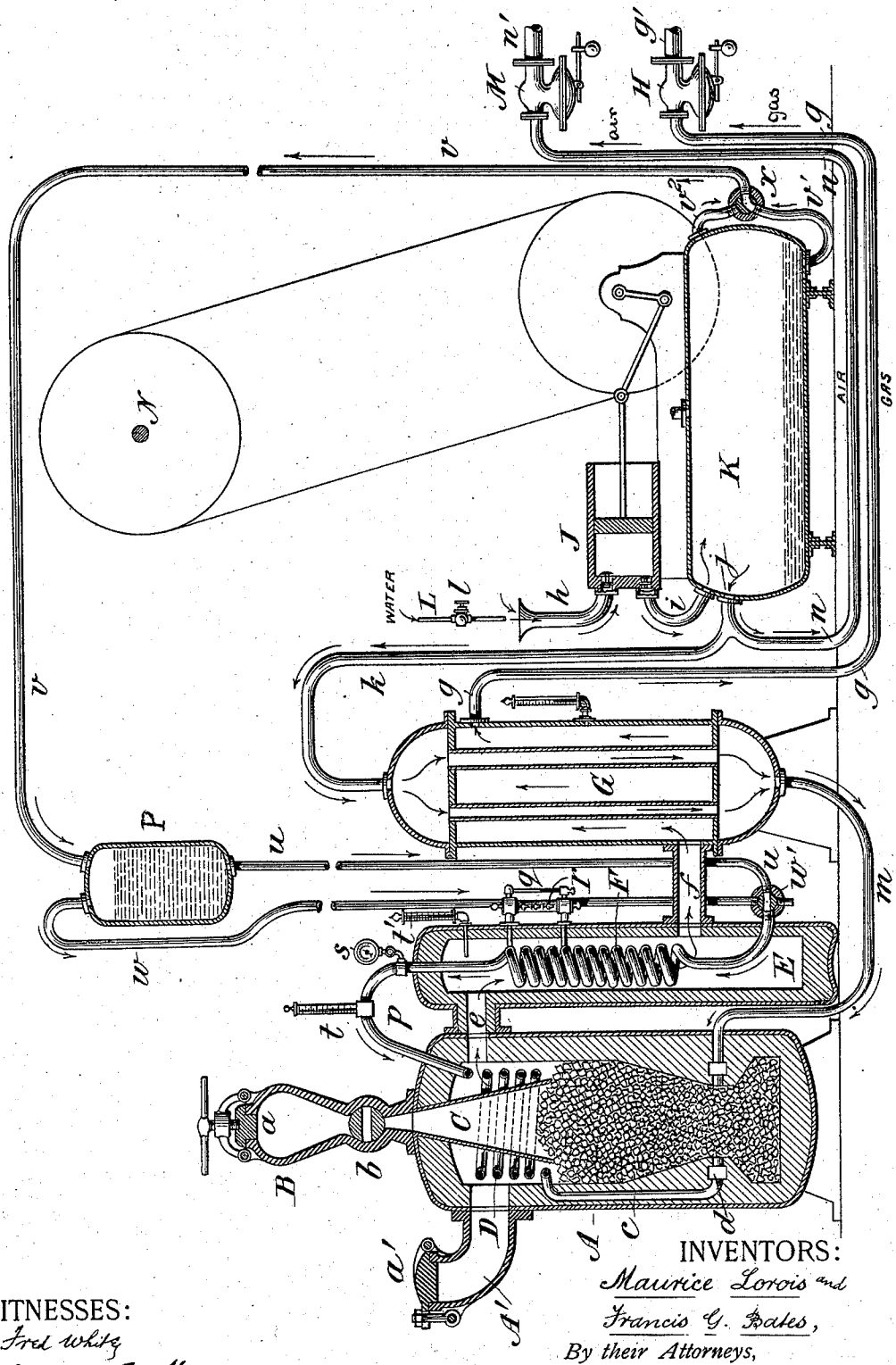
(No Model.)

M. LOROIS & F. G. BATES.

PROCESS OF AND APPARATUS FOR MANUFACTURING GAS.

No. 573,989. Patented Dec. 29, 1896.



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UNITED STATES PATENT OFFICE.

MAURICE LOROIS, OF NANTES, FRANCE, AND FRANCIS G. BATES, OF PHILADELPHIA, PENNSYLVANIA; SAID LOROIS ASSIGNOR TO SAID BATES.

PROCESS OF AND APPARATUS FOR MANUFACTURING GAS.

SPECIFICATION forming part of Letters Patent No. 573,989, dated December 29, 1896.

Application filed June 13, 1896. Serial No. 595,496. (No model.)

To all whom it may concern:

Be it known that we, MAURICE LOROIS, a citizen of the Republic of France, residing in Nantes, (Loire Inferieure,) France, and FRANCIS G. BATES, a citizen of the United States, residing at Philadelphia, Pennsylvania, have invented certain new and useful Improvements in Processes of and Apparatus for Manufacturing Combustible Gas, of which the following is a specification.

In the United States patent of Maurice Lorois, No. 529,453, there is claimed a new process of manufacturing gas characterized by the forcing of air and superheated steam under high pressure through a mass of incandescent fuel, whereby a producer-gas is formed under so high a temperature as to avoid the formation of ammoniacal and tarry impurities.

In the United States patent granted to Maurice Lorois, No. 529,452, for a gas motor is shown a combination of the apparatus necessary for producing gas by this process, with a gas-engine specially adapted to be operated by the combustion of such gas, the whole being combined coactively to constitute a motor apparatus.

The present invention relates to the manufacture of fuel or producer gas by the same general process as that of said Patent No. 529,453, providing, however, certain improvements in the manufacture whereby to adapt the process of gas manufacture for application independently of a specially-constructed motor-engine and to render it generally applicable for small gas-producing plants, or other gas-plants operated independently of motor-engines.

According to our invention we utilize the exceptionally-high temperature of the newly-formed gas, first, for effecting the superheating of steam and subsequently for effecting the generation of steam, and still later we further cool the gas and utilize its heat for effecting the proper heating of the air which is to be fed to the gas-producer. The air is compressed by an air-compressor which at the same time serves to pump water, so that the air in this compression is brought into close contact with the water, and the heat, which is rendered sensible by the compression of the air, is taken up by the water and thereby economized, while at the same time the water serves for packing and cooling the air-compressor. The same pump is thus used for acquiring a pressure both of air and of water and the mechanism thereby simplified. The compressed air and the water are received into a tank or receiver, from the lower part of which the water is taken and may be forced up to an elevated water-reservoir. From this the water is conducted to a steam generator or coil disposed in the passage through which the hot gas circulates, whereby the water is converted into steam. This steam is then conducted to the superheating-coil, which is exposed to the most intense heat of the newly-formed gas, and therefore is located, preferably, in the upper part of the gas-producer. The steam is superheated in this coil and then conducted to the lower part of the gas-producer where preferably it is mingled with the heated air, and the two are then injected into the gas-producer and forced together up through the mass of incandescent fuel therein, whereby they are converted into producer-gas of the special character described at length in said Patent No. 529,453.

The figure of the accompanying drawing is a vertical section of the entire apparatus.

Let A designate the gas-producer or "gazogene," its general construction being the same as in said Patent No. 529,453. It is provided with a feeding-hopper B, closed at top by a tight-fitting cap *a* and lower down by a rotative cock or valve *b*, which communicates with the interior of the gas-producer through a conical or downwardly-flaring funnel or magazine C, which enters deeply into the producer-chamber. A superheating-coil D is arranged in the upper part of the chamber around the magazine and communicates through a tube or passage *c* with an annular passage *d*, encircling the lower part of the producer and from which twyers enter the producer-chamber. From the upper part of the producer leads a gas-outlet flue *e*, which communicates with the upper part of a descending flue or vertical chamber E, through which the hot gas circulates downwardly around a coil F, constituting a steam-generator. From somewhat above the bottom of

the chamber E leads an outlet *f*, through which the gas is conducted to an air-heater G, through which it flows to a gas-outlet pipe *g*, leading to a pressure-regulator H for reducing the pressure of the gas before it is delivered by the pipe *g'*, which leads to the place of use.

A pump or air-compressor J is arranged to draw in air through an inlet *h* and expel it through an outlet *i* into the compressed-air reservoir or tank K. The pump J is shown diagrammatically, it being understood that any known construction of air-compressor may be employed, but preference is given to those constructions in which water is pumped along with the air for the purpose of lubricating and cooling the compressor. This is indicated diagrammatically in the figure by the introduction of a water-pipe L, controlled by a valve *l*, which introduces a stream of water into the inlet *h*, so that this water will enter the pump with the air. From the reservoir K an air-outlet *j* is provided, leading by a pipe *k* to the air-heater G, through which the air flows and takes up heat from the hot gas, and is then led by a pipe *m* to the gas-producer A, where it is introduced, preferably, into the annular passage *d* to commingle with the superheated steam before entering into contact with the incandescent fuel. Another air-pipe *n* leads from the compressed-air reservoir to a pressure-regulator M, by which the pressure of the compressed air is lowered before it enters the delivery-pipe *n'*, which conducts it to the place of use.

Water is forced through the steam-generating coil F, and by being subjected to the action of the hot gas in the chamber E steam is generated, which passes from the upper part of this coil through a connecting-pipe or goose-neck *p*, which connects with the upper part of the superheating-coil D, through which the same circulates, and from the lower part thereof it is led by the pipe or passage *c* to the annular passage *d*, communicating with the twyers. The height of the water in the generator is indicated by a water-tube or glass water-gage *q*, which connects at top and bottom through horizontal branch pipes with the coil. Petcocks *r* may be advantageously added for the same purpose, with or without the water-tube. The steam-pressure is indicated by a gage *s*. A thermometer or pyrometer *t* is provided in the pipe *p* for determining the temperature of the steam. The temperature of the gas passing over to heat the steam-coil F may be determined by a pyrometer *t'*, communicating with the chamber E. The water may be forced through the coil F by any suitable means, such, for example, as an injector or an ordinary water-pump, but the means shown consists of an elevated water-tank P, from the bottom of which a pipe *u* extends downward and connects with the lower part of the coil F. The height of the water vessel P should be such as to furnish sufficient head to overcome the pressure of the generated steam and prevent its forcing the water back from the coil F and to force the steam to pass over through the superheater and out through the resistance of the mass of fuel in the gas-producer. The reservoir P may advantageously be arranged about four meters above the gas-producer. For elevating the water to this reservoir we connect it by a pipe *v* to the bottom of the compressed-air cylinder K, so that by the air-pressure in the latter the water contained therein may be forced out through the pipe *v* and carried over into the reservoir P. To establish sufficient difference in pressures to cause this outflow to take place, the air-pressure in P can be relieved by means of a pipe *w*, leading from the upper part of reservoir P to the open air and controlled in this construction by a valve or cock *w'*. On opening this cock the air-pressure is permitted to escape until when the pressure in P is sufficiently less than that in K so that the difference exceeds the weight of a column of water extending from the level of K up to that of P this difference of pressure forces the water to flow out from K and ascend through the pipe *v* to the reservoir P. When the latter is filled, the valve *w'* should be turned so as to close the passage through the pipe *w*. This valve is constructed so that when it is opened to the pipe *u* it is closed to the pipe *w*, and vice versa. The purpose of introducing the valve *w* to close the pipe *u* when it opens the pipe *w* is to prevent any backflow of water and steam from the generator F toward the tank P upon the latter being relieved of pressure, which would occur if no means were introduced in the pipe *u* to prevent it. Other means may, however, be substituted to accomplish this result, such as two valves in the respective pipes connected mechanically together, or a check-valve might be employed in the pipe *u*. The pipe *v* connects with the reservoir K by means of a valve or three-way cock *x*, which connects with the leg or pipe *v'*, forming a continuation of the pipe *v* to the bottom of the reservoir K, and to a pipe v^2, leading to the top of the reservoir K. The pump or compressor J may be driven by any suitable power, as, for example, by means of belt-pulleys from an overhead shaft N, as indicated.

The apparatus is operated in the following manner: A fire is kindled in the producer A and supplied with coal or other suitable fuel, the fire being continued until a suitable bed of incandescent fuel has been obtained. During this time air is blown through the producer under low pressure and the products of combustion escape through a branch pipe A', the cover *a'* of which is thrown open, and the pipe is connected to a chimney-flue. When a sufficient bed of incandescent coal is attained, the flue connection is disconnected, the cap *a'* closed, and the apparatus is ready to be operated under pressure for producing gas. The air-compressor J then forces compressed air into the reservoir K and at the

same time introduces water, which is warmed by the heat liberated upon the compression of the air, so that the heat thus otherwise wasted is economized by being taken up by the water, which is thus heated before being introduced to the steam-generator. The water-reservoir P is filled with water, and cock w' being opened this water ascends through the coil F and, being highly heated thereby, is converted into steam, which steam passes over through the pipe p to the superheater-coil D, which is exposed to the greatest heat of the gases ascending above the fuel in the producer, and the steam thus superheated passes down through the passage c to the annular passage d. At the same time compressed air from the cylinder K passes through pipe k to the air-heater G and is heated therein to a high degree, passing thence by pipe m to the passage d in the producer. The superheated steam and the preheated air are commingled in this passage and are injected through ports or twyers leading therefrom into the chamber of the producer A and ascend therein through the mass of fuel, the steam being decomposed into hydrogen and oxygen and the oxygen combining with the carbon from the fuel to form carbon monoxid, while the hydrogen passes through unaltered. Of the air the nitrogen passes through unaltered, while the oxygen combines with the fuel to form carbon monoxid. The resulting gas, consisting chiefly of carbon monoxid, hydrogen, and nitrogen, passes into the upper part of the producer at a very high temperature, circulating around the superheater D to heat the latter, then passing through passage e and chamber E, wherein it heats the steam-generating coil F and is itself thereby partially cooled, passing thence through the air-heater G, in which much of its remaining heat is given up to the air, so that the gas is further cooled, and passing thence to the pressure-regulator H, which is set to prevent the flow of the gas until a certain pressure is attained. The gas is thus discharged at comparatively low pressure, but yet preferably at a pressure considerably in excess of that at which combustible gas is ordinarily transmitted, and circulates through the delivery-pipe g' to the place where it is to be used. Air also by preference passes direct from the reservoir K to the pressure-valve M, which operates in the same manner as the valve H to reduce the pressure of the air, the air at a reduced pressure then passing through the pipe n' to the place of use. The gas-pipe g' and air-pipe n' should be conducted together to the burner or burners or other apparatus for utilizing the gas wherever its heat is desired, in order that the gas may be injected together with compressed air, whereby its combustion is made most perfect and a flame yielding most intense heat may be maintained.

The water-reservoir P must be refilled with water from time to time whenever it is emptied by the running out of its water to the steam-generator. To refill it, the valve x is turned to the position shown, so as to connect the pipe v' with the pipe v, and then the valve w' is turned to close the pipe u and open the pipe w to the atmosphere. This permits a portion of the compressed air to escape from P, thereby reducing the pressure, and the greater pressure in the cylinder K expels the water therefrom and lifts it into the reservoir P until the latter is refilled, whereupon the valve w' should be turned to the position shown, after which the valve x should be turned to establish communication between the pipe v and branch v^2, in order that the air-pressure in the cylinder K may communicate through pipe v with the reservoir P, so as to permit the water in the latter to descend of its own weight to the steam-generator. Thus the normal working condition is with the valve x open to v^2 and the valve w' open to pipe u, or enough open to admit sufficient water to the steam-generator.

The pressure-regulating valves H and M may be of any suitable or known construction of valves adapted to remain closed until a given pressure is attained and to open and permit the outflow whenever that pressure is exceeded. Any ordinary construction of safety-valve or pressure-relief valve may be adapted for this purpose.

The valves H and M should be so set as to maintain a pressure in the apparatus of from fifty to one hundred pounds per square inch. The lower pressure is sufficient for producing a non-illuminating combustible gas, but the higher pressure is preferable when it is desired to make an illuminating-gas. For this latter purpose liquid hydrocarbons are sprayed into the hot air on its way from the heater G to the producer A, whereby the air is charged with hydrocarbon vapor, which in passing up through the mass of incandescent fuel is converted into a fixed illuminating-gas which should be in sufficient proportion to give the required amount of illumination. The air and steam as they enter the gas producer should have a temperature of from 300° to 400° centigrade. A close-burning coal should be used in the gas-producer, although other fuels than coal are admissible. For example, liquid hydrocarbons may be sprayed into the producer-chamber.

The gas produced by this apparatus is adapted for immediate use and requires no washing, scrubbing, lime-purifying, or other manipulations designed to remove tarry or ammoniacal substances, since the gas is free from such impurities. The gas is a fixed gas and may be delivered under any practicable pressure without danger of condensing or losing value during its transmission through mains. The gas is useful not only for driving motor-engines, but also for firing furnaces, as glass-furnaces, for example, and for illuminating purposes it may be used without enrichment for heating the incandescing mantles of Welsbach burners. For

heating purposes this gas has the great advantage over other kinds of gas that it may be used under any desired pressure according to the amount of heat required to be produced, since a gas carrying a given number of calories per cubic meter will carry any multiple thereof by compression of a corresponding number of cubic meters into the volume of one cubic meter. The gas is of great advantage for heating and welding of iron and steel, owing to its purity; also, furnaces and ovens in which it is used endure longer because the gas is free from corrosive ingredients. It also reduces the proportion of scale and rust formed on iron or steel heated by it.

It must not be understood from the exactness with which we have described our improved apparatus that our invention is necessarily limited to the exact construction and mode of operation set forth. On the contrary, our invention is susceptible of considerable modification without departing from its essential features. For example, the steam-generator need not be a coil F, but may be constructed in any other form that will be suitable for communicating the heat of the gas to the water. The water may be put under pressure by other means than those shown, it not being strictly essential to our apparatus that the water be pumped in by the air-compressor, as it might be independently introduced. We contemplate numerous changes and improvements in matters of detail, for which, in so far as they shall be patentable, special applications for patents will be made.

In the operation of our apparatus it is, as we have said, preferable to maintain a pressure of from fifty to one hundred pounds per square inch. However, a lower pressure may be used. About forty-three pounds per square inch is the lowest pressure that will give a pure gas, free from ammoniacal and tarry products. As the pressure runs below this the impurities increase. It is practicable, however, to operate under as low a pressure as, for example, eighteen pounds per square inch, in which case the gas, although very impure compared with that which is produced under the best conditions, still compares advantageously with ordinary producer-gas.

We claim as our invention the following-defined novel features, substantially as hereinbefore specified, namely:

1. The process of making combustible gas which consists in pumping air and water together, whereby the air is compressed and the water takes up the heat from the air, forcing the water thus warmed through a steam-generating passage, superheating the steam therefrom, heating the compressed air, commingling the hot compressed air and superheated steam, passing the commingled air and steam under pressure through incandescent carbonaceous matter to convert them into a fixed producer-gas, then circulating the hot gas into contact with a superheater and a steam-generator, and through an air-heater, whereby it is cooled and its heat is economized.

2. The process of making combustible gas which consists in compressing air, heating it, generating steam, superheating it, passing the superheated steam and compressed air under pressure exceeding forty-three pounds per square inch through incandescent carbonaceous matter to convert them into a fixed producer-gas, then circulating the hot gas into contact with the passage in which the steam is superheated and into the steam-generator, whereby its heat is utilized to generate and superheat the steam, and circulating the hot gas through the air-heater in which said air is heated, whereby the gas is cooled and its heat is economized.

3. The gas-making apparatus comprising a gas-producer consisting of a metal shell adapted to withstand a high internal pressure and having a lining of non-conducting refractory material, air and steam inlets to the lower part thereof, a gas-outlet from the upper part thereof, a chamber through which the hot gas circulates, a steam-generator in said chamber heated by the hot gas, a superheater receiving the steam from said generator arranged to be exposed to the newly-generated hot gas and connected to deliver superheated steam to the inlet of the producer, an air-compressor, a compressed-air pipe leading therefrom to the inlet of the producer, an air-heater arranged to heat the air on its passage, traversed by the hot gas, whereby the heat of the gas is utilized to generate and superheat the steam and heat the compressed air before their admission to the producer, and a pressure-regulating valve applied to the gas-outlet pipe for retaining the required pressure in the apparatus, substantially as set forth.

4. The combination of a gas-producer having air and steam inlets below and a gas-outlet above, a steam-generator traversed by the hot gas from said producer, a steam-superheater receiving the steam from said generator and arranged to be exposed to the newly-generated hot gas, a source of water for feeding said steam-generator under pressure sufficient to force the steam through the superheater and into the producer, an air-compressor, an air-pipe leading therefrom to the producer, an air-heater for heating the air in its passage, traversed by the hot gas, an outlet-pipe for gas, and a pressure-regulating valve on said outlet-pipe adapted to retain the required pressure in the apparatus, substantially as specified.

5. The combination of a gas-producer, a steam-generator traversed by the hot gas from the producer, an air-heater also traversed by said hot gas, an air-compressor adapted to pump air and water together, whereby the heat of the air is utilized to heat the water, a pipe leading from said compressor through said air-heater to the inlet of the producer, means for introducing the water pumped by said

compressor into the steam-generator under pressure, a gas-outlet pipe, and a pressure-regulator applied thereto.

6. The combination of a gas-producer having air and steam inlets and a gas-outlet, a steam generator and superheater traversed by the hot gas from said producer, connected to deliver superheated steam to the inlet of the producer, an air-compressor, an air-heater traversed by the hot gas, an air-pipe leading compressed air from said compressor through said air-heater to the producer, an outlet-pipe for gas, an outlet-pipe for compressed air, and pressure-regulating valves on said outlet-pipes adapted to retain in the apparatus a given pressure of gas and air, substantially as specified.

7. The combination of a gas-producer, a steam-generator heated by the hot gas therefrom, an elevated water-reservoir connected to said steam-generator, whereby it carries a head of water sufficient to force the steam from said generator into the gas-producer, an air-compressor, an air-heater heated by the hot gas from said producer, a pipe conducting the compressed air from said compressor to said air-heater and thence to the gas-producer, a gas-outlet pipe, and a pressure-regulator applied thereto to maintain a given pressure in the apparatus.

8. The combination of a gas-producer, a steam-generator heated by the hot gas from the producer, an elevated water-reservoir connected to said steam-generator, an air-compressor adapted to pump air and water together, a compressed-air reservoir receiving the compressed air and water, and means for elevating the water therefrom to said reservoir, consisting of a pipe leading thereto from the bottom of said compressed-air reservoir, and a vent from the latter for discharging air therefrom, whereby to lower the pressure therein and thereby cause the superior pressure in the compressed-air reservoir to force the water therefrom up into the elevated water-reservoir.

9. The combination of a gas-producer, a steam-generator heated by the hot gas from the producer, an elevated water-reservoir connected to said steam-generator, a compressed-air reservoir, means for compressing air into said reservoir, means for pumping water therefrom to said water-reservoir, consisting of pipes leading from above and below the water-level in said compressed-air reservoir to a valve, a pipe leading from said valve to said water-reservoir, and a vent from the latter for discharging air therefrom adapted for operation in substantially the manner specified.

10. The combination with gas-producer A, steam-generator F, elevated water-reservoir P, compressor J, and air-reservoir K, of pipe v communicating from the bottom of the latter to the water-reservoir P, pipe u communicating from the bottom of the latter to the steam-generator, vent-pipe w communicating from the top of the reservoir P to the open air, and four-way valve w' applied at the intersection of pipes u and w, and adapted to close either of said pipes while it establishes communication through the other, substantially as set forth.

11. The combination with gas-producer A, steam-generator F, elevated water-reservoir P, compressor J and air-reservoir K, branch pipes v' v^2 leading from said reservoir, a pipe v leading from said branch pipes to the water-reservoir P, a three-way cock x at the junction of said pipes, pipe u communicating from the bottom of the water-reservoir to the steam-generator, vent-pipe w communicating from the top of the water-reservoir to the open air, and a valve applied to the latter pipe, substantially as set forth.

In witness whereof we have hereunto signed our names in the presence of two subscribing witnesses.

MAURICE LOROIS.
FRANCIS G. BATES.

Witnesses to the signature of Maurice Lorois:

C. BERAUESARWOETTZ,
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Witnesses to the signature of Francis G. Bates:

ARTHUR C. FRASER,
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