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O. LANGBERG.

APPARATUS FOR GENERATING GAS.

No. 488,208. Patented Dec. 20, 1892.

Fig 1.

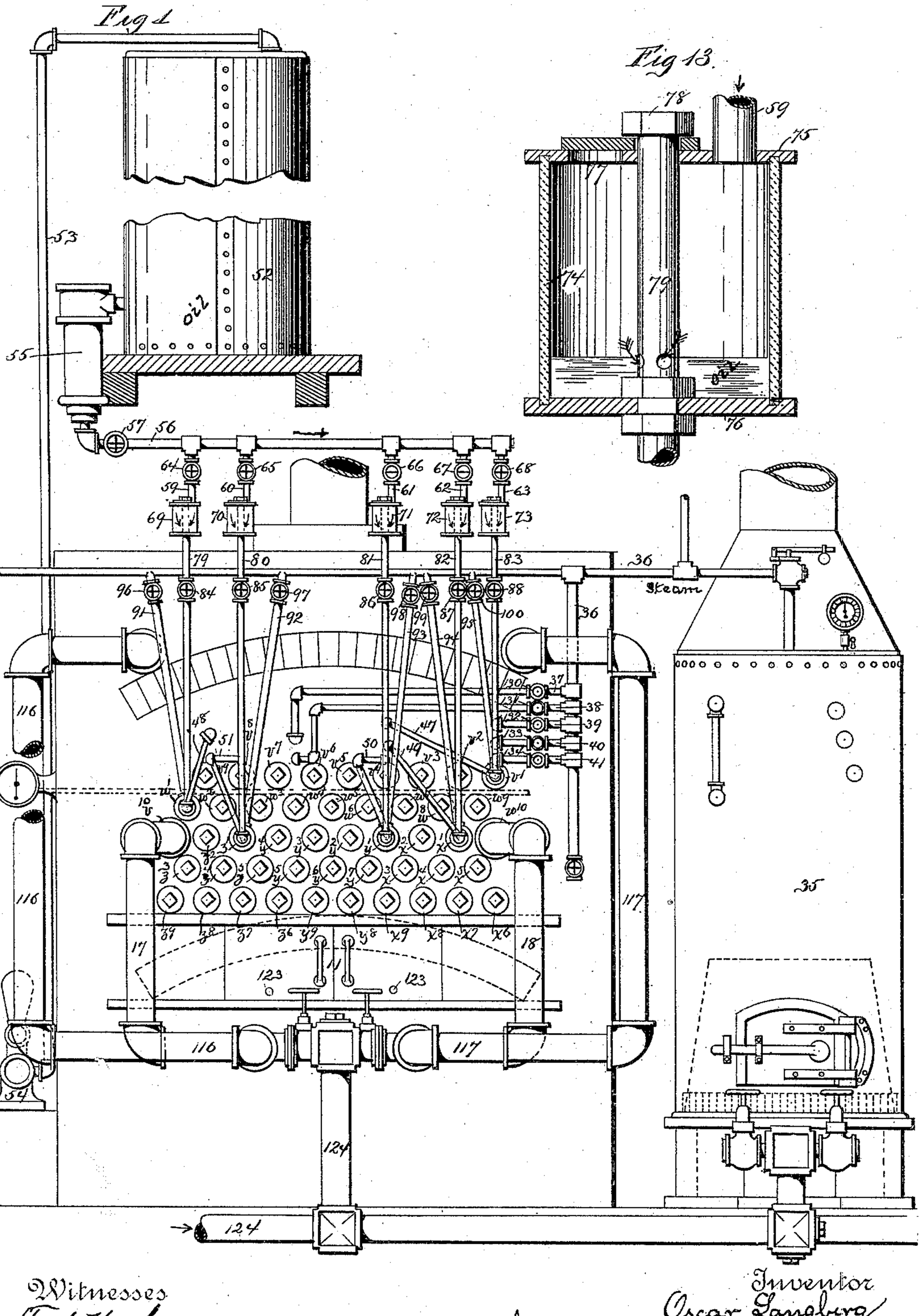

Fig 13.

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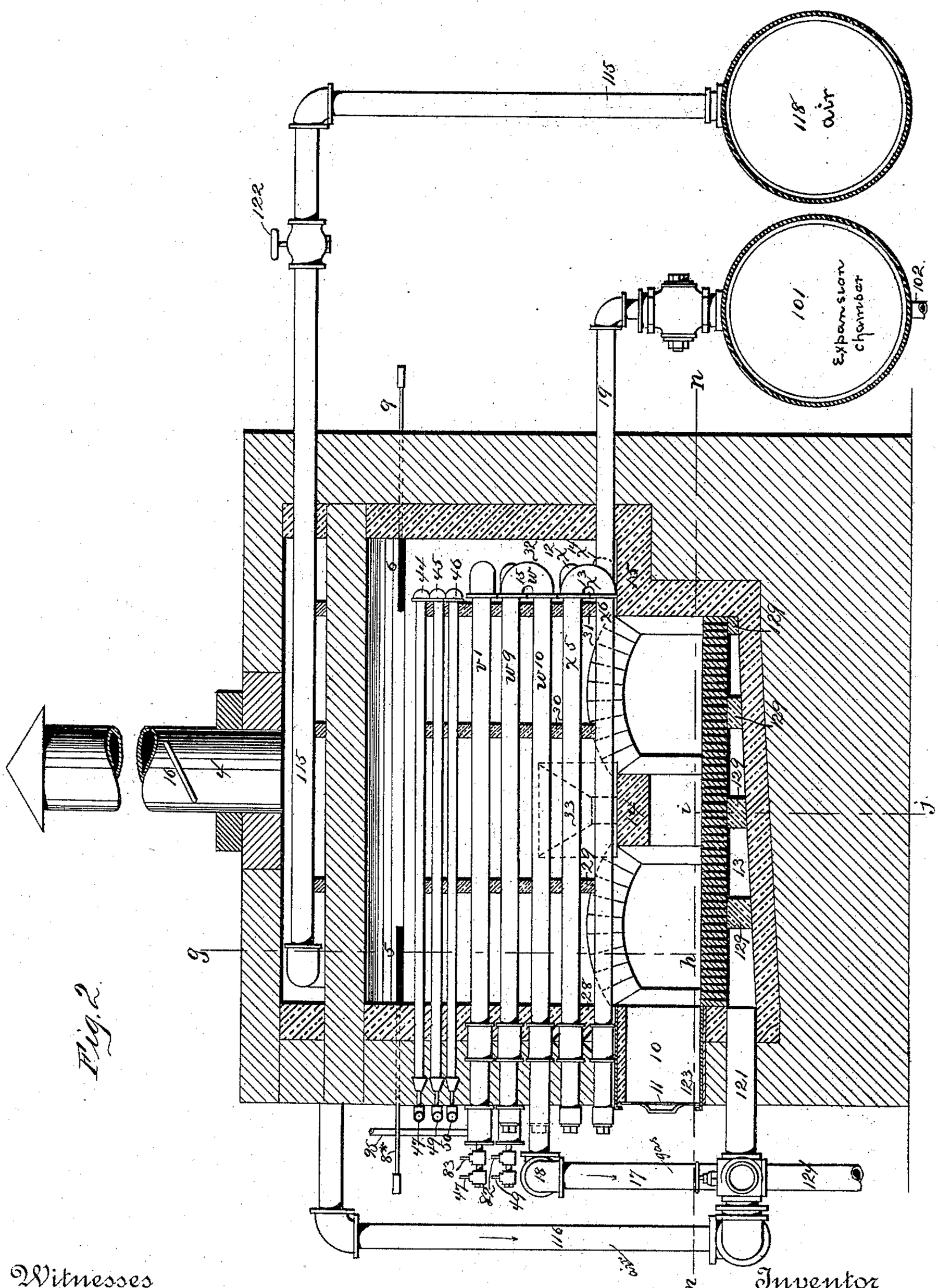

Fig. 2.

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Fig 3.

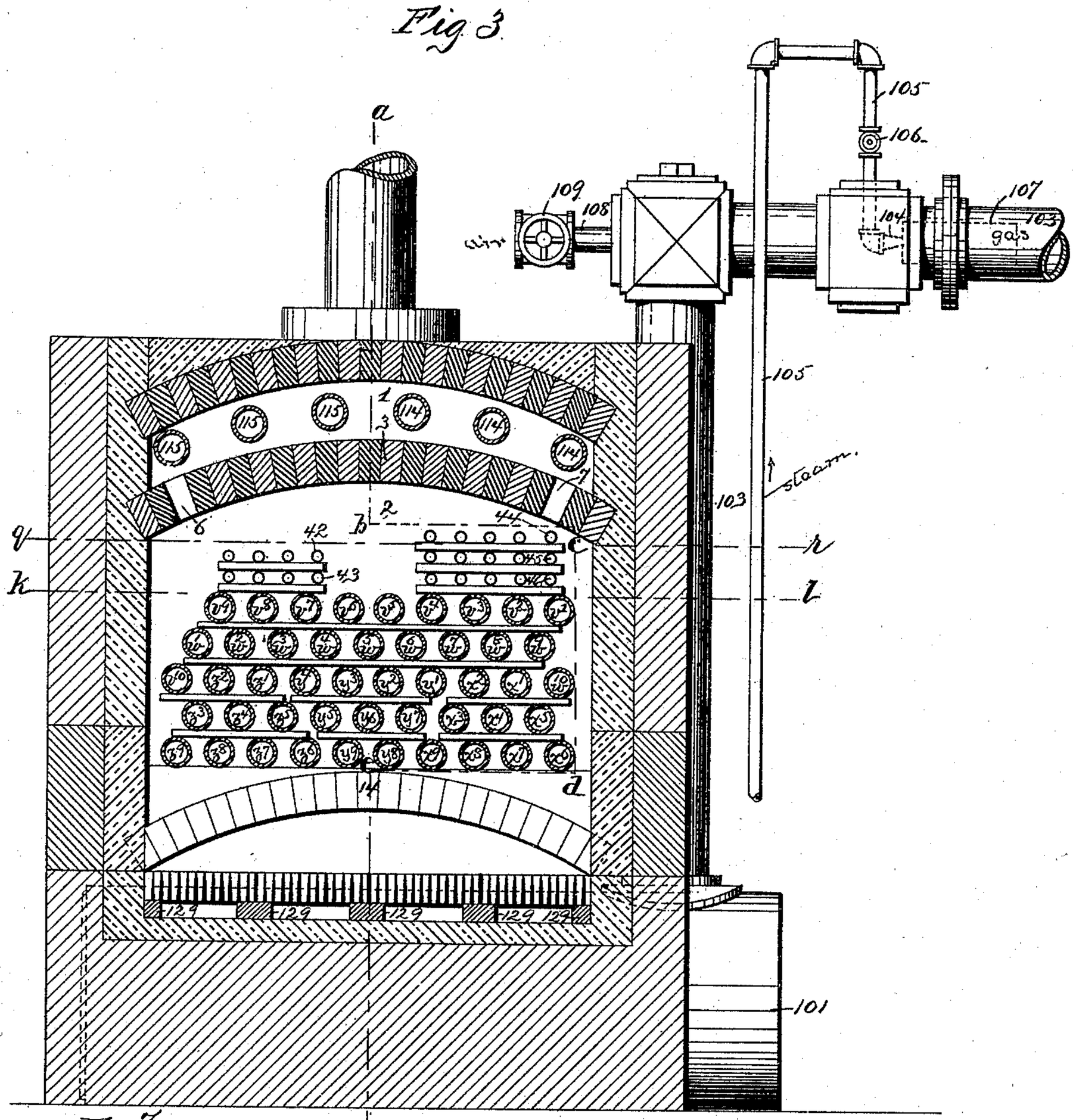


Fig. 7.

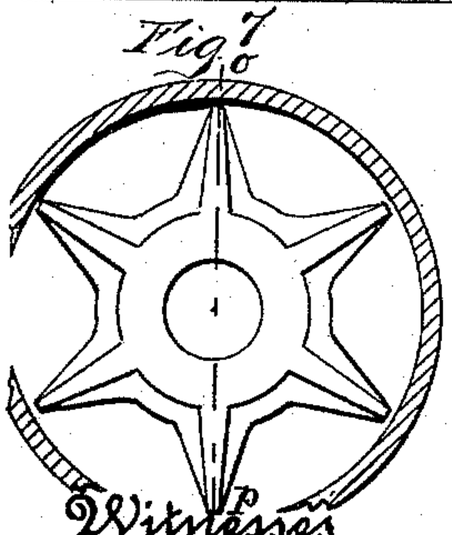
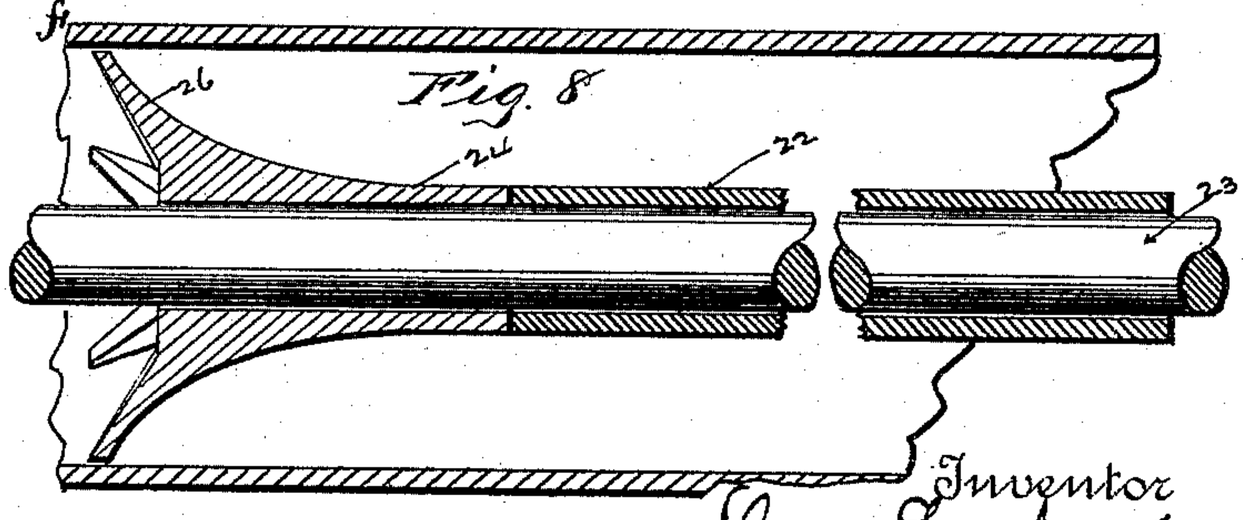


Fig. 8.



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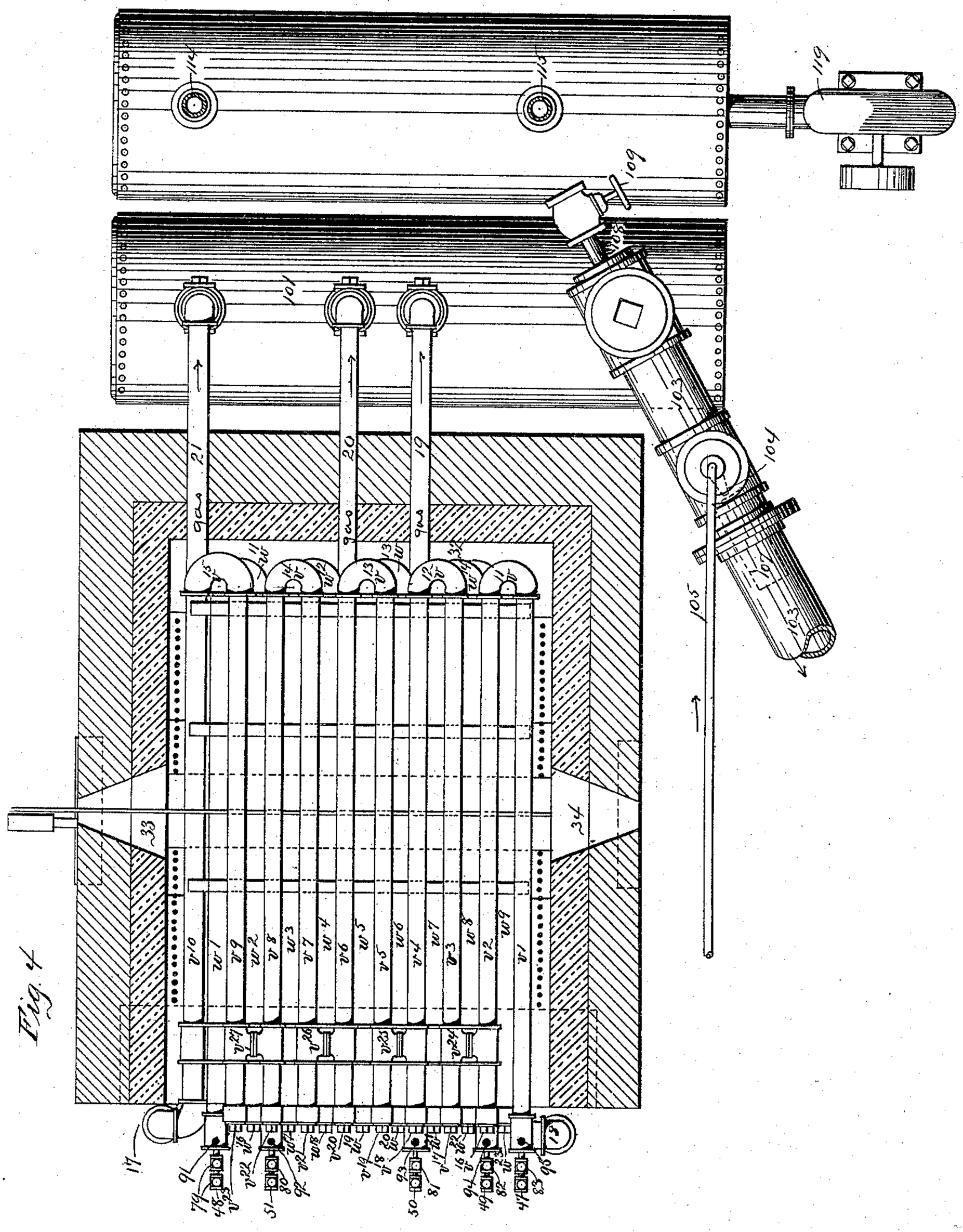

Fig. 4.

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APPARATUS FOR GENERATING GAS.

No. 488,208. Patented Dec. 20, 1892.

Fig. 5

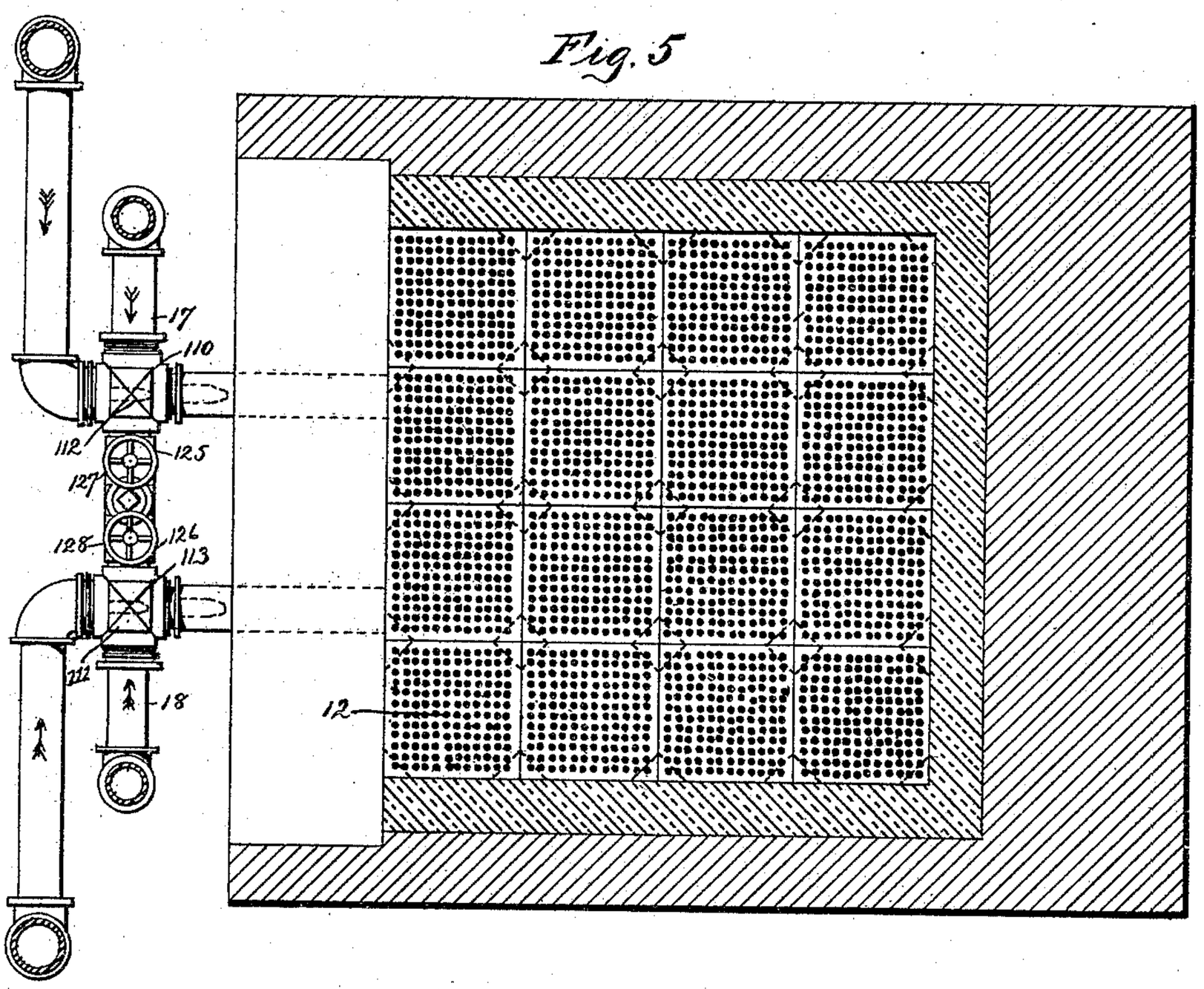
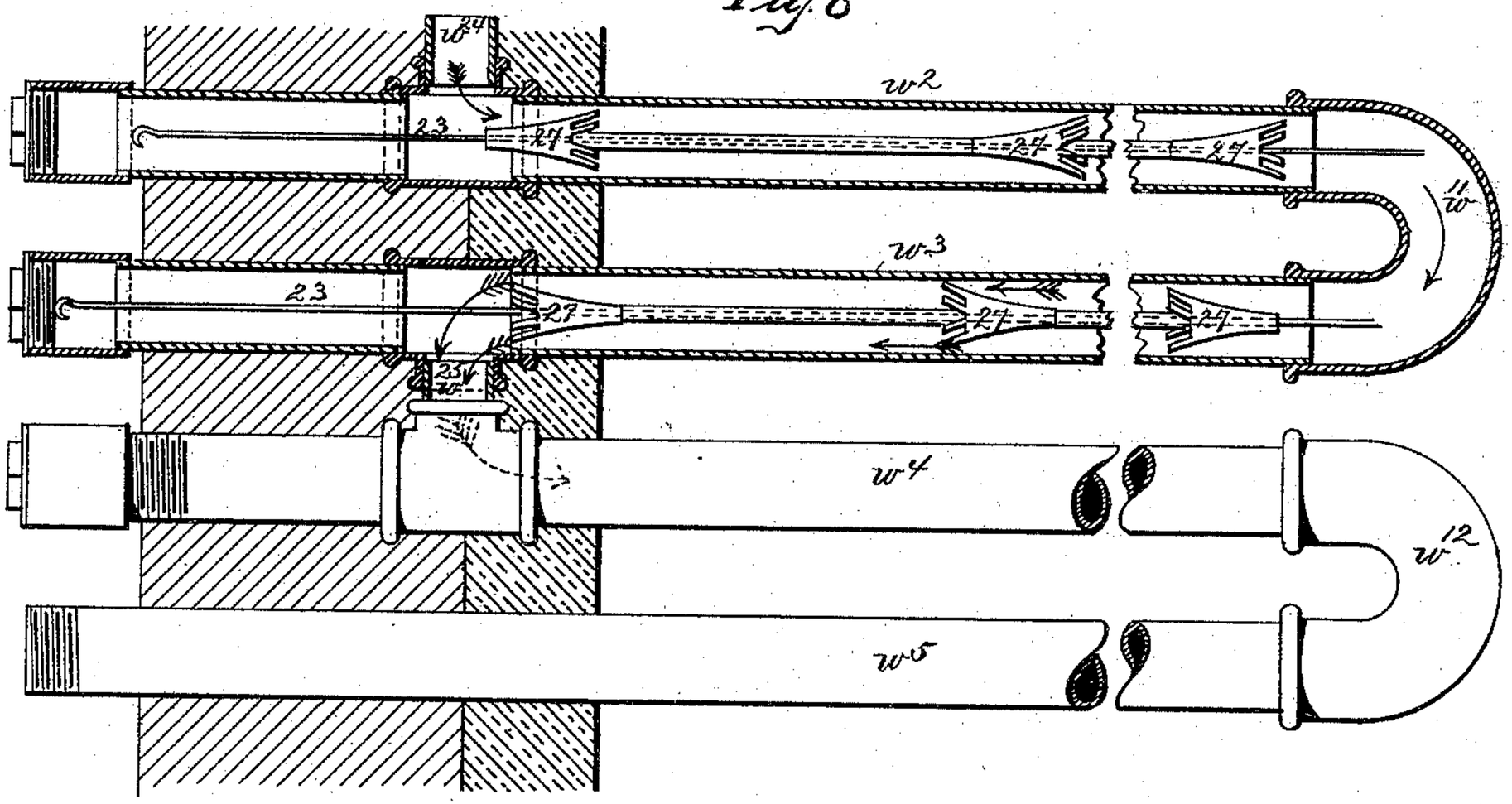


Fig. 6



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No. 488,208. Patented Dec. 20, 1892.

Fig. 9.

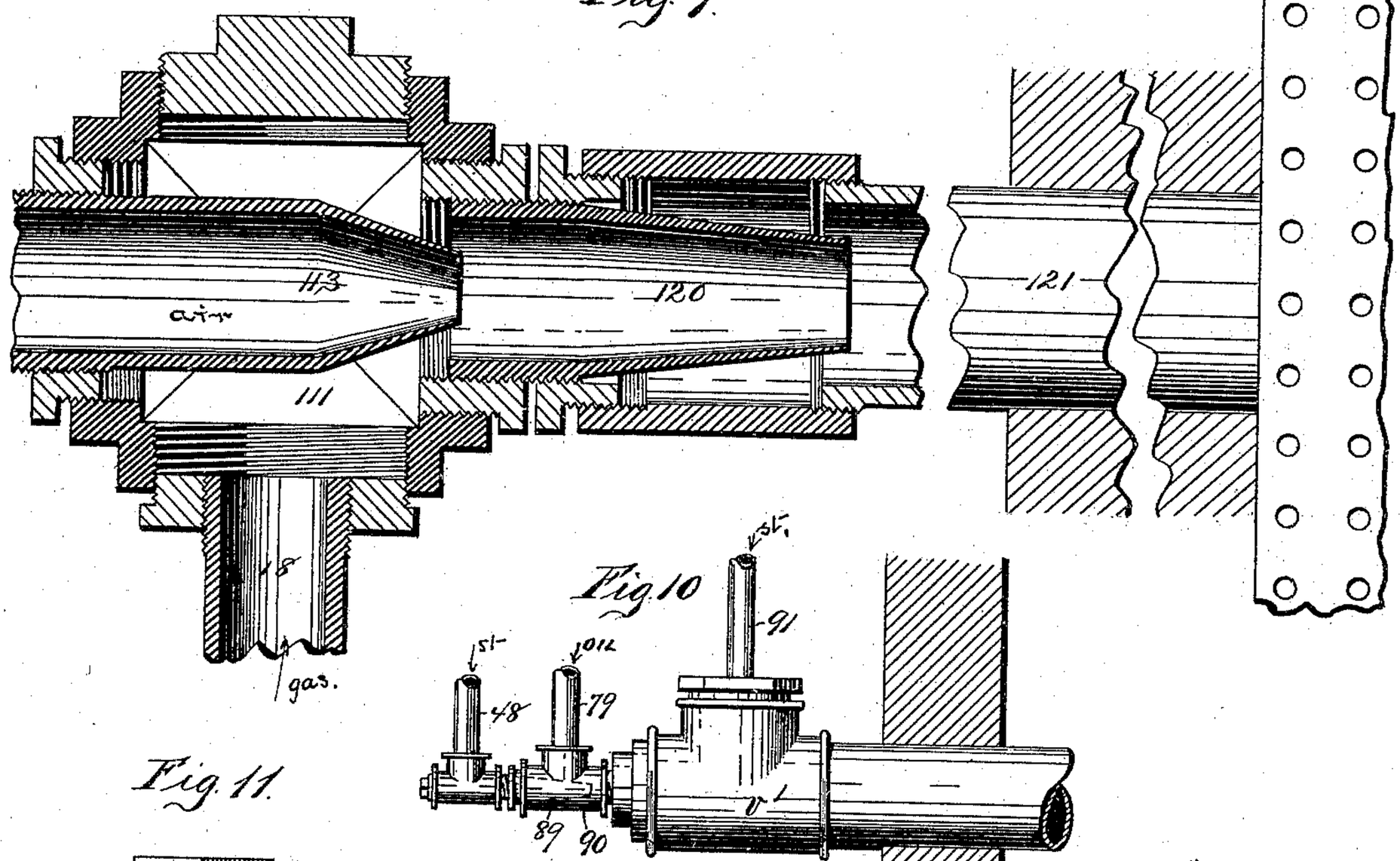

Fig. 10.

Fig. 11.

Witnesses
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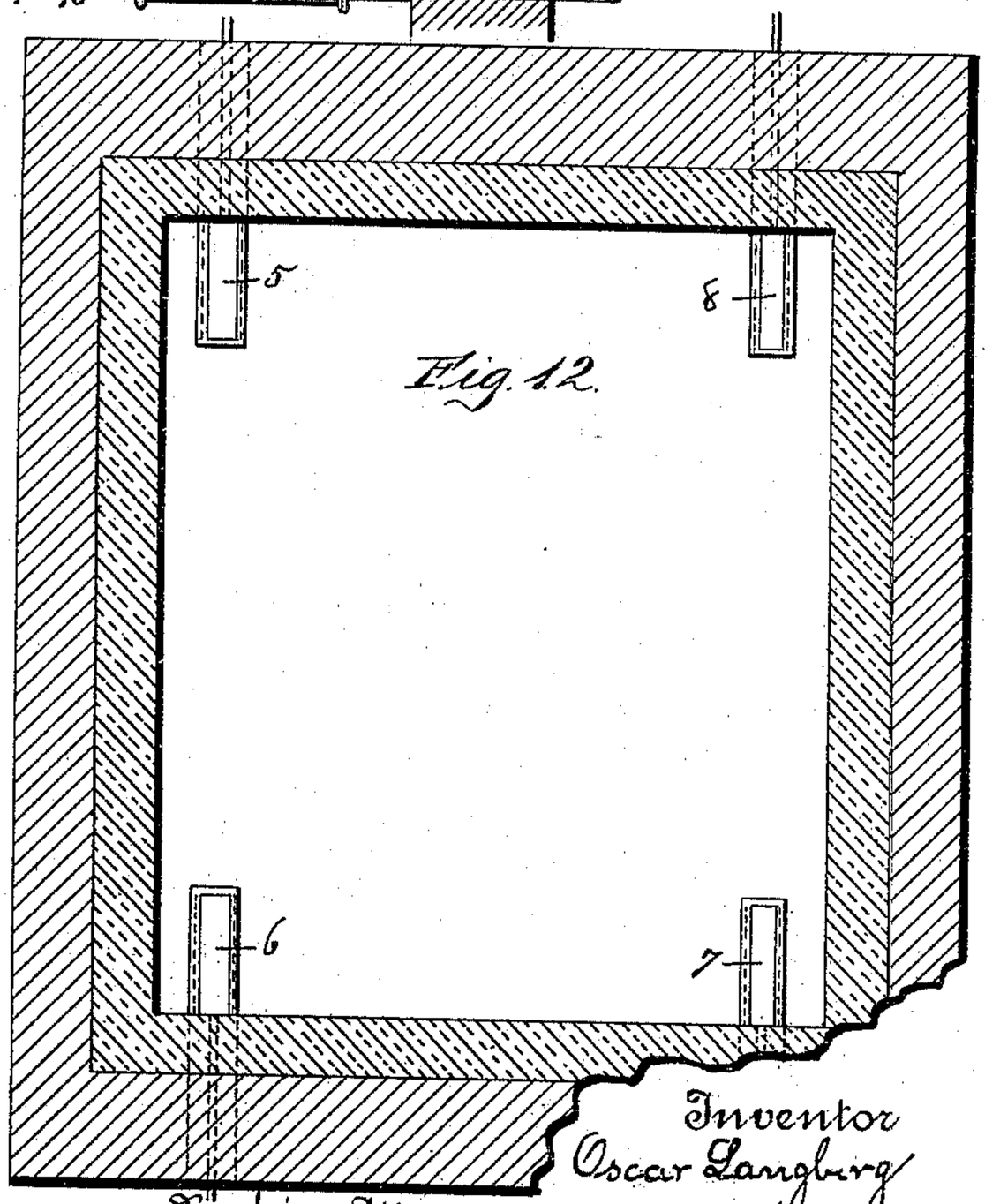
V. T. Wilson.

Fig. 12.



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UNITED STATES PATENT OFFICE.

OSCAR LANGBERG, OF BROOKLYN, NEW YORK, ASSIGNOR TO THE AMERICAN LIGHT AND FUEL COMPANY, OF NEW JERSEY.

APPARATUS FOR GENERATING GAS.

SPECIFICATION forming part of Letters Patent No. 488,208, dated December 20, 1892.

Application filed October 29, 1890. Serial No. 369,685. (No model.)

To all whom it may concern:

Be it known that I, OSCAR LANGBERG, of Brooklyn, county of Kings, and State of New York, have invented a new and useful Improvement in Apparatus for Generating Gas for Illuminating and Fuel Purposes, of which the following is a specification.

In the English patent to T. S. Lindsay No. 6938 of 1885, is described the general system of apparatus to which my improvements relate. This system embodies a furnace across which extend lengths of pipe connected on the outside of the walls of the furnace at alternate ends; the several lengths being provided with series of deflectors and flanges and the combined lengths forming a retort provided at one end with an injector whereby oil spray is injected by superheated steam, and at the other end with an exit passage leading through a main to the gas holder.

The object of my improvements is to make the apparatus above referred to, continuously operative on a commercial scale; for while the apparatus above referred to could produce a fixed gas, the difficulty lay in continuing such production for more than a brief period owing to the tendency of the constituents of the gas to clog either with tarry matter under certain conditions or with carbonized matter under others.

My improvements are therefore particularly directed to the prevention of the stoppage of the process by clogging. This object involves the combination of improvements in three principal directions neither of which can be omitted without impairing the success of the other. First. The current passing through the retort must be impelled and handled properly. Second. The heat applied to the exterior of the retort must be properly regulated. Third. Ready means must be provided for detection of the commencement of any obstruction and the rapid removal of the same.

For the purpose of properly handling the current passing through the retort, I employ a new form of deflectors which, while forcing the current into contact with the sides of the retort, opposes to the flow of the current no surfaces in such position as to baffle and which being a solid cone tends to exclude the formation of an eddy within as if it were hollow. The current of oil vapor is pushed forward at the commencement of the retort and the gas is exhausted at its exit from the retort to such a perfectly regular extent that as soon as gassification is complete the gas is removed from the retorts before caking has a chance to set in.

In order to provide for the uniform heating of the current without which the proper handling of it would not avail, the lengths of pipe contained in the retort and the connections between the same are included wholly within the furnace, the heat is supplied by the combustion of gaseous fuel above a perforated hearth forced into a fuel chamber beneath the hearth and consisting of gas injected by a forced current of air. The gas for the fuel chamber is taken from a gas retort similar to that already referred to so that there are two means of regulating the temperature, either by varying the current of air, in which case the volume admitted into the fuel chamber is varied, or by varying the quantity of oil supplied to the retort in which case the volume of fuel within the fuel chamber remains substantially constant but is varied in richness. The outlets from the combustion chamber are controlled by dampers the regulation of which enables the heat to be properly diffused.

In order to provide for the ready removal of any obstruction, a live steam pipe is connected with the inlet end of the retort from which live steam can flow through the retort from end to end sufficient to remove any obstruction that has deposited. Each length of pipe of the retort is connected with a nipple extending out through the wall of the furnace; and a rod connecting with the deflectors enables them to be pulled out through this nipple for the purposes of removing any obstruction that may have become carbonized. Provision is also made whereby the attendant may detect the commencement of the formation of an obstruction enabling him to provide the proper remedy before too late.

The materials with which I work are oil or liquid hydro-carbon and steam, with air to aid combustion. The oil, may, be any of the mineral oils; but in the following description

it should be understood that I refer in particular to the oil which is at present known in market as gas oil and which is a distillate of mineral oils.

I will first describe the process, and subsequently the apparatus which I employ in carrying out the process.

The process starts by superheating the steam which, being done in the same heating chamber in which the retorts are located, raises the superheated steam to a temperature corresponding with that of the retorts and consequently to the temperature under which the chemical transformations productive of gas are performed. A jet of this steam is used to inject the oil into the retort and for combining therewith to form the gas. The steam performing this operation may be under pressure of forty pounds to the square inch and the supply relatively to the supply of oil may be that passing from a one-eighth inch nozzle to an amount of oil passing through a one eighth inch pipe by gravity; *i. e.* without substantial pressure. The mingled superheated steam and oil vapor pass through the retort encountering, first, an open passage free from obstructions heated substantially to the same heat at which the chemical transformations productive of the gas are performed. Next the current is displaced from the center of the retort and compelled to travel through a narrow annular space next the walls of the retort, being frequently deflected outward against the walls of the retort. Next the current preferably traverses a portion of the retort heated to the same temperatue, open and comparatively free from obstructions. The retort is heated to substantially the orange red heat of wrought iron, and since this heat must be uniform for the accomplishment of the results, the means by which it is produced enter into combination with the other features of the process. A very high and regular temperature should be produced in the heating chamber surrounding the retorts, and to that end a portion of the gas produced in the retorts is conducted to a point adjacent to a mixing chamber below the heating or combustion chamber, into which mixing chamber it is injected by a forced jet of air which may be previously heated. The mixture of air and gas ascends from the mixing chamber through a perforated, non-conducting hearth and is ignited in the heating or combustion chamber above the hearth being so constructed as to prevent the descent of the combustion into the mixing chamber. A plurality of regulated openings remote from each other are provided for the escape of the products of combustion from the heating chamber, and devices are provided for regulating the supply of air and gas respectively to the mixing chamber, to the end that by regulating the escape openings for the products of combustion and the supply of air and gas respectively, the operator can command at all times perfect uniformity in the temperature of the retorts. The current passing through the retort is therefore subjected to a uniform temperature of the degree required for the transformation of the mingled superheated steam and oil vapors into a fixed gas without the disabling deposit of either tarry matter or carbon. Having reached the exit of the retort the now fixed gas to be used for illumination immediately enters an expansion chamber which forms a feature in the process, not only in lessening the obstruction to the escape of the gas from the individual retort, but also in the function of equalizing the conditions prevailing within all the retorts in case more than one are employed in the same heating chamber emptying into the common expansion chamber. This equalization is further aided by taking the steam with which the process starts for all of the retorts from a common source of supply. As the gas leaves the expansion chamber, through a pipe the diameter of which exceeds that of the retorts combined it is exhausted therefrom and forced with a sufficient dilution, to the condenser whence it passes to the gas-holder. The fixed gas to be used for fuel goes from the exit of the retort back through the heating chamber and is immediately injected at a very high temperature into the mixing chamber as before alluded to.

Having outlined the process, I will now describe more particularly the apparatus employed, referring to the accompanying drawings in which

Figure 1 is a front view of the generator furnace and certain connected mechanisms. Fig. 2 is a longitudinal vertical section taken through the line *a*, *b*, *c*, *d*, *e*, *f*, of Fig. 3. Fig. 3 is a transverse vertical section taken through the line *g*, *h*, *i*, *j* of Fig. 2. Fig. 4 is a horizontal section through the line *k l* of Fig. 3, showing the delivery apparatus from the expansion drum unsectioned. Fig. 5 is a horizontal section through the line *m n*, Fig. 2. Fig. 6 is a plan view of four pipes of a retort, two of which are in section. Fig. 7 is a section of one of the retort pipes showing inside thereof an end view of one of the deflectors drawn to a scale for perfect accuracy. Fig. 8 is a longitudinal section through the line *o p* of Fig. 7 showing to a scale the deflector and the core piece interposed between it and the next deflector in the series. Fig. 9 is a detail of the device for injecting the fuel into the mixing chamber. Fig. 10 is a detail of the injector at the inlet of the retort, and the connecting pipe for supplying steam thereto. Fig. 11 is a detail of the oil strainer. Fig. 12 is an inverted plan view on the line *q r*, Fig. 3, showing the roof of the combustion chamber and the outlet flues therefrom.

The furnace within which the generator is located contains the compartments 1 and 2 separated from each other by the arch 3. The compartment 1 is connected with the chimney 4 supplied with a damper 16. The compartments 1 and 2 communicate with each

other by the four openings or flues 5, 6, 7, 8, one of which is located near each upper corner of the compartment 2. These flues are each provided with a slide by which each can be partially or wholly closed independently of the others by rods extending to the outside as 8*, 9.

10 is a manhole leading into the compartment 2 which is closed by the doors 11. The bottom of compartment 2 is composed of a perforated hearth 12 which will be more particularly described hereinafter and beneath this perforated hearth is the mixing chamber 13. Within the compartment 2 which constitutes the combustion chamber, is placed an arch 14 for supporting the retorts at their middle portions.

15 is a bench at the rear of the combustion chamber for supporting the rear ends of the retorts.

The combustion chamber 2 contains the retorts and the superheating steam pipes.

The compartment 1 contains the air pipes through which the air is led for heating purposes on its way to the mixing chamber.

Each retort consists of several lengths of pipe connected together at their rear ends by return bends and extending out through the front wall of the furnace where they are provided with plugs. A number of these retorts are contained in the combustion chamber. In the drawings, five retorts are shown which I will designate respectively by the letters *v w x y z*, the several parts of each one being designated on the drawings by its appropriate letter with a numeral. The sprays of oil and superheated steam enter the retort at the front end of the horizontal pipe v' and pass successively through the pipes v' to v^{10} inclusive, being carried back and forth between the front and rear walls in the combustion chamber. At the rear the connection is made between the pipes by the return bends v^{11} to v^{15} inclusive. At the forward ends the pipes extend out through the front wall of the furnace and are closed by the removable screw plugs v^{16} to v^{23} inclusive. The passages v^{24} to v^{27} inclusive serve to connect every other two of the pipes at a point just within the front wall of the combustion chamber, so as to leave a portion or nipple of each pipe extending forward of the connecting passages and through the front wall of the combustion chamber. The pipe v^{10} empties into the larger pipe 17 which conducts the gas produced to the mixing chamber for fuel. The sprays of oil and superheated steam enter the retort at the front end of horizontal pipe w' and pass successively through the pipes w' to w^{10} inclusive being carried back and forth between the front and rear walls in the combustion chamber. At the rear, the connection is made between the pipes by the return bends w^{11} to w^{15} inclusive. The arrangement at the forward ends is similar to that already described for the retort, the plugs being designated w^{16} to w^{23} inclusive and the connecting passages not being visible on the drawings. The pipe w^{10} empties into the larger pipe 18 which conducts the gas from the retort to the mixing chamber for fuel. The retorts v' w' are made with ten lengths of pipe each; being used to supply fuel for the combustion chamber. It is desirable that the gas should be delivered from them at the front of the furnace. The remaining retorts being used for supplying gas to the gas-holder contain only nine lengths of pipe each; it being convenient to have them deliver their gas to the expansion chamber at the rear of the furnace. The sprays of oil and superheated steam enter the retort at the front end of the pipe x' and pass thence back and forth from front to rear of the combustion chamber successively through the pipes x' to x^9 inclusive, by which latter pipe the gas is delivered to the pipe 19 leading to the expansion chamber. The sprays of oil and superheated steam enter the retort at the front end of the pipe y' and proceed successively through the pipes y' to y^9 inclusive and are thence delivered to the pipe 20 leading to the expansion chamber. The sprays of oil and superheated steam enter the retort z'' at the front end of pipe z' and proceed successively through the pipes z' to z^9 and are thence delivered to the pipe 21 leading to the expansion chamber.

The construction of each of the retorts x' y' z', excepting the relative position of the pipes, is substantially the same as the retort v' and therefore need not be further described.

The relative arrangement of the several retorts and the pipes of each, which I have shown is convenient, but not strictly essential.

In passing through the retort x from one end of the furnace to the other, the sprays vapors or gas traverse a distance of about five feet in length, and the internal diameter of the pipe being about one and seven-eighths inches and the temperature of the retort being maintained at a heat equivalent to an orange red heat for wrought iron, the vapors will be converted into a fixed gas providing the current is properly disposed during its passage. In this connection the greatest difficulty is encountered in preventing the deposit of either tarry matter or carbon and at the same time producing a properly fixed gas; and since I believe the proportions of the retort and the disposition of the current in passing through it to be largely essential to the successful working of my process, I describe the same with great accuracy. Immediately after entering the retort, the current should pass through an unobstructed passage until it is raised to a temperature approaching that of conversion. Therefore, the first pipe of each retort (v' w' x' y' and z') contains no obstruction. However, after the current reaches a certain stage of temperature (about as when it reaches the end of the first pipe) it is essential that it should be otherwise disposed in its succeeding course, and all parts of it must

be crowded against the red hot sides of the retort but always without abrupt opposition to its passage such as would be productive of a riffle in the current. I therefore employ a core piece in the pipes (excepting the first and last) of each retort, which core piece serves to displace the gas from the center of the pipe and crowd it out in the form of a cylinder against the walls of the retort. And I further accomplish the same object by locating at frequent distances along the core pieces, deflectors which spring with an easy curvature from the surface of the core piece and incline with the direction of the current and toward the walls of the retort so that while the current is thereby deflected from the center, its motion is not abruptly arrested.

In Figs. 7 and 8 I have shown one deflector and so much of the core piece as separates it from the next deflector in the series, drawn to a scale, as employed in a retort pipe of one and seven-eighths inches internal diameter. The core piece 22 is simply a piece of pipe which, together with the deflector 27 are strung onto a central rod 23. At its smallest diameter 24, the deflector 27 corresponds with the core piece from which point it curves forward in the direction of the current indicated by the arrow and outward to within about three-eighths of an inch of the interior of the retort pipe, leaving an annular opening 25 between its periphery and the interior of the retort pipe. From this periphery and forming a continuation of the curvature of the deflector spring the fingers 26 until at their points they nearly touch (allowing for expansion) against the walls of the retort pipe and thereby act as centering devices for the deflector and core piece. Each of these fingers at its base is about one-fourth of an inch wide and tapers to nearly a point and I have found that as many as six of them may be employed without inconvenience. I employ six of these deflectors in each pipe of the retort excepting the first and last; those in the pipes adjacent to each other being inversely arranged as shown in Fig. 6 so that the inclination is always in the direction in which the current flows. In order that they may be readily inserted and removed from the pipe the rod 23 upon which they are strung is extended forward until accessible by the removal of the plug from the end of the pipe as shown in Fig. 6. The last pipe of each retort *x*, *y*, *z* and the last two pipes of each retort *v* *w*, I prefer to use without any deflector or core piece so as to give the gas an unobstructed exit way.

The lower row of pipes of the three lower retorts are supported on the arch 14 at their middle and at the back rest on the bench 15 and on top of this row for the support of the row of pipes above are placed cross pieces 28, 29, 30 and 31. Corresponding pieces are placed on top of each successive row of pipes for the support of the row above. The combustion chamber is built so as to leave a space 32 between the back ends of all the retorts and the wall of the combustion chamber so that all of the retorts may expand and contract without disturbing the walls of the combustion chamber. Peep-holes 33, 34 provided with shutters, are let through the side walls of the combustion chamber to enable the operator to determine by their color the temperature of the retort pipes at all parts of the combustion chamber.

I will now describe the structures for supplying the materials to the retort.

35 is a boiler of ordinary construction (but which may be heated if desired by gas) for supplying live steam for all parts of the process.

36 is a pipe conveying steam to each of the pipes 37, 38, 39, 40 and 41 leading to as many different superheaters and each provided with a valve as shown in Fig. 1. These pipes pass through the front wall of the furnace and connect with the superheaters 42, 43, 44, 45, 46 (one for each retort) located in the same combustion chamber with the retorts. From each of these superheaters, the steam is led out through the front wall of the furnace and to one of the retorts; namely, to the retort *v*, by the pipe 47; to the retort *w* by the pipe 48; to the retort *x* by the pipe 49; to the retort *y* by the pipe 50 and to the retort *z* by the pipe 51. This superheated steam being thus heated to practically the same temperature as the retorts, is discharged into the end of the first pipe of each retort in a one-eighth inch jet which forms an injector or inspirator to act in conjunction with the oil supply for atomizing and vaporizing the same and producing a current of mingled oil vapor and superheated steam through the retort.

The oil may be supplied from a tank 52 into which it may be pumped through the pipe 53 by the steam-pump 54. The oil passes down through the strainer 55 into the pipe 56 in which is located a valve 57. The strainer is shown in detail in Fig. 11 and contains a wire netting basket 58 of suitable size mesh to hold back any solid matter. From the pipe 56 the current of oil is distributed to the pipes 59, 60, 61, 62 and 63 containing respectively the valves 64, 65, 66, 67 and 68. These pipes connect respectively with the transparent oil receivers 69, 70, 71, 72, 73, one of which is shown in sectional detail in Fig. 13. It is composed of a cylindrical portion of glass 74 closed at top and bottom by the caps 75 and 76. The inlet pipe 59 enters through the cap, 75 and this cap is also provided with an opening 77 closed by a pivoted slide 78 which may be moved by hand. The outlet consists of holes as shown in pipe 79 which are small enough to cause the oil to back up slightly and prevent the entrance of air. The oil is conducted away from these several receptacles by the pipes 79, 80, 81, 82, 83 provided respectively with the valves 84, 85, 86, 87 and 88 and leading respectively to the ends of the retort pipes *v'* *w'* *x'* *y'* *z'* where the oil is injected into

the retort pipe by the jet of superheated steam. The arrangement for this purpose is shown in detail in Fig. 10, where the pipes 48 and 79 are respectively the superheated steam and oil pipes, and where the steam is discharged from the nozzle shown in dotted lines at 89 and the oil is discharged into the pipe 90 surrounding that nozzle so as to be vaporized and forced into the retort pipe *v'* on the principle of an injector or inspirator.

The function of the transparent oil receptacles 69, 70, 71, 72 and 73 is to enable the operator to know whether the apparatus is working satisfactorily; because if otherwise, the oil will back up in the transparent receptacle thereby showing carbon or dirt obstruction in the retorts and the necessity of cleansing them with a current of live steam as now described.

By opening the hole 77 the operator can tell whether the injector is working properly by the sound transmitted through the hole.

Pipes 91, 92, 93, 94 and 95, provided respectively with the valves 96, 97, 98, 99 and 100 respectively, lead from the live steam pipe 36 to the ends of the retort pipes *v' w' x' y' z'*. The connection between each of these pipes and its retort pipe is made as shown in Fig. 10, so that the live steam may have free access to the retort pipe independently of the injector. The object of this is so that in case any stoppage occurs in any one of the retorts, live steam may be turned on to the same so as to carry off such obstruction.

I will next describe the apparatus for disposing of the fixed gas after leaving the retorts *x y* and *z*. This is delivered by the pipes 19, 20 and 21 into the expansion chamber 101 located near the exit ends of the retorts so that the rotorts are immediately relieved from the back pressure of the gas already formed. For the three retorts already described, I employ a cylindrical expansion chamber about six feet long and twenty-four inches in diameter and I provide the same with a drip pipe 102. The gas from the expansion chamber passes to an ordinary condenser through a pipe 103 of large diameter so as to offer the least resistance, and from the condenser it passes to the gas holder. Between the expansion chamber 101 and the condenser and within the pipe 103 is placed an exhaust, the object of which is not only to overcome the back pressure from the gas holder, but to create a slight vacuum or suction in the expansion chamber so as to assist the free flow of gas from the retorts as fast as it is generated. This exhaust is shown in Figs. 3 and 4 and it consists in a nozzle 104 connected with the boiler by the pipe 105 provided with a valve 106 so as to discharge live steam into a cylinder 107 through which the gas has to pass. The pipe 103 behind the steam nozzle is provided with a diluent pipe 108 having the valve 109. The exhaust produced by the steam jet from the nozzle 104 draws air or any other gas diluent into this opening which joins the current of gas and is thoroughly mixed therewith by being injected through the cylinder 107. The power of this exhaust can be regulated by the valve 106 and the amount of diluent by the valve 109. In the particular apparatus which I am describing the steam jet from the nozzle 104 will be one-eighth to one-fourth inch in diameter; the internal diameter of the pipe 103 is from eight to ten inches; the internal diameter of the cylinder 107 is from three to four inches; the internal diameter of the air pipe 108 is from one to two inches.

I will next describe the mechanism involved in disposing of the gas from the retorts *v* and *w* and at the same time in the production of the continuous and uniform temperature within the combustion chamber. The pipes 17 and 18 lead respectively from the retorts *v* and *w* to the chambers 110 and 111 surrounding the air nozzles 112 and 113. Air (which may be previously heated by passing through the pipes 114 and 115 in the top compartment 1) of the furnace and conducted thence to the respective nozzles by the pipes 116 and 117, may be supplied by the air drum 118 in which a constant pressure of air is maintained by any suitable air forcing apparatus, such as the fan blower 119 of Fig. 4. The arrangement connected with the gas pipe 18 and that connected with the gas pipe 17 for supplying air and forcing into the mixing chamber, is shown in detail in Fig. 9 and it will be observed that the air from the nozzle 113 injects the gas from the chamber 111 into the nozzle 120 whence they are discharged into the pipe 121 leading to the mixing chamber 13. The tip of the nozzle 113 enters the rear of the nozzle 120 which is large enough to leave an annular space for the fuel gas to be drawn through. The nozzle 120 converges at its tip somewhat as shown, and is at the tip of smaller diameter than the pipe 121. The nozzle 120 performs the function of thoroughly mixing the air and gas before its introduction into the mixing chamber below the hearth. The pipes 17 and 18 are larger than the retort pipes and a suction is produced in each by the air jet so as to relieve the retort from accumulation of gas.

In the apparatus which I am describing the pipe 18 is two to three inches internal diameter; the nozzle 113 is one inch internal diameter at its top; the nozzle 120 is one and one-half inches diameter at its top and the pipe 121 is three inches internal diameter; the several parts in Fig. 9 being drawn to a scale. A valve, as 122, should be provided somewhere in the pipe supplying air to the nozzle 113 so that the amount of supply is continually under the control of the operator. By thus controlling the supply of air and the escape of the products of combustion from the combustion chamber and the quantity and richness of the gas supplied from the retorts *v* and *w* (which last he is enabled to do by the valves 84 and 88 which control the

quantity of oil admitted into those retorts,) the operator is enabled to regulate and distribute the heat absolutely; and since this is essential to the operation of the retorts, all of these elements combine with the construction of the retorts and their deflectors &c. in the production of the result sought.

This form of the mixing chamber is shown at 13, Fig. 2, it being deepest at the front end where it is four inches in depth and decreasing gradually to a depth of only one inch at the rear of the furnace. This form prevents the momentum of the gas fuel carrying it to the rear of the mixing chamber and compels the fuel to pass upward through the hearth in substantially equal quantities at all parts thereof.

The hearth 12 is four feet square and consists of sixteen perforated fire clay tiles each twelve inches square and from two to two and one-half inches thick. Each tile contains one hundred and forty-four conical perforations or jets each one-fourth inch diameter at the upper and three-eighths of an inch in diameter at the lower end. The studs 129 resting on the bottom of the mixing chamber support the tiles constituting the hearth. Holes are provided at 123 in the doors 11 to admit a limited amount of air only to the combustion chamber nearly on a level with the upper surface of the hearth.

In starting up the apparatus, it is necessary to take fuel from another source than the retorts themselves, and for this purpose I take a pipe 124 from the gas holder and connect it by the pipes 125 and 126 controlled respectively by the valves 127 and 128 with the chambers 110 and 111 respectively.

The apparatus above described is operated as follows: By opening the valves 127 and 128 gas from the gas holder is admitted to and burned in the combustion chamber until the retorts are heated to an orange red heat which is seen by means of the peep-holes in the side walls of the generator. The valves 130, 131, 132, 133 and 134 in pipes 37 and 38 are then opened and steam passes through the superheaters and by the time it reaches the nozzles at the inlets to the retorts, has been raised to about the temperature of the retorts themselves. The valves 64, 65, 66, 67 and 68 are now opened and the oil flowing by gravity from the tank is seen in the glass receptacles 69, 70, 71, 72 and 73. This oil at the entrance to the several retorts is grasped by the superheated steam and injected in the form of a vapor or finely divided spray into the first pipe of each retort. The pressure of the superheated steam continues to urge the vapors of oil through the whole nest, and the current absorbs the heat from the retorts which causes such chemical combinations that by the time they reach the outlet to the expansion chamber, they have become a fixed gas of from seventy to eighty candle power, if the proper supply of oil and superheated steam is given. While the flow or vapors is urged at the inlet of each retort by the steam jet, it is assisted at the outlet by the exhaust between the expansion chamber and the condenser. Tests show a two inch pressure in the pipe next the inlet and a zero pressure in the pipe next the outlet with a one inch vacuum in the expansion chamber. The fixed gas in its hot condition carries with it any surplus of steam, by which it is meant, steam which has not entered into any combination with oil vapor. This surplus is precipitated by the condenser thus rendering the gas cool and dry before it passes to the gas holder. If the exhaust is closed and the hot gas is allowed to escape through a jet inserted in the expansion drum, it will be found to look like a light brown smoke, which is due to the excess of steam, the earthy substances found in the oil and unfixed vapor of oil. The application of a piece of clean white paper which is colored brown is a good practical test by the operator as to the good working of the generator. The condenser condenses the steam and at the same time precipitates the earthy substances which collect in the bottom chamber of the condenser and are called residuals. These should consist only of water from the condensed steam and the earthy and non-volatile substances in the oil itself. They are found to be very small in quantity. The residuals flow from the condenser into a drip as a precipitate, so as to prevent any accumulation, and in this way the gas passing to the gas holder has no opportunity of absorbing any portion thereof.

It is a matter of great importance that there should be no interruption to the steady flow of oil and steam vapors through the retorts; for wherever any direct stoppage is created, the gas begins to deposit carbon or tarry matter rapidly, forming an obstruction to the flow of gas. This should not occur in the apparatus described; but if by inattention it should occur, the plugs and core pieces may be removed from any one of the retorts without interrupting the operation of the others. Or by cutting off the supply of oil and superheated steam, live steam may be admitted through the retort from the pipe 95 for cleansing purposes.

As soon as the retorts are working properly so that the gas has been generated in the retorts *v* and *w*, the valves 127 and 128 will be closed and the supply of gas be taken from those retorts, and not from the gas-holder. Also it will be found that the damper in the main chimney may be kept almost closed.

I believe that the results I accomplish with the above process and apparatus attest the radical character of the inventions embodied therein and I therefore desire my claims to be understood as covering all modifications which do not depart from the principle of my invention.

I claim:—

1. In combination, a retort, a series of deflectors located therein constructed for throw-

ing a current repeatedly against the interior surface of the retort, an injector constructed for forcing a current of oil spray into one end of said retort with a jet of superheated steam, and an exhaust constructed for exhausting said current at the other end of said retort; whereby the oil spray is forced forward at one end by the injector steam jet and drawn forward at the other end by the exhaust, substantially as described.

2. In combination a retort, a series of deflectors located therein constructed for throwing a current repeatedly against the interior surface of the retort, an injector constructed for forcing a current of oil spray into one end of said retort with a jet of superheated steam, an expansion chamber at the other end of said retort, an outlet to said expansion chamber and an exhaust in said outlet, substantially as described.

3. In combination a retort, a series of deflectors located therein constructed for throwing a current repeatedly against the interior surface of the retort, an injector constructed for forcing a current of oil spray into one end of said retort with a jet of superheated steam and an injector constructed for exhausting said current at the other end of said retort said ejector provided with an opening for the introduction of a diluent, substantially as described.

4. In combination a plurality of retorts, a series of deflectors located in each constructed for throwing currents repeatedly against the interior surfaces of the retorts, an injector constructed for forcing a current of oil spray into one end of each retort with a jet of superheated steam, an expansion drum with which the outlets of all the retorts are connected, an outlet passage from said drum greater in cross-section than the combined sections of said retorts and an exhaust in said passage, substantially as described.

5. In combination a retort, an injector at one end constructed for producing a current of oil spray, a rod running longitudinally in the retort, a series of deflectors on said rod each enlarging gradually toward the interior walls of the retort and provided with centering fingers; all surfaces of the deflector opposed to the current being inclined with the current whereby the current is deflected without abruptly arresting the flow, substantially as described.

6. In combination a furnace, a retort located wholly within said furnace consisting of a series of pipes connected at alternate ends, nipples in alignment with said pipes extending out through the furnace wall, plugs or caps for said nipples, a separate series of deflectors in each pipe and a rod connecting the several members of each series whereby the said deflectors may be withdrawn outside the furnace through said nipples while the products passing through said retort are retained continuously within the furnace, substantially as described.

7. A furnace containing a heating-chamber and a communicating fuel chamber beneath the same a retort located wholly within said furnace consisting of a series of pipes connected at alternate ends and nipples in alignment with said pipes extending out through the furnace wall, an injector injecting oil spray into said retort; the first of said pipes being provided with a free passage and other of which pipes being provided with deflectors whereby the current is thrown against the heated internal surfaces, substantially as described.

8. In combination, two retorts, a separate injector constructed to discharge oil spray into each retort with a jet of superheated steam, deflectors within said retorts, a furnace and a passage connecting the outlet from one of said retorts with the combustion chamber of said furnace whereby the product of one retort is employed as fuel for heating the other, substantially as described.

9. In combination, a heating chamber, a communicating fuel chamber located beneath the same, a plurality of retorts each containing a series of pipes traversing said heating chamber, an injector constructed for injecting oil spray into each of said retorts, a separate valve controlling the supply of oil to each injector, a passage leading from one of said retorts to the gas holder and a passage leading from the other of said retorts to said fuel chamber, substantially as described; whereby the fuel for heating both of said retorts is supplied by the products of one and the temperature of the heating chamber is controllable by the percentage of oil admitted to the fuel gas retort independently of the regulation of the ingredients entering the illuminating gas retort.

10. In combination, a heating chamber, a communicating fuel chamber located beneath the same, a plurality of retorts each containing a series of pipes traversing said heating chamber, an injector constructed for injecting oil spray into each of said retorts, a passage leading from one of said retorts to the gas holder, a passage leading from the other of said retorts to said fuel chamber, an injector constructed for injecting said fuel gas into said fuel chamber with a jet of air, an air forcing apparatus constructed to supply said jet, substantially as described.

11. In combination, a heating chamber provided with a plurality of flue openings, a communicating fuel chamber located beneath the same, two series of pipes each constituting a gas generating retort traversing said heating chamber, two injectors each constructed for injecting steam and oil into one of said retorts, a separate valve controlling the supply of oil to each injector, a passage leading from one of said retorts to the gas holder and a passage leading from the other of said retorts to said fuel chamber, a damper for each of said flue openings, substantially as described.

12. In combination, a heating chamber, a communicating fuel chamber located beneath the same, a series of pipes provided with deflectors constituting a gas generating retort traversing said heating chamber, an injector constructed for injecting steam and oil into said retort, an injector for injecting fuel gas into said fuel chamber with a jet of air, an air forcing apparatus constructed to supply said jet, a nozzle through which the combined fuel gas and air is injected into the fuel chamber, substantially as described.

13. In combination a combustion chamber, a retort comprising a series of pipes containing deflectors, an injector injecting oil and steam into the retort a fuel chamber underlying said combustion chamber, a perforated hearth, between said chambers an injector constructed to discharge fuel gas into said fuel chamber with a jet of air directed substantially parallel with said hearth and an air forcing apparatus, substantially as described.

14. In combination a combustion chamber, a retort comprising a series of pipes containing deflectors, an injector injecting oil and steam into the retort a perforated hearth, a fuel chamber underlying said perforated hearth, an injector constructed to inject fuel gas into said fuel chamber by a jet of air directed substantially parallel with said hearth; the bottom of said combustion chamber converging toward said hearth toward the side opposite the injector, substantially as described.

15. In combination, a heating chamber, a communicating fuel chamber located beneath the same, a series of pipes provided with deflectors constituting a gas generating retort traversing said heating chamber, an injector constructed for injecting steam and oil into said retort, an injector constructed for injecting fuel gas into said fuel chamber with a jet of air, an air forcing apparatus constructed to supply said jet, a hearth separating the heating chamber from the fuel chamber provided with perforations proportioned, substantially as described, whereby the combustion in the heating chamber is prevented from igniting the gas in the fuel chamber, substantially as described.

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Witnesses:
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