H. F. WALLMANN.

PROCESS OF MANUFACTURING GAS.

APPLICATION FILED JUNE 4, 1908.

1,146,776.

Patented July 13, 1915.

2 SHEETS—SHEET 1.

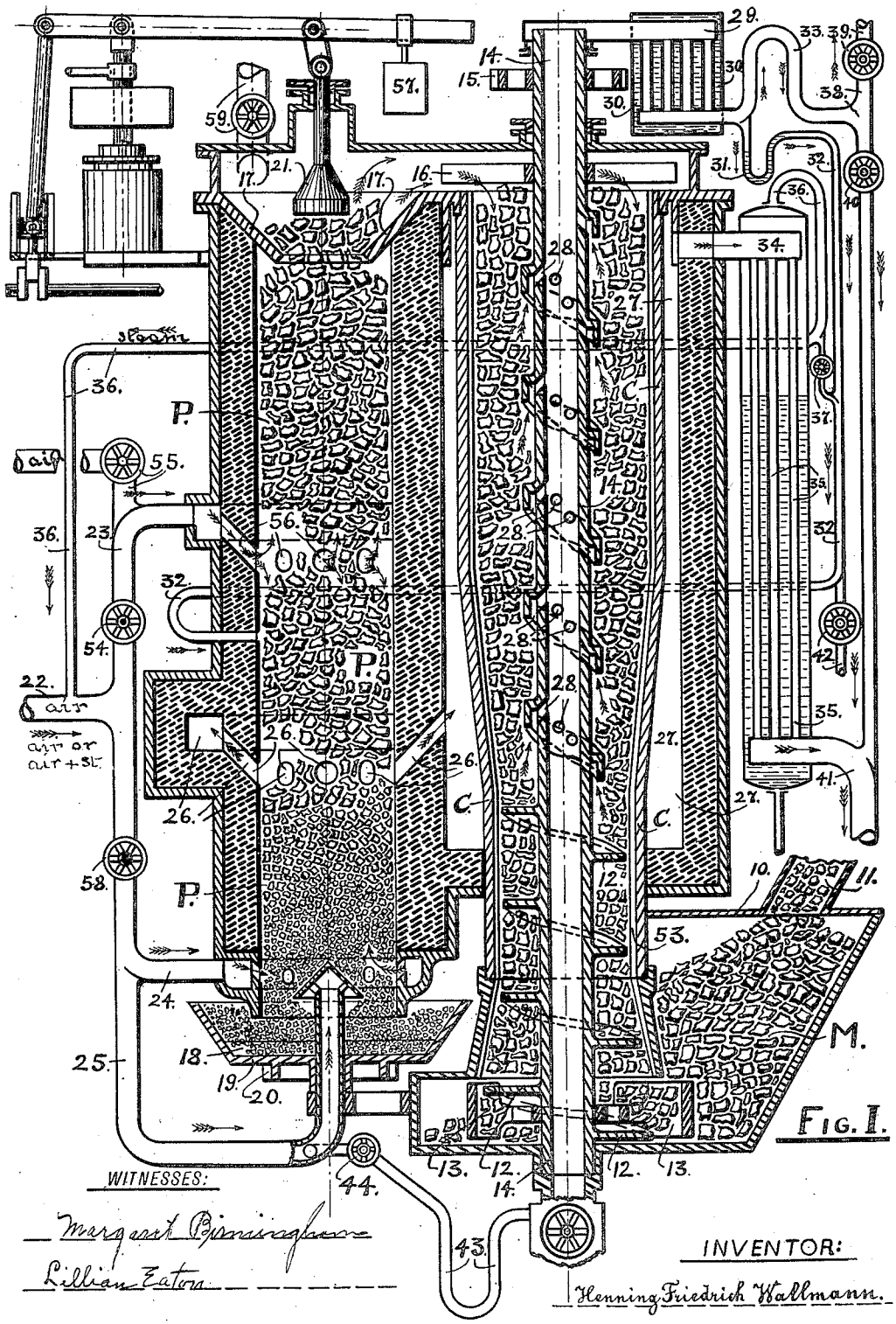


FIG. I.

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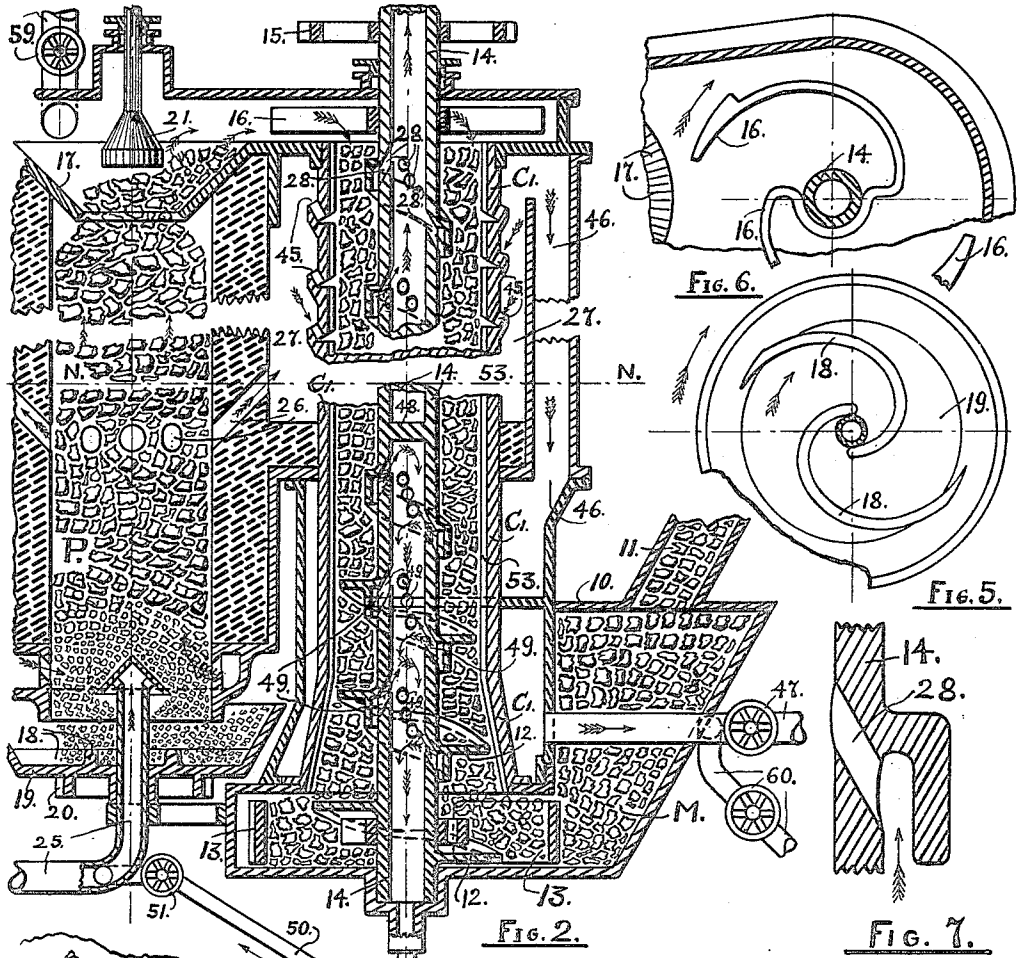


FIG. 2.

FIG. 6.

FIG. 5.

FIG. 7.

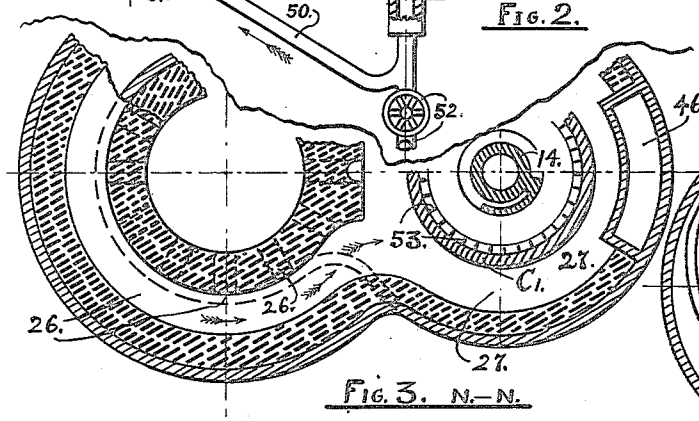


FIG. 3. N.—N.

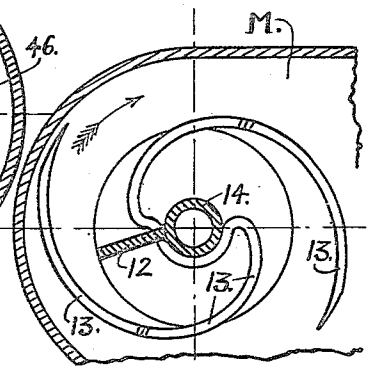


FIG. 4.

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UNITED STATES PATENT OFFICE.

HENNING FRIEDRICH WALLMANN, OF CHICAGO, ILLINOIS.

PROCESS OF MANUFACTURING GAS.

1,146,776. Specification of Letters Patent. Patented July 13, 1915.

Application filed June 4, 1908. Serial No. 437,186.

To all whom it may concern:

Be it known that I, HENNING FRIEDRICH WALLMANN, a citizen of the United States, residing in Chicago, in the county of Cook and State of Illinois, have invented a new, useful, and Improved Process of Manufacturing Gas, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming a part of this specification, in which similar letters and numerals of reference in the different figures indicate like parts.

My invention relates to the process of generating gas, or, preferably, gas and coke or charcoal or carbon and liquid distillates as tar, paraffin, ammonia, etc., out of solid fuel, preferably out of carbonaceous material, containing volatile substances, as for instance, out of bituminous coal, lignite, peat, wood, straw, cornstalks, garbage, etc., and the objects of my improvements are:

First, to provide a continuous process of distilling solid fuel of the kind named and of separating thereby volatile substances from the not evaporated residue.

Second, to provide a continuous process of consuming not evaporated volatile residue of the said distilling process, preferably by generating substantially carbon-monoxid and hydrogen, and to utilize the generated sensible heat of the generated products of combustion or of the generated gases for distilling newly supplied solid fuel of the kind named and for evaporating volatile substances contained therein.

Third, to simultaneously and separately generate by a continuous process two kinds of gases, one of superior grade having an odor or smell, and, preferably, containing substantially no nitrogen, and another gas of inferior grade substantially without an odor or smell and containing, on account of the nature of the process of its production, a considerable portion of nitrogen, the gas of superior grade being the product of distillation of solid fuel of the kind named, and the gas of inferior grade being preferably the product of a combustion of free carbon in the residue of the said distillation with air and, preferably, also with the oxygen of disassociated steam to carbon-monoxid.

Fourth, to separate the condensable distillates from the first kind of gas of superior grade and to, preferably, introduce these distillates into burning residue of previously distilled fuel.

Fifth, to unite and mix the said two different kinds of gases wholly or partly in order to produce a high grade fuel-gas with the peculiarity of possessing an odor or smell preventing the danger of poisoning people by leakage of gas or inadvertently left open gas valves.

Sixth, to utilize the sensible heat of the said gas of inferior grade, first, for distilling out of newly supplied fuel the said gas of superior grade and, second, for generating steam which by being introduced into the burning residue of the previously distilled fuel, becomes disassociated into its chemical elements and improves the gas of inferior grade by the supply of a portion of hydrogen thereto and by augmenting the portion of carbon-monoxid therein.

Seventh, to utilize the sensible heat of the said gas of inferior quality, first, for distilling dried, previously moist fuel, such as lignite, peat, wood, straw, cornstalks, garbage, etc., and, second, for drying such moist fuel before it undergoes the process of distillation, the generated steam being preferably introduced into burning residue of previously distilled fuel for the purpose stated under sixth.

Eighth, to produce a uniform gas of superior grade and also a uniform gas of inferior quality by, preferably, evaporating in every unit of time such a quantity of volatile substance in proportion to the synchronously consumed fixed or free carbon as corresponds with the proportion of the volatile substance to the free carbon as it exists in the natural state of the fuel used, or if some residue of distillation or some distillates are withdrawn for separate use from the progressing process before all of the fuel is converted into permanent gases, leaving as final solid residue only the ashes, to automatically regulate the supply of fresh fuel to the location of its distillation and the supply of the non-evaporated residue to the location of its gasifying in such a way as will result in the production of a uniform gas or two kinds of uniform gases without that the quantity of the gas or gases required and generated has an influence on the quality of the gas or the gases. As the quantity of the latter mostly depends on the amount of heat evolved, and as this

amount of heat depends in turn on the amount of free carbon consumed, the consumption of the residue of distillation may afford a means for regulating the supply of fuel and the production of gas.

Ninth, to distil the newly supplied fresh fuel preferably in one of two substantially parallel and preferably vertical vessels or conduits of which the second one is employed for gasifying residue of recent distillation.

Tenth, to preferably agitate the fuel in the vessel or conduit used for its distillation and to compress the residue of the distillation in the vessel or conduit used for its gasifying, and eleventh, to remove the generated condensable vapors and distillates either by leading the same with the generated permanent gases through a body of incandescent residue of recent distillation and by thus destroying the condensable vapors and distillates, or by concentrating the latter in a comparatively small quantity of permanent fixed gases from which they may be separated without much difficulty and may then be removed or destroyed.

These improvements are partly embodied in the construction illustrated and described in my Letters Patent No. 1,047,348 of Dec. 17, 1912, for "Gas generating apparatus."

The gas generating apparatus employed for carrying out this process may be provided with an automatic regulation of the fuel supply effecting that in every unit of time so much volatile substance of the fuel is evaporated and so much of the condensable vapors thereby generated are destroyed as correspond to the natural proportion of the free carbon consumed.

The sensible heat of the generated gases is in the above mentioned gas generating apparatus partly transferred by means of superheated steam to solid fuel moving within a conduit between a magazine for solid fuel and a vessel for gasifying solid fuel and for destroying condensable distillates evaporated from the solid fuel. The latter is thus heated and anyhow partly distilled before it has entered the vessel used for gasifying non-evaporated residue of the distillation, and before it has a chance to absorb heat from the chemical process converting such non-evaporated residue into gas.

It will be remembered that a noticeable process of distillation begins already at the temperature of boiling water or at 100° centigrade. On this basis the theory of my improvements will be understood from the following: In order to produce out of free carbon a gas with the highest possible heat value, it is necessary to mix the air burning the free carbon to carbon-monoxid with the maximum amount of steam that can be dissociated into its chemical elements by the generated heat. The amount of this heat represents for a certain kind of bituminous coal a certain fixed number of units of heat. However, a certain amount of this heat cannot be utilized for the disassociation of steam, because the gases leaving the vessel for gasifying the free carbon have a temperature which is in any case high enough to maintain incandescence. On the other hand, a certain amount of heat is required for supplying the latent heat absorbed by the evaporation of the volatile substance contained in the said certain kind of bituminous coal. If this volatile substance is evaporated by heat generated by means of an air current entering into a fuel-bed, used in common for the two processes of distillation and of gasifying the residue of distillation, in about the same direction as the newly supplied bituminous coal, in order to carry the condensable distillates into and to destroy the same within the incandescent, non-volatile residue of the distillation, and if in consequence the process of distillation takes place almost side by side with the process of consuming the oxygen supplied by entering air and steam, then the latent heat required for distillation is withdrawn from the process of gasifying the non-volatile residue of the distillation, and the heat available for the disassociation of steam becomes less for the amount of the said latent heat. I therefore distil the fuel more or less before the residue of its distillation enters the fuel-bed for its combustion to substantially carbon-monoxid and for the accompanying disassociation of steam, and for this purpose I transfer the sensible heat of the gases issuing from this fuel-bed to another vessel used specifically for distilling newly supplied fuel. This method is of minor importance, if the generated gas can be or is to be used in a hot state, for instance, for heating a boiler placed side by side with the gas producer. But if the gas is to be used in a cold state, as, for instance, in a gas engine, or if it has to be transported for a considerable distance, it is important to utilize the sensible heat of the gases in the way described and shown. Said sensible heat of the gases may be transferred in different ways to the fuel to be distilled. In the above quoted Letters Patent I use superheated steam for the conveyance of heat. The steam and the distillates pass later through the incandescent residue of the distillation in order to produce disassociation of steam into its chemical elements and in order to destroy the condensable vapors, such as tar, ammonia, etc. However, the heat of the incandescent free carbon does not only destroy the condensable vapors, it also destroys the odor of the distillates. Excessive heat destroys the odor. In the case that the generated gas is consumed in the vicinity of its production, the odor of the gas may

be irrelevant, but as the gas is very poisonous, the odor is of great importance as an advertiser of danger, if the gas is to be transported a considerable distance and to be distributed over a large district.

In this present application for Letters Patent I have shown a device for preserving the odor of the distillates of dry or dried fuel, and I have also shown a device for simultaneously generating illuminating gas and fuel gas. These devices may be combined with a device for drying moist fuel, such as peat, lignite, wood, garbage, etc., and for introducing the resulting steam and vapors into incandescent residue of recent distillation. In the case that the fuel contains so much water as to make impossible a disassociation of the created steam into its chemical elements by the combustion of non-evaporated residue of distillation to substantially carbon-monoxid, I either burn this residue to substantially carbon-dioxid in order to generate the heat required for distilling and drying the fuel, in which case the evaporated steam and vapors are allowed to escape into the atmosphere, or I burn the non-evaporated residue of distillation, as in most cases referred to, to substantially carbon-monoxid, and introduce only a part of the steam and the vapors generated into the said not-evaporated residue of distillation, allowing the rest of steam and vapors to escape into the atmosphere as in the first case mentioned. In the case, however, that it is of importance to destroy the steam and the vapors generated in drying the fuel, as, for instance, in drying garbage containing elements of contagion, I add so much coal to the garbage as to obtain by the gasifying of not-evaporated residue of distillation a sufficient quantity of heat for disassociating all the steam and vapors generated in drying the garbage, and I destroy thus all the elements of contagion.

This will be fully understood by referring to the drawings, in which—

Figure 1 is a vertical section through the main parts of a gas-generating-apparatus adapted to simultaneously generate out of bituminous coal two different kinds of gases, namely, illuminating gas and a fuel gas, or, preferably, a mixture of both, namely, a high grade fuel gas with the peculiarity of its presence being perceivable by its bad odor. Fig. 2 is a vertical section of a modification, Fig. 3 is a horizontal section at the line *n*—*n* of Fig. 2. Fig. 4 is a plan-view of the catch arms. Fig. 5 is a plan-view of the ribs employed for the removal of the ashes. Fig. 6 is a plan of the arms employed for removing the residue of distillation from the conduit used for distillation. Fig. 7 is a section through a part of the wall of the hollow spindle 14.

On top of the magazine M for solid fuel is the cover 10 and a spout 11 for supplying solid fuel to said magazine M.

C is a conduit for distilling solid fuel while in motion, and is provided inside with a screw conveyer 12 surrounding a perforated hollow spindle 14 adapted to receive the distillates from the fuel within the surrounding conduit C. The hollow spindle 14 carries at its lower part the spiral or involute catch-arms 13 adapted to cram solid fuel from the magazine M into the screw conveyer 12 and into the conduit C. A ratchet wheel or gear wheel or any other suitable mechanism 15 is rigidly connected to the upper part of the hollow spindle 14 and is adapted to rotate the catch arms 13, the screw 12, and the arms 16 of a similar shape as that of the catch arms 13, but bent in the opposite direction to the rotary motion of the spindle 14 to which they are rigidly fastened. The arms 16 are adapted to remove solid fuel from the top of the conduit C into a hopper 17 arranged on top of a vessel P, which is adapted to gasify the not-evaporated residue of previous distillation with the exception of the ashes which are removed by the rotation of ribs 18 projecting on top of the rotary plate 19 which is rigidly connected to a ratchet wheel or gear wheel or to any other suitable mechanism 20 adapted to revolve the plate 19 with its ribs 18 which are of a similar shape as the catch arms 13, but bent in the opposite direction to their rotary motion, whereas the catch arms 13 are bent in the same direction with their rotary motion. By revolving the plate 19 and its ribs 18, the ashes are removed from the space around the center of the vessel P toward its periphery. On top of the vessel P is suitably arranged the mechanical pusher and feeler 21 adapted to cram solid fuel through the lower opening of the hopper 17 into the vessel P, to somewhat compress the fuel and to push and move the fuel toward the ash removing plate 19 very slowly, but as fast as the fuel is consumed by the process of gasifying. Besides the mechanical pusher 21 may automatically regulate the speed of the ratchet or gear wheels 15 and 20 and may thereby regulate the fuel-supply, and the pusher 21 may thereby regulate the fuel supply, the fuel conveyance and the removal of the ashes.

By revolving the spindle 14 and the plate 19 and by reciprocating the mechanical pusher 21, the catch arms 13 cram the fuel from the magazine M into the screw conveyer 12 which lifts the fuel to the top of the conduit C from where the arms 16 dump it into the hopper 17. The mechanical pusher 21 pushes the fuel then down toward the plate 19 which finally removes the ashes. This shows that during every instant of the whole process of distillation and gasifying, the fuel is mechanically conveyed with an

automatic regulation of the speed which may be slow, but is as fast as the fuel is converted from a solid body into a gaseous body leaving only the ashes for final mechanical removal.

A pipe 22 and branch pipes 23, 24 and 25 supply air and, preferably, steam to the vessel P for converting not-evaporated residue of previous distillation substantially and preferably to carbon-monoxid and hydrogen, the generated gases being discharged through the openings and canals 26 into an annular space 27 surrounding the conduit C, for heating and distilling the solid fuel therein. The gases in afterward flowing through the boiler tubes 34 and 35 superheat and generate steam, which is carried through the steam pipe 36 to the air supply pipe 22 and which flows with the air therein into the vessel P. The distillates emanating from the fuel in the conduit C enter through holes 28 into the interior of the hollow spindle 14 and are discharged from the upper end thereof through a tube 29 into an apparatus 30 adapted to cool the distillates, to liquefy the condensable vapors therein, and to separate the same from the permanent, fixed gaseous distillates. The liquefied vapors, as tar, paraffin, ammonia, etc., flow through a siphon 31 and a pipe 32 into the incandescent fuel within the vessel P. Some steam may be introduced from the steam pipe 36 through the valve 37 into the liquefied vapors within the pipe 32 in order to promote the flow of these liquids. The permanent gaseous distillates flow from the cooling apparatus 30 through the pipe 33 into the T 38 and may wholly or partly be discharged either through the valve and pipe 39—in the case that this gas or a portion thereof is to be used as illuminating gas—or through the valve 40 in order to mix these permanently gaseous distillates with the gases resulting from the partial combustion in the vessel P, which latter gases after imparting their sensible heat to the conduit C and to the boiler tubes 35 are discharged through a pipe 41 suitably connected by a T and pipe to the valve 40.

As the liquid distillates of certain kinds of fuel are valuable and useful for other purposes, they may be withdrawn from the gas generating process and apparatus by means of the valve and pipe 42.

The distillates generated in the conduit C may be withdrawn from the lower end of the hollow spindle 14 instead of from its upper end and the condensable part of the distillates may thus more or less be liquefied by the cooling effect of the green fuel entering into the lower end of the conduit C, with a simultaneous transference of sensible and liberated latent heat to the green fuel.

The advantage of the construction shown in Fig. 1 mostly consists in the greater facility to carry the liquefied distillates by their own gravity into the incandescent fuel within the vessel P or, if desired, into any suitable receptacle below the spindle 14 and the conduit C. Any vapors which may condense within the hollow spindle 14 may be carried through the pipe and siphon 43 and the valve 44 into an air supply pipe 25.

The conduit C (Fig. 1) is tapered, with increasing areas of its cross sections in the direction of the motion of the fuel, in order to facilitate such motion, especially in the case that the fuel expands when heated, as does, for instance, bituminous coal. In other cases the conduit C might have a straight shape as shown in Fig. 2.

The drawing shows a full screw of the diameter of the conduit only around the lower part of the hollow spindle 14, and around the upper part of the same only some projections in the shape of a screw with greater pitch than the pitch of the screw below for agitating the fuel in the upper part of the conduit C, thereby facilitating the flow of the distillates, and for protecting the holes 28 in such a way as to prevent the solid fuel entering into the interior of the hollow spindle 14. Ribs 53 may prevent a rotation of the solid fuel with the rotating screw 12 and spindle 14.

The temperature of the gases generated in the vessel P and discharged through the holes 26 into the annular space 27 is naturally high enough to maintain incandescence between the upper and lower combustion zones in the vessel P, but the temperature of the said gases is hardly high enough to heat the conduit C to red heat. This comparatively low temperature of distillation has the following consequences: First, the conduit can be made of cast iron, especially if the fuel contains no or only a small amount of sulfur, in which case the conduit C might be provided with an inside lining as a protection against the sulfur. Second, with a comparatively low temperature of distillation the distillates have a high illuminating power and a strong odor, and the condensable distillates, after being liquefied, are a thin liquid, of almost the consistency of water. The quantity of the gas produced with a comparatively low temperature of distillation is naturally smaller than the quantity of gas produced with a higher temperature of distillation. But as the illuminating gas is in this case only a by-product or a means for imparting an odor and a greater heating value to fuel gas, this distillation of fuel at a comparatively low temperature has great advantages, although it may not be perfect inasmuch as some volatile substances may be carried with the non-volatile residue of the distillation into the vessel P. For this reason I preferably employ in the latter vessel

a lower and an upper zone of combustion with a double object. In the case that the permanent gaseous distillates issuing from the conduit C are to be used as illuminating gas and if, in consequence, any introduction of nitrogen into this gas is not admissible, I prefer to carry the volatile substance contained in the residue of distillation into a body of incandescent free carbon (coke), in order to destroy the hydrocarbons such as pitch, tar, etc., and in this case the combustion in the said lower and upper zone is promoted by a combined up and down current of air. The down current of air carries the tar, pitch, etc., into incandescent free carbon which is furthermore heated by the up current of air, and thus tar, pitch, ammonia, etc., are destroyed. But in the case that the permanent gaseous distillates are to be mixed for the purpose stated, with gas generated by a partial combustion of the non-volatile residue of distillation to substantially carbon-monoxid, and if, in consequence, it does not matter if said distillates are sooner or later mixed with some nitrogen, I prefer in some cases to introduce into the fuel not perfectly distilled a portion of the hot gas generated in the vessel P by the partial combustion of residue of previous distillation, for more effectively heating and perfectly distilling such fuel. This may be done in different ways.

In Fig. 2 the upper part of the shell forming the conduit C^1 is perforated, having holes 45. The gas issuing from the vessel P through the holes 26, after passing the annular jacket 27, may enter through the holes 45 into the fuel within the conduit C^1 and mix with the distillates generated therein. The mixture flows through holes 28 into the interior of the hollow spindle 14 from where it enters into the cooling apparatus 30, Fig. 1, or into any other suitable apparatus adapted to separate the condensable from the permanently gaseous distillates.

Another way of more effectively heating and perfectly distilling the fuel, before its residue of distillation is gasified, may be procured by causing a part of the gases generated in the lower part of the vessel P by the partial combustion of residue of previous distillation to flow through the whole body of the fuel contained in the vessel P and then through the hopper 17 into the upper end of the conduit C or C^1 and thence through the holes 28 into the hollow spindle 14.

The best way from a theoretical view is illustrated in Fig. 1 and explained in the following: The valve 54 is closed and dry air without the usual addition of steam may be supplied through the pipe and valve 55 and the holes 56 into the vessel P. The holes 56 may be placed at equal distance from the holes 26 and from the hopper 17, and the valve 54 and the pipe connection 23 between the pipe 22 and the holes 56 may be dispensed with. The air may be supplied from the same source to the pipe 22 and to the pipe 55, but no steam should preferably be admitted to the pipe 55 and the holes 56. The air entering through the latter is caused to flow toward the hopper 17 and in burning first residue of previous distillation generates heat and evaporates thereby all the volatile substance in the upper part of the vessel P. As no heat is absorbed in the disassociation of steam, all the heat generated by the up current issuing from the holes 56 may be converted into the latent heat which is absorbed by the distillation of the volatile substances in the upper part of the vessel P and the distillates are consequently mixed with the smallest possible amount of nitrogen. Therefore I preferably use in the vessel P two up currents, one on top of the other, one entering at the lower end of the vessel P and being discharged through the holes 26, the other entering through the holes 56 and being discharged through the top opening of the vessel P and the hopper 17. The lower up current consists of a mixture of air and steam, the upper up current of pure air only.

Of course, if the apparatus is used for manufacturing illuminating gas without an ingredient of nitrogen, and if the residue of distillation is used for manufacturing non-illuminating fuel gas, it is simpler to use an up and down current in the vessel P for destroying any condensable volatile matter not evaporated in the conduit C or C^1. On the other hand, the combination of two up currents in the vessel P might be used for manufacturing an odoriferous fuel gas without a preparatory distillation of the fuel in the conduit C or C^1, but in this case the sensible heat of the gases generated by the lower up current is not well utilized and the quantity of the gas containing the condensable distillates is greater than in the case that a part of the distillation takes place without nitrogen penetrating the fuel under distillation. The difficulty of separating the condensable distillates from the permanent gases becomes consequently greater and increases in proportion to the greater quantity of the latter. Finally some air might be introduced into the upper end of the conduit C or C^1, in order to have the fuel perfectly distilled therein. But the upper part of the spindle 14 might become too hot, especially as long as the ratchet wheel 15 and the arms 16 are fastened thereto.

The different methods of distilling fuel containing volatile substances as above outlined may be used separately and independently from each other, but they may prefferably be combined and mutually contribute to produce a single result. The

nature of the specific fuel distilled and the special purpose the generated gas is to be used for, determine the best way of distilling under the prevailing circumstances and conditions.

In Fig. 2 a portion of the gas generated in the vessel P after circumflowing and heating the upper part of the conduit C^1 may flow down in the canal 46 and may then, after circumflowing and heating the lower part of the conduit C^1, and after drying thereby any moist fuel therein, be discharged through a pipe and valve 47. The distillates from the upper part of the spindle 14 may, preferably after being purified, be mixed with the gas issuing from the pipe and valve 47, or the purified distillates and the gas issuing from the pipe and valve 47 may be used separately.

The interior of the hollow spindle 14 is separated by a partition 48 into a lower and an upper part. Steam and vapor generated in the lower part of the conduit C^1 may enter through holes 49 into the lower part of the hollow spindle 14 and through a pipe 50, valve 51 and air pipe 25 into the incandescent fuel within the vessel P. Or, if desired, this steam and vapor may partly or wholly escape through the valve and pipe 52 into the atmosphere. By making said part of the spindle 14 below the partition 48 and the corresponding part of the conduit C^1 long enough a part of the vapors and distillates generated at the upper end of said parts by the heat of the hot gas issuing from the gas outlet 26 and flowing through the canal 46 toward the pipe and valve 47, may be caused to condense and to liquify at the lower end of said parts by the cooling effect of the green fuel supplied into the lower end of the conduit C^1. In such case the resulting liquids may be withdrawn with the assistance of their gravity from the lower end of the hollow spindle 14 and of the conduit C^1 through a pipe 50 or 52 or in some other suitable way as has been explained with reference to the construction illustrated in Fig. 1. The advantages afforded by the general construction used for this process may be realized in considering that a withdrawal of liquified distillates from the upper part of a distillation conduit is met with difficulties and that in order to produce great heat economy by the applied process, it is profitable to move the fuel under distillation and the generated distillates in opposite directions with respect to each other within a distillation conduit toward their respective outlets therefrom, for transferring heat from the distillates to green fuel.

It is of some importance that the fuel in the vessel P is pushed down and somewhat compressed by means of the mechanical pusher 21 which may be made sufficiently heavy, or the weight and the resulting pressure of which may be sufficiently increased by an outside weight 57 Fig. 1, or spring, as will be understood by any mechanic. By the action of the mechanical pusher 21 and by the compression of the fuel below the pusher 21 the formation of any cavities and holes in the fuel is prevented, and the fuel moves down at the same rate as with which it is consumed by the process of gasifying. The result is a greater uniformity of gas.

It will be understood that, as in most other processes of manufacturing gas, some power is required for producing an air current and that besides some power is required for operating the means employed for fuel supply, fuel conveyance, removal of the ashes, and for the operation of the pusher 21. But the air current may just as well be pressed by an air pump or blower into the pipes 22 and 55 as the gas may be sucked out of the pipes 41, 39 or 47, as is done in other processes of manufacturing gas.

The proportion of the gas which can be produced by distillation to the gas which has to be produced by a partial combustion of residue of previous distillation, depends naturally on the chemical composition of the fuel used. If a certain kind of fuel is used, two air pumps might be employed, one for sucking the permanently gaseous distillates out of the pipe 39, the other for sucking the gasified residue of previous distillation out of the pipe 41. The proportion of the quantity of gas delivered by one of the pumps to the quantity of the gas delivered by the other pump should correspond to the proportion of the volatile substance to be distilled to the residue of previous distillation to be gasified. And corresponding to this proportion the air inlet valves 58 and 55 should be adjusted, as will be understood by any mechanic.

As the vessel P may be of any suitable size, several screw conveyers in conduits C or C^1 for distilling fuel may be so arranged as to dump the residue of distillation into a single common vessel P for gasifying the combustible matter in such residue, or only one of the several conduits C or C^1 may dump the residue of distillation into a vessel P, whereas the other conduits C may dump into some suitable receptacle for storing the residue of distillation (coke) or for using the residue for the intermittent process of generating water-gas. Such receptacle may be adapted to such purpose, but is no part of this invention.

The operation of the apparatus preferably used for this process of manufacturing gas may be started by kindling some wood on the plate 19 and filling the magazine M with anthracite coal or coke. By means of a valve 59 on top of the vessel P a communication from this vessel to a chimney may be opened,

and after the wood at the bottom of the vessel P is burning the spindle 14 may be started to burning the spindle 14 may be started to rotate for conveying anthracite coal or coke to the top of the conduit C from where it drops on the burning wood at the bottom of the vessel P. After a sufficient quantity of anthracite coal is in incandescence, bituminous coal or other fuel containing volatile substance may be supplied into the magazine M. The valve 59 may be closed and an air current be introduced through the pipe 22 and later through the pipe and valve 55. Then the plate 19 may be started to rotate and the pusher 21 to reciprocate. The first gas will not be odoriferous and it may be well to arrange a by-pass valve in the gas discharge pipe 41 or 47, or in the delivery pipes of the gas pumps for allowing the first gas to escape into the atmosphere as will be understood by any mechanic. But as soon as the apparatus has its regular temperature and as soon as in consequence the gas becomes odoriferous, the valves may be turned so as to lead the gas to its place of destination. In the case that a portion of the manufactured gas is consumed in the neighborhood of its production, for instance, for the propulsion of large gas engines, it may be of advantage to use for such purpose the gaseous products of partial combustion only without having them mixed with the permanently gaseous distillates, in order to use the greatest possible amount of the latter for the mixture to be distributed at greater distance from the location of the manufacture of gas. The gas discharge pipe 47 (Fig. 2) may therefore, before being united with the discharge pipe of distillates from the valve 40 (Fig. 1), be provided with a branch discharge pipe and valve 60, in order to discharge through this valve gaseous products of partial combustion not mixed with distillates. In the case that at certain hours of the day a great quantity of such gaseous products of partial combustion is consumed, the simultaneously generated permanently gaseous distillates may be stored for later consumption in a gas holder, as is in common use in the manufacture of gas.

In some of the claims I use the words: "continuously consuming (burning) combustible (fuel), etc., to gaseous products of substantially unvaried chemical character". These words "continuously" and "substantially unvaried" are to be understood as having no other meaning and as being used for no other purpose than to differentiate between my process and certain well known watergas processes, *i. e.* processes which intermittently produce gases of chemical characters different from each other.

What I claim as my invention, and desire to secure by Letters Patent is:

1. The process of manufacturing gas which consists in burning within a vessel residue of distillation with air to carbon-monoxid, withdrawing first portion of the products of combustion, introducing a second portion thereof into fuel for distilling the same, separating condensable distillates from permanently gaseous distillates mixed with products of combustion, and mixing such mixture with the said first portion of products of combustion.

2. The process of manufacturing gas which consists in burning a first portion of residue of distillation to carbon-monoxid, simultaneously burning a second portion of residue of distillation to carbon-monoxid, introducing the products of combustion of the second portion of residue into fuel for distilling the same, separating condensable distillates from permanently gaseous distillates mixed with products of combustion, and mixing such mixture with products of combustion resulting from the burning of the first portion of residue.

3. The process of manufacturing gas which consists in burning a first portion of residue of distillation to carbon-monoxid and hydrogen, simultaneously burning a second portion of residue of distillation to carbon-monoxid, introducing the products of combustion of the second portion of residue into fuel for distilling the same, separating condensable distillates from permanently gaseous distillates mixed with products of combustion, and mixing such mixture with products of combustion resulting from the burning of the first portion of residue.

4. The process of manufacturing gas which consists in drying moist fuel, withdrawing generated steam and vapors from the dried fuel, distilling the dried fuel, separately withdrawing distillates from the residue of distillation, introducing air into residue of distillation and generating heat by the combustion thereof, transferring a portion of the generated heat to fuel under distillation, transferring another portion of the generated heat to moist fuel for drying the same, and introducing steam and vapors withdrawn from the dried fuel into hot residue of distillation for producing hydrogen and carbon-monoxid in the partial combustion thereof.

5. A continuous process of manufacturing gas which consists in continuously conveying moist fuel to a location for drying the same, drying the conveyed moist fuel, withdrawing generated steam and vapors from the dried fuel, continuously conveying the dried fuel to a location of distillation, distilling the dried fuel, separately withdrawing distillates from the residue of distillation, continuously conveying residue of distillation to a location for gasifying the same, introducing air into said residue of distillation and generating heat by its com-

bustion, transferring a portion of the generated heat to fuel under distillation, transferring another portion of the heat to moist fuel within the location for drying the same, and introducing steam and vapors generated by drying the moist fuel into burning residue of distillation for destroying the vapors and for producing hydrogen and carbon-monoxid by a partial combustion of said residue.

6. The process of manufacturing gas which consists in mixing moist fuel with coal, drying the mixture of moist fuel and coal, withdrawing generated steam and vapors from the dried mixture, distilling the dried mixture, separately withdrawing distillates from the residue of distillation, introducing air into residue of distillation and generating heat by its partial combustion, transferring heat from the partial combustion to dried mixture under distillation and to a mixture of moist fuel and coal for drying moist fuel, and introducing resulting steam and vapors into hot residue of distillation for destroying the vapors and for producing hydrogen and carbon-monoxid by a partial combustion thereof.

7. The process of manufacturing gas which consists in mixing garbage and coal, conveying the mixture to a location for drying the same, introducing air into residue of distilled mixture of garbage and coal and generating heat by a partial combustion thereof, transferring a portion of heat from said combustion to said location for drying said mixture, conveying the dried mixture to a location of distillation, transferring a portion of heat from said combustion to said location of distillation for distilling the dried mixture, separately withdrawing distillates from the location of distillation and evaporated steam and vapors from the location for drying, separating condensable distillates from permanently gaseous distillates and introducing condensable distillates and steam and vapors evaporated by drying the mixture of garbage and coal into hot residue of distilled mixture for destroying vapors and condensable distillates and for producing hydrogen and carbon-monoxid by said partial combustion of residue.

8. The process of manufacturing gas which consists in conveying fuel into a conduit for primary, imperfect distillation, heating and imperfectly distilling the fuel by heat conducted through the wall of the conduit, withdrawing distillates from the residue of distillation, removing the residue of primary imperfect distillation to a location for secondary distillation, penetrating the residue of primary imperfect distillation by hot gaseous products of partial combustion, thereby heating and secondarily distilling said residue of primary imperfect distillation, and mixing resulting mixture of distillates and gaseous products of partial combustion with distillates simultaneously evaporated in the location of the said primary, imperfect distillation.

9. The process of distilling which consists in, conveying a mass of fuel from an inlet for green fuel past a quantity of burning combustible toward a receptacle for combustible residue of distillation, preventing an entrance of a consequential amount of free oxygen from the atmosphere into said mass, continuously consuming combustible of said quantity to gaseous products of substantially unvaried chemical character, transferring heat from resulting gaseous products through a heat conducting wall to fuel of said mass, leading a portion of resulting gaseous products through fuel of said mass, and withdrawing from said mass synchronously but separately from each other resulting distillates and resulting mixture of distillates and of said products.

10. The continuous three-stage process of gasifying a mass of solid fuel, coked in part, which process consists in, continuously consuming and gasifying a coked part of said mass, thereby producing hot gas, continuously leading resulting gas to the outside of a retort for heating and distilling a non-coked part of the said mass therein, continuously leading a distilling agent through a partly coked part of the said mass, discharging resulting mixture of said agent and of distillates from a location between said non-coked and said partly coked part, and continuously discharging separately from each other said gas and said distilling agent.

11. The process of manufacturing distillates which process consists in, heating and thereby distilling a mass of fuel comprising a hotter and a colder portion, preventing an entrance of a consequential amount of free oxygen from the atmosphere into said mass, leading a fluid qualified to promote production of vapors into said hotter portion, withdrawing separately from each other two portions of resulting fluid from said mass, maintaining a passageway free of but within the solid bodies of said colder portion, leading one of the two withdrawn portions of said resulting fluid through said passageway, and thereby transferring heat from said one portion of fluid to fuel of said colder portion.

12. The process of distilling which consists in, conveying a mass of fuel from a location of lower toward a location of higher temperature and in consecutive order past one and past the other of two quantities of burning combustible, leading each one of two air-currents separately from the other one thereof into contact with one of said two quantities, thereby continuously promoting consumption of combustible of each of said two quantities to one of two portions of

gaseous products of substantially unvaried chemical character, transferring heat from one of said two portions to fuel conveyed in said location of lower temperature, leading gaseous products of the other of said two portions through fuel conveyed in said location of higher temperature, and withdrawing resulting fluid from said mass.

13. The process of manufacturing gas which process consists in, distilling moist solid fuel, discharging separately from each other resulting distillates and residue of distillation, cooling discharged distillates and thereby condensing a part thereof, discharging separately from each other two portions of cooled distillates, leading air and one of said two portions into discharged residue of distillation, and thereby gasifying this residue.

14. The process of distilling which consists in, separating from a mass of solid fuel a portion, supplying said portion to a location in operative proximity and lateral to but kept apart from and at the same level with a part of the rest of said mass, continuously consuming combustible of said portion to gaseous products of substantially unvaried chemical character, and leading resulting hot gaseous products into operative proximity with fuel of said rest of said mass for distilling this said fuel.

15. The process of distilling which consists in, supplying from a conduit containing fuel a portion thereof into a combustion chamber located in operative proximity and lateral to and at the same level with a part of said conduit, continuously consuming fuel supplied into said chamber to gaseous products of substantially unvaried chemical character, leading resulting hot gaseous products into operative proximity with fuel in said conduit, and continuously discharging separately from each other resulting distillates and solid combustible from said conduit.

16. The process of gasifying fuel which process consists in, heating solid fuel, simultaneously conveying the same toward a down-draft gas-generating chamber, maintaining an open passage-way free of solid bodies of said fuel but between such bodies heated and conveyed on opposite sides of the said passage-way, moving a side-wall of the said passage-way and thereby agitating said bodies, leading gaseous fluid through the said passage-way, promoting a down-draft through the said gas-generating chamber, and transferring heat from the said chamber to solid fuel conveyed on opposite sides of the said passage-way.

17. The process of distilling which consists in, conveying solid fuel through a conduit, supplying combustible into a combustion chamber located in operative proximity and lateral to and at the same level with a part of said conduit, preventing an entrance of a consequential amount of free oxygen from the atmosphere into said conduit, continuously burning combustible supplied into said chamber to gaseous products of substantially unvaried chemical character, leading resulting hot gaseous products through fuel conveyed in said conduit, and discharging resulting combustible residue of distillation and resulting mixture of distillates and of said products from said conduit.

18. The process of gasifying fuel which process consists in, distilling solid fuel under primary distillation, conveying residue of primary distillation toward a chamber for secondary distillation, maintaining an open passage-way free of solid bodies of said fuel, but between such bodies conveyed and distilled on opposite sides of the said passage-way, leading gaseous fluid through the said passage-way, promoting a down-draft through the said chamber for secondary distillation, thereby generating gas, discharging residue of secondary distillation into an up-draft gas-generating chamber, promoting an up-draft there-through thereby gasifying discharged residue, mixing gas resulting from said up-draft with such resulting from the said down-draft, and transferring heat from the resulting gas-mixture to said fuel under primary distillation.

19. The process of distilling which consists in, supplying a mass of hydro-carbonaceous solid fuel into one of two chambers located in lateral, operative proximity and partly at the same level with respect to each other, distilling a portion of said mass in said one of said two chambers, supplying resulting residue from said one into the other one of said two chambers, preventing an entrance of a consequential amount of free oxygen from the atmosphere into said one of said two chambers, consuming at the same level with a part of said mass combustible of said residue in said other one of said two chambers, and leading resulting gaseous products past said part for thereby distilling the latter.

20. The process of distilling which consists in, conveying solid fuel through a conduit, supplying combustible into a combustion chamber located in operative proximity and lateral to and at the same level with a part of said conduit, preventing an entrance of a consequential amount of free oxygen from the atmosphere into said conduit, continuously burning combustible supplied into said chamber to gaseous products of temperature higher than that of said fuel, transferring heat from one of two portions of resulting gaseous products through a metal wall to a part of the fuel conveyed in said conduit, introducing the other one of said two portions at substantially said temperature into another part of the fuel conveyed

in said conduit, and thereby transferring heat from said other portion to and distilling the conveyed fuel.

21. The process of gasifying fuel which process consists in, heating solid fuel and simultaneously conveying the same from a magazine for fuel toward a producer shaft comprising a down-draft and an up-draft gas generating chamber, maintaining an open passage-way free of solid bodies of said fuel, but between such bodies heated and conveyed on opposite sides of the said passage-way, moving a side-wall of the said passage-way and thereby imparting motion to the said fuel, leading a gaseous fluid through the said passage-way, promoting a down-draft in the said down-draft-gas-generating chamber, promoting an up-draft in the said up-draft-gas-generating chamber, and transferring heat from both said chambers to fuel conveyed on opposite sides of the said passage-way.

22. The process of distilling which consists in, conveying fuel within a conduit from a location of lower to a location of higher temperature, consuming combustible in a chamber located in operative proximity and lateral to and at the same level with a part of said conduit, continuously preventing an entrance of a consequential amount of free oxygen from the atmosphere into said conduit, transferring heat from said chamber to fuel conveyed in said conduit, supplying a gaseous distilling fluid not containing a consequential amount of free oxygen at said location of higher temperature into said conduit, thereby distilling fuel conveyed in said conduit, and leading resulting mixture of said fluid and of distillates from said location of higher toward said location of lower temperature.

23. The process of generating distillates which process consists in, elevating a mass of fuel from an inlet for green fuel past a quantity of burning combustible toward a receptacle for combustible residue of distillation, preventing an entrance of a consequential amount of free oxygen from the atmosphere into said mass, transferring heat from said quantity to fuel of said mass during its said elevating, thereby distilling fuel of said mass, simultaneously lowering resulting distillates within said mass, and discharging resulting distillates from proximity of said mass.

24. The process of manufacturing distillates, which process consists in, elevating fuel within a conduit, from an inlet for green fuel toward a receptacle for combustible residue of distillation, preventing an entrance of a consequential amount of free oxygen from the atmosphere into fuel elevated in said conduit, heating said conduit and thereby distilling fuel elevated in said conduit, and simultaneously lowering gaseous fluid within said mass toward an outlet for fluid.

25. The process of manufacturing distillates, which process consists in, elevating fuel within a conduit, from an inlet for green fuel toward a receptacle for combustible residue of distillation, preventing an entrance of a consequential amount of free oxygen from the atmosphere into fuel elevated in said conduit, leading a hot gaseous fluid into an upper part of said conduit, thereby distilling fuel elevated in said conduit, and lowering resulting mixture of said fluid and of resulting distillates within said conduit.

26. The process of manufacturing distillates, which process consists in, elevating fuel within a conduit, from an inlet for green fuel toward a receptacle for combustible residue of distillation, preventing an entrance of a consequential amount of free oxygen from the atmosphere into fuel elevated in said conduit, heating the wall of said conduit from its outside and thereby distilling fuel elevated within its inside, leading a fluid not containing a consequential amount of free oxygen into said conduit, and discharging generated distillates from said conduit.

27. The process of distilling which consists in, heating and thereby distilling a portion of a mass comprising a hotter and a colder portion of solid fuel, maintaining a chamber free of but between solid fuel of said colder portion, discharging distillates from said hotter portion into said chamber, condensing distillates within said chamber, and discharging resulting liquefied distillates from said chamber.

28. The process of manufacturing gas which process consists in, simultaneously conveying, heating and distilling a first and a second portion of a mass of solid fuel, withdrawing separately from each other a first and a second portion of distillates from said first and said second portion respectively of solid fuel, supplying air to resulting residue of distillation and thereby heating this residue to incandescence, heating distillates from said first portion of solid fuel in the presence of free oxygen within resulting incandescent residue, and heating distillates from said second portion of solid fuel in the absence of a consequential amount of free oxygen within said resulting incandescent residue, for fixing these distillates without consuming same by free oxygen.

29. The process of manufacturing distillates, which process consists in, heating and thereby distilling a mass comprising a hotter and a colder portion of solid fuel, maintaining a passageway free of but within the solid fuel of said colder portion, discharging separately from each other two portions

of resulting fluid from said mass, leading one of said two portions of fluid through said passageway and thereby transferring heat from said one portion of fluid to fuel of said colder portion.

30. The process of manufacturing distillates, which process consists in, heating and thereby distilling a mass comprising a hotter and a colder portion of solid fuel, preventing an entrance of a consequential amount of free oxygen from the atmosphere into said mass, leading a fluid qualified to promote production of vapors into said hotter portion, maintaining a passageway free of but within the solid fuel of said colder portion, and discharging fluid substance originating from said fluid and from said mass through said passageway toward the outside of said mass.

31. The process of distilling which consists in, conveying a mass comprising a colder and a hotter portion of solid fuel from a location of lower to a location of higher temperature, heating and thereby distilling said hotter portion, maintaining a passageway free of but between solid fuel of said colder portion, and discharging distillates from said hotter portion through said passageway toward the outside of said mass.

32. The process of distilling fuel which process consists in, conveying in a predetermined direction a mass of fuel, heating and thereby distilling said mass during said conveying, leading a portion of resulting distillates inside of but kept apart from said mass substantially in the same said direction, and leading another portion of said distillates inside of said mass in a direction substantially opposite to said direction toward the outside of said mass.

33. The process of distilling fuel which process consists in, conveying in a predetermined direction a mass of fuel, transferring heat through a heat-conducting wall to said mass during said conveying, leading a hot gaseous distilling fluid not containing a consequential amount of free oxygen into said mass, leading a portion of resulting distillates inside of but kept apart from said mass substantially in the same said direction, and leading another portion of said distillates inside of said mass in a direction substantially opposite to said direction toward the outside of said mass.

34. The process of distilling fuel which process consists in, leading into a mass of fuel a hot distilling fluid not containing a consequential amount of free oxygen, moving said mass toward and through an outlet for resulting combustible residue of distillation and toward a chamber, delivering into and discharging from said chamber said residue in consecutive order and thereby maintaining in said chamber a clearance beyond the space occupied in said chamber by said residue and by the natural interstices between the parts thereof, impeding an entrance of free oxygen from the atmosphere into said chamber, and discharging separately from each other distillates from said mass and residue of distillation from said chamber.

35. The combined process of distilling carbonaceous fuel and of manufacturing liquefied distillates which process consists in, conveying a mass of solid fuel from a location of lower to a location of higher temperature, heating and thereby distilling fuel in said location of higher temperature, moving resulting distillates into said location of lower temperature, simultaneously transferring heat from resulting distillates to solid fuel conveyed in said location of lower temperature, thereby condensing the liquefying condensable distillates, and withdrawing distillates in liquid form from proximity of said mass.

36. The combined process of distilling hydro-carbonaceous substance and of manufacturing liquefied distillates which process consists in, conveying a mass of solids combined with hydro-carbonaceous substance from a location of lower to a location of higher temperature, leading a fluid not containing a consequential quantity of free oxygen into said mass, heating and thereby distilling said substance in said location of higher temperature, delivering resulting distillates into said location of lower temperature, simultaneously transferring heat from resulting distillates to solids conveyed in said location of lower temperature, thereby condensing and liquefying condensable distillates, and withdrawing distillates in liquid form from proximity of said mass.

37. The process of distilling which consists in, conveying solid fuel through a conduit, supplying solid fuel into a combustion chamber located in operative proximity and lateral to and at the same level with a part of said conduit, continuously impeding an entrance of a consequential amount of free oxygen from the atmosphere into said conduit, leading air and gaseous products of combustion in a predetermined direction through solid fuel in said chamber, delivering gaseous products from said chamber into said conduit, and leading delivered gaseous products in a direction substantially opposite to said predetermined direction through solid fuel conveyed within said conduit for distilling this said fuel.

38. The process of distilling which consists in, conveying a mass of fuel from an inlet for green fuel in consecutive order past one and past the other of two quantities of burning combustible toward a receptacle for combustible residue of distillation, continuously consuming combustible of

each of said two qualities to gaseous products of substantially unvaried chemical character, withdrawing from said two quantities synchronously but separately from each other two portions of resulting gaseous products, transferring heat from one of said two portions through a heat conducting wall to fuel of said mass, and leading gaseous products of the other one of said two portions through fuel of said mass for the distillation thereof.

39. The process of generating a mixture of gaseous products of combustion and of distillates which process consists in, conveying a mass of fuel from an inlet for green fuel past a quantity of burning combustible toward a receptacle for combustible residue of distillation, preventing an entrance of a consequential amount of free oxygen from the atmosphere into said mass, continuously consuming combustible of said quantity to gaseous products of substantially unvaried chemical character, leading resulting hot gaseous products through fuel of said mass, and withdrawing resulting mixture of said products and of distillates from said mass.

40. The combined process of fractionally distilling solid fuel and of producing a plurality of separate quantities of liquefied distillates different from each other in their chemical character, which process consists in, continuously conveying a mass of fuel comprising a colder and a hotter portion from a locality of lower temperature in consecutive order past a plurality of quantities of burning combustible toward a locality of higher temperature, preventing an entrance of a consequential amount of free oxygen from the atmosphere into said mass, supplying air to each one of said quantities of combustible, thereby continuously consuming combustible of each one of the latter quantities of gaseous products of substantially unvaried chemical character, transferring resulting heat from each one of said quantities of combustible to fuel of said mass, withdrawing resulting distillates from said mass at localities of temperatures different from each other partly past said colder portion of said mass and partly past heat absorbing fluid toward a plurality of localities separate from each other, thereby transferring heat from said distillates to said colder portion and to said fluid, and producing by resulting condensation a plurality of separate quantities of liquefied distillates different from each other in their chemical character.

41. The combined process of fractionally distilling solid fuel and of producing a plurality of separate quantities of liquefied distillates different from each other in their chemical character, which process consists in, continuously conveying a mass of fuel comprising a colder and a hotter portion from a locality of lower temperature in consecutive order past a plurality of quantities of burning combustible toward a locality of higher temperature, preventing an entrance of a consequential amount of free oxygen from the atmosphere into said mass, supplying air to each one of said quantities of combustible, thereby continuously consuming combustible of each one of the latter quantities to gaseous products of substantially unvaried chemical character, transferring resulting heat from each one of said quantities of combustible to fuel of said mass, leading a fluid not containing a substantial amount of free oxygen into said mass, withdrawing resulting distillates from said mass at localities of temperatures different from each other, partly past said colder portion of said mass and partly past heat absorbing fluid toward a plurality of localities separate from each other, thereby transferring heat from said distillates to said colder portion and to said heat absorbing fluid, and producing by resulting condensation a plurality of separate quantities of liquefied distillates different from each other in their chemical character.

42. The process of distilling which consists in, conveying a mass of fuel within a conduit from an inlet for said mass past locations of lower to locations of higher temperature and toward an outlet for residue of distillation, thereby distilling fuel of said mass, discharging resulting distillates past said inlet, delivering resulting hot residue of distillation past said outlet into a second conduit, and compressing delivered hot residue.

43. The process of distilling which consists in, conveying a mass of fuel within a first conduit from an inlet for said mass past locations of lower to locations of higher temperature and toward an outlet for residue of distillation, thereby distilling fuel of said mass, discharging resulting distillates through an aperture adjacent to said inlet, delivering resulting hot residue of distillation past said outlet into a second conduit, furthermore heating in the latter said residue, and compressing the resulting hot residue.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

HENNING FRIEDRICH WALLMANN.

Witnesses:
LADISLAV VERISTNFER,
LILLIAN EATON.

It is hereby certified that in Letters Patent No. 1,146,776, granted July 13, 1915, upon the application of Henning Friedrich Wallmann, of Chicago, Illinois, for an improvement in "Processes of Manufacturing Gas," errors appear in the printed specification requiring correction as follows: Page 11, line 85, claim 35, for the article "the" read *and;* page 12, line 1, claim 38, for the word "qualities" read *quantities;* 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 15th day of August, A. D., 1916.

[SEAL.]

F. W. H. CLAY,

Acting Commissioner of Patents.

Cl. 48—202.