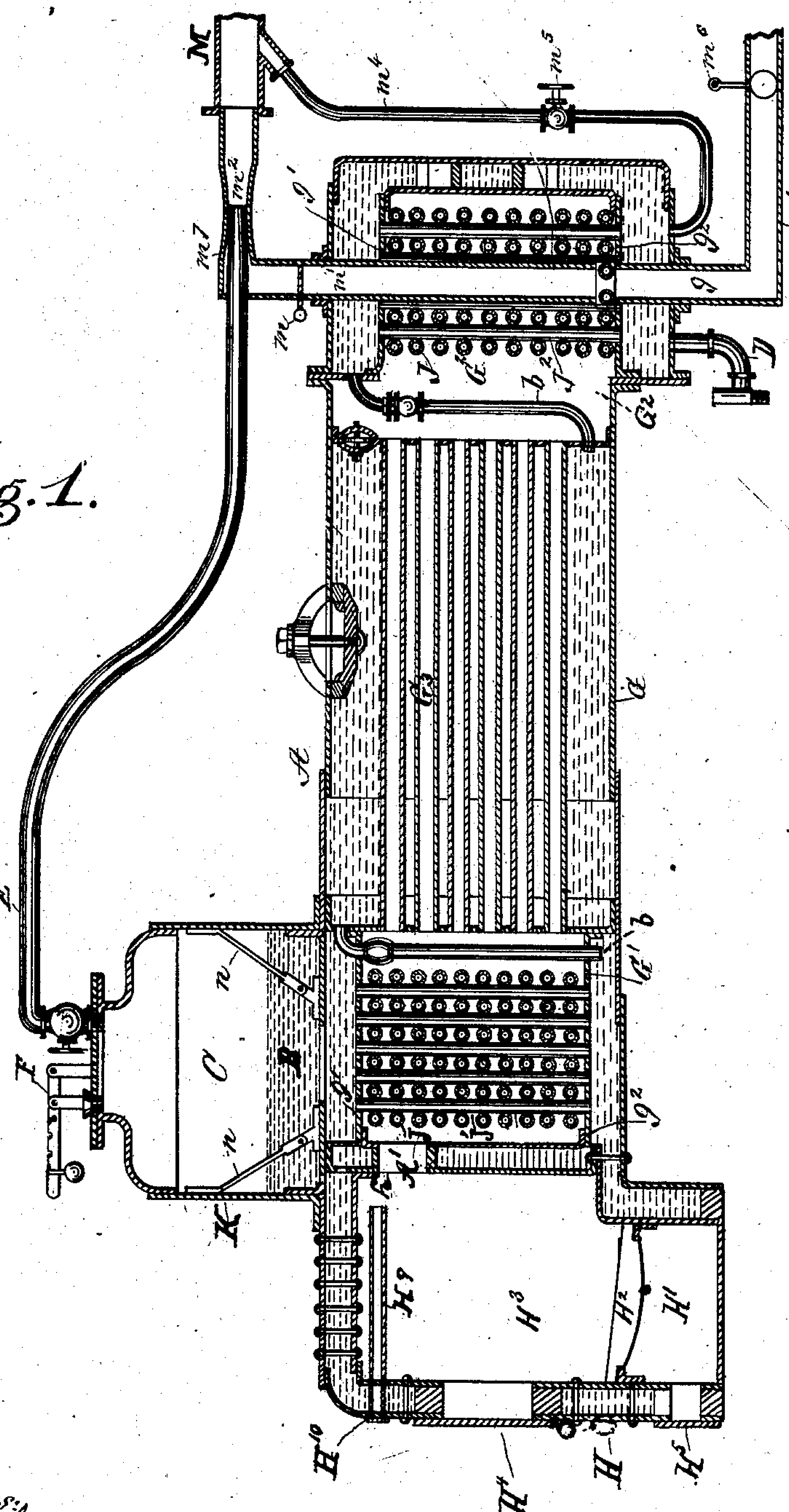
(No Model.) 3 Sheets—Sheet 1.

J. E. CULVER.

STEAM GENERATOR.

No. 289,989. Patented Dec. 11, 1883.

Fig. 1.



Witnesses:
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K. M. Supple.

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By C. Richardson
Attorneys.

(No Model.)

3 Sheets—Sheet 2.

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Fig. 2.

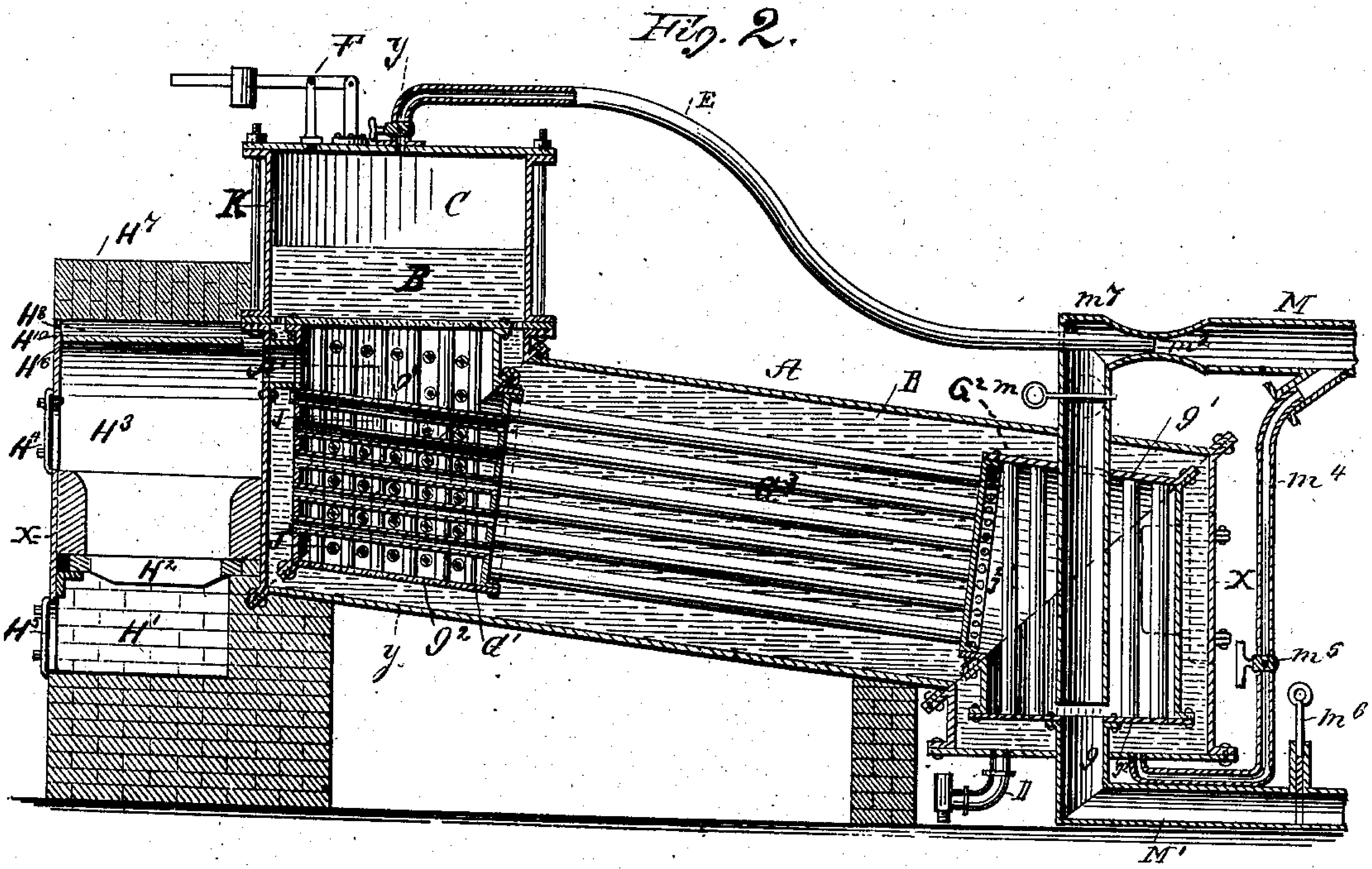
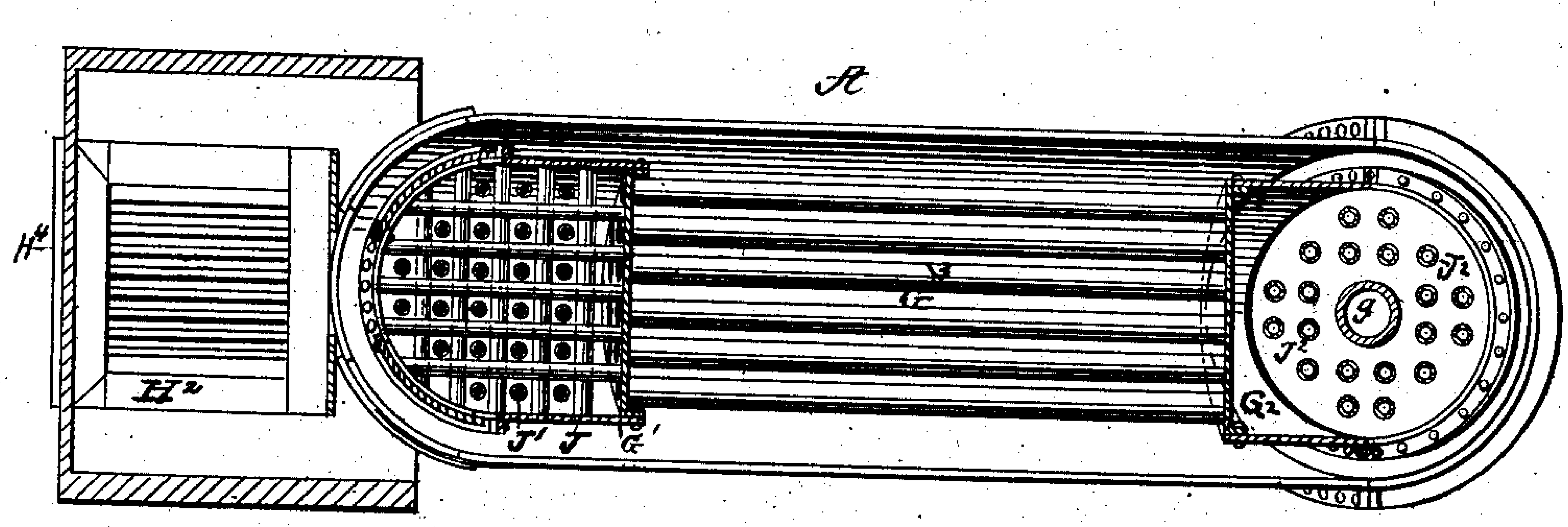


Fig. 3.



WITNESSES:
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ATTORNEYS.

(No Model.)

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Fig. 4.

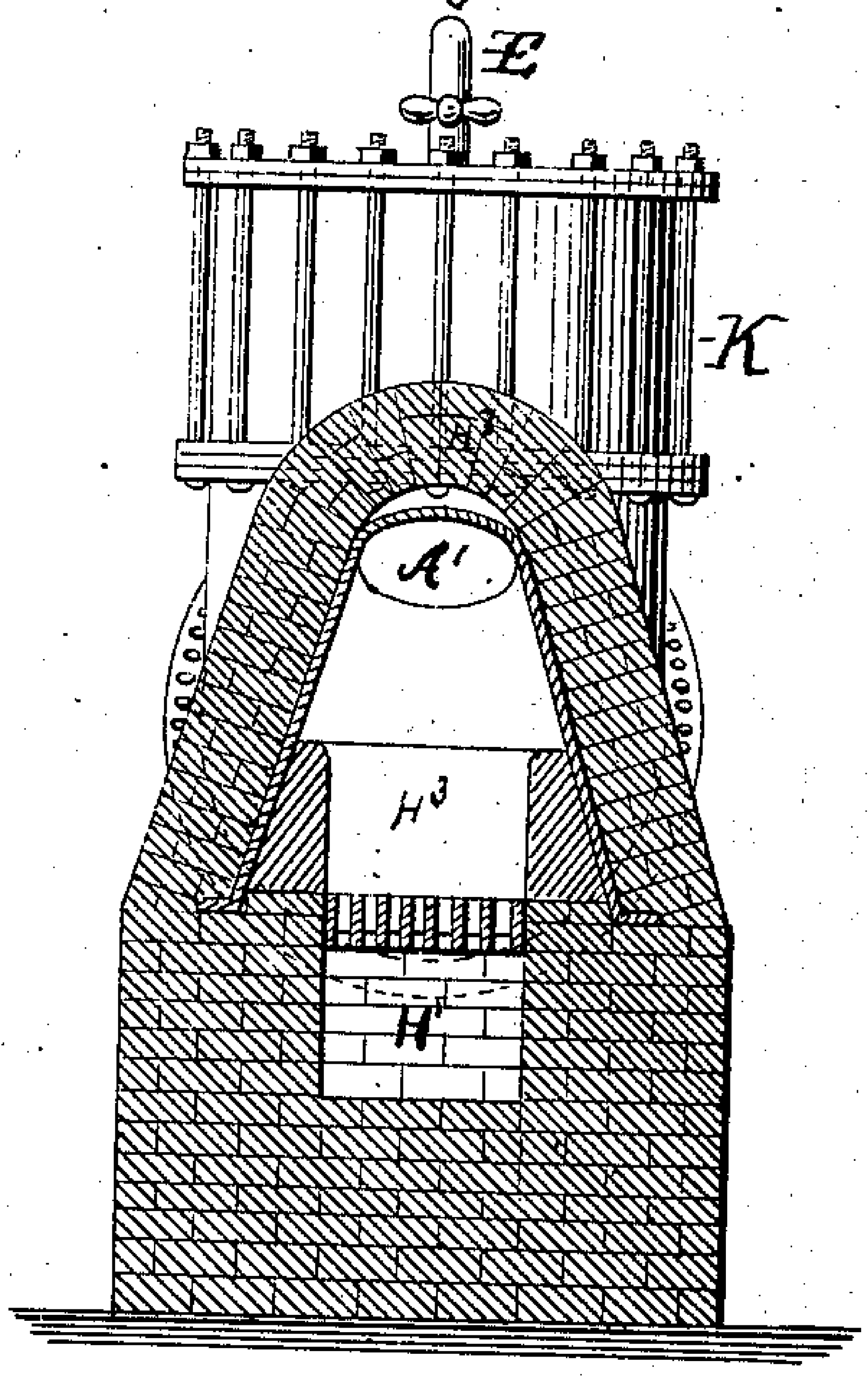


Fig. 5.

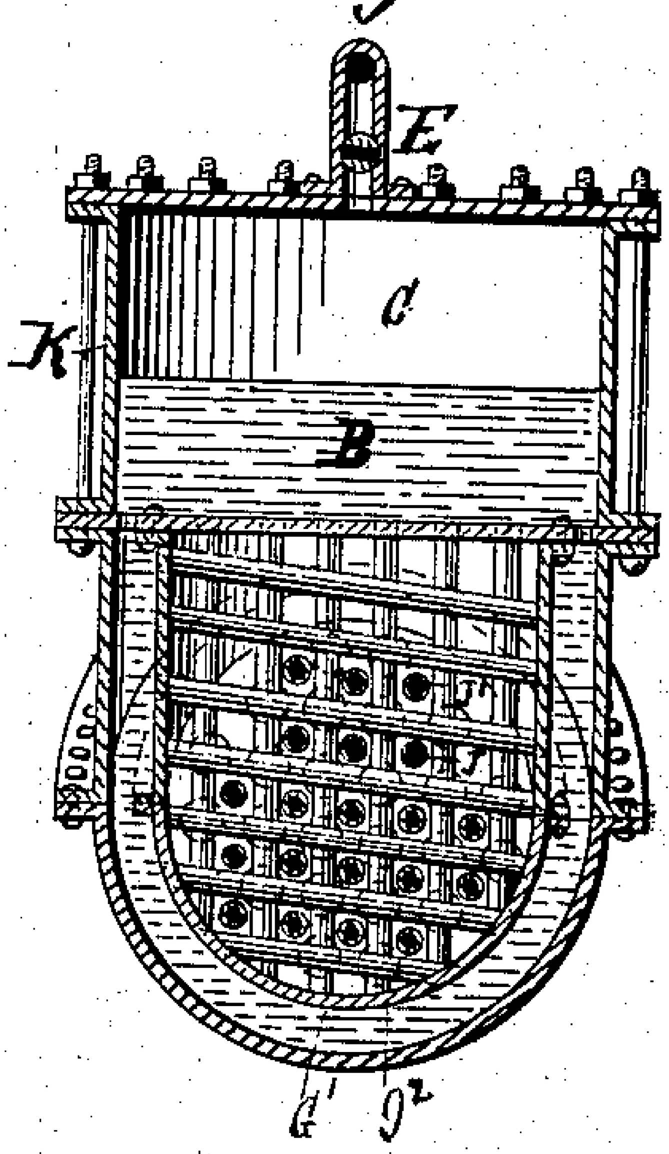


Fig. 6.

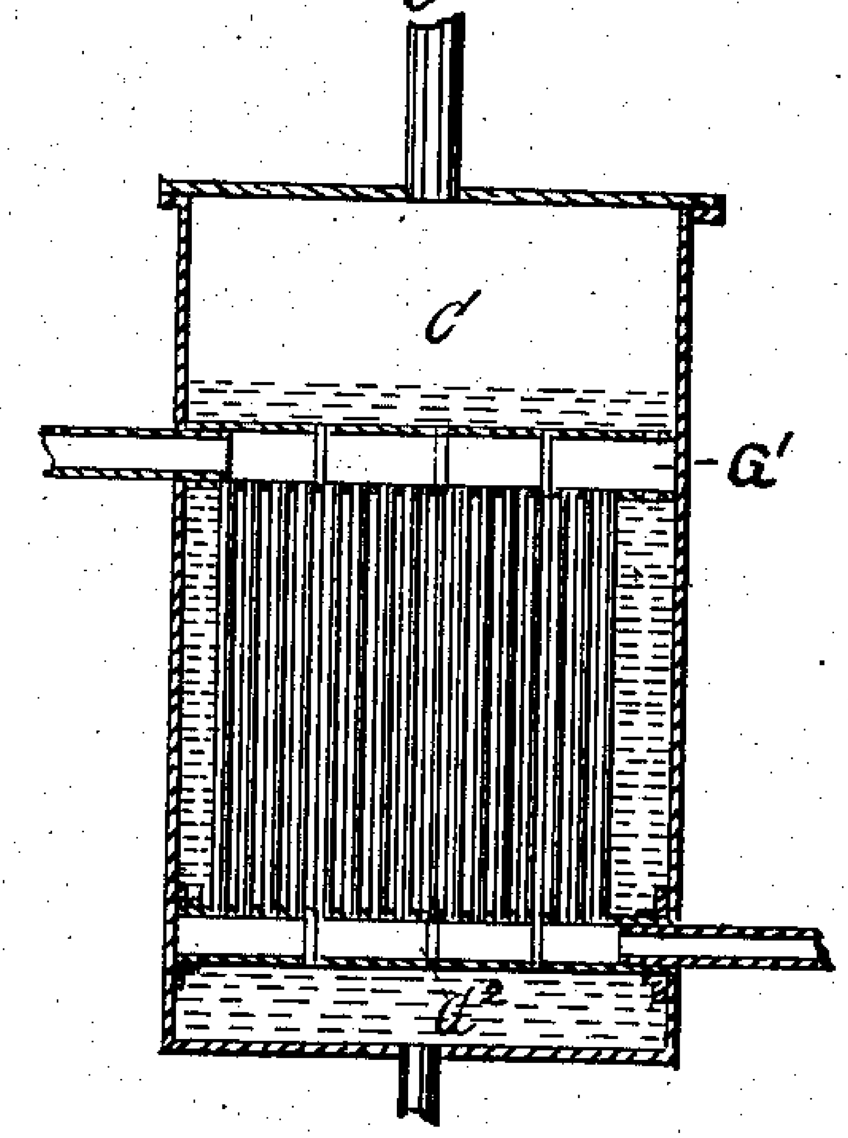
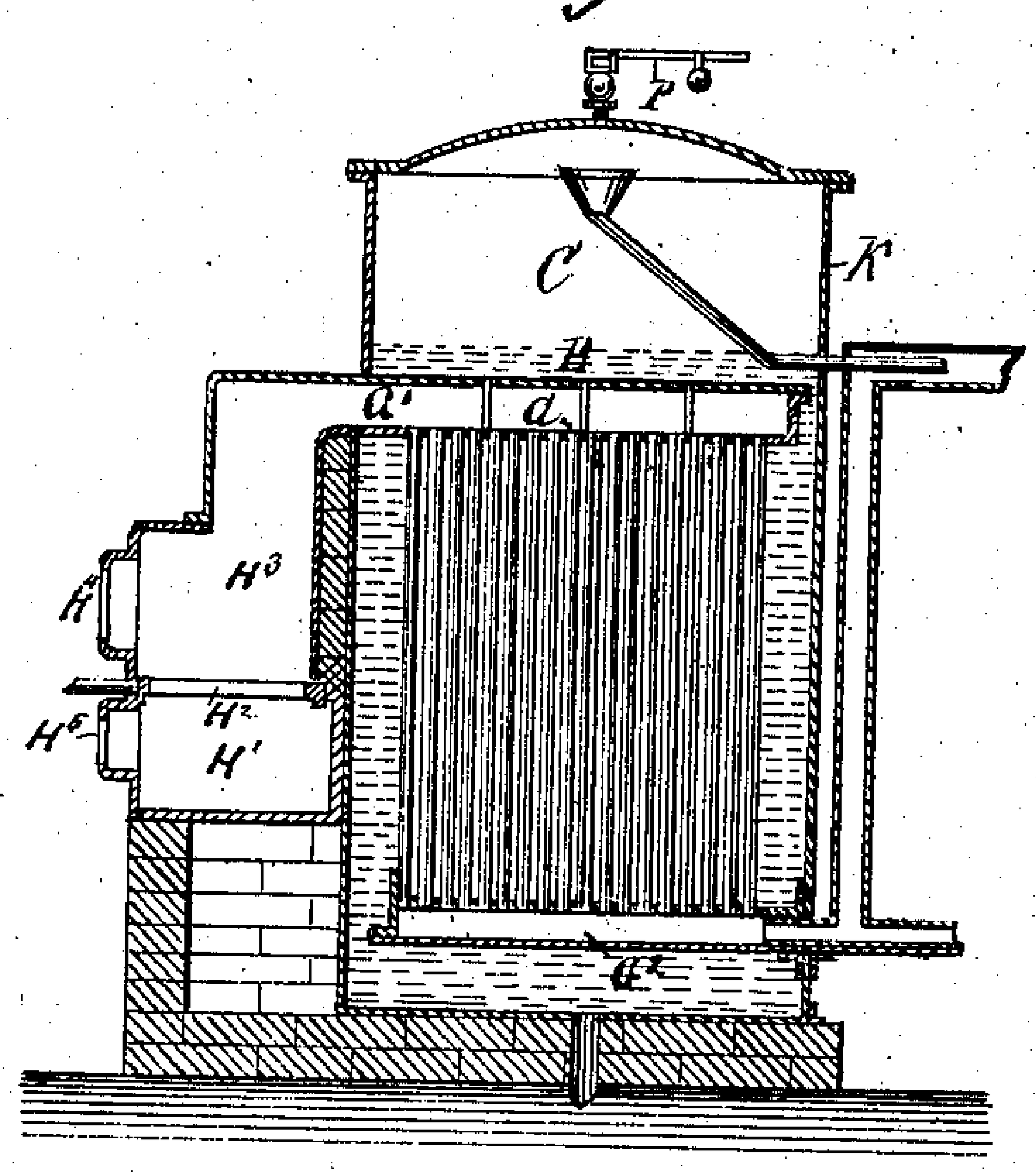


Fig. 7.



WITNESSES:
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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. 289,989, dated December 11, 1883.

Application filed July 23, 1883. (No model.)

To all whom it may concern:

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

The object of my invention is to insure that every successive portion or particle of water entering the boiler shall be heated progressively—that is to say, step by step—until it is finally converted into steam, while the calorifacient or heating gases from the furnace traverse a thermostatic flue system, the said gases advancing as they cool, and coming into contact with colder and colder flue-surfaces until they are discharged into the atmosphere at a temperature of about 100° Fahrenheit, more or less, as preferred, according to the extent of heating-surface employed and the draft maintained in the apparatus.

In carrying out my invention I employ a shell formed of boiler-iron or other suitable material, by preference of a cylindrical form, inclosing a water-space and steam-space duly proportioned and furnished with a feed-water pipe at the bottom or lower end, and a steam-pipe and safety-valve at the top or upper end. The shell of the boiler contains within the water-space, and surrounded on all sides by water, a multitubular structure, by preference formed of metal, and consisting of an upper and a lower chamber connected together by a series of boiler-tubes so arranged that the tubes shall all communicate with each other through the medium of the chambers they connect, and constitute a thermostatic balance. Through the outer shell an entrance to the upper chamber and an exit or outlet from the lower chamber is formed or provided. The parts are so formed or constructed that no leakage shall take place between the multitubular structure and the surrounding space within the shell. The area of the chambers should be sufficiently less than that of the inclosing-shell to allow of free circulation of water between them, and to the same end, however numerous and closely distributed the tubes may be, they are left out of actual contact. To complete this arrangement, and especially to prevent cushioning of steam upon the fire-plate, several nearly equidistant water-tubes cross the flue-chambers and connect the water above them with the water beneath.

The following modification of the plan of construction of the new steam-generator presents some especial advantages. The upper and lower plates of the flue-chambers, either or both of them, enlarged in diameter sufficiently, may be riveted to the outer shell of the boiler throughout the entire circumference, so as absolutely to divide the water-space into separate sections. The several water-spaces thus formed are then to be connected in a series only, or chiefly through water-tubes crossing the flue-chambers. Constituted thus, the boiler is a compound one. It includes within one continuous shell several unlike integrant parts or segment-boilers of dissimilar construction conjoined consecutively. A thermostatic flue system traverses the shell from the furnace downward to the far end, and the flames and fuel-gases pass through the several sections of the boiler in succession and impart heat to the water therein, themselves cooling as they advance. A thermostatic flue system may be constructed of tubes only or of chambers suitably connected, or of any suitable combination of chambers and tubes, arranged within the water-space of the boiler below the water-level, and freely intercommunicating one with another, especially at their lowermost parts, so connected with the furnace and with the smoke-stack that the smoke shall traverse them in a downward direction from the furnace to the exit-flue, so intercommunicating that the descending smoke in every flue, and in every branch and segment thereof, shall be left free to descend according as it is cooled and its gravity is increased, or to maintain a higher level according as it retains its heat rarefaction, so that the descending smoke preserves in all the flues at the same level a uniform temperature, a thermostatic equilibrium not liable to be disturbed by variable drafts, and that smoke which has cooled the most is at all times foremost in the descent. A single flue cannot be made thermostatic only as the subdivisional flues balance each other, each of which so balanced by the other is thermostatic.

I employ a furnace lined with fire-brick, soapstone, or other suitable material jacketed, and by preference of semi-elliptical shape in transverse section, and abutting endwise against a secondary combustion-chamber, so that its archway coincides in its span with the upper semicircle of the entrance thereto, at the same time level and continuous therewith. This furnace is furnished with a large ash-pit, a grate of suitable dimensions, and ample combustion-chamber, a door above the grate for feeding the fuel, and a door below the grate for removing ashes and for admitting air, &c. Supported upon the sides of the furnace near its top, and built into the walls thereof, an arch is arranged, by preference formed of cast-iron. This arch forms the dome of the combustion-chamber, a brick arch being constructed one or two inches above the same, leaving an open space between the arches for the purpose of forming an air-flue, which I prefer to be open at all times at the boiler end of the archway, thereby allowing of the admission of air to the upper flue-chamber or secondary combustion-chamber. The quantity of air admitted may be regulated by a slide or valve fitted to the front of the furnace. By this means the fire-box receives a properly-regulated supply of intensely-heated air arranged to mingle with the flames just at the mouth of the secondary combustion-chamber, and by this means the loss of heat from the top of the furnace is prevented.

In locomotives or similar boilers, the furnace may be inclosed in a water-hood, and a cast-iron pipe may serve as the air-inlet above the grate.

In order to prevent the escape of heat from outside surfaces by contact or radiation or convection, it is preferred that the furnace, boiler, and all appurtenances be jacketed with any suitable non-conducting material. Nevertheless, the economy of perfect combustion avails but little to enhance the mechanical effect of the fuel consumed, so long as steam-generators continue to throw away more of the heat than they utilize, for so it is in every variety of steam-boilers yet constructed that the water is heated to the same temperature throughout; and however water of uniform heat may be applied to the flues, it cannot cool the swift currents of smoke in them nearly to its own temperature. In point of fact, when the steam and water in the boiler stands at 300° to 325° Fahrenheit, the pyrometer in the flue just outside the boiler will generally mark 675° to 850°. When steamboats race together and crowd their fires, their funnels are often seen capped with flames. The hot gases from the furnace rush through isothermal boiler-flues, vouchsafing them only a momentary touch, whereas they ought to move slowly and through a scale of descending temperatures. The hottest smoke travels fastest, and the coldest lags behind, whereas the coldest ought to head the draft in every flue. The total capacity of the subaqueous flue system in tubular boilers is too small and the subdivisions are individually too large and not nearly numerous enough, so that the heating-surface of almost every variety of construction now in use is quite inadequate to transfer to the water so much as one-third of the sensible heat transmitted to the flues.

In steam-boilers of all sizes constructed and arranged according to my invention, as hereinbefore set forth, the maintaining of different temperatures above and beneath within the water-space of the boiler in a descending scale of degrees of heat from top to bottom, or one end to the other, is fully provided for, and when operated in combination with certain supplementary apparatus, hereinafter specified, promises to fulfill the problem of rendering available for heating purposes or for motive energy nearly all the heat force developed from the combustion of the fuel. The maintaining of the different strata of water within the water spaces of the boiler at different temperatures and in a descending scale of degrees of heat from top to bottom is fully provided for in upright cylindrical steam-boilers of all sizes and varieties constructed and arranged according to my invention as above set forth; but the same boilers placed in the horizontal position would operate somewhat unsatisfactorily. The imperfections can be remedied, however, by setting the cylindrical body of the boiler-shell either horizontally or aslant a few degrees from the horizontal line, and annexing to the upper or furnace end an elbow turned vertically upward, and to the lower end an elbow extending downward. The steam-dome occupies the upturned elbow. The lower elbow may be of any size demanded. It can be dispensed with altogether without impairing the thermostatic equilibrium of the flue system, provided the escape-flue pass is out from the lowermost part of the lower flue-chamber. I can form the upturned segment of the boiler of a size and shape to suit the requirements presented, and when so formed it may constitute, in part or wholly, a separate compartment or annex boiler, with its fire-plate, water-space, steam-space, &c., receiving its water-supply from the horizontal segment, as hereinafter explained. In the elbow-boiler the flue-chambers can occupy the angles front and rear, or can be located elsewhere, if preferred. The front or upper chamber I use as the secondary combustion-chamber, and it is to be provided with a suitable opening to admit the flames from the furnace. This opening or flue must be of a sufficiently small diameter, so that the passage of the products of combustion shall be slightly obstructed and deflected in their course, to the end that the gases arising from different parts of the fire shall be thoroughly intermingled, together with the superadded air, their temperatures equalized, and perfect combustion secured. A thermostatic equilibrium cannot be secured in the flue system if the products of combustion are allowed an unobstructed passage to the secondary combustion-chamber, as the gases arising from different parts of the fire vary greatly in temperature, and in case they are not thoroughly intermingled the hottest gases will pass through the flues first, leaving the cooler smoke behind. The flue-opening, in order to secure the best results and most perfect combustion, must connect the furnace and secondary combustion-chamber at their uppermost parts. The water-connections between the horizontal and upright segments of the boiler can be made chiefly through water-hoods surrounding the chambers, or partly or wholly through water-tubes crossing the chambers.

A system of water-tubes intercrossing in various directions may connect the opposite sides of the water-hood, and it will contribute efficiently to the generation of steam of high tension and give strength to the combustion-chamber. The water-tubes which cross the flue-chambers may be straight or angular, curved or spiral, as preferred. The water-hoods that surround the chambers consist of a double hood, an inner and outer plate of boiler-iron strongly riveted and braced, and having between the plates (which are set an inch or more apart) an interspace to contain water, that connects laterally with the water space of the horizontal segment of the boiler, and above with the water-space of the vertical segment. For greater convenience of access in cleaning the boiler-flue, the front and rear ends may be left more or less unhooded, and suitable doors may be substituted in order to complete the incasement of the chambers. In this case the chambers will not be entirely surrounded by water, but the thermostatic balance in the flues will be preserved.

To prevent a possible cushioning of steam on the fire-plate of the annex boiler, it is well to have fitted into the water-hood beneath a few water-pipes, that extend across the upper chamber, pass through the fire-plate at equal distances apart, and end flush with its upper surface. I arrange around the circumference of the water-hood numerous tubular communications with the water-space of the annex boiler, or, if preferred, an uninterrupted or continuous confluence throughout the entire circle of their junction. I provide similar channels between the water-hoods and the water-space of the horizontal segment of the boiler. The water in the horizontal boiler maintains a high temperature at the top and relatively a low one at the bottom. It is evident that the hottest of this water should be sent to the front water-hood, the water-tubes, and the annex boiler. Therefore I propose to connect the topmost part of the furnace end of the horizontal boiler directly to the conjoined water-hood through a single water-tube. I regulate the inflow of water according as it evaporates by a suitable valve placed in this water-tube, so as to maintain a uniform depth of water in the annex.

Water is almost an absolute non-conductor of heat. Neither water nor gases transmit heat from above downward. In my steam-generator this law for the first time finds a practical application. Above the upper chamber of the multitubular flue system steam is formed and the boiling water is violently agitated. Below this chamber the water never boils; no bubbles rise; there are no interstratic currents; all is motionless, save that the feed-water, which is added little by little, uplifts the mass integrally of which it forms the base.

In the flues like temperatures rest in horizontal planes throughout; but from top to bottom each plane is a little cooler than the one next above it. The intensest heat of the furnace is in the upper chamber, and as the combustion-gases descend therefrom through the flue-tubes and the lower chamber they impart their heat to the water surrounding them until they reach the escape-flue comparatively cold. In other words, the hot gases from the furnace descend through the flues in contact with colder and colder strata of water successively until their temperature at the outflow approximates the temperature of the cold water at its inflow; and the water entering the water-space at the bottom is heated as it rises step by step in apposition with warmer and warmer strata of gases until its temperature near its outflow approximates that of the influent hot gases from the furnace, and it is instantaneously converted into steam.

In practice I have found that in a boiler having about one square foot of grate-surface to four feet depth of water the temperature in the steam-space may be maintained for several consecutive days at or about 150° Fahrenheit higher than in the escape-flue; and it was found that a powerful artificial draft must be kept up to obtain a higher temperature in the exit-flue than in the steam-space. It will be understood that every additional foot of water-depth in the boiler adds to the disparity of top and bottom temperatures, and cools the combustion-gases so much the more. To discharge the fuel-gases from the flues at any required temperature, the velocity of the draft must be rightly proportioned to the area of the grate and the capacity of the boiler. While the fire is first kindling in the furnace, and until the water boils and steam reaches the working-pressure, a sufficient draft can be had by inserting into the exit-flue a smoke-pipe about eight feet in height. When the steam is up, the temporary smoke-pipe can be removed, and thenceforth an exhaust-fan or blower or steam-ejector may be used to expel the smoke from the escape-flue into the surrounding air; or a fan or blower operated by hand or foot can be used until the steam is up.

For the greater convenience of access to the boiler-flues, and to facilitate the process of cleaning them, suitable doors or man-holes may be fitted into the incasement of the flue-chambers. A blow-off cock in the base of each water-hood and one in the bottom of the horizontal segment will enable the engineer to wash out whatever sediment the water may deposit in the boiler.

I will now describe the steam-ejector, also known as the "mixing-pipe," its construction and uses.

I provide a suitable gate, which tightly closes the flue-exit from the boiler. A steam-pipe is made to enter into a small discharge-flue, the diameter of which is carefully proportioned to the quantity of gases to be conveyed away from the lower flue-chamber. This steam-pipe extends within the flue centrally coincident with its long axis and terminates centrally a few inches from the entrance. The internal diameter of the steam-pipe may be one-third to one-sixth of that of the flue it penetrates. The caliber of the flue tapers or grows smaller as it approaches the end of the steam-pipe within it, and, having passed this point, it gradually enlarges again. In operation, this inner pipe discharges steam outwardly along the flue it penetrates, which, according to its tension, creates a vacuum in the flue behind the steam-junction, that sweeps the gases from the furnace onward and mingles with them. This apparatus, if rightly adjusted, can be made to yield the most economical of all artificial drafts, or can produce a very powerful one. When all the steam from the generator passes through the ejector under a pressure of three or four atmospheres, and the temperature of the fuel-gases discharged therewith exceeds somewhat that of the steam, the mixture comprehends under a diminished tension all the heat force developed from the fuel consumed. This realizes the highest attainable economy, and has also other advantages, as it can be used for heating purposes or to operate the engines on steamships, or wherever a large quantity of low-pressure steam is worked. In compound engines it will be found to be less readily condensed by expansion than pure steam of the same temperature, and will require the atmospheric cylinder and the condenser to be enlarged accordingly. When the mixture is employed to drive an engine of any kind, I provide a check-valve, fitted in the mixing-pipe below the steam-junction, to act automatically and prevent reversal of the draft. Into the mixing-pipe, just beyond the steam-junction, I insert to the bore, at an acute angle to its longitudinal axis, a small pipe to convey water, preferably from the lower and colder part of the boiler. The volume of water injected I regulate by a stop-cock. Throwing a coarse spray, it can be made to cool the fuel-gases and to condense the steam in the mixing-pipe, the hot water so obtained being returned to the feed-water tank. When the mixture of gases and steam is employed to drive an engine, if the cylinder become heated, a fine spray may temper and protect the machinery. A similar arrangement of a spray in the exhaust-pipe of a high-pressure engine may furnish hot feed-water for the boiler.

The graduated steam-generator as described will be efficient and economical in all cases where steam of moderate tension is desired; but where strong drafts and fierce fires generate steam of very high pressure for high-pressure engines we may still further economize the fuel by adding to the boiler the equivalent of the extension of the subaqueous flue system, and thereby secure a prolonged cooling of the fuel-gases. In order to attain this end, I provide a tank to stand beside the boiler, which may consist of a multitubular structure within a shell, through the outer compartment of which the gaseous products of combustion driven from the boiler enter at the top, pass downward, and escape at the bottom, while the feed-water on its way to the boiler enters the tubular compartment at the bottom, fills it, and flows out at the top; or the gases from the flues may pass downward through the tubular compartment and the feed-water upward through the outer compartment. This is to be preferred when steam force is liable to be generated in the tank. For the very highest steam-pressure worked it is possible that the tank would need to be duplicated. However, the pressure of steam increases in a more rapid ratio than the temperature—the temperature in a fractional ratio that progressively diminishes the pressure in a constant arithmetical ratio. Thus steam at thirty pounds pressure per square inch (above atmospheric) has a temperature of 275.2° Fahrenheit; at seventy-five pounds, 320.36°; at one hundred and twenty pounds, 350.78°—that is to say, the pressures are as one, two and one-half, and four, and the corresponding temperatures as one and three-eighths, one and three-fifths, and one and three-fourths. Furthermore, the exhaust-steam of high-pressure engines can be utilized by my invention to run the ejector, and the mixture of gases and of steam carried through the supplementary tank and condensed therein will give up its sensible heat to the feed-water. By this means the caloric derived from the exhaust-steam can be returned to the boiler and be used in the cylinder again and again. In the meantime the heat in the tank becomes cumulative to such a degree that in a very short time after starting the engine the furnace-fire can be diminished, and even then there will be a superabundance of heat in the tank, which may be capable of producing steam in excess, but never at any time able to raise it to the working-pressure without aid from the more intense heat of the furnace. The surplus can be devoted to heating and ventilation.

That my invention may be fully understood, I will proceed to describe the same more in detail by the aid of the accompanying drawings, which illustrate what I consider the best means of carrying out my invention.

Referring to the drawings, Figure 1 is a central vertical section of my improved steam-generator. Fig. 2 is a central vertical section of a modification of my invention. Fig. 3 is a horizontal section taken on the line x x, Fig.

2. Fig. 4 is a front elevation. Fig. 5 is a transverse section taken on the line *y y*, Fig. 2. Fig. 6 is a central vertical section of my improved feed-water tank. Fig. 7 is a central vertical section, showing my invention as applied to vertical boilers.

Similar letters of reference indicate corresponding parts wherever they occur.

A represents a shell formed of boiler-iron or other suitable material, which in the drawings is shown of a cylindrical form and inclosing a water-space, B, and a steam-space, C. The shell A is provided with a feed-water pipe, D, at the bottom or lower end thereof, and with a steam-pipe, E, and safety-valve F at the top or upper end. The shell A of the boiler contains within the water-space B, and surrounded on all sides by water, a multitubular structure, G, consisting of an upper chamber, G′, and a lower chamber, G^2, connected together by a series of tubes, G^3, so arranged that the whole of the series of tubes G^3 shall communicate one with the other through the medium of the chambers G′ G^2, thereby constituting a thermostatic balance. Through the outer shell, A, an entrance, A′, to the upper chamber, G′, is formed, and an exit or outlet, *g*, from the lower chamber, G^2, is formed, as shown by Figs. 1 and 2. The parts are so formed and constructed that no leakage shall take place between the multitubular structure G and the surrounding space within the shell A. The upper plate, *g*′, and the lower plate, g^2, of the chambers G′ G^2 are by preference joined or bolted to the shell A at their circumference, so as effectually to divide the water-space B into separate sections, which are connected together by water-tubes *b*.

H is the furnace, which is provided with a lining of fire-brick, soapstone, or other suitable material, which may be inclosed in a water-hood or water-hoods, as shown in Fig. 1, by preference of a semi-elliptical shape in transverse section, and abutting against the boiler-shell A in such manner that its archway *h* nearly coincides in its span with the upper semicircle of the entrance A′ to the upper flue-chamber, G′, and is continuous therewith. The furnace H is provided with an ash-pit, H′, a grate, H^2, and a combustion-chamber, H^3. Above the grate H^2 a feeding-door, H^4, is provided for the supply of fuel; and below the grate H^2 a door, H^5, for the removal of ashes and for the regulation of the draft to the furnace.

In Fig. 2 I show supported upon the sides of the furnace H, near its top and built into the wall thereof, an arch, H^6, by preference formed of cast-iron. This arch H^6 forms the dome of the combustion-chamber H^3. Above the arch H^6, I construct a brick arch, H^7, one, two, or more inches above the arch H^6, thereby leaving an open space between the arches H^6 and H^7, for the purpose of forming an air-flue, H^8, which I prefer to be open at all times for the admission of air at the boiler end of the said passage or flue H^8. When the furnace is inclosed in a water-hood, a cast-iron pipe, H^9, (see Fig. 1,) may serve as an air-inlet above the grate. The quantity of air admitted to the flue H^8 may be regulated, as shown, by a slide or valve, H^{10}, fitted to the front of the furnace, or by any other suitable means. By this means the furnace or fire-box H receives a properly-regulated supply of intensely-heated air arranged to mingle with the flames just at the mouth of the secondary combustion-chamber G′, and by this means the loss of heat from the top or upper part of the furnace H is prevented.

J J′ J^2 are a series of tubes intercrossing one another and connecting the opposite sides of the water-hoods. To prevent cushioning of steam in the annex boiler K, I arrange a series of water-pipes, J′, extending across the upper chamber, G′, and passing through the fire-plate *g*′ at equal distances apart, and terminating flush with its upper surface.

The upper part of the furnace end of the horizontal section G^3 is connected to the water-hoods by means of a tube, *b*. The inflow of water is regulated by a valve placed in the tube *b*. Similar tubes also connect the other sections.

Above the secondary combustion chamber or section G′, I construct the annex boiler K, having the water-space B and the steam-space C. This boiler may be strengthened by braces N N, Fig. 1, or other suitable means. It is separated from the rest of the shell by a horizontal partition, *g*′, beneath it, which also serves as a fire-plate and as the roof of the secondary combustion chamber or section G′. It is fitted with a safety-valve, F, steam-pipe E, and also with suitable water-cocks, gages, &c. (Not shown.) This annex boiler may be of any required form.

M is a steam-ejector or mixing-pipe, which is provided with a gate or valve, *m*, which controls a flue or passage, *m*′, leading to the boiler.

A steam-pipe, E, connected at one end with the steam-space chamber K, is conducted into a small discharge-flue, m^2, the caliber of which tapers or grows smaller at m^7 until it passes the end of the steam-pipe E, when it gradually enlarges again. The pipe E is formed of a diameter in proportion to the quantity of gases desired to be carried away from the lower chamber, G^2. The pipe E is arranged centrally of the flue m^2, and extends, by preference, about six (6) inches within the same, in position to cause a current of steam to be centrally along the flue m^2, thereby creating a vacuum in the flue *m*′, thus sweeping the products of combustion and gases from the furnace H onward and mingling with them.

In the vertical portion of the pipe M, I arrange a check-valve, *m*, which is so constructed as to prevent the draft being reversed when the mixture is employed to drive an engine or otherwise encounter resistance.

m^4 is a small pipe, the upper end of which is inserted into the mixing-pipe or ejector M t an acute angle, as represented in Figs. 1 and 2. This pipe m^4, at its lower end, is connected with the water-space of the boiler, by preference at its lower and coolest end, as shown in the drawings. The volume of water from the pipe m^4 is regulated by a stop-cock, m^5. The spray of cold water issuing from the pipe m^4 is employed to cool the fuel-gases issuing from the furnace, and also to condense the steam in the mixing-pipe. The hot water thus obtained is returned to the feed-water tank by a suitable pipe. (Not shown.)

M′ is a large flue-exit from the bottom of the lower chamber, G^2, connecting with a suitable smoke pipe or chimney, as desired. When the ejector or mixing-pipe M is used, this flue-exit is tightly closed by a damper, m^6.

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

1. The combination, in a steam-generator, of a thermostatic flue system, as described, a feed-water inlet, sectional water-spaces and their connections, and an annex boiler, with its steam-dome, substantially as shown and set forth.

2. The combination, in a steam-generator, of a furnace, a secondary combustion-chamber, a thermostatic flue system, as described, and an annex boiler, substantially as and for the purpose set forth.

3. The combination, in a steam-generator, of a thermostatic flue system, as described, secondary combustion-chamber, a system of water-tubes crossing said chamber, and an annex boiler, the whole being arranged to operate substantially as shown and described.

4. The combination, in a steam-generator, of a thermostatic flue system, as described, a secondary combustion-chamber, an annex boiler, and an air-inlet pipe adapted to heat and discharge a current of air into the entrance of the secondary combustion-chamber, the whole being arranged to operate substantially as shown and described.

5. The combination, in a steam-generator, of a thermostatic flue system, as described, a secondary combustion-chamber, an annex boiler having a fire-plate, g', and a series of water-pipes, J′, adapted to prevent the cushioning of steam in the annex boiler, substantially as shown and described.

6. The thermostatic flue system described and shown, consisting of two or more chambers connected by multitubular flues, the chambers containing numerous crossed and interspaced water-tubes, substantially as and for the purposes set forth.

7. The thermostatic flue system described and shown, consisting of two or more chambers connected by multitubular flues, each chamber being inclosed in a separate water-hood and containing numerous crossed and interspaced water-tubes, substantially as described and shown.

8. A boiler-shell constructed with two elbows, the one nearest the furnace extending upward and adapted to contain a secondary combustion-chamber and an annex boiler, with its steam-dome, the other being the rear end of the shell prolonged downward, and adapted to contain a lower chamber inclosed in its water-hood, and to receive the feed-water-inlet pipe and smoke-exit flues, substantially as and for the purposes set forth.

9. In combination with a thermostatic steam-generator, a spraying-pipe adapted to operate, as described, either to condense steam from pipe E or temper the products of combustion employed as a source of motive power, substantially as shown and described.

10. In combination with a thermostatic steam-generator, the spraying-pipe m^4, in combination with steam-pipe E and smoke and steam mixing pipe M, substantially as and for the purposes set forth.

In witness whereof I have hereunto set my hand this 20th day of June, 1883.

J. E. CULVER.

Witnesses:
WM. E. RICHARDS,
MORRIS H. SMITH.