No. 614,352. **Patented Nov. 15, 1898.**

L. STEVENS.

PROCESS OF AND APPARATUS FOR MANUFACTURING GAS.

(Application filed Dec. 27, 1897.)

(No Model.) 2 Sheets—Sheet I.

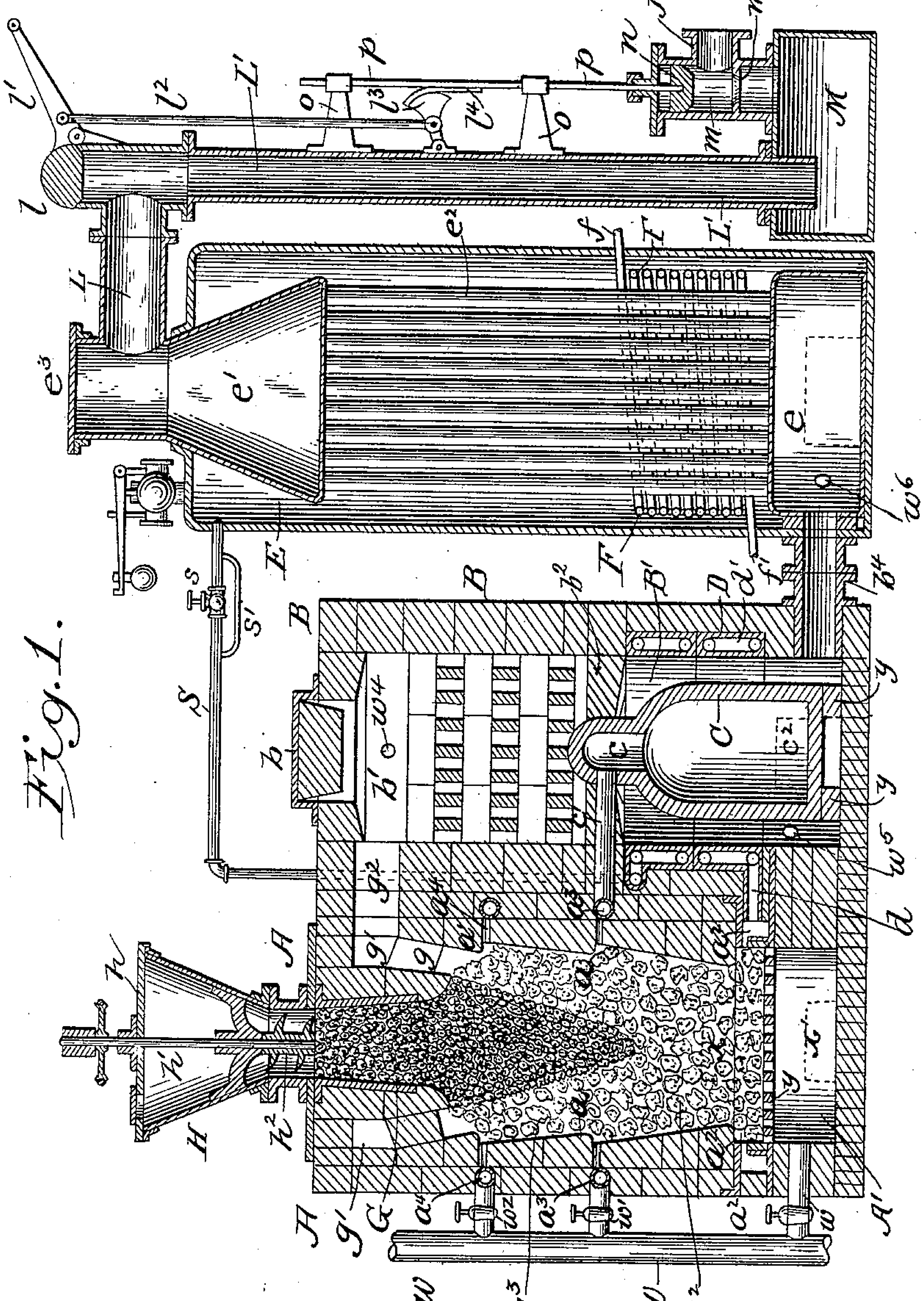

Fig. 1.

WITNESSES

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Fig. 2.

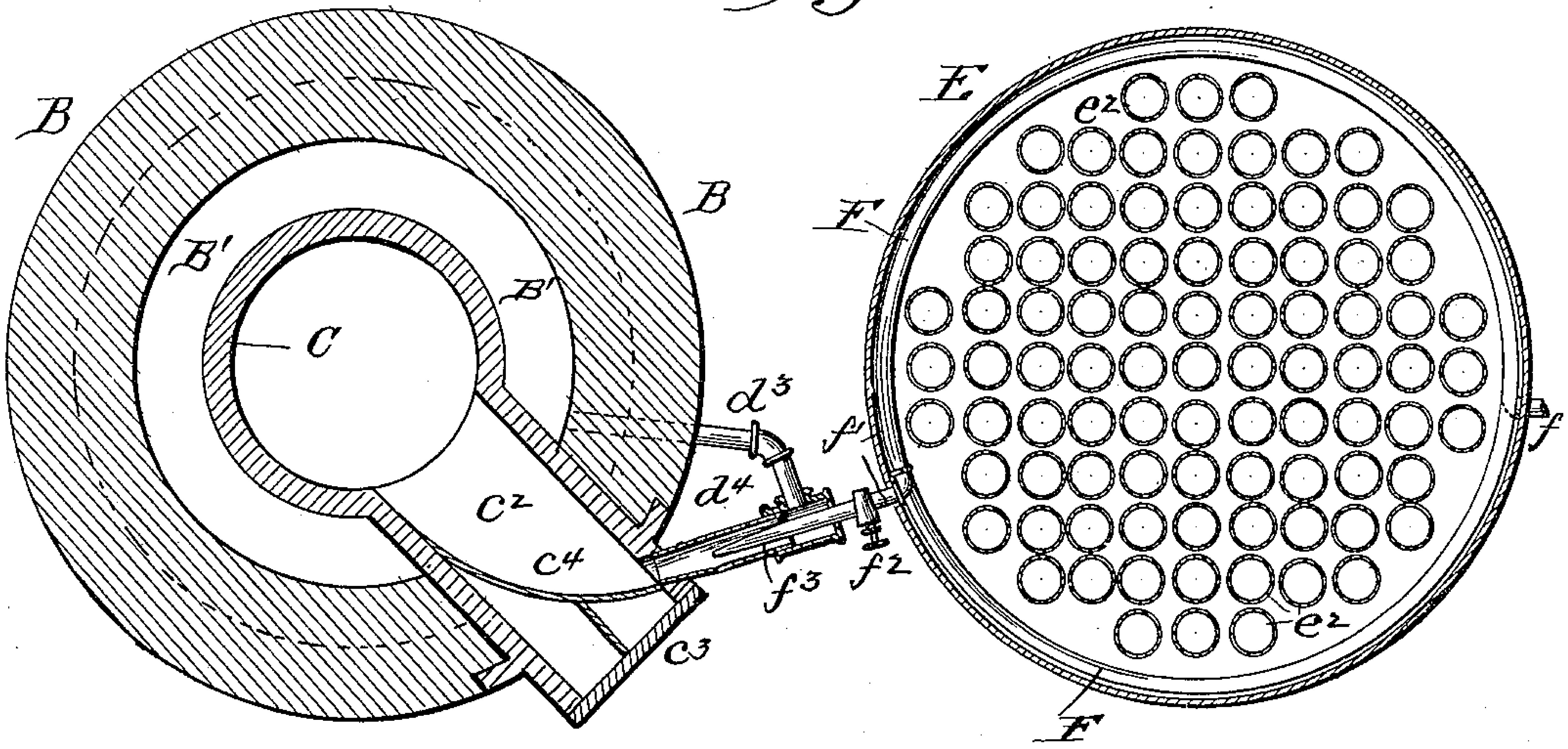
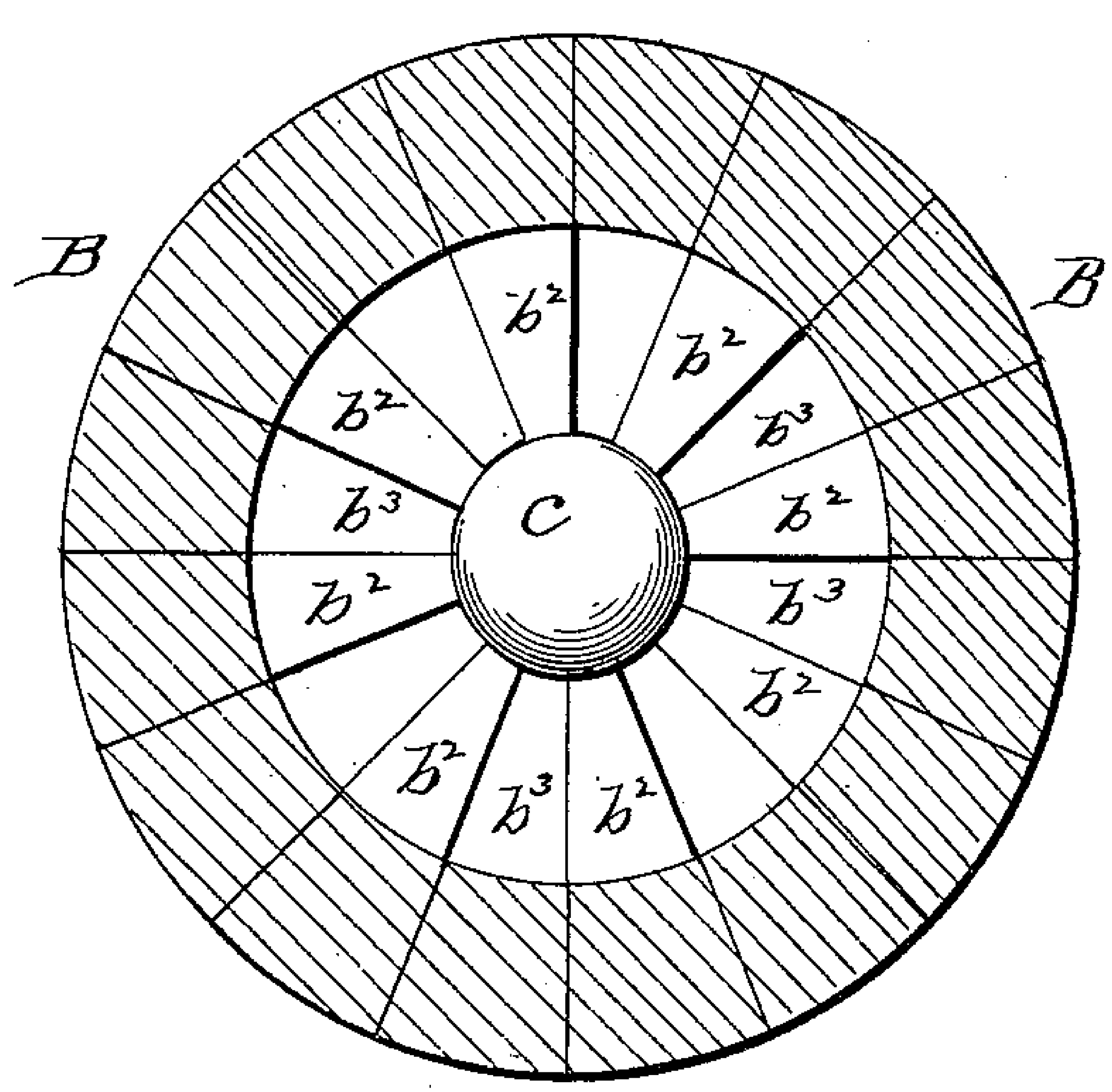


Fig. 3.



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UNITED STATES PATENT OFFICE.

LEVI STEVENS, OF TRENTON, NEW JERSEY.

PROCESS OF AND APPARATUS FOR MANUFACTURING GAS.

SPECIFICATION forming part of Letters Patent No. 614,352, dated November 15, 1898.

Application filed December 27, 1897. Serial No. 663,663. (No model.)

To all whom it may concern:

Be it known that I, LEVI STEVENS, a citizen of the United States, residing at Trenton, in the county of Mercer and State of New Jersey, have invented certain new and useful Improvements in Processes of and Apparatus for Manufacturing Gas; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to the manufacture of illuminating or carbureted water-gas by the use of bituminous coal properly distilled and coked or other solid carbonaceous fuel in conjunction with steam and heavy hydrocarbon oils.

The object of my invention is to provide for more thoroughly and effectively utilizing the waste heat of the hot gaseous products arising in the process for superheating steam, heating and volatilizing hydrocarbon oil, and combining and fixing carbureted gases to produce a well-fixed carbureted gas.

Another object of my invention is to provide for decomposing steam in contact with heated carbonaceous material at a comparatively low temperature, whereby loss of heat and energy are prevented and the formation of tenacious clinker is also prevented.

Another object of my invention is to provide for more evenly and uniformly distributing the heat through the body of fuel and other parts of the generating apparatus without producing an excessively high heat in any portion of the fuel.

Another object of my invention is to provide for effectively volatilizing and retorting the heaviest of hydrocarbon oils, which contain a large percentage of bitumen or heavy tarry matter, and in such operation preventing deposits of lampblack and hard carbon in the passages of the apparatus.

In manufacturing water-gas the oxygen of steam is combined with carbon to form carbon monoxid, (CO.) The energy given up by hydrogen when it combines with oxygen as H_2O must be restored to the hydrogen before it will release the oxygen. The hydrogen liberated in the process of making gas receives its equivalent of heat from the heat stored up in the generator. With steam at one hundred pounds pressure and at 325° Fahrenheit the stored-up heat in the fuel of the generator in the usual process is taxed to heat the steam to a temperature ranging from 1,200° Fahrenheit to 1,600° Fahrenheit before the oxygen of the steam will combine with carbon as CO and release the hydrogen.

The loss of energy in modern water-gas generators is very great in the escape of hot gases while blowing up and in heating the steam by the direct heat of the fuel in the generator to a point at which dissociation is possible. To sustain conditions for producing the desired reactions, the bodies of fuel in the generators must be blown up to a high heat, such as 3,000° Fahrenheit to 3,500° Fahrenheit, which makes a hard tenacious clinker difficult to remove and gives rise to much waste heat and energy.

To overcome the injury and annoyance caused by the high temperatures heretofore used and to economize the heat and energy heretofore lost, I have taken advantage of a well-known principle, which is that as the temperature of steam is raised the affinity of the hydrogen for the oxygen is destroyed in the ratio to the degree of heat to which it is subjected and that the affinity of carbon for the oxygen is increased in the ratio of the temperature to which it is subjected. From these well-established facts it is evident that there is a mean temperature (much lower than the temperature of modern water-gas generators) at which carbon and steam can be heated and brought together, resulting in the oxygen of the steam combining with carbon to form CO and liberation of the hydrogen. In my present invention I utilize the waste heat given off while blowing up the fuel to establish these conditions and in addition volatilize heavy oil and partially retort the resulting gas and vapors for carbureting the water-gas.

An important feature of my invention consists in distributing the heat by consuming the gases made in the lower section of the generator to heat the upper sections. Instead of blowing up and heating from six to twelve feet of coal from the base I divide the generator into sections, blow a moderate blast at the base, which makes what is known as "producer-gas," that passes the second section at a high temperature, where it is met with an air-blast and consumed and heats the next section. At the top of the next section I introduce another blast of air that consumes what combustible gases are formed in second section. In establishing uniform conditions of heat in starting a generator I close the air-valves at top and, if necessary, at the base of the second section and allow the gases to pass to any point in the apparatus, where I introduce air and burn them to equalize the temperature of the various parts at different points. With this method and a suitable arrangement of apparatus and steam at a high temperature I am able to establish and maintain conditions of heat to produce water-gas rapidly and cheaply.

Another feature of my present invention consists in my method of volatilizing and retorting the heaviest of oils, which contain a large amount of bitumen, heavy tar, or carbon, and which will deposit solid carbon in the passages and obstruct them. This I overcome by forcing the oil-vapor into the annular chamber formed by the construction of the generator, where it meets the rising current of water-gas made in the lower section and passes upward through the second section of highly-heated coal or coke, on which the heavy bitumen will be deposited. With this construction of generator and with my improved steam-superheater, as shown, the steam will be delivered into the incandescent carbon at a temperature of from 1,000° to 1,200° Fahrenheit. Under these conditions the sulfur in the coal will take oxygen from the steam and pass as SO_2 in proportion to the sulfur contained in the coal. No trace of sulfur can be found in the gas made by my method in the improved apparatus forming the subject of this application for patent.

In using heavy oils I have found it difficult to locate and protect a heating-coil in connection with any of the parts where it is not liable to be overheated and obstructed with hard carbon. This I have overcome by locating a coil in a boiler or water-heater, through which the gas and hot products of combustion pass. With this arrangement I am able to heat the oil to a uniform temperature of from 300° to 320° Fahrenheit without any possible overheating or carbonization.

Every heat-unit taken up by the steam and oil from the waste heat saves the consumption of carbon in the generator to produce it and facilitates the rapid and economical production of gas. These improved and economical results are made possible by my ability to heat steam to a high temperature and also to heat oil and volatilize it at a high temperature by waste heat before the superheated steam and oil-vapor are admitted to the decomposing-section and to the fixing or retorting section of the generator.

With oil heated to 300° Fahrenheit injected into a close chamber at a temperature of 1,600° Fahrenheit, with steam at 1,000° Fahrenheit, the heaviest oils will be volatilized and no carbon will be deposited in the passages.

The matter constituting my invention will be defined in the claims.

I will now describe the details of construction and operation of my apparatus by reference to the accompanying drawings, in which—

Figure 1 represents a vertical longitudinal section through the generator, superheater, oil-vaporizing retort, steam-superheater, steam-boiler, oil-heating coil, and connecting-pipes. Fig. 2 represents a horizontal section through the superheating-chamber and oil-vaporizing retort and the steam-boiler and showing certain connecting-pipes in top plan view. Fig. 3 represents a horizontal section through the superheating-chamber just above the oil-vaporizing retort, showing the brick arch with passages which divide the superheater into upper and lower chambers.

The principal parts of my generating apparatus, consisting of the generator A, superheater B, oil-retort C, steam-superheater D, steam-boiler E, oil-vaporizing coil F, gas-take-off pipe L L′, and hydraulic seal-box M, are shown in proper operative relation in Fig. 1.

Certain details of construction are shown in Figs. 2 and 3.

The generator A and superheater B are constructed of brick, having a lining of fire-brick or other suitable refractory material, and in practice may be provided with a tight iron jacket. (Not here shown.) These chambers may be constructed together, separated by a partition-wall, as shown, or may be constructed as two distinct chambers, having a passage between them and each inclosed in a separate iron jacket, as desired.

The interior walls of the generator A are inclined inward toward the grate to provide a contracted opening, and at a suitable distance above I construct an offset or inwardly-projecting annular shoulder a to form below it the steam-decomposing chamber A^2. Above the shoulder a I construct a second annular shoulder a', which may be a short distance below the fuel-magazine, as shown, and forming below it the gas fixing or retorting chamber A^3. Any desired number of these annular shoulders and sections may be formed in the generator between the grate and the lower end of the fuel-magazine.

The usual ash-pit A′ is constructed at the base of the generator and is provided with the usual ash-door x' and is separated from the fuel-chamber by the grate y. The generator above the grate is also provided with a door x. In the wall of the generator, at the grate-level, is constructed an annular steam-inlet flue a^2, having a series of ports opening above the grate, as shown. In the wall above and just below the shoulders a a' are constructed the annular channels a^3 a^4, having inlet-ports just below said shoulders, as shown, for admitting air. The channel and ports a^3 are also for admitting a mixture of superheated steam and oil-vapor to be retorted and fixed in the section A^3. The air-blast pipe W connects by a branch and valve w with the ash-pit, by a branch and valve w' with channel a^3, and by branch and valve w^2 with channel a^4 for admitting air at different heights in the different sections of the generator.

The fuel-feeding magazine G may be composed of cast-iron and provided with a jacket of fire-brick and is suspended centrally from the top of the generator. Between the brick jacket of the magazine and the wall of the generator are formed a number of short vertical flues g, connecting with the annular gas-escape flue g', which connects by the outlet-flue g^2 with the top of the superheater B and preferably opening into the combustion-chamber b', as shown.

On top of the generator and in connection with the magazine G, I mount the feed-hopper H, which is provided with a tight-fitting cover h, an operating-rod h', passing through the cover, and a feeding-screw h^2, secured to the lower end of said rod. By means of these devices the fresh fuel is forced centrally down through the magazine and into the body of incandescent coke or other fuel in the generator, the fresh fuel being represented by the dark lumps disposed in V shape in the body of coke or other heated fuel, as shown in Fig. 1.

The superheater B is provided at the top with an opening closed by a lid b and has in the upper part the combustion-chamber b', provided with an air-inlet w^4. It is divided horizontally by an arch composed, preferably, of inwardly-projecting brick b^2, extending from the wall to the dome c and having passages b^3 between them, as shown in Fig. 3. Above this arch or partition I preferably place the brick checker-work, as shown, for absorbing part of the waste heat carried by the outgoing gases and products. The retort-chamber B' is provided below the arch and is constructed with the annular superheaters D in its wall. Two sets of annular superheaters, constructed with connecting-passages d', are preferably used, and the lower superheater connects by a pipe d with the annular supply-channel a^2 at the base of the generator. Steam is supplied from the boiler by a pipe S, having a valve s, to the inlet of the upper superheater, said pipe passing down through the wall shown in Fig. 1.

The oil-vaporizing retort C is supported upon the fire-clay blocks y and is provided with a dome c, which connects by a pipe c' with the annular channel and port a^3. The retort C is also provided near the base with an inlet-passage c^2, extending out through the wall of the superheater and having its outer end closed by a lid c^3, as shown in Fig. 2. A curved plate c^4 is fitted in the passage c^2 and extends from the nozzle of the injector nearly to the retort, as shown, for directing the inflowing steam and vapor to the interior of the retort. A branch pipe d^3 conducts steam from the superheater D to the injector d^2. An oil-inlet pipe f', having a valve f^2, connects by a suitable tapering nozzle f^3 with the interior of the injector.

The steam-boiler E may be of the usual tubular variety and constructed with the smoke or gas chambers e e' at its upper and lower ends and connected by the tubes e^2 in the usual manner. The upper gas-chamber e' projects through the top of the boiler and is closed at the top by a plate a^3.

A gas-pipe b^4 connects the combustion-chamber B' with the chamber e. The chambers B' and e are provided with air-supply openings w^5 and w^6, which are supplied by blast-pipes (Not here shown.)

The oil-heating coil F is preferably placed in the steam-boiler E near its base and is provided with an inlet-pipe f and an outlet-pipe f', which latter has a valve f^2 and nozzle f^3, as above described and as shown in Fig. 2. Oil may be supplied to the coil from an elevated reservoir or by a pump. (Not here shown.)

The steam-outlet pipe S is provided with a valve s and with a small by-pass pipe s'. By means of this by-pass pipe the steam cannot all be shut off from the superheater and oil-vaporizing chamber nor from the base of the generator. The small current of steam thus supplied keeps the oil-vapor passages clear, and by flowing into the generator when blowing up adds materially to the value of gases produced at that time and which are utilized to heat the upper section or sections of the generator and superheater, &c.

To the upwardly-projecting part of the gas-chamber e' there is connected the gas-take-off pipe L, connecting to the vertical pipe L', which has an opening at the top for waste products and which dips at its lower end into the seal-box M. The escape-opening is closed by a tight-fitting lid or stopper l, having a lever-handle l'. An outlet-pipe N connects with the seal-box and is provided with a valve-chamber m and a seat m'. A conical or ball valve n is placed in the chamber m and is provided with an operating-rod p, which works through suitable openings in the guide-brackets o. A link or rod l^2 connects by suitable pins the lever l' with the pivoted lever l^3, having a sector-shaped outer end, to which is attached a strap l^4, which also connects with the operating valve-rod p. By means of these devices it will be seen that when the stopper l is closed upon its seat the valve m will be lifted from its seat m', thus opening the passage from the seal-box to the outlet-pipe N, and when the valve N is closed upon its seat the stopper l will be raised from its seat, thus opening the upper end of pipe L' for the escape of waste products.

Although my process and apparatus are especially designed for using soft or bituminous coal in the manufacture of gas by overcoming numerous difficulties incident to the use of such coal in water-gas generators, I wish it understood that the apparatus is also well adapted for use of other forms of solid carbon, such as coke, anthracite coal, and lignite.

In manufacturing water-gas from bituminous coal I force the fresh coal under pressure, by means of feeding-screw h^2 in hopper H, down into the body of coked and partially-coked heated fuel below, (preventing the formation of fissures,) so as to always provide a compact and uniform body of carbon for securing more thorough and uniform decomposition of steam. It is essential in order to secure the most economical and satisfactory results in the manufacture of water-gas that the steam be perfectly decomposed in the generator, resulting in the oxygen combining with carbon to form CO and liberation of the hydrogen, so that the subsequent operations of carbureting and fixing the gas may be perfectly performed, thereby avoiding loss by condensation of unfixed vapors in the hydraulic main or distributing-mains. By my method of operating I overcome these difficulties, and in order to secure perfect retorting and fixing of the carbureted water-gas I conduct the operation in one of the sections of the generator above the lower section thereof, subjecting jets of mixed superheated steam and oil-vapor to contact with the heated carbon in the presence of the rising currents of water-gas, thereby securing a perfect combination of rich carbureted hydrogen with the carbon monoxid as a fixed illuminating-gas.

The operation may be conducted as follows: A fire is kindled on the grate-bars, and any suitable fuel is gradually fed in and at first allowed to burn by natural draft, the valve l for this purpose being open. The lid b may also at first be opened, if desired. Fuel is gradually supplied until a deep body has been heated to incandescence. At any suitable period an air-blast is admitted to the ash-pit and to the sections above them, urging combustion of the fuel. A suitable body of incandescent carbon having been formed, bituminous coal is fed in, so as to fill the magazine, and is allowed to distil and become coked. When good producer-gas or other combustible gas is given off from the fuel, it may be ignited by an air-blast admitted at w^4 to the top of the superheater or by blast admitted at w^5 or w^6, and thus burned until all parts of the apparatus are heated to the proper temperatures. The air-blast will soon raise the temperature in the generator and steam in the boiler, and when all are at the proper temperature the air-blast is shut off and valve or stopper l is closed. Steam is now admitted through pipe s into the superheater D. In passing through the zigzag passages d' the steam will be heated to a temperature ranging from 1,000° to 1,200° Fahrenheit and is thence delivered through pipe d and the annular channel and ports a^2 into the incandescent carbon, where it is thoroughly decomposed. At any suitable time prior to admission of steam to the superheater heavy oil is passed into the coil F, where it is heated to a temperature of from 300° to 320° Fahrenheit. Then when ready for making gas the valve f^2 on the outlet oil-pipe is opened and the heated oil passed through its nozzle into the injector d^2, into which also is admitted a current of superheated steam through pipe d^3. The jet of oil is thus volatilized by superheated steam and forced into retort C, where the mixture is heated to a temperature of about 1,600° Fahrenheit. Superheated steam having been admitted into the base of the decomposing-section A^2, the highly-heated mixture of steam and oil-vapor is now passed into the annular channels a^3 and through the ports into the retorting and fixing section A^3 of the generator, resulting in the production of rich carbureted hydrogen gas. The rising currents of water-gas combine with such gas, and the whole product passes out through the flues g g' g^2 into the fixing-chamber B, where it is further subjected to contact with the heated surfaces, and thence passes down and around the retort C, imparting their heat thereto, and thence through pipe b^4 into chamber e of the boiler, and thence through the flues of the boiler and off by way of the take-off pipe L L' into the seal-box M, from which it is discharged through pipe N to a washer or purifier and into a holder or to any place of immediate use. The gas-making "run" is continued until the temperature of the fuel is reduced too low to effectively decompose steam, when the main supply of steam is shut off and the flow of oil also shut off by closing valve f^2. A small supply of steam will be continued through the by-pass pipe s', and thence through the heater into the generator. A small supply of steam will also pass through the oil-retort C and thence through its outlet-pipe c' into an upper section of the generator, thereby keeping the retort and its outlet-pipe free from deposits of hard carbon. The gas having been properly exhausted from the generator and boiler, the stopper l is again opened, the valve n closed upon its seat in the gas-take-off pipe, the air-blasts are again admitted to the generator and superheater as required, and the apparatus can be properly heated for manufacturing gas. Since the oil is first heated to 300° Fahrenheit and then injected by means of steam at about 1,000° Fahrenheit into a close chamber at a temperature of approximately 1,600° Fahrenheit, the heaviest oils will be volatilized without depositing carbon in any of the passages. The preliminary heating of the oil, as above described, is important in preventing the excessive and wasteful use of steam for properly volatilizing the oil. If the oil were not preheated to about

300° Fahrenheit, it would rapidly abstract heat from the steam and reduce the temperature too low for the oxygen of the steam to attack the carbon until the temperature of the steam or of the mixture of steam and oil-vapor was again raised. The volume of steam at 1,000° Fahrenheit required to properly heat and volatilize oil (which had not been preheated) would be in excess of the volume required in proportion to the illuminants in the oil. The hydrocarbon or illuminants would be injuriously diluted. It is very desirable to reduce the volume of steam at the injector and in the retorting-chamber to the lowest possible quantity which will exert the necessary mechanical force and supply the desired equivalent of oxygen. This I accomplish by the preliminary heating of the oil, as above described. Furthermore, the mixture of highly-heated steam and oil-vapor is passed directly from the retort C into the combining and fixing section A^3 of the generator, where if there is any deposit of carbon which may be in excess in the vapor it will be deposited upon the heated fuel, and thus absolutely avoid the clogging of any passages by lampblack or hard carbon. Any carbon which may be thus deposited on the fuel is subsequently utilized by being burned for heating up the fuel or is combined with the oxygen of the steam. The apparatus having been reheated, the valves are properly adjusted and the gas-making operation repeated, as above described.

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

1. The process of manufacturing gas which consists in heating heavy oil to a temperature approximating 300° Fahrenheit, then injecting it by highly-superheated steam into a retort, and therein heating the mixture to a high temperature, but below that at which the oil-vapor would be destructively decomposed, and then passing the volatilized oil-vapor and superheated steam into a body of incandescent fuel for converting them into fixed carbureted hydrogen gas, whereby the deposits of heavier hydrocarbon oils may be utilized in making gas, and the deposit of carbon in the passages is avoided.

2. The process of manufacturing gas which consists in heating a body of fuel to incandescence, superheating steam to a high temperature, decomposing it in contact with said fuel, heating oil to a temperature of about 300° Fahrenheit, injecting such heated oil by steam at a temperature of about 1,000° Fahrenheit, into a heated chamber, and passing the resulting mixture—vapor and steam—into said body of incandescent fuel, above the point where the steam alone is first admitted, whereby the rising current of water-gas will combine with the carbureted hydrogen gas made in the upper section of the body of fuel, resulting in the production of carbureted water-gas.

3. In apparatus for manufacturing gas, the generator constructed with one or more annular shoulders or offsets in its walls, at a suitable distance above the grate, to form a steam-decomposing section and a retorting-section above the same, and having an annular channel and ports in the wall below said shoulder, in combination with an air-blast pipe connecting with said channel and port, an oil-retort and an outlet-pipe leading therefrom into said channel, and pipes for supplying air and steam at the base of the generator, and a gas-take-off pipe leading from the top thereof, substantially as described.

4. In apparatus for manufacturing gas, the generator having a steam-decomposing section and an oil-gas-retorting section above the same, in combination with an oil-retort within a heated chamber, a pipe connecting it with said retorting-section of the generator, an oil-heating coil located in a steam-boiler, a pipe and an injector connecting said coil with said oil-retort, and suitable air and steam supply pipes and a gas-take-off pipe, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

LEVI STEVENS.

Witnesses:

WILLIAM HANCOCK,
CHAS. L. PATTERSON.