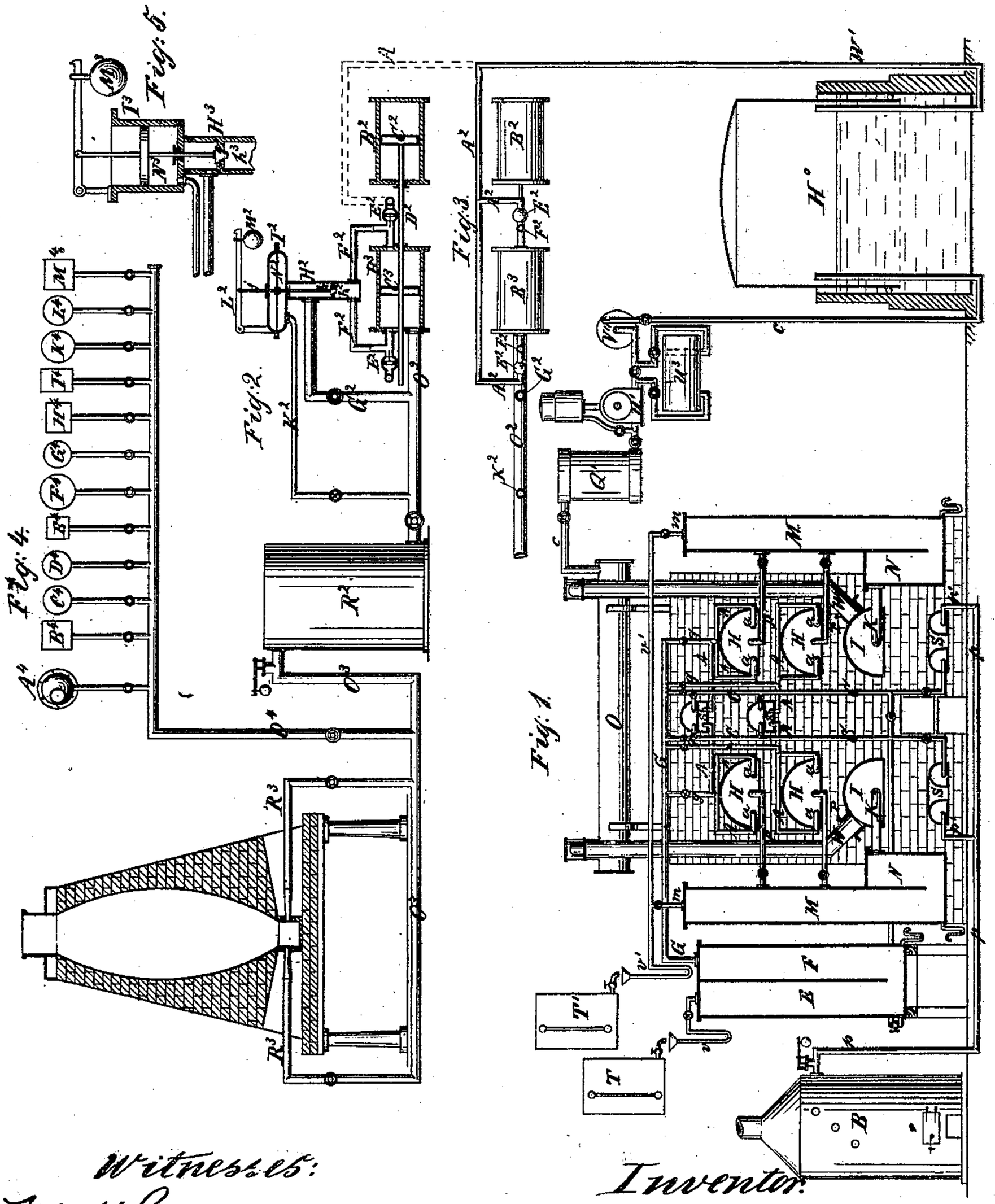
J. P. GILL.

TREATMENT OF MINERALS, ORES, &c.

No. 179,475. Patented July 4, 1876.



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UNITED STATES PATENT OFFICE

JOSEPH PEARSON GILL, OF NEWARK, NEW JERSEY.

IMPROVEMENT IN TREATMENT OF MINERALS, ORES, &c.

Specification forming part of Letters Patent No. **179,475**, dated July 4, 1876; application filed June 17, 1876.

To all whom it may concern:

Be it known that I, JOSEPH PEARSON GILL, of the city of Newark, in the county of Essex, and State of New Jersey, have invented certain new and useful improvements in the treatment and manufacture of minerals, ores, and metals, and manufactures of metals by the use of heating and illuminating gases, superheated steam and air, in combination with each other, or used alternately and in succession; and I do hereby declare that the following is a full, clear, and exact description thereof, which will enable others skilled in the art to which it pertains to understand and use the same.

My invention consists, first, in the direct application of hydrogen gas, either pure or with a small admixture of carbonic-oxide gas, and with air, as hereinafter specified, to the ores of metals, to minerals, and to metals in process of manufacture, and to manufactures of metals; second, in the application of hydrogen gas, either pure or with a small admixture of carbonic-oxide gas, to metals in the process of manufacture, to minerals, and to manufactures of metals, together with hydrocarbon vapors or carbureted-hydrogen gas, and with or without superheated steam; third, in the application of hydrogen gas, either pure or with a small admixture of carbonic-oxide gas, in the manufacture of metals, to minerals, and to manufactures of metals, in connection with hydrocarbon vapors, carbureted-hydrogen gas, and carbonic-acid gas; fourth, in interposing between the gas-holders and the blast, or other furnaces or forges, a gas-regulator, whereby the flow of the gas to the furnaces, &c., is regulated.

The apparatus referred to in the annexed drawing, and employed by me to produce hydrogen gas, either pure or with a small admixture of carbonic-oxide gas, (as retorts H,) to produce hydrocarbon vapors, (as vaporizers E F and M N,) to produce superheated steam, (as superheaters S and S′,) to produce carbureted-hydrogen gas, (as retorts I,) does not here require further description, it being the subject-matter of another application now pending in the Patent Office; but I do not confine myself to the precise forms there designated and described, claiming to use any forms of apparatus suitable for such purposes.

From the gas-holders, in which are stored the several gases named, I withdraw said gases by means of connecting-pipes and pumps, which are used to deliver the gas or air to the furnaces, or to other points, as may be required. The pumps may be either piston or rotary pumps, of any description suitable for the purpose, having an improved form of regulator attached to them for the purpose of automatically regulating the pressure-supply and distribution of the gas or air. The regulator is governed by the pressure in the outlet-pipe of the pump. This pressure is communicated by means of a pipe, K^2, to a flexible diaphragm, N^2, in a chest, I^2, Fig. 2, or a piston, N^3, in a cylinder, I^3, Fig. 5. The flexible diaphragm in Fig. 2 is connected by means of the rod *j* to a valve, h^2, and is weighted by a weight, M^2, on a lever, L^2. Another and larger pipe, G^2, connects the outlet-pipe O^2 of the pump with the chamber *h* of the regulator, above the valve h^2. The flexible diaphragm N^2 is weighted in any suitable manner, as by the weight M^2 or lever L^2, or by a spring or weights, or by steam or air pressure, to produce the pressure required in the outlet-pipe O^2. If the pressure in the outlet exceeds the required amount, it is communicated by means of the pipe K^2 to the diaphragm N^2, which rises, and in so doing opens or raises the valve h^2. The gas or air then returns through the valve h^2 by means of the pipe G^2 to the inlet of the air-cylinder, and the normal or required pressure is restored. If the pressure in the outlet-pipe O^2 falls below the required amount, the diaphragm N^2 or piston N^3 descends and closes, or partially closes, the valve h^2, thus reducing the backward flow of the gas or air through the valve, and thereby increases the pressure in the outlet-pipe O^2, restoring the given pressure. In this manner, no matter what is the quantity of the gas or air used, whether smaller or larger, up to the full capacity of the pump, the supply is maintained at a uniform pressure, which is fixed, or may be varied, to conform to the purpose required, by means of the adjustable weight on the flexible diaphragm or piston.

When gas and air are used simultaneously in this process, a regulating and distributing apparatus will be required for each.

I do not here restrict myself to the conical form of valve represented in the drawing, as attached to the movable diaphragm or piston, but employ any other suitable form of valve.

The delivery of the gases from each gas-holder is thus regulated, and the distribution maintained, either with or without receiver R^2, through pipes O^2 or O^3 to the tuyeres of a blast-furnace, as R^3, the inlet of a forge, as A^4, or to any other apparatus for the treatment of minerals, ores, metals, or manufactures of metals.

Suitable and special forms of apparatus for the purposes enumerated, and the uses thereof, form the subjects of further applications for patents therefor.

I employ the agents named—hydrogen, carbonic oxide, hydrocarbon gases and vapors, carbonic-acid or other acid gas, superheated steam and air, either hot or cold—separately and in combination with each other, in such quantities, under such degrees of temperature, and at such times, as are required by the articles under treatment, and the purpose intended to be accomplished, and apply them to the reduction of ores in furnaces and crucibles of all kinds, to the removal of mineral impurities, to the casting of pig-metal, to puddling, to the conversion of iron into steel or semi-steel, to the manufacture of malleable iron, to the production of a steel surface upon all manufactures of iron, to forges, to the welding of metals, and to the treatment of iron castings.

I make hydrogen gas pure, or with a small admixture of carbonic-oxide gas, cheaply, and in large quantities, by the apparatus and methods described in the application hereinbefore referred to, and its use in combination with the other agents named is attended with great economy, thoroughness, and expedition in the removal of sulphur, phosphorus, silicon, and other mineral impurities, in the deoxidation, carbureting, and the removal of carbon, and in the general treatment of minerals, ores, metals, and manufactures of metal. In the treatment of intractable materials and manufactures of wrought-iron and castings I secure a degree of perfectness and rapidity of execution which is not attained by any other known method.

Referring to the drawing, the hydrogen or heating gas is made in the retorts H, the carbureted-hydrogen gas in retorts I, and the superheated steam in retorts or superheaters S and S^1. This may all be done in one bench by passing the gas made in the different kinds of retorts to separate holders; or there may be separate benches of retorts for the manufacture of the different kinds of gases. The hydrocarbon vapors are made in the vaporizer E F, and I make the hydrogen gas acid by producing in the hydrogen retorts an excess of carbonic-acid gas, and pass the gas thus made into a separate holder without purification; or the gas may be made acid with sulphur or other negative element. Two or more holders are built, in which to store the different gases made and used in this process.

The principle of the method in the treatment of the different substances and for the different purposes named is essentially the same, although the results may be different in their character. First, I apply hydrogen gas to the reduction of metallic ores in the blast-furnace. When the ores are treated in the usual manner with anthracite coal and the air-blast they are deoxidized, and at the same time the iron is carbureted by the action of the fuel upon it. A cast-iron is thus produced which has to undergo a subsequent treatment for conversion into wrought-iron or steel. By my process with hydrogen, the ore is deoxidized without the iron becoming carbureted. The hydrogen being both the fuel and purifying-agent a pure iron is produced in the one process.

I admit the hydrogen gas into the blast-furnace by means of the tuyeres, and admit, at the commencement of the operation, sufficient air, either hot or cold, but preferably hot, to insure a thorough combustion of the gas, and bring the temperature of the furnace up to the melting-point of the ores. The air is then cut off, or partially so, in order to give an excess of hydrogen to act upon the ore, the heat being maintained and increased by the chemical union of the hydrogen and oxygen in the ore. The hydrogen unites with this oxygen, forming water, which passes out of the furnace with the other waste products of the treatment. It unites with the sulphur, forming sulphureted-hydrogen gas, with phosphorus, forming phosphoretted-hydrogen gas, with the carbon, when present, forming carbureted-hydrogen gases, which are consumed in the furnace, adding to the heat thereof, and so with the other earthy or mineral impurities in the ore. With proper care a pure article of iron is produced, which requires no further treatment, except to be manufactured. If requiring further treatment to render the operation perfect, the iron while hot may be run in a puddling-furnace or into a converting-furnace for further treatment under this method; or the melted iron may be run into molds and be allowed to cool, for such treatment thereafter as may be required.

Unless the hydrogen gas or a nearly pure hydrogen is made in very large quantities, and cheaply, this method of treatment is impossible, and, for want of such a cheap and rapidly-produced volume of hydrogen gas, this method or a similar one has been heretofore impracticable, all attempts being failures and all claims therefor being simply hypothetical.

By my method of manufacture and treatment the process is practically operative, and can be conducted on a large and useful scale.

In the puddling-furnace in which, by the present methods, cast-iron made in the blast-furnace is reduced to wrought or malleable iron by the use of the air-blast and carbonaceous materials for fuel—as coal, liquid hydrocarbons, or carbureted-hydrogen gases, or carbonic-oxide gases—the process is delayed, and is an involved one, the carbon in the burning fuel yielding carbon, which is the element in the iron to be removed by the action of the oxygen in the air or in the steam, when that is used; and, still further, the iron is partially oxidized through the use of the oxygen, which was the element removed in the blast-furnace.

With hydrogen as the purifying agent, I remove the carbon directly without any addition of it, and without any oxidation of the iron.

The hydrogen is admitted to the furnace and directly applied to the iron by means of tuyeres, properly located and inclined, air being admitted, when necessary, to insure the requisite degree of heat by the combustion of the hydrogen. The supply of air is then diminished, or cut off entirely, to give an excess of hydrogen, which unites with the carbon in the iron, forming carbureted-hydrogen gas, which, by the chemical union of the hydrogen and carbon, and by its combustion in the furnace, adds to and maintains the heat thereof. The hydrogen being greatly in excess, also combines with the oxygen of any air that may enter, forming water, which passes off with the other waste products of the operation, and prevents any oxidation of the metal. The carbon being thus removed, the iron is treated in the usual manner of a puddling-furnace. A similar operation takes place in the manufacture of malleable or wrought iron in crucibles of all kinds.

In the converting-furnace, in which cast-iron made in the blast-furnace is, by the present methods, converted into steel by the use of the hot-air blast and spiegeleisen or franklinite, I use the hydrogen in a manner similar to its use in the puddling-furnaces. It combines with the carbon in the iron, forming a carbureted-hydrogen gas, which, by its combustion in the furnace, intensifies the heat thereof. It also combines with the other impurities in the iron.

By the use of a proper quantity of the gas, which is ascertained by a gas-meter and by the appearance of the metal undergoing treatment, I decarburet the iron to any required degree, and produce a steel of any desired quality. The melting of spiegeleisen or other ores containing carbon, and the mixing of it with the iron in the converter, are thus avoided, and the expense and time required for the conversion are lessened.

I also apply the hydrogen gas to the treatment of iron castings, to soften and toughen their surfaces by reducing them to steel, semi-steel, or wrought-iron, thus giving them a surface which adds to their strength, and lessens their liability to breakage or fracture by an explosive force. The castings are first heated in a furnace to a temperature bordering on the softening-point, which is graduated by a pyrometer, when I admit a current of hydrogen, which unites with the carbon, reducing the surface, by the removal of the carbon, to the degree of softness required. To facilitate the operation, I admit a small quantity of carbonic-acid or other acid gas into the furnace, which, by its presence, gives energy and uniformity to the action of the hydrogen. I also employ it in giving surfaces of steel to wrought-iron manufactures, such as articles of rolled iron. Iron has the property of occluding or absorbing and retaining hydrogen in its pores. I therefore first treat such manufactures with a bath of hydrogen gas, which facilitates the subsequent combination of the carbon and iron. I also apply it to the roasting, separating, and reducing of ores containing other metals than iron, such as gold, silver, copper, &c., and in the treatment of such metals, its action in such cases being strictly analogous to that described above.

Second, in the application of hydrogen gas to metals in the process of manufacture, to minerals, and to manufactures of metals, together with hydrocarbon vapors, carbureted-hydrogen gas, and with or without superheated steam, and carbonic-acid gas. When the ore in the blast-furnace is thoroughly deoxidized by the action of the hydrogen, and iron in the metallic state is produced, I admit a blast of carbureted-hydrogen gas, either light or heavy, or a hydrocarbon vapor, for the purpose of carbureting it, and producing a steel or cast-iron of any desired quality. I proportion the quantity of the hydrocarbon to the quality of iron required. The quantity of carbon in the light and heavy carbureted-hydrogen gases, and in the hydrocarbon vapor, being known by analysis, and the quantity of it required by the iron to produce a steel containing from five-tenths to two per cent. of carbon, or a gray or white cast-iron containing as high as five per cent. of carbon, also being known, I admit the quantity of gas or vapor into the furnace which is requisite to supply the right amount of carbon to the iron.

As a less quantity of heavy carbureted-hydrogen gas, and a still less quantity of hydrocarbon vapor, contains as much carbon as a greater quantity of light carbureted-hydrogen gas, I further regulate the quantity of the hydrocarbon according to the kind used. In this manner I make a pure, or nearly pure, iron and steel, or cast-iron, of different qualities in the blast-furnace at the one treatment. I also use the hydrocarbons in regulated and definite proportions in the puddling-furnace, (in which cast-iron is being reduced to wrought iron,) for the production of steel, the required quantity of carbon being admitted to give to the iron the necessary percent-

age of carbon. By this method steel may be produced in the puddling as well as in the blast furnace, the principle of action of the agents being identical. I also use superheated steam as a purifying agent in the puddling-furnace. By its dryness, high temperature, agitating power, and supply of oxygen, it is a valuable aid, as is also carbonic-acid gas, in the treatment of the iron, in combination with the hydrogen gas, giving energy to the action and certainty to the results.

The action of the hydrocarbons and other agents in the treatment of iron in crucibles is analogous to the preceding.

In the converting-furnace I use the hydrocarbon gas or vapor, in combination with the hydrogen, to produce a steel of any desired quality. The carbon and other impurities in the cast-iron having been entirely removed by the action of the hydrogen and superheated steam, the hydrocarbons are admitted through the tuyeres in given proportions, as described, in treating of their use in the blast-furnace, to give to the iron the percentage of carbon required to produce the quality of steel wanted. The hydrocarbon under this treatment takes the place of the spiegeleisen in the ordinary treatment.

I use the hydrocarbons to give to the surfaces of iron-manufactures—such as railroad-iron and other manufactures—by rolling, a surface of steel. After treating the iron by a bath of hydrogen, as described in the treatment of such articles by hydrogen, I treat them in a hydrocarbon bath, the quantity of the hydrocarbon being proportioned to the amount of carbon required for combination with the iron. In this manner a surface of sufficient hardness is readily imparted to the iron.

By the addition of a larger proportion of carbon, and a somewhat longer continuation of the treatment, the wrought-iron is converted throughout into steel or cast-iron or malleable cast-iron. I also treat iron, for the purpose of giving it a surface of steel, or for conversion into steel or cast-iron, in gas-retorts or other suitable apparatus, by the decomposition of superheated steam and hydrocarbon vapors into hydrogen, as described in United States Patent No. 171,117, and in my application for patent filed June 6, 1876. The hydrogen thus made is used for heating purposes, or for the treatment of minerals and metals, as hereinbefore described.

In the application of the hydrocarbon gases and vapors, I use the lighter kinds, such as the light carbureted hydrogen for the treatment of iron requiring but a small percentage of carbon, and the heavier kinds, such as the heavy carbureted-hydrogen gas and hydrocarbon vapors for the treatment of iron, requiring a large percentage of carbon, such as hard steel and cast-iron.

By this process a very pure and superior quality of iron is produced, equal in quality to charcoal iron.

The special form of gas-regulator I do not here claim, that being the subject of another application.

Referring to the annexed drawing, Plate 1 is a view partly vertical and partly in plan of an apparatus, showing the connections between the several parts, consisting mainly of boiler, tanks, vaporizers, and a bench of gas-retorts, the outlets of which are in a downward direction from the bottoms of the retorts; purifying apparatus and gas-holder; also, an air or gas-pump having an automatic regulating apparatus attached, and a receiver, furnace, forge, &c.

Similar letters correspond to similar parts.

Figure 1 is a vertical view of the gas producing and storing apparatus, including the retorts in which the iron is treated. Fig. 2 is a vertical section of the air-pump with the regulating apparatus attached, receiver, and furnace. Fig. 3 is a plan of the air-pump, showing the connections. Fig. 4 is a view of pipes connecting the outlet of the pump with a forge; puddling, reverberatory, converting, annealing, malleable, and welding furnaces; furnaces for giving iron a surface of steel, for decarbureting the surfaces of iron castings; also a roasting-furnace, ore-separator, and metallic refinery with chemical laboratory. Fig. 5 is a section of cylinder and piston to substitute for the flexible diaphragm in the regulating apparatus.

Fig. 1—B indicates the boiler, from thence to W that indicates the stand-pipes leading from the retorts I. The apparatus shown in the drawing is referred to in my application for patent filed June 6, 1876. O indicates the hydraulic main. *c* indicates the pipe from hydraulic main O to condensers Q′. Q′ indicates the condensers. U^1 indicates the exhauster. U^3 indicates the purifiers. V‴ indicates the station-meter. H^0 indicates the gas-holder. W′ indicates the outlet-pipe from gas-holder.

Fig. 2—A^2 indicates the pipe leading from the holder to the air or gas pump B^3. B^2 indicates the steam-cylinder of the air-pump. C^2 indicates the piston. B^3 indicates the air or gas cylinder of the pump. C^3 indicates the piston. D^2 indicates the rod of the pistons. E^2 indicates the valves in the inlet-pipe A^2, opening inward. H^2 indicates the compensating-regulator. h^2 indicates the valve in regulator. F^2 indicates the pipes leading from chamber below valve h^2 to the inlet-pipe A^2 of the pump. I^2 indicates the chest containing the flexible diaphragm N^2. N^2 indicates the flexible diaphragm. *j* indicates the rod connecting the flexible diaphragm with the valve h^2 and lever L^2. L^2 indicates the lever. M^2 indicates the weight on the lever. O^2 indicates the outlet-pipe from the air or gas cylinder B^3 to receiver R^2. R^2 indicates the receiver and its safety-valve, which receives the gas or air from the pump. O^3 indicates the pipe leading from receiver R^2 to the tuyeres R^3 of a furnace, inlet to a forge, or to any other apparatus

for the treatment of minerals, ores, metals, and manufactures of metals. K^2 indicates the pipe leading from outlet-pipe O^2, to communicate the pressure therein to the flexible diaphragm N^2 in chest I^2 of the automatic regulating apparatus. G^2 indicates the pipe leading from the outlet-pipe O^2 to the chamber *h* above the valve h^2 of the regulating apparatus, for the return of the gas or air to the inlet of the air or gas cylinder when the valve h^2 is open. O^4 indicates the pipe leading from the outlet-pipe O^3 from the pump to the connecting-pipes of different kinds of furnaces, &c.

Fig. 5—I^3 indicates a cylinder. N^3 indicates a piston to take the place of the flexible diaphragm in the regulating apparatus. h^3 indicates the valve. M^3 indicates the weight.

I am aware that it has been heretofore suggested to consume hydrogen gas in furnaces, in combination with atmospheric air or carbonaceous substances, as a fuel, the atmospheric air acting, so far as appears, to supply an amount of oxygen to combine with the whole of the hydrogen. I am also aware that pure hydrogen has been suggested for treatment of castings, to decarburet their surfaces, and also, in connection with other substances, to anneal and toughen.

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

1. In the reduction of ores and treatment of molten metals, the direct application of hydrogen gas, either pure or with a small admixture (less than ten per cent.) of carbonic oxide, and without the presence of any other fuel or purifying agent, said hydrogen gas being applied at the beginning of the process with a supply of atmospheric air to produce full combustion of the hydrogen, but subsequently with an excess of hydrogen, as and for the purpose set forth.

2. The direct application of hydrogen gas in succession, the hydrogen being applied first in order, in connection with hydrocarbon vapors or carbureted-hydrogen gas, and either with or without carbonic-acid gas and superheated steam, in the manufacture of steel and cast-iron or malleable cast-iron from iron, or in the process of giving a steel surface to articles of wrought-iron, substantially in the manner as herein described, and for the purpose set forth.

3. A gas-regulator, substantially such as is described, interposed between the gas-holders and the blast or other furnaces or forges, as set forth.

4. The direct application of hydrogen gas, either pure or with a small admixture (less than ten per cent.) of carbonic oxide, and with a small percentage of carbonic acid, and with or without superheated steam, to articles of cast-iron, said articles having their surfaces wholly exposed in a heated chamber, as and for the purpose set forth.

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

JOSEPH PEARSON GILL.

Witnesses:

JOSEPH W. BEATLEY,

WM. H. GRENELLE.