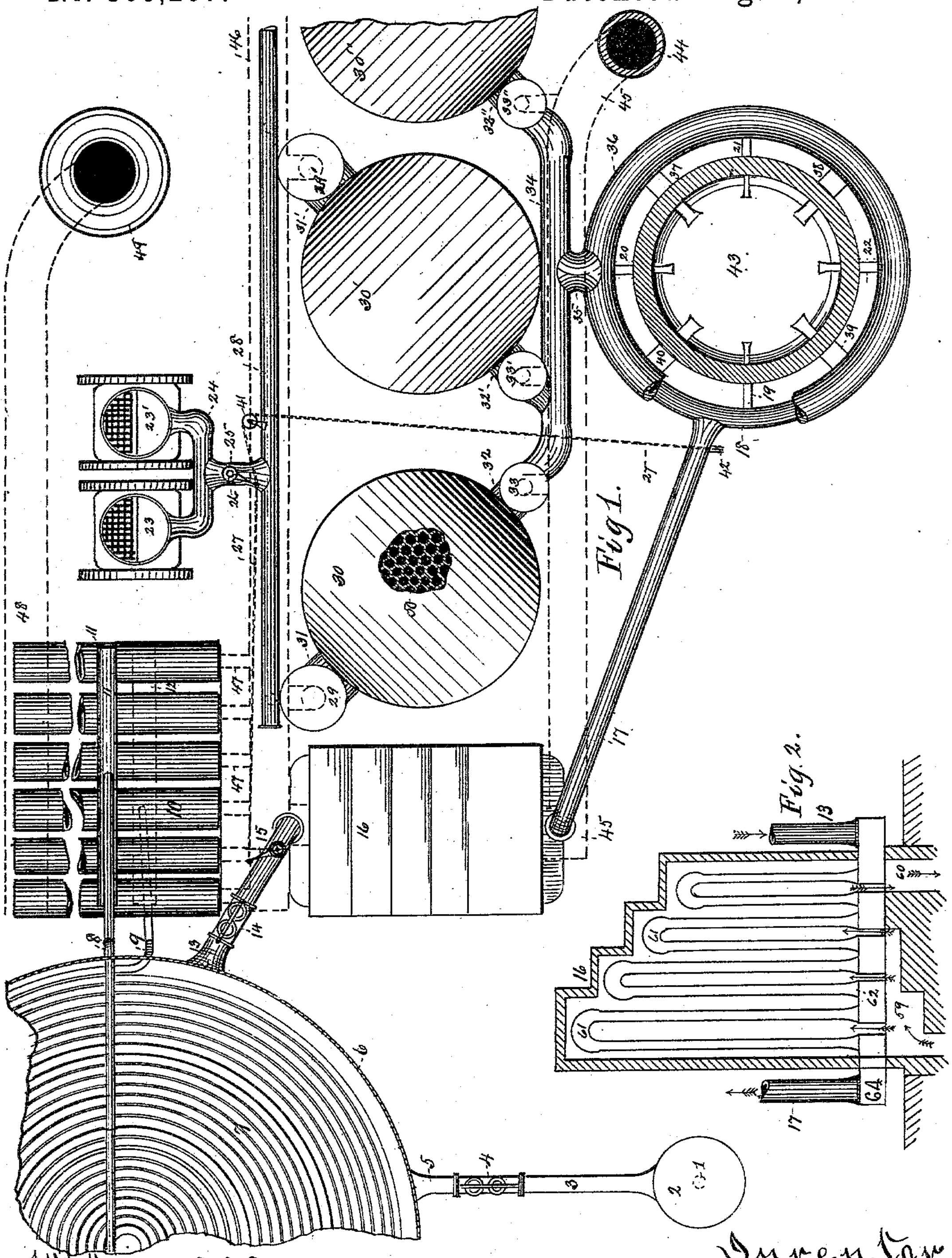
(No Model.) 2 Sheets—Sheet 1.

J. F. BENNETT.

BLAST FURNACE PLANT FOR USING GAS.

No. 303,207. Patented Aug. 5, 1884.



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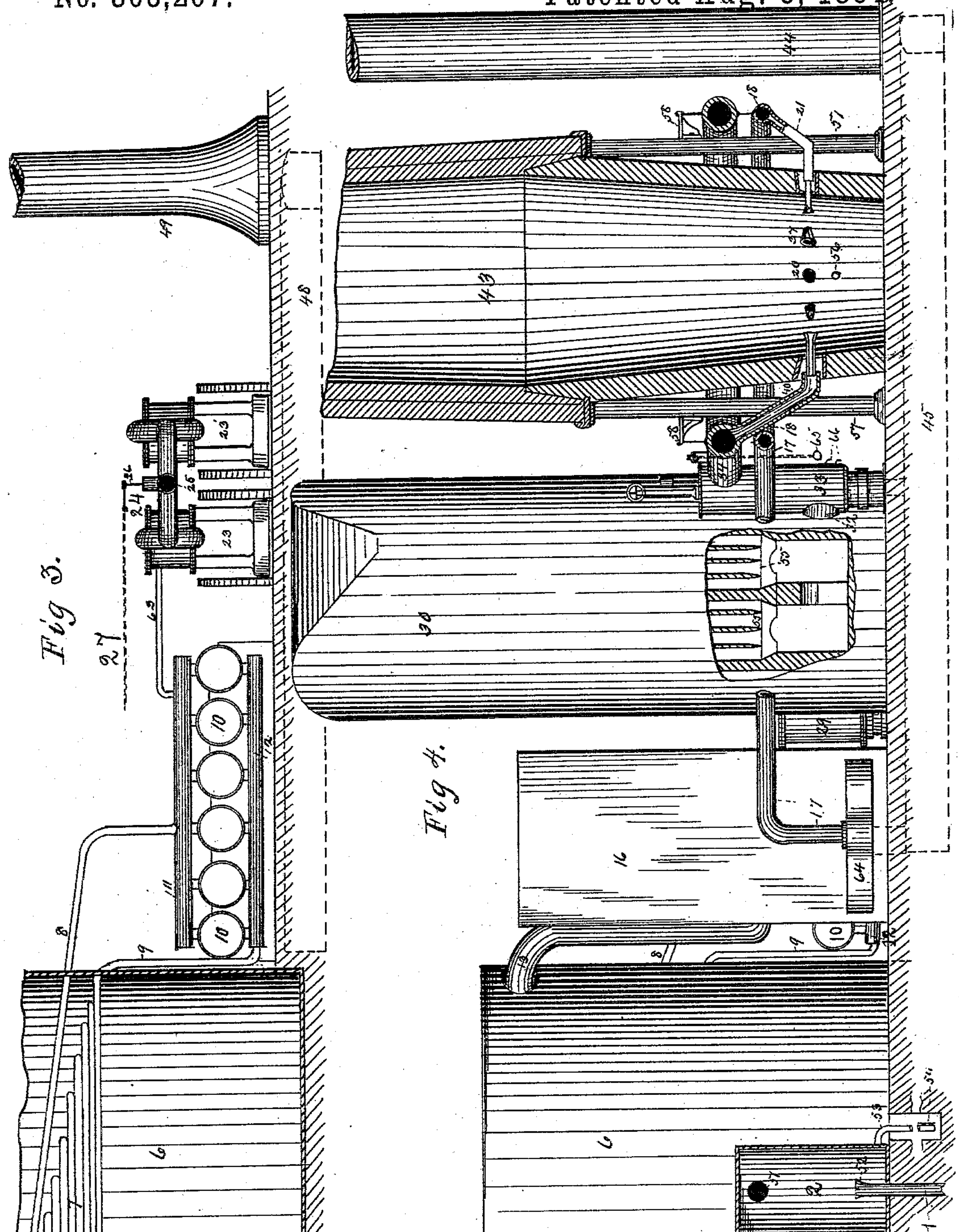

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UNITED STATES PATENT OFFICE.

JOHN FRANCIS BENNETT, OF PITTSBURG, PENNSYLVANIA.

BLAST-FURNACE PLANT FOR USING GAS.

SPECIFICATION forming part of Letters Patent No. 303,207, dated August 5, 1884.

Application filed December 12, 1883. (No model.)

To all whom it may concern:

Be it known that I, JOHN FRANCIS BENNETT, of Pittsburg, in the county of Allegheny and State of Pennsylvania, have invented certain new and useful Improvements in Blast-Furnace Plant for Using Gas; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form part of this specification.

My invention relates to the art of smelting ore in a blast-furnace; and the objects thereof are, first, to economize the cost of smelting by using wholly or partially natural or artificial gas as fuel; second, to effect a more rapid and less expensive reduction of the ore by improved means of securing approximately all the heating-power stored in the fuel; and, third, to accomplish these objects with simplicity of plant. I attain these objects by the plant shown in the accompanying drawings, in which—

Figure 1 is a plan view of my invention, showing the relative location and juxtaposition of the elements. Fig. 2 is a vertical section through the iron-pipe stove. Fig. 3 is an elevation, partly in section, showing the relation subsisting between the receiver, the boilers, the blowers, and the exhaust-shaft; and Fig. 4 is an elevation, partly in section, showing the relative location of the gas-well, the reservoir, the iron-pipe stove, the fire-brick stove, the blast-furnace, and its downcomer.

The same designations indicate corresponding parts.

1 is a pipe inserted in a natural-gas well, having its delivery end enlarged, as shown by 52.

2 is a reservoir collecting the gas. It is of such temperature as to assist the liquefaction of aqueous moisture suspended therein, and a tap, 53, is provided for its eduction. A pressure-regulator, 54, is connected with the reservoir. An exit, 51, connects the reservoir with the pipe 3, permitting the passage of the gas to a gas-holder, 6. A pressure-regulator, 4, is placed in the pipe, and its entrance 5 into the holder enlarged to facilitate the passage of the current.

7 is a foraminous floor, composed, preferably, of coils of pipe, which radiate to the circumference of the holder, starting from the steam-inlet pipe 8 and terminating in the eduction-pipe 9, which respectively connect with the upper drum, 11, and the lower drum, 12, of the steam-boilers 10. A pipe, 13, connects the top of the gas-holder 6 with the bottom of the iron-pipe stove 16, where the gaseous current is heated in transit to the blast-furnace. While this current traverses a vertically-increasing path through tubes enlarged, as shown at 61, and rounded, as shown at 62, to obviate obstruction to the passage, the waste gases from the blast-furnace, coming through downcomer 44, flue 45, and combustion-chamber 59, cross the stove in an opposite direction in a decreasing vertical path, thus heating the tubes, enter the passage 60, flues 47, part with remaining heat under the boilers 10, are thence drawn through the flue 48 by the natural draft of the chimney 49, and discharged to the atmosphere.

14 is a pressure-regulator in the pipe 13, and 15 is a valve therein, operated by a chain, 27, whose ring 65 is normally held on the hooks 66.

17 is a pipe conducting the heated gaseous current from the stove 16 to the bustle-pipe 18, whence it is delivered by tuyeres 19, 20, 21, and 22 to the blast-furnace, meeting at that point a heated-air current injected through bustle-pipe 36 and tuyeres 37, 38, 39, and 40, thus producing an intense heat.

23 and 23′ are blowers to compress atmospheric air. They are operated by steam from the boilers 10, delivered through pipe 63. The air is forced through pipes 24 26 28 into the fire-brick stoves 30 30′ 30″. A valve, 25, in the pipe 26 controls the feeding, and is operated, together with the gas-inlet valve 15, by the chain 27, so that the closure of the one is simultaneous with the opening of the other. This operation of the chain 27 is accomplished by changing the direction of applied force through pulleys 41 42.

46 is an underground main, which conducts the blast-furnace waste gases, after utilization, from the fire-brick stoves 30 30′ 30″ to the shaft 49, after passage through flues 47 48. These waste gases are received from the blast-furnace through downcomer 44, flue 45, and pipes 32 32′ 32″, which have two-way valves 33 33′ 33″ therein, so that they may traverse

the stoves 30 30′ 30″ entirely, depositing in transit their heat upon the hexagonal tubes 50, rounded, as shown at 55, whence it is afterward taken up by the atmospheric current, subsequently passing in a reverse direction from the pipe 28 through the two-way valves 29 29′, and discharged in a heated condition through the two-way valves 33 33′ 33″ into the hot-blast main 34, thence by connecting-pipe 35 to the bustle-pipe 36, and injected through tuyeres 37 38 39 40 into the blast-furnace 43, where the heated gaseous current is met, as before described. Brackets 58 are attached to the columns 57 to support the bustle-pipes, and the furnace is provided with suitable tuyere-holes and a slag tap-hole, 56.

59 is an entrance or combustion chamber to the iron-pipe stove 16, where the blast-furnace waste gases meet an air-current from a common regulator on the outside of the stove, (not shown in the drawings,) and thus intensify the heat they already possessed.

60 is an exit for the waste products of combustion, conducting them under the boilers through flues 47.

64 is a chamber receiving the heated gaseous current after passage through the stove 16, whence they are conducted to the furnace by main 17.

The natural gas rising from wells in the Pittsburg, Pennsylvania, district consists, chiefly, of one equivalent of carbon combined with four equivalents of hydrogen, a smaller portion consisting of two equivalents of carbon with six equivalents of hydrogen, and of a still smaller portion of free hydrogen, constituting together a percentage, by weight, of carbon sixty-five and of hydrogen thirty-five, if the aqueous moisture infinitesimally commixed therewith is not considered. The liquefied moisture varies according to the pressure and velocity of the gas, and averages six per cent., by weight. The carbonic-acid gas, being less than one per cent., is not sought to be removed, because of its comparative unimportance in this connection. The natural gas, being of the same temperature as its surrounding subterranean bed, approximates 75° Fahrenheit at a depth of fifteen hundred feet, and issues from the surface of the earth at about 50° Fahrenheit when at one hundred and fifty pounds pressure on the square inch. If it were then permitted to expand to a pressure of five pounds, its temperature would be lowered below the freezing-point of water, when any contained moisture would be converted into snow and check the progress of the gas from the reservoir; hence to obviate this the first step in my improvements is to reduce the pressure and remove the moisture. I cause the rising gas to flow from the well into a wrought-iron receiver, where a great part of the saline moisture over and above the six per cent. mentioned is deposited, liquefied, and whence it is educted. I convey the gas by suitable pipes into the vicinity of a blast-furnace, and thence by main or branch pipe into a reservoir or gas-holder, which I construct of sufficient capacity to contain a thirty minutes' supply for the blast-furnace of the usual type, which heretofore required twenty thousand cubic feet of air per minute. I make the gas-holder of about forty feet in diameter and thirty-two feet high, having a capacity of forty thousand cubic feet, or of such different size or shape as conduces most effectively to cause the deposition of moisture, and of sufficient strength to withstand the maximum expansion pressure of the gas. I make all the straight pipes to and from the receivers, gas-holders, stoves, and blast-furnaces bell-mouthed, as and for the reason explained in my Patent No. 298,657, granted May 13, 1884; and I construct all curved pipes with enlargement at the point of curvature, as and for the reason explained in my Patent No. 298,059, granted May 6, 1884.

In the branch pipe 3, which enters the gas-holder near the bottom, I place a regulator, 4, just before entrance to the gas-holder 6, so that the gas entering the holder is invariably of that pressure at which the regulator is set, whatever may be that on the other side thereof. The pipe 13 is attached near the top of the holder. A regulator, 14, is placed in this main to render more certain the pressure of the gas-blast.

Inside the gas-holder 6, I place at distances of six to eight feet foraminous floors, preferably of sheet-copper, suitably supported by the iron rods, which hold together and brace the walls of the gas-holder, so that the gas entering at the bottom may in its ascension come in contact therewith and prevent freezing, due to expansion, by heating these floors with steam; or it may be preferable, as shown in the drawings, to attain a sufficient temperature by forming these floors 7 of coiled steam-pipes 8 9, connected with the steam-boilers 10. This may be a pipe of one and one-half inch inside diameter, wall one-eighth inch thick, with a distance one-fourth inch between each layer, which would require seven thousand lineal feet to make one floor. The object is to partially obstruct the gas in the gas-holder during its ascension, and thus assist the liquefaction of the moisture mechanically suspended therein, thereby preventing its freezing into snow by the expansion from the volume due to the pressure in the pipe to the volume due to its emersion therefrom into the gas-holder, when it approximately has a pressure of five pounds, and is suitable to enter the furnace.

I attach thermometers to the gas-holders to indicate the temperature of the gas. To the bottom of the gas-holder a one-inch perpendicular pipe is attached, containing a pressure-regulator, (not shown on the drawings,) to tap water of condensation. A regulator admirable for this purpose, because its valve can be set to respond to any pressure, is described in Patent No. 209,602, granted to me November 5, 1878. By operating this apparatus I at once secure efficiency of the gas in the blast-furnace and attain equability of pressure. The desirable pressure of air-blast for the furnace being determined and indicated by pressure-gages (not illustrated) near the blowers, I set the two pressure-regulators 4 and 14 to correspond therewith. The blast-furnace 43 is provided with downcomer 44 and flue 45, conveying its waste gases to the stoves 30 30′ 30″ 16 and the boilers 10, as more fully described in my Patent No. 294,003, granted February 26, 1884, and application No. 107,253, to be patented August 5, 1884, and having all the pipes connecting the blast-furnace and blower constructed in accordance with the principle covered in my application No. 107,252, to be patented August 5, 1884.

The blower is made to accord with the plan described in my application No. 107,250, to be patented August 5, 1884.

The fire-brick stoves are preferably constructed as described in my application No. 107,251, to be patented August 5, 1884, with hexagonal tubes. These tubes have bell-mouthed entrances and exits, as described in my Patent No. 297,663, granted April 29, 1884.

The cast-iron-pipe stoves are designed after the principle shown in my application No. 107,256, to be patented August 5, 1884. It is desirable to preheat the stock before admission to the furnace, as explained in my application No. 107,254, to be patented August 5, 1884.

The air is blown into the furnace through suitable tuyeres, 37 38 39 40, and is heated mediately by passage through the fire-brick hot stoves, taking up the heat previously deposited in the tubes by the waste-gas current. The natural gas is heated in transit from the reservoir 6 to the furnace by traversing the iron-pipe stove 16, whereby simultaneously with its passage in one direction a waste-gas current crosses in an opposite direction, and is injected through tuyeres 19 20 21 22. The tuyeres admitting atmospheric air may be of any desirable area at the nozzles, which should extend so far beyond the inner wall of the furnace that the area of the furnace in that plane shall be equally divided—one part in front of the nozzles and the other between them and the wall. The tuyeres admitting the gas are of the same number, one-twelfth the area, and extended to the same circumference of the horizontal plane. The air and gas tuyeres are disposed in equidistant location on the circumference of the horizontal plane. Thus, if there are four tuyeres admitting air, having a nozzle diameter of eight inches and an area of 50.2656 square inches, those admitting the gas are four in number, with nozzle diameter 2.3 inches and area of 4.19 square inches.

To heat the air the Siemens fire-brick regenerative stoves are preferable, and for the gas the iron-pipe stoves, care being exercised to prevent leakage, not for fear of explosion, but on account of the disproportionate weights of air and gas fed under such circumstances. When for any reason the blast is shut off from the furnace, it is necessary there should be a simultaneous stoppage of the air and gas, which is effected by valves 25 and 15, respectively, in the pipes 26 and 14, which are so set that they are closed by the same operation of the chain 27, and opened automatically when the stress on the chain is released. The equivalents by volume of gas and atmospheric air, at a common temperature and pressure, respectively, in the gas-holder and at the blowers, are one of gas to 11.44 of air; but in order to secure complete combustion I prefer to force an excess of ten per cent. of air into the furnace. Throughout this specification I have calculated on this basis, taking also in account that the respective weights of air and natural gas are one and fifty-six. For example, in one hundred pounds 56.813 per cent. of the whole volume of air blown into the furnace will combine with the hydrogen of the natural gas, generate intense heat at the zone of fusion, form steam, and be useless for heating the stoves. 34.095 per cent. will combine with the carbon of the natural gas and constitute carbonic-acid gas, generate heat with increased rapidity, and therefore with greater intensity, at the zone of fusion than if it combined with solid carbon, and then transform into carbonic-oxide gas, which is highly useful to deposit heat in the stoves, and 9.092 per cent. will combine with .844 per cent. solid carbon fuel, form carbonic acid, generate heat, and change into carbonic-oxide gas, which is utilized in heating the stoves. The 43.187 per cent., by weight, of the air, having become carbonic-acid gas, consumes 3.722 per cent. of the solid carbon during deoxidation into carbonic-oxide gas. The total weight of the solid carbon transformed is 4.566 pounds. If solid fuel alone were used, the consumption thereof would be 17.47 pounds; hence, in proportion to the weight of air blown into the furnace, natural gas replaces 73.864 per cent. of solid carbon fuel, and it is therefore economical to use them jointly, in the manner stated, for the operation of the furnace.

Blast-furnaces that heretofore required two thousand five hundred pounds of carbon to produce a ton of pig-iron need now only 6.53 pounds thereof and a remainder of natural gas. This calculation omits consideration of the ashes, which vary with the proportion of impurities in the solid fuel of different districts, and also allowance for the extra deposition of carbon in the pig-iron, which may, however, be added to the weight of solid carbon charged, if necessary. From the great increase of intensity of heat in the zone of fusion there results a less weight (per ton of pig-iron) of fuel and a larger product of pig-iron. The currents of air and gas forced into the furnace mingle sufficiently to attain combustion before arrival at the ceiling of the zone of fusion, especially because assisted by the ten per cent. surplus of air. The hydrogen of the natural gas liquefies instantly upon combination with its equivalent of the air-blast, and, transforming into steam, is not serviceable for deposition of heat when traversing the stoves subsequently; but this disadvantage is more than counterbalanced by the beneficial effect of the concentrated intensity of heat generated upon combination in the zone of fusion, where such instant intensity of heat is of far greater importance than the same number of caloric units continued for a longer time. If by additional improvements in operating blast-furnaces a greater weight of solid carbon is requisite to generate heat for the stoves and boilers, or the necessity for preheating the gaseous current vanishes, or it becomes desirable to charge both the air and gas in a cold state to the furnace, it should be observed to retain a constant proportion of weight and pressure of the air and gas.

I do not restrict myself to the use of separately-placed tuyeres for the air and natural gas, as the gas may enter the furnace through a pipe or tuyeres placed in the middle of the air-blast tuyere; nor to the sole use of natural gas for this purpose, as it may be found economical either to use the natural and artificial gases jointly or entirely substitute the latter for the former without material changes in the effect produced.

By the term "artificial gas" is comprehended illuminating, producer, and water gases as obtained by the numerous processes and various means known in the art.

Heretofore natural gas has been utilized as a fuel in the reduction of iron ores. An interposed reservoir or boiler between the gas-well and the furnace served to deposit the moisture therein, either because of direct contact with the low or high temperature of the reservoir or boiler artificially induced, or because of the natural expansion of the gas due to its passage from a contracted to an enlarged area. These means have been inefficient in securing the end to be attained—the continuous, instantaneous, prolonged, and intense heating-power developed in the union of atmospheric air with dry gas. Any suspended moisture in the gas, when it reaches the furnace, proportionately delays and diminishes its effectiveness; also, the customary method of precipitating the aqueous moisture induces the congelation of the moisture and the formation of snow, which, because of lightness, does not spontaneously isolate, but remains in the current until liquefied in the proximity of the stoves and furnace. It will be observed that my apparatus is addressed to the careful manipulation of the gas so that these results shall be obviated. This I accomplish by indirect contact of the gas with a heated medium for the segregation of the moisture between the gas-well and furnace or preheating-stoves. Where there is direct contact of the gas with a heat-generator—as a boiler—there is a premature and sudden combustion induced which is unnecessary, and impairs its subsequent utility in the furnace in that ratio. Therefore I place the reservoir interposed between the well and the furnace in communication with boilers, so that there shall only be sufficient increment of heat imparted to prevent the formation of snow and crystals and secure rapid liquefaction without detracting from the efficiency of the gas in the furnace.

Having thus fully described my improvements, what I claim, and desire to secure by Letters Patent of the United States, is—

1. In combination with the tapping-pipe and holder, communicating boilers and pipe-flooring for diffusing the heat gradually.

2. The tapping-pipe, holder containing pipe-flooring, and boilers, in combination with the blast-furnace and intermediate preheating-stoves.

3. The blowers, regenerative stoves, and blast-furnace, in combination with the tapping-pipe, reservoir, holder containing pipe-flooring, and communicating boilers.

4. The tapping-pipe, accumulating-reservoir, holder containing pipe-flooring for diffusing a gradual and indirect increment of heat to the gas, and communicating boilers, in combination with preheating-stove, blast-furnace, regenerative stoves, and shaft.

In testimony that I claim the foregoing as my own I affix my signature in presence of two witnesses.

JOHN FRANCIS BENNETT.

Witnesses:

J. J. McCormick,

J. V. McCormick.