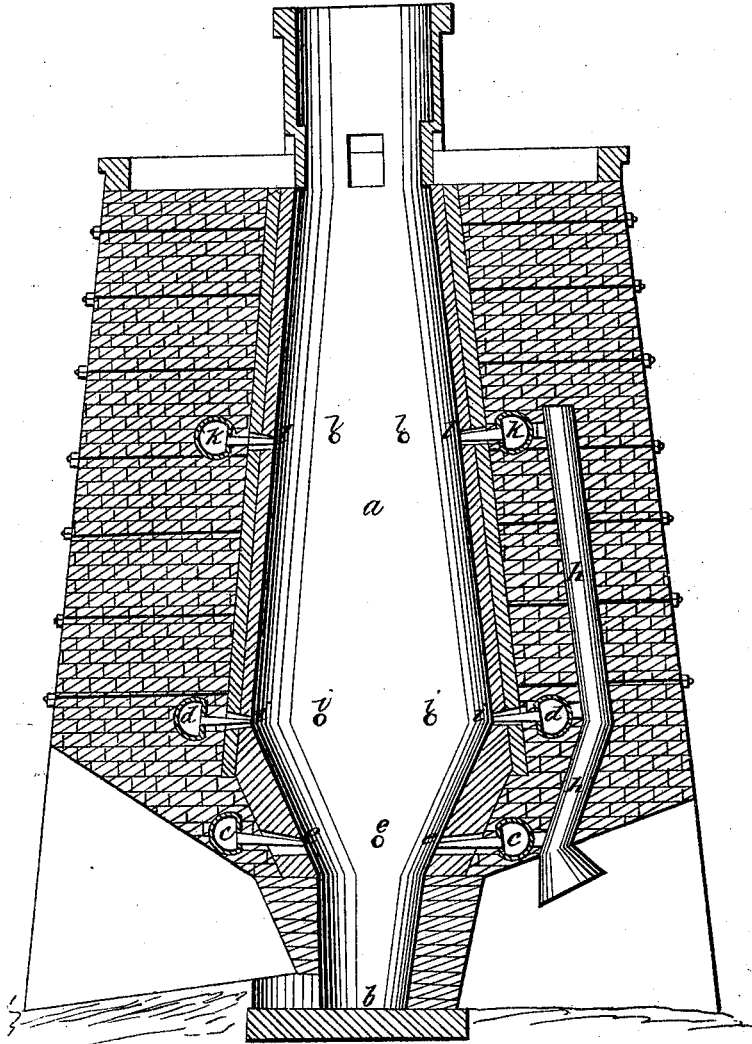


J. F. BENNETT.

Blast Furnace.

No. 53,104.

Patented Mar. 13, 1866.



Witnesses:

W D Lewis
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Inventor:

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UNITED STATES PATENT OFFICE.

JOHN F. BENNETT, OF PITTSBURG, PENNSYLVANIA.

IMPROVED MODE OF RAISING HEAT BY THE COMBUSTION OF FUEL OF VARIOUS KINDS.

Specification forming part of Letters Patent No. **53,104**, dated March 13, 1866.

To all whom it may concern:

Be it known that I, JOHN F. BENNETT, of Pittsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improved Mode of Raising Heat by the Combustion of Fuel of Various Kinds; and I do hereby declare the following to be a full, clear, and exact description thereof.

The principle which I have discovered is applicable to various purposes in the arts and manufactures, and is calculated to produce an entire revolution in the construction and plan of operation of furnaces of all descriptions; and in order to enable others skilled in the various arts and manufactures to use my said invention in its practical application thereto, I will proceed to describe and illustrate my invention as adapted to the generation of heat in a blast-furnace, and in so doing shall show its application to the present form of blast-furnace, although, as I believe, and shall hereinafter explain more fully, a change might be advantageously made in the construction of the blast-furnace which would better adapt it to the manufacture of iron, and enable it to be made direct from the ore in a condition for casting, molding, or rolling without the intermediate processes of puddling and boiling.

Before describing particularly the practical application of my invention (by way of example) to a blast-furnace I will state briefly the principles of natural science on which it depends.

Most of the known elements are metals, and are capable of combustion when entering into combination with oxygen, the degree of heat evolved depending upon the atomic proportions or quantity of oxygen with which they are respectively combined. For example, the metal manganese exists in six states or conditions, namely: deutoxide, protoxide, the metal cold, (which are solids,) the metal boiling, (fluid,) and protacid and deutacid, (which are gases.)

The process of combustion resulting from the combination of metals with oxygen consists of distinct operations, which fact forms the basis of my discovery, by the use of which any required degree of heat may be attained, limited only by the capacity of the metallic case for heat, and the capability of the material of the furnace in which the operation is conducted to resist fusion. Thus, suppose the

metal manganese cold or solid at 0° Fahrenheit, to make it boiling a certain degree or amount of heat must be added, which done, another certain amount of heat must be added to make this boiling fluid a protacid gas, and, again, another certain amount of heat must be added to convert the protacid gas into a deutacid gas. These various steps or stages of condition are attained by the access of successive amounts or degrees of heat, which accession of heat is in each case to be effected by causing atoms of oxygen to impinge upon the subject under treatment, in its various stages of deutoxide, protoxide, the cold metal, the boiling metal, the protacid, and the deutacid, successively, and the chemical combination with the oxygen effecting the required change of condition in each instance. It is evident, however, that two atoms of oxygen could not be made to impinge so violently on the solid or cold metal as to cause them to combine. The metal must first be brought into a condition to receive the oxygen into combination, which is done by heat, artificially applied, to raise the metal to a boiling-point, when, the oxygen gas finding the metal becoming vapor, can impinge upon it so violently as to cause it to combine with the evolution of one stage of heat; but even thus the two atoms of oxygen cannot simultaneously and together combine with the rising metallic vapor, but first one atom of oxygen combines with one atom of the metal, forming the protacid of the metal, a distinct body, as separate and different from all other conditions of the metal as the oxide of the metal is from its base, or from its vapor, or from its deutacid. If, however, we cause another atom of oxygen to be impinged upon the atom of protacid gas, (as it is nascent, and before it has lost the heat which it has evolved,) this second atom of oxygen gas combines with the protacid and forms deutacid gas, with the evolution of one additional stage of heat. Thus, then, we have illustrated three stages of heat, viz: first, from the metal solid and cold at, say, 0° Fahrenheit, up to the metal boiling and becoming vapor; second, from the metal as a vapor to its combination with one atom of oxygen and becoming protacid gas; third, from the protacid gas to its combination with one atom of oxygen and becoming deutacid gas, each change producing an additional stage of heat, and here, at the third stage, the height of

the heat that can be possibly attained terminates, because the deutacid gas is not capable of combining with another atom of oxygen gas, but has reached its highest stage of oxidation. Each of these stages of heat is 2,700° Fahrenheit. The metal being at 0° Fahrenheit becomes vapor at 2,700° Fahrenheit. The vapor becomes protacid gas at 2,700° Fahrenheit plus 2,700° Fahrenheit or 5,400° Fahrenheit above the metal at 0° Fahrenheit, and the protacid gas becoming deutacid gas at 2,700° Fahrenheit more, or 8,100° Fahrenheit above the metal at 0° Fahrenheit, and this degree of heat, (8,100° Fahrenheit,) as before stated, is the highest heat which this atom of metal is capable of evolving, because it is incapable of receiving any more oxygen; but the elevation thus attained affords a stepping-stone for the attainment of still higher degrees of heat, for, commencing again with the deutacid gas at 8,100° Fahrenheit, and causing it to pass through or impinge upon particles of hot solid metal, (its own metal or any other,) heated to the same degree as itself, we thereby deoxidize the deutacid gas one stage, reducing it to protacid gas of 8,100° Fahrenheit, and then cause to be impinged upon it another atom of oxygen, when they will combine, forming again the deutacid gas and evolving an additional stage of 2,700° of heat, and giving a total result of 10,800° Fahrenheit, and so on, *ad infinitum*, in theory, but limited, as before stated, to the capacity of the furnace or crucible to resist the degree of temperature to which it is exposed.

I will now proceed to explain the mode of applying this general law to the manufacture of iron in a blast-furnace, referring to the accompanying drawings, in which—

Figure 1 represents an exterior view, and Fig. 2 a vertical section, of a blast-furnace of ordinary shape and general construction, but so altered as to adapt it to my improvement.

In the drawings, *a* is a blast-furnace; *b*, the hearth. *c* is a circular pipe, communicating the blast (either hot or cold) to the interior of the furnace through the tuyere-pipes *e e*, &c. At a height of six feet (more or less) above the circular blast-pipe *c* is another circular blast-pipe, *d*, similarly constructed to the lower blast-pipe, *c*, and from the upper pipe, *d*, a number of tuyere-pipes, *i i*, &c., enter the chamber of the furnace. These blast-pipes and tuyere-pipes may be repeated at regular intervals, so as to admit the blast into the chamber of the furnace at different heights, and be connected with a common duct or passage, *h*, for the admission of the blast.

The blast-furnace *a* is charged with charcoal or coal and iron ore, in the usual way, and, being lighted at the lower end, above the hearth, and the blast of air being introduced through the tuyere-pipes *e e* and *i i*, the operation is as follows: Supposing the blast to be cold atmospheric air at the ordinary temperature—say, 60° Fahrenheit—and the contents of the furnace, before ignition, to have

been at the same temperature, then, when the furnace is started, one atom of the oxygen of the air-blast acts upon the charcoal or carbon in the furnace, producing carbonic oxide at, say, 2,700° Fahrenheit. Then another atom of oxygen enters into combination with the carbonic oxide, producing carbonic acid and evolving a heat of, say, 5,400° Fahrenheit. The carbonic acid at 5,400° Fahrenheit then acts upon the iron ore and reduces it to a metallic state, causing it to run down into the hearth of the furnace, and also acts on another atom of carbon (of the fuel) at a more elevated point in the furnace—say, six feet higher up—and is thereby reduced in temperature by its conversion into carbonic oxide of 2,700° Fahrenheit, but of double the volume or quantity. At this point a fresh blast of atmospheric air is introduced through the upper tuyere-pipes, *i i*, and the result is as follows: The upper stratum of carbon, being heated by the carbonic oxide to 2,700° Fahrenheit, combines with one atom of the oxygen of the upper blast and produces carbonic oxide of 5,400° Fahrenheit, and then immediately combines with another atom of oxygen, and the result is carbonic acid of 8,100° Fahrenheit. This carbonic acid at 8,100° Fahrenheit then acts upon the iron ore, reducing it to a metallic state, and is reduced thereby to carbonic oxide at 5,400° Fahrenheit. If a third blast of cold air be now introduced at another stage or station of the furnace—say, twelve feet above the hearth—the heat will be similarly increased still further. The carbonic oxide at that point, already raised to 5,400° Fahrenheit, having raised the carbon or charcoal to the same degree of temperature, one atom of oxygen enters into combination with the carbon at 5,400° Fahrenheit and produces carbonic oxide at 8,100° Fahrenheit, and then, immediately combining with another atom of oxygen, produces carbonic acid of 10,800° Fahrenheit. This carbonic acid then acts upon the iron ore and reduces it to metallic iron, which runs down into the hearth, while the carbonic acid, trebled in volume, combining with one atom of carbon, is reduced to carbonic oxide at 8,100° Fahrenheit, and by repeating the blast of air at a short distance still farther up, the heat may be raised to 10,800° Fahrenheit, and so on *ad libitum*.

The figures given to represent the degrees of heat produced may not be absolutely correct, but are given as approximations; and in practice the heat could not be raised so rapidly, because some heat would be lost by the heating of the impurities of the iron ore or other metal to be acted on, by the heating of the walls of the furnace, and of the cold carbon, in order to bring it up to one stage of heat until it is capable of becoming carbonic oxide, and of the carbonic oxide produced at the lower stages of the operation, and of the nitrogen of the atmospheric blast. Nevertheless, the result attained, notwithstanding the necessary amount of lost heat, would be a

very rapid and continually-increasing elevation of temperature, susceptible of indefinite augmentation within the limits of the capacity of the furnace to resist fusion.

In the application of my invention to the description of furnace ordinarily used, where the fire is lighted at the bottom, it is obvious that the heat would be greater in the upper than in the lower part of the furnace, and, consequently, the iron produced in the lower part would mingle with that from the upper part, which, having been exposed to a much higher degree of heat, would be purer. I therefore would prefer to light the furnace at the top and introduce the blast there first, so as all the metal would pass through the hottest part of the furnace.

In order that the principles on which my improvement is based may be better understood, I will give another illustration.

Let fire be lighted in an ordinary reverberatory furnace, with coal as fuel. If properly managed the total and highest heat raised will be 5,400° Fahrenheit, and the product carbonic-acid gas of two stages of heat or 5,400° Fahrenheit, as before. Now, suppose the bed of the furnace to be unoccupied. Let us build at the end of it farthest from the fire a wall of loose coal, and by draft, or otherwise, compel the carbonic-acid gas to pass through this wall of coal until the coal is raised to the same temperature—5,400° Fahrenheit—and then continue to cause the hot carbonic acid to pass through the coal into another chamber beyond it. The carbonic-acid gas in passing through the coal becomes partially deoxidized, losing one atom of oxygen, and becomes carbonic oxide of 5,400° Fahrenheit, and in that state capable of combining with one atom of oxygen, and thus evolving an additional stage of heat, 2,700° Fahrenheit, thus producing the result of carbonic acid at 8,100° Fahrenheit. Let us now introduce into this second furnace-bed, beyond the first wall of coal, another atom of oxygen, and the result is carbonic acid of 8,100° Fahrenheit, capable of being applied to the reduction of any metal or metallic ore, or of being passed through another wall of coal and increased to the next stage of heat, and so on *ad libitum*. Now, let us suppose the crystalline Lake Superior or Missouri iron, improperly called iron ore because it has evidently been pure iron in a metallic state once fused and crystallized in cooling. It requires the same degree of heat that it lost in cooling to be again applied to fuse it. This degree is not known, but may be supposed not to exceed 5,000° Fahrenheit, inasmuch as the combination of iron and carbon will melt, as cast metal, at 2,800° Fahrenheit or thereabouts. Let this

crystal metal be placed on the first bed of the furnace just described, in which is present carbonic acid of 5,400° Fahrenheit, and it would require a very long time to reduce it to a melted state; but let it be put in the second furnace-bed and heat it to a bath of carbonic acid of 8,100° Fahrenheit, and it will rapidly become fused.

In reducing a metal, a bath of carbonic acid would be proper; but for an ore or oxide of a metal carbonic-oxide gas would be the bath. Now, suppose we desire to reduce the ore alumina to its metallic state and produce aluminum by my process. At present its melting state is not known. But suppose the ore alumina placed in a bed of the furnace before described, heated to the third stage, or 8,100° Fahrenheit, and there subjected to a bath of carbonic oxide of that temperature. If not reduced by that treatment it would be removed to the next hotter furnace-bed, heated to the fourth stage, or 10,800° Fahrenheit, and there subjected to the action of carbonic-acid gas of that degree of heat, and so on until a bath of the requisite temperature was obtained which would convert the ore into metallic aluminum.

The same treatment, with a like result, would answer for the ores of nickel and other metals.

It is probable that no known metal would require a higher degree of heat than this fourth stage—10,800° Fahrenheit—to melt it, and the metals at their respective boiling or vaporizing points would themselves become fuels.

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

The mode hereinbefore described of producing any required degree of heat for the reducing of metallic oxides, or for other purposes in the arts where high temperatures are required, by introducing two or more blasts of oxygen or atmospheric air, (either hot or cold,) at such different points in the furnace as that a fresh supply of oxygen shall be introduced at or a little beyond or above the point at which the gaseous deutoxide or acid gas, produced by the first supply of oxygen, has been reduced to the gaseous protoxide or oxide-gas, by the chemical combination of one atom of the oxygen of the gaseous deutoxide with the element used as fuel, and thus, by a series or successions of combustions, continually adding to the heat produced by the first combustion, substantially in the manner and for the purposes hereinbefore described.

In testimony whereof I, the said JOHN F. BENNETT, have hereunto set my hand.

JOHN F. BENNETT.

Witnesses:

ALLAN C. BAKEWELL,
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