

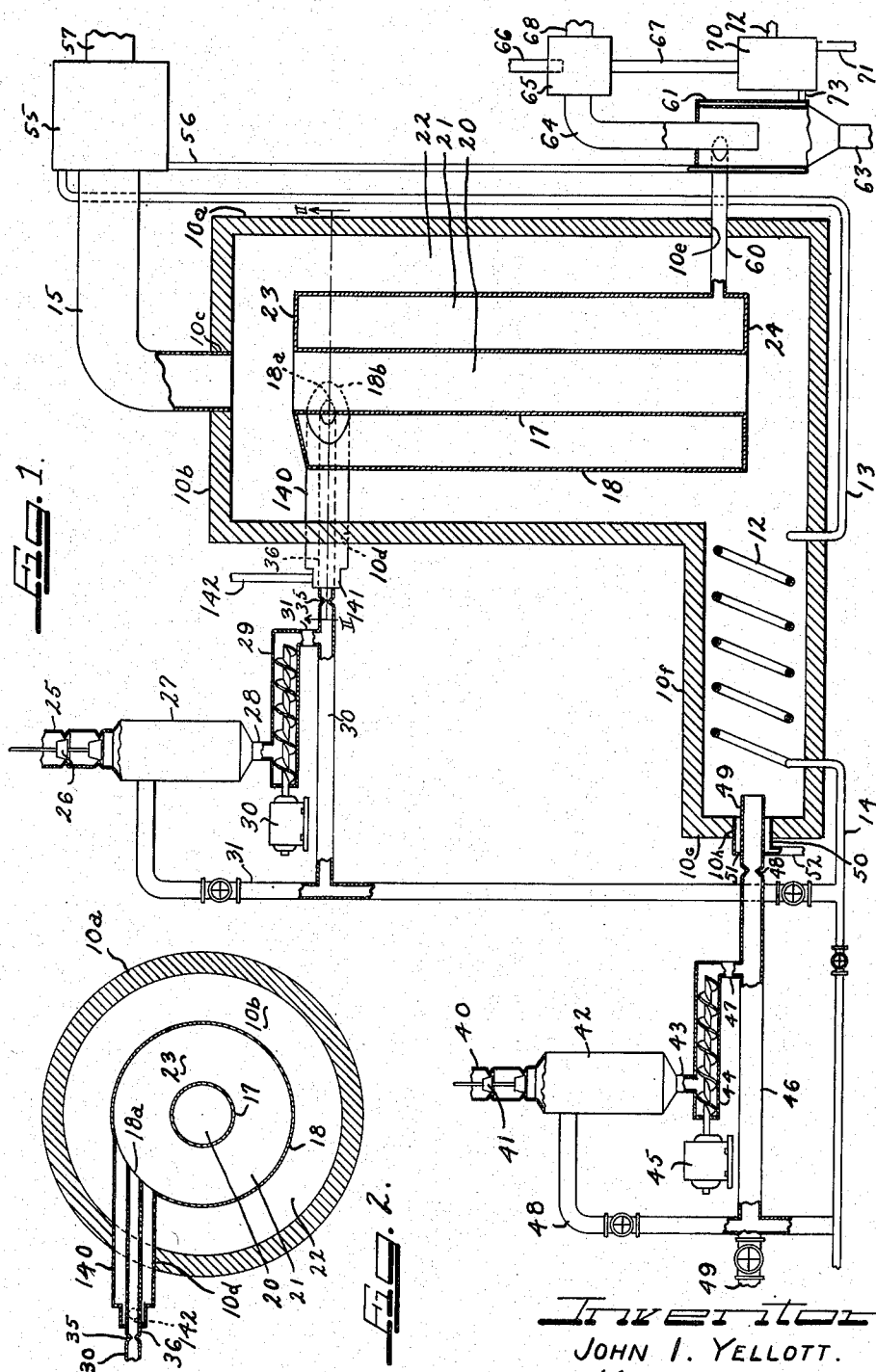
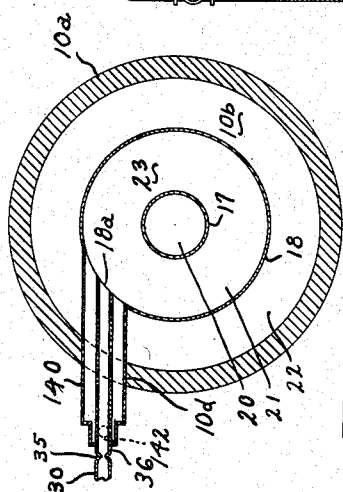
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MANUFACTURE OF CALORIFIC GAS

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MANUFACTURE OF CALORIFIC GAS

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3 Claims. (Cl. 48—197)

1

This invention relates to a method and apparatus for the continuous gasification of comminuted carbonaceous material involving, as an initial step, the flash pulverization of coal or the like followed by admixture of air or oxygen to the resulting rapidly flowing gaseous suspension of comminuted coal particles which is raised to a temperature adapted to bring about a gas forming reaction between the comminuted coal particles and the gaseous suspension medium.

Reference is made to my copending application Serial No. 530,177, filed April 8, 1944, and now forfeited, and entitled "Method of and Apparatus for Flash Pulverizing" (of which the present application is a continuation-in-part), and to my copending application entitled "Comminution Device," filed on or about July 22, 1947, Serial No. 762,589. A continuation-in-part of the first application has now issued as Patent No. 2,515,542. The second application has now issued as Patent No. 2,515,541. These applications disclose a method for flash pulverizing involving the steps of forming a rapidly moving entrainment of coarse solid particles to be comminuted in a gas under pressure moving through a constricted open-ended tube. As said entrainment rapidly moves through said constriction toward said opening, the gas is instantaneously accelerated, at said constriction, to critical velocity and there is effected a practically instantaneous pressure drop that explosively shatters the entrained coarse particles to form a gaseous entrainment of shattered particles. In such flash pulverizing apparatus, the tube containing the entrainment of the coarse particles to be shattered may be constricted at the open end of the tube or further upstream. In either case, there is a conversion of pressure head into kinetic energy, so that the final gaseous entrainment of comminuted particles moves more rapidly but under less than one-half of the initial pressure (upstream of the constriction) of the original gaseous entrainment of relatively coarse particles to be comminuted.

According to the present invention, the suspension of coal particles shattered by flash pulverization, as by the use of superheated steam, has air or oxygen admixed therewith and the resulting mixture is conducted into a gasifying chamber in which the mixture travels along a vortical path. A gasifying temperature is maintained in this chamber by partial combustion of the shattered particles, by heating the chamber surfaces to effect heat transfer therefrom by radiation or by contact, or by a combination of these two methods. The ratio of air or oxygen

2

to steam may be controlled to prevent fusion of the ash. Gaseous products with ash and unreacted fuel will leave the gasifying chamber to enter dust and heat recovery means.

It is therefore an important object of the present application to provide method and apparatus for producing gas from carbonaceous material such as coal in which steam or air or oxygen are utilized both to pulverize or comminute the coal and to enter into a gasifying reaction between comminuted coal and added air or oxygen.

Another important object of the present invention is to provide method and apparatus for the production of gas in which coal or the like is initially flash pulverized, as in superheated steam under pressure, air or oxygen is admixed with the resulting gaseous suspension of comminuted coal, the resulting mixture is caused to move along a vortical path while partial combustion and gas formation is effected at an elevated temperature, and ash and heat are thereafter removed or recovered from the gas thus formed.

Other and further objects and features of the present invention will become apparent to those skilled in the art from the following description of the apparatus shown in the appended drawings and from the accompanying claims.

On the drawings:

Figure 1 is a diagrammatic representation, in vertical cross-sectional view, with parts shown in elevation, of an illustrative example of an apparatus according to the present invention; and

Figure 2 is a fragmentary cross-sectional view taken along the line II—II in Figure 1.

In the drawings, the reference numeral 10 indicates generally an enclosed furnace made of heat resistant and heat insulating material and including an upright portion 10a of generally cylindrical form having its top closed by a roof portion 10b pierced by a central aperture 10c. On the left-hand side, and near its top, the furnace portion 10a is pierced by an aperture 10d extending transversely and in parallelism with the plane of section in Figure 1. Further, at the opposite side, and near its bottom, the cylindrical portion 10a is pierced by an aperture 10e. The furnace generally indicated at 10 also includes a relatively smaller, horizontally extending generally cylindrical portion 10f branching off from the lowermost portion of the upright cylinder 10a and having its end closed by a vertical wall 10g centrally pierced by an aperture 10h.

In the furnace portion 10f hot gases or combustion gases are generated by means of a device described hereinbelow, for generating super-

3

heated steam in a coil 12 within and concentric with the furnace portion 10f. Steam is introduced into the coil 12 through a conduit 13, and the resultant superheated steam is withdrawn through a conduit 14. From the furnace portion 10f, the hot gases or the combustion gases, as the case may be, are discharged into the cylindrical furnace portion 10a and travel upwardly for discharge through a conduit 15 having a terminal portion fitted into the aperture 10c. While passing upwardly through the furnace portion 10a, the hot gases or the combustion gases transfer heat to a metallic upright structure made up of two spaced cylindrical walls 17 and 18 concentric with the upright furnace portion 10a and spaced from each other and from the upright furnace portion 10a so as to define a central upright passage 20, an annular interspace 21 between the walls 17 and 18, and an outermost annular space 22 between the wall 18 and the insides of the upright furnace portion 10a. The cylindrical walls 17 and 18 are spaced from the roof 10b of the upright furnace portion 10a as well as from the bottom thereof, being supported within the furnace by any suitable means such as legs (not shown). Further, the annular space 21 is closed off at the top and bottom thereof, respectively, by generally horizontal annular walls 23 and 24. It will be noted that, in this manner, there is provided a vertical annular chamber 21 not accessible to the hot gases entering the upright furnace portion 10a. These gases nevertheless have free passage upwardly through the furnace portion 10a on both sides of the annular space 21, through space 22 and through the central passage 20. Thus, as will be described in more detail hereinbelow, when the space 21 is utilized as a gasifying chamber, heat from the hot gases or combustion gases generated in the furnace portion 10f can contribute to the maintenance of the chamber 21 at any desired temperature.

The materials entering into the gasifying reaction within the annular space 21 are supplied thereto by the following devices. Carbonaceous material to be gasified, such as coarsely fragmented coal, is received by a hopper 25 having a conical bottom. The hopper 25 is provided at its discharge end with a double bell and hopper device or other gas lock means 26 for discharge into a tank 27 having a conical bottom discharging into a conduit 28. The latter communicates directly with and serves to conduct the coal to be comminuted into horizontally extending tubularly enclosed screw feeder or conveyor 29 driven by a motor 30. The screw conveyor 29 moves the coal or other carbonaceous material to be comminuted into a horizontally extending conduit 30 by way of a vertical extension 31 of the enclosed conveyor 29. Gas under pressure, such as superheated steam, is introduced into the upper part of the tank 27 through a valved conduit 31 tapping the conduit 14 and also serving to supply the conduit 30 with compressed gas.

The right-hand end portion of the conduit 30, downstream of the conduit 31, is sharply constricted, as at 35, to form a convergent-divergent nozzle followed by a conduit 36 of at least the same diameter as the conduit 30 but smaller than the aperture 10d. This conduit 36 extends through the aperture 10d into the upper part of the furnace portion 10a and discharges tangentially into the annular space 21, as through the aperture 18a.

The tube 36 is contained within a generally cy-

4

lindrical tubular member 140 fitting into and projecting from both sides of the aperture 10d. Within the upright furnace portion 10a, the tubular member 140 extends horizontally and communicates tangentially with the space 21, as by an aperture 18b. Outside the upright furnace portion 10a, the tubular member 140 extends about the conduit 36 to a point short of the nozzle 35 and is closed off from the outside atmosphere by an annular end wall 141 fitting around the conduit 36. A pipe 142 serves to admit oxygen, air or the like into the space between the conduit 36 and the tubular member 36, for more or less tangential discharge into the space 21, along with the suspension of comminuted coal or the like and steam or other compressed gas issuing from the conduit 36.

As disclosed hereinabove, gas formation occurs within the space 21 by the interaction between the comminuted coal, steam, air or oxygen or the like tangentially discharged into the annular space 21 through the conduit 36 and the tubular member 140. Gasification of the coal takes place at an elevated temperature brought about by partial combustion of the comminuted coal and/or by heat transmitted through the walls 17 and 18 from combustion gases generated in the horizontal furnace portion 10f. While this combustion may be brought about by conventional means and methods, for instance, by the injection of liquid or pulverized fluid into the furnace portion 10f through the aperture 10h, I prefer to generate hot gases in the furnace portion 10f by means and methods described as follows.

Solid fuel to be comminuted, such as coarsely fragmented coal, is received in a hopper 40 having a conical bottom and provided at its discharge end with a double bell and hopper device or other gas lock means 41 for discharge into a tank 42 having a conical bottom discharging into a conduit 43. The latter communicates directly with and serves to conduct the coal or other fuel to be comminuted into a horizontally extending tubularly enclosed screw feeder or conveyor 44 driven by motor 45. The screw conveyor 44 moves the coal or other fuel to be comminuted into a horizontally extending conduit 46 by way of a vertical extension 47 of the tubularly enclosed conveyor 44. A gas under pressure, such as superheated steam, is admitted into the upper part of a tank 42 through a valved conduit 48 tapping the conduit 40 and also serving to supply the conduit 46 with compressed gas. If desired, superheated steam, air or other compressed gas may be fed to the conduit 48 from a valved line 49.

The right-hand end portion of the conduit 47 downstream of a discharge opening of the conduit 47 is sharply constricted, as at 48, to form a convergent-divergent nozzle followed by a short conduit 49 at least as wide as the conduit 46 but not as wide as the furnace aperture 10h, through which the conduit 49 extends into the furnace portion 10f. A tubular member 50 fits into the aperture 10h and extends about the conduit 49 outside the furnace wall 10b, short of the nozzle 48. The tubular member 50 is closed off from the atmosphere by an annular end wall 51 fitting the conduit 49. Oxygen or air may be admitted into the conduit 50 and into the furnace 10f to a pipe 52. Thus, coal comminuted on passage through the conduit 46 and nozzle 48 and suspended in superheated steam, together with air from the conduit 50, enters the furnace portion 10f, for partial or complete combustion, with accompanying generation of heat and upward flow

through the furnace portion 10a (through the spaces 20 and 22), with concurrent transmission of heat through the tubular walls 17 and 18, being discharged from the furnace 10 through the conduit 15. The latter takes the hot gases through a waste-heat boiler 55 receiving water from a conduit 56 and discharging steam into the conduit 13, the cooled combustion gases being discharged through a conduit 57 for venting into the atmosphere (in the case of gases resulting from complete combustion) or for recovery and utilization (in the case of calorific gases resulting from incomplete combustion).

The gases generated in the space 21 pass through a horizontal conduit 60 communicating with the space 21 near the bottom thereof and projecting outwardly from the furnace 10a through the furnace aperture 10e, to discharge said gases tangentially into a cyclone separator 61 provided with double spaced side walls for receiving cooling water. From the cyclone, the ash is discharged downwardly through a conduit 63, while the gases are discharged upwardly through a conduit 64 into a water scrubber 65 receiving scrubbing water through a conduit 66 and discharging heated scrubbing water through another conduit 67. Finally, the scrubbed gases are led through a conduit 68 to a storage or utilization device.

The heat content of the scrubbing water discharged through the conduit 67 is recovered in a heat exchange device 70 and, after heat exchange, discharged therefrom through a conduit 71. In the heat exchange device 70, heat is transferred to water entering through a conduit 72 and, after heating, conducted through a pipe 73 to the water jacket of the cyclone 61. After further heating in said jacket, the water is suitably discharged into the conduit 56 for conversion into steam in the boiler 55.

At the start of the operation of the above described apparatus, coal or other carbonaceous fuel in coarsely fragmented form is charged through the hopper 40 and the gas lock 41 into the tank 42. Superheated steam or other gas under pressure is initially introduced through the conduit 49 and caused to flow through the conduit 48 into the tank 42 and, rapidly, through the conduit 46. The screw conveyor 44 is operated to advance coal to be comminuted into the stream of steam or other compressed gas passing rapidly through the conduit 46. The nozzle 48 is so spaced from the discharge opening of the conduit 47 that the coal discharged into the conduit 46 will attain approximately the same speed as the gas flowing through the conduit 46 before reaching the nozzle 48. Instantaneous expansion occurs continuously as the compressed gas in the pipe 46 passes through a nozzle 48 and causes an explosive shattering of the solid particles by virtue of the expansion of the compressed air, steam or other gas contained within the porosities of the solid particles. From the nozzle 46, the expanded gas-communited coal mixture passes into the conduit 49 and is discharged into the interior of the furnace portion 10f.

The operating pressure for the steam or other gas in the conduit 46 should be at least 5 lbs. per sq. in. and may be as high as 750 lbs. per sq. in. If upstream pressures of 5 lbs. per sq. in. are used, however, the required downstream pressure will be below atmospheric and the degree of comminution is not so great. Superheated steam at a temperature of between 350° and 450° or higher is suitably employed. At the preferred

operating pressure of about 200 lbs. per sq. in. or higher in the conduit 46, the pressure in the conduit 49 may suitably be about 60 lbs. per sq. in. or less.

It should be understood that the extent of comminution is determined, inter alia, by the pressure level of operation, by the difference between the upstream and the downstream pressures on the two sides of the nozzle 48, by the ratio of gas to solids passing through the nozzle 48, and by the rate of movement of solids through the nozzle 48. Finer comminution is effected by the maintenance of maximum upstream and minimum downstream pressures, by the use of relatively large amounts of gas as compared to the amount of solids, and by the establishment of rapid flow of solids through the nozzle. By far the best results are obtained when the pressure upstream of a nozzle is at least twice the pressure downstream of a nozzle and when, consequently, critical velocity is reached in the nozzle.

Air or oxygen may be admitted into the furnace portion 10f through the pipe 52 and the tubular member 51 at a ratio (with respect to the amount of comminuted coal introduced into the furnace portion 10f) such as to bring about complete combustion of the coal. However, the amount of air admitted may be so restricted as to bring about only a partial combustion of the coal.

Once combustion (partial or complete) has been established within the furnace portion 10f, and the water passing through the boiler 55 has been converted into steam and this steam has been superheated to a desired extent on passing through the coil 12, the flash pulverizing device including the nozzle 48 may be operated from this superheated steam, the supply of steam, air or other gas through the pipe 49 being shut off.

When, as described hereinabove, combustion in the furnace portion 10f has been well established, and hot gases flow through the furnace portion 10a, then flash pulverization may be initiated at the nozzle 35, by introduction of coal and superheated steam into the tank 27, operation of the screw conveyor 29, and establishment of rapid flow of steam through the conduit 30, with resultant passing of a suspension of coarse coal particles in gas through the nozzle 35. Flash pulverization and discharge of a suspension of comminuted coal particles in steam through the conduit 36 is effected exactly as described hereinabove in connection with flash pulverization of coal in the comminuting device including the nozzle 48 and the discharge conduit 49. The suspension of comminuted coal particles in steam discharged from the conduit 36 through the aperture 18a tangentially into the space 21 flows in a vortical path downwardly through the space 21, is discharged from this space through conduit 60, and enters the cyclone 61, where ash is separated and discharged downwardly through the conduit 63, while the separated gas flows through the conduit 64 into the scrubber 65 and thence through the conduit 68 to a storage or utilization device.

The gas forming reaction within the space 21 includes a reaction between the coal and the oxygen (or air) admitted from the pipe 42 through the tubular member 40 by the way of the orifice 18b into the annular space 21 for admixture with the comminuted coal-stream suspension discharged into the annular space 21 through the conduit 36 by way of the aperture 18a. Thus, the oxygen (or air) also flows downwardly in the space 21 along a vortical path, in

intimate admixture with the steam and comminuted coal particles.

The temperature to be maintained in the gas flowing vortically through the space 21 is preferably such as not to bring about complete fusion or, at most, with such slight softening of the ash as might still produce an ash capable of being carried in suspension by the gases. The temperature in question will vary according to the fusion point of the ash derived from the particular coal being utilized and will generally range from about a maximum of 1800° to a maximum of 2800° F.

The actual temperature in the annular space 21 is reached as a composite result of a number of factors. Heat generation in the apparatus of the present invention is effected (1) by partial or complete combustion in the furnace portion 10f and (2) by partial combustion in the space 21. The amount of heat generated in the furnace portion 10f depends on the amount of coal introduced, the amount of air or oxygen introduced from the pipe 52, the amount of steam introduced along with the coal (steam having a tendency to lower combustion temperature in the furnace portion 10f due to an endothermic water gas reaction between steam and coal), and the amount of heat abstracted by water in the coil 12. Likewise, the amount of heat generated in the space 21 depends upon the amount of coal introduced into the space 21, the amount of air or oxygen introduced into the space 21, and the amount of steam introduced into the space 21. Further, in both the heat generating reactions, the particular reactions effected influence the amount of heat generated, as by a more or less complete combustion. Further, the temperature in the space 21 depends upon the rate of flow, both of gases generated in the furnace portion 10f and of gases through the conduits 36 and 40 discharging into the space 21, as well as on the rate of flow of gas through the conduit 15, the boiler 55, the cyclone 61, and the conduits 60, 64 and 68. These various factors are so balanced by the operator as to bring about the desired temperature in the space 21.

Hot gases of various compositions may be produced within the furnace portion 10f and discharged through the conduit 57 and produced in the space 21 and discharged through the conduit 68. In each instance, the exact composition of the gas will vary according to the amount of coal, oxygen or air, steam and the temperature. These conditions can be adjusted by the operator according to well known principles to produce whatever gas feed or whatever specific composition may be desired. With the minimum amount of steam required for flash pulverization and air, say, about 700 cubic feet for each 20 pounds of coal, a producer gas may be generated; by operating with about 230 cubic feet of air, 170 cubic feet of oxygen and 13 pounds of steam for each 32 pounds of coal, a mixed gas may be produced; by operating with 270 pounds of oxygen and 20 pounds of steam for each 40 pounds of coal, blue gas may be generated, at a temperature of from 1700° to 1900° F.

Many details of construction and operation may be varied within a wide range without departing from the principles of this invention, and it is therefore not my purpose to limit the patent granted on this invention otherwise than necessitated by the scope of the appended claims.

I claim as my invention:

1. The method of manufacturing a calorific gas from granular coal which comprises providing a source of gas under a pressure of at least five

pounds per square inch; continuously and uninterruptedly discharging compressed gas from said source while confining the discharged gas to establish a stream of compressed gas flowing uninterruptedly and continuously from said source to and past a discharge point spaced from said source; concurrently, continuously and uninterruptedly introducing said granular coal into said stream ahead of said discharge point for acceleration and suspension of said granules by said gas ahead of said discharge point; at said discharge point establishing and continuously and uninterruptedly maintaining a sharp gas pressure gradient, the pressure of said granule-suspending gas being instantaneously reduced as said granule-suspending gas continuously and uninterruptedly flows past said discharge point; said stream of compressed gas having a substantially uniform cross sectional area upstream of said discharge point and being sharply constricted only at said discharge point whereby the total pressure drop in said stream is concentrated at said discharge point; the drop in gas pressure at said discharge point being continuously and uninterruptedly maintained at a value of at least five pounds per square inch and the gas pressure immediately downstream of said discharge point being reduced at least to a point where further downstream pressure reduction will not bring about a substantially increased weight rate of flow past said discharge point; said coal being introduced into said stream in the form of granules smaller than the cross section of said stream at said discharge point; each of said suspended granules being carried in suspension by said streaming compressed gas along a substantially straight path to and past said discharge point and there further accelerated and subjected to said instantaneous drop in gas pressure whereby said granules are disintegrated and there is formed a flowing suspension of shattered coal particles in expanded gas; immediately forming said suspension into a vortex; incorporating with said vortex, in a stream separate from said flowing suspension of shattered coal particles in expanded gas, a gas capable of reacting at an elevated temperature with said coal particles to form a calorific gas; and maintaining said vortex at an elevated temperature to bring about generation of a calorific gas.

2. The method of manufacturing a calorific gas from granular coal which comprises providing a source of steam under a pressure of at least five pounds per square inch; continuously and uninterruptedly discharging compressed steam from said source while confining the discharged steam to establish a stream of compressed steam flowing uninterruptedly and continuously from said source to and past a discharge point spaced from said source; concurrently, continuously and uninterruptedly introducing said granular coal into said stream ahead of said discharge point for acceleration and suspension of said granules by said steam ahead of said discharge point; at said discharge point establishing and continuously and uninterruptedly maintaining a sharp steam pressure gradient, the pressure of said granule-suspending steam being instantaneously reduced as said granule-suspending steam continuously and uninterruptedly flows past said discharge point; said stream of compressed steam having a substantially uniform cross sectional area upstream of said discharge point and being sharply constricted only at said discharge point whereby the

total pressure drop in said stream is concentrated at said discharge point; the drop in steam pressure at said discharge point being continuously and uninterruptedly maintained at a value of at least five pounds per square inch and the steam pressure immediately downstream of said discharge point being reduced at least to a point where further downstream pressure reduction will not bring about a substantially increased weight rate of flow past said discharge point; said coal being introduced into said stream in the form of granules smaller than the cross section of said stream at said discharge point; each of said suspended granules being carried in suspension by said streaming compressed steam along a substantially straight path to and past said discharge point and there further accelerated and subjected to said instantaneous drop in steam pressure whereby said granules are disintegrated and there is formed a flowing suspension of shattered coal particles in expanded steam; immediately and in a tangential direction injecting said last mentioned suspension into a cylindrical space to form said suspension into a vortex; injecting into said vortex, in a stream separate from said flowing suspension of shattered coal particles in expanded steam, an oxygen-containing gas capable of reacting at an elevated temperature with said coal particles to form a calorific gas; and maintaining said vortex at said elevated temperature to bring about a reaction between said coal particles and said gas generating a calorific gas.

3. The method of manufacturing a calorific gas from granular coal which comprises providing a source of steam under a pressure of at least five pounds per square inch; continuously and uninterruptedly discharging compressed steam from said source while confining the discharged steam to establish a stream of compressed steam flowing uninterruptedly and continuously from said source to and past a discharge point spaced from said source; concurrently, continuously and uninterruptedly introducing said granular coal into said stream ahead of said discharge point for acceleration and suspension of said granules by said steam ahead of said discharge point; at said discharge point establishing and continuously and uninterruptedly maintaining a sharp steam pressure gradient, the pressure of said granule-suspending steam being instantaneously reduced as said granule-suspending steam continuously and uninterruptedly flows past said discharge point; said stream of compressed steam having a substantially uniform cross sectional area upstream

of said discharge point and being sharply constricted only at said discharge point whereby the total pressure drop in said stream is concentrated at said discharge point; the drop in steam pressure at said discharge point being continuously and uninterruptedly maintained at a value of at least five pounds per square inch and the steam pressure immediately downstream of said discharge point being reduced at least to a point where further downstream pressure reduction will not bring about a substantially increased weight rate of flow past said discharge point; said coal being introduced into said stream in the form of granules smaller than the cross section of said stream at said discharge point; each of said suspended granules being carried in suspension by said streaming compressed steam along a substantially straight path to and past said discharge point and there further accelerated and subjected to said instantaneous drop in steam pressure whereby said granules are disintegrated and there is formed a flowing suspension of shattered coal particles in expanded steam; immediately and in a tangential direction injecting said last mentioned suspension into a cylindrical space to form said suspension into a vortex; injecting into said vortex, in a stream separate from said flowing suspension of shattered coal particles in expanded steam, an oxygen-containing gas capable of reacting at an elevated temperature with said coal particles to form a calorific gas; maintaining said vortex at from 1800° to 2800° F. to bring about a reaction between said coal particles and said gas generating a calorific gas; and separating residual solid material from the resulting calorific gas at a temperature below the fusion point of said solid material.

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