No. 627,060. Patented June 13, 1899.

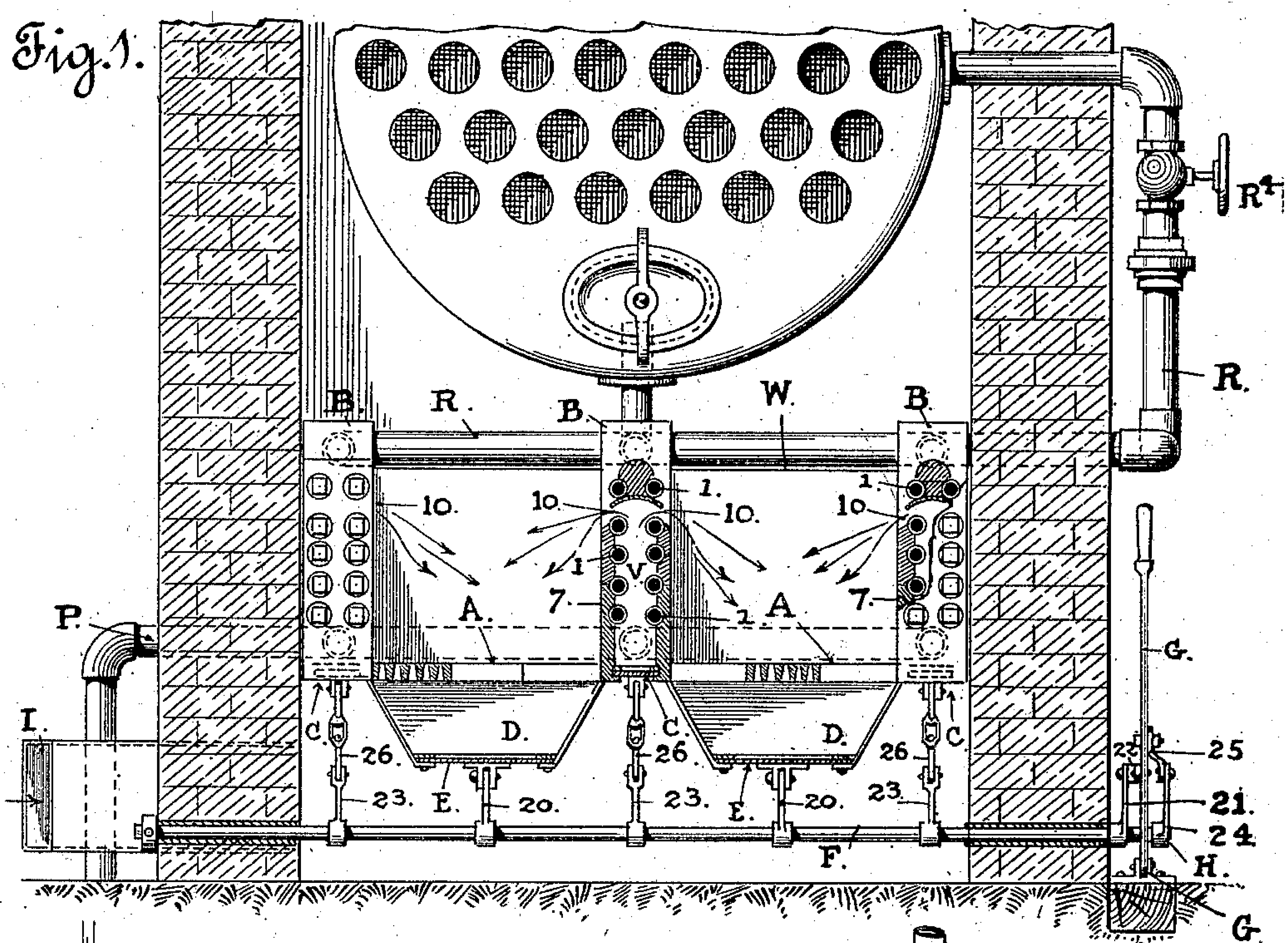
A. HEBERER.

METHOD OF AND APPARATUS FOR BURNING COAL IN FURNACES WITHOUT SMOKE.

(Application filed Sept. 28, 1898.)

(No Model.) 2 Sheets—Sheet 1.

Fig. 1.



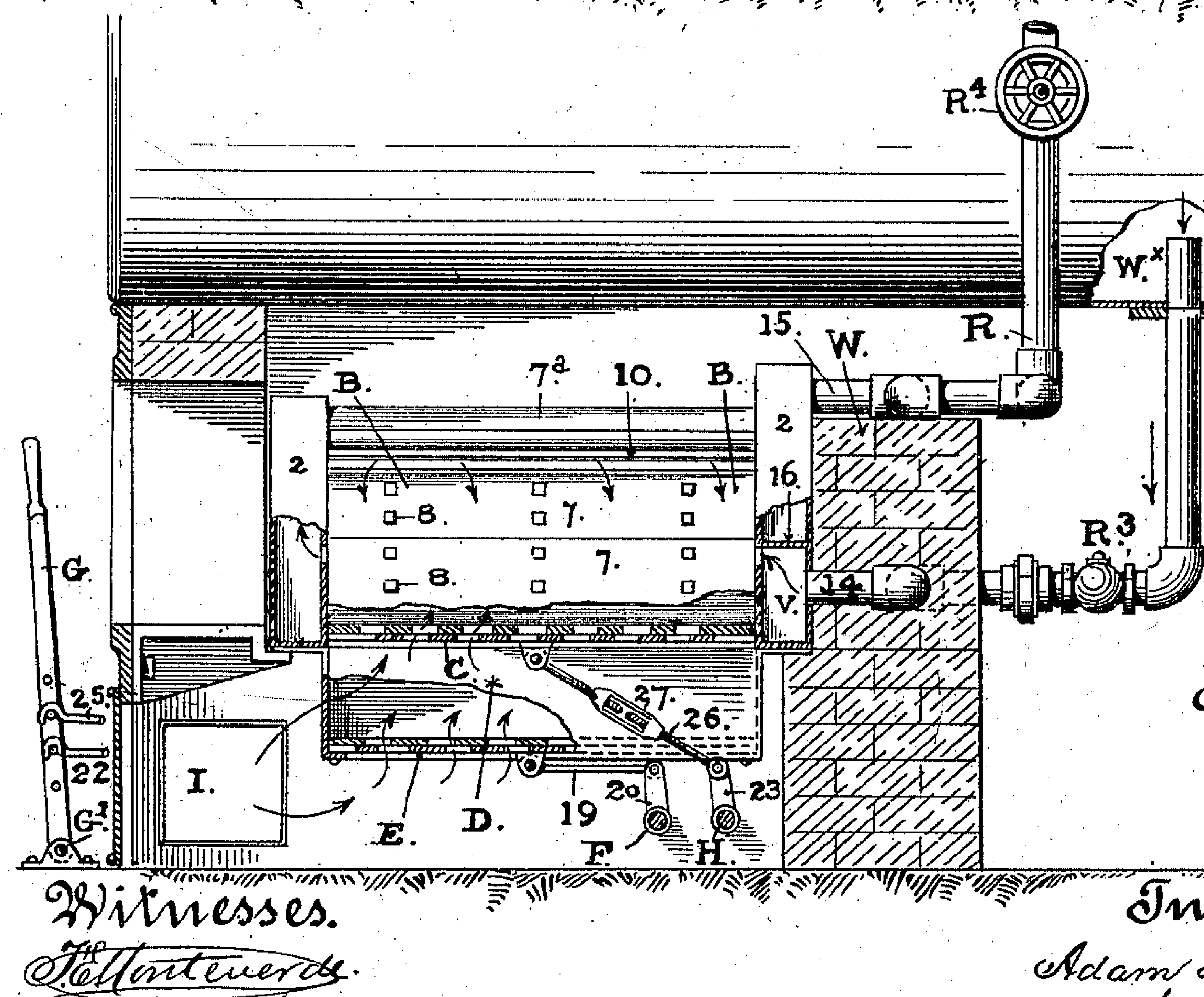


Fig. 2.

Witnesses.

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Fig. 3.

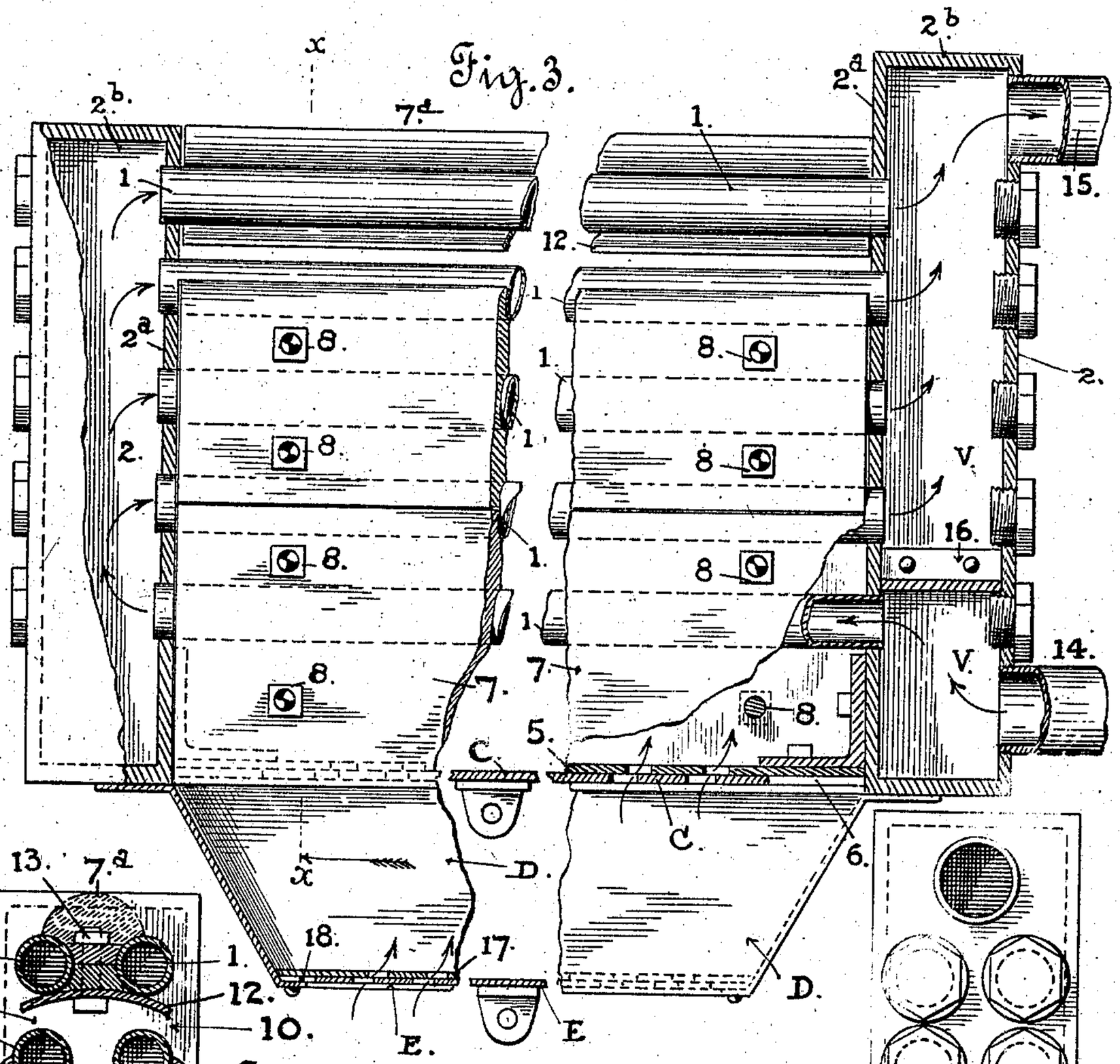


Fig. 5.

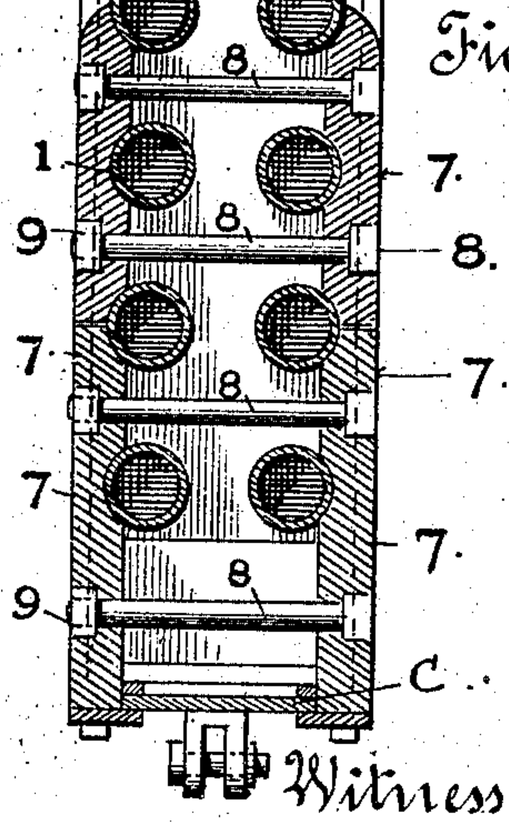
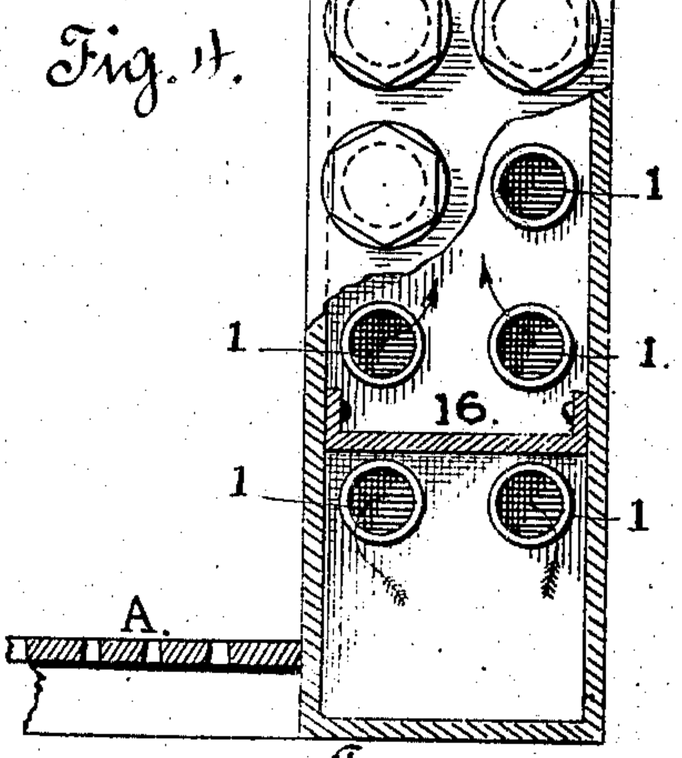


Fig. 4.



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UNITED STATES PATENT OFFICE.

ADAM HEBERER, OF ALAMEDA, CALIFORNIA.

METHOD OF AND APPARATUS FOR BURNING COAL IN FURNACES WITHOUT SMOKE.

SPECIFICATION forming part of Letters Patent No. 627,060, dated June 13, 1899.

Application filed September 28, 1898. Serial No. 692,107. (No model.)

To all whom it may concern:

Be it known that I, ADAM HEBERER, a citizen of the United States of America, residing in the city of Alameda, county of Alameda, and State of California, have discovered and invented certain new and useful Improvements in Methods of and Apparatus for Burning Coal in Furnaces without Smoke, of which the following is a specification.

This invention relates to improvements made in burning coal in the furnaces of steam-boilers and in other similar situations in the arts and manufactures where heat is to be generated and applied for various useful purposes; and it relates more especially to a method or process of producing an economical combustion of all the grades of bituminous and lignite coals without the production of smoke.

This invention is based on the discovery I have made that in the process of burning coal of a bituminous character the escape of the combustible gaseous products in an unconsumed or partially-consumed state can be prevented and a thorough combustion of such products can be effected by excluding or reducing the draft or current of air from the ash-pit upward through the body of fuel to a degree or condition sufficient to retain the volatile and gaseous compounds in the region of greatest heat, when and where they are generated and released from the solid portion of the fuel, and by delivering and distributing air within the furnace above the surface of the fuel in sheets or streams downward against or in close relation to the combustible products at varying and opposing angles under sufficient degree of pressure to cause the currents or streams of air to meet together over the mass of fuel, and thereby cover the entire surface of the mass, the quantity or volume of air so distributed being properly regulated to supply the required proportion or quantity of oxygen for the complete conversion and combustion of the combustible products from the bituminous portions of the fuel. In this process or operation the desired result—that is, the effectual combustion of the volatile and gaseous compounds without the production of smoke—depends not only upon supplying air in proper quantity to furnish the necessary volume of oxygen, but also upon delivering and distributing the air in such intimate contact with or relation to these combustible products when and where they are set free from the solid portions of the fuel that the oxygen is compelled to mix and combine with these combustible compounds before they can decompose or precipitate or condense in the solid form of soot and thus produce smoke; and this mixing or mingling of the oxygen with the combustible compounds must be effected also while they are in suitably close relation to the incandescent fuel or in the region of greatest heat in order to secure the thorough conversion of the combustible compounds into carbonic-acid gas. My said invention, based on this discovery, consists in introducing and distributing air in sheets or streams downward against or in close relation to the surface of the mass of fuel at opposing angles, so as to meet together above the surface of the fuel lying on the grate-surface and entirely cover the same and in regulating the upflow of air through the body of fuel, also in delivering and distributing air under pressure in sheets or streams downward toward the surface of the fuel at opposing angles, so as to meet together over the surface of the fuel and mingle with the gaseous compounds while they are retained in the region of greatest heat, the updraft of air through the mass of fuel being controlled and regulated in volume or quantity from time to time as required to maintain active combustion of the solid portions of the fuel and at the same time to avoid forcing the combustible gases away from close proximity to the fuel during the operation.

The invention embraces also a device or apparatus of novel construction for delivering and distributing air above and beneath the body of fuel on the grate-surface and for regulating from the outside of the furnace from time to time as required during the operation the volume or quantity of air so admitted above and beneath the fuel.

The following description explains at length the nature of the said invention and the manner in which I proceed to carry out and perform the same, reference being had therein to the accompanying drawings, forming a part thereof, in which—

Figure 1 of the drawings represents in front elevation a construction of coal-burning furnace for a steam-boiler adapted for the combustion of fuel in accordance with my said invention, the front of the furnace being removed to expose the interior. This figure also illustrates means for operating the air-regulating valves from a common rock-shaft. Fig. 2 is a longitudinal section with parts of the fuel-supporting surface and the air-troughs broken away to show internal parts. This view also represents a construction of mechanism for regulating the two sets of air-valves independently of each other from the outside of the furnace. Fig. 3 is a side elevation on an enlarged scale, with parts in longitudinal section, showing in detail the construction of the standing sides of the fuel-trough and the water-circulating tubes. Fig. 4 is an end view taken from the right-hand side of Fig. 3, showing the front partly broken away and a portion of the grate-surface in section. Fig. 5 is a vertical cross-section at *x x*, Fig. 3.

In carrying out this invention I exclude or reduce the updraft or flow of air-currents from beneath the fuel-supporting surface upward through the mass of fuel to an extent or degree sufficient to prevent the too-rapid decomposition of the coal and the too-rapid liberation and movement of the volatile and gaseous elements away from the incandescent mass, thereby holding them in the region of greatest heat for effective contact and mixture with the oxygen and until there has been effected a complete combination between these combustible elements and the oxygen before they escape and are carried over the bridge-wall. The updraft should be reduced and regulated to furnish a suitable proportion of air for maintaining active combustion and an incandescent condition in the carbonaceous or solid portions of the fuel and at the same time to avoid such a degree of upward pressure through the mass of fuel as would tend to force or carry the gaseous products out of the region of greatest heat while meeting and becoming mixed with the streams of air descending from above. The quantity of air admitted under the mass of fuel is determined and regulated by the conditions existing from time to time in the operation of the furnace, and as these are found to vary during combustion the supply of air is to be varied to meet the conditions. An excess or surplus of upwardly-flowing air-currents through the fuel will be indicated by the presence of smoky vapors in the furnace or a dull smoky appearance of the flame, and, on the other hand, the lack of a sufficient quantity of air admitted under the grate-surface at any time will be indicated by the condition of the fire in the solid portions of the mass. This supply of air from below should be the least quantity that will supply the solid portions of the fuel with the proper volume of oxygen for combustion of the solid carbonaceous portions of the fuel. Atmospheric air in sufficient volume to supply the required proportions of oxygen is introduced also and distributed from above the mass of fuel in sheets or streams downward toward the surface of the fuel at varying and opposing angles from opposite directions, so as to meet together over the fuel and cover the surface from front to rear and from side to side of the furnace. The air is forced through slits or apertures inclining downward at the required angle, as before described, and under such degree of pressure above that of the atmosphere that the streams coming from opposite directions will meet together over the mass of fuel and be brought in intimate contact with the volatile and gaseous elements from the bituminous portions of the fuel while they are in close relation or proximity to the incandescent fuel in what is herein designated as the "region of greatest heat." Ordinarily a pressure of one ounce to the square inch above atmospheric pressure will be the greatest that will be required, and in some cases I have secured excellent results with one-half that pressure.

The best amount or degree of pressure to maintain in the furnace at any time will be readily ascertained by inspecting the conditions of the combustion going on in the furnace. As the volume of volatile and gaseous compounds set free from the fuel is constantly varying, it will be necessary to regulate the pressure and the volume of air so distributed above the fire; but as low a degree of pressure must be employed as will produce the desired effect and will insure the free circulation of the burning gases and heat products over the bridge-wall and under the boiler without a too-rapid upward movement of the unconverted or partially-consumed gases away from the surface of the fuel. I have obtained good results in a furnace of ordinary dimensions having about twenty (20) square feet of fuel-supporting surface, with air-distributing slits or apertures extending longitudinally over the fuel from front to rear of the furnace, set at about eighteen (18) inches apart widthwise of the furnace and about twelve (12) inches above the fuel-surface, the air being supplied to these outlet-apertures at between one-half an ounce and one ounce pressure above that of the atmosphere. The conditions existing in the furnace while the combustion is going on, to be ascertained by inspection through the furnace-door, are the best guide in regulating and varying the volume of air to secure effective results.

In the accompanying drawings I have illustrated a construction of coal-burning furnace for a return tubular steam-boiler which is specially adapted for the combustion of bituminous coal without smoke in accordance with my said process.

For the fuel-supporting surface A, I use either the ordinary grate-bars, Fig. 1, or a flat perforated plate, Fig. 4, extending from the front back to the bridge-wall W. This grate-

surface is divided into several separate troughs by upright partitions B B, carried from the front of the furnace back to the rear end and extending perpendicularly upward from the grate-surface. These partitions are similarly constructed, and a detailed description of one will serve for all. The walls or sides of each partition are constructed of a number of horizontal water-tubes 1 1 and hollow heads or box-like ends 2 2, substantially of rectangular shape, into which the ends of all the horizontal tubes are fixed. The top 2^b of the box end is permanently closed, and the bottom is fitted with a gridiron-valve formed of a stationary slotted plate 5 and the gridiron-plate C, fitted to slide in grooves 6 in the sides of the box. By a longitudinal movement of this plate the area of the inlet-apertures is increased or diminished.

The water-tubes connected together by the box ends 2 2 are set in two parallel rows at intervals apart, and the spaces between all the tubes on the same side are closed by plates or tiles 7 7, laid against the tubes from the outside with butt-joints covering the outer sides of all the tubes, the plates being drawn up and held to place by long bolts 8 and nuts 9. The open space between the two top tubes is filled by a block or tile 7^a with curved or recessed sides to fit between the tubes. The hollow space thus inclosed by the plates or tiles 7^a between the two tiers or rows of water-tubes forms an air-chamber, into which air is admitted through the valve C in the bottom, and from this chamber or space outlets 10 for the air are made in the sides of the partition by leaving an open space between the top tube and the next highest tube in the tier on the same side of the partition, the aperture 10 being made of suitable form to deflect or turn the stream of air at an angle toward the bottom of the trough. A plate 12 with a curved edge is set in the top part of the hollow space projecting through the slits 10 and inclined downward, so that its concave side forms the roof of the air-chamber. This plate is fastened by bolts 13 against the bottom of the block. The function of this plate is to deflect the outgoing currents of air toward the grate-surface, and when properly placed it should give the air such an angular direction that the currents or streams from the two opposing partitions will meet together over the bottom of the trough and at all times above the top line or level of the fire, so as to confine, baffle, or hold the volatile and gaseous compounds in proximity to the incandescent fuel. The angle or degree of deflection of such air-currents is regulated by giving this plate a greater or less degree of curvature. The outlet-apertures 10 should also be situated below the line of the opening at the rear over the bridge-wall in order to prevent the volatile and gaseous products as they are generated and released from the surface of the fuel from escaping underneath the streams of air and so passing out over the bridge-wall and to compel these combustible gases to mix and effectively combine with the oxygen of the air while confined between the sides of the trough.

The water-spaces in the standing partitions are connected into the circulating system of the boiler by a supply-pipe P, carried from the feed-water pipe across the rear of the furnace behind the bridge-wall and connected to the hollow end of each partition by a short pipe or coupling 14, through which the water is made to circulate through the lower ones of the horizontal water-tubes to the front end and return through the upper ones to the rear box or end of the partition, at which end an outlet-pipe 15 connects the water-space of each partition with a pipe leading into the upper part of the water-space of the boiler. Instead of connecting the water-spaces V in the hollow end 2 of the troughs with the feed-water pipe they can be connected into the water-space of the boiler by carrying a pipe R^2 from the lowest part of the water-space downward behind and across the bridge-wall and coupling the inlet-pipe 14 to it, a check-valve R^3 being placed in the pipe R^2. This arrangement of tubes for carrying the circulation of the boiler-water through the water-jackets of the troughs is shown in Fig. 2. A horizontal partition 16 in the hollow end of the partition above the water-inlet divides the hollow space into an inlet side and an outlet side, and in this manner a circulation of water is maintained through the water-spaces of the standing sides of the troughs from end to end. A suitable valve R^4 is placed in the water-pipe for regulating the supply of water.

To regulate the quantity of air admitted to the fuel from below, that portion of the grate-surface between the standing sides of each fuel-trough is boxed in or separated from the ash-pit, and in the bottom of this box D is set a gridiron-valve formed of a stationary plate 17, having narrow air-slots, and the movable plate E, similarly slotted. This last-named plate is fitted to slide in grooves 18 and is connected by a rod or link 19 with an arm 20 on a horizontal rock-shaft F, the ends of that shaft being carried in bearings in the side walls of the ash-pit. To a hand-lever G outside the furnace is connected the rock-shaft F by an arm 21, fixed on one end of the shaft, and a connecting-rod 22, pivoted to the end of the arm and attached to the hand-lever by an open connection formed of a hook on the end of the rod and a pin on the lever. To this same hand-lever the slide plates or valves C that control the air-inlets in the bottom of the standing partitions are connected by a common rock-shaft H, having an arm 24 on the outer end, from which a connecting-rod 25 is carried to the hand-lever G, an arm 23 being fixed on the shaft H under each inlet-valve, with a link or rod 26 connecting that arm with the slide-plate C. This connection 26 is composed of two sections united by a turn-

buckle 27, so that the lead of the valve can be regulated to vary the area of the inlet-openings C over that of the lower valve controlling the admission of air into the box D below the grate-surface. By one movement of the hand-lever both valves are moved and set to increase or reduce the area of the two air-inlets C E, and by adjusting the points of connection between the rods 22 25 and the lever G up or down with respect to the pivot G′ of the lever the length of throw of one slide over the other is varied as circumstances are found to require a greater or less increase in the quantity of air introduced above the fire over that admitted under the grate-surface. The throw of the slides C E is varied by unhooking the rods 23 25 and shifting their points of attachment on the lever up or down. Either slide can also be adjusted independently of the other by detaching from the hand-lever the rod of the slide that is to be thrown out of action. The air being introduced first into the ash-pit is thus admitted for distribution into the air-boxes D under the grate-surface through the inlets E, and also into the standing partitions through the inlet C. The supply of air under required pressure is maintained by connecting the air-space in the ash-pit with an air-blower or other suitable apparatus, such as a pressure-fan, by means of an air-pipe I, carried through the side of the furnace.

Having thus fully described my invention, what I claim therein as new, and desire to secure by Letters Patent, is—

1. The improvement in the combustion of coal, which consists in delivering and distributing air in sheets at varying angles downward over the mass of fuel and in close relation to the surface thereof and so as to cover the surface; and in regulating the flow of air upward through the fuel-supporting surface, as required.

2. The improvement in the combustion of coal, which consists in delivering air under pressure in sheets at varying angles over the mass of fuel and in close relation to the surface thereof, so as to meet together and cover the entire mass of fuel; and in regulating the flow of air from beneath upward through the fuel.

3. In a furnace for burning coal, the combination, with a fuel-supporting surface, of means for delivering air in sheets at varying angles downward from opposite directions over the surface of the fuel, so as to meet together and cover the entire surface of the mass of fuel; means for introducing air beneath the fuel-supporting surface; and means for regulating and varying at will from the outside of the furnace during the operation the quantity of air so distributed above and beneath the mass of fuel.

4. In a furnace for burning coal, the combination of a fuel-supporting surface, hollow standing partitions dividing the fuel-surface into fuel-troughs, air-inlets in the standing partitions connected with a source of supply outside the furnace, air-outlets in the sides of the standing partitions situated above the surface of the mass of fuel having inclined throats adapted to deliver the air in sheets at angles across the trough and toward the surface of the fuel as described, so as to cover the surface thereof, air-outlets beneath the bottom of the fuel-supporting surface, valves adapted to control the air-delivering apertures above and beneath the fuel-supporting surface, and means for regulating said valves from the outside of the furnace, as required.

In testimony that I claim the foregoing I have hereunto set my hand and seal.

ADAM HEBERER. [L. S.]

Witnesses:
JOHN A. HOWARD,
JAMES L. KING.