(No Model.)

A. HENNIN.

PROCESS OF MAKING AMMONIA AND GAS.

No. 459,193. Patented Sept. 8, 1891.

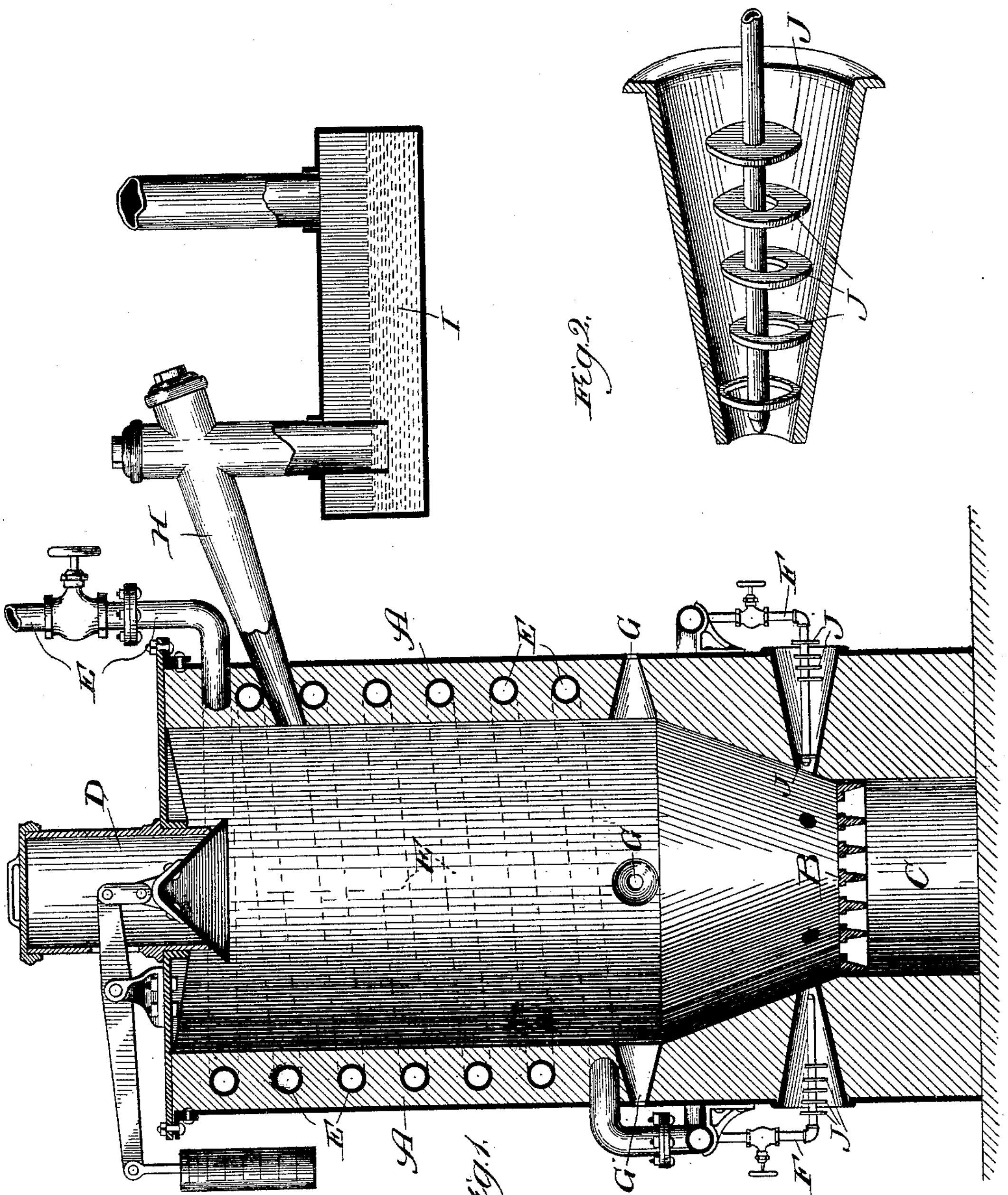

Fig. 2.

Fig. 1.

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PROCESS OF MAKING AMMONIA AND GAS.

SPECIFICATION forming part of Letters Patent No. 459,193, dated September 8, 1891.

Application filed December 24, 1889. Serial No. 334,842. (No model.)

To all whom it may concern:

Be it known that I, ALPHONSE HENNIN, a citizen of the Republic of France, and a resident of Springfield, Illinois, have invented new and useful Improvements in Processes for the Manufacture of Ammonia and Gas, of which the following is a specification.

The object of my invention is to simultaneously and continuously generate gas and ammonia from bituminous coal, shale, or other suitable fuel, and, stated broadly, I accomplish this result by introducing air and steam or oxygen and steam, the steam being preferably, though not necessarily, superheated, into the incandescent portion of a body of fuel contained in any suitable vessel or generator, regulating the amount of air or oxygen so as to maintain a zone of incandescence or body of fire of sufficient size and temperature to decompose steam and reduce carbonous to carbonic oxide, (CO_2 to CO,) while also maintaining a sufficient body of fuel at a lower temperature beyond such zone of combustion to allow of the formation of ammonia, and causing the gases to pass off at a temperature sufficiently low to prevent the disassociation of the ammonia.

In the accompanying drawings I have shown one form of apparatus which may advantageously be used to carry out my process and which I myself have used; but I do not desire to be understood as limiting myself to this form alone, inasmuch as any other suitable apparatus may be used, if desired, provided it is capable of carrying out the various steps of the process hereinafter described.

Figure 1 represents a vertical sectional view of the generator used in my process, and Fig. 2 an enlarged view of the injector and washers.

A is the generator; B, the grate; C, the ash-pit; D, the feed-hopper; E, the steam-pipe coiled within the generator-wall; F F, a series of injecting-tuyeres with adjustable reducing-rings; G G, poker-holes; H, a pipe for the escaping gases, and I a water-main.

The generator A is made in any desired shape, preferably round, and of suitable refractory material. It is provided with the well-known bell and hopper D, through which the fuel is fed, and holes G G, through which the fuel may be stirred and broken up as desired. At a point preferably a short distance above the grate B, I construct a number of radial tuyeres F, and into these tuyeres I insert steam-injectors, as shown, provided with suitable cocks or valves to control the admission of the steam. Steam is supplied to these injectors from any boiler by means of a pipe E, which is preferably coiled within the walls of the generator, as shown, in order to superheat the steam by means of the radial heat.

A pipe H is provided to carry off the gases produced and to conduct them to a hydraulic main I. If the air is to be used with the steam it is drawn in through the tuyeres by means of the injectors, and the same method is employed with a steam and oxygen blast, the tuyeres in this case being connected with any suitable oxygen-supply. (Not shown.) By placing the injecting tuyeres just above the grate I am enabled to introduce the air or oxygen and steam to the hottest part of the fire, and to insure a more uniform distribution and complete decomposition of the steam. I also avoid the necessity of shutting off the blast when cleaning the grate and removing ashes, as must be done when the blast is introduced into the ash-pit unless the inconvenient plan of a water seal is adopted.

The water-main I is connected with any suitable apparatus for condensing and cleansing the gas, and which, being well known, requires no further description.

Upon the injectors I mount adjustable reducing-washers J J, made of any suitable material, and shown more particularly in Fig. 2. These washers are formed with holes of different sizes, and when it is desired to control the amount of air or oxygen admitted one of the washers is pushed inward, as shown at the right hand of Fig. 1, and only so much air as can pass between the injector and the washer is admitted. If it be desired to lessen this amount, another washer having a smaller hole is pushed inward, and so on. This is, however, but one way of regulating the air-supply, and any other suitable mechanism may be used as a damper, the object of this part of my invention being merely to control the supply of air or oxygen admitted to the fuel.

The apparatus being constructed as above described, my process is carried out in the following manner: Bituminous coal, shale, or other suitable fuel is introduced through the hopper and ignited and allowed to burn until a bed of incandescent fuel five or six feet in thickness is formed. At about the same time a blast of air or oxygen and superheated steam is admitted through the tuyeres. The producer is then gradually filled up until the coal reaches a depth of from ten to twelve feet, the upper portion of this charge consisting of green coal drying and partially distilling. In this portion or zone, which I call the "black zone," the temperature is not allowed to rise above 350° centigrade, being regulated by feeding in fresh fuel, as required, and most of the liquid hydrocarbons of the fuel are here driven off. Immediately below this zone lies a zone of a higher temperature, in which the volatile matters of the coal are distilled. The temperature of this zone of distillation varies from 350° to 700° centigrade. Here practically all of the volatile matters are distilled and a percentage of ammonia formed equivalent to about twenty pounds of sulphate per ton of coal consumed. Any steam arriving at this zone of distillation is decomposed, forming carbonic oxide (CO,) carbonous oxide (CO_2,) and hydrogen (H,) and the nascent hydrogen unites with the nitrogen of the coal to form an additional amount of ammonia. The amount of carbonic oxide (CO) formed in this zone is below fifty per cent. of the amount of carbonous oxide (CO_2,) since the temperature, although sufficiently high to decompose steam, is too low to convert all of the CO_2 into CO, which reaction commences at 550° centigrade, and is only complete at a temperature of 1000° centigrade. Below this zone of distillation lies a still hotter zone, the temperature whereof varies from 700° to 1000° centigrade, and which I call the "zone of combustion." It is into this zone that the steam and oxygen or air are introduced, as above stated. In this zone a large amount of steam is decomposed, half of the fixed carbon of the coal being thus oxidized, setting free an equivalent amount of hydrogen, and by then properly regulating the supply of air or oxygen the remainder of the carbon is oxidized, raising the temperature to the point proper for the reduction of the CO_2 to CO. All of the nitrogen of the fuel is, by contact with the nascent hydrogen, set free from the fuel and converted into ammonia. The hot zone in which these reactions occur does not exceed, say, a few inches, and the ammonia formed there is instantly removed by the action of the exhauster along with any steam remaining undecomposed to a region already cooled by the reduction of CO_2 into CO and mostly secured in the upper zone, where decomposition of ammonia cannot occur, owing to the low temperature, and where all of the steam remaining is decomposed.

I have by means of this process, with very crude and imperfect means of separating the ammonia from the gas, obtained ammonia equivalent to about half of the nitrogen contained in the coal, and simultaneously therewith obtained a fuel gas of the following composition: CO_2, 6.5 per cent.; CO, twenty-nine per cent.; CH_4, 2.25 per cent.; H, forty-three per cent. (Experiments at the time showed that still more ammonia was formed but escaped, owing to the imperfect condensation.) This gas is practically free from undecomposed steam, and posseses the proper qualities of a high grade of gas for heating and metallurgical purposes, one of the main points of my process.

As far as I am aware I am the first to accomplish the conversion of fifty per cent. or more of the nitrogen of the coal into ammonia under conditions which would allow of the reactions which take place in my process, especially of the conversion of the CO_2 produced in the zone of combustion into CO, and thus enabling me to produce simultaneously with the ammonia a gas very low in carbonic acid (CO_2) and high in carbonic oxide (CO.)

The greatest care must be taken to regulate the temperature of the various zones. If the temperature rises too high, no ammonia will be formed, or, if formed, will be immediately disassociated by the heat. The ammonia and gases are allowed to pass off at a temperature low enough to prevent the dissociation of the ammonia. They pass through the pipe H into the hydraulic main, from whence they are drawn into any of the well-known apparatus for separating the ammonia, removing the tar and other impurities.

I am aware that in previous gas processes air has been heretofore used to blow up the fire, and that after a sufficient bed of incandescent fuel has been formed the air has been shut off and steam admitted to the fire and decomposed, and, furthermore, that air and steam have been simultaneously admitted to the fire; but in these processes the gases that first pass off from the fuel are generally burned or used to heat a separate chamber, to which the gases created by the decomposition of steam, &c., are to be admitted for the purpose of fixing or permanently combining them through intense heat. As this is precisely what I desire to avoid, I use no superheating or fixing chamber, nor do I consume the gases first coming off the coal, since I desire to preserve and utilize these gases, which are among the most useful products of the distillation. I am thus able to secure all the gases contained in the coal for fuel purposes, and hence my process will produce more gas per ton of coal than any other now known.

The object of the former process has been to obtain a fixed combined gas for illuminating and other purposes, and in order to do this intense heat has been necessary both in the generator and in the retort or fixing-chamber, whereas, my object being to simultaneously produce ammonia and gas, I dispense with any retort or fixing-chamber, and using merely the simple generator I so control the temperature at different points thereof as to first decompose the steam and reduce the carbonous oxide (CO_2;) second, to allow the ammonia to form, and, lastly, prevent its disassociation.

If any ammonia has been made in the former processes for the production of gas other than the retort or illuminating-gas process, it has been a by-product produced unintentionally and almost accidentally, and has been at once destroyed by the heat that was necessarily used to accomplish the purpose of the inventions. Its formation was a thing rather to be avoided than sought, and, if formed, it must at once be destroyed. In the majority of prior gas processes ammonia could never be formed at all, and if formed it would last but an instant and then be destroyed, as above stated, so that the operator would be in ignorance of its formation and no advantage could be taken of it. In the ordinary process of making illuminating-gas in closed retorts a certain percentage of the nitrogen of the coal combines with hydrogen and forms ammonia, which is collected in the scrubbers and purifiers; but the larger portion of the nitrogen still remains in the coke and is lost. In all previous fuel-gas processes the ammonia has been neglected, if not altogether lost sight of. As stated before, it has either never been formed or at once destroyed. I have, however, discovered, after careful investigation and experiment, the possibility of so controlling the operation of the generator that ammonia can not only be made simultaneously with the fuel-gas and separated from it without detriment to the quality of the gas, but that the nascent hydrogen of the decomposed steam unites with most of the nitrogen, which would be lost in the coke of the retort-gas process. I am thus able to secure as a by-product from three to four times as much ammonia per ton of coal consumed as is secured in the retort-gas process. The low temperature which I maintain in the coolest zone of the generator, where the gases escape, also enables me to secure, at the same time with the ammoniacal liquors, a considerable quantity of tar of a superior quality, thus adding still further to the value of my by-products.

The increased demand for ammonia to be used as a fertilizer and for other purposes has increased the price thereof, and consequently I am able to dispose of the ammonia I manufacture at such a price as to greatly lessen the cost of the gas produced therewith, inasmuch as it costs little, if any more, to produce both the ammonia and the gas by my process than it costs to produce ammonia or gas alone.

Although I have alluded to three zones—the zones of combustion, of distillation, and the black zone—it will be evident to any one skilled in the art that there can be no well-defined line between them, but that one must gradually fade into the other, and that there may be considered to be one or more intermediate zones in which part of the reaction of each of the principal zones may take place in a gradually-diminishing degree.

The operation, being once commenced, may be carried on as long as desired, the gas and ammonia being simultaneously produced throughout the operation.

Although I have shown and described the steam and oxygen or air as entering at the same point, it will be evident that the steam-blast may be admitted at one point and the oxygen or air blast at another, provided they are simultaneously introduced. By the use of a blast of oxygen instead of air-blast I avoid the introduction of atmospheric nitrogen, which is not only useless but positively injurious to the gas, and I am thus able to produce a hydrogenized producer gas of high calorific value, which is practically free from nitrogen and is all combustible, consequently much more economically distributed and more efficient and valuable for fuel purposes.

I claim—

The process of simultaneously and continuously making gas and ammonia, which consists in injecting air or oxygen and steam into a bed of incandescent fuel, controlling the temperature of the generator, first, by introducing such proportions of steam and oxygen or air as to maintain a zone of combustion at a temperature sufficient to reduce to carbonic oxide (CO) practically all the carbonous oxide (CO_2) formed by the complete combustion of the fuel and to decompose practically all the steam so introduced in the blast, and, second, by regulating the supply of fresh fuel to maintain beyond the zone of combustion a zone of distillation cool enough not only to allow the formation of ammonia, but to prevent the disassociation of that already formed, leading off the ammonia and gas and separating them by condensers, washers, or other suitable means, substantially as described.

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Witnesses:
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