(No Model.) 2 Sheets—Sheet 1.

J. HENDERSON.

METALLURGIC FURNACE.

No. 267,346. Patented Nov. 14, 1882.

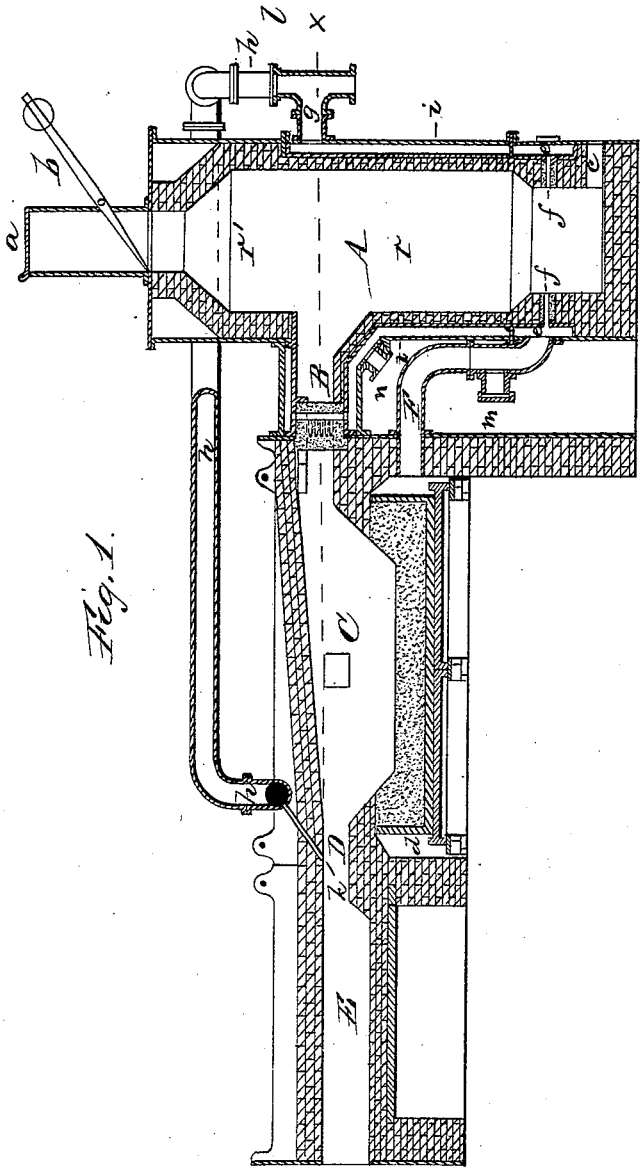


Fig. 1.

WITNESSES:

W. L. Bennett

Wm. A. McKee.

INVENTOR

James Henderson

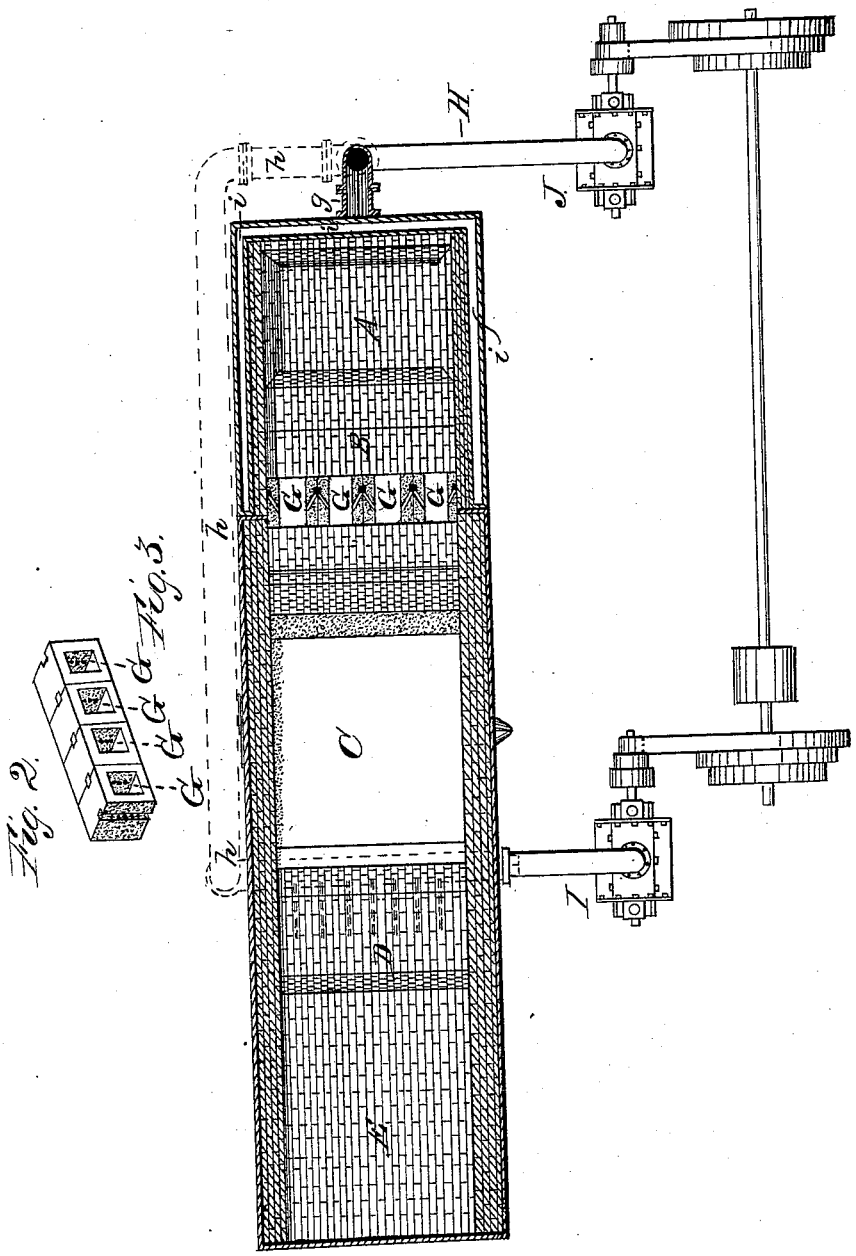
(No Model.)

2 Sheets—Sheet 2.

J. HENDERSON.

METALLURGIC FURNACE.

No. 267,346. Patented Nov. 14, 1882.



WITNESSES:

W. L. Bennett.

Wm. A. McKee

INVENTOR

James Henderson

UNITED STATES PATENT OFFICE.

JAMES HENDERSON, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO CHARLES G. FRANCKLYN, OF SAME PLACE.

METALLURGIC FURNACE.

SPECIFICATION forming part of Letters Patent No. 267,346, dated November 14, 1882.

Application filed March 21, 1878.

To all whom it may concern:

Be it known that I, JAMES HENDERSON, of the city, county, and State of New York, have made an invention of certain new and useful Improvements in Furnaces, consisting generally of novel combinations of elements in apparatus for metallurgical manipulations. At the same time my improvements are adapted to other heating uses.

It is the object of my invention to promote greater economy in the use of fuel by arranging a furnace in such manner that complete control of the quantity and of the intensity of the heat, with perfect command of the chemical nature of the flame, are obtained without waste of fuel or loss of heat other than that unavoidably radiated and carried off by the nitrogen, carbonic acid, and watery vapor passing away from the chimney.

The first part of my invention relates to the peculiar construction of gas-flues and air-tuyeres at the neck of the furnace, whereby the gas from the gas-producer and air to burn that gas are mixed under greatly increased pressure and introduced to the combustion-chamber; and it consists of a gas-inlet neck divided by walls into separate gas-channels of continuous sectional area, and fitted with diagonal air-tuyeres whose outlet-orifices are arranged within the said gas-channels, whereby the air from the adjoining air passages or grooves is conducted in to the gas-channels, which are of the same sectional area on each side of the entrance of the air-tuyeres, so that the commingled gas and air have a velocity equal to the sum of the velocity of the gas and of the air before they come together, which velocity is further increased by the expansion of the mixture of gas and air in combustion.

Another part of my invention relates to the arrangement for the combustion of the gases from a gas-producer in successive heating-chambers, to the first of which the gas is supplied in separate streams from the gas-producer, while the second heating-chamber receives the gas from the first; and it consists of the combination of devices by means of which the combustible gas from a gas-producer is divided into separate streams, and the supply of air is divided into two portions, one portion of which is supplied to the streams of gas passing to the first heating-chamber, while another portion is delivered to the gas for the first chamber and another portion being delivered to the gas proceeding from the first heating-chamber to the second.

Another part of my invention relates to the supply of air for combustion of the fuel and of the resulting carbonic oxide, so as to produce flames having different chemical qualities, as desired, whether oxidizing, reducing, or neutral; and it consists of the method of working gas-furnaces by supplying the air for the production of the combustible gas and the air for the burning of the gas produced in measured quantities, which are varied according to the quality of flame required.

The residue of my improvements consists of sundry combinations and constructions of devices, and in a new mode of working the gas-producer for carrying out effectually the above-stated improvements.

The various improvements constituting my invention are set forth in detail at the close of this specification; but in order that the same may be properly understood I will proceed to set forth the system, mode, or manner in or under which the same is or may be used or carried out in practice, reference being had to the accompanying sheets of drawings, and to the letters and figures marked thereon—that is to say:

In the drawings, Figure 1 is a longitudinal section of the furnace in which my improvements are used. Fig. 2 is a perspective view of the gas-flues with the gas-passages, air-channels, and tuyeres; and Fig. 3 represents a horizontal section of the apparatus through *x x* of Fig. 1.

A shows the gas-producer, from which the flue B of the inlet-neck of the furnace is the outlet for the resulting gases, as well as the inlet into the heating-chamber C of a reverberatory furnace, from which the gases escape by the outlet-flue D of the outlet-neck of the furnace to a second heating-chamber, E, and thence by the chimney to the external air. The interior of the gas-producer is formed of two fuel-chambers, *r r'*, the former, *r*, being beneath the gas-outlet B, and being therefore

designated the "lower" fuel-chamber, while the other chamber, r', is above the said outlet and is therefore designated the "upper" fuel-chamber. It is designed that the interior of the gas-producer A shall at all times, when working, be charged to the top with fuel that will fall automatically as it burns away at the bottom, thus supplying the fire, while the fuel becomes gradually heated, decreasing in temperature to the top.

a shows a hinged cover at the top of the fuel-hopper; *b*, a weighted lever-valve to close the hopper air-tight when charging fuel at *a*.

c shows a port or opening at the bottom of the gas-producer for removing the contents and igniting the fuel.

In operating the apparatus kindling is inserted at *c* and the fuel at *a*. The kindling being ignited, the fuel-blower I is brought into action. The air from it passes by a pipe connected with the opening in the plating of the furnace into the cavity *d* of the flue-bridge, and thence under and along the reverberatory hearth to the pipe F, leading into an annular pipe, *e*, surrounding the lower fuel-chamber of the gas-producer. From this annular pipe the air enters the lower fuel-chamber, *r*, through the air passages or tuyeres *f f*, and acts upon the fuel in the gas-producer A, decomposing the fuel. The gases resulting from the decomposition, rising up through the interstices of the fuel, escape by the gas-flue B and gas-channels G into the reverberatory chamber C. The heat incident to the decomposition of fuel in the lower fuel-chamber, *r*, acts upon the fuel in the upper fuel-chamber, r', effecting a distillation of the fuel therein, and causing the fuel to evolve gases, which pass into the gas-delivery flue B and serve as an admixing supply to the gas from the lower fuel-chamber. The lower fuel-chamber, *r*, is contracted at its bottom, so that a contracted bottom or hearth is formed, and the tuyeres are arranged to deliver air into this portion of the gas-producer only, so that the fuel in the wider portion of the fuel-chamber above the air-inlets projects horizontally over the inlets for the entrance of air, thus insuring the passage of the air upward through the mass of the fuel.

I effect the combustion of the gases passing through the outlet B by air supplied by a distinct blower, J, from which air passes through an air-conduit system, as follows:

H represents an air-pipe from the blower J, that measures the quantity of air delivered into the pipe H, as required. The pipe H has two branches, one, *g*, of which passes horizontally into a heating-chamber, *i*, which is applied to the exterior of the lower fuel-chamber, *r*, and in this instance surrounds it and is extended so as to form air-passages above and below the flues G. This flue, which is the outlet (or a part thereof) for the gas-producer and the inlet for the heating-chamber, is divided into a series of channels by means of walls of fire-clay or other refractory material, formed of hollow rectangular blocks, as a preferable shape, and nearly cubical, the centers of the blocks being open through the blocks for the passage of the gases, as shown in all the figures. Grooved recesses are made in the sides of each block, so that when the blocks are connected together these recesses form external air-passages, say three inches deep and three inches wide. From these external air-passages tuyere-orifices are pierced horizontally and obliquely forward, with their exit-orifices opening into the central gas-channels, so that the jets of air may be projected toward the reverberatory chamber, as shown in Fig. 3, so as to impel the gases toward said chamber, but are discharged into the gas while the latter is within the gas-channels. A second branch pipe, *h*, to the air-pipe H, leads vertically and turns horizontally along and over the furnace to a place near the flue D, where it turns and crosses over to the opposite side of the furnace.

The transverse portion of the pipe is pierced for and receives at short intervals iron pipes or tuyeres *k*, that are set diagonally forward into and through the masonry to the outlet-flue D, said tuyeres serving to supply air for complete combustion of gases that may not be burned at G.

A valve is placed in the pipe H at *l* to shut off the blast from *h* when required. *m* and *n* are openings or muzzles, at one of which some of the air may be allowed to escape for the purpose of varying the character of the flame produced by the action of the residue, or at one of which an additional quantity of heated air to that supplied by the blowers may be injected for the purpose of varying the character of the flame produced by the air delivered by the blowers previously described.

The blowers I J or blast-cylinders may be of any efficient and convenient construction, and should be of equal capacity when coke is used for the fuel, one of the two, however, being provided with means for driving it at variable speeds, so that the volume or weight of air delivered may by it be varied as required.

When the fuel is bituminous coal, which evolves hydrocarbon gases, it is preferred to increase the size of the blower or cylinder J, that supplies the air for the combustion of the combustible gases, as compared with the size of the blower I, that supplies the gas-producer, the proportion of such increase being determined by the character of the gases produced and the quantity of air required for their combustion, and this blower or cylinder is provided with means for varying its speed, so that the volume or weight of air delivered may be varied, as required, to meet the varying qualities of the fuel and gases and to produce the quality of flame required.

The blowers here shown are arranged to have their speeds varied by being driven by belts applied to pulleys of different diameters, to which the belts may be shifted. The air supply may, however, be furnished by one

blowing-machine, which must have distinct pipes, with a meter for each, caused or permitted to move at the proper relative speeds for measuring the quantities of air.

In order to supply the proper relative quantities of air, the chimney or outlet-flue may be exhausted by jets of steam, thereby inducing partial vacuums in the flues, so that the air and gases will be driven in by the atmospheric pressure, meters or measuring-blowers being provided to determine the relative quantities of air supplied to the gas-producer and to the tuyeres for burning the gas.

The temperature of the reverberatory heating-chamber C and the proportions of reducing-gases burned therein are regulated by the valve *l*, which causes a portion of the air to be diverted from the pipe *g* to the pipe *h* and the tuyeres *k* of the second heating-chamber, E, which may be used for heating scrap-steel or for melting cast-iron; or this heat may be used to generate steam, or may be applied to other purposes. A spout is shown from which the metal or slag may be run from the hearth of the reverberatory chamber through a tap-hole in the side wall, provided for that purpose.

The drawings represent my improvements as applied to reverberatory furnaces; but the system described of conducting the quantity of combustible gas to a heating-chamber and supplying air sufficient to burn only a portion of such quantity, and of conducting the gas from the first heating-chamber to a second, and supplying air sufficient to burn the residue of the combustible gas, or thereabout, for heating said second heating-chamber, will be found of value for the heating of chambers for other purposes.

When the system is applied to steam-boilers and other uses where the great intensity of heat obtained by combustion taking place under pressure is not required, I prefer that the flues be arranged with the tuyeres at or near the exit ends of the flues, so that the combustion will take place beyond the flues and in the heating-chamber.

The space in the gas-producer below the tuyeres *f* is the receptacle for ashes and slag, which are withdrawn through an opening, *c*, provided for such purpose. The opening should be stopped up when working. A hearth is shown in the drawings, but plain or step grates may be used and the blast applied through them.

It is preferable, when grates are not employed, to charge limestone or some equivalent into the gas-producer to flux the ashes or earthy constituents of the fuel, thereby producing a liquid slag which can be permitted at intervals to flow out of a tap-hole made in the stopping of the opening *c*.

The hearth is composed of sand in the form of a dish with a slight depression to the tap-hole, the temperature of its exterior being modified by the air from the blower I, which cools it. The diagonal tuyeres in the bridge G may be pierced through the tops and bottoms of the blocks or sections, and may be supplied by suitable air-channels, as well as through the sides or division-walls, as previously described; but I prefer the latter arrangement.

Heretofore in gas-furnaces the gas and air have been introduced to one another in a combustion-chamber, or in a series of combustion-chambers arranged at the neck of the gas-furnace, but in every instance that I know of the sectional area of the chamber allowed for the mixture of air and gas has been as great as or greater than the sum of the sectional areas of the gas-passage and the air passages or tuyeres, while in this my invention the sectional area of the passage or chamber for the mixture of gas and air is of the same sectional area as that of the gas-channel, whereby the gas and air are more intimately mixed, and the blast of the mixture is made equal to the sum of the blast of the air and of the gas, which blast is augmented and increased by the expansion incident to the combustion within a narrowly-confined space. The gas being separated into small volumes, the air supplied to each volume in jets, and the mixture confined under pressure, make a more perfect combustion than can be made in any other known way.

A gas-furnace is described in my English Patent No. 1,267, dated April 13, 1874, and in application 7,717, made by me 17th of April, 1880, and application 32,777, made by me May 5, 1881, for Letters Patent of the United States, in which the air supplied for generating the combustible gases, and the air for burning the said gases after their production, are simultaneously measured by means of two blowing-cylinders connected together; but there is no arrangement shown or described in that patent or either application above mentioned for producing an oxidizing-flame by use of an excess of air, or a reducing-flame by using less air than is required for perfect combustion; nor is there any means described for varying the operation of the apparatus when the fuel varies in composition.

The improvement herein described, according to which the blower or cylinder that supplies air to the gas-producer and the blower or cylinder that supplies the air for the combustion of the gases may be driven at variable speeds, enables the operator to produce a neutral flame with the highest temperature that can be attained practically by the precise amount of air for perfect combustion, with the capacity of obtaining an oxidizing-flame by supplying an excess of air, and also of obtaining a reducing-flame by supplying less air than is required for perfect combustion, and it also permits the variation of the air-supply when the fuel varies in character.

The combination of the fuel-chamber in the upper part of the gas-producer (which insures a regular supply of gases of uniform composition and temperature) with the gas-channels, with diagonal air-tuyeres arranged to burn the

gases under pressure by means of air preheated by the side walls of the fuel-chamber, and supplied in exact and measured quantities for the production of gas and for its combustion, produces a great economy of fuel, accompanied with great intensity of heat.

Having now described the nature of my invention and the system, mode, or manner in or under which the same is or may be used or carried out in practice, I would observe, in conclusion, that I do not claim merely the combination of a fuel-burning gas-generating chamber with a reverberatory furnace, nor the use of flues or spaces constructed within the walls of a furnace to cool the walls and to heat the air forced into the apparatus for the conversion of the fuel into combustible gases, and also to burn these gases therefrom at a separate outlet, nor the use of tuyeres for delivering air, heated or otherwise, for consuming the gases in their transit through an apparatus for metallurgical or other heating uses, nor the use of heated air or air under pressure for such uses, nor the fuel-chamber in the upper part of the gas-producer A above the gas-outlet B for drying and preparing the fuel for conversion into gas when tuyeres are employed as inlets for air, so as to burn the hydrogen by the heat developed in the lower fuel-chamber; nor do I claim in this patent the simultaneous measurement of the air supplied for generating the combustible gas, and for burning the said gas after its production, when blowing or measuring appliances capable of being operated at variable speeds are not used, nor the use of perforated chambers placed upon the fire-bridge or behind it, when combined with a steam-boiler furnace for supplying air to consume the smoke given off directly after fueling when bituminous coal is charged in thin layers upon an ordinary grate upon which the carbon of the fuel is directly consumed, such combination differing from mine in the respects that the smoke, under these circumstances, cannot be perfectly consumed without the employment of about four times the proper quantity of air, which should be admitted at times when there is no evolution of the volatile products of the fuel, whereas in the furnace hereinbefore described there is no sudden or unusual evolution of volatile products after charging fuel, and no more air is required for complete combustion at one time than at another.

In English Patent No. 1,267, A. D. 1874, a description is given of the invention made by me of the charging of "caustic lime" with the fuel in the gas-producer; but such lime requires to be prepared by burning limestone previous to use. The last part of the invention herein specified is based upon the discovery that limestone or its equivalent (such as blast-furnace cinder) can be advantageously employed in the gas-producer, thus obviating the necessity of the previous burning required for caustic lime.

I am aware that metallurgic furnaces have been made in which the gas has been introduced by a series of gas-channels and the air by a series of converging air-passages so arranged that the gas and air from the several passages are mingled and consumed in a combustion-chamber outside of the gas-passages.

What I claim, and desire to secure by Letters Patent, is—

1. The heating-chamber provided with a neck divided into a series of gas-channels of continuous sectional area, and with air-passages connected by diagonal air-tuyeres with the gas-channels a short distance from the discharge end of the gas-channels, whereby air from the air-passages may be forced into the gas-channels, substantially as specified.

2. The hollow block having an interior passage for gas of continuous sectional area and an external air-groove, and walls perforated from the external air-groove diagonally to the gas-channel at a short distance from the discharge end of the gas-channel, as specified and set forth.

3. The combination of the gas-producer, a blower for supplying air to the producer, a second blower for supplying air to burn the gas produced, and a furnace and adjustable mechanism for driving the two blowers at variable rates, substantially as specified.

4. The combination of gas-producer, a blower for supplying a measured volume of air to the producer, and a second blower for supplying air to burn the gas produced, and a furnace and adjustable mechanism for driving the two blowers, and mechanism for separating the air from the second blower into separate portions, and supplying the separate portions to the gas produced at successive stages of its combustion, as specified and set forth.

JAMES HENDERSON.

Attest:
CHAS. G. HEISER,
J. B. HYDE.