

Aug. 6, 1929.

J. E. HACKFORD

1,723,418

OIL GAS PROCESS

Filed Oct. 22, 1923

2 Sheets-Sheet 1

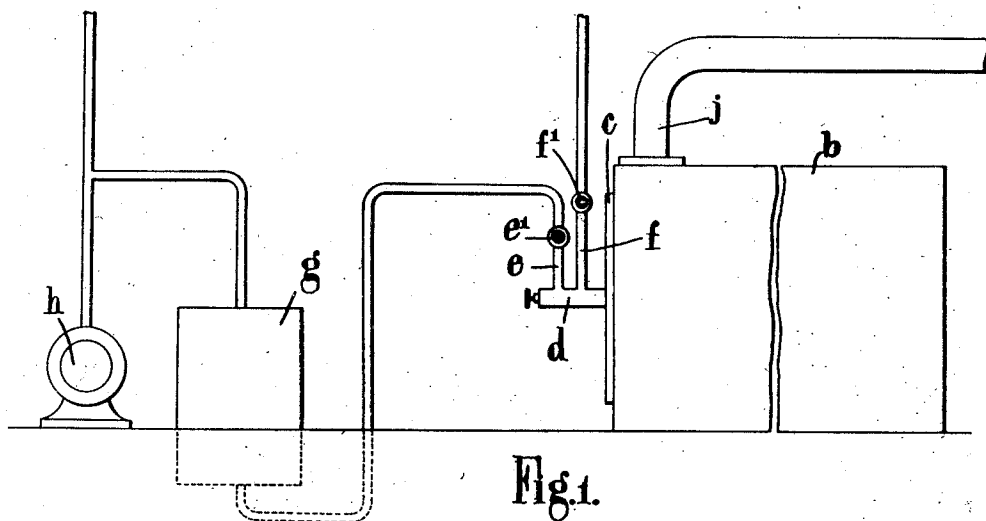


Fig. 1.

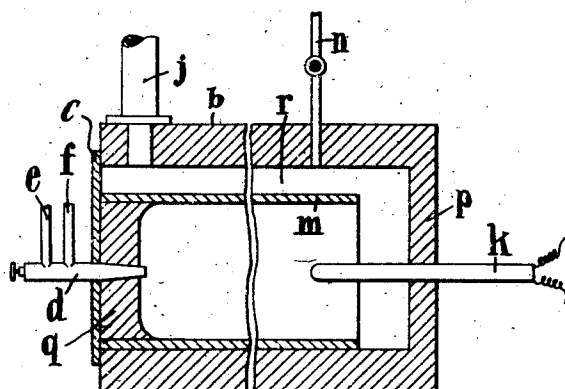


Fig. 4.

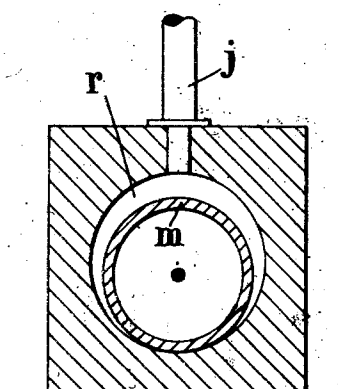


Fig. 5.

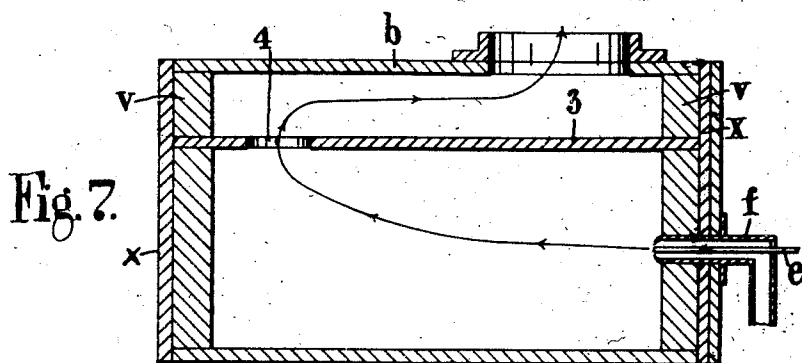


Fig. 7.

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2 Sheets-Sheet 2

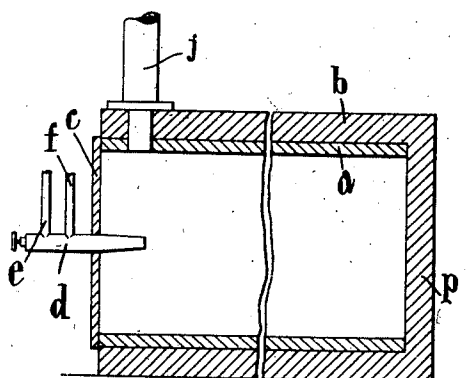


Fig. 2.

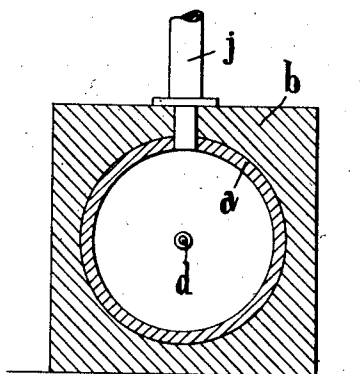


Fig. 3.

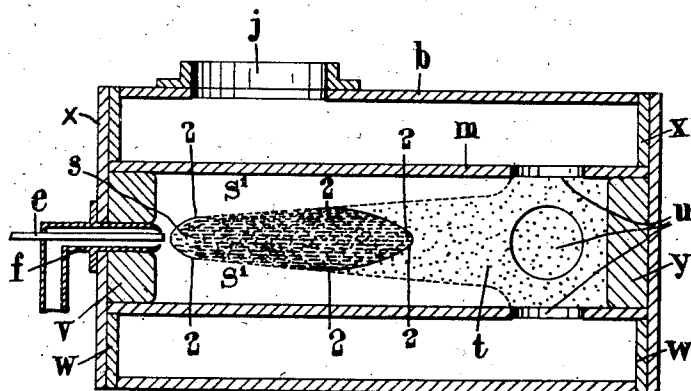


Fig. 6.

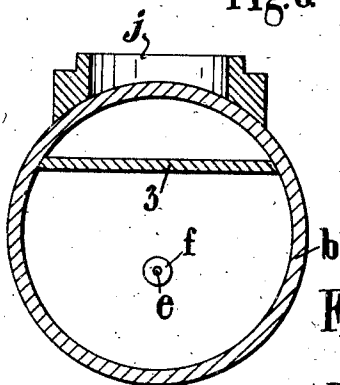


Fig. 8.

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UNITED STATES PATENT OFFICE.

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OIL-GAS PROCESS.

Application filed October 22, 1923, Serial No. 670,158, and in Great Britain December 19, 1922.

This invention relates to the production of gas from animal, vegetable or mineral oils, and more particularly from oils which leave a residue on volatilization, or which carry heavy carbonaceous matter either in solution or suspension.

This invention has for its object to enable gas to be produced in an extremely simple manner without appreciable solid deposit in the generator.

Referring to the accompanying diagrammatic drawings:—

Figure 1 shows in elevation a convenient arrangement of a plant in connection with the present invention;

Figure 2 is a vertical longitudinal section of the gas generator with the nozzle in position;

Figure 3 is a vertical transverse section through the generator;

Figure 4 is a vertical longitudinal section of a modified form of generator with a burner shown in position;

Figure 5 is a vertical lateral section of the generator shown in Figure 4;

Figure 6 is a vertical longitudinal section of a further modification;

Figure 7 is a vertical longitudinal section of a further modification, and

Figure 8 is a cross-sectional view of the construction according to Figure 7.

In carrying the invention into effect in the form illustrated by way of example in Figures 1 to 3, I provide a receptacle *b* having a lining *a* of refractory material through the centre of one end *c* of which a burner nozzle *d* projects inwards so that the longitudinal axis of the latter lies normally to the opposite end wall *p* of the receptacle or generator casing. The burner incorporates two concentric passages connected respectively with an air supply pipe *f* and a liquid fuel supply pipe *e*. Adjacent the burner I provide an outlet *j* through which the gases, after being partially burned, are conducted for use, this outlet being disposed in any convenient position such that the gases before leaving the receptacle must pass in close proximity to the nozzle *d*. In order to start the generator from a cold state, charcoal is introduced into the combustion chamber and lighted. As soon as a small portion of the charcoal glows red the door *c* in which the burner *d* is fitted is closed and the air blast is

turned on, which causes a considerable proportion of the surface of the charcoal to glow with a white heat. As soon as the issuant gases register a temperature of about 200° C. the oil valve *e'* is gently opened, when a little oil is sprayed in, which burns inside the combustion chamber owing to the excess of air present. As soon as the temperature of the issuant gases exceeds about 500° C., the oil is turned on to the required proportions, when the inflammable gases required issue from the burner outlet. During operation, air and atomized oil are sprayed from the nozzle under pressure and the mixture is partially burned.

The air supply from a blower *h* is controlled by a regulating valve *f'* and the liquid fuel in the tank *g* is subject to this air pressure, as will be apparent from Figure 1, whereby liquid fuel is conveyed to the burner through the conduit *e*.

The flame tends to impinge upon the end wall *p* of the receptacle and is deflected backwards thereby so as partially to mix with the flame at its earlier stages and preferably to sweep the surface of the nozzle *d* itself finally (so as adequately to maintain the temperature of the latter) before emerging through the outlet *j*. Subsequent to emergence from the nozzle the oil is partially burned and the oil gas produced finally enters the outlet conduit without any solid residues having been deposited.

The issuing gas when required for direct combustion as in boiler furnaces and the like does not require filtering but for internal combustion engine and similar uses should be filtered in any of the well known ways, e. g. the gas is passed through a suitable receptacle preferably provided with filtering surfaces and means for cleaning the same.

The avoidance of deposition is attained in practice in the example so far described by causing the flame to return and sweep the surface of the nozzle so as adequately to maintain the temperature of the energizing oil and gas mixture. This result may, however, be attained by otherwise ensuring the maintenance of the necessary temperature, (i. e. a temperature exceeding about 600° C.).

Although a minimum temperature of about 600° C. is indicated as essential as regards the combustion initiation region yet the op-

erating temperatures (as measured at substantially the hottest part of the flame) are higher than this and the composition and calorific value of the gas produced varies with the particular operating temperatures employed in the combustion chamber.

The following analyses illustrate how the composition and calorific value of the gas can be varied by operating at different temperatures, the oil used in this case being heavy Mexican bunker oil having a specific gravity of .95 to .96:—

Gas generated at.....	800° C.	850° C.	900° C.	950° C.	1000° C.	1050° C.
Carbon dioxide.....	6.2%	2.6%	3.1%	3.4%	4.8%	2.4%
Oxygen.....	1.0%	0.1%	0.2%	0.3%	0.2%	0.0%
Carbon monoxide.....	11.4%	17.1%	16.9%	18.1%	14.6%	13.2%
Hydrogen.....	0.0%	7.2%	8.8%	16.3%	6.2%	10.0%
Methane.....	9.4%	5.9%	4.2%	4.2%	6.2%	1.1%
Nitrogen.....	72.0%	67.1%	66.8%	57.7%	68.0%	73.3%
B. t. u. (Gross).....	132.8	142.1	143.6	157.7	133.3	90.2
Volume of gas produced.....	118	112	112	104	127.5	152.0
Efficiency.....	85%	86%	87%	88.5%	92%	74.5%

Regarding the above analyses the temperatures were measured at a point just beyond the apex of the combustion initiation region, i. e. substantially at the point of maximum temperature of the flame; the volumes of the gas produced represent cubic feet (at normal temperature and pressure) per lb. of oil and efficiency is based upon the ratio of B. t. u. per cubic foot of gas to B. t. u. per lb. of oil.

It is desirable for gas intended for power purposes to avoid working temperatures exceeding about 1050° C.

Alternatively to starting up the gas generator by means of charcoal as described above, the combustion chamber may be initially heated, e. g. electrically, to a temperature of about 500° C. or a dull red heat, after which the oil is turned on to the required amount necessary for the production of gas. Or again, the inside of the chamber may be brought to the temperature of about 500° C. or so by means such as a gas burner or blow lamp, and then the above procedure followed.

An important feature of that form of the present invention wherein heat of combustion is utilized to maintain in the generator the necessary temperature of the combustion initiation region is that when the output of the gas produced falls below the minimum necessary for the maintenance of this temperature condition the fuel and air may be completely burned within the generator so as to maintain the temperature of the latter and to render it capable of being brought into operation for gas production immediately from a starting or stand-by condition.

When operating under the above-mentioned conditions of complete combustion the products may be diverted from the normal gas outlet conduit, e. g. by being conducted

away through a suitable exhaust conduit.

This diversion may be achieved by any convenient means, e. g., a gate valve controlling a forked conduit and adapted to shut one conduit branch before opening the other, and these means may be actuated in accordance with the output conditions by hand or conveniently by coupling the diverting means with the fuel regulating valve.

In some cases I may shape the back wall of the receptacle so that its inner surface, facing the nozzle, facilitates the turning backwards of the flame towards the latter, and the vessel may be cylindrical, rectangular or of any other convenient shape. Furthermore, it is not essential for the nozzle to be placed in the centre of one end of the receptacle or in all cases for the returning flame actually to sweep the nozzle, e. g. the nozzle may be disposed adjacent one side of the receptacle and the gases forced to return either by suitably disposing the outlet or by the provision of baffles, so as to cause the flame to turn back and pass through the emerging gases adjacent the nozzle for exit from the receptacle.

According to a modification, as illustrated in Figures 4 and 5, the nozzle *d* is fitted to a door or end plate *c* as before, but a member of refractory material *q* shields the burner to a large extent from the heat of combustion. *b* represents the generator casing as before, but in this case a cylindrical lining *m* of refractory material is provided within the casing so as to leave a space *r* for the passage of the hot generated gas between the exterior of the lining and the interior of the casing. This space *r* may be utilized as a gas enriching chamber, in which case oil may be supplied through the pipe *n*, as shown. In this example a pyrometer *k* is provided, as shown, in order to ascertain the temperatures prevailing within the generator, and it will be understood that in both the examples described above various qualities of gas can be obtained dependent upon the relative quantities of oil and air used and upon the resulting temperature determined, for example, by means of a pyrometer.

I may provide for the automatic regulation of the relative proportion of fuel and air in order to maintain approximate constancy of working conditions with varying output. This conveniently may be effected by thermostatic or pyrometric apparatus. The thermostatic apparatus in one form may comprise a conical fuel nozzle valve carried upon a stem of silica (or other suitable material having a low coefficient of expansion) disposed within the fuel jet and rigidly anchored at its end remote from the nozzle. The fuel jet, which is constructed of copper (or other suitable material possessing a high coefficient of expansion) is disposed within a conduit for air which is heated in accordance with the generator temperature, say by passing it

through a jacket surrounding the delivery pipe, and is rigidly anchored at its end remote from the nozzle. By this means when, for example, the temperature of combustion falls, owing to the passage of excessive fuel through the fuel nozzle, the jet will contract longitudinally and by co-operation with the fixed conical fuel valve will reduce the jet nozzle opening. Likewise, when the combustion temperature rises, owing to insufficient fuel being passed, the jet will expand longitudinally and effect an enlargement of the jet nozzle opening.

The pyrometric apparatus in one form may comprise an electric pyrometer whose thermocouple is disposed within the gas generator, a suitable throttling device being provided which is adapted to be operated by the pyrometer circuit so that when, for example, the pyrometer reading rises, the throttling device operates to reduce the proportion of air to fuel. Likewise, when the pyrometer reading falls the throttling device will be operated to increase the proportion of air to fuel.

According to a further modification, the liquid fuel tank is arranged at or near the nozzle level and is connected to the air supply at a point where only a pressure difference due to flow is available to effect feeding as where a throttle orifice is used. Fuel feed is thus proportional to the air delivered. A fuel nozzle is preferably chosen in which only a small pressure drop is required for atomization.

Thus, varying outputs within the limits of the generator may be produced at will by merely regulating the air supply valve, the predetermined quality of the gas remaining substantially unchanged.

Alternatively to supplying air under pressure to the burner, as described above, such pressure feed may be dispensed with if desired, the air conduit and the fuel container being subjected to atmospheric pressure and reduced pressure being applied instead to the outlet conduit or orifice *j*.

In some circumstances, in order conveniently to vary the quantity of gas produced, I interconnect the air and fuel so that movement of a single control effects simultaneous adjustment of both fuel and air. This may conveniently be effected by mechanically interconnecting two separate air and fuel cocks or by providing a composite valve which controls simultaneously conduits for both fuel and air.

In order to explain the action of the gas generator and the meaning of the term "combustion initiation region" reference may be had to Figure 6, in which is represented a modified construction with a concentric inner barrel *m* of refractory material having outlet holes *u* for the products of partial combustion. The burner in this example comprises two concentric tubes *e*, *f*, the former

serving to convey oil and projecting, say $\frac{3}{16}$ " beyond the outlet of the air tube *f* and both passing through a centrally perforated refractory block *v*. The block *v* rests within one end of the barrel *m* which itself is supported at both ends in centrally perforated refractory discs *w*, *w* and is held between end plates *x*, *x*. A refractory block *y* is placed at the opposite end of the barrel *m*, as shown, with its exposed face lying just behind the series of outlet holes *u* formed in the barrel. When the producer is in operation and producing gas, oil and air emerge through their respective nozzles and partial combustion immediately commences. A typical resulting flame is represented by the dotted area *t*, of which the area *s* bounded by the envelope 2 represents the mixture of unburnt oil and air of a low temperature, say 200° C., while the border or envelope 2 of the area *s* represents the "combustion initiation region" and is of a comparatively high temperature, say 600° C. The flame *t* in sweeping through the ports *u* and over the barrel *m* maintains this combustion initiation region and incidentally also the area *s'* adjacent to *s* at the temperature of 600° C. by thermal influence.

The temperature under the conditions stated above of the region of the envelope 2 must be maintained essentially according to the present invention at about or above 600° C. for the action of the producer to be continuous although the temperature external to this region may be somewhat lower and inside, i. e., in the area *s*, is lower due to the air flow. The flame sweeps forward and the products of partial combustion pass outwards in the apertures *u* in the sheath *m* and return over the exterior of this sheath through the compartment formed within the casing *b*, finally emerging from the gas outlet *j*.

It may be remarked that the areas *s* and *t* will alter considerably in accordance with the prevailing conditions of burning (e. g., proportions of air to oil, rate of output, &c.) and those depicted in Figure 6 are given for the purpose of explanation only.

Further essentials to satisfactory operation according to the present invention are, however (1) that the lateral dimensions of the envelope or region 2, 2, shall not be so great as to result in the region coming in contact with the containing space (in this case the interior of the barrel *m*) and (2) that the region shall not be so elongated as to extend through the gas outlet *j*.

According to the further modification illustrated in Figures 7 and 8, a casing *b* of refractory material is furnished with a partition 3 perforated at 4 and the burner *e*, *f*, is disposed in one end wall comprising end plates *x*, *x* and a refractory block *v*. A refractory block *y* is provided at the opposite end of the apparatus and the flame is caused to return so as to sweep the surface of the par-

tition 3 after having passed through the orifice 4. The necessary temperature of combustion initiation is thus ensured.

By burning oil in the presence of air in accordance with this invention permanent oil gas can be produced, containing nitrogen, gaseous hydrocarbons, hydrogen and carbon monoxide, and the calorific value of the gas and the actual proportion of the various constituents can be controlled within limits by a suitable regulation of the oil and air supplies. Furthermore, the gas generator may be operated continuously and the whole of the constituents of the oil utilized throughout a wide range of output.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:—

1. The method of producing fixed gas from hydrocarbons by partial combustion of the same, which consists in producing a spray stream of the material and air in a converter, partially burning the produced spray stream thereby forming a combustible gas, and utilizing the heat of combustion in maintaining the combustion initiation region close to the place at which the hydrocarbon and air spray stream commences at a temperature exceeding about 600° C.

2. A method of producing fixed gas from hydrocarbons by partial combustion, which consists in injecting into a refractory chamber a spray stream of hydrocarbon and air, partially burning the stream and thereby gasifying the unburnt oil portion, and passing the resultant hot combustible gas in countercurrent relationship with said spray stream so as to maintain both the region adjacent the place at which the said intermixing commences and also the combustion initiation region at a temperature exceeding about 600° C.

3. A method of producing fixed gas from hydrocarbons by partial combustion, which consists in injecting into a refractory chamber a spray stream of hydrocarbon and air, the admixture of hydrocarbon and air taking place only after injection, and causing the products of partial combustion to flow in countercurrent relationship with said spray stream so as to maintain both the region adjacent the place at which the said intermixing commences and also the combustion initiation region at a temperature exceeding about 600° C.

In testimony whereof I have signed my name to this specification.

JOHN EDWARD HACKFORD.