3 Sheets—Sheet 1.

T. VAN KANNEL
Gas Generator.

No. 233,956. Patented Nov. 2, 1880.

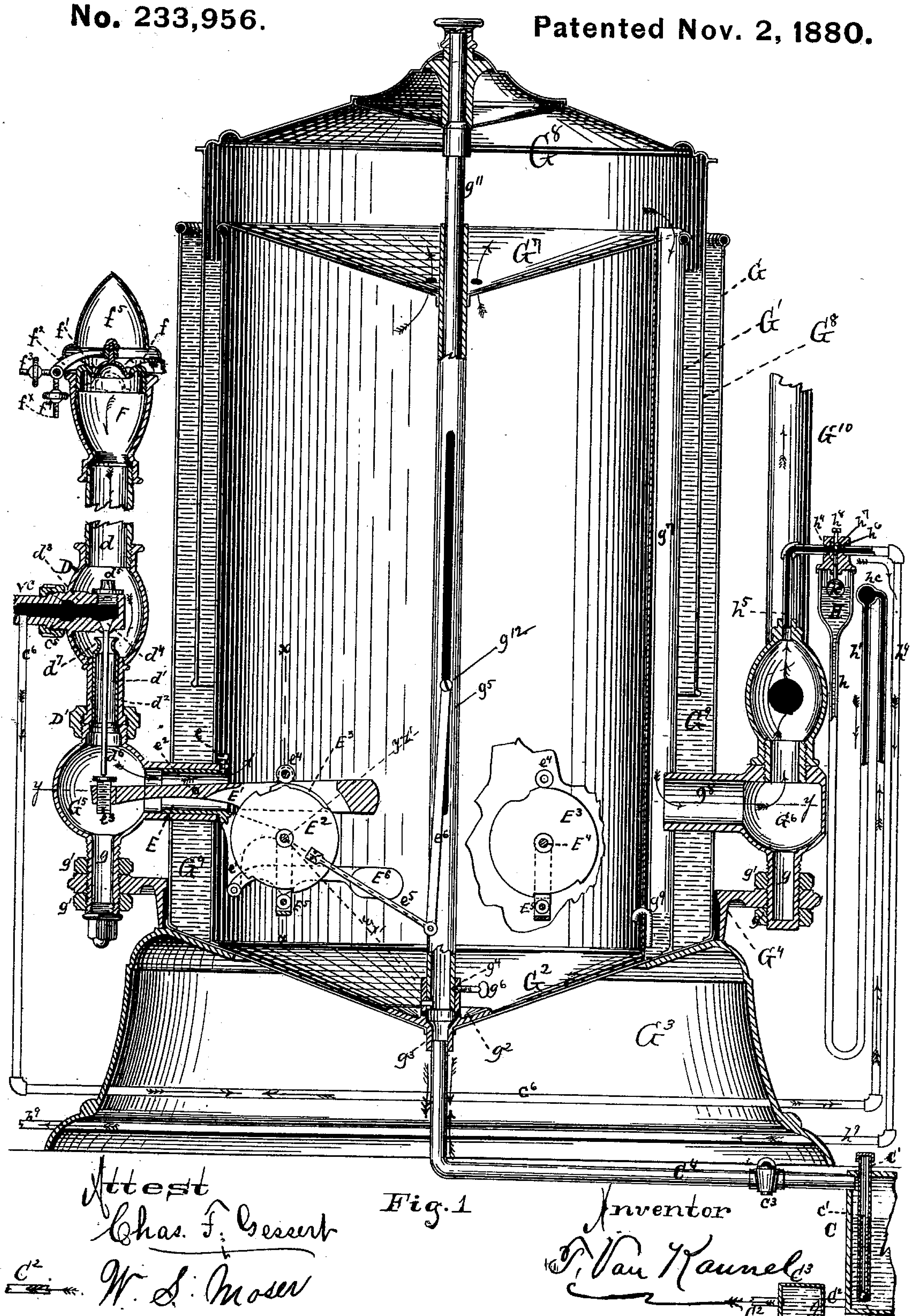

Fig. 1

Attest
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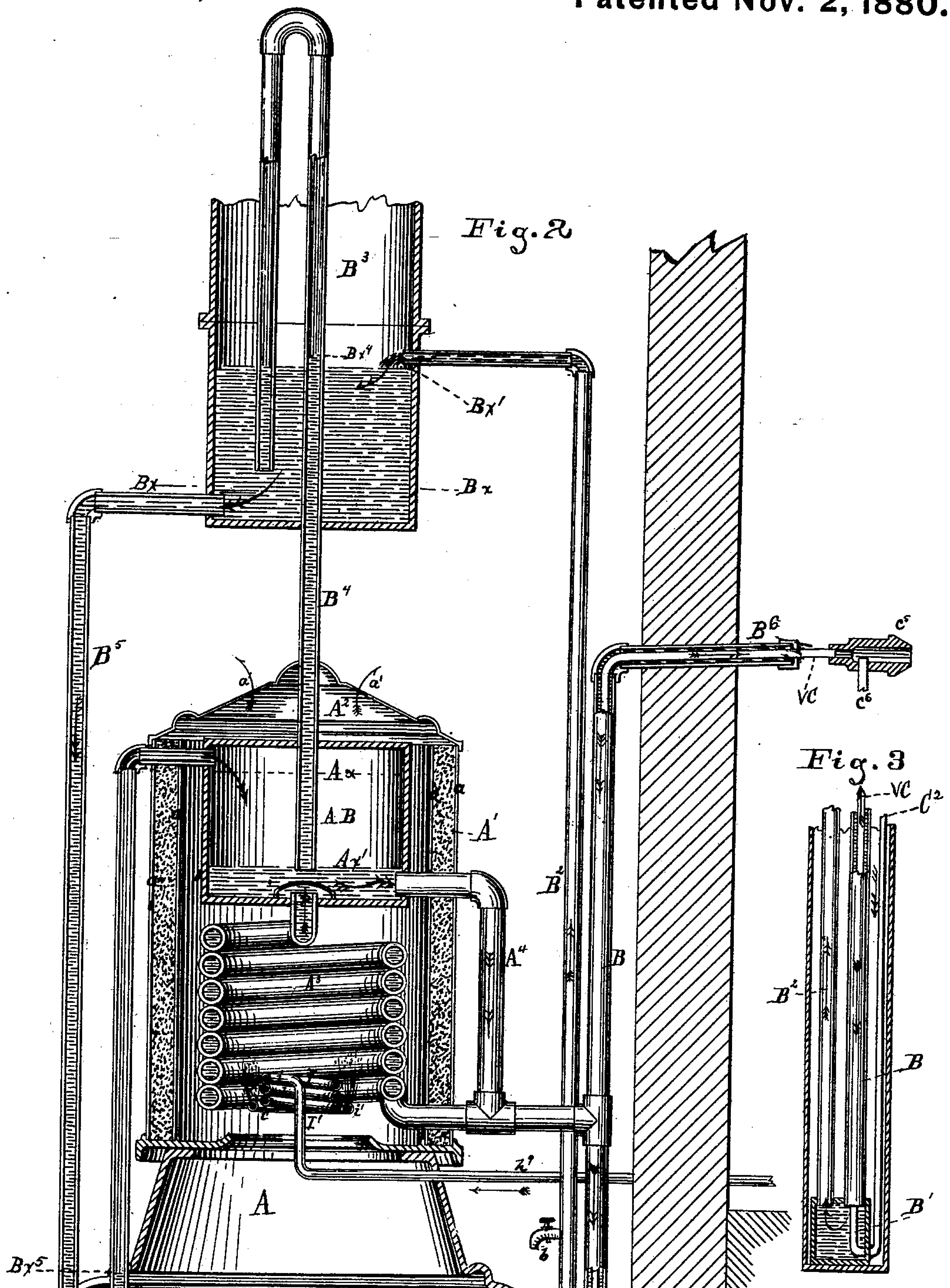

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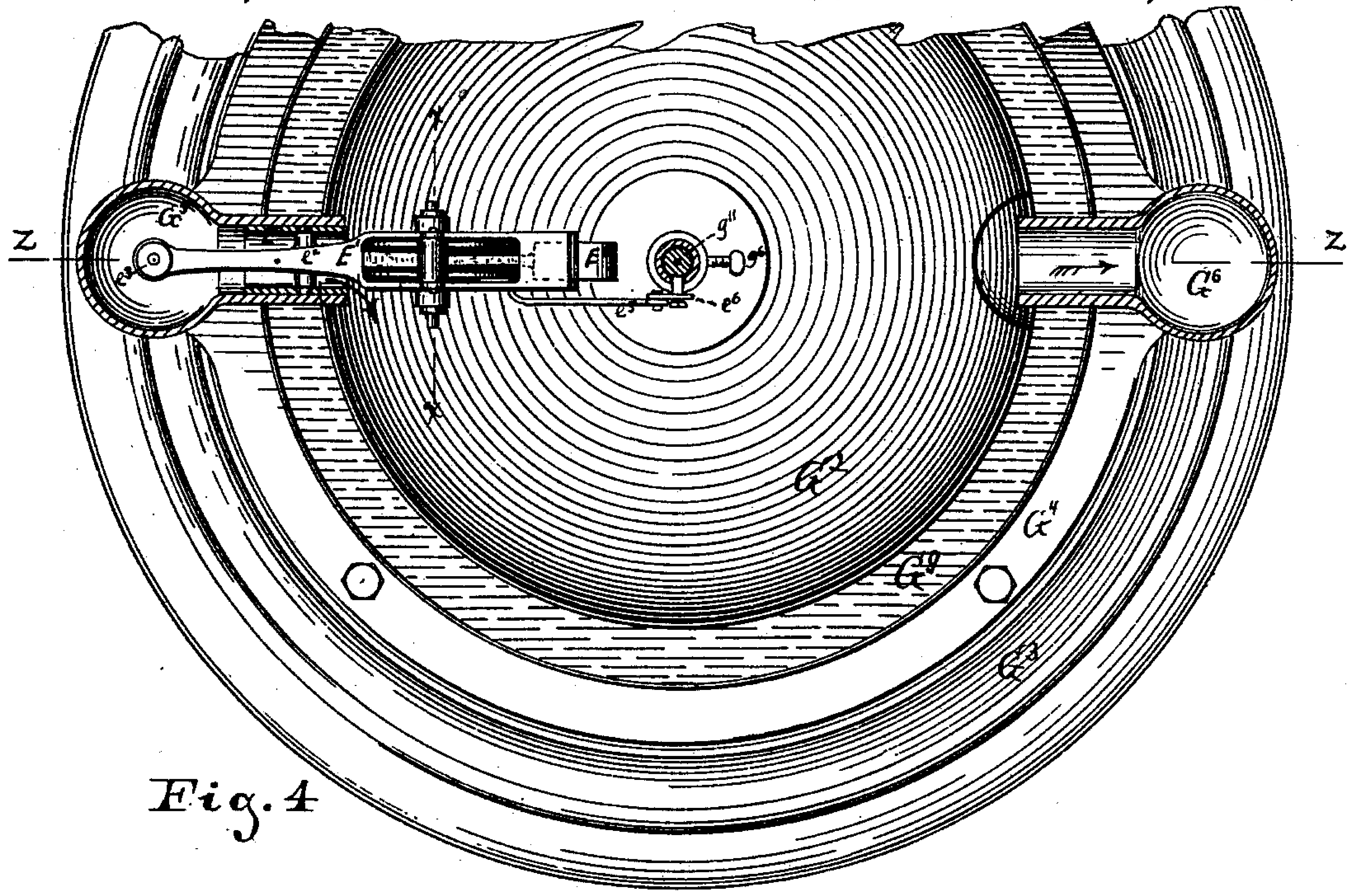


Fig. 4

Fig. 6

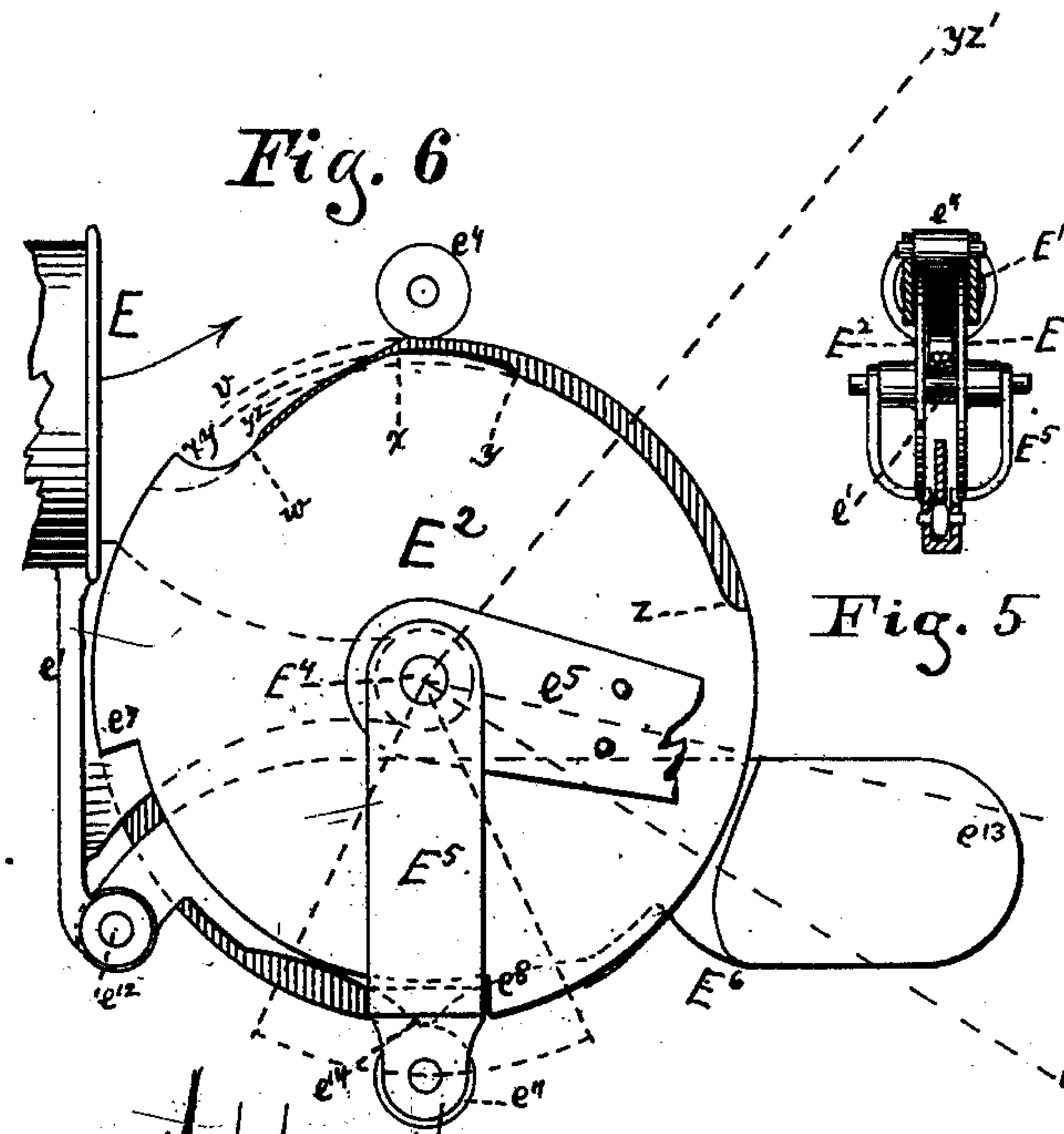
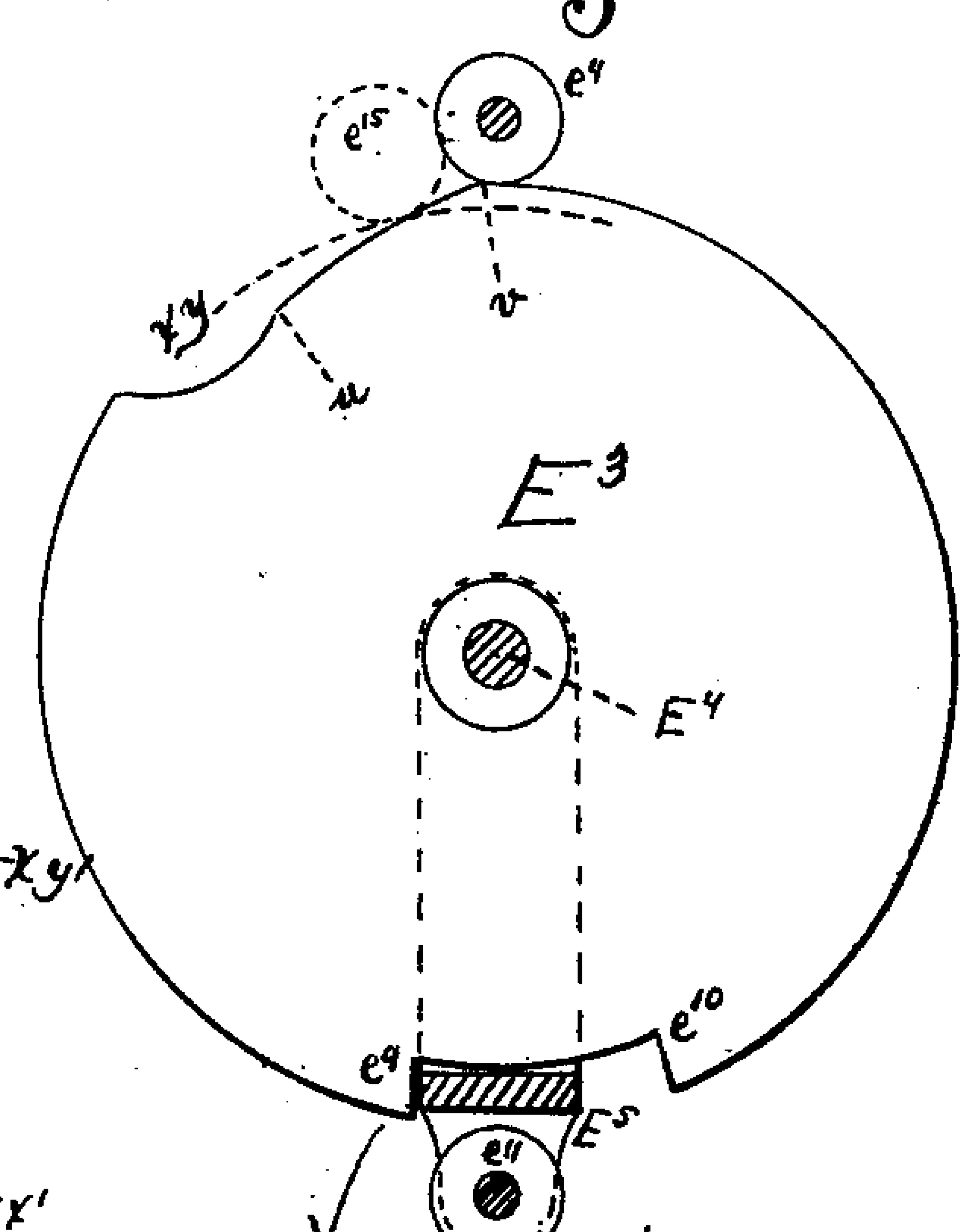


Fig. 5

Fig. 7



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UNITED STATES PATENT OFFICE.

THEOPHILUS VAN KANNEL, OF CINCINNATI, OHIO.

GAS-GENERATOR.

SPECIFICATION forming part of Letters Patent No. 233,956, dated November 2, 1880.

Application filed December 31, 1879.

To all whom it may concern:

Be it known that I, T. VAN KANNEL, of Cincinnati, county of Hamilton and State of Ohio, have invented a new and Improved Gas-Generator; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, making a part of this specification.

This invention relates to that class of apparatus for making illuminating-gas in which the vapor of gasoline, or its equivalent, obtained by the action of heat, is united with atmospheric air; and it consists mainly, first, in the employment, in connection with a vapor-column extending above the gasoline-tank and discharging into an inhaling-chamber, of a hydrostatic gasoline-column, the pressure of which injects the vapor into the inhaling-chamber with sufficient force to obtain the inhalation of the required amount of atmospheric air; second, in the employment of a steam-generating apparatus and water-circulating system of peculiar construction, by means of which hot water is forced in a downward direction from the heating-point to any desired extent against the action of the natural laws governing the circulation of liquids exposed to the action of heat; third, in the employment, broadly, of the tension of the vapor-column for regulating the supply of gas to the heating-burner; fourth, in the combination, with a single vapor-valve and intermediate connections, of actuating mechanism adapted to control the movements of the valve with respect to the amount of gas being consumed, the construction being such that when less than a predetermined number of burners are lighted the valve is alternately opened and closed, and that when a greater number are lighted the valve is opened in exact proportion to the amount of gas exhausting; fifth, in the special construction of the gaoline-tank and its connections; and, sixth, in the special construction of the gas-tank and its connections.

This invention consists, further, in certain details of construction relating to the features before named and to other features, all of which will be fully described hereinafter.

In the drawings, Figure 1 is a vertical section taken in line *z z* of Fig. 4, representing the gasoline-tank and connections, the gas-tank and gasometer, the heating-burner regulator, the inhaling-chamber, the vapor-valve, the air-valve, and the actuating mechanism for controlling the movements of the vapor-valve. Figs. 2 and 3 together represent a vertical section of the heating apparatus, the water-circulating system, the heating-burner, and the vapor and gasoline pipe. Fig. 4 is a horizontal section taken on the line *y y* of Fig. 1. Fig. 5 is a vertical section of the actuating mechanism for controlling the vapor-valve, taken on the line *x x*, Figs. 1 and 4. Fig. 6 is an enlarged side elevation of the actuating mechanism for controlling the vapor-valve, and Fig. 7 is an enlarged side elevation of the cam E^3 of actuating mechanism and the parts in immediate connection therewith.

The direction of the flow of the various fluid-currents in the apparatus is indicated by arrows, the different fluids being distinguished from each other by the number of barbs, as follows: air-currents by one barb; gas-currents by two barbs; vapor-currents by three barbs; water-currents by four barbs; gasoline-currents by five barbs.

To enable others skilled in the art to make and use my improved apparatus, I will now proceed to describe fully the construction and operation of the same.

For convenience and clearness the subject-matter of the specification will be described under the following heads: first, the steam-generating apparatus and water-circulating system; second, the gasoline-tank, its filling and measuring appliances and connections; third, the means for and method of obtaining the vapor-column opposed by a gasoline-column, and giving the former the requisite pressure to produce the proper vacuum in the inhaling-chamber by injection; fourth, the vapor-valve and inhaling-chamber; fifth, the actuating mechanism for controlling the movements of the vapor-valve; sixth, the air-valve and its relation to the vapor-valve; seventh, the gas-tank, gasometer, and connections; and, eighth, the means for and method of employing the tension of the vapor-column for regulating the supply of gas to the heating-burner.

I. *The steam-generating apparatus and water-circulating system.*—In order that this construction may be more readily understood, the purpose sought to be accomplished by it will first be briefly referred to.

It is essential in this apparatus, for purposes hereinafter explained, that hot water shall be forced downward below the source of initial heat the distance of about twenty feet, more or less. This result, however, cannot be accomplished without the employment of special means, because, while the laws of nature permit readily the circulation of hot water in an upward direction and on a horizontal plane, they will not permit the flow of the same in a downward direction to any considerable distance below the source of the heat.

A, Fig. 2, represents a base-piece of any suitable construction, and A′ a housing or case resting thereon, consisting of the two concentric walls *a a*, having an intermediate filling of any suitable non-conducting material, as shown.

A^2 represents a suitable lid or cover, having small openings *a′ a′* for the escape of the carbonic-acid gas thrown off by the gas-flame of the heating-burner.

A^3 represents a coil of pipe, the upper end of which opens into the steam-chamber A B and the lower end of which is connected, by a horizontal pipe, to the vertical pipe B of the circulating-system, as shown.

A^4 represents a branch-pipe, by means of which the steam-chamber and the lower end of the coil A^3 are connected.

The foregoing description relates specially to the steam-generating apparatus. The following relates specially to the water-circulating system.

B represents a descending water-pipe, extending in a downward direction some twenty feet, more or less, and opening into a chamber, B′, which latter is in effect a return-elbow, by means of which connection is made with the pipe B^2. The pipe B also extends some distance in an upward direction, terminating above in the extension-arm B^6, as shown.

V C represent an extension of the gasoline-pipe C^2, which is inclosed by the pipes B and B^6, the latter forming a hot-water jacket for the same, for the purpose hereinafter described.

B^2 represents a water-pipe extending from the chamber B′ below to the store-chamber B^3 above, the discharge-mouth of the same being located some distance above the lower wall, as shown.

B^4 represents a vent-pipe, the lower end of which opens into the steam-chamber A B near the bottom of the same, and the upper end of which extends upward some distance above the discharge-mouth of pipe B^2, and, bent upon itself, opens within store-chamber B^3, as shown.

B^5 represents a check-pipe, which, beginning at the bottom of the store-chamber B^3, extends some distance below the steam-chamber, and, being bent on itself, opens into the latter just above its upper wall, as shown.

The extension of pipe B^4 above the discharge-mouth of B^2 and the extension of pipe B^5 below the steam-chamber for a considerable distance are made necessary, because the water in these pipes being a part of the water-column in pipe B, and the water of this column having a higher temperature than that of pipe B^2, to which it is opposed, it follows that the former column is specifically less and must be extended to compensate for this variation. In addition to this, the vent-pipe and check-pipe must be still further extended to give a resisting pressure sufficient to withstand the friction presented by the pipes to the water in its circuit from A B to B^3. These parts form a system, in connection with the steam-generating apparatus before described, for circulating the heated water to any required distance below the source of heat.

b represents a faucet located in pipe B^2, preferably below the coil, the purpose of which will be hereinafter described.

The general operation of the water-circulating system is as follows: Water having been poured into the store-chamber B^3 until the water-level in all the pipes and chambers has been raised to about the line B^x, and the heating-burner having been lighted, the action, when steam is generating, will be substantially as follows: The pressure of steam in chamber A B is exerted equally in all directions and on all the pipes entering A B, but the flow will move necessarily in the direction of least resistance—that is, out of the pipe A^4, down the pipe B, up the pipe B^2 into the store-chamber B^3, which, it will be observed, is placed a considerable distance above the steam-chamber A B. As the generation of the steam continues the surface of the water in A B falls to about the dotted line $A^{x\prime}$, while it rises in B^3 to about the line $B^{x\prime}$. The steam also fills the check-pipe B^5 to about the line B^{x5}, but does not ascend in the longer leg, for the reason that the weight of the column of water being displaced by the steam exceeds the weight of the column from $B^{x\prime}$ to $A^{x\prime}$. The water-column in B^4 also rises until it reaches a point which will enable it, with B, to balance the column in B^2, the point being near the line B^{x4}. The vent-pipe and check-pipe are thus each given a column of water conjointly with B higher than B^2.

Whenever, in the operation of the apparatus, water in the steam-chamber is caused to fall below the lower mouth of the pipe B^4, the entrance of steam into the same is permitted, in consequence of which the pressure on the steam-chamber is relieved. Some of the water contained in the pipe B^4 falls into the chamber A B, while the remainder is forced by the steam into chamber B^3, the steam itself which follows being finally condensed in the water in B^3. The pressure being now removed from the steam-chamber, the tendency of the water contained in the store-chamber is to flow down and fill the steam-space in A B. It is evident, however, that the water cannot return through pipe

B^2, although the water contained therein will come to an equilibrium with that in A B, and will fall approximately to a level with it. It is evident, also, that the water cannot descend by the vent-pipe B^4, as the long leg of this siphon-shaped pipe is filled with steam, and cannot, therefore, act as a siphon. The water, however, meeting no resistance in pipe B^5, flows freely through it, its movement in this direction being assisted also by the partial vacuum resulting from the condensation of steam in chamber A B.

The water now has made one complete revolution, and as long as steam is generated the described operation will continue to be performed.

It will be observed that this heating and circulating system is entirely without valves or other mechanical moving parts.

The purpose of pipe B^4 is simply to give vent when the water in chamber A B arrives at the line $A^{x\prime}$, and the purpose of check-pipe B^5 is to convey water from B^3 to A B whenever no steam-pressure is present in the latter. The term "check" is applied to this pipe because it acts in the capacity of a check-valve—that is, it opens downward and permits flow in that direction, but closes against an upward flow.

The store-chamber B^3 may extend upward some distance above the broken line and be closed at the top, for the purpose of preventing evaporation, in which case the same must be sufficiently large to furnish the proper air-space to accommodate the variation of the water-level.

An important feature in the operation of this apparatus is that under no circumstances will cold water be forced downward through the circulating system, because, first, no circulation at all can take place until steam is generated in chamber A B, and, second, that when steam has been generated sufficiently to cause circulation the water necessarily is in a highly-heated condition.

If desired, the apparatus may be quickly put into operation by the use of water previously heated in the following manner: Open the draw-off faucet *b* and pour hot water into the store-chamber B^3, from which the same will flow through check-pipe B^5 into chamber A B, coil A^3, and down pipe B, the heavier cold water being forced before it in a connected stream through the draw-off faucet *b*. The heating-pipe being thus filled with hot water, the operation of the apparatus may begin, and a sufficient amount of gas being thereby generated, the heating-burner may be lighted to continue the supply of heat. Where steam is to be obtained this agent may be employed to great advantage, instead of water heated by gas, by introducing the steam into the pipe B with sufficient pressure to force the condensation resulting from the steam out through the discharge-pipe B^2, and leading it off as waste water, retaining a steam-column in pipe B. In this case the heating apparatus and remaining parts of the circulating system may be dispensed with, retaining only the pipes B and B^2.

If desired, also, hot air may be used, or heat may be directly applied to the pipe by any suitable means.

II. *The gasoline-tank, its filling and measuring appliances and connections.*—C, Fig. 1, represents the gasoline-tank, which, in practice, is placed below the level of the lower part of the gas-tank. It may, if desired, be placed in the ground for the purpose of obtaining greater safety, in which position it is unaffected by the variation of the natural temperature.

C′ represents a filling and measuring pipe, secured to the top wall and extending downward in a vertical direction to near the bottom of the tank, where it opens. The upper end of this pipe extends above the surface of the ground, and is provided with a screw-cap or other proper means for closing the same.

c represents a float provided with the stem *c*′, which is loosely held in the filling-pipe, as shown. This is properly graduated to indicate known quantities, as gallons, thus giving the aggregate quantity of gasoline in the tank.

C^2 represents the gasoline-pipe, extending from the gasoline-tank from a point near the bottom of the same to the trap-chamber C^3, near the top of the same, as shown, and then from the trap-chamber upon the opposite side a farther distance, beginning upon the same level.

The trap-chamber consists of a small vessel of any suitable shape, which is provided with a cock, c^2, for drawing off any heavy or objectionable deposits.

The gasoline-pipe, at any proper point in the portion which extends from the trap-chamber, is depressed a proper distance—say twenty feet—and then, being bent on itself, rises again within the hot-water pipe B to a point above the gasoline-tank, and is connected by means of a union with the inhaling-chamber, as shown.

C^4 represents a vent and condensation pipe, which enters the tank C horizontally near its upper wall and extends to the lower part of the gas-tank.

c^3 represents a stop-cock located in the pipe at any convenient point between the two tanks.

It is essential that the pipe C^4 should be so arranged that no trap whatever will be found therein to prevent the ready circulation of the gas between the gasoline and gas tank.

The operation of these parts is substantially as follows: The filling-pipe C′, having been opened above, the gasoline may be led into the same from the barrel by a hose or other convenient means. The air contained in C then finds its way through vent-pipe C^4 to the gas-tank, where it elevates the gasometer. After the first filling the air will be highly carbureted, and consequently when the same is delivered from the gasometer to the burners it will be consumed like other gas. This highly-carbureted air cannot, of course, escape into the open air, because the same is trapped off by the extension of the pipe C′ below the surface of the gasoline.

The gasoline within pipe C′ being always on a level with the body of the fluid contained in the tank, with the exception of the slight difference which results from the pressure of the gasometer, which difference may be provided for in the graduation of the scale on stem c', it follows that the quantity of gasoline on hand may be readily determined, when desired, by permitting the float c to rise to the top of the gasoline. The top of the pipe C′ then being taken as the fixed point, the position of the scale relatively thereto will indicate the quantity.

The gasoline-pipe C^2 serves to convey the gasoline from the tank disconnectedly through the trap-chamber to the foot of the hot-water pipe B, forming a hydrostatic column, and by means of the heat in B surrounding pipe V C a vapor-column is formed in the latter throughout its length, ending in the inhaling-chamber, which will be more fully described hereinafter.

In the trap chamber C^3 are caught the liquids and substances which are heavier than gasoline, such as water, oil, sediment, &c. These may be drawn off at stated periods through the cock c^2.

The operation of the vent and condensation pipe C^4 is substantially as follows: As a condensation-pipe it serves to conduct any condensation accumulating in or flowing into the gas-tank from the gas-pipes to the gasoline-tank. In consequence of this permanent capacity for complete drainage it follows that no liquid can remain in the gas-tank, and that hence the gas passing through cannot be overenriched by its presence. As a vent-pipe it conducts the carbureted air from the gasoline-tank to the gas-tank when the former is being filled, and it also supplies the gasoline-tank with gas for the purpose of filling the space which would otherwise be left vacant by the withdrawal of the gasoline. A perfect equilibrium is thus insured at all times between the gasoline-tank and the gas-tank.

III. *The means for and method of obtaining the vapor-column opposed by a gasoline-column, giving the former the requisite pressure to produce the proper vacuum in the inhaling-chamber by injection.*—The means employed for obtaining the vapor-column and giving it the requisite pressure have already been referred to. The gasoline pipe C^2, after leaving the tap-chamber C^3, descends at some proper point in its extent about the distance of twenty feet, more or less, and then ascends to a point above the gasoline-tank, and finally discharges into the inhaling-chamber. The descending leg of the pipe, being surrounded by natural temperature, conveys the gasoline throughout its entire extent without change. The ascending leg, however, being enveloped by the hot-water pipe B, conveys the vapor which is formed therein by the application of heat to the inhaling-chamber. By this means a gasoline-column is opposed to a vapor-column, and consequently a hydrostatic effect is obtained which gives sufficient pressure for inhaling the necessary amount of air to carry the vapor to the burners.

The vapor-pipe V C, it will be observed, is extended above the gasoline-tank before it reaches the inhaling-chamber, and consequently the contents of the tank can never be caused to flood the inhaling-chamber or gas-tank in case the heating apparatus should become accidentally cooled off. The formation of vapor in the pipe V C necessarily forces back any surplus gasoline into the tank; but no pressure is formed therein, because an equilibrium is maintained by means of its direct connecting-pipe C^4 with the gas-tank.

The vapor-column having no appreciable weight and the gasoline-column having the usual hydrostatic pressure, it follows when the depression of the pipe is twenty feet that a pressure will be exerted on the entire vapor-column of about seven pounds to the square inch. As long as no outlet is given to the vapor and the application of heat is continued the pressure remains the same, further vaporization being suspended. When outlet is given the vapor it is injected into the inhaling-chamber with the amount of pressure above stated. As fast as the vapor is delivered to the inhaling-chamber above gasoline from the tank enters the vapor-pipe below and is vaporized to take its place.

IV. *The vapor-valve and inhaling-chamber.*—D, Fig. 1, represents the inhaling-chamber which receives vapor from pipe V C, united thereto by means of a union, c^5.

d represents an air-pipe having an air-valve above.

d' represents a sleeve fitting snugly within the interior of the neck d^2, which is attached, by means of a union, D′, to the bulb G^5 leading into the gas-tank. The sleeve d' is contracted at its upper end and provided with a bell or trumpet shaped mouth, d^7, as shown. This sleeve is adjustable vertically for the purpose of obtaining the most complete vacuum to a given size of opening and a given amount of pressure.

d^3 represents a permanent stud cast in the side of the inhaling-chamber, the outer portion of which forms a part of union c^5, as shown, and the inner portion of which forms a seat for the vapor-valve. The cavity for the valve is bored from the top, the same being closed by means of a tight-fitting flanged screw-plug, d^5, as shown.

d^4 represents the vapor-valve, of conical form, which fits a ground seat of the same size and shape, the lower portion of the valve coming nearly flush with the opening in the valve-seat, as shown.

d^6 represents a valve-stem permanently attached to the valve, which is adapted to move in a vertical direction, the construction being such that when the valve is free to act the combined effect of gravitation and vapor-pressure tends to close the same. The movement being in a direct vertical plane, it follows that there is no tendency whatever to wear the sides unequally.

The operation is substantially as follows: When the vapor-valve d^4 is elevated by mechanism hereinafter described the vapor above it escapes through the valve-opening in a stream converging in the direction of the walls of the valve. The area of the opening at the point where the vapor leaves the same is less than at any point above it, no matter whether the valve is opened to a greater or less extent, and hence the vapor-stream is confined most just at the point of escape. By this means an injecting force of great power is obtained under all degrees of opening of the valve. The walls of the valve-seat also being parallel with the adjacent wall of the valve, it follows that the vapor-stream is not obstructed at any point in its flow. This special construction, in connection with the sleeve d', is adapted to draw in the maximum amount of air with a minimum opening and pressure.

The inhaling-chamber acts in connection with the vapor-valve, its operation being easily understood from the foregoing description.

The sleeve d may be adjusted for the purpose of locating the same in the best position relatively to the vapor-valve.

The inhaling-chamber and vapor-valve may be readily removed, if desired, by means of the unions c^5 and D′.

V. *The actuating mechanism for controlling the movements of the vapor-valve.*—Two methods of operating apparatus of this class have been before employed. First, where the gasometer has a continuous reciprocating movement in a vertical direction when the machine is in operation, the vapor-valve being fully opened when the gasometer has reached the proper point in its descent and fully closed when it has reached the proper point in its ascent. In consequence of this action the speed of the movement of the gasometer is caused to depend upon the amount of gas consumed, and hence when many burners are lighted the movement is rapid, and the parts consequently are exposed to undue wear and strain. A large and correspondingly expensive gasometer also is required, and the action of the apparatus is necessarily irregular. In the second method the gasometer moves up and down only as the amount of consumption is varied, the valve never being entirely closed while the apparatus is in operation, but being adjusted by the direct action of the gasometer according to the amount consumed. This construction is also defective because the amount of vapor required to supply a single burner is so minute that no valve-opening sufficiently small can be made to give the proper proportion of vapor, or have so small a vapor-stream to draw in the necessary amount of air by injection to carry the vapor. For this reason, where few burners are used the gas becomes overcharged with vapor, producing a smoky light and depositing large quantities of condensation in the apparatus.

In my improved gas-generator I retain the advantages of a comparatively small and cheap gas-tank and gasometer, and at the same time avoid the objections of the second method above set forth.

From the least consumption of gas—say one burner or less to ten—the gasometer has a vertical reciprocating motion, descending and opening the valve fully, then ascending and closing it fully; but if more than the ten burners are open, then the gasometer stands still, varying only as the outlet of the gas is varied, the vapor-valve injecting a constant stream, taking in a regular proportion of air at all times.

E, Figs. 1 and 6, is a sleeve held in the bulb-elbow G^5 by a set-screw, e. This sleeve has cast or otherwise attached on its lower wall a triangular plate, e', to hold in place and act as a bearing for the various working parts of the actuating mechanism.

E′, Figs. 1 and 4, is an oscillating lever pivoted in a sleeve, E, at e^2, which is its fulcrum.

e^3 represents an adjustable screw-table upon the short arm of the lever, extending into the bulb-elbow G^5, as shown.

d^6 represents the stem of the vapor-valve d^4, the lower end of which rests near to the screw-table e^3, as shown.

The long arm of lever E′ extends into the gas-tank, and is weighted sufficiently to raise the valve against the vapor-pressure when free to act.

e^4 represents a roller pivoted in the long arm of lever E′ in the proper position to rest upon the cams E^2 E^3, from which the lever E′ receives its motion. The cam E^2, which is nearly circular in form, is adapted to receive an oscillating movement of about ninety degrees.

e^5 represents an arm, which at one end is permanently attached to cam E^2 and at the other is joined to pitman e^6, which is itself pivoted to the guide-rod g^{11}, attached rigidly to the gasometer G^8, Fig. 1.

The special construction of the bearing portion of cam E^2 gives three elements of motion to lever E′. From w to x is a gradual incline, with the lowest point at w; from x to y is a short concentric segment; from y to z is another concentric segment, lower and longer than x y. The concentric distance of the line x y from the point w is indicated by the dotted line x y. The concentric distance of the line y z from the point w and line x y is shown by the dotted line y z. These three elements of motion merge by easy gradations into each other.

The dotted line w x' represents the position of the arm e^5 when at the lowest point. When the arm is in this position the roller e^4 is at w, and consequently the long arm of lever E′ is also at its lowest point, while the short arm of the lever thus being raised to its highest point, the valve necessarily is opened thereby to its fullest extent.

The dotted line $x\ y$ shows the arm e^5 at what may be called the "lower tripping-point," in which position the roller rests upon the cam E^3, as shown in the drawings. The dropping of the roller by the further movement of the arm opens the valve sufficiently to supply the vapor for ten burners.

The dotted lines $y\ z'$ represent arm e^5 at its highest point, which may be termed the "upper tripping-point." When the arm is in this position the vapor-valve is entirely closed.

A recess is cut out of the periphery of E^2 to receive the bow E^5, touching only the two stops e^7 and e^8 of the recess.

The cam E^3 is seen more distinctly in Fig. 7. It oscillates on shaft E^4 concentric with cam E^2. It gives but a single element of motion to the lever E', this element being represented by an incline from u to v. The relative position and point of intersection of incline $u\ v$ with segment $x\ y$ of cam E^2 is shown by the dotted line $x\ y$ in Fig. 7. Cam E^3 has also a recess cut out of the lower portion of its periphery. Its stops e^9 and e^{10} also come in contact with the bow E^5. This bow can be seen more clearly in its front view, Fig. 5, swinging also on shaft E^4, so that the two cams E^2 and E^3 and bow E^5 all oscillate concentric with each other.

The bow E^5, as stated, swings freely in the two recesses cut out of the two cams, touching only the stops or end walls of the recesses. A friction-roller, e^{11}, is journaled into the lower part of bow E^5, on which rests the cam-weight E^6. This piece is pivoted into plate e' at e^{12}, having its free end e^{13} weighted and its lower side, formed into a V-shaped cam, e^{14}, resting on roller e^{11} of bow E^5.

The operation of the valve-actuating mechanism is as follows: When the gasometer G^8 is in the position seen in Fig. 1, and yet descending, the arm e^5 has moved the cam E^2 to the position seen in Fig. 6, and stop e^8 has moved the bow E^5 so that its roller e^{10} rests just under the point of V-shaped cam e^{14}, having brought bow E^5 in contact with stop e^9 of cam E^3, Fig. 7. Suppose there are to be nine burners taking their gas from the apparatus, the gasometer G^8, when it descends a small degree farther, moves, as shown above, the roller e^{11} still more to the left, and as soon as it passes the V-point of e^{14} the latter moves the bow with some force to the left, and as the bow was then in contact with stop e^9 it is evident that it will move the cam E^3 with it. This has the effect of moving the incline $u\ v$ to the right, dropping roller e^4, and consequently lever E', into which it is journaled, on the segment $x\ y$ of cam E^2. This opens valve d^4 sufficiently (having been adjusted to this point by screw-table e^3) to admit vapor to support ten burners, and as but nine are now open, as above stated, there will be a greater volume of vapor and air admitted than is going out, and hence the gasometer will rise. This it begins to do slowly. The segment $x\ y$, known as the "ten-burner point," is gradually drawn to the left by the direct action of arm e^5 until the point y is under the roller, which lowers the same slightly and elevates valve d^4 correspondingly. The gasometer rises with increased speed, as the vapor coming in when the roller is between y and z is sufficient to support about one-half of the full capacity of the apparatus. When arm e^5 arrives at the dotted line $y\ z'$ the stop e^7 has brought the roller of bow E^5 back under the V-point of cam-weight E^6, while stop e^{10} is now in contact with bow E^5 and roller e^4 has just come in contact with incline $u\ v$, as seen at e^{15}. It is now ready to make the upper trip, and the roller e^{11} is moved past the V-point of cam-weight E^6. The weight thereof presses on roller e^{11}, forces the bow to the right, taking cam E^3 with it, so that incline $u\ v$ elevates roller e^4 and lever E' to the position seen in Fig. 7, which entirely removes screw-table e^3 from the stem of valve d^4, so that the valve closes entirely from the force of gravity and the pressure of the vapor acting in conjunction. If the nine burners, or any less number, are kept in operation, the gasometer will now descend, again open the valve, dropping roller e^4 on segment $x\ y$, as above described, again rise and close the valve entirely, and so on. If we now open one more burner, making ten in all, the gasometer, after descending, will not rise, but will keep roller e^4 resting on segment $x\ y$, at which point, as stated, the incoming vapor and air united being just equal to the outgoing volume of ten burners, the gasometer will neither rise nor fall, but will remain stationary, the vapor-valve admitting a constant stream of vapor, drawing in a constant and proportionate quantity of air through the air-valve. Should we now light more burners, then the volume of outgoing gas will be greater than that coming in, and the gasometer will for this reason descend. This will lower the roller e^4 on the incline $w\ x$, and so on, the more burners that are opened the lower will the gasometer descend, lowering roller e^4 on $w\ x$ proportionately until the valve is full open, which will constitute the full capacity of the apparatus. It will then be observed that roller e^4 will be on incline $w\ x$ or segment $x\ y$ when the gasometer stands still, and a constant stream of vapor enters the same; but when fewer than the ten burners are used, then the gasometer has a vertical reciprocating motion, alternately opening and closing the vapor-valve fully.

To recapitulate briefly, the oscillating cam E^2 receives its motion, through arm e^5, pitman e^6, and guide-rod g^{11}, from the gasometer G^8. It transmits its motion to valve d^4 in two ways—first, directly to lever E', through its roller e^4, by means of cam-shaped periphery w, x, y, and z; second, through bow E^5, assisted by cam-weight E^6, to cam E^3, and thence to lever E'. Cam E^3 simply elevates and holds up lever E' while the gasometer is descending to make the lower trip, and is pushed aside to drop lever E′ in making the same. Cam-weight E^6 is lifted by bow E^5, operating on one side of V-shaped cam E^{14}, and returns the force to the bow, and thence to cam E^3 by the weight acting on the other side of the same. Bow E^5 receives motion from cam E^2, of any speed, and transmits it, by the assistance of weight E^6, instantaneously and uniformly to cam E^3.

VI. *The air-valve and its relation to the vapor-flow.*—F represents a body of suitable shape, screwed upon the air-pipe *d*, which latter connects the same directly to the inhaling-chamber. The seat *f* is tightly fitted into body F, the ground surface being below, and closed by means of the valve *f′*. This valve is ground air-tight with seat *f*, and opens inwardly. It is held in position by the arm f^2, pivoted on brackets projecting from the body F.

f^3 represents an adjustable counter-weight, which balances the valve in any position. f^4 represents another weight, the center of gravity of which is directly below the point of suspension. These two weights are a part of arm f^2, and are attached rigidly to the same.

f^5 represents any suitable cap, the same being placed over the valve to protect it from any falling obstruction, a space being left between it and F to admit air freely.

The operation of the air-valve is substantially as follows: When the vapor-valve D^4 is open and a stream of vapor is passing out a partial vacuum is formed in the inhaling-chamber and the space beyond. As stated, the air-valve opens inwardly, and as soon as a vacuum is established the pressure of air without opens the air-valve, supplying the demands made by the vacuum below. As soon as the vapor-valve is closed the gasometer attempts to force its gas out through the inhaling-chamber and the air-valve, whereby, the currents being reversed from the action above stated, the air-valve closes automatically. As before stated, the vapor flow varies greatly as to its volume, and beyond ten burners, just in proportion to the consumption of the gas. This variation consequently requires that the air-valve should have a capacity for self-adjustment in order that the quantity of air taken in may always be in the same proportion to a given quantity of vapor injected. This capacity is obtained by the employment of the weight f^4, which, being placed vertically below the fulcrum of arm f^2, is neutral as a resistant at the closing-point of the valve, but as soon as it is opened the weight begins to leave the vertical line, and, rising, resists the opening of the valve. This resistance is gradually increased as the weight rises in the arc f^x. It is, however, necessary to adjust the amount of resistance in the same ratio throughout the stroke of the valve. If a gas-light of low candle-power is desired—say twelve—it is needed only to elevate weight f^4 to a given point, thus reducing the resistance of the valve throughout its movement. If a higher candle-power of gas is required—say sixteen—we lower weight f^4, which presents an increased resistance to the ingoing air, enriching the gas proportionately. If it is desired to resist the valve uniformly throughout its stroke, the weight f^3 may be moved from the fulcrum, thus resisting the valve also in the first part of its opening. By means of these two adjustments the gas at the burners can be regulated as to candle-power to burn uniformly for all gravities of gasoline and for all number of burners in use.

VII. *The gas-tank, gasometer, and connections.*—The gas-tank is cylindrical in form, having double concentric walls G′ G′, which are joined below by a conical bottom, G^2. The structure rests upon a bell-shaped base, G^3, and is more firmly held in position by the annular ring G^4, permanently bolted to the base. The bulb-elbows G^5 and G^6 are soldered strongly and tightly through G G′, and are fastened to ring G^4 by their shanks *g* by means of lock-nuts *g′*. The bottom G^2 has a conical disk, g^2, passing from within to the lower side of the same, a projecting socket, g^3, which connects with vent and condensation pipe C^4, already described. Within this tank the disk terminates in a socket, g^4, to receive the guide-sleeve g^5. This is held in position at the lower end by a screw, g^6, and above by the sheet-metal cone G^7, which is perforated, and rests with its flanged periphery over the top of G′. A semi-circular tube, g^7, begins above cone G^7 and extends to bottom G^2, passing some distance from and over the gas-outlet g^8, but is soldered gas-tight to the interior wall G′ and bottom G^2. A small trap-pipe, g^9, allows condensation from the house-pipes, &c., to flow into the main gas-tank and thence to the gasoline-tank C.

The gasometer G^8 is constructed in the ordinary way, and is made with conical top to receive the guide-stem g^{11}, sliding freely in guide-sleeve g^5. The guide-stem g^{11} receives the pivoting-screw g^{12}, whereby the vertical movement of the gasometer is transmitted to the valve-actuating mechanism heretofore described. The diameter of the gasometer is made so as to reach about midway between walls G and G′, and of a depth to keep its open end always under the sealing-fluid G^9.

The operation of these parts is substantially as follows: As gas of a varying density may sometimes be forced into the gas-tank, the gas on the way to the riser G^{10} must first flow above cone G^7, then down g^7, and through g^8. It has the opportunity of depositing the heavier particles when it is too rich before it passes to the burners; also, any condensation forming flows directly to the gasoline-tank, preventing an over-enrichment of the gas.

The operation of the remaining parts is obvious without further description.

VIII. *The means for and method of employing the tension of the vapor-column for regulating the supply of gas to the heating-burners.*—The means employed for regulating purposes depend for their action on the height of the column and the consequent pressure in the vapor-pipe V C, already described. If this vapor-pipe is heated sufficiently to vaporize the gasoline thoroughly, there will be a pressure on the vapor equal to a column of gasoline extending from the tank C to near the bottom of the hot-water pipe, and when this is the case it is sufficiently heated for the proper operation of the machine. If the heat is reduced, the gasoline consequently will enter the pipe V C from below, and to the extent that this is the case the pressure on the vapor column will be diminished. Also, should the vapor become heavy from a reduction of heat, its weight will assist to counterbalance the gasoline column, and to this extent reduce the pressure in the upper part of V C.

It is evident to obtain a mechanically-complete means of regulating the gas of the heating-burner we now only need use the tension of the vapor-column so it will close off the gas of the heating-burner when the vapor-column is complete to the bottom and to let on more gas when the vapor-column and consequently the pressure is diminished.

An ordinary steam-gage taking its pressure from the vapor-column, if attached to and operating a gas-key controlling the gas to the heating-burner, as above stated, would, in general, fulfill these requirements.

The regulator, however, herein described is constructed as follows: A pipe, c^6, leads from the vapor-pipe down some distance near the floor, across the bottom of base G^3, then up to a point, *h c*. This pipe is to be filled with any suitable fluid, as water or glycerine, for the purpose of preventing the heat of the vapor from being communicated to the regulator. H is a glass bulb, terminating below in a small tube, *h*, which descends some sixteen inches, then returning as *h'* is connected to c^6 at *h c*. The bulb H and tubes *h* and *h'* are filled partly with mercury. A float, h^3, rests on the surface of the mercury, having a stem, h^4, extending upward, where it closes off the gas to the heating-burner. The gas-pipe supplying the heating-burner begins at h^5, where it receives its supply from the main and continues to the gas-valve h^6. This has simply a straight horizontal bore intercepted and entirely closed by stem h^4 when the mercury is at its highest. A small independent conduit, h^7, is seen directly above the valve, which passes around the main passage. This conduit is adjusted, as to its main opening, by a small screw, h^8, and is termed the "safety-flow," which keeps the flame of the heating-burner lighted at the lowest degree that is safe against being accidentally extinguished. The gas-pipe then continues on at h^9 to the heating-burner, which it supplies with gas from the apparatus.

The operation is substantially as follows: When the heating-pipe B is cold the gasoline in vapor-pipe V C extends up to the level with the gasoline in tank C, and therefore gives no pressure in the upper part of the vapor-pipe. This allows the mercury in bulb *h* to descend, forming a level with that in tube *h'*, drawing down float h^3 and its stem, thus letting on a full supply of gas to the heating-burner. As soon as vapor-pressure is produced in V C the same is at once transmitted to tube *h'*, depressing the mercury in the same and elevating it in tube *h* until the vapor-column is complete, at which time the mercury in bulb H has risen to a point shown in the drawings, when it has closed entirely the main passage of the gas, reducing the light of the heating-burner to the minimum degree, and supported only by the small stream of gas passing through conduit h^7. This quantity of gas, however, is quite insufficient to generate steam in the heater, and for this reason no hot water will, for the time being, be forced down pipe B. Eventually the heat becoming diminished, the vapor-column will become shortened, lessening the pressure. As soon as this has progressed to some extent, the mercury in H having also lowered proportionately, float h^3 lowers, which lets on more gas to the heating-burner, which immediately generates steam in the heater and forces a charge of hot water down B, thus restoring the heat and again completing the vapor-column, and consequently again closing off the gas more or less under the heater, and so on. By this means the pressure of the vapor-column can be kept from varying more than half a pound to the square inch, keeping always a sufficient heat, yet not wasting the gas by overheating the vapor.

It will be observed that the supply of gas for heating the water and vaporizing the gasoline is regulated according to the vaporizing-point of the gasoline under the necessary pressure to operate the apparatus; hence a high gravity of gasoline, which is comparatively easily vaporized, does not demand as much gas under the heater as lower gravities, and no matter what grade is used the regulator automatically supplies the exact amount of heat requisite for its thorough vaporization. This, too, is the case when condensation finds its way back to the gasoline-tank and passes into the vaporizing-pipe. Also, should much gas be used at the burners, and consequently much gasoline present itself for vaporization, the regulator gives the exact amount of gas to the heating-burner to supply the increased demand. Also, should the natural temperature change, the regulator gives sufficient, but not too much, gas to keep the vapor-column complete. We have therefore the means of automatically regulating the heating-flame to meet the demand of varying qualities of gasoline or its condensation, of varying volumes of gas being consumed, and in variations of natural temperature, meeting every condition of variation as well as their several combinations.

The heating-burner I, which is shown in the drawings, is constructed of various heating-coils, *i i*, to expand the gas before it is emitted for combustion from the perforated coil *i'*; but any heating-burner having the usual requisites of a good heater may be made use of.

The general operation of the machine as a whole will now be described.

The gasoline can be at any time introduced into the gasoline-tank without interfering with the operation of making gas, the air contained therein flowing to the gas-tank through the open vent-pipe C^4, whence it may be consumed from the burners of the house. The gasoline then passes through the trap-chamber, deposits therein any objectionable material, and flows down the gasoline-pipe, establishing the necessary hydrostatic pressure to produce the propelling force for the apparatus. The gasoline-pipe then enters a hot-water pipe, whereby the gasoline is vaporized, and escapes through the vapor-valve with sufficient force to produce a vacuum to draw air through the air-valve, which obeys the action of the vapor-flow, the air and vapor automatically mixing to produce a good illuminating-gas. As it enters the gas-tank it is controlled in its inlet by the gasometer acting through the valve-actuating mechanism. The gas then flows to the burners by the force exerted thereon by the weight of the gasometer, the heating apparatus heats water, and the force of the steam generated forces the heated water down around the vaporizing-pipe and returns it to the heater, overcoming the resistance of gravity and the friction of the pipes by the circulating system described, which is entirely free from all mechanical working parts.

The gas given to the heating-burner is automatically controlled and economized by a regulator that acts in accordance with the completeness of the vapor-column, that being the condition necessary for the proper working of the apparatus.

Some of the advantages of my improved apparatus are as follows: By the employment of the method herein described to obtain the pressure of the vapor-column a regular uniform pressure is obtained for the operation of the apparatus, and the dangers, losses, and inconveniences of flooding the apparatus, under all conditions, by gasoline from its tank are wholly obviated without the employment of any auxiliary safety mechanism for that purpose. The supply of gas to the heating-burner is automatically regulated according to the vaporizing-point of the gasoline under all conditions of temperature, quality of gasoline used, and volume of gas consumed. The condensation accumulating in or flowing into the tank, or any leakage from the vapor-valve, is automatically drained into the gasoline-tank, from which it is used over again, thus preventing the supercarbureting of the gas. Ready means are afforded also of ascertaining the amount of gasoline on hand at any time and of replenishing the tank with safety without disturbing the operation of the apparatus or taking the pressure off of the gasoline-column. The expense of tankage also is reduced, because there is no pressure on the tank except that given by the gasometer, whereby danger of leakage is incidentally reduced. Equilibrium is also established at all times and under all conditions between the gas and gasoline tanks. Uniformity of pressure is obtained and the danger of overpressure or collapsion in the latter avoided, which result might otherwise occur by the expansion and contraction of the gas in changes of the natural temperature. Continuous gas-vent is given to the gasoline-tank, the space left by the consumption of gasoline being supplied by gas from the gas-tank. The labor, attention, expense, and room are saved of any special apparatus for storing up a power to operate the apparatus, such as pumping any gas or liquid or elevating the gasoline or other liquid above the apparatus to obtain a working pressure.

By the employment of the heating apparatus and water-circulating system the water is heated slightly above the boiling point, and is forced down the heating-pipe surrounding the vapor-pipe, the water being then returned to the heater, thereby avoiding the loss of the water by evaporation, without the employment of any valve or mechanically-moving parts, thus increasing durability and reliability to a maximum degree.

The apparatus also may be quickly started by using water previously heated.

By the employment of the special regulator herein described, or its equivalent operated by the tension of the vapor-column, the gas flow to the heating-burner is almost entirely cut off, thus saving all superfluous gas when the vapor-column is completed, and suddenly increasing the flame to a degree sufficient to generate steam in the steam-chamber to force the heated water through pipe B when the vapor-column becomes diminished.

The regulator is free from intricate working parts, so that the chances of clogging or other disarrangements are reduced to a low average.

By the described construction of the vapor-valve and inhaling-chamber the simplest form of a valve is made use of to give a strong injecting force to the vapor in all the various stages of its opening, and especially where a small stream only is required.

By the employment of the valve mechanism in conjunction with the vapor-valve and chamber the apparatus is enabled to supply a large quantity of gas by constant injection with a stationary gasometer, and also to give a full opening of the vapor-valve and a reciprocating motion of the gasometer where few burners are used, thus avoiding the expense and space of a large gas-tank, overworking of the valve-actuating mechanism, and the uneven flow of the gas. It also avoids, on the other hand, so intricate and minute an adjustment as would be necessary for making gas for a single burner or less.

By the employment of the improved air-valve herein described the air-current is always proportional to the vapor flow, and the proportion of air mixed with the vapor can be adjusted for all varying flows of the vapor.

The construction of the valve is such that it can be easily taken apart and cleaned as required without disarranging the adjustment of the various parts.

I am aware that a steam-generating apparatus having a coil of pipe with return-pipe for connecting the top and bottom of the same is not new.

I am aware, also, that the combination, broadly, of an inhaling-chamber with a vapor-valve is not new.

I am aware, also, that the combination of a vapor-valve with trip mechanism actuated by the gasometer is not new.

I am aware, also, that a gasoline-tank having a filling-pipe with float and rod is not new; but,

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

1. In combination with the steam-generating apparatus A B, having the check-pipe B^5, the water-circulating system B B^2, substantially as described.

2. In combination with the steam-generating apparatus and the water-circulating pipes B B^2, the vent-pipe B^4, extending above the discharge-mouth of the pipe B^2, as described.

3. In combination with the steam-chamber A B, the store-chamber B^3 and check-pipe B^5, as described.

4. In a circulating system substantially as described, the vent-pipe B^4 and check-pipe B^5, in combination with the chambers A B and B^3, as described.

5. The circulating system described, consisting, essentially, of the following combination of elements: the steam-chamber A B, descending water-pipe B, return-pipe B^2, store-chamber B^3, vent-pipe B^4, and check-pipe B^5.

6. The combination of the following elements: a gasoline-tank, a continuous pipe extending therefrom to the inhaling-chamber, having a descending and ascending leg, the latter of which rises above the gasoline-tank, and means, substantially as described, for applying heat to the same.

7. The described method of supplying enriching vapors to an inhaling or air-mixing chamber located above the source of the supply of enriching material, which consists in generating the vapor from a column of enriching material and injecting the generated vapor into the inhaling-chamber directly by the hydrostatic pressure of the column of enriching material from which the vapor was obtained, the column being of sufficient height to obtain the inhalation of the requisite amount of atmospheric air, as set forth.

8. In combination with the gasoline-pipe having an ascending and descending leg, a heating-pipe encircling the ascending leg, substantially as described.

9. In combination with the gasoline-pipe c^2, the hot-water pipe B, having the extension B^6, as and for the purpose described.

10. The method described of regulating the supply of gas to the heating-burner, which consists, essentially, in actuating the regulating mechanism directly by the tension of a column of vapor of the substance employed to generate the gas.

11. In combination with the inhaling-chamber D, having the stud d^3, the vapor-valve d^4, as described.

12. The lever E′, pivoted at e^2 and having adjusting screw-table e^3, adapted to adjust the opening of valve d^4, as specified.

13. In combination with the lever E′, the cam E^3, having incline *u v*, adapted, substantially as described, to elevate lever E′ for the purpose of closing the valve.

14. In combination with the cam E^2, having stops e^7 and e^8, the cam E^3, having corresponding stops, and the intermediate bow, E^5, as described.

15. In combination with the cams E^2 E^3 and the bow E^5, the weight-cam E^6, as and for the purpose described.

16. In combination with a cam, E^3, adapted, substantially as described, to drop the lever E′ for opening the valve a predetermined extent, a cam, E^2, adapted, substantially as described, to drop the lever E′ still lower for opening the valve wider.

17. The air-valve F, having counter-balance f^3 and weight f^4, the latter adapted to present a gradually-increasing resistance to the opening of the valve.

18. The air-valve herein described, having arm f^2 and valve f' pivoted and attached to the valve-seat, so that the working parts may be removed and replaced without disarranging the same, as set forth.

19. In a gas-tank constructed substantially as described, the combination of cone G^7, gas-passage g^7, and trap g^9.

20. The combination of the following elements: gasoline-tank, gasoline-pipe, vapor-pipe, inhaling-chamber, and delivering-pipe, gas-pipe, and condensation-pipe C^4, the construction and arrangement being such that a complete circuit may be made through the entire gas-making apparatus.

In testimony whereof I hereunto set my hand this 10th day of November, 1879.

T. VAN KANNEL.

Attest:

THOMAS WOOD,
W. S. MOSER.