No. 692,539. Patented Feb. 4, 1902.

H. NIEWERTH.

PROCESS OF REDUCING ORES.

(Application filed Aug. 13, 1897.)

(No Model.) 2 Sheets—Sheet 1.

Fig. 1

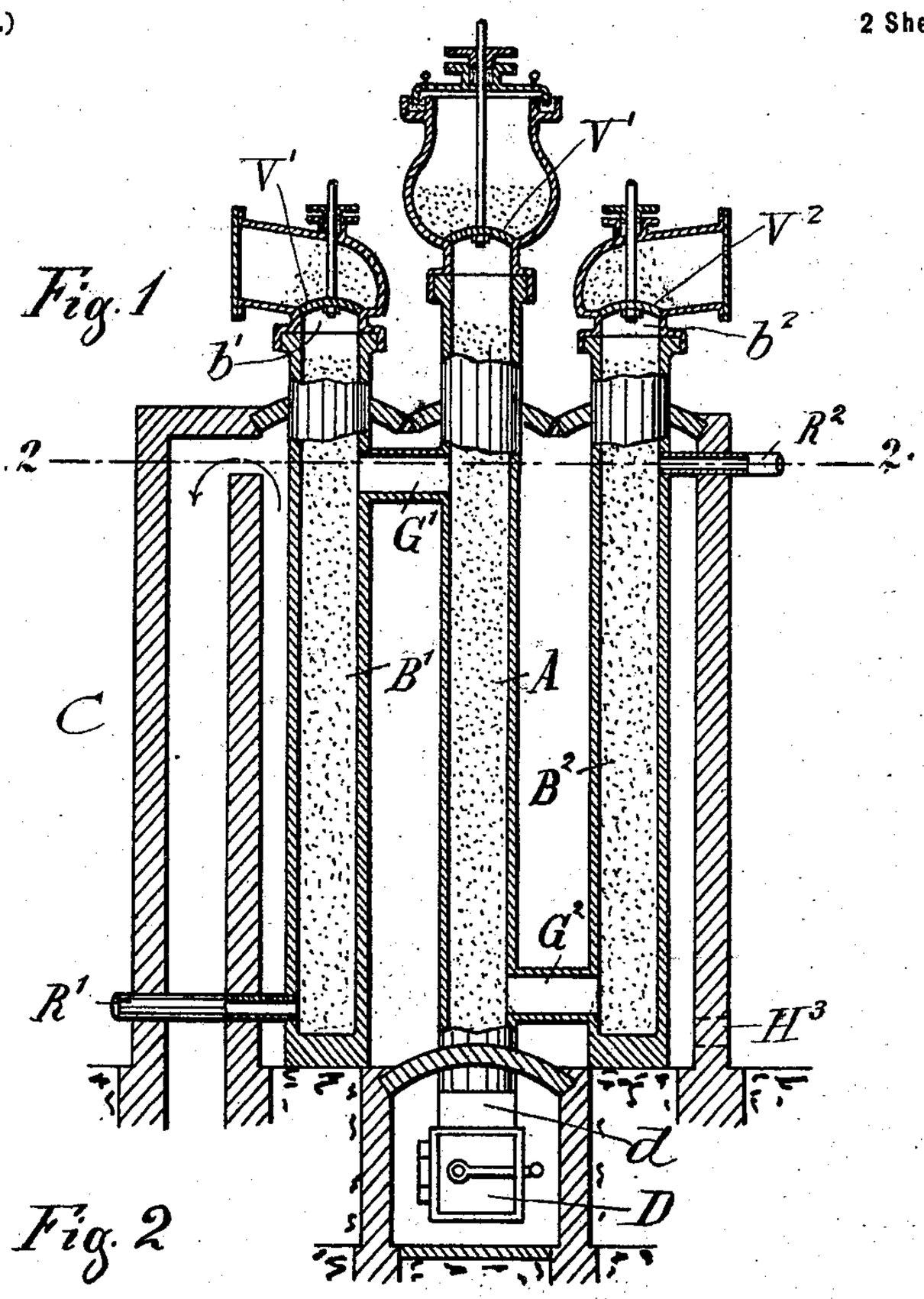
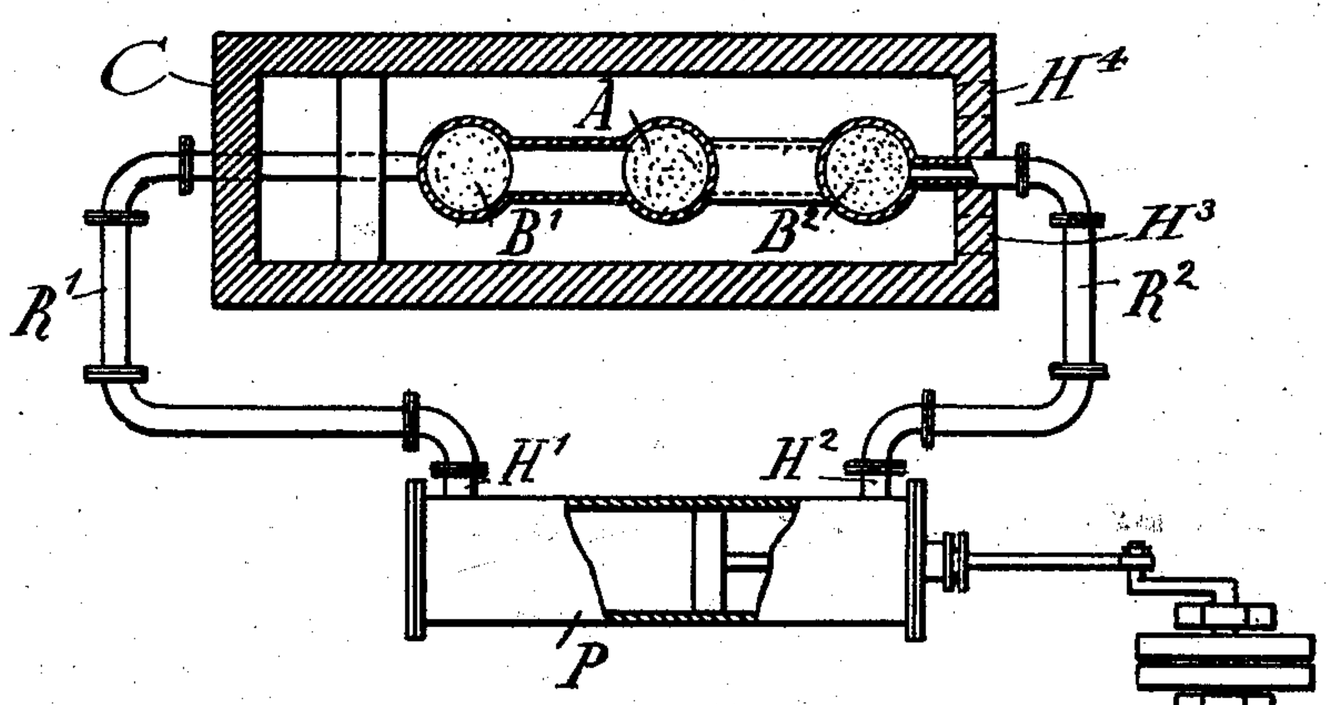


Fig. 2



WITNESSES:
Karl Kaelber
Geo. B. Geibel

INVENTOR
Hermann Niewerth
BY Gould & Eaguer
ATTORNEYS.

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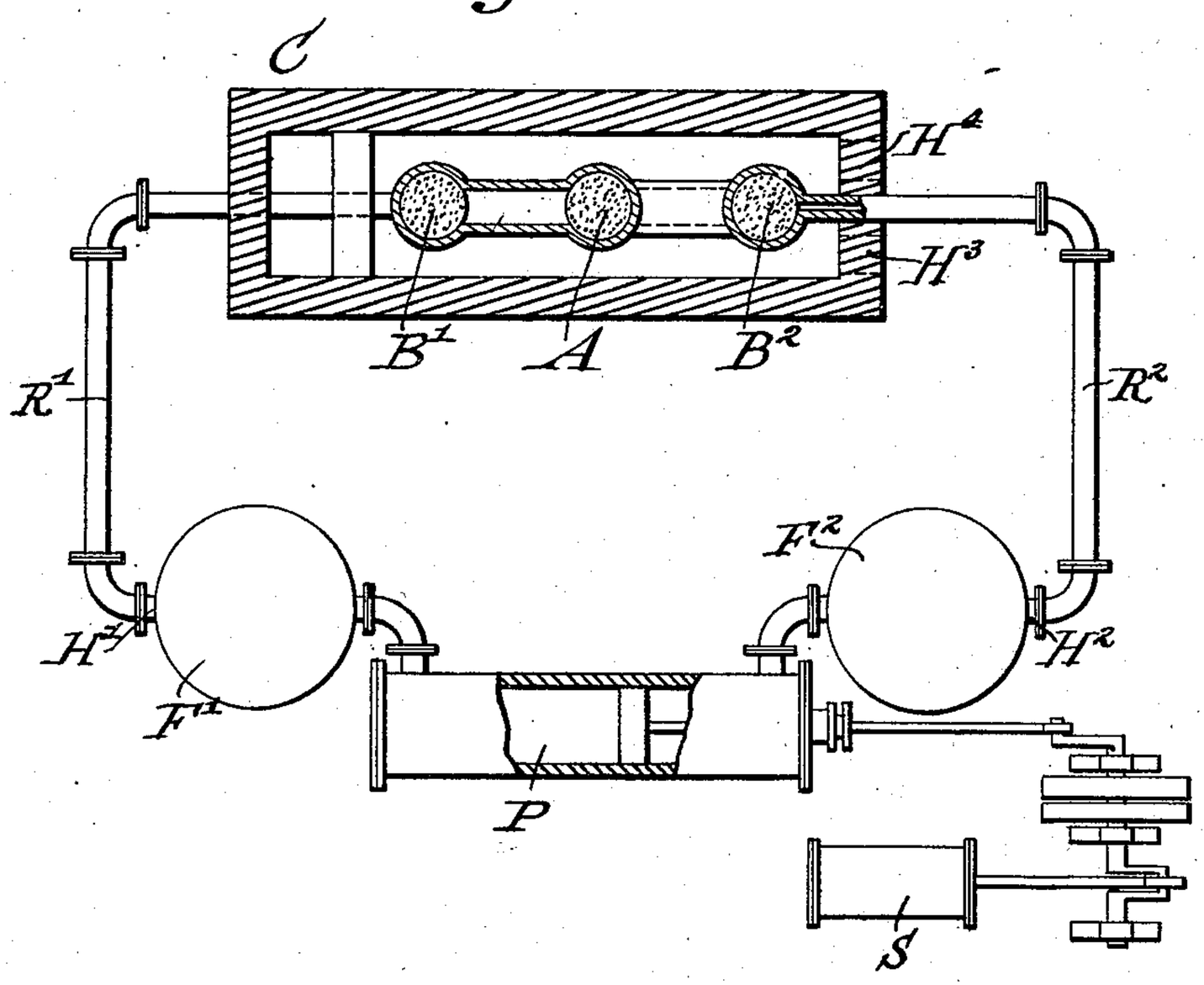
Fig. 3.



WITNESSES:
Walter Wallheim.
Joseph H. Niles.

INVENTOR
Hermann Niewerth
BY Goepel & Wahle.
ATTORNEYS

UNITED STATES PATENT OFFICE.

HERMANN NIEWERTH, OF BERLIN, GERMANY.

PROCESS OF REDUCING ORES.

SPECIFICATION forming part of Letters Patent No. 692,539, dated February 4, 1902.

Application filed August 13, 1897. Serial No. 648,162. (No specimens.)

To all whom it may concern:

Be it known that I, HERMANN NIEWERTH, a citizen of the German Empire, residing at Berlin, Germany, have invented certain new and useful Improvements in Processes of Reducing Ores, of which the following is a specification.

This invention relates to processes of reducing ores for obtaining the contained metal or metals; and the object of the invention is to provide a process of this kind which may be carried on with economy and convenience and by which a rapid and effective reduction of the ore can be practically accomplished.

For this purpose the invention consists of the process herein described of reducing ore, which comprises the steps of heating the mass of ore to be reduced, heating two bodies of carbonaceous material, forcing a heated reducing-gas from one of said carbonaceous bodies into the ore for reducing the same, withdrawing the decomposed gas from the ore back into the first carbonaceous body for regeneration, forcing a quantity of reducing-gas from the second carbonaceous body into the ore for reducing the same, returning the decomposed gas into the second carbonaceous body for regeneration, and alternately continuing the movements of the heated reducing-gases through the ore until the reduction of the same is completed.

In the drawings, Figure 1 is a vertical central section of the preferred form of apparatus used; and Figs. 2 and 3 are transverse sections showing two modifications, both on line 2 2, Fig. 1.

The apparatus preferably used consists of three chambers or retorts A, B′, and B^2, which are preferably built in suitable masonry-work C and connected with each other by the pipes G′ G^2, pipe G′ connecting the upper ends of retorts A B′, and pipe G^2 connecting the lower ends of retorts A B^2. The chambers B′ B^2 are connected, respectively, at the upper and lower ends by pipes R′ and R^2 with inlet-pipes H′ and H^2 of a pump-cylinder P without valves.

In the connecting-pipes R′ and R^2 there may be arranged, at any desired point, gas-receivers F′ and F^2—as, for instance, in Fig. 3—or they may be arranged in any other suitable manner. The pump-cylinder P requires no valves or similar arrangements, and it is operated by a crank motion (shown in Fig. 2) or directly by a steam-engine S, as in Fig. 3, or by any other suitable motor mechanism. The pump has the object to force the gas in the apparatus forward and backward—that is to say, the gas is caused to make a motion first in one and then in the other direction without leaving the apparatus as the piston of the pump makes its forward or return stroke.

In place of the pump any other mechanism may be used with which the same effect can be produced—as, for instance, two vessels which are alternately filled with water and then emptied.

The apparatus A, B′, and B^2 is provided with openings *a b′* b^2, which can be hermetically closed by suitable valves V V′ V^2 and which permit in case it should be necessary new substances to be fed under exclusion of the gas into the different parts of the apparatus. The construction of these closures is not new and can readily be understood from the drawings and can be carried out in any suitable manner. The chamber A has, furthermore, a slide *d* and a closing device D to enable the emptying of the same.

The chambers or retorts A, B′, and B^2 are shown in the drawings in the form of tubes; but they can have any other suitable form. They are preferably made from suitable fireproof material, such as fire-clay; but metal may also be used for the same. The chambers or retorts A, B′, and B^2 have to be heated up in carrying out my improved process, and this heating can be accomplished either directly by means of a fire underneath or by means of gas. In the drawings it is assumed that they are heated by gas, the gas-inlet openings being shown at H^3 and H^4.

The retorts B′ B^2 may be conveniently emptied by suitable scrapers or lifting devices inserted through the upper openings *b′* b^2.

The operation of the apparatus is as follows: The generating-chambers B′ and B^2, which are exteriorly heated, are filled with carbonaceous material, while the reducing-chamber A is filled with the material to be reduced—say iron ore. The gas-receivers F′ and F^2 are charged with pure carbon-monoxid gas or with a mixture of carbon monoxid and hy-

drogen or with any other suitable gas directly or during the process; but it must be a gas that is capable of reducing iron from its combinations and which is capable of doing it during the course of the process. I will take carbon monoxid, for example. When the chambers are filled with the gas which is required for the reduction process, the pump can be worked for some time, so that all atmospheric air which is contained in the apparatus is forced to and fro through the glowing fuel, so as to be changed into carbon monoxid. After the gas is thus obtained or charged directly into the apparatus the motion of the pump will keep the same continuously in motion, so that the gas contained in chamber B′, which is heated, is forced in contact with the ore in chamber A, so as to exert a reducing action on the same. By the reaction which takes place the carbon monoxid is changed into carbon dioxid (in oxid-containing ores) and metal iron obtained which for the purposes of description may be termed the "decomposed" gas from the iron ore. The carbon dioxid obtained is returned by the change of the piston-stroke of the pump from chamber A back into chamber B′, while simultaneously a new quantity of the reducing-gas—carbon monoxid—is forced into the chamber A from the chamber B^2. The carbon dioxid, which is returned to the chamber B′, strikes the fuel, which is at red heat in the same, so as to reduce the carbon dioxid into carbon monoxid, while the carbon monoxid forced into the chamber A from the chamber B^2 reduces the iron ore to metallic iron and is again changed into carbon dioxid, as before. At the next change of the stroke of the piston carbon dioxid is returned from the chamber A into chamber B^2 through the red-hot fuel and the same changed into carbon monoxid, while, on the other hand, from the chamber B′ carbon monoxid is again forced into the chamber A, which work is alternately performed with each stroke of the piston of the pump P until all the ore in the chamber A is reduced. The oxygen of the ore is transferred in this manner into the fuel-chambers and the fuel changed into gas and returned to the oxygen of the ore by the work of the pump. The size of the gas-receivers F′ and F^2 and the connecting-pipes R′ and R^2 has to be so dimensioned that no hot gas is transferred to the pump, so that the pump at ordinary temperature forces highly-heated gases to and fro, while the gas-filled spaces that are interposed between the fuel-chambers and the pump are isolated from the high temperature of the same.

As the gases never leave the apparatus and as the continuous reduction of the iron ore into iron takes place the quantity of gas which is contained in the apparatus will be steadily increased, as the gas formed from the combination of the iron and of carbon possesses a larger volume than the substance from which this is obtained.

By the operation described continuously new quantities of chemically-pure gases are obtained, which increase the pressure of the apparatus. As higher pressure promotes the work of reduction, an additional advantage is thus obtained. The pressure can be considerably raised within certain limits, so that effects are obtained by which the expense of the work of reduction is essentially diminished. As soon as the required pressure is obtained or passed the surplus of gas can be used for heating the apparatus—such as, for instance, for heating the reduction-chamber. On the pressure-gages it is possible to observe the progress—that is to say, to ascertain and control the termination of the process of reduction on any quantity of ore charged into the apparatus.

When the reduction process is terminated, the reduced metal is drawn off from the apparatus by opening the door D and the slide *d* at the lower end of chamber A and new ore charged into the same. It is also possible, however, to increase the temperature after the reduction has been completed and melt the metal directly.

If the reduced ore is removed from the apparatus in unmelted form, the same can be treated by any one of the well-known processes—either by melting, alloying with other metals, &c.

If ammonia-gases are mixed with the gas of reduction, then the gas which has passed the chambers B′ and B^2 contains ammonium cyanid. If metal sodium is placed in the chambers B′ B^2 or formed in the furnace by suitable compounds, the vapor of this metal is contained in the gas of reduction. The vapors referred to can then be used for the reduction of metals which cannot be reduced by carbon monoxid or hydrogen gas. The vapors employed are regenerated by being forced through the chamber A into the chambers B′ B^2 in the same manner as before described in connection with carbon monoxid or hydrogen gas. Copper, silver, lead, &c., are treated in the same manner. If reduction agents are used which become solid or liquid when cooled off, then proper receiving vessels have to be arranged in the pipe-lines in which these agents are collected and from which they are then returned back to the apparatus.

In the same manner as just described other substances may be separated—as, for instance, calcium carbonate into calcium oxid and carbon dioxid—and the separation takes place at a temperature which is below red heat, while in the processes heretofore known high white heat is necessary, so that a considerable cheapening of the operation takes place.

It can be readily seen from the foregoing description and explanation that owing to the reciprocating motion of the gases in the apparatus the heat of the same is not cut off by the apparatus, but that the work accomplished is advantageously utilized, inasmuch

as the gases which are formed as the secondary product furnish combustible gas. Furthermore, by the motion of the gases themselves the molecules or parts of the same are set into vibration in such a manner that the reduction is accomplished more easily than in other processes. It is further known that it requires time to carry out any desired work, may this time be as short as is possible, while in my process the gas has all the time necessary for carrying out the proper work, inasmuch as at each stroke of the pump and of the reversing of the direction of motion of the gas a certain rest takes place in the motion, by which the gases receive the necessary time for doing their work.

The great simplicity of the apparatus, the further fact that no heat is lost from the same, the further fact that surplus gases which are obtained by reduction can be utilized as a secondary product, and, lastly, the increased capacity of reaction of the individual bodies toward each other, which is a peculiarity of my improved process, &c., produce the effect that any products obtained by my improved process can be obtained at a less cost than has been the case heretofore, while also the handling of the apparatus is much simpler.

Generally speaking, the process has many and obvious advantages, which can be clearly seen.

What I claim is—

The herein-described process of reducing ores, which consists in heating the mass of ore to be reduced, heating two bodies of carbonaceous material, forcing a heated reducing-gas from one of said carbonaceous bodies into the ore for reducing the same, withdrawing the decomposed gas from the ore back into the first carbonaceous body for regeneration, forcing a quantity of reducing-gas from the second carbonaceous body into the ore for reducing the same, returning the decomposed gas into the second carbonaceous body for regeneration, and alternately continuing the movements of the heated reducing-gases through the ore until the reduction of the same is completed, substantially as set forth.

In testimony that I claim the foregoing as my invention I have signed my name in the presence of two subscribing witnesses.

HERMANN NIEWERTH.

Witnesses:
EDWIN DWIRK,
A. HENNIGER.