No. 658,315. Patented Sept. 18, 1900.

A. H. COWLES.

ELECTRIC FURNACE.

(Application filed Oct. 22, 1895.)

(No Model.) 3 Sheets—Sheet 1.

Fig. 1

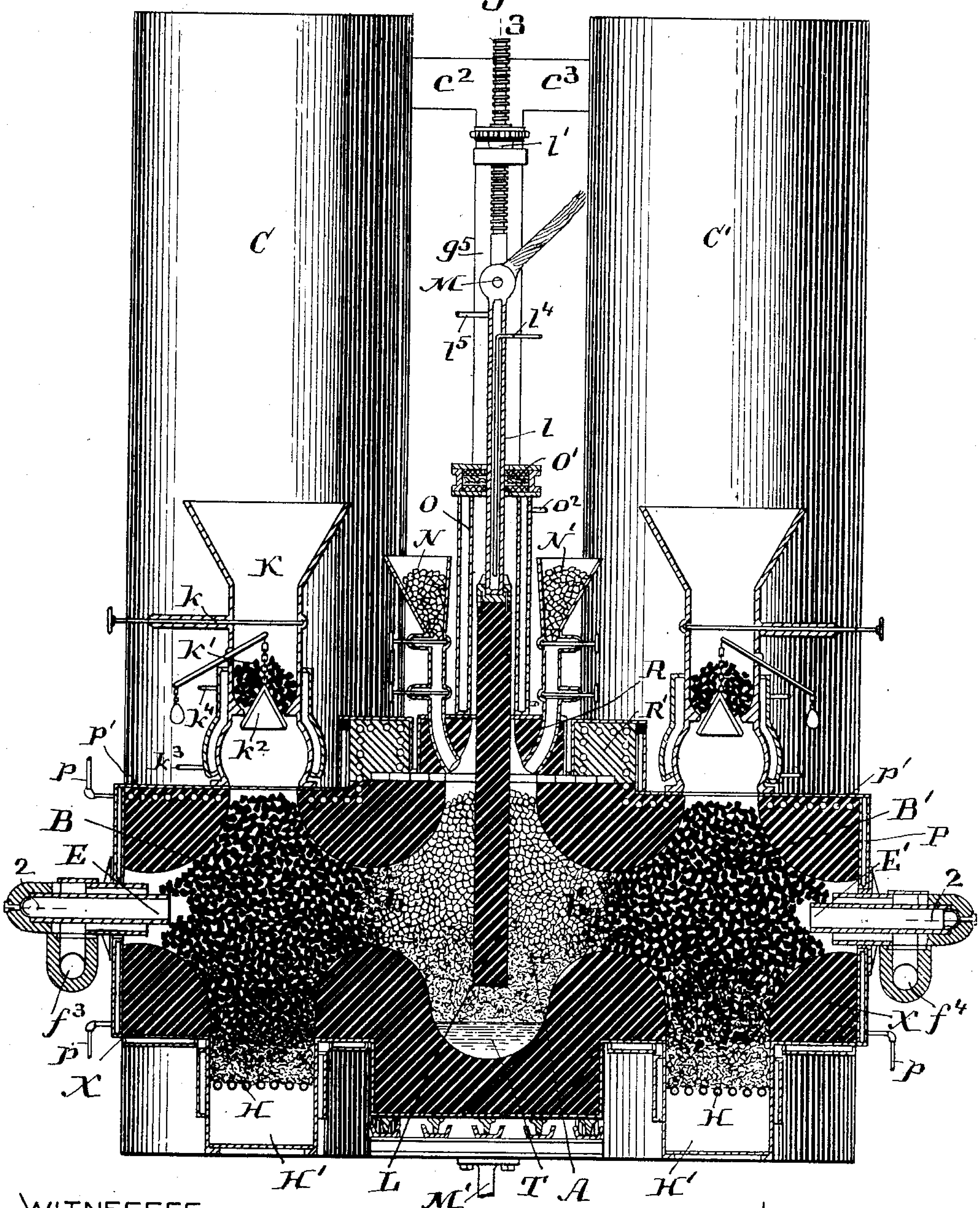

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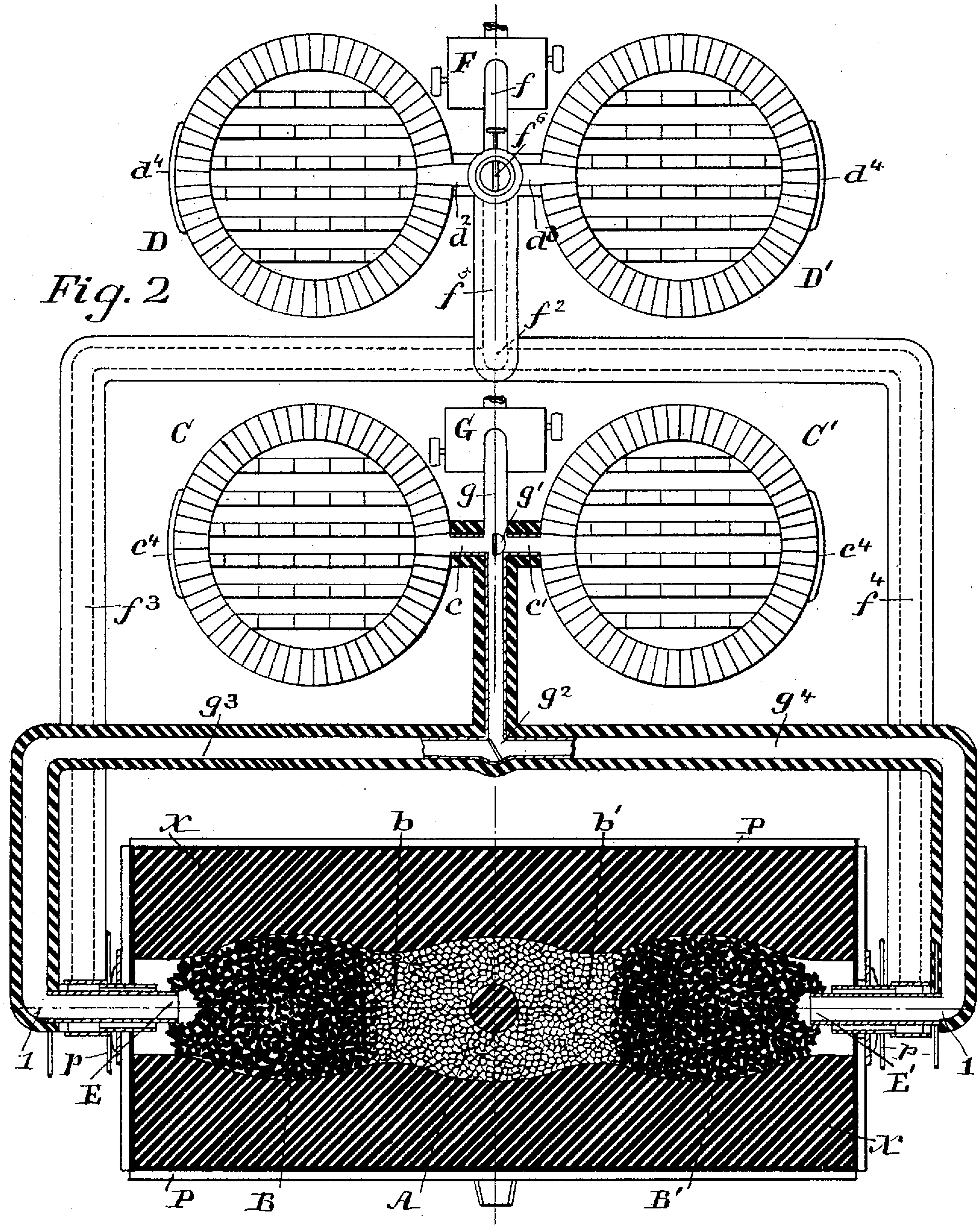
Fig. 2



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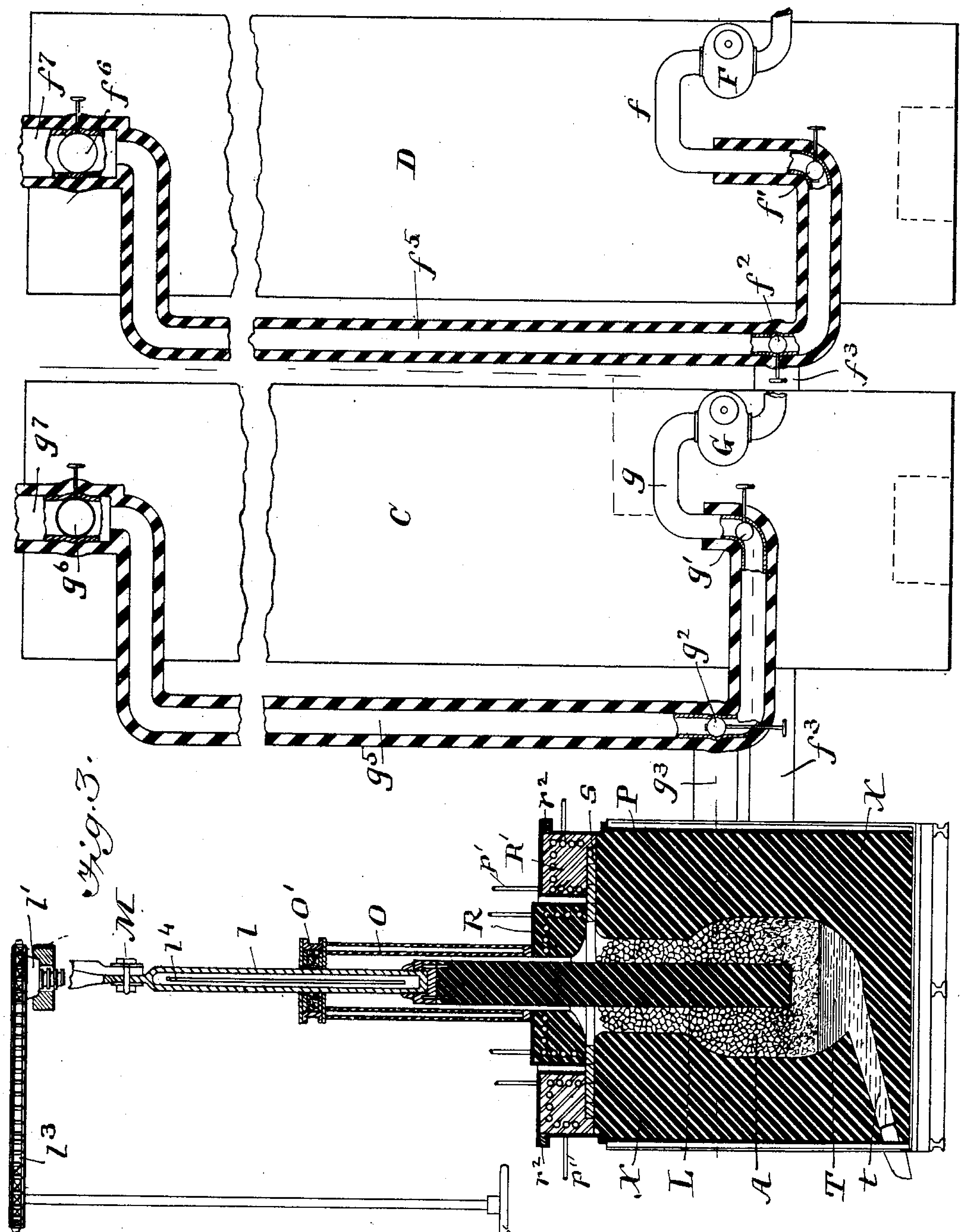

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UNITED STATES PATENT OFFICE.

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ELECTRIC FURNACE.

SPECIFICATION forming part of Letters Patent No. 658,315, dated September 18, 1900.

Application filed October 22, 1895. Serial No. 566,567. (No model.)

To all whom it may concern:

Be it known that I, ALFRED H. COWLES, a citizen of the United States, residing at Cleveland, in the county of Cuyahoga and State of Ohio, have invented certain new and useful Improvements in Electric Furnaces; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to letters of reference marked thereon, which form a part of this specification.

In certain companion applications heretofore made I have shown and described certain improvements in electric smelting processes and furnaces whereby a control can be secured of the field of heat in an electric furnace by means of an alternating flow of gas therethrough. This is specially set forth in an application filed by me July 6, 1895, Serial No. 555,116, and I have also described an improvement embodying a combination of a regenerative furnace with an electric furnace whereby the heat of combustion can be employed up to the highest temperature that the combustion-furnace is capable of producing, and then the finish can be given with electric heat, this latter improvement being set out in an application filed by me August 19, 1895, Serial No. 559,728.

A further improvement in the art of electric smelting and in furnaces therefor involves a combination of the regenerative principal with an electric furnace and the coincident application of the heat of hot gases with the heating, electrolytic, and reducing effects of an electric furnace or the successive application of the heat of combustion and electric heat to the material under treatment in place, and this improvement constitutes the subject-matter of the present invention.

The object in view is to provide a smelting apparatus which shall admit of the smelting or reduction of the refractory ores or compounds being carried on very much more economically than ever before and on a larger scale and to this end shall economize the heat and employ the heat of combustion, supplemented by electrical heat and energy, to render the final reduction possible with a small consumption of electrical energy. The practical construction of such a furnace requires the application of the water-jacketing principle, which is also set forth in a prior application, Serial No. 301,377, of July 27, 1889, for it becomes desirable in the operation of a furnace with such high heats to confine the spread of high temperature within definite bounds in order that they may be run continuously. This result I secure by the combination, with an electric furnace, whether of the incandescent or arc type, of a regenerative flow of gases therethrough and the utilization of the heat of the escaping gases for the purpose of heat regeneration. For example, I locate the electric furnace between two bodies of carbon, coke, or fuel and pass through the electric furnace and the juxtaposed masses of carbon a current of air, or a current of mixed air and gas or of gases may be preheated in heating-stoves or by regenerative checkwork, or the preheating feature may be omitted. In either case the bodies of carbon act as regenerative masses and with each reversal of the flow of gas therethrough increase the temperature. Thus in an apparatus having masses of incandescent fuel in conjunction with an electric smelting-chamber charged with ore to be reduced or with material for metallurgical treatment, all of the chambers being closed in and so connected that a current of air or gases can pass successively through them, the effect is that the inflowing current of gas or air burns in the first combustion-chamber or fuel-body, and the heat from the hot gases passing therefrom through the electric furnace-chamber is supplemented by the electric heat and gives therein a temperature which is higher than is possible by combustion, and this temperature, together with possible electrolytic and reducing effects of the current, effects reduction of the most refractory compounds, such as lime, clay, sand, aluminium, &c. It will be understood that the temperature obtainable under these conditions where there is a movement of gases through a field of electric heat has limitations due to the temperature of dissociation of carbonic oxid. This limitation does not extend to the arc itself, but to the temperature of the chamber outside of the arc, which will be held down to that of the dissociation of carbonic oxid, and hence I preferably so arrange the furnace that the flow of hot gas through the electric furnace-chamber will be removed from the immediate center of electric heat and will be through the material approaching the electric-heat center, so that the ore will receive the heating benefit of the hot gases within the electric furnace-chamber prior to the finishing electric heat; but at the same time the high temperature of the electrically-heated zone immediately around the arc center will not be reduced by the gas-flow. The hot gases issuing from the electric chamber pass through another combustion-chamber or body of fuel and add heat thereto by reason of the hot gases being hotter than the incandescent fuel, and the gases after passing therethrough go preferably to heating-stoves to effect further economies in the process. After the apparatus has been thus running for a proper interval of time the flow is reversed and what may be called the "second combustion-chamber," with its superheated mass of incandescent fuel, becomes the active combustion-chamber of the series. The inflowing air or gas or mixed air and gas now flows through the interstices of the mass of superheated material in the second chamber, combustion there takes place, and the gases of combustion pass into and through the electric furnace at a higher temperature than before, due to the preheating of the fuel in this combustion-chamber. The hot gases then pass out through the first mass of incandescent fuel and superheat the same. Thus with each reversal of the direction of the flow the temperature is added to, and it is built up until the point of maximum efficiency is reached.

In the electric furnace-chamber the addition of the heat of the electric arc supplements the heat of combustion and effects the reduction of the ore or other material charged into the same, and by reason of the high initial temperature obtained by the regenerative flow of gases therethrough the electrical energy is consumed only in the supplementing and finishing of the reduction, and a large amount of material can be treated in the furnace with a relatively-small expenditure of electrical power per pound of product.

As stated, the electric furnace may be either of the arc or incandescent type, or sometimes it may have within it an arc and at others the action may be purely incandescent. The method of operation in the present case therefore consists in the alternate flow of gases through an electric furnace, and through one or more masses of carbon or incendescent fuel coöperating therewith and adapted to have the gases pass through them before passing through the electric furnace, or in preheating the gases in regenerative chamber before they enter the fuel furnaces, whereby the full efficiency of the heat of combustion and the regenerative effects of the waste heat is utilized in the electric furnace, and the material operated on therein is reduced by means of the heat of combustion employed to its fullest extent and supplemented by electrical heat and energy.

It will be seen that this case differs from the invention set out in my application of date August 19, 1895, Serial No. 559,728, in this respect. In the present case the ore or other material is entirely treated in the electric furnace, while in the former case referred to the material is first treated in a reverberatory or combustion furnace, and the finish is given to it in an electric furnace. In both cases, however, the heat-combustion is employed as far as possible and the electric furnace supplements and finishes the work.

An apparatus for properly putting in practice the invention possesses many points of novelty which will be hereinafter fully described in detail. The leading feature thereof is an electric furnace-chamber capable of being closed in and having means for charging it with ore and operating in conjunction therewith one or more fuel-chambers, all connected so that gases can be passed through them in series and the flow from time to time reversed. Added to the foregoing there are heating-stoves for utilizing the hot waste gas for regeneration and means for charging the several furnaces therethrough.

In the accompanying drawings, Figure 1 is a longitudinal sectional view of the furnaces, taken on the line 1 1 of Fig. 2, with the heating-stoves in the rear appearing in elevation. Fig. 2 is a sectional plan view taken on the line 2 2 of Fig 1, and Fig. 3 is a vertical sectional view taken on the line 3 3 of Fig. 1.

The electrical furnace-chamber is shown at A flanked on either side by the fuel-chambers B B′, the three chambers being in a horizontal line, with communicating flues *b b′* and with the gas-ports E E′ at the ends of the line of furnace-chambers. In the present case the furnace-chambers are all formed with solid-carbon walls, and collectively they form a carbon block X X, with the several chambers, flues, and passages therefor formed therein, as clearly shown by the sections thereof in the several figures. This, however, is not an essential feature, it being immaterial how the furnace-chambers are constructed.

C C′ and D D′ are two pairs of heating-stoves, and a proper system of flues, valves, and blowers is provided to direct and control the flow of the air and gases, so that the hot gases issuing from one end of the furnace can pass through one pair of regenerators—as, for example, the stoves C′ and D′—while fresh air and fresh gas are being forced through the other pair of regenerators C and D and into the opposite end of the furnace. To this end F and G are blowers for gas and air, respectively. The flue *f* from the gas-blower

F has a cross and a butterfly-valve f', with branch flues leading therefrom into the bottom of the two heating-stoves D D', so that the gas can be turned into either stove. At f^2 the flue has a second cross and valve therefor, the branch flues f^3 f^4 leading, respectively, to the ends of the furnace and the flue f^5 leading up to a cross and butterfly-valve f^6, from which the flues d^2 and d^3 connect with the upper parts of the heating-stoves D D', respectively, while the flue f^7 is a chimney-outlet for spent gases. In like manner the flue g from the air-blower G has a cross and valve at g', with the branches c c' leading to the bottom of the two heating-stoves C C', so that the air, and likewise the hot gases, can be turned into either stove. At g^2 the flue has a second cross and valve, with branch flues g^3 g^4, leading, respectively, to the two ends of the furnace, and the flue g^5, leading up to a cross and valve g^6, from which the flues c^2 c^3 connect with the upper ends of the stoves C C', respectively, while the flue g^7 is a chimney-outlet for the spent gases. Doors at the bottom of the several stoves are indicated at d^4 c^4 for admission of air for the burning of the gases therein.

The inlet and outlet ports E E' are illustrated in the present case as compound orifices discharging into the end chamber a flow of hot air from the central flue g^3 (taking the burner E) and a flow of hot gas from the annular outlet around it from the gas-flue f^3. When, on the other hand, the hot gases pass out at the end of the furnace—as, for example, at the end E'—the flow divides between the two flues f^4 and g^4. Part flows out through the central opening to the flue g^4 and part through the annular passage to the flue f^4, and the hot gases are conducted by the respective flues to two of the stoves.

The two furnaces B B' are counterparts of each other, and a detail description of one will suffice for both. The grate-bars H are for the purpose of cleaning out the accumulation of ashes from the combustion-chamber, and when the furnace is in operation the ash-pit H' and all outside entrances to the fuel-chamber are closed, though there may be an air-draft up through the grate-bars for a brief period when the furnace is first started until the fuel in the chambers B B' is well ignited.

At the top of the chamber there is a double-valved charging-hopper K for the fuel, k being a slide which can be withdrawn for the admission of fuel into the lock-chamber k', and k^2 a cup-and-cone valve to allow for the dropping of the fuel charge into the chamber B when the slide k has been closed.

Referring now to the central electric furnace-chamber, L is a carbon electrode vertically adjustable within the chamber by means of the supporting-rod l. This rod is shown as screw-threaded at its upper portion and fitted with a nut l', supported in bearings and which can be turned by means of the hand-wheel l^2 and the sprocket-wheel-and-chain connection l^3 for raising and lowering the carbon pole. One of the electric connections is made with the carbon-holder at M, and the other connection is made to the furnace, as at M'. The lower portion of the carbon-holder is hollow, and it is cooled by a flow of water therethrough.

l^4 is a water-pipe leading into the bottom of the hollow holder, and l^5 an outflow-pipe therefor.

Two charging-hoppers N N' are shown on opposite sides of the carbon pole to give a uniform distribution of the charge material within the furnace-chamber and around the electrode. Each charging-spout has two valves, so that the material can be passed in without the escape of gas from the furnace.

To inclose the carbon electrode and its holder, there is a water-jacketed pipe O, extending up from the cover R of the furnace, with an insulating stuffing-box O' for the holder-rod. The water-pipes for the water-jacket are shown at O^2. In like manner the charging-hopper K is water-jacketed, K^3 K^4 being the inlet and outlet pipes therefor, and the casing P of the furnace-body is a water-jacketed shell, some of the water-pipes therefor being shown at P P P. Cooling-coils P' may be embedded in the carbon furnace-block itself, and the central-carbon cover R and the ring-section R' are provided with like cooling-coils.

S is a course of insulating-bricks for the cover, and the ring-section R' may be of insulating material, with insulation between the parts of the casing thereof at r^2.

The sump T is preferably low enough below the lateral gas-flues b b' to drop the position of the electric arc or electric-heat center below the path of the through-flowing gases, so that the latter will not traverse directly through the zone of highest heat, but just above it, for the reason before stated. A tap-hole t for the molten product is shown in Fig. 3.

From what has preceded the operation of the furnace will doubtless be understood, but it will be briefly reviewed. I wish it distinctly understood, however, that the illustration of the furnace with all its details herein given is solely for the purpose of presenting a full embodiment of the invention and that the structural features described are not all essentials, but that they can be omitted or modified as judgment may dictate.

In starting the furnace the chambers B B' are charged with coke and ignited, and the apparatus is run with a blast of air alternating in direction of flow through the furnace until the fuel in the chambers is incandescent, or the furnace may be started with both the air and gas blasts, or the furnace may be started solely with electrical heat in the electrical chamber and with a reversal flow of gas therethrough. The coke masses in the chambers B B' become regenerative bodies and receive and store up the heat from the out-flowing gases and impart it to the inflowing gas until the coke masses become highly-heated incandescent bodies. When the furnace is in operation, the gases evolved are suitable for passing through the furnace in a reversing flow and may be blown in unmixed with air, the coke masses in this case serving entirely as regenerators and as collectors of heat. When the valves are set for the inflow of air and gas at E and the outflow of hot gases at E', the valve f' is set to turn the gas from the blower F into the bottom of the stove D, the valve f^6 to direct it down the flue f^5, and the valve f^2 to send it by the flue f^3 to the burner E. The air from the blower G in like manner is turned into the bottom of the stove C by the valve g'. It issues hot at the top and is directed down the flue g^5, and the valve g^2 is turned to send it by the flue g^3 to the burner E. At the other end of the furnace one half of the hot gases issues by the flue f^4 to the valve f^2, to the valve f', and in at the bottom of the stove D', where they burn, air being admitted therefor through the door d^4. The spent gases issue at the top of the stove and are turned up the chimney-flue f^7 by the valve f^6. The other half of the hot furnace-gases passes out through the flue g^4 to the valve g^2, then to the valve g', in at the bottom of the stove C', where the gases are burned, the final spent gases passing up the chimney-flue g^7. On the reversal of the several valves the course of the gas is via the blower F, flue f, valve f', the hot stove D', valve f^6, flue f^5, valve f^2, and flue f^4 to the burner or entrance-duct E', the air flowing from the blower G via the flue g, valve g', hot stove C', valve g^6, flue g^5, valve g^2, and flue g^4 to the burner, while the hot furnace-gases divide between the flues f^3 and g^3 and pass to the stoves D and C and heat them up. When the furnace is sufficiently heated up, the ore or other material is charged into the electric furnace through the hoppers N N' and is fed in from time to time as the reduction takes place, and the product is tapped off at t to keep a body of ore in the path of the gas flowing therethrough. The through-flowing current of hot reducing-gases heats the ore to a high temperature before it descends to the immediate neighborhood of the electric arc or zone of reduction, and the full efficiency of the heat of combustion is thus utilized.

What I claim as new is—

1. The combination in a furnace, of an electric smelting-chamber to be charged with the material to be reduced and having electrodes and electric-circuit connections therewith, two chambers to be charged with fuel, flues connecting the electric smelting-chamber intermediate with the fuel-chambers, and means for causing a reversing flow of an æriform fluid through the fuel-chambers and the intermediate electric smelting-chamber.

2. The combination in a furnace, of an electric smelting-chamber having electrodes and electric-circuit connections therewith, two or more fuel-chambers with the electric smelting-chamber interposed between them, and with communicating flues therebetween, with a blast mechanism for causing a flow of a gas through the series of fuel-chambers and electric chamber, and a reversing mechanism for said gas-flow, whereby ore or other material in the electric smelting-chamber can be preheated by a regenerative gas-flow.

3. The combination in a furnace, of an electric smelting-chamber having electrodes and electric-circuit connections therewith, two fuel-chambers with the electric smelting-chamber therebetween and communicating flues therefor, each of said chambers having gas-tight charging-ports, together with a draft mechanism for causing a reversing flow of gas through the series of chambers.

4. The combination in a furnace, of an electric smelting-chamber having electrodes and electric-circuit connections therewith, a pair of hot-blast stoves, and a chamber to be charged with fuel, with flues connecting the hot-blast stoves with the fuel-chambers, and the fuel-chamber with the electric smelting-chamber, and the controlling-valves therefor, as and for the purpose set forth.

5. The combination in a furnace, of an electric smelting-chamber having electrodes and electric-circuit connections therewith, a pair of hot-blast stoves, and a pair of fuel-chambers, with flues connecting the hot-blast stoves with the fuel-chambers and the latter with the electric smelting-chamber, means for reversing the flow of gases, together with valves therefor, whereby a reversing flow of hot gases can be sent through the fuel-chambers and the smelting-chamber, as and for the purpose set forth.

6. The combination in a furnace, of an electric smelting-chamber the same having electrodes and electric-circuit connections therewith, and two fuel-chambers formed in a solid block of carbon with connecting flues, the fuel-chambers flanking the smelting-chamber, and reversing means for causing a flow of gas through or between the series of chambers.

In testimony whereof I affix my signature in presence of two witnesses.

ALFRED H. COWLES.

Witnesses:
FRANK M. ASHLEY,
STORY B. LADD.