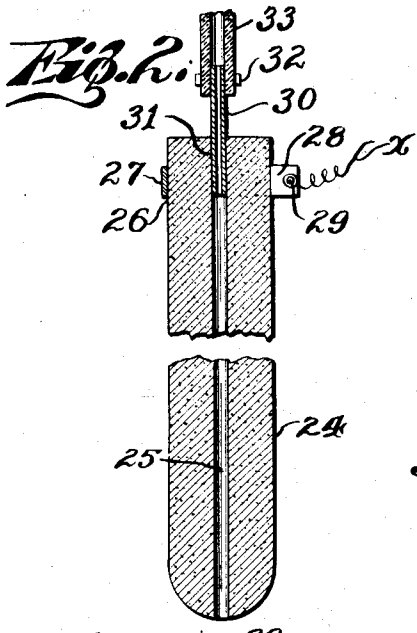

Fig. 2.

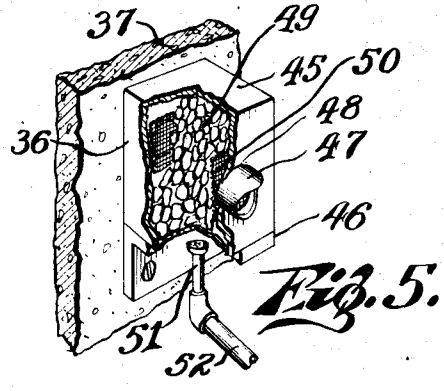

Fig. 5.

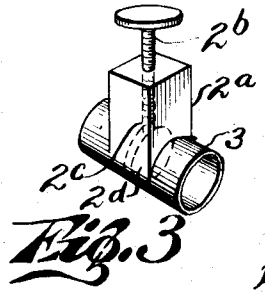

Fig. 3

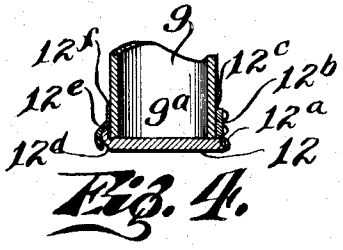

Fig. 4.

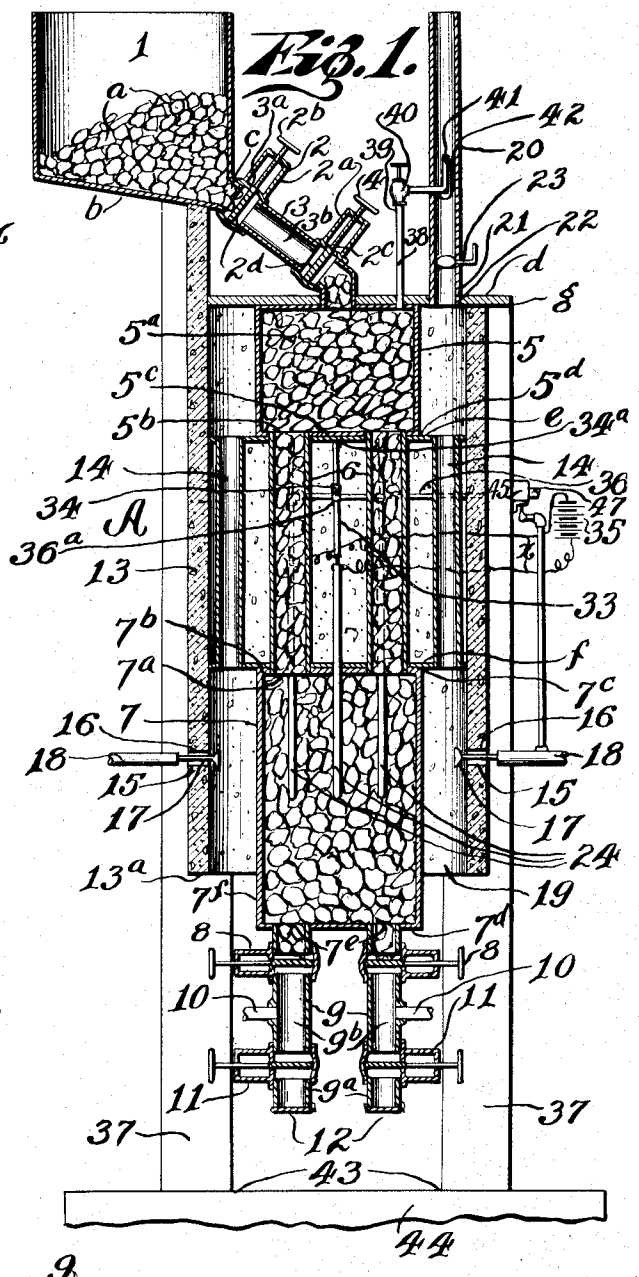

Fig. 1.

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UNITED STATES PATENT OFFICE.

EMIL MILL, OF LOS ANGELES, CALIFORNIA, ASSIGNOR OF ONE-HALF TO ALTHERTON L. GRAY, OF LOS ANGELES, CALIFORNIA.

APPARATUS AND PROCESS FOR REDUCING AND REFINING ORES.

Application filed September 28, 1920. Serial No. 413,352.

To all whom it may concern:

Be it known that I, EMIL MILL, a citizen of the United States, residing at Los Angeles, in the county of Los Angeles and State of California, have invented new and useful Improvements in Apparatus and Processes for Reducing and Refining Ores, of which the following is a specification.

This invention relates to apparatus and process for reducing and refining ores, and particularly to the reduction and refining of iron ores. The process and apparatus about to be described are particularly adaptable to ores mined in Western States. It has been found that European ores and ores found in Eastern States sometime require particular methods in refining and reducing same. The invention has for an object the turning of oxides of iron into metallic iron. Another object is the production of an apparatus and process for producing metallic iron in a more direct, inexpensive and quick manner than is now possible by existing known means.

In practicing the invention I provide a suitable hopper or container into which iron ore, broken into small pieces, may be placed. Associated with the lower portion of said hopper are valve means spacedly disposed within a duct, which duct joins with the chamber of a retort. The iron ore is permitted to pass through the duct and into the chamber and thence through pipes joining the lower wall of said retort with a further retort spaced from said upper retort. Surrounding both the upper and lower retort members is a wall of fire clay or other heat resisting means, and playing through apertures within the fire clay wall or heat resisting wall are nozzles through which gas may be passed. Said gas when ignited allows a flame to play on the outer surface of the lower retort and by conduction allows the heat to pass within the retort. Within the lower retort are spacedly arranged a plurality of electrodes. Said electrodes depend through apertures in the upper wall of said lower retort. The electrodes are preferably made of graphite and are provided with a longitudinal bore through which bore a carbonaceous gas is passed. The electrodes are likewise provided with electrical contacts and electrical circuit paths connect with said contacts. The bottom wall of the lower retort is provided with depending pipes having spaced valves therein, the stretch between the upper valve and lower valve being provided with means for feeding a carbonaceous gas therein. The division effected between the upper retort and lower retort by pipes joining the same in spaced relation to each other is necessary in order that an operator may remove any wornout or burnt-out electrodes from the lower retort. What may be termed baffle plates are associated on the exterior of the bottom wall of the upper retort and upon the exterior of the top wall of the lower retort. In order that the heat that is generated by the combustion of gases and which heat impinges against the outer surface wall of the lower retort may also heat the upper retort, conducting pipes extend between the upper baffle plate and lower baffle plate. This method of heating the upper retort allows for a gradually increasing heat, as any ore contained within the upper retort passes downwardly through the pipes above mentioned into the lower retort. The particular arrangement of the electrodes allows for a heating within the lower retort, and when a low potential current is effected between the electrodes an arc appears, which arc is not sufficient to in any way fuse the ore within said retort. Inasmuch as a carbonaceous gas is being passed through the heated electrodes, I believe that the gas will tend to absorb more carbon and thus when discharged from the openings in said electrodes, the gas will be in a highly nascent state, readily combining with any oxygen confined within the ore and forming a carbon dioxide gas, and leaving metallic iron, which is coated with carbon deposit throughout the voids of said iron.

Ordinarily in reducing iron ore, a blast of air is forced through the ore when the ore is heated, but in this invention all air is excluded from the retorts. I believe that it is a commonly known fact that ore of all forms, and particularly iron ore, has a great deal of air confined within the same, and by heating the ore as has been described, the ore will crack, similar to the method of cracking oil to produce gasoline. This cracking of course allows the imprisoned oxygen and other gases confined within the ore to escape, and immediately upon its escape the carbonaceous gas which is introduced within the retort may combine with

the same forming another gas of some complex chemical composition and allow carbon to be deposited over the iron and in all interstices, pores and voids of the iron.

It is also known that any iron when heated to a high temperature and exposed to the atmosphere before allowing it to cool, the same may immediately oxidize. However, by the method just described the iron may be removed from the retort, and due to the fact that it is covered throughout with carbon the metallic iron will not rust or oxidize. Obviously the metallic iron removed from said retort will not require further carbon in the making of the same into steel. In fact, the ore removed may be again heated to the desired temperatures and the carbon present will be sufficient for steels of various forms. It will immediately be seen that this eliminates two operations ordinarily incident to the making of steel.

The invention has for further objects to provide a process as well as apparatus of the character above mentioned which will be relatively simple and inexpensive in carrying on or practicing or furtherance, taken in conjunction with efficiency and expediency and general adaptability.

The invention consists in the novel and useful means and process hereinafter disclosed, and finally pointed out in claims.

It will be understood that many variations in detail may be made in departure from the specific definition of the process as well as the apparatus about to be disclosed.

In the drawing:

Figure 1 is a cross sectional view of a furnace which may be utilized in reducing and refining ores;

Figure 2 is a fragmentary cross sectional view of an electrode used in practicing the invention;

Figure 3 is a fragmentary perspective view of a valve used in connection with the invention;

Figure 4 is a fragmentary cross sectional view of a trap door used in the ducts; and

Figure 5 is a fragmentary view of a filtering device used in practicing the invention.

Corresponding parts in all the figures are designated by the same reference characters.

Referring with particularity to the drawing, A designates the completed furnace of which 1 is a hopper into which the broken pieces of ore such as iron oxide *a* may be introduced. The hopper has its bottom wall member *b* slanting downwardly, so that the ore *a* within the hopper 1 will tend to move toward one point as *c*. At said point there is an opening provided with a duct 3. The duct 3 has adjacent the opening *c* a sliding door valve 2 which is illustrated in Figure 3, in which figure it will be observed that the duct 3 has a boxing 2^a formed on the outer surface thereof and which boxing 2^a is a part of the valve 2. Passing through said boxing is a hand screw 2^b provided with threads, the lower stretch of which as 2^c has connected therewith a circular door 2^d. The duct 3 is slotted as at 3^a a sufficient width so as to permit the door 2^d to be drawn through the same upwardly or downwardly dependent upon rotation of the means 2^b. This arrangement permits closing the duct 3 at its upper end and prevents any of the ore *a* within the hopper 1 from entering said duct. The duct 3 passes through a plate *d* into the interior of a retort 5. Just above said passage into the retort 5 is located a further valve 4 which in all particulars is similar to the valve 2 just described. It will thus be seen that in order to properly introduce any ore *a* from the hopper 1 into the retort 5 and the chamber 5^a thereof, it will be necessary first to raise the valve 2 allowing the ore to pass into the space 3^b between the valves 2 and 4, at which time the valve 2 has its gate 2^d screwed downwardly so as to close the opening in the duct 3, and then the valve 4 is so screwed that the gate of the same will be raised and the contents within the space 3^b allowed to pass into the chamber 5^a of the retort 5. The purpose of all this is to prevent the atmosphere from directly entering the retort 5. It will be noticed upon reference to the drawing that the retort 5 is provided with openings 5^b through its lower wall 5^c, and into said openings 5^b are passed and confined pipes 6. The pipes 6 are of extended length and communicate with a lower retort 7 through openings 7^a in the upper wall 7^b of said retort 7. Pipes 6 likewise pass through what may be termed baffle plates *e* and *f*. The upper plate *e* joins the bottom plate of the retort 5 on the exterior thereof as at 5^d and the bottom plate *f* joins with the top wall on the exterior thereof as at 7^c of the retort 7. These plates *e* and *f* are preferably circular in formation, although I do not wish to be restricted to this particular contour. The lower retort wall 7^d of the retort 7 has dependent through holes 7^e therein pipes 9.

The pipes 9 are similar to the duct 3 previously described, and said pipes 9 are provided with upper and lower valves 8 and 11 arranged in spaced relation each to the other. The valve 8 is arranged a short distance below the opening 7^e and the valve 11 is arranged adjacent an end 9^a of the pipes. The space confined intermediate the valves 8 and 11 as 9^b has communicating therewith a pipe 10. Said pipe 10 normally conducts a carbonaceous gas to the space 9^b of the pipes 9. The lower end of each of the pipes 9 is provided with trap doors 12. Said trap doors are illustrated in Figure 4, in which it will be noticed that the door 12 is hinged to the pipe 9 as at 12^a by means of a strap

12[b] riveted to the exterior of the pipe 9 as at 12[c]. The opposite end of the trap door 12 is provided with a hook projection 12[d], which hook projection engages with a leaf spring 12[e] attached at one end as 12[f] to the pipe 9. Thus the trap door may be opened by releasing the spring 12[e] from the projection 12[d], or the trap door 12 may be readily snapped into position. Surrounding the outer periphery of the plates *e* and *f* as well as the retorts 5 and 7 and the pipe 6, is a circular wall 13. Said wall 13 extends upwardly and joins with the plate *d* as shown at *g*. A lower portion of said wall 13, as 13[a] does not completely enclose the retort 7 but allows a lower stretch of the same as 7[f] to be exposed. The retorts 5 and 7 are each in spaced relation to the inner wall surface of the wall 13. The wall 13 is preferably made of fire clay provided with a tile lining, although the wall may be made of any heat resistant material. Extending between the plates *e* and *f* and communicating with the space between the wall 13 and the outer surface of each of the retorts 5 and 7, are pipes 14. Passing through perforations 15 located as at 16 in the wall 13 are nozzles 17 through which is conducted by means of pipes 18, a gas of some form suitable, when ignited to heat the outer wall surface of the retort 7. Obviously the gas flowing within the space confined between the retort 7 and the wall 13 will tend, when ignited, to present a solid flame completely around the retort 7. Of course oxygen for proper combustion will be drawn upwardly into the space for the reason that the wall 13 terminates so as to permit air to be drawn upwardly into said space, as shown at 19. The heated air and gases will surround the chamber 5 and heat the same. From thence the heated gases are allowed to pass upwardly through a stack 20 confined within a hole 21 in the wall *d* as at 22. A damper 23 regulates the outward flow of the heated gases to the atmosphere. It will be seen that the retort 5 is really pre-heated and does not have a flame playing against the same.

Depending within the lower retort 7 through apertures in the upper wall 7[b] thereof and through apertures in the wall 7[c] are electrodes 24. Said electrodes 24 are arranged in a spaced relation each to the other as shown in the drawing.

Referring to Figure 2 it will be seen that the electrodes 24 are tubular in formation or provided with a longitudinal bore 25 concentric within said electrodes 24. The electrodes are preferably made of graphite, and surrounding an upper stretch of said electrodes as at 26 is a copper band 27 provided with ears 28 for clamping the band to the electrodes 24. Through said ears a screw 29 is passed for firmly securing the band 27 to the electrodes 24. A short pipe 30 communicates with the bore 25 as at 31. Said pipe is likewise attached by suitable means as 32 to a non-electrical conducting tube or pipe 33. Referring to Figure 1 the non-conducting tube or pipe 33 passes upwardly and is capped or closed as at 34. Likewise it is joined to the wall *e* as at 34[a] so that the electrodes 24 may be retained in position. A pipe 36 passes through perforations in the walls 13 and 37 and connects with an enclosed box-like structure 45. Said pipe 36 likewise connects with each of the tubes 33 as at 36[a]. The box-like structure 45 is suitably supported by means of a bracket 46. Said bracket 46 is located exteriorly of the wall 37 and is held to same by means of rivets. A further pipe 47 communicates with the interior of the box 45 as at 48. Within the box 45 are small carbon granules 49. Where the pipes 36 and 47 enter the box is placed a fibrous cloth 50. The pipe 47 connects with the source of supply for a carbonaceous gas. Beneath the bracket 46 is a heating means 51 provided with a jet. A pipe 52 connects said jet with a source of gas supply. It is the intention to light the jet 51 and heat the box 45. It will thus be seen that the carbonaceous gas first passes through the pipe 47, through the cloth 50, then through the carbon granules 49 within the box 45, then through a further cloth, and then into the pipe 36 and down through the bore in the electrodes 24 into the retorts 7.

Electrical conducting paths such as wires X are joined to each of the electrodes 24 at the ears 28 of the band 27. The electrical conducting wires X are connected with a source of electrical supply 35 of low potential. Two parallel walls 37 arranged in spaced relation each to the other, normally support the wall *d*, the wall 13, and the hopper 1. Thus the parallel walls 37 tend to support the entire furnace, inasmuch as the plate members *e* and *f* are embedded within the wall 13. When the furnace is in operation a gas such as carbon dioxide is driven off from the ore and said gas is allowed to pass through a pipe 38 communicating with the interior 5[a] of the retort 5. Said pipe has at an upper end as at 39 an automatic pressure valve 40 which allows the burnt or waste gases to escape through the same and into the pipe 41 passing within the stack 20 as at 42. The automatic pressure valve 40 permits any gas to escape from the retorts 5 and 7, but does not permit any air passing back into the same.

The walls 37 are supported as at 43 upon a suitable foundation 44.

The operation is as follows:

The ore is first introduced in small chunks within the hopper 1, whereupon the valve 2 is operated and a quantity of the ore is allowed to pass into the duct 3. The valve 2

is then closed and the valve 4 opened and the ore passed into the chamber 5^a of the retort 5. From thence the ore passes through the pipe 6 into the retort 7 and then the same may be passed through the pipe 9 by opening the valves 8 and 11.

First the gas used for heating the exterior of the retort 7 is ignited at the nozzle 17 and as the flame plays around the retort 7 the retort is heated, and the heated gases allowed to pass upwardly through the pipes 14 and heat the retort 5. Ore is introduced within the retorts 5 and 7 so as to completely fill the same, and as it is necessary that each piece of ore go through the same operation it is essential that the ore confined within the retort 7, to begin with, be drawn off through the pipes 9 and again placed in the hopper 1. Obviously the ore already within the retort 5 will not be again placed in the hopper 1. As the flame plays around the retort 7 electricity is passed through the electrodes 24 and while so passing an arc will be formed between the electrodes. This arc is of low potential and not sufficient to fuse any ore within the retort 7. Obviously the arc will tend to heat the interior of the retort 7 and while the electrodes are so heating the ore in combination with the heat being absorbed through the wall of the retort, a carbonaceous gas is passed through the bore 25 of the electrodes. The temperature within the retort 7 is preferably maintained at 1100 degrees and this amount of heat I believe tends to cause the electrodes 24, which as has been stated, are formed of graphite, to be in a state of agitation; that is, the molecules of carbon making up the electrodes 24 are in a vibratory state, and as the carbonaceous gas passing through the same is heated by the electrodes the gas I believe tends to absorb more carbon and thus becomes saturated with carbon and in a highly unstable and nascent state.

It will be seen that as the ore passes from the chamber 5^a of the retort 5 downwardly into the chamber portion of the retort 7, that the ore will gradually become heated more and more, and when in the retort 7 the heat is sufficient to crack the ore. It will now be obvious why a double system of valves as 2, 4, 8 and 11 is employed. They are employed in order to keep out the atmosphere from the retorts 5 and 7. I am of the opinion that all ores contain a certain number of gases and when the ore cracks the gases are released and which gases immediately combine, I believe, with the carbonaceous gas and in so combining carbon is deposited in the voids of the ore, effectively sealing the ore against a re-introduction or re-oxidization of the ore. Obviously when the furnace is in operation the valve 2 is first lifted, the ore allowed to pass in the space 3^b of the duct 3, the valve 2 closed, and the valve 4 opened allowing the contents within the space a to pass into the chamber 5^a of the retort 5. This arrangement plus the heated gases passing upwardly through the pipe 6 into the retort 5 tends to exclude any air from entering the chamber 5^a of the retort 5. Likewise the particular arrangement of the valves 8 and 11 perform a similar function, in that the ore *a* may be drawn through the pipe 9 into the space 9^b by opening the valve 8, then closing the valve 8. In order to insure that the metallic ore which has been reduced and refined may not oxidize again in case the same has not been properly covered with carbon throughout its voids. further carbonaceous gas is introduced into the space 9^b through the pipes 10. Upon opening the valve 11 the ore may be permitted to drop downwardly and into the open when the trap door 12 is released.

Obviously any impurities within the iron ore would be burnt by the heat within the retort 7 and the burnt gas allowed to escape upwardly through the pipe 38 and then into the stack 20.

It will be noted that the wall 13 is cut out between the plates *e* and *f*. In actual practice of the invention a plurality of furnaces similar to that shown in Figure 1 is included between the parallel wall members 37. In order that an operator may successfully replace worn-out electrodes 24 it is essential that the operator be permitted to pass within the space confined between the plates *e* and *f* to further similar spaces in duplicate furnaces.

It has been found that little slag is formed when a filter means such as the box 45 containing carbon granules 50 therein is employed. The inventor is not sure as to the exact chemical re-action occurring within the retorts 7 and 5. However, when the carbonaceous gas is passed through what is termed the filter, thence through the electrodes 24 and then into the retorts 7 and 5, the gas in some manner is more active, and any silicon or sulphur within the iron is immediately burned out and the resultant ore is practically pure metallic iron. In fact, by using the filter a more perfect product of iron is produced.

It is manifest that many variations and changes may be made with respect to the disclosure of the foregoing furnace in connection with the particular method of refining ores such as iron ores, just described, within a fair spirit of interpretation of the invention.

Having thus disclosed my invention, I claim and desire to secure by Letters Patent:

1. The herein disclosed method of reducing and refining iron ore within the work-holding retort of a furnace, which consists in introducing heat exteriorly and interiorly

of the retort so as to heat the ore and crack same; passing a carbonaceous gas within the retort and preventing access of other oxygen than that already present within the retort and ore.

2. The herein disclosed method of reducing and refining iron ore within a work-holding retort of a furnace, which consists in introducing heat exteriorly and interiorly of the retort so as to heat the ore and crack the same; passing a super-heated carbonaceous gas within the retort and preventing the access of other oxygen than that already present within the retort and ore, thus allowing the carbonaceous gas to combine with the oxygen present and at the same time to fill all the interstices and voids of the ore with a deposit of carbon, thereby preventing re-oxidization of the ore.

3. The art of reducing and refining ores, which consists in placing ore in a retort, heating the ore by application of heat both exteriorly and interiorly of the retort, injecting a carbonaceous gas into the retort, and preventing access of other oxygen than that in the ore during the process.

4. The art of reducing and refining iron ore, which consists in placing the ore in a retort, heating certain portions of the retort both exteriorly and interiorly so as to subject the ore from a known minimum to maximum heat sufficient to crack the ore, preventing the access of oxygen within the retort and introducing a carbonaceous gas within the retort.

5. The art of reducing and refining iron ore, which consists in placing the ore in a retort, heating certain portions of the retort both exteriorly and interiorly so as to subject the ore from a known minimum to maximum heat sufficient to crack the ore, preventing the access of oxygen within the retort and introducing a carbonaceous gas within the retort which has first been allowed to flow through heated carbon.

6. A furnace for reducing and refining ores, comprising an upper and a lower retort spaced from each other; pipes communicating with the chambers of said retorts, means for directly heating the lower retort and indirectly heating the upper retort so that there is a progressively varying heat upwards in the chambered portion of the lower and upper retorts; means for introducing a carbonaceous gas into the upper retort, and means for passing said gas in a superheated condition into the lower retort chamber.

7. A furnace, comprising upper and lower retorts in spaced relation to each other, intercommunicating means joining the chambers of said retorts, an outer refractory wall spaced from the retort walls, said lower retort wall and refractory wall forming between them a continuous combustion space, means for supporting combustion in said combustion space, whereby the lower retort wall is heated; and means for supplying a carbonaceous gas to the space confined by said upper and lower retort walls.

8. A furnace, comprising upper and lower retorts in spaced relation to each other, intercommunicating means joining the chambers of said retorts, an outer refractory wall spaced from the retort walls, said lower retort wall and refractory wall forming between them a continuous combustion space, means for supporting combustion in said combustion space, whereby the lower retort wall is heated, means for conducting the heated gases of combustion to the space confined by the upper retort wall and refractory wall so as to heat the upper retort wall, and means for supplying a carbonaceous gas, etc.

9. A furnace, comprising an outer wall of refractory material, an inner retort wall spaced therefrom, said walls forming between them a combustion space; means for supporting combustion in said combustion space; means within said retort for heating said retort; and means for supplying a carbonaceous gas to the space confined by said retort wall.

10. A furnace, including upper and lower retorts in spaced relation to each other; an outer refractory wall spaced from the retort walls, said lower retort wall and refractory wall forming between them a continuous combustion space; a plate joined with the upper wall of the lower retort and embedded in the refractory wall dividing the lower retort from the upper retort; means for supporting combustion in the combustion space, and means for supplying a carbonaceous gas to the space confined by said upper and lower retort walls; there being intercommunicating means joining the chambers of said retorts.

11. A furnace, including an outer wall of refractory material; plate members arranged in spaced relation embedded in said wall and dividing same into compartments; a retort interposed between two of said plate members with the walls of said retort spaced from said outer wall, a lower retort dependent from another of said plate members, said last named retort being in spaced relation to the outer wall; intercommunicating means joining the chambers of said retorts, and means for heating said retorts.

12. A furnace comprising an outer wall of refractory material, an upper and a lower retort confined within said outer wall and in spaced relation thereto, inter-communicating means joining the chambers of said retort members and means for supplying a carbonaceous gas within said retorts; means likewise being provided for passing work into said upper retort and means associated

with said last named means for preventing access of any air while passing said work to said retort.

13. A furnace comprising an upper and lower retort, intercommunicating means joining the chambers of said retorts; a hopper located above said upper retort and means joining said hopper and chamber of said upper retort whereby any work within said hopper may be passed into said upper retort; said means joining the hopper and upper retort being provided with means for preventing the access of air from the outside into the said retort; means likewise being provided for introducing a carbonaceous gas within the chambered portions of said retorts.

14. A furnace comprising an upper and lower retort, intercommunicating means joining the chambers of said retorts; a hopper located above said upper retort and means joining said hopper and chamber of said upper retort whereby any work within said hopper may be passed into said upper retort; said means joining the hopper and upper retort being provided with means for preventing the access of air from the outside into the said retort; means likewise being provided for introducing a carbonaceous gas within the chambered portions of said retorts; means likewise being provided dependent from a bottom wall of said lower retort for removing any work contained within said retort and means associated with said last named means for preventing the ingress of any air while removing any work from the retort.

15. A furnace, comprising a work-holding retort, means within said retort for heating the same, means for introducing a carbonaceous gas within said retort, and means for filtering said gas before its introduction within the retort.

16. A furnace, comprising a work-holding retort, means within said retort for heating the same, means for introducing a carbonaceous gas within said retort, and means for filtering said gas before its introduction within the retort; said means for filtering said gas comprising a container filled with carbon granules, around which granules the gas first passes before its introduction into the retort.

17. A furnace, comprising a work-holding retort, means within said retort for heating the same, means for introducing a carbonaceous gas within said retort, and means for filtering said gas before its introduction within the retort; said means for filtering said gas comprising a container filled with carbon granules, around which granules the gas first passes before its introduction into the retort; means likewise being provided for heating said granules.

18. A furnace, comprising a work-holding retort, means for heating said retort, means for introducing a carbonaceous gas within said retort, and means for filtering said gas before its introduction within the retort.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses.

EMIL MILL.

Witnesses:
MILDRED LEACH,
J. CALVIN BROWN.