(No Model.) 2 Sheets—Sheet 1.

J. F. BENNETT.

BLAST FURNACE STOVE.

No. 303,208. Patented Aug. 5, 1884.

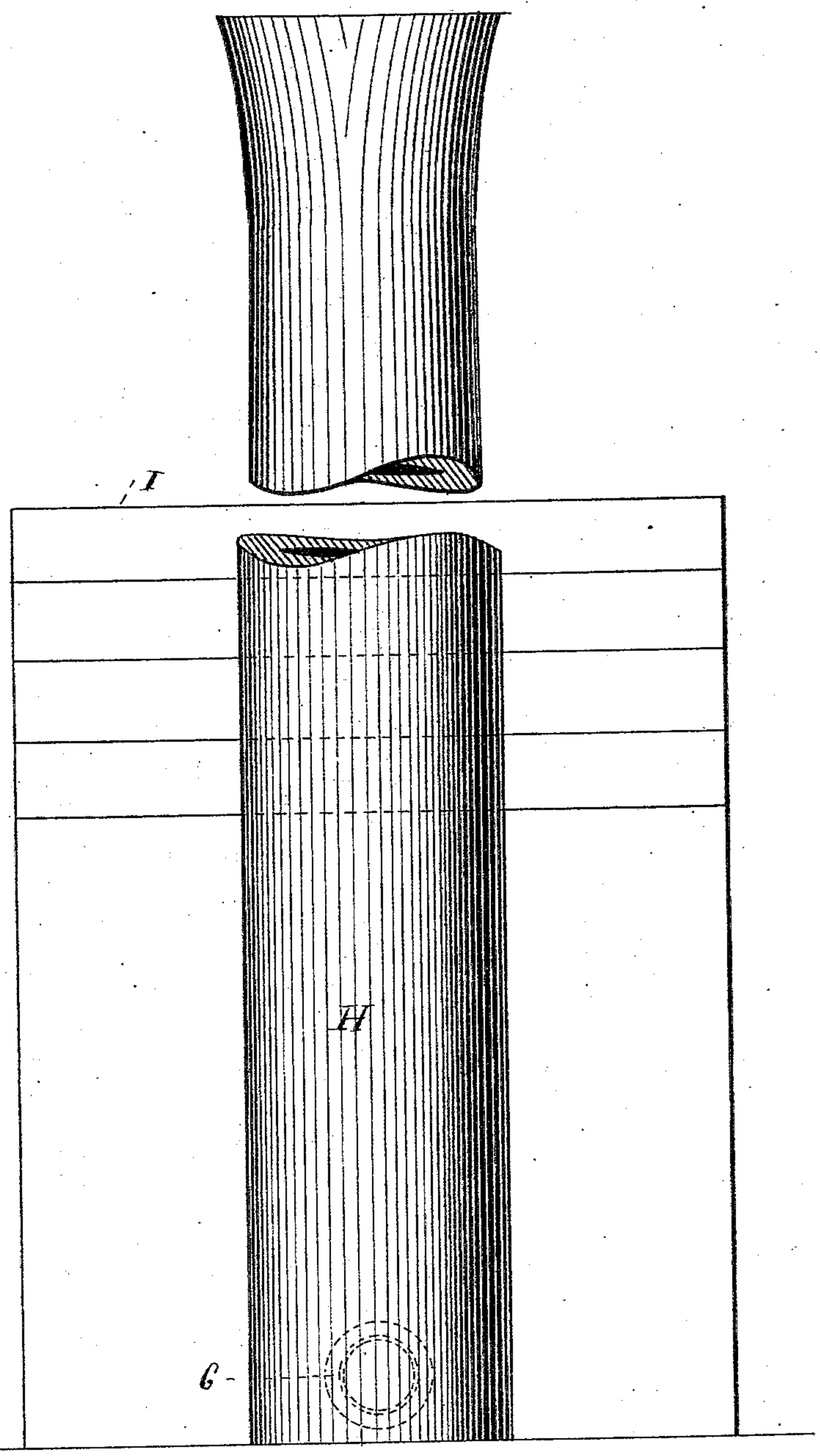

Fig 1.

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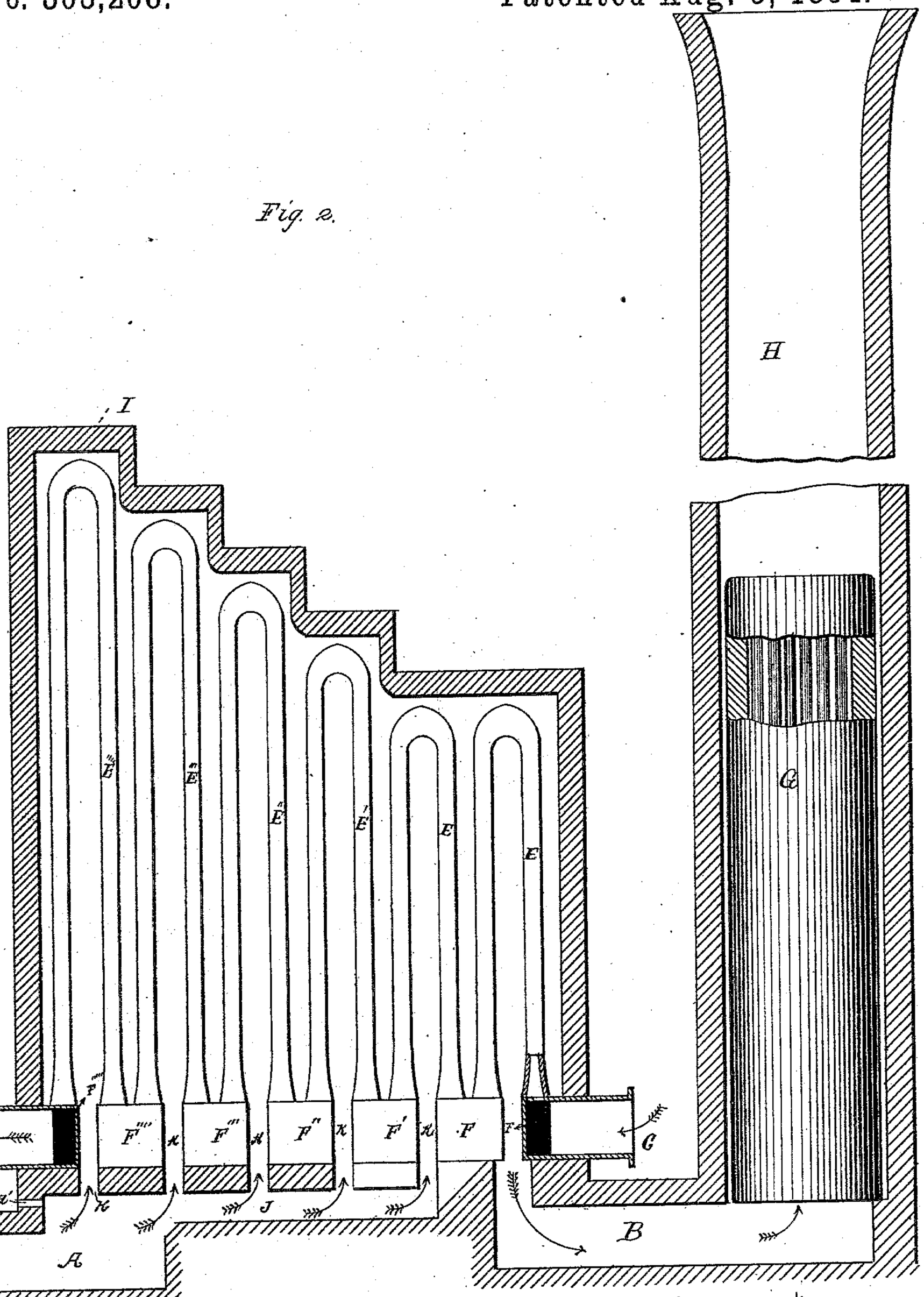
Fig. 2.



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UNITED STATES PATENT OFFICE.

JOHN F. BENNETT, OF PITTSBURG, PENNSYLVANIA.

BLAST-FURNACE STOVE.

SPECIFICATION forming part of Letters Patent No. 303,208, dated August 5, 1884.

Application filed September 24, 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 Stoves; 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 improvements in blast-furnace iron-pipe stoves in which two currents of air or gas are permitted simultaneously to pass through the stove in opposing directions; and the objects of my improvements are, first, to facilitate the passage of the air by shaping the ducts so as to offer the least resistance thereto; second, to provide an increasing or decreasing vertical path for the heating-gases, according to the direction being pursued; third, to deprive the waste gases of approximately all their heating-power by causing their successive contact with air-pipes in the stove and with a boiler to generate steam; fourth, to attain these objects with the maximum simplicity of construction. I attain these objects by the means illustrated in the accompanying drawings, in which—

Figure 1 represents an elevation of the plant, the view being taken from behind the chimney. Fig. 2 is a longitudinal section of the same, partially broken to show construction.

Similar letters refer to corresponding parts in each view.

A represents a duct admitting the hot gases from a furnace or other source to a stove.

A′ is a valve-box in which a slide-valve reciprocates, thereby conveying atmospheric air to meet the hot gases, insuring combustion in the chamber J.

B is a passage leading said gases, deprived partially of their heat by contact with the pipes and the walls of the furnace, to the chimney H, in the bottom of which is located a steam-generator, to deprive the gases of any heating-power remaining in them. It is obvious, however, that the boiler might be placed elsewhere with equal efficiency, provided its location is somewhere between the exit of the hot gases from the stove and the chimney.

C is the entrance of an iron pipe conducting cold or atmospheric air to the stove, and D is the exit for this air, heated by traversing the iron pipes E E E′ E″ E‴ E⁗ and their connecting-boxes F F′ F″ F‴ F⁗ F⁗′.

I represents the outer walls of the furnace, which I so construct that the roof gradually increases in height as it approaches a perpendicular to the inlet A. I regulate this vertical enlargement by the increasing height of the iron pipes E E′ E″ E‴ E⁗, preserving in each case the same distance between the top of the iron pipes and the roof-wall of the furnace. The iron pipes E E, being of the same altitude, are covered by portions of the roof in the same horizontal plane; but each of the other pipes is covered by portions thereof in different planes.

When I use this stove singly, in connection with blast-furnaces, I make the pipe C of a diameter equal, approximately, one-half of that of the blower-exit; when two are needed, about one-fourth; and for three, about one-sixth. I construct each of the boxes F F′ F″ F‴ F⁗ F⁗′ of an area equal to that of the pipe C. From the first box F the air is forced by the blower into the first pipe E, and then successively into the second box F, second pipe E, box F′, pipe E′, box F″, pipe E″, box F‴, pipe E‴, box F⁗, pipe E⁗, box F⁗′, and out through iron pipe D. I make the entrances and exits of the iron pipes E E E′ E″ E‴ E⁗ greater than the bodies of the respective pipes by approximately fifty per cent. The slope of this increase on the two ends of each pipe extends for about two diameters of the pipe. I prefer to make these entrances and exits oblong with flat sides, about sixteen by four inches, rather than round of a diameter of eight and five-tenths inches, these two having the same area. Near the top of the pipes E E E′ E″ E‴ E⁗ I gradually increase the diameter until at the crown the area is fifty per cent. greater than that of the body of the pipe. Usually I place forty-eight pipes in each stove and six boxes. Pipes E E, I generally give an altitude of twelve feet, and leave a space of about six inches between the outer surface of the top of the pipe and the inner surface of the furnace-roof wall. The pipes E′ E″ E‴ E⁗ are then made to have re-

spective heights of fourteen, sixteen, eighteen, and twenty feet, and an equal space between their crowns and the roof of the furnace. The inlet and outlet air-pipes C and D are made of areas equal to the box F. The inlet-pipe A terminates in a combustion-chamber, J, combustion being assisted by the atmospheric air introduced by the slide-valve A′. The combustion-chamber extends as far as the inner perpendicular of the box F, and conducts the hot gases, products of combustion from the furnace-gases, and air from the inlet A′ to passages K K K, between the boxes, by which a continuously-ascending passage is provided for the gases, after which the gases descending between the first and second boxes F F arrive at the outlet B, whence they are conducted under a boiler, G, to utilize any heating-power remaining therein, and then discharged to the atmosphere by the shaft H. When the shaft rises one hundred and fifty feet above the surface of the ground, the boiler G may be constructed with a height of about twenty feet. The boiler, though concentric with the shaft, leaves a space of about four inches between its outer surface and the inner wall of the shaft, providing ample passage for the gases. The boiler may have suitable safety-valves, gages, water-supply and steam pipes, and the usual connection with an engine. The chimney is so placed as to carry off all the waste gases from the blast-furnace plant of which the stove or stoves form a part.

Iron-pipe stoves as heretofore constructed receive the blast-furnace gases (in best practice) at an average temperature of 400° Fahrenheit, mixed with proper proportions of air, having an average yearly temperature of 50° Fahrenheit, admitted through suitable slide-valves. The gases and air combine and expand in a combustion-chamber. The blast-furnace gases are chiefly carbonic oxide, with accompanying proportion of nitrogen, the same proportion as exists in the atmosphere. If they were entirely of this composition, and of 0° Fahrenheit, and combined with their equivalent of atmospheric air, admitted through slide-valves, also at 0° Fahrenheit, the products of combustion would be five times the initial volume, and be of a temperature of 2,700° Fahrenheit, (carbonic-acid gas and nitrogen.) In practice, however, the blast-furnace gases contain about fourteen per cent. of carbonic-acid gas and its accompanying nitrogen, also a percentage of vapor of water, varying according to the freedom from moisture of the stock charged into the furnace and the dry or humid condition of the atmospheric air blown into the furnace; also, the atmospheric air with which the blast-furnace gases combine in the chamber beneath the iron pipes contains more or less moisture. These non-combustible gases and vapors have to be raised to the average resulting temperature, and in being raised decrease the average intensity of the heat of the resulting products of combustion, although the volume of gases is increased. Blast-furnace gases entering the stove at 400° Fahrenheit, and the atmospheric air with which they combine entering at 50° Fahrenheit, there being added thereto the heat of the combination, (2,700° Fahrenheit,) giving an average temperature of 2,925° Fahrenheit, if free from foreign substances; but in good practice hitherto the resulting heat obtained is about 2,000° Fahrenheit. As the products of combustion conveying this heat of 2,000° Fahrenheit pass from the chamber up through the stove, they heat the iron pipes, and then pass out of the stove through little chimneys K K in its roof at a temperature of about 1,000° Fahrenheit. The atmospheric air entering at the blower end of the first row of pipes at a temperature of 50° Fahrenheit in passing through the series of pipes is gradually increased in temperature until it passes out at a temperature in degree according to the aggregate length of the pipe, the height of the walls, and the velocity of the current of air passing through the pipes. For example, an iron-pipe stove containing eight rows of pipes at an average double length of sixteen and six-tenths feet, or, total, two hundred and sixty feet—eight pipes in each row—the area of each pipe being sixty and fifty-six hundredths square inches, with a given velocity of air, gives a temperature to the air passing out of 1,000° Fahrenheit, which is the best average practice yet attained. There is also the disadvantage of a great velocity of the hot current burning the first rows of pipes, because striking the rows of pipes nearest the entrance of the burning gases with greater degree of heat and velocity than the rows of pipes nearest the blower. This is to some extent overcome in practice with constant watching by closing a damper immediately above the top of the little chimney between the rows of pipes first reached. In spite of all care, the pipes do frequently burn and crack, and have to be replaced. In the new stove the burning gases pass in at the same temperature and deliver the greatest intensity of heat to the rows of pipes nearest their entrance, but becoming cooler as their heat is abstracted by the pipes and air passing through the pipes, and consequently heavier, and being pushed out of the way by the velocity and pressure of the continuously-rising hot gases, and being continually drawn away by the draft of the hot chimney, they gradually course toward the cooler end of the stove and are drawn out at an average temperature of about 700° Fahrenheit. The result is that an additional temperature of 300° Fahrenheit is given to the hot-air blast. In the best practice the old iron-pipe stove gave an average temperature of 1,000° Fahrenheit to the blast, but the new iron-pipe stove will give it an average temperature of 1,300° Fahrenheit. As practically 100° Fahrenheit is equal to three per cent. of the best coke fuel, or a greater per cent. of inferior fuel, therefore 300° Fahrenheit is equal to nine per cent. of fuel saved. In addition the blast-furnace produces nine or

about ten per cent. more pig-iron. Again, the gases passing out of the stove at 100° Fahrenheit instead of being delivered into the air are made to pass under the boilers and raise steam enough to drive the engines for the blower and the whole plant, passing finally out of the chimney at 350° Fahrenheit. Heating-gases under boilers must pass off at 350° Fahrenheit, because that is the temperature of the water in the boilers at a pressure of one hundred pounds to the square inch. There being a difference in temperature of from 300° to 400° Fahrenheit between the iron outside wall of the pipes next to the burning gases and the iron inside of the pipes next to the heating-air, the air cannot attain the same temperature as the gases that heat it. In practice there is a limit to the temperature of iron pipes conveying heated air. In the old iron-pipe stove it has been limited to heating the blast to 1,000° Fahrenheit at its outlet, the outlet rows of pipes being excessively and dangerously heated by the intensity and velocity of the hot current; but it is of record that an iron-pipe stove with its pipes almost white hot was kept during the entire night at a temperature of 1,900° Fahrenheit without injury to the pipes. The rounded entrances to the iron pipes obviate all friction, excepting that of the air against the walls, which is trifling. This is a great saving of engine-power. For example, the blower of one of the furnaces now largely in use delivers a blast of cold air into three hot stoves, each stove containing sixty-four pipes, (eight rows of eight pipes each,) each pipe being sixty square inches in area, or twenty-four currents of one thousand four hundred and forty square inches, each at a pressure of three or four pounds to the square inch in the cold-air main pipe, which air, being heated while passing through the hot stoves to 1,000° Fahrenheit, and expanded to twice its initial volume, enters the hot-air main pipe at a pressure of two and a quarter pounds to the square inch, thus having lost nearly thirty per cent. of the pressure of the blower by the obstruction to the air while passing through the eight square-edged entrances and exits and the eight restricted curved crowns of the pipes. Thus it will be seen that estimating the loss at one and a quarter per cent. for each diminution of area in two hundred and sixty feet length of pipe, even at this low pressure, amounts to a heavy loss in volume.

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

1. The combination, with a hot-blast stove having its roof formed in steps, of a series of hot-air pipes of varying heights and arranged in relation to said steps, substantially in the manner and for the purpose specified.

2. A stove, I, having its roof formed in steps, in combination with the iron pipes E E E′ E″ E‴ E⁗, of fixedly differing altitudes, boxes F F′ F″ F‴ F⁗ F⁗⁗, blast-furnace gas-inlet A, cold-air inlet A′, combustion-chamber J, and outlet B, cold-air inlet C, and outlet D, intervening passages K K K, the chimney H, and boiler G, the whole in the relation and for the purpose herein described and shown.

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

JOHN F. BENNETT.

Witnesses:
M. E. HARRISON,
ALEX. RANDOL.