PATENT SPECIFICATION

688,915

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624

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COMPLETE SPECIFICATION

Improvements in or relating to the Production of Gas

We, ENTREPRISE GENERALE DE CHAUFFAGE INDUSTRIEL PILLARD FRERES & CIE., a French body corporate, of 60, Cours Pierre-Puget, Marseilles (Bouches-du-Rhône), France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a process and an installation for the production of town gas from a combustible such as lignite fines or other pulverized solid or liquid fuel.

It is well known to produce a gas by gasifying a combustible by means of steam and a gas containing free oxygen in a gasification zone (usually of the form of a vertical column), the gasification being performed under high pressure or otherwise and at a high temperature, the gases obtained leaving the vertical column to be subjected to the usual processes before use. It is also known to provide an air or water jacket between the wall of the gasification zone and the outer wall of the column so as to preserve the life of the refractories and, sometimes, to produce steam for use with the fuel to be gasified, thereby improving the thermal efficiency of the unit. But these known processes do not give a gas of high calorific power, that is, a high methane gas. The maximum proportion of methane is obtained when the pressure inside the column is high, the temperature not too high, and the time of gas contact with the walls is prolonged. However, the initial gasification of the fuel by the steam and the gas containing oxygen is best performed under high pressure and high temperature. The requirements are satisfied by two zones, a first zone hereinafter termed gasification zone and a second zone wherein the methane forming reaction occurs, with means for gradually decreasing the temperature of the gases formed by gasification to the lower temperature necessary for forming methane, and means for obtaining gas velocities securing a prolonged gas contact with the walls of the second zone.

This process is characterised in that the gases from the gasification zone pass through an aperture therein and thereafter through a diverging intermediate zone to said second zone of larger cross-sectional area than said gasification zone.

This process renders possible, owing to the initial gasification which occurs at a high temperature (between 1000 and 1200 degrees centigrade for example), the total suppression of any formation of tar, which is very objectionable owing to the fouling that it produces. Furthermore the reaction which follows the initial gasification and the methane-forming reaction take place continuously and enable the production under extremely simple conditions, and therefore at a very low cost, of a gas having a high calorific power (4000 to 4200 kilogramme-calories per cubic metre) from fuels which are practically worthless at the present time and encumber the ground spaces in mines.

The invention likewise relates to an installation of very simple construction for the application of this process. This plant is characterized in that said gasification zone is contained at the lower end of a long tubular vessel and communicates with an upper elongated zone through an upper aperture and an upwardly flared frusto-conical intermediate zone, means being provided for cooling said elongated and frusto-conical zones, and said elongated zone having a larger cross-sectional area than said gasification zone and terminating in an outlet for the gases produced.

Owing to this arrangement, any combustible particles which have not been gasified, and which the gases produced would have a tendency to entrain in an upward direction, descend again by gravity.

Other features and advantages will be apparent from the following description.

In the accompanying drawing, given merely by way of example:

Figure 1 is a diagrammatic longitudinal sectional elevation of an installation for the application of the process according to the invention;

Figure 2 is a horizontal section thereof on the line 2—2 in Figure 1, of the actual column of this plant; and

Figure 3 is a graph, giving, as a function of the temperatures in the gasification zone, chosen as abscissae, the quantities in gramme-molecules (for a gramme-molecule of effectively gasified carbon) of the gaseous products or products carried along by the gas to the outlet of the gasification zone (CO, CO_2, H_2, C), and of the gaseous products (oxygen and steam) introduced into the gasification zone.

According to the example of construction illustrated in Figures 1 and 2, the plant comprises a base 1, on the top 2 of which is fixed, by iron fittings 3, a chamber having a long vertical tubular body 4 of cylindrical form, of axis X—X, formed by a fluidtight assembly of iron sheets, capable of resisting, with the usual margin of safety, an effective internal pressure of at least 20 kilogrammes per square centimetre.

Except at its base this chamber has a concentric inner shell 6 forming an annular space 5 with the outer wall 4.

The lower part of the chamber comprises internally a thick heat-insulating lining 7 which defines the gasification zone 8. This zone has preferably the form of a surface of revolution about the axis X—X, its radial section having a substantially trapezoidal form *a b c d*, and the surface generated being at least approximately inscribed in a sphere.

The lower end of this zone 8 communicates by an orifice 9, preferably of upwardly flared form, arranged within the heat-insulating lining 7, and a metallic conduit 10 cooled by a jacket 11 with external circulation of water or other fluid, with a lock chamber 13 designed for removing any ash formed and remaining in the zone 8. This lock chamber 13 is provided with an inlet valve 14 and an outlet valve 15. This latter valve puts the lock chamber into communication with an ash discharge conduit 16. These valves 14 and 15 may open automatically or may be opened by hand against the resistance of springs 17, 18. The manual opening may be effected for instance through the medium of a rod 19 and of a tube 20 in which this rod slides, and of rods 21 and 22 respectively.

The zone 8 is connected by an aperture 23 to a zone 24 of frusto-conical or like form, defined by the upper part of the heat-insulating lining 7. This conduit 24 opens directly into the unlined part of the chamber 6, which forms, above the zone 24, an elongated zone 25, surrounded by the annular space 5.

In order to make the matter more explicit, the length of the frusto-conical zone 24 is of the order of from 2.50 to 3 metres, and that of the cylindrical part of the zone 25 is of the order of from 3.50 to 4 metres, for a zone having an internal diameter of the order of from 1 to 1.20 metre.

The upper end of the zone 25 has an outlet 26 for the gases formed.

This chamber has means for feeding pulverized fuel thereto as hereinafter described.

Into the gasification zone 8, open a number of injection nozzles, so oriented that their jets are directed tangentially to the zone and toward the aperture 23 which connects the zone 8 with the frusto-conical zone 24, as shown in Figure 2, which shows in dotted lines the arrangement of the said nozzles in plan.

In point of fact, each nozzle is double, or, to be more precise, is formed of two concentric nozzles 27 and 28.

Each internal nozzle 27 is fed under pressure independently of the other nozzles 27 by a pipe 30 with a mixture of steam and pulverized fuel. The pressure is for instance 20 kilogrammes per square centimetre. The steam is superheated to a temperature of the order of about 500 to 550 degrees centigrade. The particles of fuel are for instance such that they pass through a sieve of 200 meshes per square centimetre. The proportions of steam and fuel will be hereinafter specified.

Each pipe 30 is provided with a regulating valve 31. The mixture under pressure is obtained on the upstream side of this valve in any appropriate manner, for instance by means of a distributing appliance.

In Figure 1 only the feeding means relating to one nozzle 27 have been illustrated; the means relating to the other nozzles are identical.

According to this constructional example each pipe 30 is supplied, on the upstream side of the valve 31, with superheated steam coming from any boiler of standard type 32[a], furnishing for instance steam superheated to about

550° C. at a pressure of the order of 40 kilogrammes per square centimetre.

Between the steam supply and the valve 31 is arranged on the pipe 30, to the right of each distributor of pulverized fuel, an ejector formed of a nozzle 32 discharging into an ejector body 33. This body is in communication, through an aperture 34, provided at its upper part, with the bottom of fluidtight enclosure or chamber 35. At the top of this chamber opens the lower aperture 36 of a hopper 37 containing the pulverized fuel 38. A rotary-disc distributor 39, driven for instance by an electric motor 40, and a scraper 41, effect the distribution of the fuel in the form of a jet 42, which falls freely towards the aperture 34.

The vessel 35 is under a pressure in the neighbourhood of 20 kilogrammes per square centimetre, for there is a drop in the pressure of the steam issuing from the nozzle 32. The same pressure is exerted in the upper space 43 of the hopper above the pulverized material 38, by means of a pipe 44 which puts the vessel 35 into communication with the top of the hopper.

In order to obviate condensation, in the space 43, of a portion of the superheated steam which is thus admitted at a pressure of the order of 20 kilogrammes per sq. cm., the hopper comprises a double wall 45 in communication with the conduit 30 by a pipe 46. A reducing valve 47 is provided on this pipe for lowering the steam pressure to a value of the order of that (20 kilogrammes per sq. cm.) prevailing at 43 in the hopper. In this way it is possible to maintain in the interior of the hopper, and in particular in the upper space 43, a temperature of the order for example of 200 degrees centigrade, obviating any condensation of water in this hopper.

Each peripheral nozzle 28 is designed for the admission into the gasification zone 8 of gaseous oxygen at the same pressure as the mixture of steam and pulverized fuel, for instance at 20 kilogrammes per square centimetre. Each of these nozzles receives oxygen under pressure through a pipe 49. Only one pipe 49 has been shown. The similar pipes relating to the various nozzles 28 are connected in parallel to a common source of oxygen under pressure. Upon each pipe 49 is provided a regulating valve 50, preferably controlled by the flow of the steam. This may be done by the aid of any one of the known flow metres utilized for controls of this nature. To be specific, this flow meter may be constituted substantially in the following manner: on each side of an orifice 51, arranged in the pipe 30 connected to the associated internal nozzle 27, there is provided a differential pressure connection, formed of two tubes 52 and 53, which lead into a fluidtight casing 54, one on each side of a diaphragm 55. This diaphragm, maintained by two opposing springs 56 and 57, is connected to the control rod 58 of a servo-motor 59 of any known hydraulic, pneumatic or other type. The latter, by a rod 60 and a lever 61 for example, controls the valve 50 as a function of the difference between the pressures prevailing on the two sides of the orifice 51 in the pipe 30, that is to say, definitely as a function of the flow of steam through the orifice.

The plant is also provided with a series of tubes 62 for the admission of superheated steam into the elongated zone 25, substantially at the upper end of the zone 24. The tubes 62 are open at their lower ends, where they terminate preferably in outlet nozzles 63, directed obliquely downwards towards the axis X—X. These tubes 62 preferably extend upwards substantially throughout the entire height of the zone 25. They leave it radially at their upper ends, and are connected to a circular header 64. This header is itself connected to a source of superheated steam at a temperature of the order of 500 to 550° C. In the example illustrated, this header 64 is simply connected to the boiler 32ᵃ by a pipe 65 with a regulating valve 66 and a pressure-reducing valve 67, enabling superheated steam to be admitted to the zone 25 at a pressure equal to that which prevails in the column.

The regulating valve 66 may be manually actuated as illustrated, or may be controlled by a device, such as a thermostat, the flow depending on the temperature prevailing in the lower gasification zone 8, so that the flow of steam arriving by way of the outlet nozzles 63 in the zone 25 increases when the temperature rises in the zone 8.

Finally the annular space 5 which is designed to form a water jacket, surrounding zones 24 and 25, and thus to ensure a temperature regularly decreasing in an upward direction in the zones 24 and 25, receives water through a pipe 68, while the steam formed escapes through a pipe 69 to be used in any suitable manner or to the boiler 32ᵃ, or else to the tubes 62. Preferably this water is admitted at room temperature, and the pressure in the annular space 5 is of the order of that prevailing in the vessel 25, so that the inner wall 6 is substantially in pressure equilibrium on its inner and outer faces, and can therefore be less strong than the outer wall 4.

The plant is further provided with all the usual control devices, such as a pyrometer 70 in the zone 8, another pyrometer 71 at the level of the outlet nozzles 63, a thermometer 72 on the outlet pipe 26, a pressure gauge 73 in the zone 25, etc.

Man-holes 74 and 75 permit of inspection and repair.

The operation of the plant, which corresponds to the statement of the process according to the invention, is as follows:

Normal running being assumed to have been established, there is continuously admitted through the nozzles 27 into the zone 8, where the temperature is of the order of 1000 to 1200° C., a mixture at a pressure of 20 kilogrammes per sq. cm., for instance of superheated steam at 500 to 550° C. and pulverized fuel, while through the concentric nozzles 28 there is admitted a suitable quantity of oxygen at the same pressure.

The quantities will be specified hereinafter.

Owing to the tangential arrangement of the nozzles the final mixture that enters the zone 8 undergoes an intensive agitation therein, and undergoes a very thorough gasification (at least 90 per cent.) in conformity with the following reactions:

$$[I]\begin{cases} C+O_2=CO_2+94 \text{ cal.} \\ 2C+O_2=2CO+52 \text{ cal.} \\ CO_2+C=2CO-39 \text{ cal.} \\ C+H_2O=CO+H_2-32 \text{ cal.} \\ C+2H_2O=CO_2+2H_2-22 \text{ cal.} \end{cases}$$

It is therefore a mixture consisting essentially of CO, CO_2, H_2, the excess H_2O and O_2 not utilized, and of the small proportion of unburnt carbon of the order of 10 per cent. that passes, through the throat 23, into the frusto-conical zone 24.

The particles of unburnt fuel are carried upwards towards this zone by the gases, but by gravity these particles tend to fall back and remain in fact in the zone 24, where they continue to burn, yielding a fresh quantity of CO and CO_2. The gaseous volume increases. The form of this zone 24 enables this increase of volume to be taken into account.

In all this first part of the operation there is a liberation of heat. The metallic walls are protected by the refractory lining 7.

Towards the top of the zone 24 there is delivered into the ascending mixture the steam ejected at 63 by the tubes 62. Under the action of this steam there is produced in the region A of the zone 24 first the reactions:

$$C+H_2O=CO+H_2$$
$$C+2H_2O=CO_2+2H_2$$

with the last traces of carbon, which lowers the temperature of the mass, terminating the gasification; and then, immediately thereupon the reaction:

$$[II]\quad CO+H_2O \rightleftharpoons CO_2+H_2 \mp 10 \text{ cal.}$$

Above this region A, as the gaseous mixture rises, the temperature progressively falls, due to the action of the water jacket, until it reaches a value of the order of 300° C. at the outlet pipe 26.

Owing to this fall of temperature, formation of methane occurs in the region B of zone 25, according to the standard equilibrium reactions:

$$[III]\begin{cases} CO+3H_2 \rightleftharpoons CH_4+H_2O \pm 51 \text{ cal.} \\ CO_2+4H_2 \rightleftharpoons CH_4+2H_2O \pm 41 \text{ cal.} \\ 2CO+2H_2 \rightleftharpoons CH_4+CO_2 \pm 61 \text{ cal.} \end{cases}$$

It should be noted that, incidentally, a small portion of 2 to 3 per cent. of the methane obtained is obtained in the gasification zone 8 and in the zone 24, where a very slight formation of methane occurs.

Through the outlet 26 there is therefore collected a gaseous mixture formed of: CO_2, CO, remaining H_2, CH_4, H_2O (excess steam), H_2S, inert gases, such as nitrogen, and carrying the greater part of the ash formed by the impurities of the fuel utilised.

A very large part of the ash is in effect carried along by the gaseous mixture, so that the quantity of ash to be extracted through the lower lock chamber 13 by the set of valves 14, 15 is very small. It is to be noted that the double valve 14, 15 serves as a safety valve, owing to the springs 17, 18.

There is moreover no deposit of pre-distillation tars on account of the initial gasification in the zone 8, so that the plant undergoes practically no fouling.

At the outlet from the plant, the gases produced may be led, as known in itself, through cooling and dust-removing appliances, and then through a tower for washing with water, under pressure.

According to the sulphur content of the fuel utilized the gases may also be passed through an iron oxide purifier. Finally the inert gases, in particular the CO_2, may be eliminated in the known manner.

The output of methane, and even of its homologues, depends essentially on various factors, including: the initial composition of the charge; the pressure under which the charge is gasified; the temperatures of the products introduced into the various zones of the chamber; the scale of temperatures through the various zones of the chamber; and the duration of the passage of the gases through the chamber.

An inspection of the sets of equations set forth above calls for the following observations:

As regards the gasification reactions [I], those leading to the formation of hydrogen are endothermic, hence the necessity of a maximum superheating of the steam admitted (500° C. at least) in order that the thermal balance may remain positive in the gasification zone 8, notwithstanding as low a consumption of oxygen as possible.

Reactions [II] and [III] are equilibrium reactions. Reaction [II] is not affected by pressure. The methane-forming reactions [III] which are accompanied by a diminution of volume, are on the other hand greatly influenced by the pressure, for the volume of the gases decreases when the methane formation increases. Formation of methane is therefore promoted by the pressure, which will preferably be maintained between 20 and 25 kilogrammes per sq. cm. or more, the limit of the pressure depending only upon the mechanical strength of the plant.

Methane formation is, moreover, a function of the temperature and of the duration of the reaction.

From the law of mass action:

$$\frac{\text{Concentration of } CH_4 \times \text{Concentration of } H_2O}{\text{Concentration of } CO \times (\text{Concentration of } H_2)^3} = K$$

the concentrations being those obtained when once equilibrium is established. At atmospheric pressure the coefficient K decreases when the temperature of the reaction increases, according to a hyperbolic function. For a given value of K, however, corresponding to a given temperature, the time necessary for the establishment of equilibrium will become shorter as the temperature of the reaction becomes higher, that is to say, at low temperatures the theoretical concentration of CH_4 is very high, but the time necessary for obtaining this concentration is very great, and at high temperatures the final concentration of CH_4 is low, but is rapidly attained. The influence of pressure is expressed by an increase in the speed of reaction (due to the increase in the number of useful impacts between reacting molecules, according to the kinetic theory of gases), which is very favourable to formation of methane. There is not yet in existence any advanced study enabling the combined effect of these various factors to be expressed by experimental curves. What is certain is that the maximum concentration of methane is obtained by the following means:

(1) pressure in methane-forming reaction zone high;

(2) temperature in methane-forming reaction zone not too high (of the order of 700° to 300° C.) with the condition of obtaining as long a time of surface contact as possible.

Pressure will preferably be selected between 20 and 25 kilogrammes per sq. cm.

As for the temperature, in the methane formation region B in zone 25 it decreases regularly upwards from 650 to 700° C. to about 300° C., these limits being obtained by the water jacket, by the action upon the temperature of introduction of the steam into the zone 8 and through the tubes 62, and by the choice of the proportions of oxygen, fuel and steam introduced into the zone 8.

The higher the quantity of primary steam is raised, the quantity of oxygen remaining constant, the less exothermic is the sum effect of the reactions [I], and the lower is the temperature in the zone 8, and consequently in the chamber as a whole.

Finally the duration of surface contact will be the longer according as the column is higher, for the same horizontal cross section.

By way of example, very good results are obtained when operating at a pressure of 20 kilogrammes per sq. cm. by introducing:

(1) into the zone 8 a mixture formed of: pulverised fuel (lignite with 10% H_2O) about 1 kg.; steam superheated to 500 to 550° C., 0.8 to 1 kg.; oxygen at room temperature of about 20° C., 0.16 to 0.20 cubic metre; and this at the rate of 110 kilogrammes of this mixture per minute; and

(2) through the tubes 62, from 25 to 40 kgs. of steam at 500 to 550° C. per minute; the duration of the passage of the gases through the column being of the order of 30 seconds.

Under these conditions the temperatures are substantially those indicated above.

The composition of the gases varies of course up the chamber, and does so according to the normal temperature selected.

Figure 3 gives by way of example, as a function of the temperatures in the gasification zone, chosen as abscissae, the quantities q in gramme-molecules for each gramme-molecule of carbon effectively gasified, gaseous products or products transported by the gas at the outlet of the gasification zone (CO, CO_2, H_2, C), products introduced through the nozzles (O_2, H_2O).

At the outlet from the plant, the crude gas, for this charging, has approximately the following composition by volume:

CO_2 - - - - -	20 to 25%
CO - - - - -	16 to 18%
H_2 - - - - -	20 to 22%
CH_4 - - - - -	20 to 22%
Residual water vapour H_2S, inert gases -	15 to 20%

After washing, removal of the entrained dust and absorption of CO_2 and H_2S, a gaseous mixture is obtained having approximately the following characteristics:

Composition:	
CO - - - -	less than 22%
CO_2 - - - - -	less than 5%
H_2 and CH_4 -	about 65 to 70%
inert constituents -	less than 10%
Density in relation to air - - - -	0.45 to 0.50
Higher calorific power (water condensation heat included)	4000 to 4200 calories per cubic metre

The output is of the order of 0.800 cubic metre of purified gas at 16° and 760 millimetres of mercury per kilogramme of lignite treated.

A column of about one metre in diameter and from six to seven metres in height can produce about 50,000 cubic metres of purified gas per 24 hours.

To recall to mind the principal advantages of the process and of the plant according to the invention:

Production of a town gas of high calorific value (more than 4000 calories per cubic metre) from fines, which may have a high ash and be of poor quality, and which are practically useless at the present time;

Practically complete gasification of the fuel, the large particles of those carried along by the current of gas falling back by gravity for gasification;

Simple plant, in which there is no fouling, for all deposition of tar is eliminated;

Little ash to evacuate, the very fine ash being carried away by the gas produced, from which it is separated as dust;

No formation of clinker, and therefore no need for movable elements, such as the usual rotary turning gratings of complicated and fragile construction.

Of course the invention is by no means limited to the form of construction illustrated and described, and to the numerical values given, which have been given merely by way of example.

The isothermals in the plant, and the temperature gradient along the column, may be different from those indicated; they will depend largely upon the ratio between the height and the diameter of the column for a given flow.

Instead of introducing part of the steam directly into the region A in the column, all the necessary steam might be introduced directly into the gasification zone, but this latter solution would have the disadvantage of lowering the temperature of gasification, a disadvantage which is obviated by the solution described, with two admissions of steam.

Instead of treating pulverized solid fuel a liquid or pasty fuel may be utilized, brought unmixed with steam by circulating pumps to, and introduced into, the gasification zone 8 through the oxygen nozzles, with or without preliminary heating, this fuel mixing with the steam in the gasification zone.

The higher pressure of 25 kilogrammes per sq. cm. does not represent the maximum pressure that can be utilised, subject to the walls of the plant being of appropriate strength; the higher the pressure is raised, the richer will the gas be in CH_4 and in the higher hydrocarbons.

Finally the plant may comprise a plurality of columns in parallel, the feeding means being common to them or not.

What we claim is:—

1. A process for the production of town gas from a combustible such as lignite fines or other pulverized solid or liquid fuel wherein the fuel is substantially gasified in a gasification zone that is fed under high pressure with a mixture of fuel and steam and a gas containing free oxygen, and the gases thereby obtained pass from said gasification zone through a second zone in the course of which while remaining substantially at the same pressure they are progressively cooled, this method being characterized

in that the gases from the gasification zone pass through an aperture therein and thereafter through a diverging intermediate zone to said second zone which is of larger cross-sectional area than said gasification zone so as to obtain gas velocities securing a longer duration of the passage of the gases through said second zone.

2. A process for the production of town gas as claimed in claim 1, characterized in that in order not to lower the temperature of gasification, only a portion of the steam utilized is introduced into said gasification zone, further steam being introduced in said second zone substantially in the region thereof adjacent the intermediate zone.

3. A process for the production of town gas as claimed in claim 1 or 2, characterized in that the mixture of steam and fuel is at a temperature of about 500—550° C., the temperature in the gasification zone is about 1000—1200° C., the temperature of the gases in the region of said second zone adjacent the intermediate zone is about 600°—700° C. and the temperature of the gases progressively falls to about 300° C. during their passage from said region through said second zone wherein a methane formation reaction occurs, the gas producing operation being carried out at a constant pressure of at least 20 kilogrammes per sq. cm., this selected pressure depending upon the quantity of methane required in the resulting gases.

4. A process for the production of town gas as claimed in claim 2 or 3, characterized in that the charge introduced into the gasification zone is composed approximately of the proportions of 1 kilogramme of fuel such as lignite containing 10 per cent. moisture, 0.8—1 kilogramme of steam superheated to 500—550° C., and 0.16—0.20 cubic metres of oxygen at about 20° C., this charge being introduced at the rate of about 110 kgs. per minute, and the quantity of steam introduced into the region of said second zone which is adjacent the intermediate zone being from 20 to 40 kgs. of steam per minute at about 500° to 550° C.

5. A process for the production of town gas as claimed in any of the preceding claims, characterized in that the gases are caused to remain in the second zone for a period of about 30 seconds.

6. A process for the production of town gas as claimed in any of claims 2—5, characterized in that water is utilized in the cooling of the gases in their path through said second zone and said water produces steam which is introduced, at least in part, into the region of the second zone which is adjacent the intermediate zone.

7. A plant for the production of town gas from a combustible such as lignite fines or other pulverized solid or liquid fuel having a heat insulated gasification zone provided with means for the introduction under high pressure of a mixture of steam and fuel and a gas containing free oxygen, characterized in that said gasification zone is contained at the lower end of a long tubular vessel and communicates with an upper elongated zone through an upper aperture and an upwardly flared frusto-conical intermediate zone, means being provided for cooling said elongated and frusto-conical zones, and said elongated zone having a larger cross-sectional area than said gasification zone and terminating in an outlet for the gases produced.

8. Plant for the production of town gas from a combustible as claimed in claim 7, characterized in that said gasification zone has the shape of a surface of revolution inscribed in a sphere and the means for the introduction of the pressurized mixture of steam and fuel and a gas containing free oxygen comprise nozzles that are so arranged in said gasification zone that the jets issuing therefrom provoke turbulence of the gases in said zone.

9. Plant for the production of town gas from a combustible as claimed in claim 8, characterized in that the nozzles are so orientated that their jets are directed tangentially to the gasification zone and towards the aperture through which it communicates with the elongated zone.

10. Plant for the production of town gas from a combustible as claimed in any of the claims 7 to 9, characterized in that the lower part of the gasification zone is provided with means for withdrawing any ash that is not carried away by the gases produced.

11. Plant for the production of town gas from a combustible as claimed in claim 10, characterized in that the said ash withdrawal means includes a lock chamber.

12. Plant for the production of town gas from a combustible as claimed in any of the claims 7 to 11, characterized in that the means for cooling the elongated and the intermediate zones consists of a water jacket.

13. Plant for the production of town gas from a combustible as claimed in any of the claims 7 to 12, characterized in that means are provided for the introduction of steam into the said elongated zone in the region thereof adjacent the intermediate zone.

14. Plant for the production of town gas from a combustible as claimed in claim 13, characterized in that the said steam-introducing means comprise tubes which extend along the wall surface of the water jacket in the interior of the vessel in a downward direction with a view to utilizing a portion of the heat of the gases for superheating the steam passing therethrough.

15. Plant for the production of town gas from a combustible as claimed in any of the claims 7—14, characterized in that means are provided, controlled by the flow of the steam for the said mixture of fuel and steam, for controlling the flow of oxygen.

16. A process for the production of town gas from a combustible such as lignite fines or other pulverized solid or liquid fuel substantially as hereinbefore described.

17. Plant for the production of town gas from a combustible such as lignite fines or other pulverized solid or liquid fuel substantially as hereinbefore described with reference to the accompanying drawings.

MARKS & CLERK.

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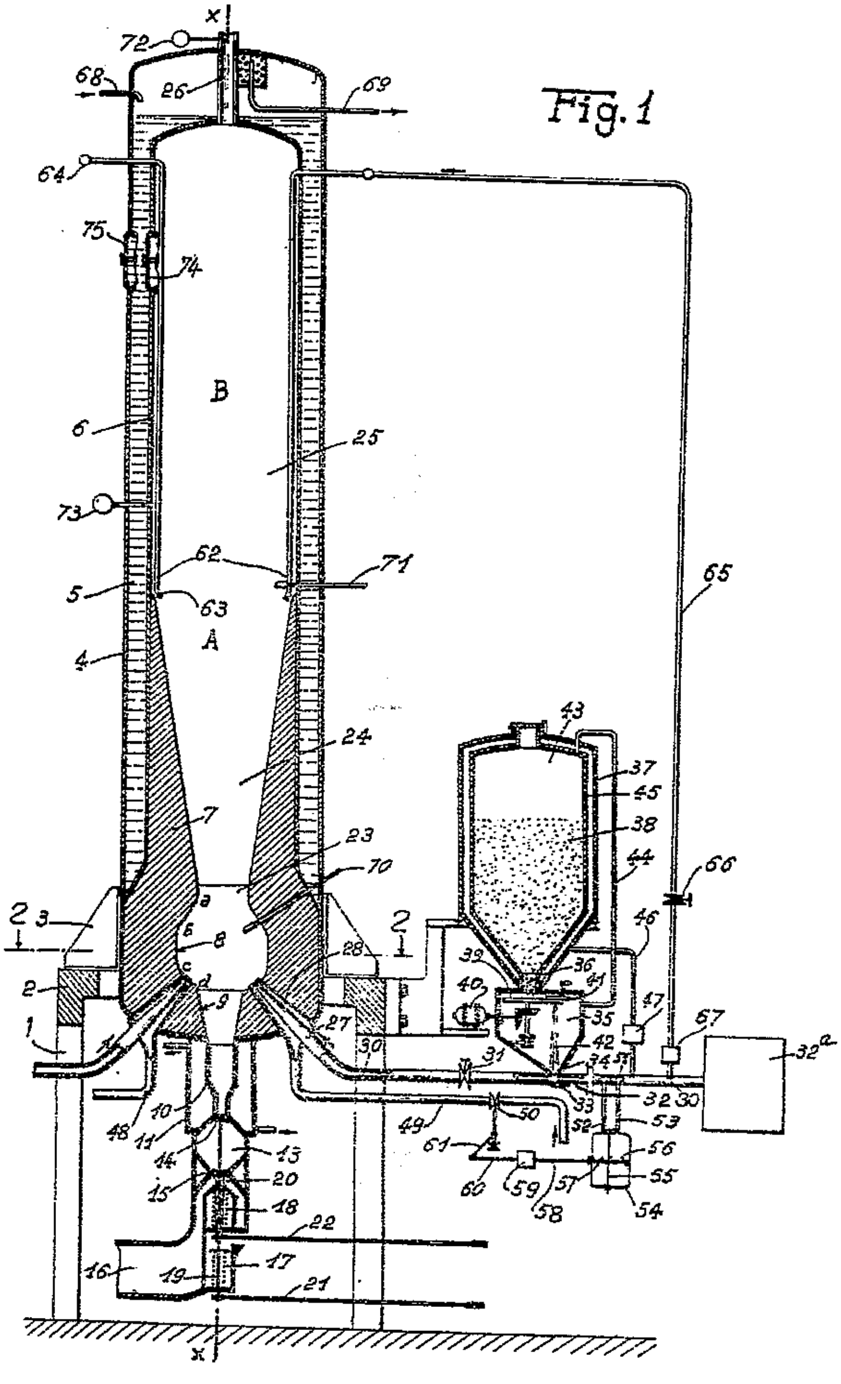
Fig. 1
x
72
68
26
69
64
75
74
B
6
25
73
62
71
5
63
65
A
4
24
43
37
45
7
38
23
70
44
66
2 3
a
b
8
2
28
39
36
40
41
46
c
d
9
35
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1
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42
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67
32^a
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49
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33
32 30
52
53
14
13
61
60
59
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56
55
15
20
58
54
18
22
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17
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x

688,915 COMPLETE SPECIFICATION
2 SHEETS

This drawing is a reproduction of the Original on a reduced scale.

SHEETS 1 & 2

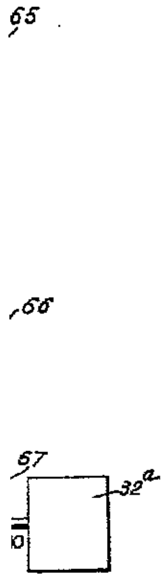


Fig. 2

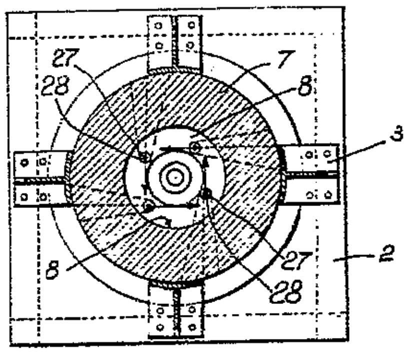
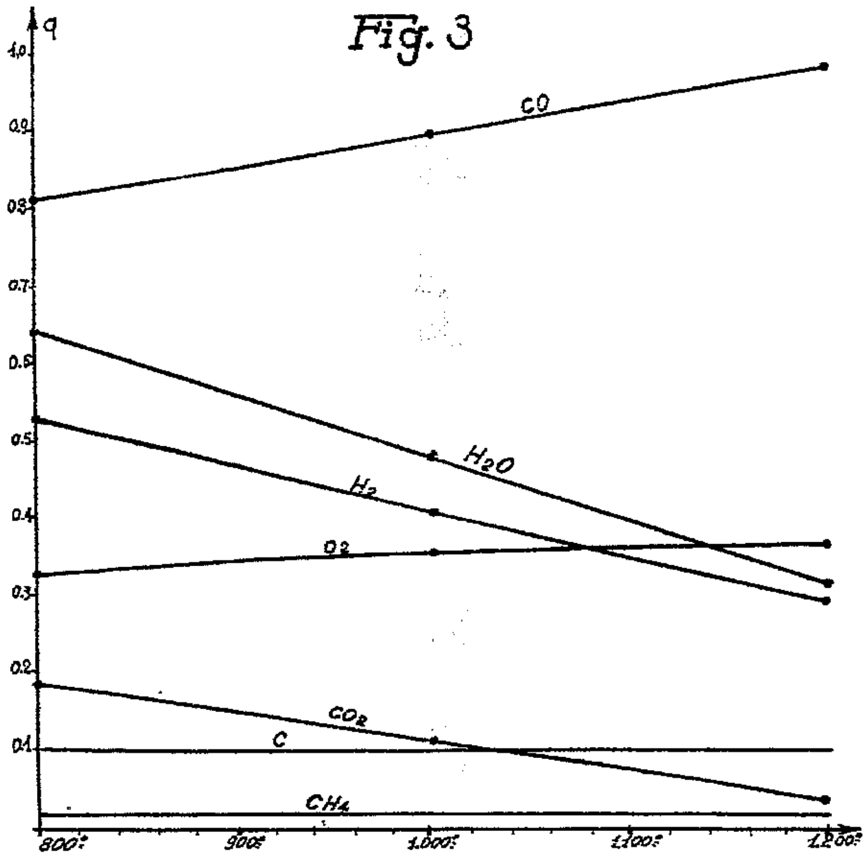


Fig. 3



688,915 COMPLETE SPECIFICATION
2 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

Fig. 1

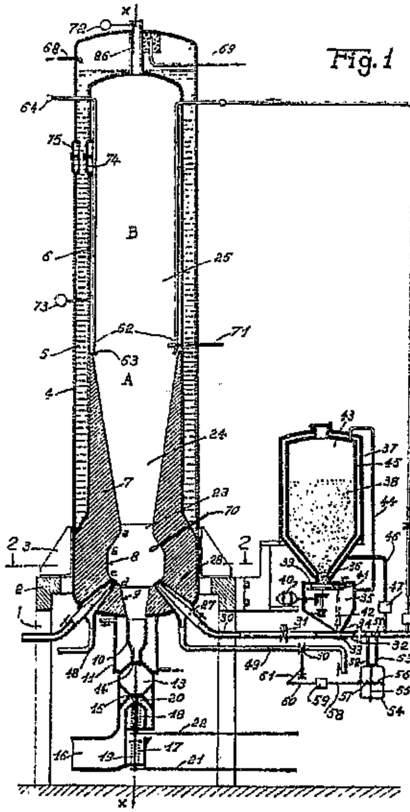


Fig. 2

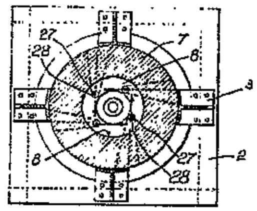


Fig. 3