CONTINUOUS GAS PROCESS AND APPARATUS FOR PRACTICING SAME

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This invention relates to the manufacture of fuel gas from hydrocarbon oils and/or gases and more particularly to process, and apparatus in which such process is carried out, for the production of high B.t.u. gas useful as a substitute for natural gas, and for both domestic and industrial purposes and also useful for the production of higher gravities and higher B.t.u. gas employed for chemical purposes, which latter gas is hereinafter referred to as chemical gas. Domestic and industrial gases, generally employed as substitutes for natural gas, have a B.t.u. per cubic foot of 1000 to 1050 and a specific gravity of from 0.6 to 0.74 (air=1). Chemical gas, on the other hand, has a B.t.u. of about 1300 and a specific gravity of about 0.9. The process of the present invention, with minor adjustments, can produce gases having desired high B.t.u. contents of say from 900 to 1300 and gravities within the range of 0.6 to 0.74.

With the advent of natural gas pipe lines, gas utilities generally supplied by such lines, have been confronted with the problem of providing equipment for generating a natural gas substitute, which can be supplied to consumers for burning in appliances set to burn natural gas, without adjustment of such appliances, to meet peak demands for natural gas and in the event of pipe line failures. Most, if not all of such utilities, had water gas equipment and processes have been developed utilizing such equipment with necessary modification to generate low gravity B.t.u. gas (specific gravity about 0.7 and B.t.u. around about 990, usually about 1000). Such processes generally involve alternate blanketing or heating and make cycles; during the blanketing or heating cycle, usually of 3 to 10 minutes duration, fuel (usual oil) is burned to heat the oil cracking and fixing zones to the necessary temperature and during the subsequent make cycle, usually of substantially the same duration as the preceding blanketing cycle, oil is cracked in the cracking zone and the oil vapors fixed by passage through the fixing zone. Obviously, in such processes gas is made during the make cycles only and the full potential capacity of the equipment is not utilized.

Of the continuous oil gas processes, the so called Dayton process (U.S. Patent 1,506,164) involves the atomization of hydrocarbon oil with a limited amount of preheated air in a hot retort and combustion of part of the oil to furnish the heat to crack the rest of the oil and produces a gas having a B.t.u. of 450 to 500 and a relatively high gravity so that it is not a satisfactory substitute for natural gas.

Another continuous process has been suggested involving the cracking of oil and the fixing of oil vapors in a plurality of heated tubes, the oil being introduced at the top and the fixed oil gas withdrawn from the bottom of these tubes. Tubes 28 feet long or longer and having an inside diameter of about 4 inches are employed to obtain adequate vaporization, cracking and fixing of the oil gas. Such procedure and equipment is objectionable not only because of the special design of the equipment required but the maintenance and operational difficulties entailed with the extremely long, small diameter tubes, particularly when heavy oils are employed as the oil feed for the process.

It is among the objects of the present invention to provide continuous process for generating low gravity high B.t.u. gas, including oil gas useful as a substitute for natural gas, completely or substantially completely free of the objections to heretofore known continuous procedures for making such gas.

It is another object of this invention to provide a continuous process for generating high B.t.u. gas which process is flexible and with minor adjustments produces gas of desired substantially constant gravity within the range of 0.6 to 1 and desired high B.t.u. within the range of from about 1000 to 1500.

Still another object of this invention is to provide such process in which any and all available hydrocarbon oils and gases may be used as the hydrocarbon from which the gas is made; for example, relatively high grade gas oils, as well as low grade hydrocarbon oils such as heavy cracked residuum having a Conradson carbon number in excess of 10, and hydrocarbon gases, such as propane, butane etc., may be employed in the practice of the process of this invention.

Still another object of this invention is to provide such continuous process which can be carried out in equipment general similar to existing water gas or oil gas equipment with necessary modification of the interiors of the generators or reactors and superheaters or fixers of such equipment to adapt same to the practice of the continuous process of this invention.

A further object of this invention is to provide apparatus for practice of the continuous process of this invention which apparatus is of a character such that it involves not too extensive modification of known oil gas and water gas equipment when such equipment is modified to adapt same for the practice of the process of this invention.

Other objects and advantages of this invention will be apparent from the following detailed description thereof.

In accordance with this invention, fuel gases are produced continuously by spraying hydrocarbon oil and/or gas into a reaction zone through which is passed a stream of carrier gas, the oil is vaporized and the gas, if used, reformed by radiant heat supplied by passing heating gases in indirect heat exchange relation with this reaction zone and the mixture of gas thus produced and carrier gas is passed from the reaction zone through a fixing zone where the gas is fixed, which fixing zone is heated by hot gases flowing in heat exchange relation therewith.

In the accompanying drawings which shows for purposes of exemplification, a preferred form of apparatus embodying this invention, and for practicing the process of this invention to which form, however, the invention is not limited:

FIGURE 1 is a vertical section through the gas generating apparatus embodying this invention; and
FIGURE 2 is a view looking down on the apparatus of FIGURE 1, the reactor, fixer and combustion chambers communicating therewith being shown in horizontal section.

Referring to the drawings, reactor 10 is communicably connected by conduit 11 with fixer 12. A conduit 13 leads from the base of fixer 12 into wash box 15. The outer wall structure and dimensions of reactor 10 and fixer 12 may be the same as conventional two shell water gas and oil gas equipment, e.g., the outer wall structure may consist of a metal shell provided with a layer of heat insulating material consisting of a refractory material. The reactor and fixer may each have an external diameter of from 5 to 15 feet and a height of from 5 to 30 feet. The outer shells of existing water gas and oil gas equipment, having the top of the generator or reactor, as the case may be, connected to the top of superheater or fixer, respectively, require little or no modification to adapt such equipment for the practice of this invention.

In accordance with this invention, reactor 10 has there in a reaction zone 16, defined by a cone 17 extending from the base 18 to the base 19 of the dome-shaped free space 21 at the top of reactor 10. Tube 17 is of a material of
Good heat transfer properties at high temperatures and having a surface such that oil and/or oil residuum does not adhere thereto under operating conditions. Carborundum, i.e., silicon carbide, or a metal such as Hastelloy or stainless steel can be used. Carborundum is preferred. The diameter of tube 17 will depend upon the outside dimensions of reactor 10. For an 11-foot diameter reactor 10, tube 17 should have an inside diameter of 6 or 7 feet. The wall thickness will depend chiefly upon the material of construction, in general, it should be as thin as possible, consistent with strength requirements. The axis of tube 17, in the embodiment of the invention shown on the drawings, is coaxial with that of reactor 10.

Tub 17 defines an annular heating chamber 22 within reactor 10. This chamber is closed at its base by refractory seal 23 and at its top by a refractory or other suitable seal 24. Communicating with chamber 22 through a conduit 25 leading tangentially as at 26 into the base of chamber 22 is a combustion chamber 27 supplied with fuel, e.g., oil by line 28 and with air to support combustion by line 29. Combustion chamber 27, desirably, has refractory baffles 31 and 32 therein to provide for a circuitous flow effecting removal of suspended particles from the combustion products. A stream of products of combustion relatively free of suspended solids enters tangentially into the base of annular heating chamber 22 and flows spirally in an upward direction, exiting through port 33.

A line 34 leads into the base of reaction zone 16 and has a discharge port 35 positioned coaxially with the axis of tube 17, through which port 35 steam and/or combustion products are supplied under pressure sufficient to effect flow through the equipment to function as a carrier gas for the oil vapors generated or the reformed gas formed in reaction zone 16. The combustion products, if used, may be withdrawn from main 36 communicating with a flow controller 37 of any suitable design (for example, a blower, a steam ejector or steam injector) which feeds the products of combustion through line 38 leading into the supply line 34. For equipment in which low grade heavy oils, such as Bunker C oils or cracked residuum are supplied through the inlet 39 disposed near the top of reaction zone 16, a flow controller 41 similar to a venturi is formed within tube 17 as shown in the drawing, from Carborundum brick or other suitable high temperature refractory material. The flow controller 41 has a central port 42 having downwardly flared walls 43 below this port and upwardly flared walls 44 above this port. When gas oil or other light oils are vaporized in reaction zone 16, or when hydrocarbon gases are reformed in zone 16, flow controller 41 may be omitted. This flow controller 41 is positioned just above port 35 and causes the carrier gas to sweep through the upper portion of reaction zone 16 at a higher velocity than would otherwise be the case, to carry unperturbed particles out of the reaction zone, preventing accumulation of deposits therein.

Inlet 39 has its axis coaxial with that of tube 17 and is disposed near the top of this tube. Thus an unabaffled entrance having a cross-sectional extent, the same as that of the inside of tube 17 and of a length of at least about 3 to 5 feet or more, is provided for vaporization of the oil or reformation of hydrocarbon gases by radiant heat supplied continuously by the hot combustion products flowing upwardly through the annular heating chamber.

The highest temperature within reaction zone 16 is above flow controller 41 and the temperature decreases in the direction of carrier gas flow which is the same as the general direction of flow of the products of combustion through annular heating chamber 22. The carrier gas flows upwardly through zone 16. This mode of operation ensures substantially complete vaporization of the oil introduced into reaction zone 16 with no solid deposits on the walls of tube 17 or the base of the reaction zone.

When feeding heavy residuum, this desirable result is insured by the flow controller 41, which as noted, causes the carrier gas to sweep through the reaction zone 16 at a velocity to sweep any unvaporized oil out of the reaction zone 16.

Fixer 12 is provided with a tube 45 having its axis coaxial with that of the fixer and extending from just above the base 46 of fixer 12 to the base of the free space 47 at the top of fixer 12. Tube 45, desirably, is made of the same material of construction as tube 17, e.g., Carborundum, Hastelloy, or stainless steel. The base of tube 45 has a refractory seal 48 bonded to its outer wall and to the inner wall of fixer 12. A similar refractory seal 49 is bonded to the outer wall of tube 45 at its top and to the inner wall of fixer 12. Seals 48 and 49 define, respectively, the bottom and top of an annular heating chamber 51 surrounding tube 45.

Annular heating chamber 51 communicates at its base with a combustion chamber 52 through a passageway 53 leading tangentially as at 54 into the base of chamber 51. Combustion chamber 52 has refractory baffles 55 and 56 therein. Baffles 55 and 56, like baffles 31 and 32, are arranged as shown in the drawing to provide for a circuitous flow of the products of combustion through the combustion chambers and thus effect removal of suspended particles, so that relatively clean hot gases enter tangentially into the annular heating chambers. Line 56, as best shown in FIGURE 2, leads tangentially from the top of annular heating chamber 22 tangentially into the lower portion of heating chamber 51. The hot gas from combustion chamber 52 mixes with that entering annular heating chamber 51 through line 36 and the mixture flows spirally upwardly through annular chamber 51 exiting therefrom through port 37 leading into conduit 58 which communicates with a stack or a waste heat boiler (not shown).

The interior of tube 45 is filled with checker-brick or refractory material 61 arranged as customary for checker-brick in fixing chambers. Desirably, silicon carbide brick are used but other high temperature refractories may be employed. Exit chamber 62 at the base of fixer 12 communicates with conduit 13 leading into the wash box 15 of any conventional type.

A return line 63 leads from exit chamber 62 to a flow controller 64, similar to controller 37. Flow controller 64 controls the recirculation of gas from chamber 62 through lines 63 and 65 to reaction zone 16. Line 65 enters tube 17 tangentially thereto, as shown in FIGURE 2. The make gas thus recirculated from chamber 62 through reaction zone 16 is cracked and reformed producing lighter gravity gas and thus controlling the gravity of the make gas fed to the wash box 15, as hereinafter more fully described.

The controlling equipment will now be described. 70 is a specific gravity controller of any known type, such as the well known Renexer control through which is passed a minor portion of the make gas leaving the wash box 15. Controller 70 controls the amount or volume of gaseous products of combustion introduced into the reaction zone 16 to function as a carrier gas for the oil vapors, when the gaseous products rather than steam or in conjunction with steam, are employed as the carrier gas, and the amount or volume of gas withdrawn from chamber 62 and fed through lines 63 and 65 into the reaction zone. In other words, controller 70 controls the flow controllers 37 and 64. When steam alone is employed as the carrier gas introduced through line 38, controller 70 controls only the amount of gas recirculated from exit chamber 62 through reaction zone 16. For very low gravity gas, little or no products of combustion are recirculated through reaction zone 16.

Controller 71 is a calorimeter, such as the well known Clifton or Hammer calorimeter, through which a minor portion of the make gas is passed and which measures the B.t.u. of the gas. Controller 71 controls the amount of...
hydrocarbon gas making fluid such as oil or gas to be reformed fed to the reaction zone 16. Should the B.t.u. content of the make gas fall below the set or desired value determined by the setting of controller 71, the latter effects opening of the valve 71a controlling the gas making fluid supply to increase its rate of flow to the reaction zone. Should the B.t.u. content of the gas rise above this value, controller 71 partially closes valve 71a and thus reduces the rate of gas making fluid flow to the reaction zone 16.

At the control point 72 in fixer 12, a pyrometer is positioned to control the heat input to the process, i.e., the amount of fuel supplied to combustion chamber 27. By means of these three controls, the process operates continuously to provide gas of desired gravity and B.t.u. to produce as desired, a low gravity high B.t.u. gas satisfactory for use as a substitute for natural gas (gravity 0.61, B.t.u. about 1000), industrial gas (gravity 0.74 B.t.u. about 1000), or chemical gas (gravity 0.5, B.t.u. about 1300), or gas having other desired gravity and/or B.t.u.

In operation, the products of combustion enter the heating chamber at a temperature within the range of 1300° to 2400° F., preferably about 2000° F. to 2300° F. The temperature at the control point is about 1200° F. to 1500° F. The temperature within the reaction zone just above the controller 41 is from 1000° to 1800° F., preferably about 1300° to 1700° F. Temperature gradually falls in the direction of gas flow through the equipment reaching 1200° F. to 1300° F. at the control point 72. The carrier gas is supplied through nozzle 35 at a pressure of from 5 to 125 p.s.i.g. Oil is introduced through nozzle 39 under a pressure of from 50 to 200 p.s.i.g. The amount of oil, of course, will depend upon the capacity of the equipment and the desired B.t.u. of the make gas. Instead of the oil or along with the oil hydrocarbon gas such as propane, butane, pentane, mixtures thereof or lighter hydrocarbon fractions such as "H" fuel to be reformed, can be produced.

The process is continuous. Products of combustion in volume controlled by the pyrometer at control point 72 is introduced into the base of annular heating chamber 22, flow spirally upward, exiting through port 33, flowing through main 36 entering tangentially into the base of the heating chamber 51 where it mixes with hot products of combustion entering tangentially through conduit 54 from combustion chamber 52, if the heat supply from the gases leaving chamber 22 is inadequate to maintain fixer 12 at the desired temperature, and the mixture of hot gases flow spirally upward through chamber 51 and exit at the port 31.

A portion of the products of combustion, particularly when making a high gravity gas, is withdrawn from main 36, the volume controlled by controller 70, and this portion introduced in the reactor zone 16 through nozzle 35. If desired, steam is also introduced through this nozzle or may be employed as the sole carrier gas medium. The carrier gas sweeps upwardly through reaction zone 16 countercurrent to the atomized oil spray, the particles of oil being vaporized by radiant heat derived from the hot gases passing in heat exchange with the outer wall of tube 17. Similarly, when hydrocarbons are reformed, the hydrocarbons introduced in a downward direction through inlet 39 is cracked by radiant heat derived from the hot gases passing in heat exchange with the outer wall of tube 17 and the reformed gases are swept upwardly through reaction zone 16 by the carrier gas stream.

The oil vapor and/or reformed gas and carrier gas mixture flows through conduit 41, free space 47, down through the checkerbrick 61, into and through chamber 62, conduit 13 and wash box 15. A portion of the gas, if desired, is withdrawn from chamber 62 and passes through flow controller 64, line 65, into reaction zone 16. The volume thus recycled is controlled by the specific gravity controller 79 to produce a make gas having the desired gravity. When a low gravity gas is desired, the portion thus recycled is used to the exclusion of the introduction of products of combustion through nozzle 35; steam zone is then introduced through nozzle 35. The lower the desired gravity, the greater the volume of gas recycled through the reaction zone.

All of the above described flows take place continuously.

The following example is given to illustrate a preferred mode of practicing the process of this invention. In this example temperatures are in degrees Fahrenheit and pressures in inches of water gauge. It will be understood that the invention is not limited to this example.

The example is carried out in equipment of the type shown in the drawing in which the reactor 10 and fixer 12 each have an inside diameter of 11 feet, the inside diameter of tubes 17 and 45 are each 6 feet 9 inches and the height of reactor 10 and fixer 12, i.e., the distance from the base of these units to the median of conduit 11 is approximately 30 feet.

Flow controller 70 is set to control the recirculation of products of combustion passing through controller 37 to give a make gas having a specific gravity of about 0.76. The B.t.u. controller 71 is set to control the supply of gas oil to inlet 39 to produce a make gas having a B.t.u. of about 1050. The pyrometer controller regulating the supply of liquid fuel (a No. 6 commercial heating oil) to combustion chamber 27 is set to maintain a temperature of about 1300 at the control point 72.

The average feed of gas oil through inlet 39 into the reaction zone 16 is about 30 gallons per minute. Approximately 4 gallons of fuel-oil per minute are supplied to the combustion chamber 27 and one-half gallon of fuel-oil per minute is supplied to combustion chamber 52. Approximately 600 cubic feet per minute of products of combustion at a temperature of about 1700 are introduced through inlet 35 at the base of the reaction zone 16.

At the base of the annular heating chamber 22 the products of combustion are at a temperature of about 2300 and a pressure of about 30. The products of combustion leave chamber 22 through port 33 at a temperature of 1700 and enter the base of the annular heating chamber 51, where they mix with high products of combustion generated in combustion chamber 52. The temperature of the mixture at the base of the annular heating chamber 51 is about 2300 and the pressure about 50. The products of combustion leave the top of annular heating chamber 51 at a temperature of about 1100 and at a pressure slightly above or at atmospheric pressure.

The carrier gas stream, in amount of about 600 cubic feet per minute of products of combustion withdrawn from conduit 36 at a temperature of about 1700, enters the base of reaction zone 16. The pressure just above controller 44, is about 50. The temperature at this point is about 1300. The oil vapors are vaporized and cracked by radiant heat in the reaction zone 16. The carrier gas stream and oil vapors flow through conduit 11, where the temperature is about 1100 down through the fixing zone 45, which is heated by the hot gases passing through chamber 51 in indirect heat exchange relation with the fixing zone. The gases passing through the fixing zone are thus heated. The gases leaving the fixing zone are cooled in flowing through chamber 62 and conduit 13. They enter wash box 15 at a temperature of about 1000 and leave this wash box at a temperature of about 200. Approximately 180,000 cubic feet of gas per hour are thus produced, having a B.t.u. of about 1050 and specific gravity of 0.76.

It will be noted that the present invention provides a continuous process which is flexible and with the comparatively simple controls above described properly set, generates continuously a low gravity high B.t.u. gas useful as a substitute for natural gas or a high B.t.u. industrial gas of desired gravity, or chemical gases of still higher B.t.u. and gravity, depending upon the setting of the controls. All available hydrocarbon oils, including
gas oil heavy oils, and oil residuums, can be used as the oil feed to the reaction zone 16. Instead of or along with such oils, light hydrocarbon fractions such as "II" fuel, or hydrocarbon gases such as propane, butane, etc. may be reformed. The process requires for its practice, equipment in general the same as existing two-shell water gas or oil gas equipment, requiring not too extensive modification thereof, namely, (1) the addition of the combustion chambers 27 and 52, if the latter is required, (2) the tube 17 defining the reaction zone 16, (3) the checkerbrick containing tube 45 for flow therethro of the gas to effect cracking and fixing thereof, and (4) the controls hereinabove described.

Since certain changes in carrying out the continuous gas process and certain modifications in the apparatus which embody this invention may be made without departing from its scope, it is intended that all matter contained in the above description, or shown in the accompanying drawings, shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A continuous process for generating combustible gas in combustible gas-generating equipment consisting essentially of a reactor and fixed, each comprising a shell having a height of from about 5 feet to about 15 feet, having a single tubular zone therein with the axis thereof coincident with the axis of the shell in which the tubular zone is disposed, each of said tubular zones having a crosswise dimension greater than one-third the said crosswise dimension of its shell and being defined by a tubular wall of good heat-transfer properties spaced from the wall of the shell in which it is disposed to form a substantially annular heating chamber surrounding the tubular wall for substantially the full height thereof, each of said tubular zones extending substantially the full height of the shell in which it is disposed, the tubular zones in the reactor, constituting the reaction zone being substantially unabstructed and thus providing a free space for the gasification of hydrocarbon fluids introduced thereinto, the upper end of said reaction zone communicating directly with the upper end of the tubular zone in the reactor containing the annular heating chamber surrounding the tubular zone in the reactor being communicatively connected with the annular heating chamber surrounding the gas-fixing zone for series flow of heating gases therethrough, which process comprises:

(a) continuously withdrawing the resultant combustible gas from the exit end of said fixing zone.

2. The process as defined in claim 1 in which the hydrocarbon fluid introduced into the reaction zone is heavy oil atomized to form an oil spray directed to an external water gas zone, and the carrier gas is introduced through a restricted opening located near the base of said reaction zone with the axis thereof substantially coincident with the longitudinal axis of said reaction zone, the carrier gas being expanded as it passes through said restricted opening in said reaction zone, flowing upward therethrough and sweeping out of said reaction zone oil vapors produced by the vaporization of the heavy oil in said reaction zone, the resultant mixture of carrier gas and oil vapors being passed from said reaction zone through the gas fixing zone to produce the fixed gas.

3. Apparatus for making gas, in combination,

(a) a reactor shell having a height of from about 5 feet to about 30 feet, a crosswise dimension equivalent to that of a shell having an external diameter of from about 5 feet to about 15 feet, said shell having therein a single inner longitudinally elongated reactor tube having a crosswise dimension greater than one-third the said crosswise dimension of said reactor and and of high temperature, heat resistant and heat conducting material spaced from the inner walls of said reactor shell to define an annular heating chamber surrounding said reactor tube, the longitudinal axis of said reactor tube being substantially coincident with that of said reactor shell;

(b) a reactor shell having a height of from about 5 feet to about 30 feet, a crosswise dimension equivalent to that of a shell having an external diameter of from about 5 feet to about 15 feet, said shell having therein a single inner longitudinally elongated reactor tube having a crosswise dimension greater than one-third the said crosswise dimension of said reactor and and of high temperature, heat resistant and heat conducting material spaced from the inner walls of said reactor shell to define an annular heating chamber surrounding said inner reactor tube, the longitudinal axis of said reactor tube being substantially coincident with that of said reactor shell, said reactor tube having therein heat resistant material for flow of make gases thereover to effect fixing thereof;

(c) the annular heating chamber surrounding said inner reactor tube being communicatively connected with the annular heating chamber surrounding said inner reactor tube for series flow of heating gases from the annular heating chamber surrounding said reactor tube through the annular heating chamber surrounding the fixing tube;

(d) the upper end of said inner reactor tube being directly communicatively connected with the upper end of said reactor tube for flow of make gas from said inner reactor tube over the heat resistant material in and through the inner reactor;

(e) means for supplying heating gases to said annular heating chamber surrounding said reactor tube;

(f) a nozzle positioned in said inner reactor tube for supplying hydrocarbon fluid thereto;

(g) means for supplying a carrier gas to said inner reactor tube to sweep make gas produced in said reactor tube out of said reactor tube and pass the resultant mixture of make gas and carrier gas through said inner reactor tube over the heat resistant material therein to produce fixed gas; and

(h) means for withdrawing the fixed gas from the lower end of said reactor tube.

4. Apparatus for making gas, in combination,

(a) a reactor shell having a height of from about 5 feet to about 30 feet, a crosswise dimension equivalent to that of a shell having an external diameter of from about 5 feet to about 15 feet, having therein a single inner longitudinally elongated reactor tube...
having a crosswise dimension greater than one-half the said crosswise dimension of said reactor shell and of high temperature, heat resistant and heat conducting material spaced from the inner walls of said reactor shell to define an annular heating chamber surrounding said reactor tube, the longitudinal axis of said reactor tube being substantially coincident with that of said reactor shell; 

(b) a reactor shell having a height of from about 5 feet to about 30 feet, a crosswise dimensional equivalent to that of a shell having an external diameter of from about 5 feet to about 15 feet, having therein a single inner longitudinally elongated reactor tube having a crosswise dimension greater than one-half the said crosswise dimension of said reactor shell and of high temperature, heat resistant and heat conducting material spaced from the inner walls of said reactor shell to define an annular heating chamber surrounding said reactor tube, the longitudinal axis of said reactor tube being substantially coincident with that of said reactor shell and said reactor tube having therein heat resistant material for flow of make gases thereover to effect fixing thereof; 

(c) the top of the annular heating chamber surrounding said reactor tube being communicably connected with the base of the annular heating chamber surrounding said reactor tube for series flow of heating gases up through the annular heating chamber surrounding said reactor tube and up through the annular heating chamber surrounding the reactor tube; 

(d) the top of said inner reactor tube being directly communicably connected with the top of said reactor tube for flow of make gas from the top of said inner reactor tube downwardly over the heat resistant material in the inner reactor tube; 

(e) means for supplying heating gases to the base of said annular heating chamber surrounding said reactor tube and flowing said gases upwardly through said heating chamber surrounding said reactor tube and thence into the base of and upwardly through the annular heating chamber surrounding the fixing tube; 

(f) an oil spray nozzle positioned in said inner reactor tube; 

(g) means for supplying a carrier gas to the base of said inner reactor tube for upward flow therefrom to sweep make gas produced in said reactor tube out of the top of said reactor tube and pass the resultant mixture of make gas and carrier gas into the top of said inner reactor tube and downwardly therethrough to fix the make gas; and 

(h) means for withdrawing the fixed gas from the base of said reactor tube.

5. The apparatus for making gas as defined in claim 3 in which said inner reactor tube and said inner reactor tube are of Carborundum.

6. Apparatus as defined in claim 4 having means for recirculating fixed gas through the inner reactor tube; means for supplying a portion of the heating gas employed to heat the annular heating chamber surrounding the inner reactor tube to the inner reactor tube to serve as said carrier gas; a control responsive to the specific gravity of the fixed gas removed as product from the exit end of said reactor tube to control the volume of gas recirculated to the inner reactor tube in the reactor and the volume of heating gases supplied as carrier gas to the inner reactor tube; a control responsive to the P.T.U. of the fixed gas withdrawn from the exit end of the reactor tube to control the volume of oil supplied to the oil spray nozzle in the reactor and a control responsive to the temperature at the control point of the reactor tube for controlling the volume of heating gases supplied to the annular heating chamber surrounding the reactor tube.

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