(No Model.) 3 Sheets—Sheet 1.

J. E. CULVER.

STEAM GENERATOR.

No. 368,573. Patented Aug. 23, 1887.

Fig 1.

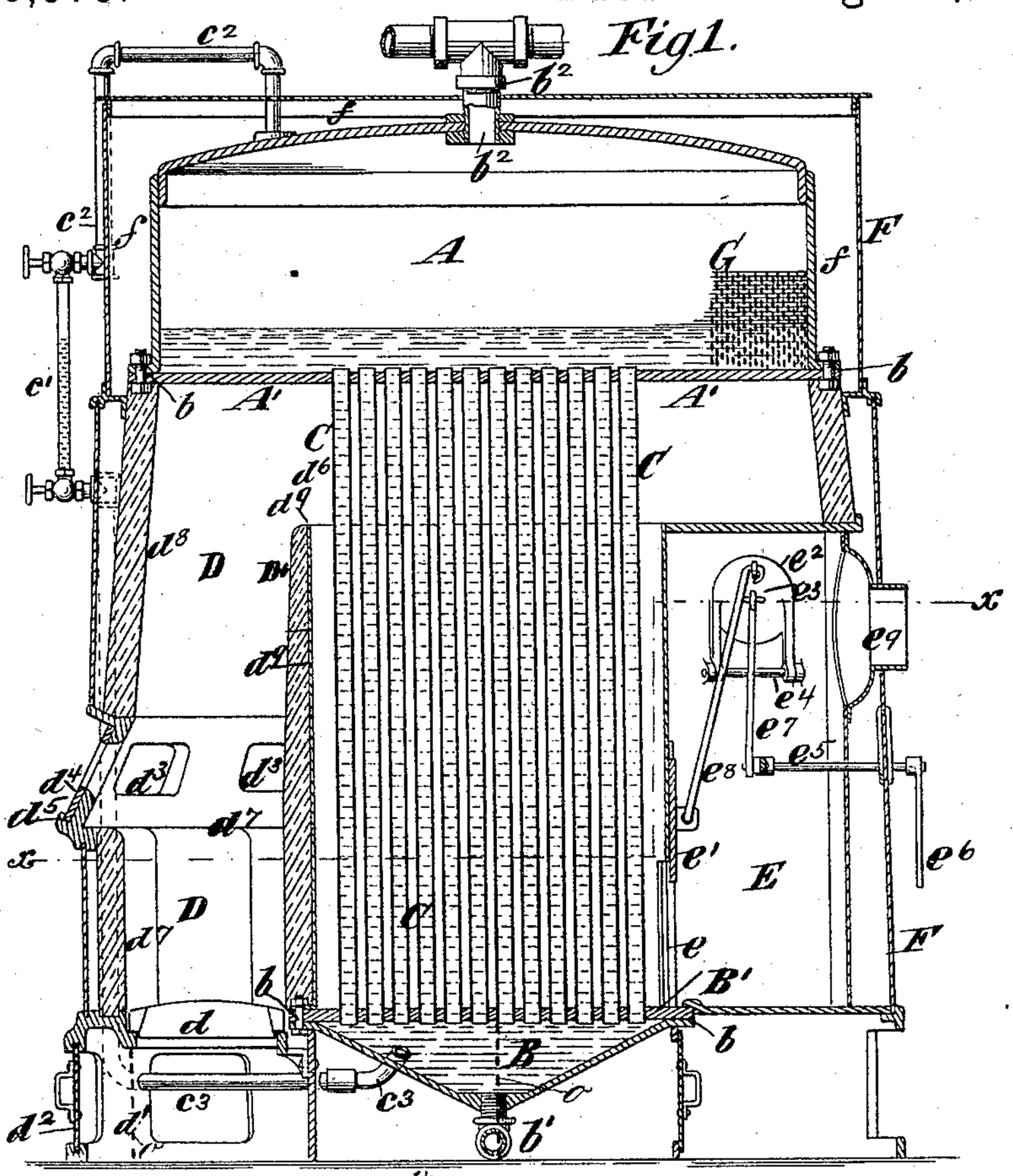
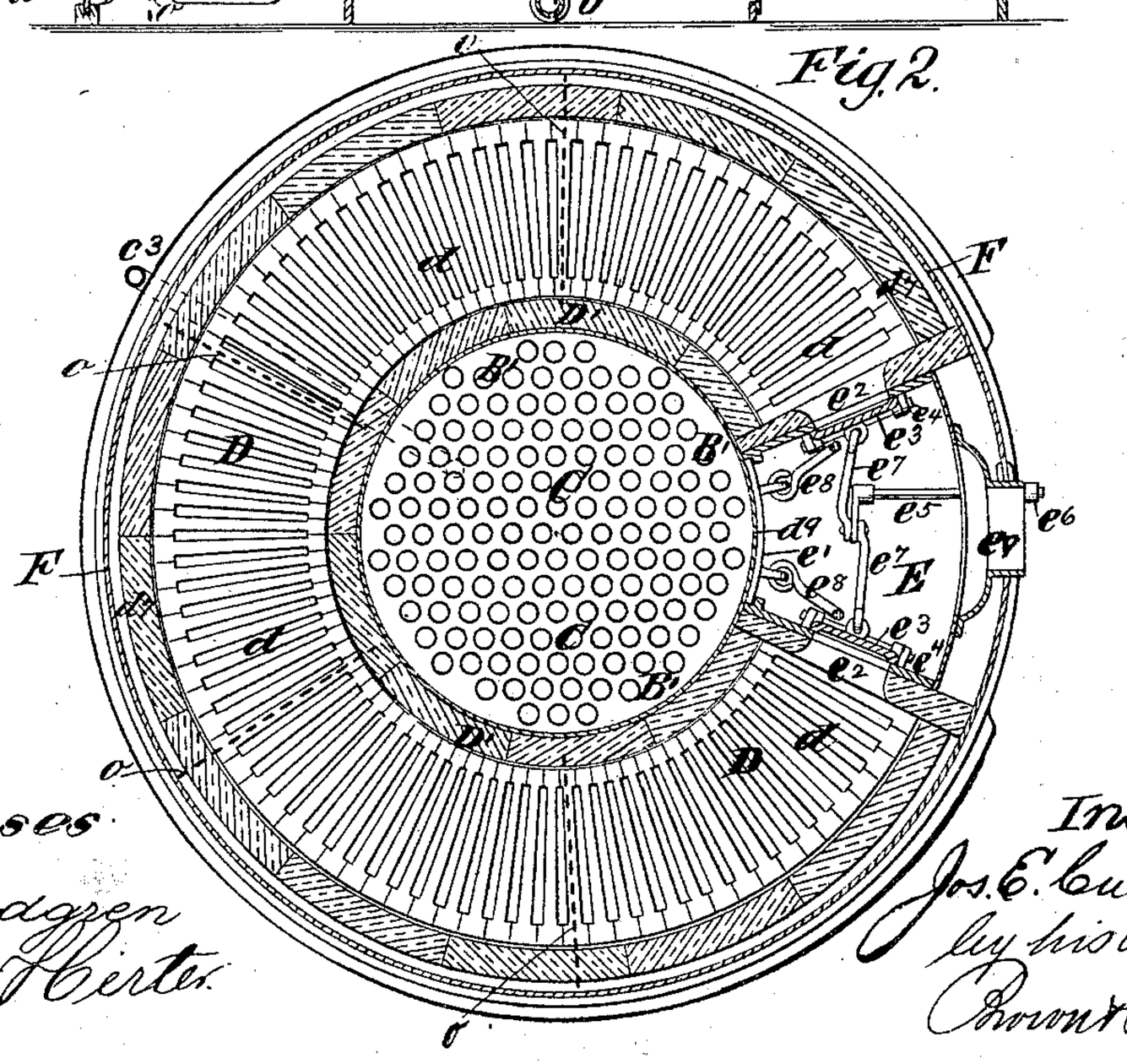


Fig 2.



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(No Model.) 3 Sheets—Sheet 2.

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STEAM GENERATOR.

No. 368,573. Patented Aug. 23, 1887.

Fig. 3.

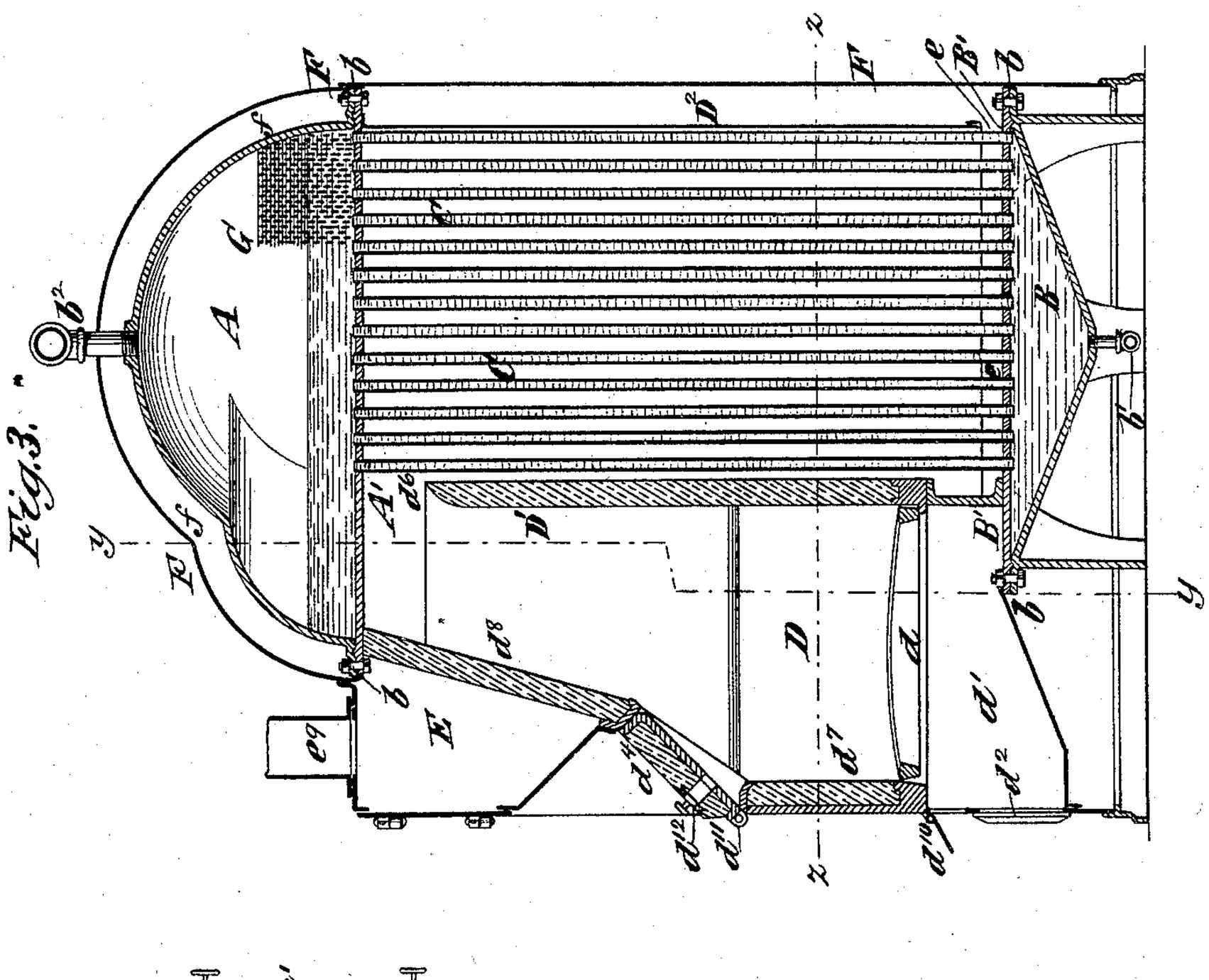
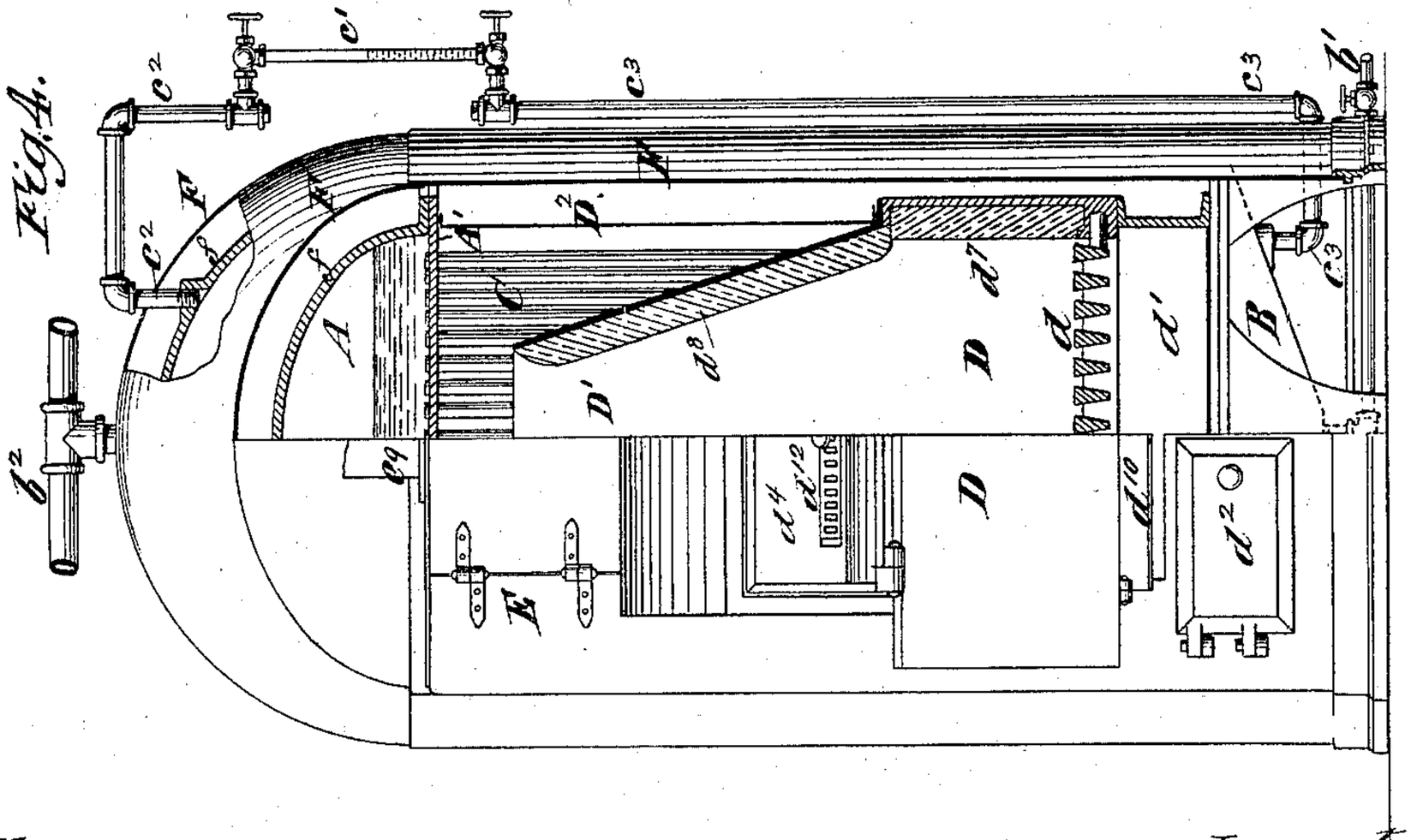


Fig. 4.



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(No Model.) 3 Sheets—Sheet 3.

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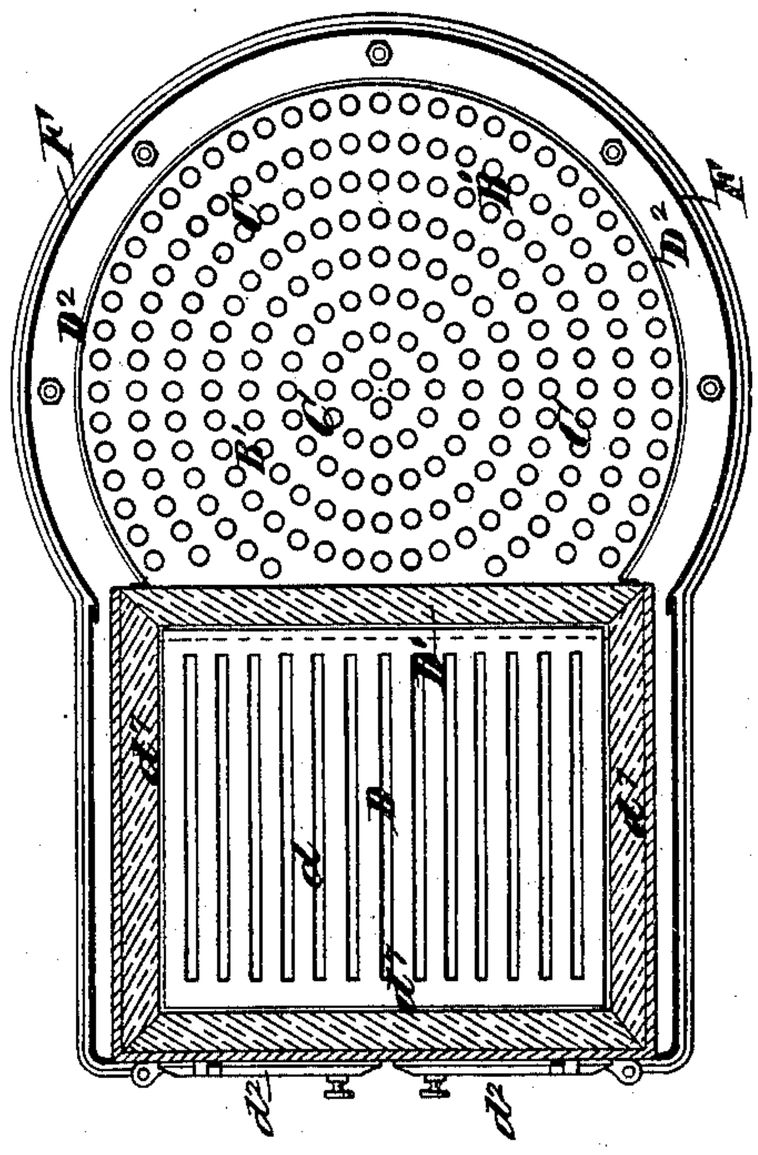
Fig 5



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UNITED STATES PATENT OFFICE.

JOSEPH E. CULVER, OF JERSEY CITY, NEW JERSEY.

STEAM-GENERATOR.

SPECIFICATION forming part of Letters Patent No. 368,573, dated August 23, 1887.

Application filed August 23, 1886. Serial No. 211,634. (No model.)

To all whom it may concern:

Be it known that I, JOSEPH E. CULVER, of Jersey City, in the county of Hudson and State of New Jersey, have invented a new and useful Improvement in Steam-Generators, of which the following is a specification.

My invention relates to that class of steam-generators in which the upper portion of the body of water in the generator near the surface is subjected to the hottest smoke, gases, and products of combustion which escape from the furnace, and in which every portion or particle of water entering the boiler is heated progressively until it is finally converted into steam, while the heating gases and products of combustion from the furnace move downward as they cool and come into contact with colder and colder contact-surfaces until they are discharged into the atmosphere at a comparatively low temperature, say about 100° Fahrenheit, more or less, as may be desired, according to the extent of heating-surface employed and the draft maintained in the apparatus. Steam-generators of the class above referred to are shown in my United States Reissue Letters Patent No. 10,241, dated November 14, 1882, and Letters Patent No. 289,989, dated December 11, 1883. In boilers of this class the heating of the water is always performed from the surface downward in contradistinction to the more common class of generators, in which the most intense heat is applied to the bottom of the generator or to the lower portion of the body of water contained therein, and in which ebullition takes place from the bottom of the generator.

Steam-generators of the class to which my invention relates are economical in their operation, and also have other important advantages which render them very desirable for producing steam, either for heating or for power purposes. In such generators ebullition takes place only in the extreme upper portion of the body of the water near the surface, and inasmuch as the steam has not to ascend through a considerable depth of water very dry steam is produced by the generator, and priming or the carrying off of water in suspension by the steam is entirely avoided. Again, heat descends but very slowly through a body of water, and in boilers of this class there is practically no water-circulation, save that the water in the lower portion of the boiler, with the feed-water which is there introduced, gradually ascends without ebullition, and is gradually increased in temperature during its ascent by the action of the hot gases and products of combustion. These gradually decrease in temperature as they descend to the escape-flue, which is situated near the lower portion of the body of water in the generator. Such a construction of boiler renders it possible to transmit nearly all of the heat of the gases and products of combustion to the water, because the gases and products of combustion, as they descend and become colder or gradually reduced in temperature, exert their effect upon water which is also of less and less temperature.

My present invention consists in the combination, in a steam-generator, with a lower water-chamber and an upper water and steam chamber of larger horizontal area than the lower chamber, and upright tubes connecting them, of a jacket or wall surrounding the tubes and provided near the top of the tubes with an inlet-opening for products of combustion and near the bottom of the tubes with an escape-opening, and a furnace arranged external to the jacket or wall which surrounds the tubes and beneath the portion of the upper chamber, extending laterally beyond the tubes, and which communicates directly with the tube-space through the inlet-opening at the top of the jacket or wall.

In connection with the features above described, I also divide the ash-pit below the grate by upright partitions, whereby air may be supplied to support combustion on any desired portion of the grate, and may be excluded from the other portions of the grate. In this way provision is afforded for maintaining an extensive or limited fire upon the grate, the combustion upon the portion of the grate used being active in either case.

In what I now consider a preferable construction of the generator the tubes are substantially surrounded by a furnace, which is separated from them by a wall rising nearly to the upper chamber and having immediately below the upper chamber an inlet-opening for the entrance of products of combustion among the tubes, and such furnace may entirely surround the tubes, save for the smoke-chamber at one side of the tubes, and such smoke-chamber may communicate through the lower portion of the wall with the space containing the tubes, and may also communicate by openings

with the upper portion of the furnace directly, and these openings may be provided with valves, whereby the products of combustion may be caused to take their normal course downward among the tubes and thence into the smoke-chamber near the bottoms of the tubes during the ordinary operation of the generator, or may be caused to pass directly into the smoke-chamber without passing downward among the tubes to the bottom thereof when kindling a fire in the generator. This arrangement of valves and escape-openings to the smoke-chamber is important, because when kindling a fire, which usually requires wood or light material and produces smoke charged with soot and other impurities the deposit of such impurities upon the tube-surfaces is avoided, and such surfaces are kept clean and in a condition to produce their greatest useful effect.

In the accompanying drawings, Figure 1 is a vertical section of a generator embodying my invention, and in which upper and lower chambers of circular form are employed, connected by tubes arranged within a circular area, and a circular furnace which substantially surrounds the body of tubes and is separated therefrom only by an inner wall of the furnace. Fig. 2 is a horizontal section on the dotted line *x x*, Fig. 1. Fig. 3 is a vertical section of a generator of modified form, also embodying my invention, and in which the furnace is arranged on one side only of the group of tubes. Fig. 4 is a view, one vertical half of which represents a front elevation and the other vertical half of which is a section upon the plane of the dotted line *y y*, Fig. 3; and Fig. 5 is a horizontal section upon the plane of the dotted line *z z*, Fig. 3.

Similar letters of reference designate corresponding parts in all the figures.

Referring first to Figs. 1 and 2, A designates an upper steam and water chamber, the lower horizontal wall, A′, of which constitutes a tube-sheet, and B designates a lower water-chamber, the upper plate or wall, B′, of which also constitutes a tube-sheet. The two chambers, A B, are connected by a number of upright water-tubes, C, which are arranged as near together as is practicable, and may be of any suitable diameter. The upper and lower ends of these tubes C are secured in the tube-sheets A′ B′ in any suitable manner. They may, for example, be expanded into the tube-sheets or they may be screwed therein.

The upper and lower chambers, A B, may be constructed of either wrought or cast metal, and their component parts may be secured together by joints *b*, which may be bolted, riveted, or otherwise rendered fluid-tight.

In the operation of the generator it is only intended to carry the level of water slightly above the tube-plate A′ of the upper chamber, A, as shown in Fig. 1, and the level of water may be indicated by a gage-glass, *c′*, connected at its upper and lower ends by pipes c^2 c^3 with the upper and lower chamber, respectively. The feed-water may be introduced into the lower chamber, B, through a feed-pipe, *b′*, and the steam for heating or power purposes may be taken from the upper chamber, A, through a pipe, b^2.

D designates the furnace, which substantially surrounds the group of tubes C, and which is here represented as of circular form. The group of tubes might, however, be arranged within a horizontal area of square or other form, and the furnace be correspondingly shaped. In this example of my invention the furnace D entirely surrounds the group of tubes C, save that I provide on one side of the group of tubes a smoke-chamber, E, from which leads the escape-pipe e^9, for the spent products of combustion. The furnace D is provided with a grate, *d*, which may be made of separate bars, as shown in Fig. 2, or of sections. Below the grate *d* is an ash-pit, *d′*, entrance to which is controlled by suitable doors, d^2, either sliding or hinged; and arranged at such distance above the grate *d* that the depth of fire will always be entirely below them; are feeding-openings d^3, which may be controlled by doors d^4. As here represented, the doors d^4 are arranged to slide in a suitable guide, d^5, formed upon the furnace-casting, and have openings in them which correspond to the openings d^3. When the doors d^4 are shifted horizontally, so as to uncover the openings d^3, fuel may be introduced into the furnace at any point around the circumference thereof.

With a green fire I prefer to close the doors d^4 and more or less open the ash-pit doors d^2, to admit air below the grate; but in the later stages of the combustion of the fuel I may close the ash-pit doors d^2 and more or less open the doors d^4, so as to admit air above the grate and burn from the top of the body of fuel within the furnace, thereby producing a slow combustion, which conduces to economical working.

The furnace D is separated from the group of tubes only by an upright wall, D′, which extends from the grate upward nearly to the tube-sheet A′, leaving over the top of the wall an inlet-opening, d^6, through which the products of combustion may pass from the furnace directly beneath the tube-sheet A′, and thence downward among and around the water-tubes C. The furnace may be constructed or lined with any suitable material; but I prefer that the lining of the furnace immediately above the grate shall be of soapstone or other refractory material, d^7, and the outer portion of the furnace above the inlet-openings d^3 may also be formed by slabs or sections, d^8, of soapstone or other refractory material. The circular wall D′ may also be constructed of soapstone or other refractory material, and as here shown such material is arranged outside a cylindric wall or casing, d^9, which may be of sheet metal, and may rest upon the metallic portion of the structure.

The entire generator may be inclosed with

an outer casing, F, which may be of sheet metal, and which forms a dead-air space, *f*, around the upper chamber, A, and those parts of the generator from which loss by radiation of heat would otherwise occur.

Near or at the bottom of the wall D′ is an outlet-opening, *e*, which is controlled by a door, *e′*, arranged to slide upward and downward, or otherwise made movable to open and close said opening *e*, and through this opening the tube-space, within which the group of tubes C is arranged, communicates at the bottom of the tubes with the smoke-chamber E. The smoke-chamber E also has in its upper part other openings, e^2, which communicate directly with the furnace around the wall D′, as shown in Fig. 2, and which are controlled by suitable doors or valves, e^3, here represented as hinged below their lower edges by pins or pivots e^4, so that they may open by swinging downward into the smoke chamber E. These or other equivalent doors or valves, *e′* e^3, may be controlled either simultaneously or separately by any suitable system of connections. I have here represented a rock-shaft, e^5, which may be operated by a handle, e^6, on the outside of the generator, and which has upon it an arm connected by rods e^7 with the doors or valves e^3. The doors or valves e^3 are likewise connected by rods e^8 with the sliding door or valve *e′*, and by turning the rock-shaft e^5 the doors or valves *e′* e^3 will be operated simultaneously, and the door or valve *e′* will be opened when the doors or valves e^3 are closed, and vice versa.

In addition to the escape opening *e*, leading from the tube-space at the bottom thereof into the smoke-chamber E, it is advantageous to provide the openings e^2, leading directly from the furnace into the smoke-chamber, because when kindling a fire the doors or valves e^3 may be opened and the products of combustion, which are heavily charged with soot and other impurities, may pass directly into the smoke-chamber E, and thence to the escape-pipe e^9, without coming in contact with the tube-surfaces, and the tube-surfaces will therefore be kept clean.

As clearly shown in Fig. 1, the upper chamber, A, and tube-sheet A′ have a greater horizontal area than the lower chamber, B, and tube-sheet B′, and the portion of the tube-sheet A′ which is around and beyond the group of tubes C is immediately over the furnace, while the inlet-opening d^6, leading to the tube-space within the wall D′, is immediately beneath the tube-sheet A′. The tube-sheet A′ is covered to a very slight depth with water, and hence the hottest products of combustion from the furnace come directly against this tube sheet and heat the thin layer of water above it intensely, and, passing through the inlet-opening d^6, pass downward among the tubes C, and finally issue through the outlet-opening *e* at the lower ends of the tubes into the smoke-chamber E. The products of combustion, as they pass downward among and in contact with the tubes C, become reduced in temperature by the heat which they give up to the water within the tubes, and inasmuch as the water within the tubes is also of gradually-decreasing temperature downward the products of combustion transmit nearly all their free heat to the water in the tubes and escape at the opening *e* at a very low temperature, as compared with the escaping products of combustion in other steam-generators; hence the generator is very economical in its working, and inasmuch as the extreme upper portion of the body of water very near the surface is subjected to most intense heat, the steam generated from the water will not have to pass through a great depth of water to escape into the steam-space, and hence will be comparatively very dry, and the generator will not prime.

In order to still further produce the generation of dry steam, I prefer to arrange within the upper steam and water chamber, A, a filling, G, of wire-cloth, perforated sheet metal, or other analogous material, which will extend from beneath the surface of the water upward into the steam-space. In Fig. 1 I have represented a portion of such filling within the upper chamber, A, and it affords numerous surfaces along which the steam may creep upward from the water into the steam-space in the upper part of the chamber A. This filling is very advantageous in preventing globules of water from passing off in suspension with the steam.

In the example of my invention shown in Figs. 3, 4, and 5 the arrangement of the upper and lower chambers, A B, having the tube-sheets A′ B′, and water-tubes C, extending between the two chambers and secured in the tube-sheets, is substantially similar to that shown in Fig. 1, although the upper chamber is of different form. In this example of my invention the furnace D is upon one side only of the group of tubes C, and the walls and lining D′ d^7 d^8 of the furnace may be of soapstone or other refractory material, as above described. In the furnace is the grate *d*, below which is the ash-pit *d′*, having doors d^2 at the front, and also having above the doors a damper, d^{10}, for controlling the admission of air to the ash-pit, and thence upward through the grate *d* and the fire thereon. In this example of invention the furnace is provided at such distance above the grate *d′* that it will always be above the fire, with the door d^4, which may be hinged at d^{11}, and may also be covered or lined with soapstone or other refractory material. In this door d^4 is a draft-damper, d^{12}, which may be opened after the fire has become thoroughly kindled and during the later stages in the combustion of the coal, in order to admit air above the fire and thereby produce a slow combustion, as before described. In this example of my invention the wall D′ is continued upward near to the tube-plate A′, and immediately beneath the tube-plate is an inlet-opening, d^6, through which the products of combustion may pass

among the tubes C, and thence downward in contact with the tubes. In this example of my invention I have shown the group of tubes as surrounded by a jacket, D^2, which may be of asbestus cloth or any other suitable material, either flexible or otherwise, and which extends upward entirely to the tube-sheet A′, save on the side at which the furnace D is situated, and on which is the inlet-opening d^6, for the entrance of the products of combustion among the tubes. This jacket D^2 terminates slightly above the lower tube-sheet, B′, as shown in Fig. 3, in order to form the outlet or escape opening *e*, through which the products of combustion may escape from the jacket after they have imparted their heat to the tube-surfaces. The generator is surrounded by an outer casing, F, which communicates with the smoke-chamber E at the front of the generator above the furnace, and from which leads the escape-pipe e^9. The part of the casing F which surrounds the upper chamber, A, may be separated from the portion of the casing F which receives the products of combustion, and may form a dead-air space, *f*, to lessen the loss by radiation from the chamber A. I have also shown in Fig. 3 a portion of the wire-netting or other analogous filling, G, which is contained in the upper steam and water chamber, A, and which prevents the water from being taken off in suspension by the steam.

In some cases it may not be desired to maintain a fire on the whole of the grate, and I may therefore provide in the ash-pit *d′* vertical partitions extending upward to the grate *d* at different points in its circumference. I have represented these partitions in Fig. 2 by radial dotted lines *o*. When it is desired to maintain a fire upon a small part of the grate, one or more of the ash-pit doors are opened and air admitted to one or more of the spaces between the partitions *o*, and the fire will then be maintained only on the grate portion or portions over such space or spaces.

I am aware of patent to D. A. Morris, No. 106,392, dated August 16, 1870, which shows upper and lower chambers of about equal horizontal area arranged within a casing and connected by helicoidal or serpentine tubes and a furnace or fire-place at the side of the casing and communicating therewith. I am also aware of German Patent No. 24,809, granted November 23, 1883, which shows a generator having an upper steam and water chamber with tubes depending therefrom, and provided at their lower ends with heads severally having hand-holes and connected by nipples with each other, said parts being arranged within a casing with which a furnace communicates below said upper chamber. In my aforesaid Reissue Patent No. 10,241 is shown a generator having upper and lower chambers or compartments which are connected by tubes and a furnace from which products of combustion pass first into contact with the tubes near their upper ends. I do not here claim anything shown or described in the aforesaid patents.

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

1. The combination, with a lower water-chamber and an upper water and steam chamber of larger horizontal area than the lower chamber, and water-tubes connecting said chambers, of a wall or jacket surrounding the tubes and provided near their upper ends with an inlet-opening and near their lower ends with an outlet-opening, and a furnace external to the wall or jacket which surrounds the tubes, and beneath the portion of the upper chamber which extends laterally beyond the tubes and which communicates directly with the said inlet-opening at the top of said wall or jacket, substantially as herein described.

2. In a steam-generator, the combination, with an upper steam and water chamber, a lower water-chamber, and upright water-tubes connecting them, of a jacket or wall surrounding the tubes and provided near the top of the tubes with an inlet-opening for products of combustion and near the bottom of the tubes with an escape-opening, a furnace external to the jacket or wall surrounding the tubes and communicating directly with the inlet-opening at the top thereof, and upright partitions in the ash-pit below the grate, whereby air may be supplied to support combustion on any desired portion of the grate and excluded from the other portions of the grate, substantially as herein described.

3. The combination, with an upper steam and water chamber, a lower water-chamber, and water-tubes connecting them, of a furnace substantially surrounding the tubes and separated from them by a wall rising nearly to the upper chamber and having immediately below the upper chamber an inlet-opening for the entrance of products of combustion among the tubes, and an escape-passage for spent products of combustion leading from said wall near the lower ends of the tubes, substantially as herein described.

4. The combination, with an upper steam and water chamber, a lower water-chamber and upright water-tubes connecting them, of a furnace surrounding the tubes, save for a smoke-chamber at one side thereof, and separated from the tubes by a wall rising nearly to the upper chamber and having immediately below the upper chamber an inlet-opening for the entrance of the products of combustion among the tubes, escape-openings for the products of combustion from the lower portion of said wall into the smoke-chamber and from the upper portion of the furnace directly to the smoke-chamber, and valves whereby said escape-openings may be controlled, substantially as herein described.

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