(No Model.) 4 Sheets—Sheet 1.

J. E. CULVER.

STEAM GENERATOR.

No. 414,297. Patented Nov. 5, 1889.

Fig. 1.

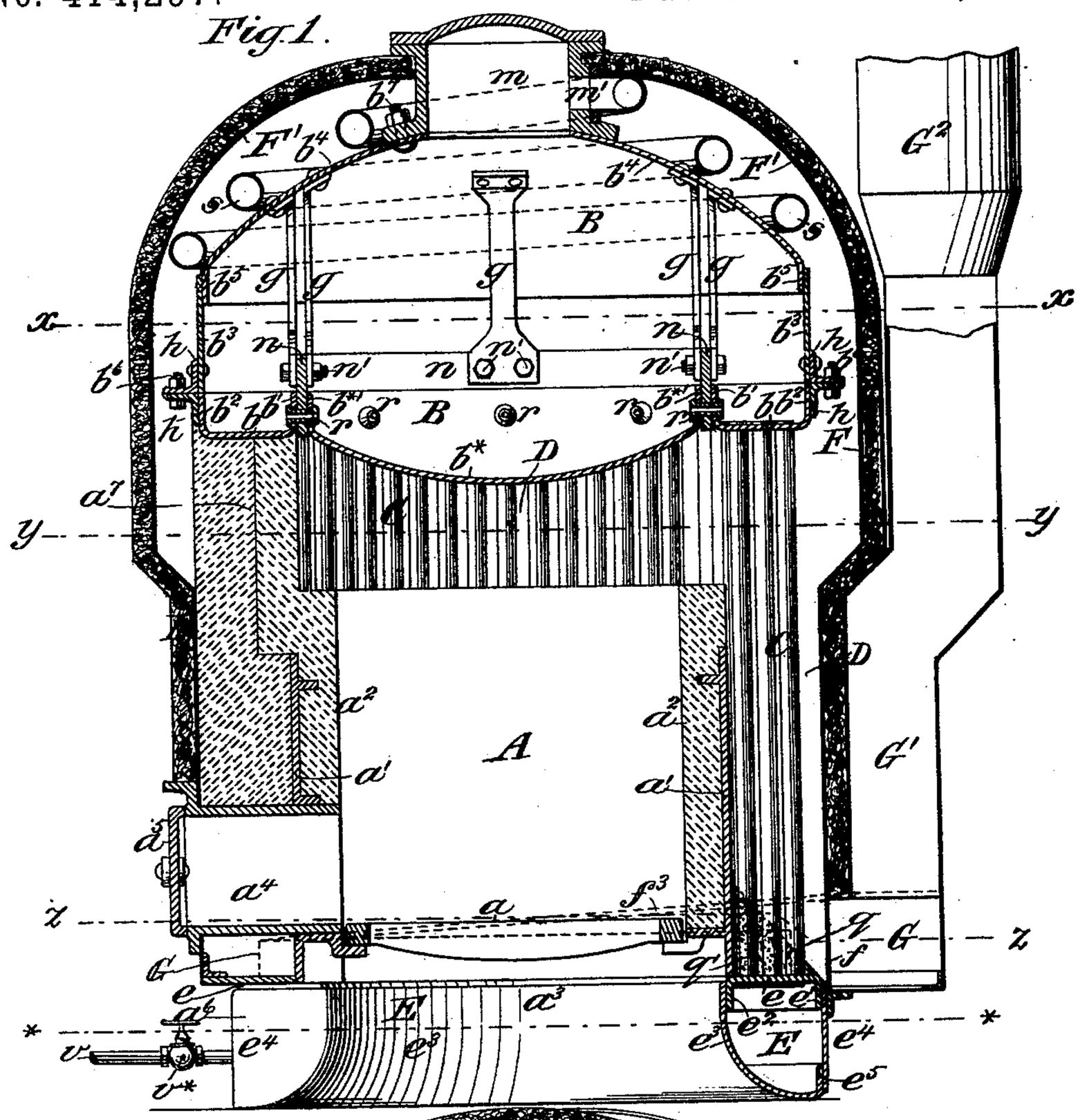
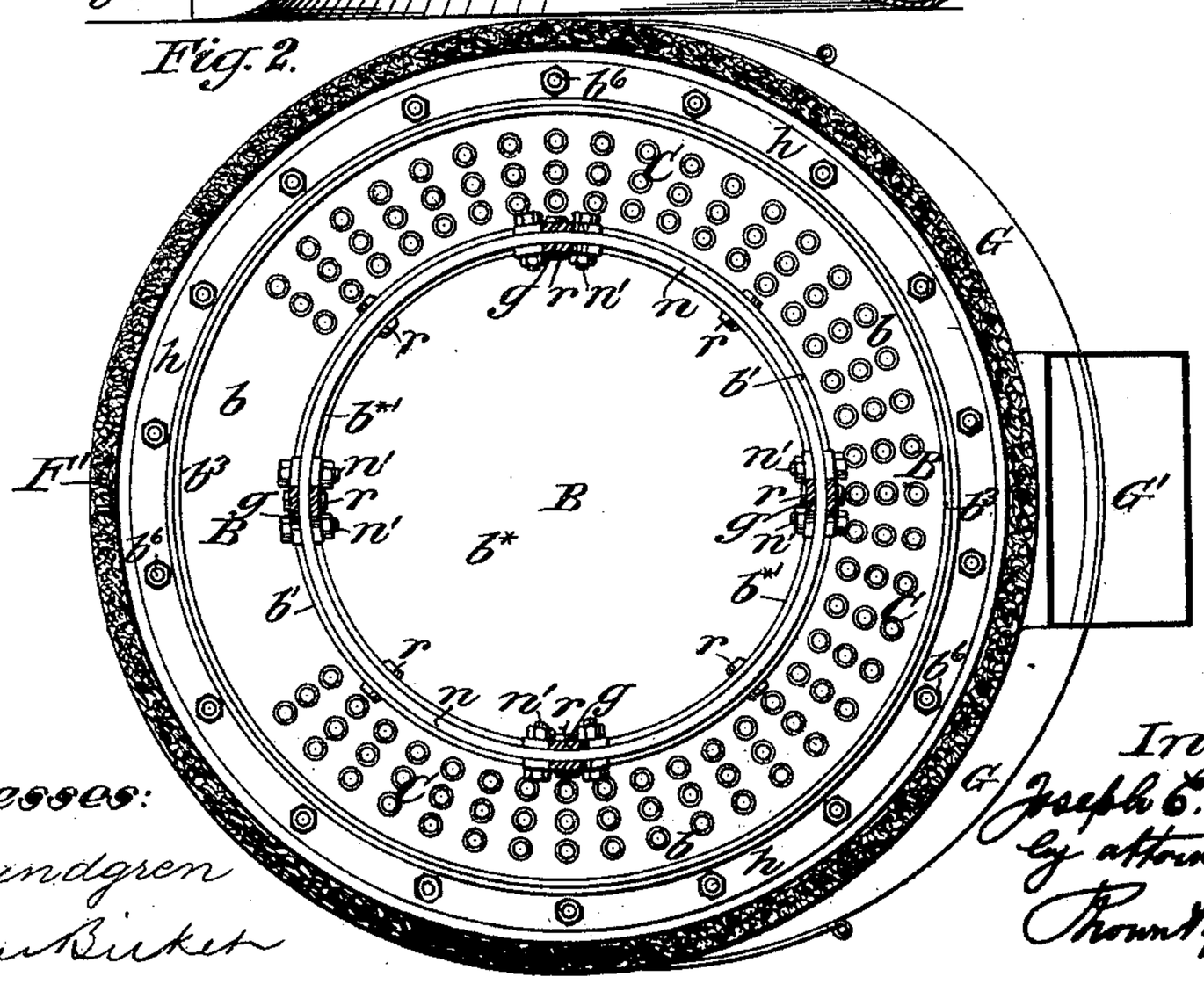


Fig. 2.



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by attorneys
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(No Model.) 4 Sheets—Sheet 2.

J. E. CULVER.

STEAM GENERATOR.

No. 414,297. Patented Nov. 5, 1889.

Fig. 1.*

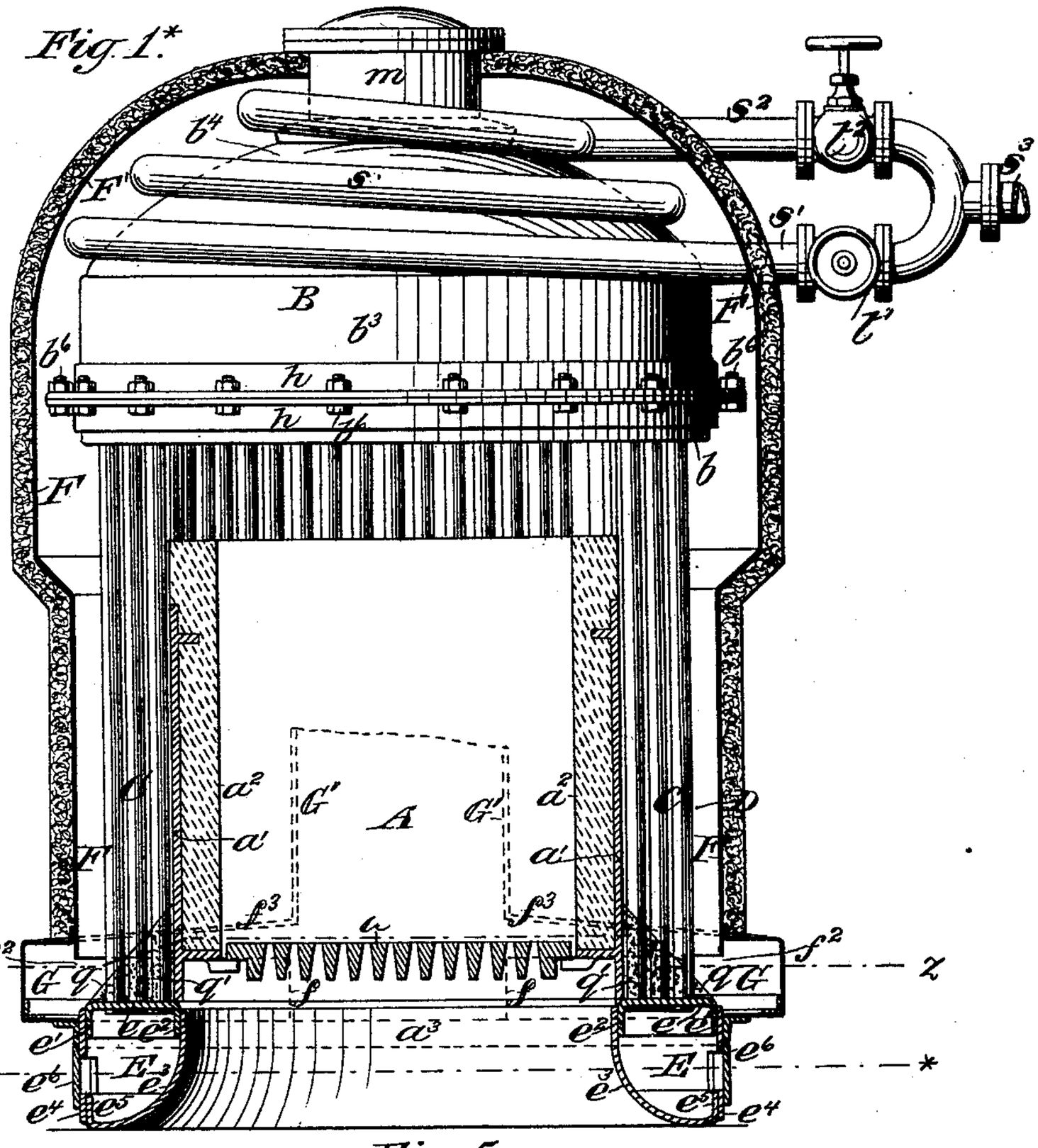
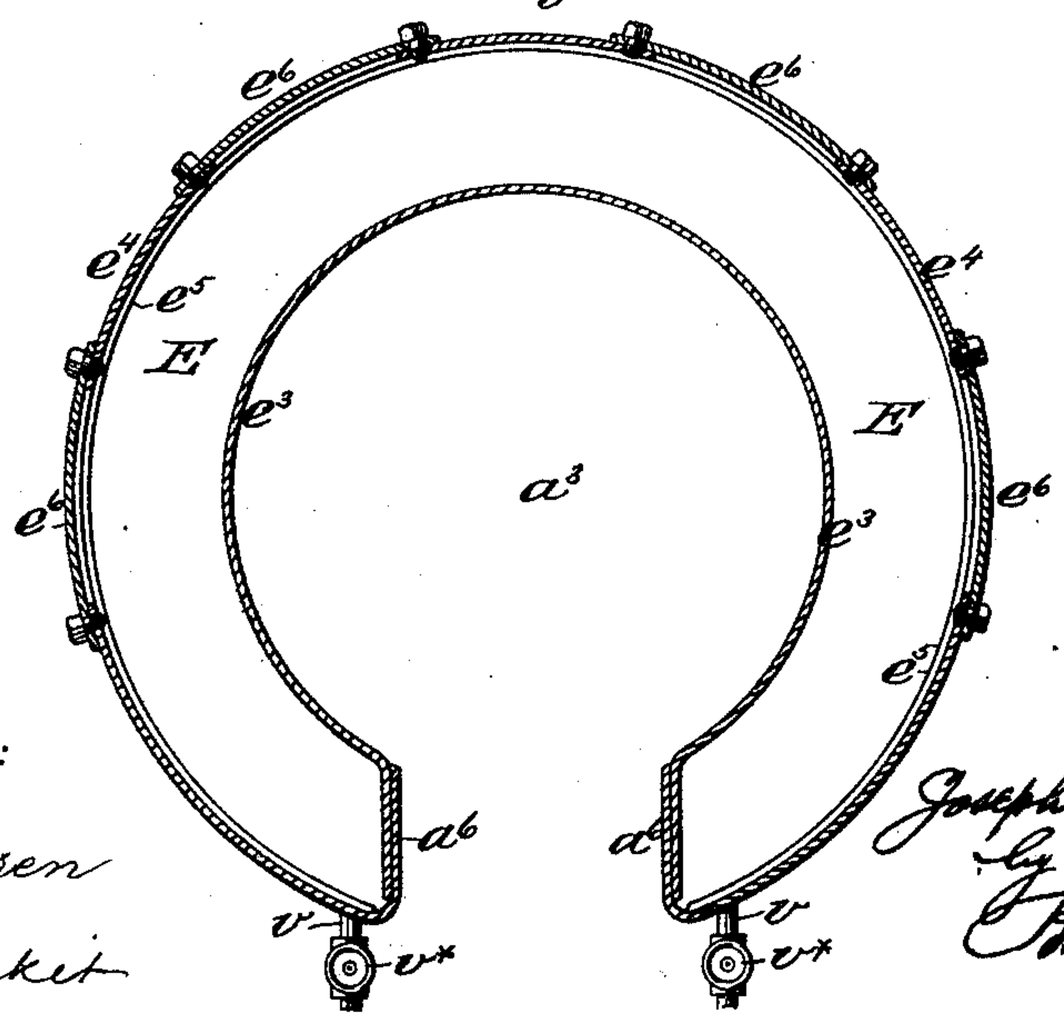


Fig. 5.



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(No Model.) 4 Sheets—Sheet 3.

J. E. CULVER.

STEAM GENERATOR.

No. 414,297. Patented Nov. 5, 1889.

Fig. 3.

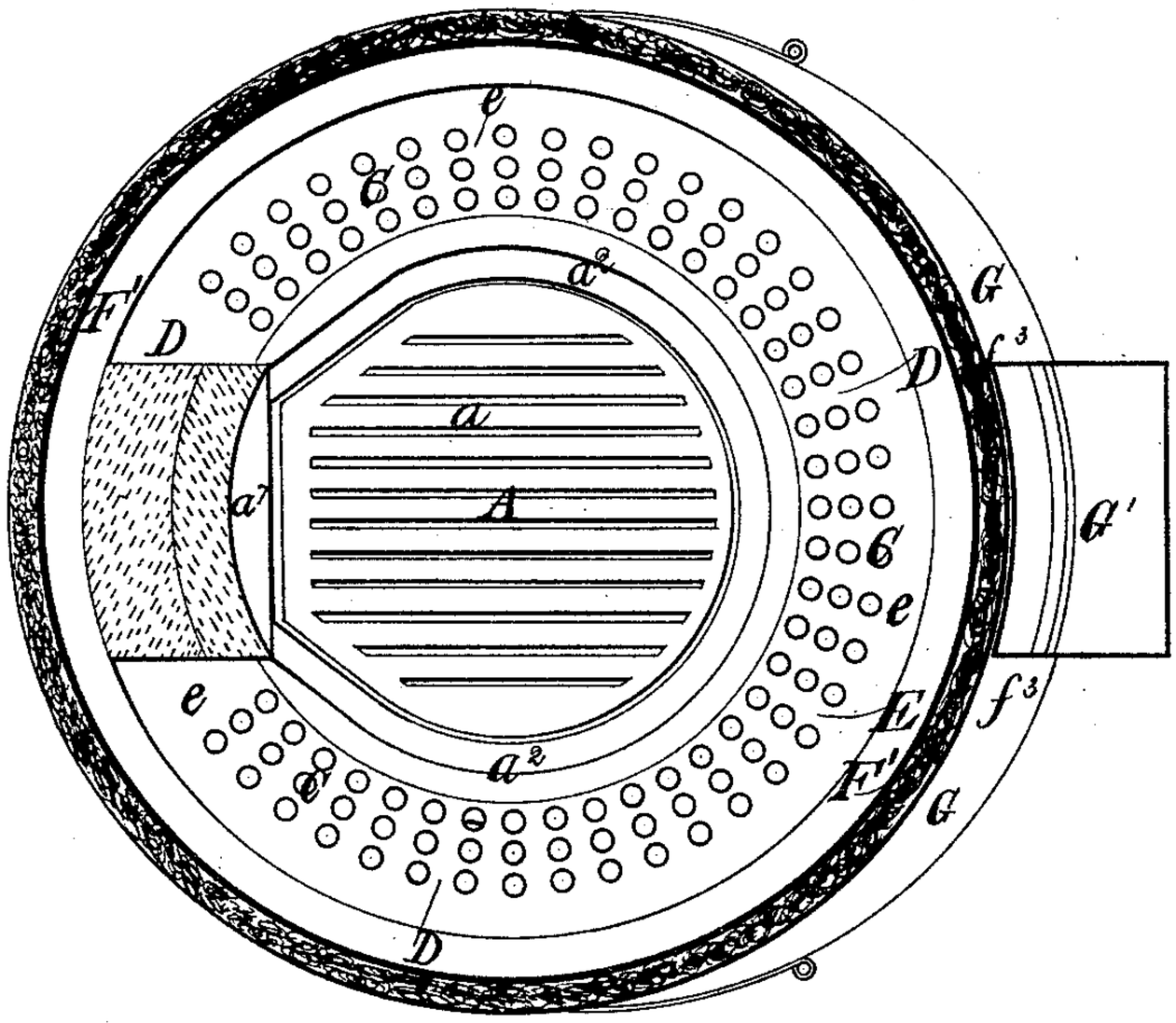
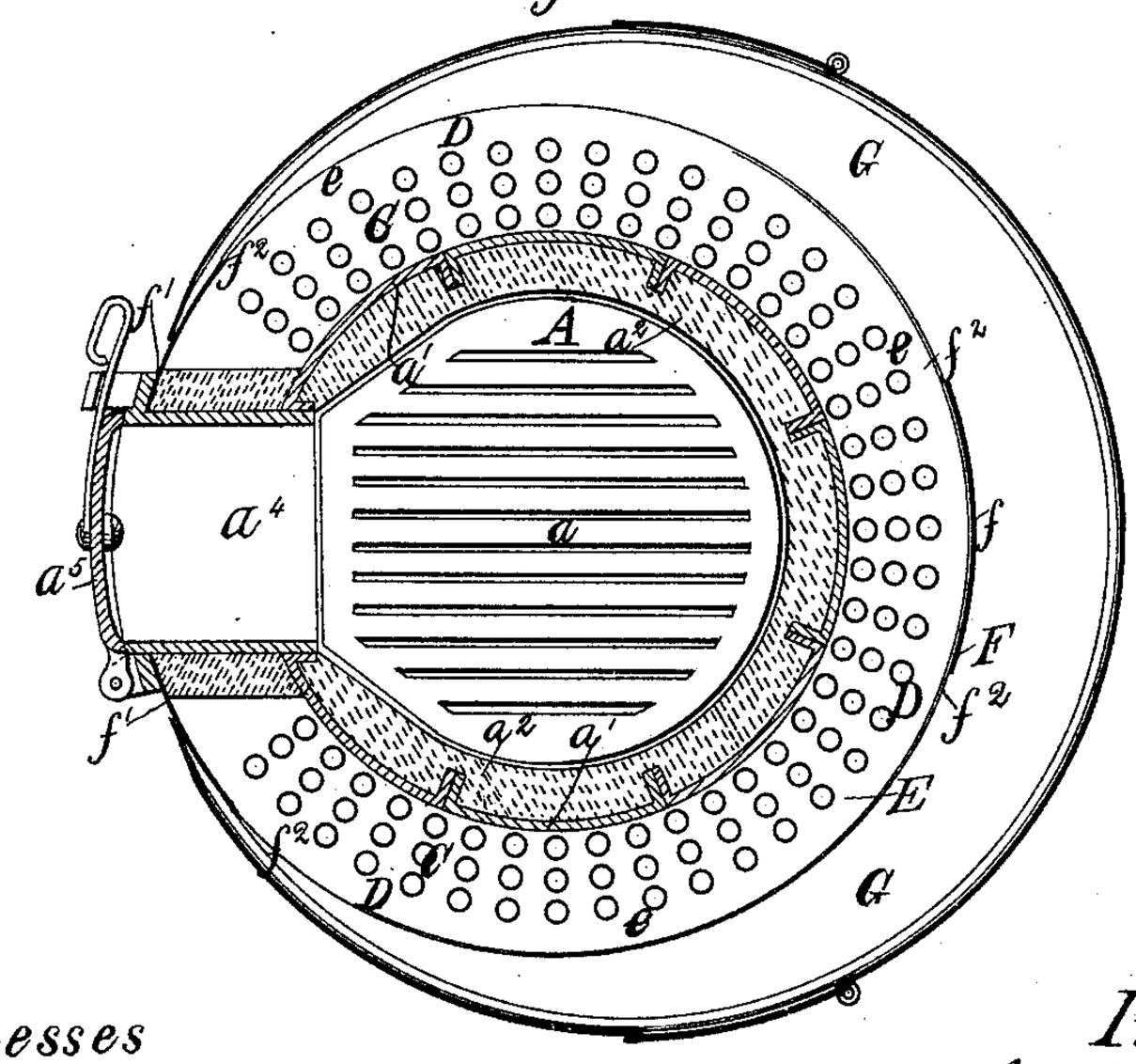


Fig. 4.



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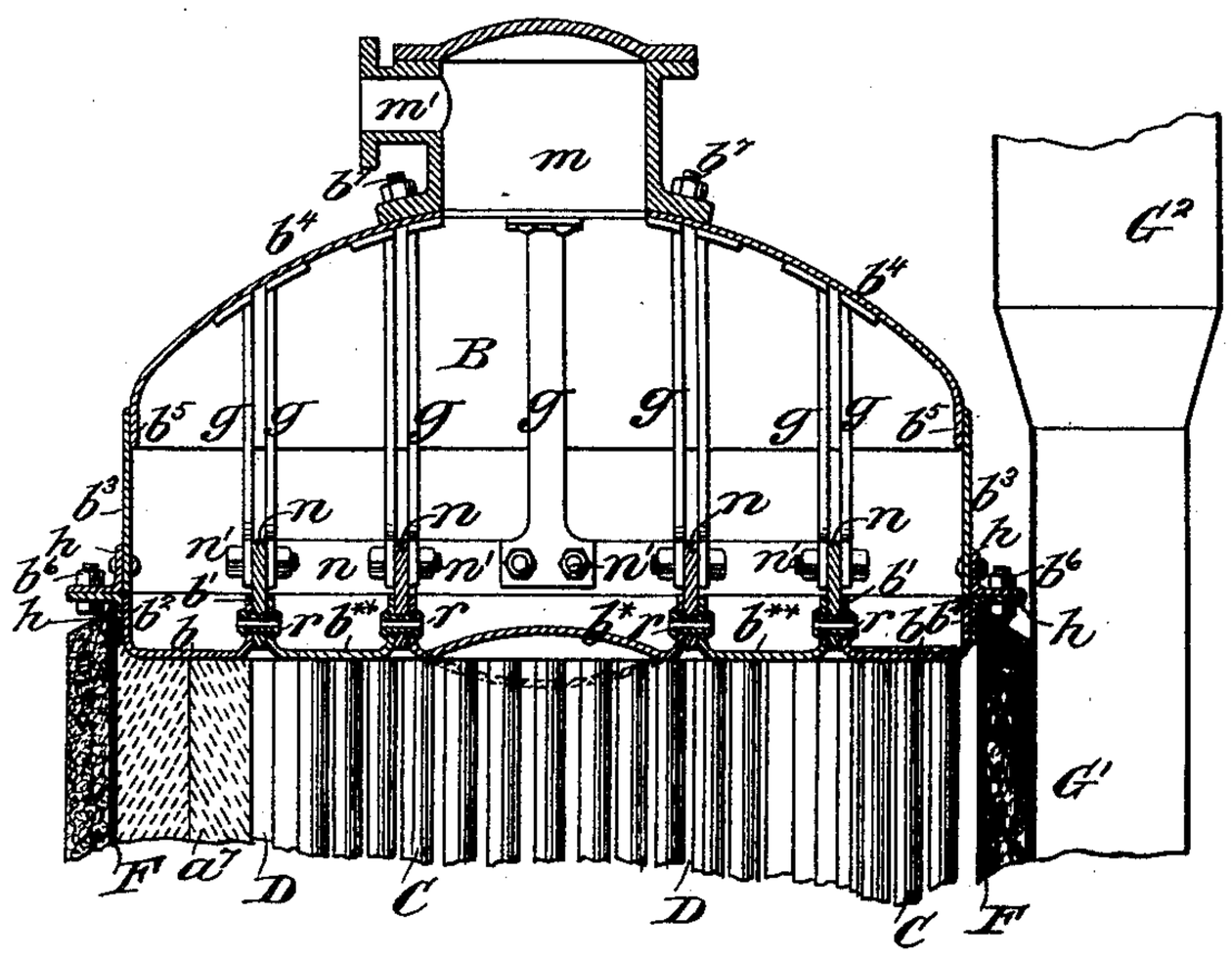
(No Model.) 4 Sheets—Sheet 4.

J. E. CULVER.

STEAM GENERATOR.

No. 414,297. Patented Nov. 5, 1889.

Fig. 6.



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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. 414,297, dated November 5, 1889.

Application filed November 14, 1888. Serial No. 290,766. (No model.)

To all whom it may concern:

Be it known that I, JOSEPH EDWIN 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, reference being had to the accompanying drawings.

The object of my invention is to construct a steam-generator which shall embody great strength, durability, simplicity of parts, and compactness of structure, and which shall demonstrate in operation a degree of economy, efficiency, power, safety, and facility of management not hitherto attained, and from which all and every of the above-described imperfections shall be practically eliminated.

I will now describe my invention with reference to the accompanying drawings, and afterward point out its novelty in claims.

Figure 1 represents a central vertical section of a steam-generator embodying my invention, taken through the furnace-door and smoke-uptake. Fig. 1* represents a central vertical section at right angles to Fig. 1; Fig. 2, a horizontal section taken on the line $x\ x$ shown in Fig. 1; Fig. 3, a horizontal section on the line $y\ y$ in Fig. 1; Fig. 4, a horizontal section on the line $z\ z$ in Figs. 1 and 1*; Fig. 5, a horizontal section on the lines * * in Figs. 1 and 1*; Fig. 6, a central vertical section of the upper part of the boiler, illustrating a modification of the invention.

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

The principal parts of this steam-generator are a furnace A, a water and steam chamber B, water-tubes C, a tube-space D, a water-receptacle or water-way E, a casing F F′, and a smokeway G G′.

I will first describe the furnace A.

Having determined upon the dimensions of the boiler to be built, I construct a grate a of the shape required and of about half the number of square feet of surface usually assigned to a horizontal tubular boiler of the same horse-power and provide for it a suitable support. In the example represented this support is provided in a frame-work a', of cast-iron, which encircles the furnace and contains a fire-brick lining a^2, which constitutes the furnace-wall. The furnace is represented as of upright cylindrical form. The wall a^2 extends from the grate upward two-thirds of the distance to the crown-sheet of the furnace. The part a^3 of the furnace inclosed below the grate is the ash-pit, having an opening at a^6. So much of the space above the grate as shall contain the burning fuel is the fire-chamber, and all the rest of the furnace between the fire-pot beneath and the crown-sheet b above is the combustion-chamber, and is capacious enough for combustion of the fuel to be completed therein. The entrance a^4 to the fire-chamber is furnished with a door a^5, hinged upon the furnace-front.

I will next describe the water and steam chamber B. The bottom of this chamber is the fire-plate of the boiler, carrying water upon its inner or upper surface, while against its outer or under surface the flames and hot gases from the furnace-fire play, and are deflected thence down the tube-space. The bottom of the said chamber is therefore the crown-sheet of the furnace. The fire-plate may be made of one continuous piece of sheet metal, or, preferably, of two or more concentric pieces flanged and riveted together in the manner hereinafter described. In Figs. 1 and 2 the said plate is represented as made of two concentric portions b and b^*. The central portion b^* of the fire-plate directly above the furnace is without tubes, for the reason that there is no room for water-tubes within the space occupied by the furnace from ash-pit to crown-sheet. This untubed center portion is represented in Fig. 1 as wrought or molded into a segment of the surface of a sphere, so that in position its concavity, or water-surface, shall be presented upward and its convexity, or fire-surface, downward. Its outer edge or perimeter is flanged vertically upward all around, as shown at $b^{*\prime}$. The tube-sheet b, of annular form, entirely encircles the untubed central plate b^* and extends horizontally outward therefrom. Both margins of the tube-sheet are turned vertically upward—the inner margin b' to constitute a flange to match the flange $b^{*\prime}$ on the center plate b^*, the outer margin b^2 to meet and join the lower edge of the lateral upright wall or barrel b^3 of the chamber. The roof b^4 of the chamber (represented as a dome) may be spherical or conical, constructed of boiler-

plate of suitable thickness, and flanged vertically downward around its lower margin b^5, and there overlapped by and riveted to the upper border of the barrel b^3 of the dome. A turret m is represented as surmounting the apex of the dome b^4 and securely fastened to it by screw-bolts and nuts b^7, and this turret has an outlet m', through which the steam passes out. A deep ring n, of steel or other suitable metal, is fitted between the upturned flanges of the tubed and untubed divisions b and b^* of the crown-sheet, so as to project above the ends of said flanges. In this position the flanges b' $b^{*\prime}$ and the interposed ring n are to be fastened together by double riveting through them; also, a number of hollow rivets r, having their interior calibers one-half inch, more or less, in diameter, pass through the said flanges and ring and provide adequately for maintaining the same water-level in the dome on both sides of the flange-partition. Strong braces g, as many as are desirable, are arranged to reach perpendicularly from the upper projecting part of the steel ring to the roof or dome b^4, secured to the latter by rivets and to the steel ring by bolts and nuts. These braces are represented in pairs, one on each side of the ring, the upper section of the chamber B consisting of the barrel b^3 and the dome or roof b^4, and the lower section composed of the central plate b^* and the tube-sheet b, which are provided with lateral flanges for the purpose of uniting them together. These flanges are represented as composed of the outward projection of angle-iron bands h h, which are riveted, respectively, to the barrel b^3 and to the upturned margin b^2 of the tube-sheet b. The flanges of the two sections are riveted or bolted together by rivets or bolts passing through them, but preferably bolted together by screw bolts and nuts b^6, which are removable at pleasure to permit the removal of the dome b^4 and all of the chamber B which is above the crown-sheet and tube-sheet for the purpose of getting at the tubes when necessary. The turret m has a removable cover, and is itself removable to permit the entrance of a man or boy to remove the bolts and nuts n' to permit the removal of the upper domed portion of the chamber B.

I will now describe the tubes C and tube-space D.

The tube-space D is formed between the furnace-wall a^2 and the surrounding cylindrical exterior casing F, which will be hereinafter more fully described. This tube-space is occupied by concentric rows of upright water-tubes C. The entrance a^4 to the furnace in the front of the boiler takes up some of the space between the furnace-wall and the outer shell or incasement F, as shown in Fig. 4, and thereat prevents the rows of tubes from completing a circle and leaves a small area of the tube-sheet overhead untubed. Between this untubed portion and the furnace-entrance a^4 the space may be filled up with fire-brick or solid material, as shown at a^7 in Figs. 1 and 3. Elsewhere the upper ends of the water-tubes C are expanded into the tube-sheet b of the chamber B, and their lower ends are expanded into the tube-sheet e of the bottom water-receptacle E, which will presently be described. The tube-space D is therefore somewhat of horseshoe shape in horizontal section, as shown in Figs. 3 and 4, and it extends vertically from tube-sheet e to tube-sheet b. The hot gases that rise from the furnace strike against the crown-sheet b^*, and are thence deflected down through the tube-space D, which may therefore be called the "reverberatory." There is a right angle within the tube-space at the bottom formed by the intersection of the plane of the lower tube-sheet e with the vertical plane of the furnace-wall. From a horizontal line drawn around the outside of the furnace-wall at a suitable distance above the proximate border of the tube-sheet a diagonal q, (see Figs. 1 and 1*,) slanting downward across the tube-sheet to its outermost edge, will inclose a spatial angle, into which I insert a filling q', of putty, cement, or suitable composition, to produce an inclined smooth upper surface, whereon dust or cinders falling down the tube-space D may be shunted out into the surrounding smokeway. This putty joint between the furnace-wall and tube-sheet must be air-tight.

I will next describe the water-receptacle E.

The lower tube-sheet e is an exact counterpart to the tubed portion of the upper tube-sheet b, not only in all its dimensions, configurations, and horizontality, but also in the number and relative positions of its tube-holes. It has both its outer and inner margins e' e^2 flanged downwardly. It encircles the furnace as far as the tubes extend, but does not encroach upon the ash-pit. This lower tube-sheet e is the upper plate of the water-receptacle E. The inner flange of this tube-sheet is riveted through a lap-joint to the upper edge of a plate e^3, (see Figs. 1, 1*, and 5,) which in its vertical section (shown in Figs. 1 and 1*) is curved downwardly and outwardly, convex on its outside surface, and concave within and flanged upwardly at its lower border, as shown at e^5, into the perpendicular plane of the downward flange on the exterior edge of the tube-sheet e. A vertical plate e^4 connects the flange e^5 on the curved plate to the outer tube-sheet flange e', being fastened to each flange by a riveted overlap joint. These three plates united in the manner described complete the water-receptacle E, extending from end to end thereof, the said receptacle being in its horizontal section (shown in Fig. 3) of the form somewhat like a horseshoe or a ring, a portion of which has been removed from one side corresponding with the tubed portion of the upper tube-sheet b, the gap formed in the annular contour thereof at a^6 being the entrance to the ash-pit a^3. Doors e^6 are provided in the out-

side or vertical plate e^4 of the water-receptacle numerous and large enough to allow the work of expanding the tubes into the lower tube-sheet to be done through the openings. Into each closed end of this water-receptacle a suitable pipe v is fitted, extending through the boiler-cover in front, one on each side of the ash-pit. Outside of the cover each pipe v may be furnished with a valve v^*. Either may be the feed-water pipe, the other the blow-off.

I will next describe the casing F F′ and the smokeway G G′.

The casing F F′ consists of a shell of sheet-iron completely surrounding and inclosing the tube-space and furnace. In the example shown in Figs. 1, 1*, 2, and 3 this shell also incloses the upper water and steam chamber B. In this example the lower part of the said shell is cylindrical and of a size only large enough to inclose the lower portion of the tube-space D, as shown in Figs. 1 and 1*; but just opposite the top of the wall a^2 of the fire-chamber it becomes larger around the upper parts of the tubes C and around the water and steam chamber B, terminating at the top in a dome F′, which meets the steam-turret m. The casing thus constructed extends from the water-receptacle E to the turret m, and its upper part incloses a space around and above the chamber B. The lower cylindrical portion F is fastened to the water-receptacle E for a space f (see Fig. 4) directly in front of the smoke-stack, and also to and around the ends of the said receptacle anteriorly, as shown at f' in Fig. 4; but between these points from front to rear on either hand the shell or cover terminates, as shown in Fig. 1*, some distance above the lower tube-sheet, thus forming on opposite sides of the boiler lateral smoke-exits f^2 (see Figs. 1* and 4) from the bottom of the tube-space into the outside horizontal smokeways G. The casing has also provided in it an opening for the entrance a^4 of the furnace. The smokeways G, preferably made of sheet-iron, begin narrow just outside each anterior horn of the lower tube-sheet, and, having their floor throughout about the same level as the tube-sheet, (see Figs. 1 and 1*,) pass around the boiler in opposite curves to the rear, where, enlarged, they meet and communicate with the uptake G′, leading to the smoke-stack G^2. The horizontal measurement of the smokeways G widens uniformly from the points of beginning to their common termination, whereat it may at least equal the antero-posterior diameter of the uptake G′. The smokeways G may also be enlarged upward in their course, rising more and more above the lateral exits along the outside of the casing, as shown by dotted lines at f^3 in Fig. 1*. The casing is represented as covered with a thick jacket of asbestus and felt or other non-conductor of heat.

In Figs. 1 and 1* the steam-delivery pipe s, connected at the steam-outlet m', has the form of a coil, which surrounds the dome b^4 within the space between the chamber B and the upper part F′ of the casing, which is filled with hot gases of combustion. In this space thus occupied by the coil there is little or no circulation, the circulation from the fire-chamber to the lower smokeways being outward between the fire-chamber wall a' and the tube-sheet b, and thence downward through the tube-space D. The heat in the said space will therefore be insufficient to burn the steam-pipe or injuriously superheat the steam passing therethrough, yet sufficient to give the steam the requisite dryness.

In order to insure that the steam may have the requisite dryness without being injuriously superheated, I provide at the outer end of the coil s a branch pipe s', provided with a stop-valve t', and I also provide the said coil, at a suitable point between the said end and the outlet m' of the steam-turret, with another branch pipe s^2, furnished with a stop-valve t^2. The two branches s' s^2 are connected with a single pipe s^3, by which the steam is conducted to the engine or place wherein it is to be used. By opening one of the valves t' t^2 and closing the other the steam may be taken from the coil, after having passed a greater or less distance within it, and hence having been more or less subjected to the heat within the upper part F′ of the casing.

In the example of the invention shown in Fig. 6 the boiler-casing F does not include the water and steam chamber B, but only extends from the lower water-receptacle D to the lower part of the said chamber B. The lower part of the said casing (not represented in this figure) is intended to be precisely like the lower part of the casing shown in Figs. 1, 1*, 2, 3, and 4, and hereinbefore fully described. The upper part is fitted snugly around the exterior of the base of the water and steam chamber, and thence extends over the steam-dome.

In Fig. 6 the fire-plate, instead of being composed of two plates—viz., an untubed center plate and an annular tube-sheet—as in the first-described example, is represented as composed of three pieces—viz., an untubed center plate b^*, an outer annular tube-sheet b, and an annular plate b^{**}, interposed between b and b^*. These three pieces are united by upturned flanges provided upon them and interposed rings n, similar to those which have been described with reference to the first example, the said rings n being united with the dome b^4 by means of similar braces g.

In front of the furnace the frames of the doors closing the entrance to the fire-pot and ash-pit, respectively, may be fastened to the outside of the shell, each in its proper position, the doorways made by cutting away the shell from within the frames, and the doors fitted and hinged to close and open. Instead of this a cast-iron furnace-front complete may be substituted.

The entire metallic surface of the cover, boiler, dome, and smokeways may be overlaid with a wash or layer of lime hydrate or sulphate, magnesia, asbestus, white clay, or other good incombustible reflector of radiant heat, and outside of this, over all, the thick jacket of felt or of an equivalent non-conductor of heat may be superimposed and confined in place by means of canvas wrappings.

Safety-valves, gage-glasses, water-cocks, steam-gages, indicators, &c.—such as are used on other boilers—are to be attached to my invention and operated in the usual manner.

The steam-dome being full of water, it can be employed for heating by hot-water circulation.

The advantages of this steam-generator are as follows:

First. Combustion is perfect. The smoke escaping is as clear as the surrounding air.

Second. The flames are not quenched prematurely and the draft does not carry ashes into the smokeways.

Third. The combustion-gases move slowly down through the reverberatory, the coldest foremost, in contact all the while with a great expanse of water-tube surface, and nearly all their sensible heat is transferred to the water in the boiler.

Fourth. Even cold feed-water does not check the generation of steam. It does not mingle with the boiling water at all, nor even with that in the tubes.

Fifth. The down-moving gases in the reverberatory as they cool are at every step brought into contact with colder water-tube surfaces, wherefore approximate equalization of temperature between the heating-gases and the heated water is impossible.

Sixth. Steam does not cushion upon the heating-surfaces and lift the water from them, and thus cause them to become overheated. There is no siphoning.

Seventh. No formation of "scale" takes place in my steam-generator.

Eighth. Steam does not form in the water-tubes, but only in the shallow depth of water upon the fire-plate within the boiler-dome. There is no foaming or uprush of water nor any water-circulation whatever within the boiler-tubes except the slow upward advance of the feed-water everywhere to replace that which is removed by evaporation. The steam as it is liberated from the water is saturated steam-dry or nearly dry.

Ninth. The steam can be delivered dry or even superheated to any degree required.

Tenth. It takes a long time for the water to travel from the receptacle to the steam-dome, moving as it does through so many water-tubes simultaneously. Meantime it becomes heated and rarefied and lets fall into the receptacle all the inorganic and heavy substances it holds in suspension. The receptacle E can be washed out by opening wide and to the same extent at once both the feed-pipe and the blow-off.

Eleventh. All parts of the boiler are so shaped, constructed, and combined as to withstand, without rupture or strain, steam of the highest tension that can be worked in any engine. The parts having the greatest diameters—the steam-dome and water-receptacle—can be subdivided each into several smaller ones should occasion demand it. Nowhere are braces, bolt-heads, and rivets exposed to the direct action of the fire.

Twelfth. This boiler uses water-tubes one inch to one and one-half inch in diameter without any risk or inconvenience; hence it gives within the same cubic space two to four times as much heating-surface as locomotive-boilers.

Thirteenth. Repeated experiments have shown that this boiler approximately attains the theoretical limit of evaporation—namely, fifteen pounds of water per pound of coal consumed. Use dry coal, not wet.

Fourteenth. Unequal expansion and contraction of the metal do not affect this boiler injuriously.

Fifteenth. The quantity of steam evolved per minute per square foot of water-surface is very great. Generated at the same rate deep beneath the surface amid a rapid water-circulation the steam would drive all the water into the top of the boiler. In this boiler, however, the steam is at all times uppermost, resting upon boiling water only a few inches in depth, beneath which, five feet deep, is water which does not boil.

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

1. The combination, in an apparatus for generating steam or heating fluids or fluent bodies, of a central furnace, a water and steam chamber arranged above the said furnace, and the bottom of which comprises a tube-sheet, a lower water-receptacle, the upper part of which is a tube-sheet arranged near the bottom of the furnace, a series of water-tubes arranged in the tube-space around the exterior of the furnace and connecting the said water and steam chamber and said lower water-receptacle, a wall surrounding the furnace between it and the lower part of said water-tubes, but terminating at a distance below said chamber to form an opening to the upper part of said tube-space, a shell or casing surrounding the furnace, the tube-space, and water-tubes, and a smokeway communicating through openings in the lower part of said shell or casing with the lower part of said tube-space, substantially as herein described.

2. The combination, in a water and steam chamber constituting the upper part of a boiler, of a base comprising a central untubed plate and a surrounding annular tube-sheet, both having upright flanges, a ring interposed and secured between said flanges, a dome

forming the roof of said chamber, and braces connecting said ring and dome, substantially as herein described.

3. The combination, with two plates forming the bottom of a water and steam receptacle of a boiler and the crown-sheet of a furnace and having upturned flanges, of hollow rivets passing through and uniting said flanges and forming water-passages through said flanges, substantially as and for the purpose herein described.

4. The combination, with the furnace A, steam and water chamber B, lower water-receptacle E, and water-tubes C, of the surrounding casing or shell F, having openings f^2 in the lower parts of its opposite sides, the external smokeways G outside of said openings, and the uptake G′, in which said smokeways have a common termination, substantially as herein described.

5. The combination, with the furnace-wall a^2 and the surrounding external shell or casing F, having between them the tube-space D and tubes C, the water-receptacle below said space having for its upper part the tube-sheet *e*, receiving the lower ends of the tubes C, of the filling q', forming within the said tube-space the slanting surface for the descent of dust and ashes falling within said space, as herein set forth.

6. The combination, with the central fire-chamber, the upright water-tubes partly surrounding said chamber, and the water and steam chamber arranged over said fire-chamber and tubes and connected with the upper ends of the tubes, of a water-receptacle in the form of a ring, with a gap in one side thereof, arranged below and connected with the lower ends of said tubes, and feed and blow-off pipes connected with the said receptacle, one at each of the ends which are formed therein by the gap, all substantially as herein described.

7. The combination, with a central fire-chamber, water-tubes arranged in a tube-space external to and around said chamber, an upper water and steam chamber above said fire-chamber and tubes, and a water-receptacle at the bottom of said tubes, of a smoke-casing surrounding and inclosing the said fire-chamber, upper water and steam chamber, tube-space, and tubes, and having its communication with the fire-chamber below the upper parts of the tubes and below the upper water and steam chamber, and having its outlet to the chimney at its bottom, substantially as herein described, whereby a space for gases of combustion is provided within the said casing around the upper water and steam chamber out of the course of circulation between the fire-chamber and chimney, substantially as and for the purpose herein set forth.

8. The combination, in an apparatus for generating steam, of a fire-chamber, a water and steam chamber above the said fire-chamber, and a casing surrounding and covering said water and steam chamber and communicating with the fire-chamber, of a steam-delivery pipe in the form of a coil within the said casing, and separate branch pipes from said coil at different points, and stop-valves in said branch pipes, all substantially as and for the purpose herein set forth.

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Witnesses:
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