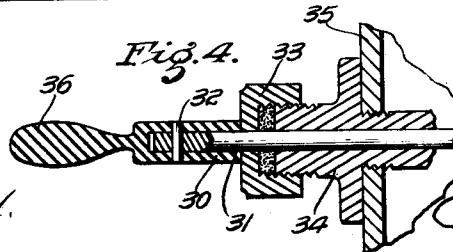
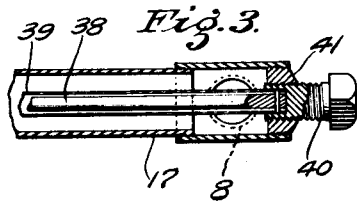
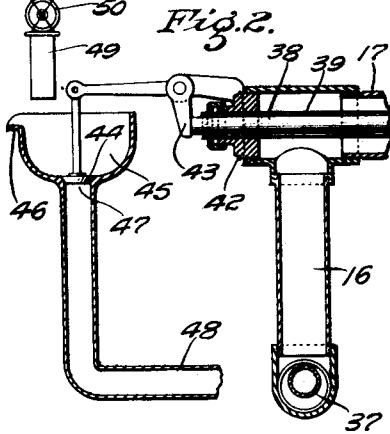
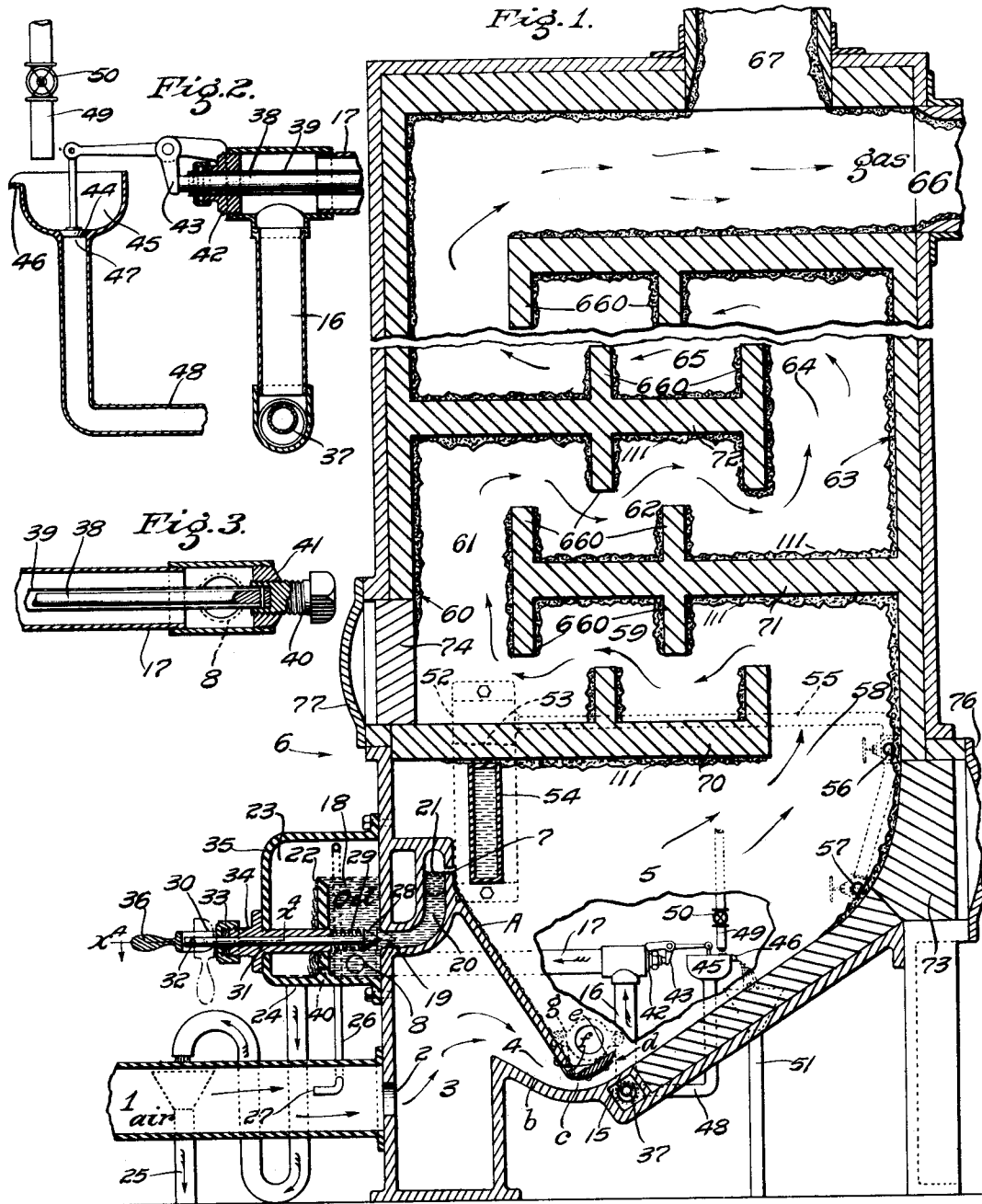


O. H. ENSIGN.  
METHOD OF PRODUCING GAS.  
APPLICATION FILED MAY 27, 1909.

Patented June 10, 1913.

1,064,625.

5 SHEETS—SHEET 1.



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5 SHEETS—SHEET 2.

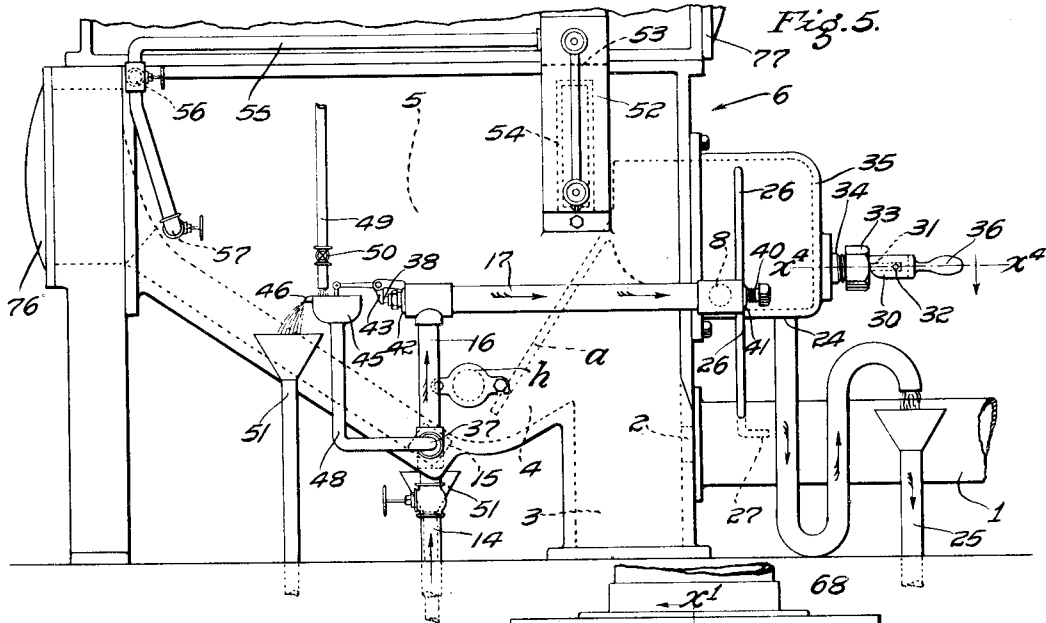
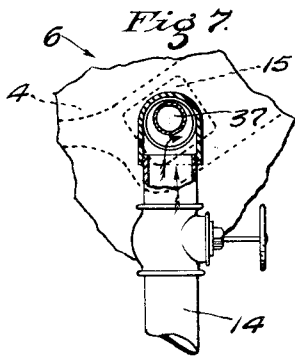
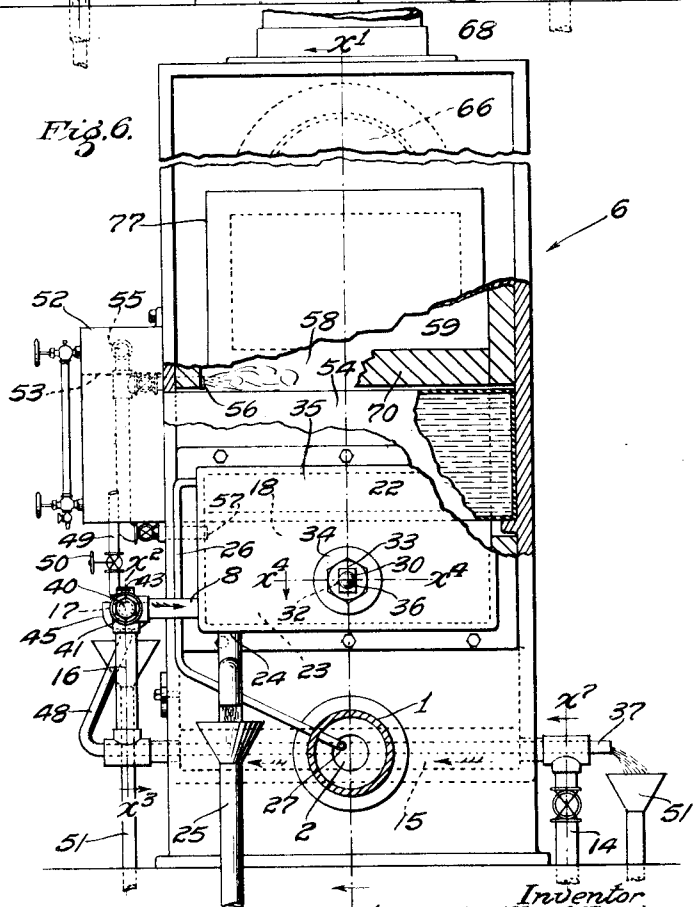


*Fig. 6.*



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5 SHEETS—SHEET 3.

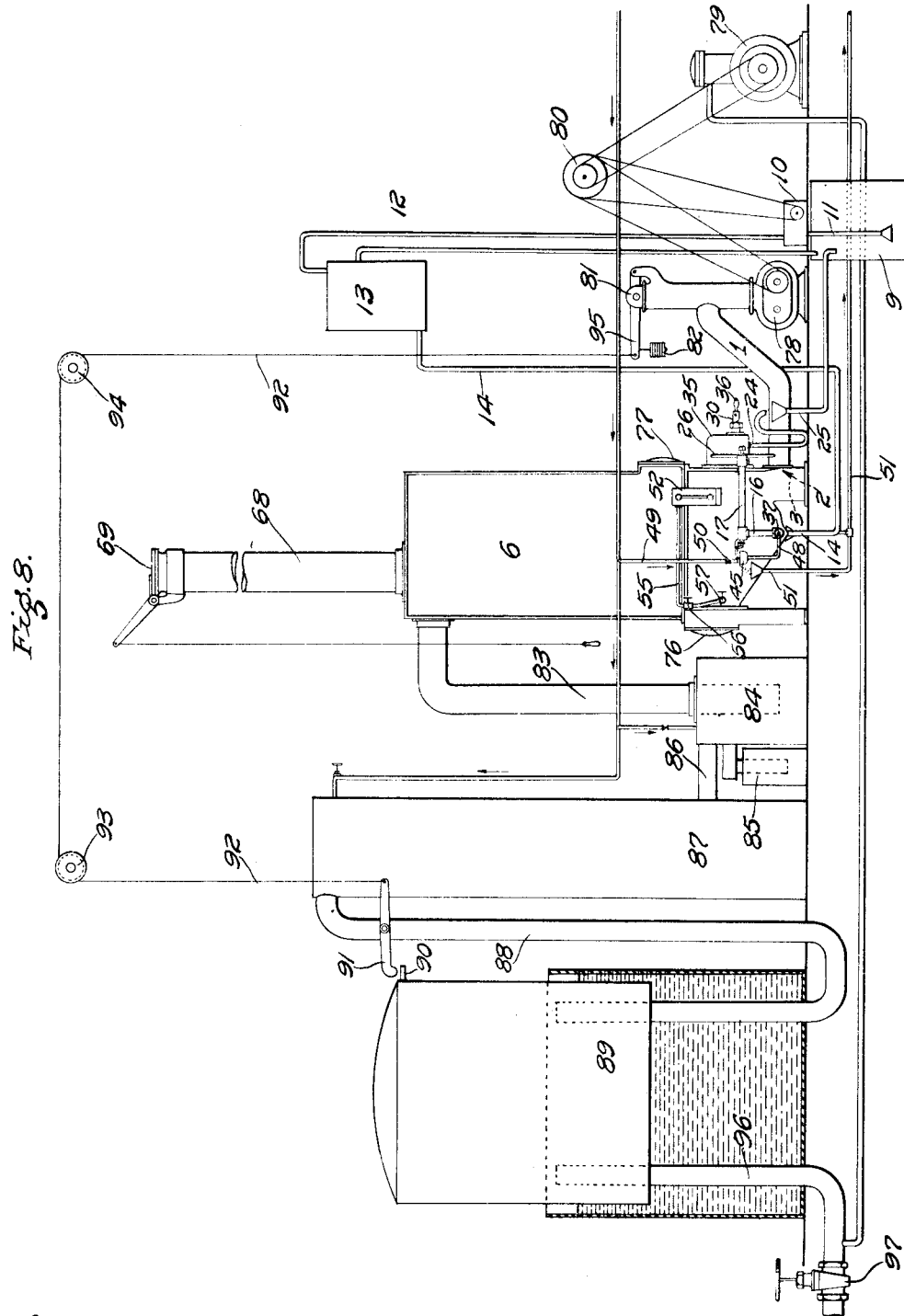


Fig. 8.

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5 SHEETS—SHEET 4.

Fig. 9.

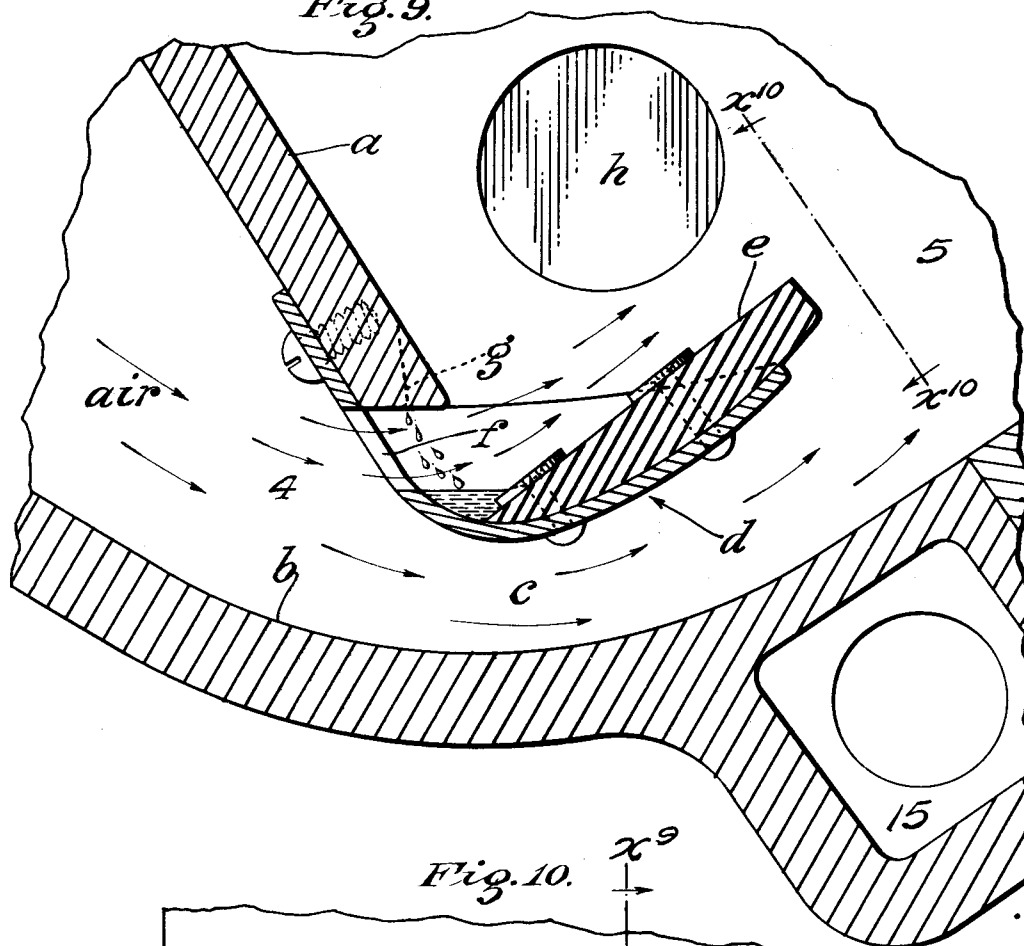
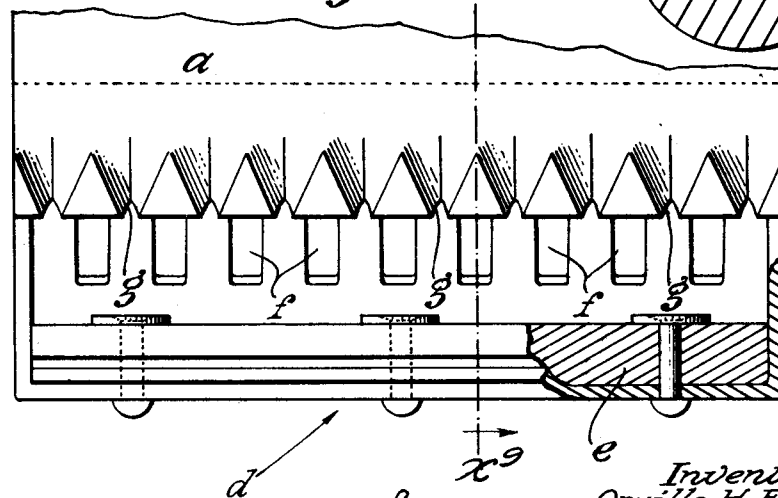


Fig. 10.



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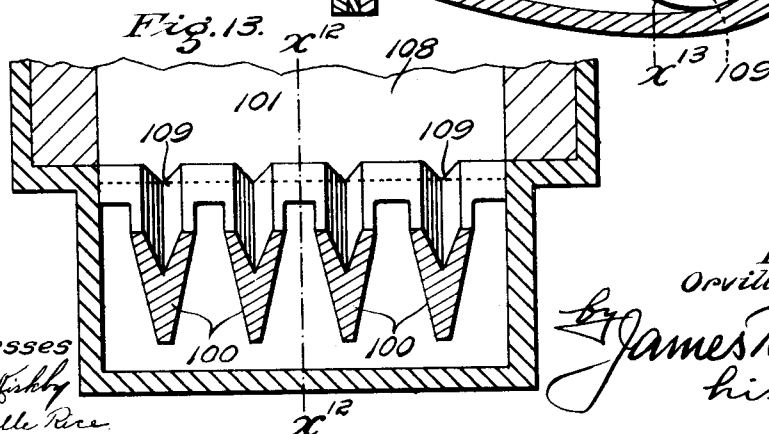
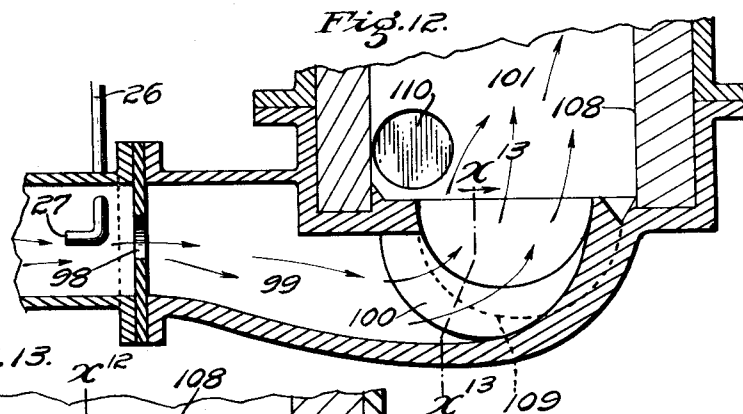
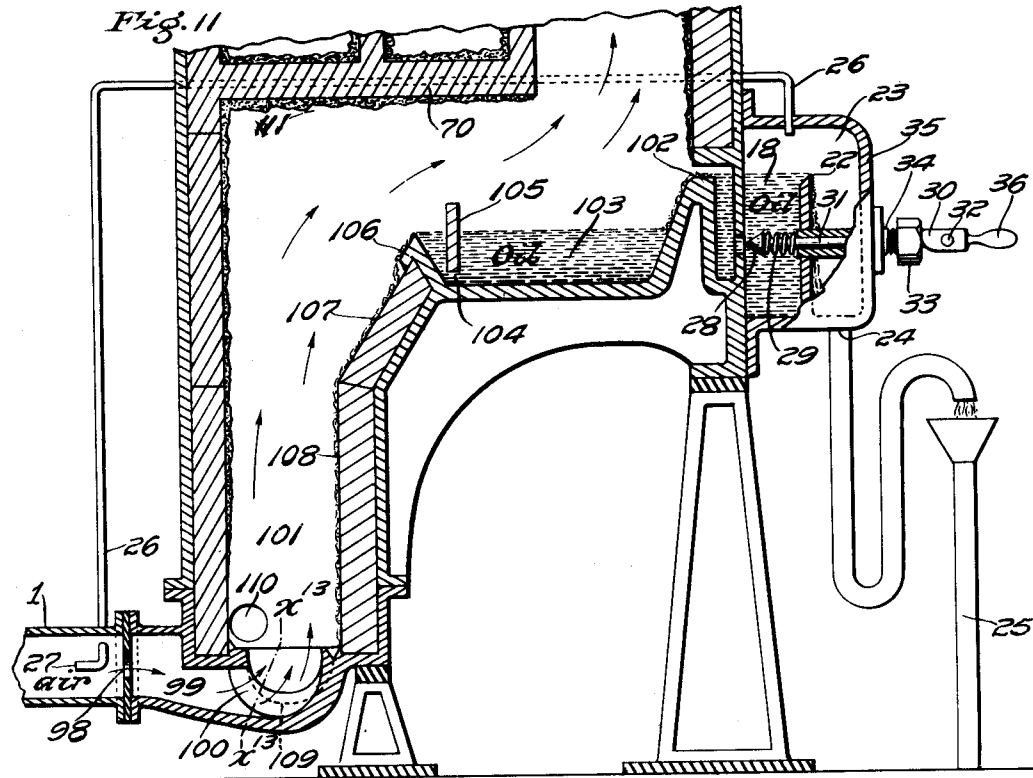
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6 SHEETS—SHEET 5.



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# UNITED STATES PATENT OFFICE.

ORVILLE H. ENSIGN, OF LOS ANGELES, CALIFORNIA.

## METHOD OF PRODUCING GAS.

1,064,625.

Specification of Letters Patent.

Patented June 10, 1913.

Application filed May 27, 1909. Serial No. 498,764.

*To all whom it may concern:*

Be it known that I, ORVILLE H. ENSIGN, a citizen of the United States, residing at Los Angeles, in the county of Los Angeles and State of California, have invented new and useful Improvements in Methods of Producing Gas, of which the following is a specification.

This invention relates to the production of gas from crude-petroleum and air with or without steam, for power and other purposes.

This invention relates to improvements upon the Amet method of and apparatus for producing gas, said method being described in Letters Patent of the United States, No. 885,903, patented Apr. 28, 1908, to E. H. Amet, for method of producing gas.

Objects of the invention are:—to produce a minimum oxidation of the constituents of the fuel; to directly utilize in the most convenient and efficient manner the asphaltum or other heavy or stubborn constituents of the hydrocarbon-fuel for the purpose of maintaining the heat necessary to distil, dissociate and recombine the elements to produce the inflammable gas; to minimize the production of solid or liquid by-products such as coke, lamp-black, and coal-tar; to produce a uniform quality of gas throughout the operation of the apparatus, regardless of the quantity produced; to minimize the size and cost of apparatus, and as far as possible to make the production of the gas an automatic operation with a minimum amount of attention and labor.

An object of this invention is to make a producer-gas containing a maximum percentage of hydrocarbon gaseous compounds, a comparatively small percentage of carbon-monoxid, a desirable percentage of free hydrogen for power purposes, and minimum percentages of carbon-dioxid and nitrogen; said producer gas being rich in illuminants and being unlike natural gas.

In the gas produced by this improved method, by far the greatest percentage of the heat-units is contained in hydrocarbon gases, a small percentage of the heat-units is contained in carbon-monoxid, a small percentage of heat-units is contained in free hydrogen which is desirable for power purposes; and the dilution of the gas by nitro-

gen and carbon-dioxid is kept down to an extent not attainable by former producer-processes using the same character of fuel.

Some of the features of improvement over methods heretofore known are as follows:—keeping the fuel automatically at a constant temperature and hence constant viscosity, so that it will flow at a constant rate through a fixed orifice or opening for any particular constant pressure applied; maintaining an accurate ratio between the fuel supplied and the air supplied, by applying the air-pressure on opposite sides of a resistance in the air-supply source, to the opposite sides of a resistance in the oil-supply source; regulating the amount of gas made, to meet the demand; by controlling the amount of air supplied; regulating the steam supplied to the generator in proportion to the amount of gas made in the generator, which is in detail controlled by the amount of heat liberated against a fixed heating surface of steam-generating apparatus; and furthermore, breaking up and recombining certain products of combustion or dissociation which may occur in the flame-zone of the apparatus, which products move through passages on their way to the washing-apparatus, said passages being of such a character that they will retain the major portion of the heat of said products of combustion and hold them together with such portion of the heat for a considerable length of time and yet allow sufficient dissipation of heat to cause deposits of incandescent carbon upon and along the walls of said passages for the purpose first, of adding carbon to the carbon-dioxid produced in the flame-zone and thus producing carbon-monoxid that can be conducted away as an inflammable gas, and to break up those hydrocarbon vapors which may have been distilled in the presence of the flame-zone and not attacked by the oxygen, and thus producing a fixed inflammable gas; providing for the retention of the less volatile portions of the oil at a place where the same may be consumed to produce heat used in carrying on the process of breaking up the vapors and the products therefrom and producing the fixed inflammable gas. And further, to retain all or nearly all the consumed carbon and prevent its reaching

the washing apparatus, and to utilize such carbon to produce fixed inflammable gas without rehandling the carbon.

The apparatus for carrying on my newly-invented process of making producer-gas may be variously constructed without departing from the principle of the invention.

In carrying on this process, atmospheric pressure may be employed to supply the air and cause the flow of fuel, the suction of an engine or a blower being depended upon to cause the requisite relatively low pressure in the combustion-chamber; but I at present deem it more advisable to apply artificial air-pressure at the intake end of the producer.

The accompanying drawings illustrate apparatus adapted for use in carrying on the new process.

Figure 1 is a broken vertical mid-section on line  $x^1$ , Fig. 6, of a gas-producer constructed in accordance with this invention. Figs. 2 and 3 are fragmental, sectional details showing the opposite ends of the thermostat for regulating the temperature of the fuel. These views are taken on line  $x^2-x^3$ , Fig. 6, looking toward the right. Fig. 4 is a sectional plan on line  $x^4$ , Figs. 1, 5 and 6. Fig. 5 is an elevation from the left of Fig. 6. Fig. 6 is a front elevation from the left of Fig. 1 and the right of Fig. 5. Fig. 7 is a vertical section on line  $x^7$ , Fig. 6, looking to the left. Fig. 8 is an elevation of a plant embodying apparatus illustrating this invention. Fig. 9 is an enlarged sectional detail to illustrate the means whereby the less volatile parts of the liquid hydrocarbon, as the asphaltum, tar, and so forth, are subjected to combustion. Fig. 10 is a view from the plane indicated by line  $x^{10}$ , Fig. 9. Fig. 11 is a section of a different type of combustion-chamber. Fig. 12 is an enlarged fragmental detail of the same. Fig. 13 is a fragmental section on line  $x^{13}$ , Figs. 11 and 12. In the form shown in Figs. 11, 12 and 13 the passage above the combustion-chamber and not shown in these views will be the same as that shown in preceding views.

The novel method of distillation will be better understood by referring to the two forms of apparatus shown, as in each of these forms it will be seen the mingling of the air with the fuel for the purpose of combustion takes place remote from the point at which the fuel enters and distillation occurs. The principal advance made by this new method over the previous art, especially referring to the Amet method described in United States Patent No. 885,903, dated April 28, 1908, is that the amount of air supplied and the manner of its supply is such that the air is consumed by union with the heavier constituents only; such union taking place at a point or zone

remote from the place where distillation of the lighter portions of the fuel occurs; thus allowing the lighter constituents to be acted upon by the heat while free from the presence of oxygen, the combustion of fuel only occurring in connection with the heavy material which reaches the bottom of the combustion chamber because of the admission of only enough air to cause the required combustion of heavy portions of the fuel. This results in a total combustion of a minimum amount of the fuel supply and therefore less air is supplied for a given amount of gas and less nitrogen results in the ultimate gas.

A noted difference in the results of the Amet process and apparatus, and the present process and the apparatus constructed in accordance with this invention, is that the volume of gas produced by this invention is greatly in excess of the volume of air introduced while with the patented process the volume of gas produced is practically equal to the volume of air introduced.

In carrying out my newly-invented method to produce a fixed inflammable gas from liquid hydrocarbon and steam by means of the apparatus shown in Figs. 1 to 10, air is forced from a suitable source which may be a blower of any type,—through a pipe 1 provided at its end with a resisting orifice 2, and thence into an enlarged air-passage 3 and through an inlet 4 into the combustion distilling and heating chamber 5 of the gas-producer 6. The enlarged passage 3 and the inlet 4 are of such dimensions relative to the resisting orifice 2 that under normal operative conditions pressure in the combustion-chamber 5 will be practically the same as that in the enlarged chamber 3.

Oil or other fluid fuel is supplied to the gas-producer through a slot 7 and over an apron or slide A which delivers it to the air flowing through inlet 4. The oil is supplied by means so connected to the air supply means that whatever the quantity of air entering the producer the same will carry a proportionate amount of oil, and will force such oil into the combustion chamber, the proportions being so adjusted that there results from the ignition of the air and fuel a flame in which only partial combustion occurs.

The oil is supplied through a pipe 8 from an oil-circulating system shown in Figs. 1, 5, 6 and 8, and which system comprises a main underground supply-tank 9 from which oil is drawn by a pump 10 through suction-pipe 11 and delivered by pipe 12 into an elevated tank 13 from which it flows through supply-pipe 14, a heating passage 15, a riser 16, and a horizontal thermostat-pipe 17, to the pipe 8 from which it enters the first oil-receptacle 18 from whence it flows through regulatable orifice 19 and

passage 20 to a second oil-receptacle 21 from which it may flow through orifice 7 into the combustion-chamber 5 whenever the air pressures are such as to cause such flow, the surplus oil flowing over a weir 22 formed by one wall of the first oil-receptacle 18 which wall terminates at such a level below the bottom of the orifice 7 that when the air-pressure on the surface of the oil in receptacle 18 equals the air-pressure at the oil-orifice 7 in the combustion-chamber 5, the orifice 19 being open and the level of the oil in the second oil-receptacle 21 being even with the bottom of the orifice 7, an amount of oil sufficient to operate the producer 6 at full capacity will be discharged over the weir 22; so that immediately when air is forced through the orifice 2 by reason of an excess of air-pressure in pipe 1 over that in the combustion-chamber 5, such pressure augmented by the velocity of the air in the pipe 1, flowing toward the orifice 2 at the mouth 27 of the Pitot tube 26, will be transferred through the Pitot tube to the surface of the oil in the first oil-receptacle 18, and will consequently reduce the level of the oil in said receptacle 18 and raise the level of the oil in the receptacle 21, thus to cause a flow of oil through the orifice 7 depending upon the difference of pressures and the size of the orifice 19.

It is to be understood that the variation of the level of the oil in either receptacle may be very slight, but that the variation may be such that when operating the producer to its full capacity all of the oil supplied through pipe 8 will flow out through the orifice 7. However, it is not necessary that the pipe 8 supply only enough oil to operate the producer at its full capacity, and it is preferable that there be a little excess to allow certainty in supply. The first oil-receptacle 18 opens at its top into an air-chamber 23 which has a sealed outlet 24 discharging through the open air into a waste-pipe 25 that returns the surplus oil to the sunken oil-reservoir 9. The mouth 27 of the Pitot tube 26 which connects the air-supply-pipe 1 with the air-chamber 23 is directed, at the center of the air-supply-pipe 1, against the current of the inflowing air, so that the pressure of air in the air-chamber 23 will be determined by the velocities and pressures of the air in the air-supply-pipe. By this construction and arrangement, so long as no air is flowing through the orifice 2, no oil will flow through the orifice 7. The orifice 7 is just above the level of the top of the weir 22 so that immediately the air-pressure in chamber 23 is greater than the air-pressure at the orifice 7 the oil is thereby forced to rise in the second oil-chamber 21 and will flow out through the oil-slot 7 at a depth determined by the excess of the air-pressure in the

chamber 23 over that at the slot 7, and by the resistance imposed by the orifice 19.

Since liquids and gases follow the same law for the rate of flow through an orifice for small changes of pressures, the amount of liquid fuel supplied to the combustion-chamber through the slot 7 will be always proportional to any variable amount of air supplied through the air-supply pipe 1. This assists in carrying out my process by maintaining constant proportional relations between the oil and air supply, thus producing a gas of an average constant quality with a resulting constant fuel consumption for a given demand.

The oil-orifice 19 is controlled adjustably by a valve 28 closed by a spring 29 and opened by a cam 30 that is pivoted to the valve-stem 31 by a pin 32 and that engages an adjustable gland-nut 33 which screws onto a valve-stem-guide 34 that screws into the case 35 of the air-chamber 23 and fits at its farther end into the weir-wall 22 of the first oil-chamber 18, the valve 28 being of slightly less diameter than the valve-stem guide 34 so that it may be inserted through the case 35 and the weir 22. By turning the adjusting-nut 33, the space between the valve 28 and the seat in the orifice 19 may be increased or decreased so as to increase or diminish the orifice 19, so that when the handle 36 of the cam is thrown up as shown in solid lines in Fig. 1 to open the orifice 19, the valve 28 will always stand open at a position determined by the position of the adjusting nut 33; and when the handle 36 is thrown down as indicated in dotted lines in Fig. 1, the spring 29 will always force the valve 28 to close the orifice 19.

The object of the adjusting-nut 33 is to allow greater or less quantities of oil to flow through the orifice 19 in proportion to the air-supply and to thus increase or diminish the heat value or quality of the gas produced, and the adjustment remains fixed in any one open position for any particular quality of gas through a wide range of quantity, which quantity is determined by the air-pressure and velocity in pipe 1 and communicated to chamber 23 by the Pitot-tube; and such adjustment is not disarranged by opening and shutting the valve.

The rate of fuel-flow depends upon the viscosity of the particular fuel as well as upon the difference of pressures between the levels in the first and second oil-chambers. Provision is made for maintaining a determined fluidity of the fuel by regulating the temperature thereof. This is done by means of the heating passage 15 which is located at the bottom of the combustion-chamber where a wall of such chamber is exposed to the heat of the combustion-chamber.

The oil flows through the heating passage 15 and its temperature is regulated by

a cold-water pipe 37 carrying a variable amount of water controlled by the action of a thermostat which is operated by the temperature of the oil that flows to the first oil-chamber 18. The oil flows from the heating chamber 15 through the riser 16 to the thermostat-pipe 17, inside of which is a sensitive-rod 38 which may be of ebonite contained in a heat-conducting tube which may be copper, aluminum, or other suitable metal. The sensitive-rod 38 and its containing-tube 39 are both fastened at one end to an adjusting screw 40 which is screwed into a plug 41 in one end of the pipe 17. The other end of the pipe 39 passes through a stuffing-box 42 at the other end of the pipe 17, and the ebonite-rod 38 projects into engagement with a bell-crank-lever 43 which is pivotally-connected with a valve 44 that is located in the bottom of a water-receptacle 45 having an overflow-outlet 46 and valved outlet 47 which communicate through the pipe 48 with the cold-water pipe 37. A constant supply of water is delivered to the receptacle 45 through a supply-pipe 49 controlled by a valve 50. The cold-water pipe 37 discharges into the open air; the waste-pipe 51 being provided to carry away discharge.

In the larger producers it is found to be advantageous to supply aqueous vapor to the combustion-chamber in determined proportions corresponding to the amount of heat generated in said chamber. This is accomplished through the medium of a steam-boiler 52, the water in which is kept at a determined level 53 by any well-known means, as a float-valve, not shown; said boiler being provided with a water-leg 54 below said water-level that extends into the combustion-chamber and is heated by the heat produced therein; the vapor flowing from the boiler through a pipe 55 into the combustion-chamber through one or more outlets 56, 57, which may be arranged at different levels as shown in the drawings.

In the production of gas from crude petroleum and air, with or without steam, the character of the gas can be varied by causing more or less complete combustion of the heavier constituents, as the asphaltum or tar, which occur in western oils; and in order to completely utilize these heavier constituents, the oil may be delivered from the slide through an air-current, or between streams of air, onto a receptacle which is located above an air-passage, so that the incoming air will be more intimately mingled with the heavier constituents and aid their complete consumption for gas-making purposes. When such receptacle at the bottom of the slide is omitted, gas having a certain heating value is easily produced with a certain amount of lamp-black by-product, and a small amount of harder carbon; the lamp-

black passing out of the combustion-chamber and a small quantity finally appearing in the wash-water and the harder carbon clinging to the sides of the combustion-chamber in small quantities. With this receptacle at the bottom of the slide, gas of much higher heating value may be obtained with a great reduction in the production of lamp-black and the harder carbon.

It is essential in this process that the flow of the material over the slide after entering the heated chamber shall be slow and the distance through which the material must flow before reaching the point of combustion must be comparatively great, so that the lighter oils will become distilled outside of the zone of combustion in the chamber. With this object in view the slide is arranged at an angle of about 60° and its length from the oil inlet to the air inlet is about 15 times the width of the total air inlet from top to bottom and the area of the slide is about 15 times that of the air inlet. By this means the amount of air admitted will only be sufficient to effect the combustion that is required to produce the heat necessary to vaporize the oil and fix the gas. Vaporizing, gasifying and fixing is effected without any contact of the vapor with free oxygen and in this manner the dilution of the gas by nitrogen and carbon-dioxid is minimized. Furthermore by inclining the slide to a gentler slope than that employed in the Amet process, and making the slide so long and of such increased length and area relative to the vertical width and the total area of the air inlet, the heating is effected wholly by combustion of the heavy hydro-carbonaceous materials from which the lighter oils have been vaporized. Furthermore the cubical contents of that portion of the chamber which extends over the slide is greatly enlarged as compared with the Amet process. This is done to avoid mingling free oxygen with the vapors and also to keep the freshly admitted oil at a more moderate temperature than in the Amet patent, the object being to allow the vaporization to take place without any explosive distillation and without any breaking up of the chemical constituents at that point of the operation. In this improved method the oil is spread out into a thin sheet before it is admitted to the slide and the function of the slide is simply to retard the flow of the oil and to expose the oil in such a manner as to most effectively vaporize the lighter constituents thereof. The advantage of this method is that the vapors which have been distilled from the upper end of the slide receive their decomposing and recombining heat by mingling with the red or white hot products of combustion produced from the heavier constituents; the result being that the hydrogen combined with the carbon in

the form of distillates and vapors is retained still in combination with carbon in the resultant gas, producing a high percentage of the illuminants and marsh gas. With the short slide and large air opening of the Amet process the air to a very great extent was brought into contact with these vapors; also there was nothing like the amount of vapor distilled, if any was at all; hence the combustion or partial combustion existent attacks the hydrogen gas thus producing water vapor instead of producing a marsh gas or illuminants together and in large quantities. Some marsh gas was produced and a large amount of carbon monoxid. Much of the hydrogen was burned to water vapor and absorbed by the washer. The total result of this improved method is a much higher efficiency because it retains in the final gas as far as possibly can be, the original proportions of hydrogen and carbon. Over 70 per cent. of the heat units in the gas are represented by the hydrocarbon carbons. This improved method is particularly distinguished from the Amet process in that oxygen is excluded by special isolation from the vapors and gases evolved from the oil, save only the flame of the heaviest constituents of the oil: the lighter elements are prevented from kindling or producing flame. In this improved method the flame which supplies the necessary heat is extinguished by exhausting the oxygen by means of a large surplus of hydrocarbon and such flame is so regulated as to insure the fixing of practically all the gases produced from the hydrocarbons that do not reach the bottom of the slide.

For an understanding with regard to this, reference is now made to Figs. 1, 9 and 10. The liquid fuel,—preferably petroleum,—after it is delivered through the oil-outlet 7, flows in a thin sheet down a slide *a* which terminates at a distance above the floor *b* of the producer, thus providing an air-inlet *c* between which and the bottom of the slide is a receptacle *d* that is arranged to receive the drippings from the bottom of the slide *a*, and that may or may not be provided on the side which extends into the combustion-chamber 5, with a plate of asbestos or other refractory material slanting upward rearwardly toward the outlet 58 from the combustion-chamber 5. That side of the receptacle *d* which is beneath the slide *a* and is nearest the air-orifice 2, is provided with a series of holes *f* through which air flows beneath the slide into the receptacle and over the contents thereof and upwardly over the plate *e* when such plate is present; said slide being provided along its lower edge on the inner side with a series of grooves *g* opening downwardly between the holes *f*, so that the fluid delivered to the receptacle from the slide will flow between the streams

of air issuing through the holes *f*. When the oil is ignited as by a light which may be inserted through an opening *h* that is normally closed, ignition occurs at the bottom of the slide, the air-supply from orifice 2 sustains combustion, and there is produced a flame which, after a few moments of operation, becomes very intense, and the radiant heat thereof acts to distil or vaporize the lighter portion of the liquid-fuel flowing down the slide *a*, so that only the heavy material, as asphaltum or tar, drops off the lower edge of the slide. By reason of the grooves *g* the drops of oil or heavier products are caused to fall between the streams of air flowing through holes *f*, and these streams supply oxygen to the same drops of fuel on all sides, and also to the surface of the accumulations in the receptacle for the combustion of such accumulations. The drops of liquid are thus drawn out into attenuated sheets and spread thinly over the upper inclined heated surface of the plate *e* and in this manner are more readily consumed. I find in actual practice that this causes the carbonaceous residue that flows from the slide to be consumed.

The plate *e* and in fact the whole receptacle may be omitted, and the slide may be constructed without the grooves. In case the receptacle is omitted the drops of oil or asphaltum flowing from the slide are projected by the blast of air underneath the slide *a* and are carried backward to lodge upon the bottom, the side walls, and the rear end of the generator, where they finally lose all fluid matter and remain as small grains of hard coke which are apt to cement together and form a mass of coke that may finally require that the producer be opened for the purpose of removing the coke by means of suitable tools.

By providing the receptacle and directing the drops of asphaltum or other carbonaceous residue to fall between the streams of air flowing through the holes *f* so that such drops are acted upon only by gravity and the induced draft, being protected from direct force of any blast, they are not carried farther than the plate *e*. The streams of air ply upon the heated thick liquid-fuel upon the plate which projects well into the combustion-chamber and absorbs heat therefrom so as to instantly heat the residue falling thereon and such air facilitates the complete consumption of the heavier products. By mounting this receptacle and plate at the bottom of the slide, the residue material is consumed in much closer proximity to the oil-slide and is not thrown onward throughout the whole length of the generator. In other words, a shorter, hotter flame is produced in the vicinity of the lower end of the slide, than would be produced without the receptacle; and this in turn tends to reduce

the amount of fuel which can reach the bottom of the slide, and therefore increases the amount of fuel which is distilled without contact with oxygen. This is an important  
5 feature as the fuel which is distilled without contact with oxygen ultimately forms hydrocarbon gases. A stream of fresh air flows beneath the receptacle; and into this stream the products that flow over the edge  
10 of the plate are carried, the same being in an intensely heated condition and the undistilled portions being in a very thin sheet become consumed readily by the action of the air. This is necessary to satisfactory  
15 operation with asphaltic oils because the heavy asphaltum resulting from the distillation of such oils is not readily burned unless it is heated to a very high temperature and supplied with very hot air.

20 In practical operation the oil-slide *a* is heated from the flame in front of it and is kept from becoming too hot by the air behind it. The outflowing air takes some of this heat but does not become so hot as to  
25 insure sufficient consumption of the residuum falling into it unless the residuum itself is brought to a very high temperature. This receptacle performs the function, first, of causing some of this residuum to be directly consumed by the air on top of it, the  
30 residuum being spread over the plate *c* in the heat of the flame; and second, to make that which is not thus consumed and which flows into the stream of air through *c*, so  
35 hot that it is bound to be consumed.

By retaining the asphaltum or heavy portions of liquid-fuel close to the slide and causing them to burn there, thus to produce  
40 intense heat in the immediate vicinity of and below the freshly-supplied fuel which is on the slide, rapid distillation is caused to occur immediately above the flame-zone thus produced, and the products of this distillation are affected by the heat and are  
45 broken up into fixed hydrocarbon gas.

The steam outlets 56, 57 are arranged at the rear end of the combustion chamber to discharge steam into said chamber at a point where the combustion of the fuel with  
50 oxygen of atmospheric air is finished so that the introduction of this steam will not lower flame temperature as it would if it entered at any point between the one shown and the inlet 4. If the steam is discharged  
55 into the generator before combustion is complete the tendency is to extinguish the flame. The object of using steam is to enrich the gas by so introducing the aqueous vapor that it will be decomposed and the  
60 hydrogen and oxygen from the result of such decomposition will combine with any incandescent carbon occurring in the producer thus to form hydrocarbon gases or carbon monoxid. The steam is admitted  
65 into the generator by either or both of the

two inlets 57 and 56 beyond the zone of combustion and without excessive pressure. The amount of steam thus admitted is entirely controlled by the amount of gas made  
70 as follows: The heating surface of the boiler is fixed and the water level is automatically maintained constant, hence the amount of steam generated and introduced through the  
75 free inlets 56 and 57, is regulated by the amount of heat liberated in the combustion chamber which again is proportional to the amount of gas generated and the fuel thus consumed. The products of combustion  
80 pass through the outlet of the generator 58 into a sinuous passage lined with refractory heat insulating material. This heat insulating material is of such depth that in the ordinary operation of the generator the heat of the products of combustion and of the vaporized carbon suspended therein will  
85 be so conserved that only a small portion of the vaporized carbon is condensed in the form of fine and highly-porous carbon on the passage. Such condensation will accumulate to only a moderate depth because,  
90 first, the carbon thus deposited, being a poor conductor, will add to the heat insulation by such condensation and thus limit the depth; and second, because the carbon-dioxid formed by any perfect combustion which  
95 may take place in the combustion-chamber, coming in contact with this deposit of incandescent carbon, gives up a molecule of oxygen which attacks the incandescent carbon, forming a molecule of  
100 carbon-monoxid and leaving of the original carbon-dioxid another molecule of carbon-monoxid. The chemical equation of this combination is  $\text{CO}_2 + \text{C} = 2\text{CO}$ . The surface of the sinuous passage may be further kept  
105 from accumulation to a great depth by the carbon which deposits being attacked by the oxygen and hydrogen of the decomposed steam admitted below. This passage is preferably so arranged that the gases and  
110 other products from the combustion-chamber are caused to be continuously stirred and to impinge against the walls of the passage. For the purpose of simplicity of construction the design shown in the drawings is  
115 preferred. The gases after passing through the opening 58 move along into the horizontal way 59 and impinge against the wall 60, passing through the opening 61, through the horizontal way 62, impinge upon the  
120 wall 63, and pass through the opening 64 into the horizontal way 65, and so on to the outlet 66. The sinuousness of the passage is increased by baffles 660.

The opening 67 leads to the stack 68 controlled by a stack-valve 69. This stack is  
125 for the purpose of creating draft for starting the fire in the producer or for any other similar purpose. The side-walls of the ways 59, 62, 65, etc., as well as the end-walls 60 130

and 63, etc., are surfaces against which carbon is condensed. The partition-walls 70, 71, 72, etc., are of heavy fire-brick or other similar material for the purpose of diverting the flow of gaseous substances as desired. Carbon also deposits on these surfaces. The special brick 73 and 74 are designed to be removable and may be got at through the doors 76 and 77 for the purpose of examining the inside of the combustion-chamber and the first passage 59, and for the purpose if found necessary, of removing from these two spaces any surplus carbon which may have accumulated to the detriment of perfect operation. This has been necessary in generators of this type heretofore, though it is expected that the improvements embodied in this invention make it unnecessary to open the producer at any point except at very long intervals.

The amount of gas generated to supply any given demand is controlled by the regulation of the amount of air forced into the generator as follows:—78 is a blower supplying the air which may be driven from the engine 79 through shafting and belts 80. This blower is equipped with a safety-valve 81 having adjustable weights 82. The adjustment of these weights limit the maximum pressure of air supplied, and thus fix the maximum rate at which the gas may be produced. After starting the plant into operation the gas passes from the producer 6 through the pipe 83 to the seal 84 having the overflow 85; from thence by pipe 86 to the washer 87, from thence through the pipe 88 to the holder 89 which may rise until full, whereupon the contact-arm 90 will engage the rocker-arm 91 and through the medium of cable 92 over the pulleys 93, 94, from which it runs to the lever-arm 95 of the safety-valve 81, so that upon such contact the lever-arm 95 will be operated to cause air to escape from the safety-valve and thus prevent further gas-making.

If gas is being used or taken from the holder by means of pipe 96 and valve 97 for any purpose whatever within the limits of the capacity of the producer which has been previously adjusted by the weights 82 of the safety-valve 81, the holder upon rising and making contact with rocker-arm 91 will only move the lever-arm 95 of safety-valve 81 to such extent that the amount of air supplied to the producer will be in accordance with the demand or use of such gas taken from holder 89; and the producer will continue to make gas to meet the requirements through wide variations of demand; the amount of air forced into the producer being regulated as hereinbefore related, and such air will always take into the producer the correct amount of oil to produce a constant value of gas according to the adjustment of nut 33.

It is found in practice that at certain points in the apparatus carbon will deposit in quantities detrimental to continuous operation. Such deposits are easily removed by opening the stack-valve 69, shutting off the oil, and allowing only air to pass through the producer. With the form shown in Figs. 1 to 10 this may be done at intervals varying from one-half an hour to three hours apart, according to capacity and method of operating the producer. The length of time for which the stack is open at each burning-out may be from half a minute to a minute and a half. It is found that in this process of burning-out the surplus carbon the oil should be shut off some time before the stack-valve is opened, because the producer will make gas from the deposits for a short period, and the stack-valve should only be opened when the product is no longer an inflammable gas but is inert material, and this is determined by the flame of the usual tell-tale (not shown) on the gas-main leading to the holder.

With the form of combustion chamber shown in Figs. 11 and 12, the parts outside the combustion chamber will be of a construction corresponding to that previously described, but the oil is admitted at one end of the combustion chamber and the air at the other. 98 represents the restricted orifice through which the air enters a passage 99 and thence flows between the grids 100 into the combustion flue 101. The fuel oil will enter through the oil slot 102 and flow into the oil receptacle 103 passing through the port 104 underneath the iron baffle 105 and thence over the edge 106 of the oil receptacle 103 down the faces 107, 108 of the combustion flue. When this oil reaches the bottom of this flue, it will accumulate in the grooves 109 formed in the top of the grids 100 and here may be ignited through the normally closed opening 110 provided for the purpose, and combustion ensues in the flue, thus readily heating the same. For a time oil will continue to flow down the faces 107 and 108, and will reach the grids, combustion occurring from the grids upward. Such combustion and the products thereof, heat the whole exposed interior of the combustion flue and the chamber and passage leading therefrom; and the radiant heat from the walls and also the heat from the products of combustion passing over the oil in the receptacle 103 will cause distillation of the lighter hydrocarbons to occur from the surface of such oil, while the heavy residuum consisting of asphaltum or other combustible material will pass downward through ports 104 under the baffle 105, and will flow thence over the edge 106 and down the faces 107 and 108, where they will be subjected to the heat in the combustion flue, and thus will be readily consumed in such

flue or the immediate vicinity thereof. The air being admitted to that side of the flue opposite the faces 107 and 108, becomes heated as it rises. The asphaltum progresses through the flame zone toward the air-supply, and is thus heated so that combustion takes place readily in contact with the air. The distilled products from the oil in the receptacle 103 will, as described with reference to the apparatus of Figs. 1 to 10, mingle with the heated products, and this combustion of the residuum and flowing on into the passage beyond the receptacle will be broken up by the heat of such combustion to produce hydrocarbon gases, the same as heretofore described. It is understood that the relative proportions of the receptacle 103 and surfaces 107 and 108 are not limited to those shown in the drawings but may be varied as may be found necessary to secure the best results.

A distinctive feature of this process is that the freshly-supplied fuel approaches the zone of combustion in a thin sheet, and is subjected to rapidly-rising temperature, as distinguished from an instantaneous application of intense heat; and the combustion is maintained in such manner that the heat of combustion is applied at all times to the surface of the freshly-supplied fuel under all variations of amounts of gas made, the zone of combustion being kept close to the zone of distillation. Thus the various light hydrocarbon products of distillation of petroleum are liberated in their turn as they approach the zone of maximum heat. At this zone of maximum heat sufficient residuum or material which is not capable of much further distillation, is supplied to furnish the heat and to entirely satisfy the oxygen of the supplied air, leaving the hydrocarbon-vapors previously distilled unattacked by oxygen and still in a nascent gaseous form, and being held in this state mingling with the hot gaseous product of the combustion of the residuum, are broken up into closely-related hydrocarbon-gases; the ultimate products showing a very high percentage of illuminants and methane, relative to the amount of carbon-monoxid.

The air, before it reaches the resisting orifice 98, may be heated to any extent found desirable, by passing through pipes or passages in contact with any suitable exterior portions of the generator where the heat may be picked up for the purpose of heating such air.

It has been demonstrated in actual practice with the form of slide A shown in Fig. 1, that each inch in width of each slide A and corresponding length of fuel-slot 7 and air-port 4, will generate 1300 cubic feet per hour of gas containing 230 B. T. U. when California asphaltic crude-oils of 16° gravity Baumé is used; the fixed gas delivered,

containing approximately 70 per cent. of the heat-units originally contained in the oil supplied to the producer.

In practical operation the deposits of carbon 111 will be in an incandescent state.

It is thus seen that the process takes place in the confined space formed by the combustion chamber and the sinuous passage; and that the deposits of carbon are produced around a mass of vapor and gases that are constantly mixed under the action of heat and that the contents of the mass of vapor and gas are subjected to contact with an external heated surface formed by the walls of the sinuous chamber.

I claim:—

1. The method of producing gas, which consists in supplying to a heated chamber air and hydrocarbonaceous material having light and heavy constituents; there separating the lighter constituents from the heavier constituents; causing combustion of the heavier constituents, thereby producing heat; applying such heat to produce from the lighter constituents without kindling the same, fixed hydrocarbon-gases; mingling these hydrocarbon-gases with the fixed products of combustion in contact with incandescent carbon, and thus producing a fixed inflammable gas.

2. The method of producing fixed gas, which consists in causing a continuous flow of air and oil into the combustion-chamber, the oil flowing toward the air; causing combustion of the oil at the confluence of the oil and air; causing the distillation of the more volatile portions of the oil by the heat of such combustion before such volatile portion reaches the zone of combustion, satisfying the oxygen of the air-supply by the combustion of the residuum and thereby maintaining sufficient heat in the zone of combustion to break up the distilled vapors and so convert that portion of the oil into hydrocarbon-gases; and then causing these products mingled together to pass onward through heated passages in contact with hot carbon, thus adding carbon to any carbon-dioxid formed in the flame-zone and reducing this carbon-dioxid to carbon-monoxid, the resultant gas being a mixture of carbon-monoxid, hydrocarbon-gases and a small percentage of free hydrogen.

3. The method of making producer gas set forth, which consists in supplying to a confined space, oil and air under a common pneumatic pressure and thereby causing adjustable proportionate amounts of oil and air to be supplied in said space; igniting portions of the oil and thereby consuming the air; adjusting the proportions of oil and air until a flame results from the ignition of a portion of the mixture and until only a partial combustion ensues; employing the heat thus developed to dissociate and distil

without kindling the remainder of the fuel introduced into said space, thereby producing a heated vaporous mass; causing said mass to move onward meanwhile retaining the heat of the mass and continually stirring and mixing the materials of said mass; depositing from said mass at the outer limits thereof a thin coating of incandescent carbon from portions of the gas in said mass; bringing other portions of the gas into contact with such carbon deposit, thereby taking up the carbon and continuing the process without material cooling of the mass until there is eliminated from the mass the combustible hydrocarbon vapors and such vapors are transformed into hydrocarbon gases.

4. The method of producing gas from hydrocarbon oil, which consists in mingling in a confined space atmospheric air and hydrocarbon vapors under a heat sufficient to effect partial combustion and to break up hydrocarbon vapors into gases; then conducting the resulting product onward in a mass and causing deposits to form around the body of the gases, maintaining such deposit at a high temperature and a fixed thickness by constantly depositing carbon from the gaseous vapors and taking up carbon by gases having an affinity therefor, thus causing the carbon-dioxid contained within the mass to give up a portion of its oxygen and to take up a portion of the carbon from the deposit, thereby forming carbon-monoxid from the dioxid originally formed, also keeping whatever portion of the fuel may be in the form of a distillate or vapor from the original petroleum at a high temperature sufficiently high to gradually convert such portion of the fuel into the nearest hydrocarbon compound which is a gas.

5. In the process of making gas from hydrocarbon oils, the method set forth which consists in maintaining a heated passage having a carbon lining, and conducting therealong gas containing carbon-dioxid at a temperature to break up in contact with said lining to form a carbon-monoxid product; the temperature of said carbon lining being practically maintained at a degree at which the condensation of carbon and the breaking up of the carbon-dioxid will balance each other substantially as and for the purpose set forth.

6. The process set forth of producing fixed combustible gas which consists in supplying to a producer-chamber determined proportions of hydrocarbon oil and air, causing a partial combustion of the oil in said chamber for the purpose of producing heat sufficient to gasify the oil, thereby producing some carbon-dioxid and various other carbon compounds, conducting said products from said producer-chamber

through a passage having a lining of carbon, and maintaining said lining at such a temperature by suitable heat-insulation as to condense the free carbon-vapor at a certain rate, thus supplying carbon to the molecules of carbon-dioxid, thereby transforming the carbon-dioxid to carbon-monoxid; the carbon thus condensed on the semi-heat-insulated walls being dissipated by contact with the carbon-dioxid and for any particular proportion of air and oil remaining practically constant in depth.

7. In the process of making gas, the method set forth of regulating the quality of gas, which consists in applying air-pressure on opposite sides of a resistance in the air-supply source, to the opposite sides of a resistance in the oil supply source and thereby maintaining an accurate ratio between the air-supply and the oil supply.

8. The method of regulating the flow of oil into a gas-producer, which consists in supplying air under external pressure through a resistance to produce a pressure in the combustion-chamber of the producer, supplying oil to said combustion-chamber through a body of oil having an overflow both inside and outside the combustion-chamber, a resistance to the flow of oil being introduced in the body of oil, and applying said external air pressure to such body of oil exterior to the resistances to maintain a flow of oil requisite to supply the producer.

9. The method of regulating the flow of oil into a gas-producer, which consists in supplying air under external pressure through a resistance to produce a pressure in the combustion-chamber of the producer, supplying oil to said combustion-chamber through a body of oil having an overflow both inside and outside the combustion-chamber, a resistance to the flow of oil being introduced in the body of oil, applying said external air pressure to such body of oil exterior to the resistances, to main a flow of oil requisite to supply the producer, and adjusting the resistance in the oil-body for the purpose of adjusting the quality of gas.

10. In the process of making producer-gas with liquid-hydrocarbon and air, the method set forth of adjustably proportioning the oil and air, which consists in maintaining a body of oil between and in open communication with the combustion-chamber and with an external air-chamber, supplying oil to said body, allowing overflow of the oil from such body both outside and inside the combustion-chamber, supplying air under pressure to an air-inlet and through such inlet to the interior of the combustion-chamber and applying a like pressure to the air on the surface of the oil-body outside the combustion-chamber and thereby causing the level of the oil to rise and fall in the combustion-chamber as the

pressures at the inlet and in the combustion-chamber relatively vary to increase and decrease the amount of oil discharged into the combustion-chamber.

- 5 11. The method of regulating the flow of oil into a gas-producer which consists in supplying air under external pressure through a resistance to produce a pressure in the combustion-chamber of the producer  
10 and then applying said external air pressure to a body of oil having an overflow

both outside and inside the combustion-chamber, and supplying oil to such body of oil to maintain a flow thereof requisite to supply the producer.

In testimony whereof, I have hereunto set my hand at Los Angeles, California, this 21st day of May 1909.

ORVILLE H. ENSIGN.

In presence of—

JAMES R. TOWNSEND,  
M. BEULAH TOWNSEND.

15

It is hereby certified that in Letters Patent No. 1,064,625, granted June 10, 1913, upon the application of Orville H. Ensign, of Los Angeles, California, for an improvement in "Methods of Producing Gas," errors appear in the printed specification requiring correction as follows: Page 8, line 88, before the word "thereby" insert the words *at a point sufficiently remote from the place of separation to prevent contact of the lighter gases with the oxygen or the flame*; Page 9, line 110, for the word "main" read *maintain*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 19th day of August, A. D., 1913.

[SEAL.]

THOMAS EWING,  
*Commissioner of Patents.*