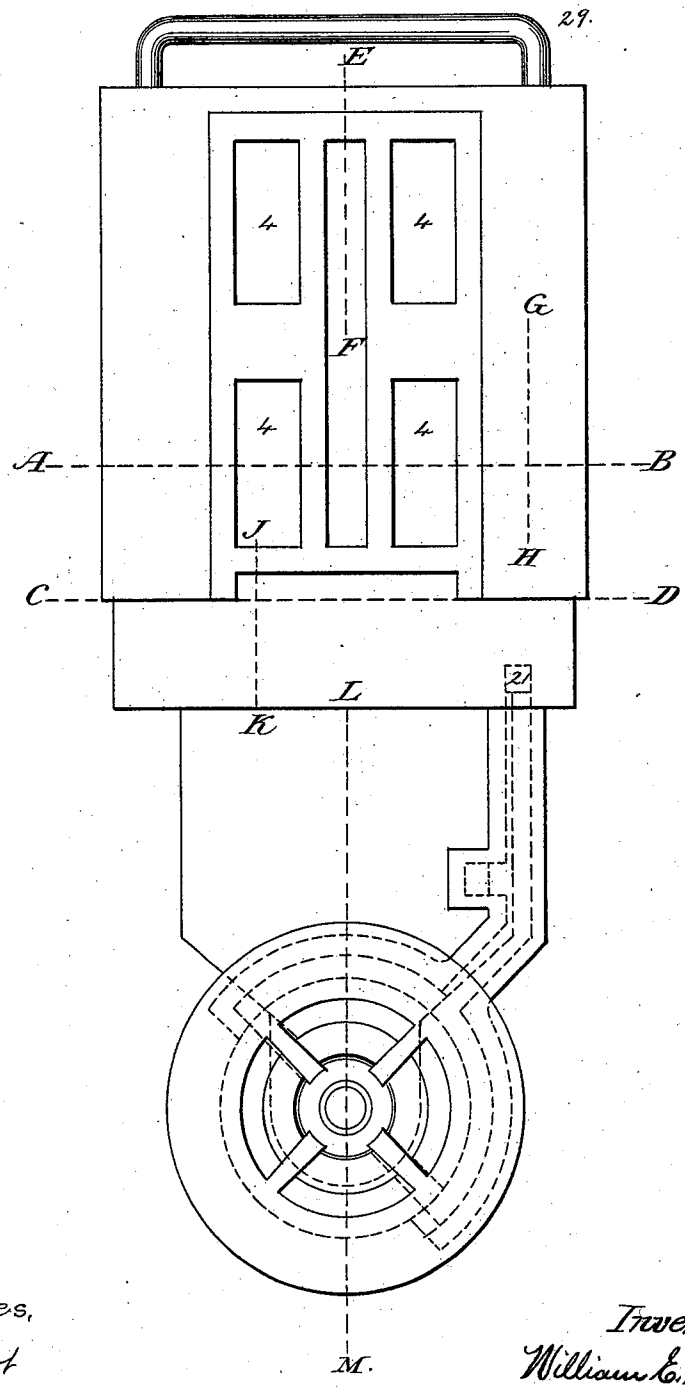
3 Sheets—Sheet 1.

W. E. C. EUSTIS.

Process and Furnace for Reducing and Smelting Ores.

No. 209,554. **Patented Nov. 5, 1878.**

Fig. 1.



Witnesses,
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A. Scott

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3 Sheets—Sheet 2.

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Fig. 2.

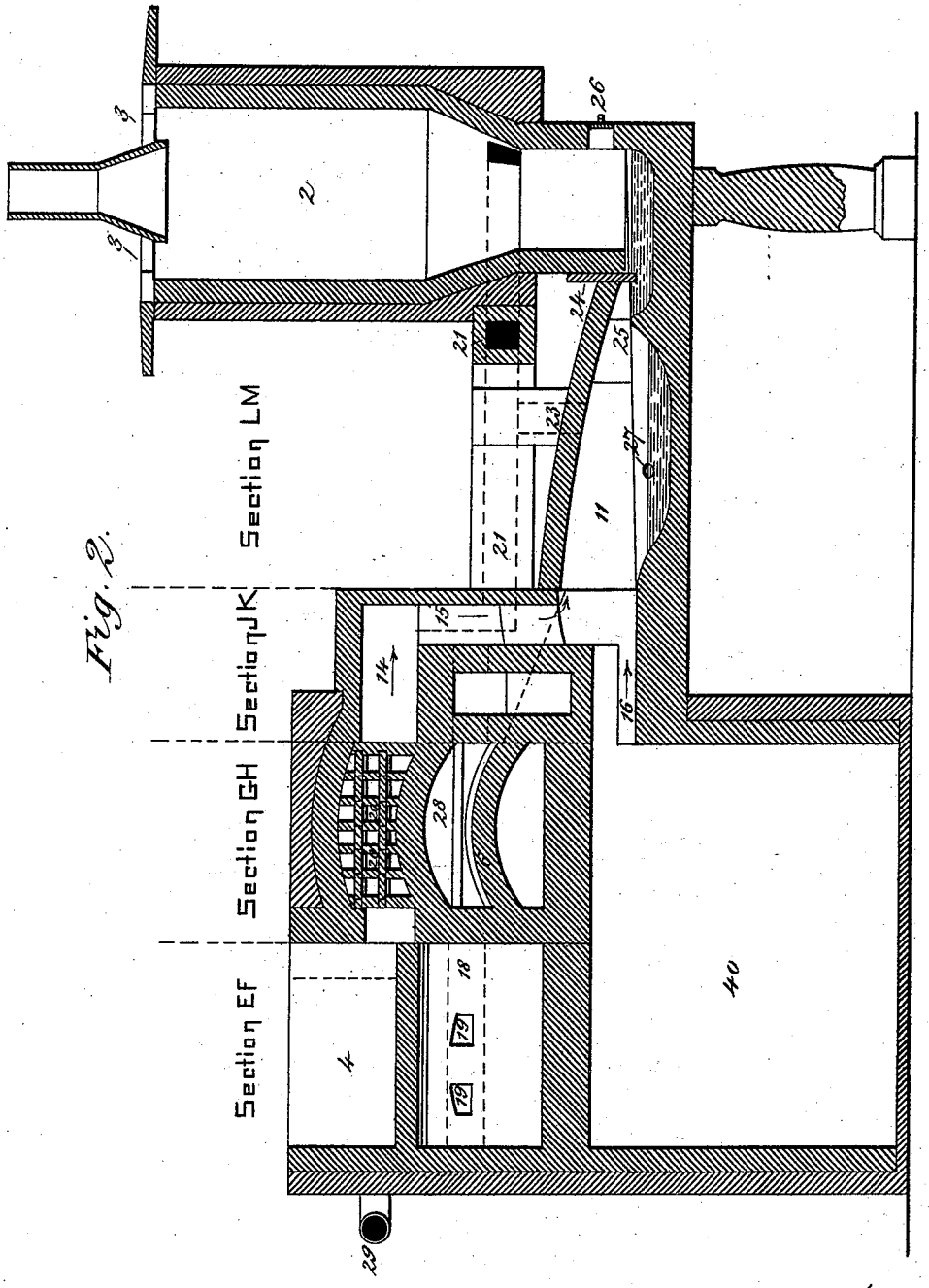

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Fig. 3.

Section, A.B.

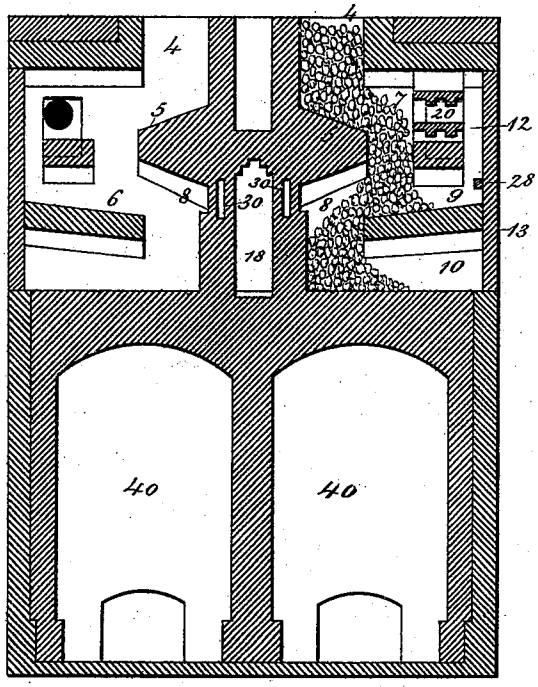
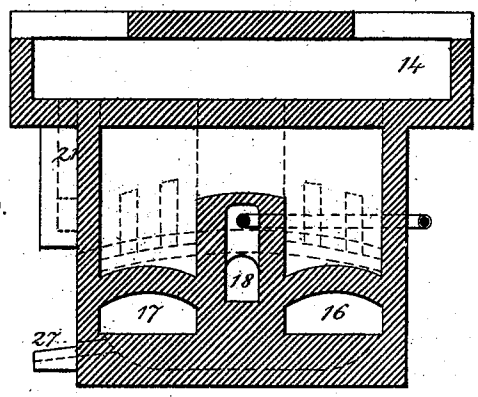


Fig. 4.

Section, C.D.



Witnesses.

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A. Scott

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William E. C. Eustis.

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UNITED STATES PATENT OFFICE.

WILLIAM E. C. EUSTIS, OF MILTON, ASSIGNOR OF ONE-HALF HIS RIGHT TO HENRY M. HOWE, OF BOSTON, MASSACHUSETTS.

IMPROVEMENT IN PROCESSES AND FURNACES FOR REDUCING AND SMELTING ORES.

Specification forming part of Letters Patent No. **209,554**, dated November 5, 1878; application filed September 8, 1877.

To all whom it may concern:

Be it known that I, WILLIAM E. C. EUSTIS, of Milton, in the county of Norfolk and State of Massachusetts, have invented an Improved Mechanism and Process for Reducing and Smelting Ores, of which the following is a specification:

This invention relates to mechanism by which to reduce and smelt ores of copper, iron, &c., and also to a method or process of reducing or smelting such ores, as hereinafter set forth.

I will first describe the invention as applied to the reduction or smelting of copper, which is generally combined with iron-ore.

To separate the copper, I employ a mixture composed chiefly of highly-heated carbonic oxide or other reducing gases and highly-heated carbonic-acid gas or steam, this mixture reducing the copper, but not the iron, to the metallic state.

I employ, for the reduction of that portion of the ore which it is desired to reduce, such a combination of gases as will act upon and reduce to the metallic state the desired ore and be inert upon others present in the furnace.

In this invention the gas-producer is fed with the products of combustion of the combustion-chamber rather than with air, whereby a material portion of the actual energy of the heat of the flame of the combustion-chamber is converted into potential energy, thus making the producer a recuperator, capable of giving the same result as the regenerator of other furnaces.

To enable the producer to act as a recuperator, I pass a portion of the products of combustion of the combustion-chamber directly into the fuel in the producer, thereby reducing the carbonic acid of the products of combustion into carbonic oxide, whereby with a given amount of fuel in the producer I am enabled to supply at the combustion-chamber double the amount of combustible gas that would be possible with a producer having a like amount of fuel and fed with air rather than with products of combustion.

It will thus be seen that the actual energy that existed in the products of combustion in the combustion-chamber in the condition of heat now becomes potential energy contained in the combustible gas, to be carried forward and converted again into actual energy in the combustion-chamber by burning the gas.

This last-mentioned chemical operation, although producing double the amount of gas with a like expenditure of fuel, causes a very great lowering of temperature in the gas-producer, equivalent to about 1,000° centigrade. This large amount of gas led from the gas-producers to the combustion-chamber is there mixed with heated air which has not been passed through fuel, and is effectually consumed, producing intense heat.

In some forms of furnaces the air to feed the producer is heated by the outgoing products of combustion, causing an enormously high temperature in the producer, while in our case the products of combustion fed to the producer cause a lowering of the temperature; and by as much as the heat generated in our producer is less than that generated in the hot-air form, by so much is the heat produced in our combustion-chamber greater than that produced in the combustion-chamber of such hot-air form.

The products of combustion are herein carried from the combustion-chamber to the producer by means of a steam-jet from a pipe, 33, connected with a suitable steam-supply. This jet is capable, also, by means of suitable apparatus of drawing along with the products of combustion a large amount of air, by means of which the temperature of the producer can at any time be raised to any desired point, so that by means of the steam on the one hand and air on the other the temperature of the producer is absolutely under control. This lowering of temperature is of great advantage, in that it saves wear of the brick-work.

Figure 1 represents, in top view, sufficient of a reducing and smelting furnace to illustrate this invention; Fig. 2, a vertical longitudinal section taken on the lines E F, G H, J K, L M, Fig. 1; Fig. 3, a vertical cross-section on line A B, Fig. 1; and Fig. 4, a cross-section on line C D.

The ore to be reduced is placed in the shaft 2, it being introduced through suitable open-

ings 3 at the top. The fuel to produce the gas is placed in the chambers 4 4 of the producer, four such producers being shown. Each chamber is provided with arches or projecting portions 5 6, to so hold the fuel as to form air-spaces 7 8 9 10. The air to support combustion is introduced into the combustion-chamber through any usual or suitable air-heating apparatus, 40, called a "recuperator." (Not necessary to be herein described.) The fire having been kindled in the producer-chambers to be used, the operation is as follows: The combustible reducing-gas passes through the checker-work of the producer into a space, 12, between the checker-work and door 13, or it may be the wall, and thence into a flue, 14, Fig. 2, from which lead two downward flues, 15, (one only being shown,) into the combustion-chamber 11, as designated by full arrows. The heated air from the recuperator enters the combustion-chamber 11 through the hot-air flue 16, where it meets the gases from the producer, such gases moving along flue 15. The gas and air so united in the combustion-chamber ignite and pass around such chamber, a part passing out through a flue, 17, like the flue 16, it, however, leading to the recuperator, and a part through the producer-flue 18, thence through ports 19 (shown only at the left of Fig. 2) to the producer-chambers 4, each of which chambers have ports, like 19, connecting it with the flue 18. The products of combustion thus led from the combustion-chamber to the producers, for the purposes previously described in this specification, issue from the ports 19 and enter the fuel through its natural slope, as shown, next the space 8, instead of through grate-bars; thence through the column of fuel, as indicated, between spaces 7, 8, and 9 issuing thence, through the spaces 7 and 9, and the checker-work 20, into space 12 and flues 14 15, as before described, the products of combustion, by their passage through the glowing fuel, being converted into combustible gases containing potential energy and lowered in temperature, as before described.

In this invention the fuel is sustained by the arches or projections in such manner that the products of combustion from ports 19 have free passage therethrough, as if supported on grate-bars, which, if herein used, could not stand the degree of heat employed.

Another important feature of this invention is, that the products of combustion used to feed the producers are made to pass directly through the hottest part only of the mass of fuel, instead of through the cool top crust of the fuel, as in common practice. I gain by this that any moisture contained in the fuel (there always being more or less) is resolved into its constituent gases—hydrogen and oxygen. The hydrogen so produced forms, with the fuel, hydrocarbons. The oxygen forms carbonic oxide, and these two combustible gases are carried forward to the combustion-chamber, whereas in common practice steam only would be carried forward. For the same reason, hydrocarbon gases being highly heated become more stable, and will not, therefore, deposit in the flues. A portion of the carbonic oxide passes from the flue 14 into shaft-flue 21. (Shown in dotted lines, Figs. 1 and 2.)

A flue, 23, leads from the highly-heated combustion-chamber into the flue 21, and conducts the non-reducing carbonic-acid gas of the combustion-chamber at high temperature into and mixes it with the reducing carbonic oxide and hydrocarbons in flue 21, they also, at high temperature, passing directly from the gas-producers to the stack, and such combined gases entering the mass of ore in the shaft 2 act, as before described, to reduce to the metallic state the desired part of the ore and remain inert upon others present in the furnace, the proportion of these gases being regulated by means of suitable dampers in the flues 21 and 23.

The most reduced ore is always at the bottom of the shaft on the shaft-hearth, where it is protected from the oxidizing-atmosphere of the combustion-chamber by a seal of usual construction, as at 24, made movable in suitable guideways. At the bottom of this shaft it melts and runs over the bank 25 into the hearth of the combustion-chamber, or is pushed over by an operator by means of a rabble inserted through the door 26. This hearth is made double by means of the bank 25, in order to allow of continuous working of the shaft 2, for it is at times desirable to treat the metal on the hearth of the combustion-chamber separate from that on the hearth of the shaft. The metal is finally drawn from the hearth of the combustion-chamber through the tap-hole 27.

By means of suitable dampers in passages 30 either of the gas-producing chambers may be cut off from the others to clean them, and when either of the producer-chambers crossed by the line A B, Fig. 1, is so cut off the pipe 29 connects the two chambers at the end of the furnace.

In Figs. 2 and 3, 28 represents a rest to support false grate-bars when it is desired to clean the fire, as, for instance, by removing the waste below the arch 6.

So far this invention has been described for operation upon copper ores containing more or less iron; but it is obvious that it is applicable to the reduction of other compound ores, it being only necessary to supply such ores with the proper combination of reducing-gases.

Portions of this invention are applicable to melting as well as smelting furnaces. All the producers are provided with checker-work and flues, as described. The shaft with its hearth constitute a shaft-furnace, and the combustion-chamber is simply that of a reverberatory furnace.

The producers are placed very close to the combustion-chamber to avoid the loss of heat

which would result in conducting the gases through pipes, as in some other forms of furnaces.

For treating a compound ore of copper and iron, I have found 50 CO to 50 CO_2 at a bright-red heat to reduce copper entirely to the metallic state, and not to give a trace of metallic iron.

If the ore is a sulphuret it should be calcined before being placed in the stack.

I claim—

1. The herein-described process of reducing one metal of a compound ore while the other metals therein remain unreduced, which consists in subjecting the ore in a furnace or shaft to a mixture of reducing and non-reducing gases in proportions and under conditions appropriate to the particular metal to be reduced, substantially as herein described.

2. In the working of working ores, the process herein described of continuously generating and burning reducing-gases and utilizing the heat therefrom, which consists in passing the products of the combustion of said reducing-gases effected in the combustion-chamber through the fuel in the gas-producer, then conducting the gases so produced to the combustion-chamber, again admitting thereto a supply of heated air, thereby causing complete combustion, and heating said combustion-chamber, and then again conducting the products of this combustion to the gas-producer, thus rendering the process continuous, substantially as described.

3. The combination, with fuel-holding projections 5 6 in the producer, of checker-work 20, substantially as described.

4. The shaft to contain the ore to be treated and its hearth, in combination with a reverberatory-furnace and its hearth, placed contiguous to the shaft-hearth, but separated therefrom by a bridge, and with the gate 24, to protect the reduced ore in the shaft and its hearth from the action of the oxidizing-gases in the combustion-chamber, substantially as set forth.

5. The hearth of the combustion-chamber and a flue, 15, to receive the gases from the producers, in combination with a flue, 16 or 17, to carry a part of the products of combustion to a recuperator, and a second flue, 18, to carry another portion of such products of combustion back to the producers, to operate substantially as described.

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

WILLIAM E. C. EUSTIS.

Witnesses:

G. W. GREGORY,

W. J. PRATT.