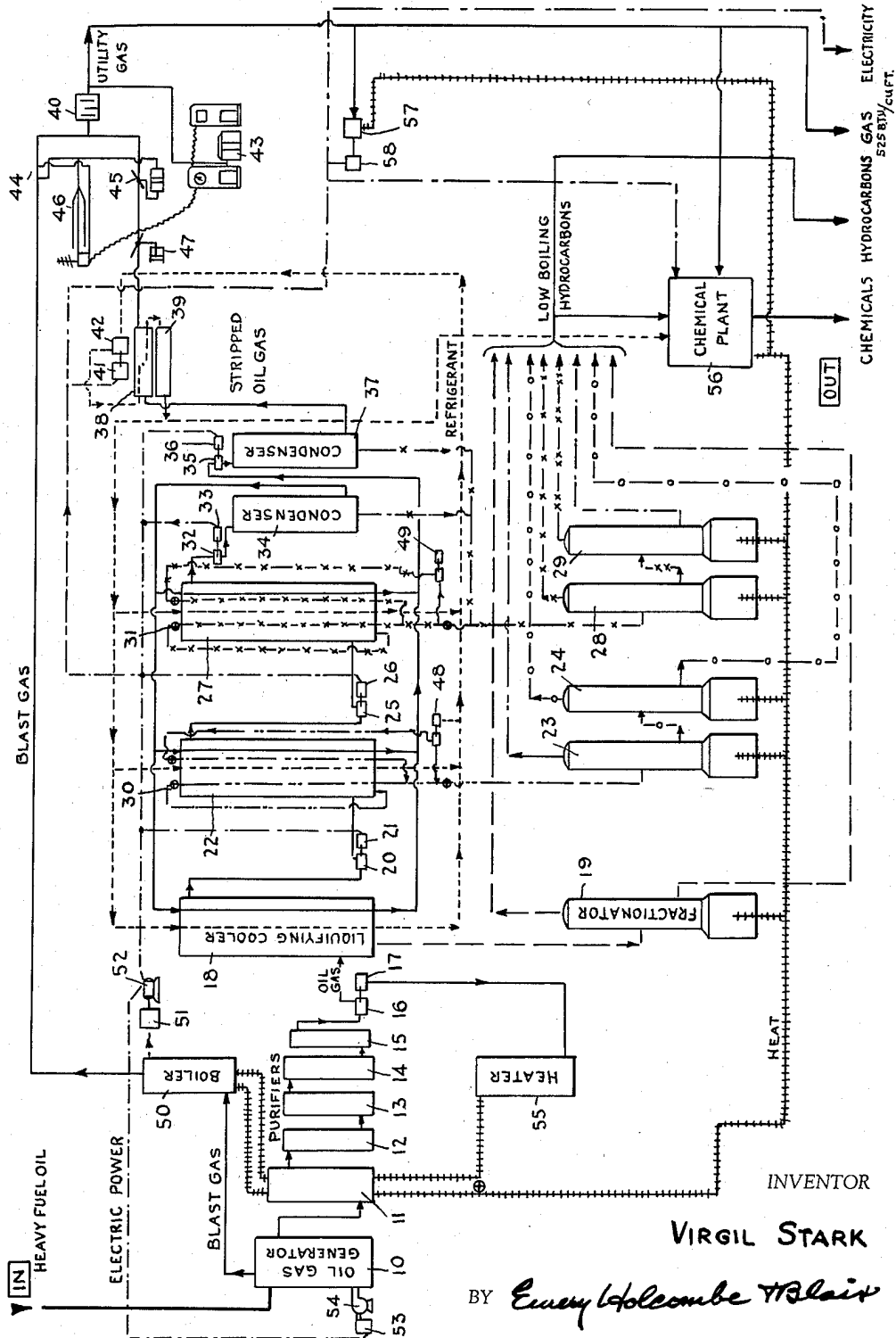


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PROCESS OF TREATING OILGAS TO PRODUCE UTILITY GAS OF LOW  
HEAT CONTENT AND LOW GRAVITY WITH VALUABLE BY-PRODUCTS  
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**PROCESS OF TREATING OILGAS TO PRODUCE  
UTILITY GAS OF LOW HEAT CONTENT AND  
LOW GRAVITY WITH VALUABLE BY-PRODUCTS**

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6 Claims. (Cl. 43-211)

This invention relates inter alia to the production of heating gas from petroleum oils specially heavy oils (called fuel oil No. 6 or Bunker C oil) for distribution by public utilities and use by others, of lower heat content and lower gravity similar to those commonly supplied by utilities today, instead of a high heat content and high gravity which are usual characteristics of oilgas.

The primary object of the invention is to utilize what is known as oilgas for producing a low heat content gaseous fuel by extracting the higher hydrocarbons having value, as such, in forms that can be marketed to advantage, and in so doing to utilize the heat and power produced in the process for carrying such process on and for other purposes, whereby the entire operation and material cost is within the sales value of the hydrocarbons produced, and the gas is produced without cost to the producer.

Other objects of the invention relate to the manner of controlling the heat content and gravity of the gas and liquid hydrocarbons produced, and to the apparatus utilized for carrying out the process in a readily controllable and economical manner.

Particular advantages of the invention are the selective control provided for the various components produced, the manner of extracting higher hydrocarbons from the oil to reduce the heat content and gravity of the gas, the use of self-refrigeration by compressing and expanding the gas in intermediate stages, the use of high pressure for extracting heavy hydrocarbons from the gas prior to cooling and condensing liquid constituents and maintaining the gas under the high pressure developed in the process until it is delivered to the transmission lines for distribution, the recuperation of power by expanding gas in heat engines under the high pressure produced during its manufacture, the use of heat interchangers for conserving heat energy throughout the process, the conjoint use of heat, pressure and expansion combined with absorption by solvents for purifying the gaseous and liquid components produced in a generator and separating out those having a good market and substantial commercial value from the non-liquifiable constituents, purification of the gas by elimination of sulfur compounds and other detrimental unsaturates prior to fractionation and con-

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densation of desirable components, recuperation of power and heat expended in some stages for use in other stages of the process, reduction of the toxicity of the gas produced by controlling the amount of CO developed or present in the constituents at all stages of the process, and utilizing the power and heat developed to manufacture other chemical products from those produced by the process, all as hereinafter described and claimed.

Oilgas is one of the cheapest gases produced as it can be made not only from gasoil but from heavy oils and residues of refinery operations in oilgas generators operating at high temperatures.

However, oil gas has a high heat content (950-1050 B. t. u./C. F.) and high gravity (0.75-0.85). Oilgas cannot substitute as such for gas usually distributed from gas plants, for instance of 525 B. t. u./C. F. and 0.65-0.68 gravity, without adjusting the appliances which is costly. Moreover, oilgas distribution will show a higher "unaccounted for" loss in the gas distribution, and difficulties may be encountered due to condensation in the distributing system of unsaturates present in the oilgas.

The disadvantage of oilgas used as such can be eliminated by applying my invention in such a way as to change the oil gas into gas of similar heat content and gravity with the gas presently distributed, and extract the unsaturates, presently troublesome in distribution, turn them to account as valuable commodities.

One of the purposes of my invention is to provide a process and means for reducing the heat content and the gravity of oilgas so as to make a gas suitable, and better gas, for distribution having the characteristics of other gases distributed by utilities.

Means are provided to reduce the cost of the process, and also to obtain valuable byproducts which will reduce considerably the cost of gas produced, and eventually provide gas and/or electricity at no cost. The basic idea is to start specially from heavy petroleum oils and, through the application of teachings of this invention, obtain finally gas at no cost covering the expense of all the plant by the byproducts obtainable, and my invention enables this to be done.

The constituent parts of this invention qualify the other parts thereof and enter into the whole in achieving together the purposes sought, that is a superior gas, adapted for use without prior adjustment of appliances, free of matter likely to cause difficulties in its distribution, and accomplishing all of the same without expense by the extraction of valuable basic products, and eventual manufacturing thereafter of chemicals from such extracted products.

The oilgas can have a variable analysis depending on the kind of fuel used, the temperature and process to which it is subjected, and different methods of production.

There are present in the oilgas higher hydrocarbons (C<sub>2</sub> to C<sub>8</sub>) mostly unsaturates which represent 22% to 35% of the volume of oilgas. Out of these the main compounds are the ethylene which can be from 14%-21%

of the total volume and propylene 4%–3%. A typical analysis is shown in the following table:

esses for lowering the heat content and gravity of oilgas. The technique for extracting hydrocarbons from a gas

Analysis of typical gas

	Percentage	Boiling points at atm. press.	Heat content, B. t. u./C. F.	Gravity, Air=1	Partial heat content per cu. ft. of gas, B. t. u.	Partial gravity of gas, Air=1	
(a)	O <sub>2</sub> .....	0.5	-183	1.100	-----	0.005	
	CO.....	3.0	-313	0.960	9.6	0.028	
	H <sub>2</sub> .....	19.5	-423	0.069	63.0	0.013	
	N <sub>2</sub> .....	14.0	-320	0.967	-----	0.132	
	CH <sub>4</sub> .....	31.5	-258	1,013.6	0.550	320.0	0.173
	68.5				392.6	0.351	
(b)	CO <sub>2</sub> .....	3.5	-109	1.520	-----	0.053	
(c)	Ethylene C <sub>2</sub> H <sub>4</sub> .....	15.1	-155	1,615	0.970	244.0	0.145
	Ethane C <sub>2</sub> H <sub>6</sub> .....	3.3	-127	1,793	1.090	59.0	0.036
	Propane C <sub>3</sub> H <sub>8</sub> .....	0.3	-43	2,591	1.550	7.7	0.004
	18.7				310.7	0.185	
(d)	Propylene C <sub>3</sub> H <sub>6</sub> .....	4.5	-52	3,386	1.480	107.0	0.066
	Butylene C <sub>4</sub> H <sub>8</sub> .....	0.7	+21	3,088	1.930	21.0	0.013
	Butadiene C <sub>4</sub> H <sub>6</sub> .....	1.1	+24	3,150	1.950	35.0	0.021
	Pentadine C <sub>5</sub> H <sub>8</sub> .....	0.3	+108	2,200	2.300	6.6	0.007
	Pentane C <sub>5</sub> H <sub>12</sub> .....	0.1	+97	4,020	2.500	4.0	0.002
	6.7				173.6	0.109	
(e)	Benzene C <sub>6</sub> H <sub>6</sub> .....	1.9	+176	3,776	2.710	72.0	0.052
	Toluene C <sub>7</sub> H <sub>8</sub> .....	0.5	+231	4,485	3.170	22.0	0.015
	Styrene C <sub>8</sub> H <sub>8</sub> .....	0.04	+290	4,700	3.400	1.8	0.001
	Xylene C <sub>8</sub> H <sub>10</sub> .....	0.2	+282	5,221	3.660	10.4	0.007
	2.6				106.2	0.075	

The foregoing typical gas as shown by its analysis has 983 B. t. u./C. F. and gravity 0.77.

The aromatic hydrocarbons under (e) represent 2.6% in volume with a participation of 106.2 B. t. u. in the heat content (10.8%) and a participation of 0.075 in the gravity (10%). The hydrocarbons (c) to (d) represent 25.4% in volume and a participation in the heat content of 484.3 B. t. u. (49%) and a participation in gravity of 0.294 (36.5%). Another heavy component in the oilgas is CO<sub>2</sub> (b) which represents 3.5% volume and 6.8% of the gravity.

For lowering the heat content and gravity of the oilgas, I propose to extract from the oilgas as produced in a suitable generator, the CO<sub>2</sub> and the higher hydrocarbons, and thereafter separate such hydrocarbons into salable commercial products, utilizing the heat produced for power and processing purposes.

The extraction of the higher hydrocarbons can be partial, selected, or total as shown hereafter. The gas can thereafter be either enriched or diluted by automatic controls as hereafter described, so as to produce a gas of desired and constant heat content and gravity.

The following is an example:

A gas of 525 B. t. u./C. F. and 0.65–0.68 gravity (similar to the commonly known carburetted water gas) is desired. If the above typical analysis is taken as a basis, the extraction of all the hydrocarbons (C<sub>2</sub> to C<sub>8</sub>) representing 28% of the volume, and the extraction of CO<sub>2</sub> representing 3.5% of the volume, will reduce the gas to 395 B. t. u. for 0.685 C. F. that is 568 B. t. u./C. F. and gravity 0.505. If only approximately 90% of the C<sub>2</sub> hydrocarbons and 95% of C<sub>3</sub> to C<sub>5</sub> hydrocarbons and all of C<sub>6</sub> to C<sub>8</sub> hydrocarbons are extracted and approximately all of the CO<sub>2</sub>, the heat content of the gas will be 607 B. t. u./C. F. and 0.536 gravity.

By diluting the latter gas with 13.5% of flue gas or air, the heat content of the gas will be 525 B. t. u./C. F. and the gravity will be 0.6.

Further extraction, selection and separation of components from the gas after extraction can be made as hereafter shown.

To my knowledge there is no process of and no plant in existence furnishing the means for making oilgas and using either of the foregoing specified proc-

is not, in itself, new. Hydrocarbons have been extracted, for instance, from refinery gas, coke oven gas, which are themselves byproducts of oil refineries and coke oven plants. The beginning product in such processes has been either crude oil or coke, products which are in every instance different from the feed I propose to start with such as heavy oil. No process hitherto known or in operation proceeds from heavy oil for instance in its initial stage, in order to produce oilgas in a gas generator, continues thereafter to improve the quality of such oilgas in order to make it readily adaptable for gas distribution without the necessity for prior readjustment of appliances, and also extract unsaturated hydrocarbons which are both wasteful and troublesome for gas distribution, and by extracting them not only reduce the heat content and specific gravity of the gas, but also derive marketable products of such value as to defray the cost of my process for the production of a better utility gas.

My invention embraces a known technique as a step within a new, improved and complete process applied to a new field. My process, by which a better gas is produced at no cost, will have a profound effect on the conservation of basic resources, the supply of chemicals for which there is growing need, and the eventual production of power at no cost from gas at no cost.

There are several methods of extraction which may be used in my process:

(a) The gas can be compressed in stages and refrigerated in stages. If the gas is refrigerated below the temperature corresponding to the partial vapor pressure of the hydrocarbons, such hydrocarbons will begin to condense. The condensation process will gradually continue depending on the gradual reduction of vapor pressure and the temperatures. The condensed hydrocarbons can be separated by fractionation. The pressure of the gas can also be released by stages creating self-refrigeration of the gas which also can be used for condensation.

(b) Another method is to absorb the heavier hydrocarbons from the gas with a liquid absorbent and then to extract from the absorbent the different hydrocarbon constituents and separate them by fractionation. The gas can be compressed and the liquid absorbent

can be cooled to increase the absorption capacity. The rich absorbent can be fractionated to release the hydrocarbons in different stages. The lean absorbent can be re-used in the process. Ethylene, which is one of several possible byproducts of the extraction process, can be used as a refrigerant of this absorbent.

(c) The extraction of hydrocarbons from the oilgas mixture or from the liquid absorbent can be done by solid adsorbers such as activated carbon, silica gel, etc., and then separation by heat and fractionation as is well known.

(d) The separation can be done by chemical methods using chemicals to react with hydrocarbons to form new compounds and separate same from the gas.

Other methods can be used for separation of hydrocarbons from oilgas mixtures such as various combinations of the above methods, thermal diffusion, etc., as is well known.

My invention provides important improvements for the first method (a) of the process above outlined, as hereinafter described.

An illustrative system and procedure for carrying out my invention is shown in the accompanying diagram, based on the first method (a) above described.

Bunker oil, refinery residue or other oil is fed to the oilgas generator 10 and cracked by contact with the highly heated checkerwork to form oilgas, which passes to the heat exchanger 11 where the temperature of the oilgas is reduced from about 1600° F., or whatever temperature at which it leaves the oilgas generator, to cooling water temperature preliminary to passing through the tar separator 12, naphthalene scrubber 13, CO<sub>2</sub> separator and H<sub>2</sub>S purifier 14, to the dryer 15. The tar and light oils removed from the oilgas at this stage of the process are withdrawn and stored for sale or used for heating the generator and other uses in the plant.

The dry oilgas is compressed to about 110 p. s. i. g. in a suitable compressor 16, driven preferably by a gas engine 17 and cooled to -30° F. in a tower 18 where a large percentage of the aromatic hydrocarbon constituents are liquified and withdrawn separately for fractionation in a suitable tower 19 and further treatment to prepare them for sale. The oilgas passes from the tower 18 through a compressor 20 driven by an electric motor or gas engine 21 into a second cooling tower 22 at a pressure of about 600 p. s. i. g. where the temperature is reduced to about -120° F. and additional aromatic hydrocarbons and other hydrocarbons, specially C<sub>3</sub> to C<sub>6</sub>, are condensed and withdrawn for fractionation in the towers 23, 24 to separate them into salable products.

From the second cooling tower 22 the gaseous constituents are preferably again compressed to a pressure of about 1200 p. s. i. g. in a suitable compressor 25 driven by an electric motor or gas engine 26, and are again cooled to about -130° F. in a third cooling tower 27 to condense most of the remaining liquifiable hydrocarbons, which are withdrawn to a pair of fractionating towers 28, 29 for further separation and treatment to prepare them for sale. The second and third cooling towers, 22, 27, are provided with expansion valves 30, 31 for reducing the pressure on the condensate and thereby causing it to expand with a consequent lowering of temperature to aid in cooling these towers and obtain more complete liquification of the desired hydrocarbons.

From the third cooling tower the stripped oilgas is advantageously expanded in a suitable type engine 32 to reduce its pressure and lower its temperature, at the same time producing power in a suitable generator 33 for producing electric power for operating such of the compressors as are driven by motors. The oilgas may be reduced by steps from 1200 p. s. i. g. in engines 32, and discharged into the condenser 34 at a low temperature. The cold gas may be circulated through the several coolers and back to another engine 35 operating

a generator 36 also supplying electric power for use in the process, where its pressure is reduced to about 5 p. s. i. g. and exhausts into a second condenser 37 at a very low temperature.

Alternatively after the gas is compressed either after the second stage to 600 p. s. i. g. for instance or after the third stage, the gas can be expanded in an expansion engine. Such an expansion can also be made by steps for instance from 1200 p. s. i. g. to 400 p. s. i. g. and from 400 p. s. i. g. to 100 p. s. i. g. The temperature of the gas will be lowered by such expansion to low temperatures, increasing the condensing yield.

In the apparatus illustrated, the stripped oilgas is passed through a heat interchanger 38 forming part of a refrigeration unit 39 for a suitable refrigerant used for cooling purposes in the process and is discharged to the mixer 40 and devices for controlling the volume and heat content of the finished gas as hereafter described.

Part of the stripped low temperature oilgas can be used as the refrigerant in a closed circulating system comprising the refrigeration unit 39 and the three coolers 18, 22 and 27, or a special refrigerant may be used such as ethylene, which boils at -155° F. After passing through one or more of these coolers in a coil or pipe system in which the refrigerant becomes vaporized by extracting heat from the contents of the coolers, the refrigerant is compressed in the refrigerating unit and condensed and liquified by the cool oilgas on its way to the mixer to be delivered to the gas main for distribution to users. An electric motor 41 is preferably provided for driving the compressor 42 of the refrigeration unit as this can be operated by electricity produced elsewhere in the system.

The treated and stripped oilgas as it comes from the last stage of the apparatus illustrated in the drawing may have a heat content of from 580 B. t. u./C. F. to 600 B. t. u./C. F., and for delivery to the using services it is desirable to reduce this to 525 B. t. u./C. F. which may be done advantageously by mixing it with a suitable volume of blast gas from the oilgas generator 10, the amount being determined by any suitable type of volume and heat content control apparatus 43 operating valves 44, 45 in the blast gas and stripped oilgas lines, respectively, through valve control means 46. An additional control valve 47 is provided for maintaining the desired pressure on the stripped oilgas line.

Condensate for the liquefying coolers 22, 27 may be recirculated through the motor-driven compressor units 48, 49 for still further lowering the temperature in these vessels if desired, suitable valves being provided in the system for this purpose, as shown in the diagram.

The hot blast gas from the oilgas generator 10 is passed through a waste heat boiler 50 where it makes enough steam to operate a turbine 51 which in turn drives a generator 52 for operating the motor 53 which drives the blast gas blower 54 and supplying electric power to the system. Some of the heat recuperated from the generator in the heat exchanger 11 may be used for heating the fractionators 19, 23, 24, 28 and 29, and for chemical fabrication. Also the exhaust gases from the gas engines 17 are passed through a heat exchanger 55 and utilized for heating water for the waste heat boiler, and for supplying heat to the chemical manufacturing plant 56, thereby supplementing the other sources of heat and power comprised in the system.

The extracted hydrocarbons condensed in the cooler at high pressure and then vaporized by releasing the temperature (and used for cooling) can again be compressed for instance at 400 p. s. i. g. The pressure can again be released and temperatures dropped and again cooling obtained. Part of the low B. t. u./C. F. gas produced can be utilized in a gas engine 57 for producing electric power in a generator 58.

It may not be necessary to use all of the possibilities and all the stages of compression, cooling, etc., given

above and shown in the diagram. It may be, for instance, sufficient to compress the gas only to 600 p. s. i. g. and even lower for instance 350 p. s. i. g. In such case (for instance, 350 p. s. i. g. or lower) only one compression stage would be required and the compressed gas may be refrigerated in the successive towers 18, 22 and 27 to convenient temperatures, for example  $-30^{\circ}$  F.,  $-80^{\circ}$  F. and  $-120^{\circ}$  F. It is customary to cool the compressed gas after each compression stage before entering the cooling tower, utilizing cooling water or low temperature stripped gas for suitable heat exchangers for this purpose; and the heat thus recuperated can be used for the heat requirements of the process and for other purposes in the combined plants, such as heating oil and tar, purification of  $H_2S$  and  $CO_2$ , making steam, regeneration of ammonia or other refrigerant for producing refrigeration for the plant requirements, any surplus being disposed of in any convenient manner as is well understood in the art. The pressure can be released (in stages) to near to atmospheric pressure and a temperature drop to  $-210^{\circ}$  F. for instance obtained. The cool gas at such low temperatures can cool the gas under pressure (at different stages) and selected temperatures for instance  $30^{\circ}$  F. (1st stage)  $-120^{\circ}$  F. (2nd stage)  $-140^{\circ}$  F. (3rd stage) etc., and obtain the selected condensations. Additional refrigeration can be obtained for one or more stages for either one or more of the following possibilities:

(a) Release of condensate pressure.

(b) Extra separate refrigeration.

(c) Repressure of vapor of extracted product (for instance ethylene) and thereafter pressure drop.

Above compression and cooling can also be combined after selected stages with absorption or adsorption or chemical extraction etc.

In other words, above diagrams and above description give only an example with suggested improvements, however, a variety of stages, pressures, temperatures, etc., can be combined depending on the analysis of the gas and the percentage of extraction and what separations are desired.

When oil gas is produced, air is blasted in the generator and oil is used for heating the checker bricks. The heat content of the blast ( $h$ ) is generally lost. The oilgas is produced at a temperature of approximately  $1600^{\circ}$  F. When cooling the gas the sensible heat in the oilgas ( $h_1$ ) is generally lost.

The compressors for compression at various stages can be driven by gas engines or a central gas engine will provide electricity and the compressors can be driven by electric motors. In both cases the heat from the exhaust gases ( $h_2$ ) of the gas engines can be used for the heat requirements of the plant.

I propose to use this heat ( $h+h_1+h_2$ ) for producing steam at higher pressures to drive steam turbines with or without back pressures and/or to recuperate the heat to supply heat requirements to the plant.

It is figured that the power recuperated will cover a good part of the requirements of the process, and the heat recuperated will cover most of the heat requirements of the plant.

As the gas can have a variable heat content because the variety of fuels and methods used in its generation and if a lower heat content than 590 B. t. u./C. F. is desired, I propose the following process to obtain a gas of constant heat content and desired lower heat content.

The gas obtained after extraction can have 590-650 B. t. u./C. F. and a gravity of 0.53-0.61. The gas made in the United States in carburetted water gas sets has generally 525 B. t. u./C. F. and approximately 0.64-0.68 gravity. The gas after extracting can be diluted with flue gas from the oil-gas generator or air. If the gas has for instance 607 B. t. u./C. F. and 0.536 gravity, it will be necessary to mix 13.5% of air or flue gas to obtain a gas of 525 B. t. u./C. F. and 0.6 gravity. The gas can also be

enriched with some of the extracted hydrocarbons to a higher heat content and then be diluted with air or flue gas. The enriching and dilution can be automatically controlled with motor operated or hydraulic operated butterfly valves and on the supply lines of gas and/or diluent and/or enricher. Such valves can be automatically controlled and acted upon either by a combination of heat valve controls with or without a volumetric control.

With the above method the gas is compressed first for obtaining the necessary partial vapor pressures of the components for condensation, and then by expansion of the gas refrigeration is obtained which will cool the gas to very low temperatures helping again to condense the hydrocarbons. The heat available at the oilgas generator and exhaust of the engines, and the power obtained from expansion engines, are used to produce a good part of the power necessary for compression. The heat recuperated is used for the requirements of the plant and the low temperature of the gas is again used for cooling. In this way important saving not only in power but in refrigeration and heat requirements are made, which are characteristics of my process only.

My process constitutes an extension completion and improvement of an oilgas generating plant using the heat and power obtainable from the oilgas generator for continuing and supplementing process in the extraction plant.

As primary feed for my process for cracking in an oil-gas generator and then hydrocarbon extraction not only heavy oil (fuel oil No. 6) but other petroleum oils (for instance fuel oils No. 1-No. 5) and other products such as paraffins (propane, butane, etc.) vegetable oils, etc.

The cracking of the primary feed can be made not only in an oilgas generator of known design, but also in a gas generator as covered by my Patent No. 2,465,666 and my patent application, Serial No. 192,865, with or without using a catalyst. As the formation of olefins, dienes and aromatics from the feed is dependent on the temperatures of cracking and time of contact, my generator as per above patents, can well be applied with above feed and/or steam and/or air. The desired and controlled temperatures and time of reaction can be better obtained as with other generators. The carbon which may be formed can be eliminated by periodical and/or continuous injection of air and/or steam with or without the feed either in the direction of the process or as periodical backrun in a direction contrary to the process.

The reduction of heat content of the gas can also be made without above extraction process by catalytical cracking of the gas. However, in this case heat is needed for the catalytical cracking and the efficiency is only 60%-70%. The high value hydrocarbons are destroyed instead of separated and recuperated. The CO produced during catalytical cracking will increase and make the gas more toxic.

The catalytical cracking could, however, be applied after extraction of the unsaturates from the gas, and the  $CH_4$  and  $C_2$  to  $C_5$  changed mostly (up to 97%) in  $H_2$  and CO. The CO can also be converted in  $H_2$  and  $CO_2$  and the  $CO_2$  extracted by known means. In such case the remaining gas will be mostly  $H_2$  and partially  $N_2$  and could be used for producing ammonia ( $NH_3$ ) and fertilizer at lower cost.

The generator as per my above patents can also be used for different stages of my process. A first generator can be used for instance without a catalyst for cracking fuel oils and producing a gas with a large percentage of unsaturated hydrocarbons. The unsaturates can then be extracted as aforesaid. The remaining gas containing a high percentage of  $CH_4$  (approx. 45%) and a small balance of unextracted unsaturates (approx. 3%) can then be cracked catalytically in a second generator, for instance a generator as per my Patent No. 2,465,666 with steam and/or air in the presence of a catalyst. The  $CH_4$  and other hydrocarbons will form  $H_2$ , CO,  $CO_2$  and thereby

the heat content and gravity of the gas will be further reduced (275 B. t. u./C. F. for instance and gravity 0.32 for instance). Such reformed gas can then be enriched with low value hydrocarbons either part of the extracted ones or supplied separately (for instance propane), and obtain a gas of desired heat content even up to 1,000 B. t. u./C. F. which can be used as reserve or peak load requirements for natural gas distribution.

Other possibilities are available using another generator as per my above Patent No. 2,465,666 and patent application, Serial No. 192,865, that is to heat the gas after extraction of unsaturates to high temperatures (above 1,300° C.) with air or oxygen and produce from the CH<sub>4</sub> in the gas acetylene which can be removed from the gas and use the remaining gas for utilities or other purposes. Such gas will have a higher H<sub>2</sub> content and lower heat content and gravity, and can be enriched to desired heat content as above said.

The hydrocarbons produced as above described can be separated and have a high market value. For a gas of the above typical analysis, the hydrocarbons represent 28 lbs./MCF of gas processed out of which ethylene constitutes 10.8 lbs./MCF, propylene 5.15 lbs./MCF, butadiene 1.67 lbs./MCF, ethane 2.5 lbs./MCF, benzene 4 lbs./MCF, and toluene 1.25 lbs. per MCF. A high percentage of these constituents can be extracted and separated into grades suitable for sale.

The hydrocarbons which can be separated have a market value which can be in excess of the heavy oil for making the gas which means that the gas of desired heat content and desired gravity may be obtained without cost. Ethylene can be used to make a number of chemicals such as: Ethylalcohol, vinyl chloride, ethylene oxide, ethylene glycol, ethanolamine, styrene ethylene chlorhydrine, ethylchloride, ethylene dichloride, ethyl benzene, polyethylene, ethyldibromide, acrylonitril, ethylacetate, etc. From propylene can be produced chemicals such as: isopropylalcohol, acetone, allylchloride, propylene oxide, propylene glycol, etc. Gas at no cost and/or heat available from the plant can also be used for the production of the above chemicals.

In the manufacturing of the chemical products from extracted hydrocarbons by my process, heat and/or refrigeration and/or power may be necessary.

By aggregating the three types of plants that is: (1) production of oilgas—(2) extraction—(3) manufacturing of chemicals from extracted products, heat and/or refrigeration and/or power and/or excess byproducts can be aggregated, combined and used from one plant to another and increase the economies of production of final products. There will also be a new method of operation of such plants considering the available elements and heat and power from each of the 3 different types of plants aggregated to produce final compounds.

Some of the products extracted from the gas and separated could be combined thereafter to produce chemical products. For instance ethylene can be reacted with benzene to produce styrene of higher market value. Styrene and butadiene can be used for making synthetic rubber.

The gas after extraction can be obtained at a pressure which eventually can be used for piping it at longer distance for supply in high pressure transmission pipes. In this way the pressure needed for such supply is also used for the extraction process. Moreover, the volume of the extracted gas is reduced at high pressure and low temperature. The gas can be stored in pressure tanks of smaller capacity instead of large holders which can reduce the investment cost for storage.

The carbon oxide (CO) is of concern to gas distribution because it is toxic. The carburetted water gas has approximately 30% CO and the mixture of coal gas, water gas and producer gas used in certain plants show 15–20% CO. The gas from oil after extraction of hydrocarbons shows only approximately 4% CO which makes the gas less toxic than other presently distributed

gases. The unsaturated hydrocarbons in the oilgas eventually condense in the gas distribution system and cause difficulties. The extraction of the unsaturates will eliminate them, and the compression and cooling of the gas will purify the gas from water and impurities. Consideration must be given to the purification of oilgas from sulphur in form of H<sub>2</sub>S and organic sulphur compounds. It is preferable to purify the gas before processing. However, the sulphur compounds can also be extracted during the process at appropriate pressures and temperatures. This can apply specially to the organic sulphur compounds such as carbon disulfide, mercaptans, thiophenes which have a higher boiling point. Instead of destroying the organic sulphur compounds, they could be separated and obtain marketable products. It is also possible to separate CH<sub>4</sub> or H<sub>2</sub> from the gas produced at no cost and use same for production of chemicals at lower cost.

Thus the above process will not only provide a gas of desired heat content and gravity, but also will provide a purified gas eventually at high pressures, and the savings and recuperation of power, heat and refrigeration will allow a more economical process. The outstanding advantage is that the market value of the extracted compounds, such as valuable hydrocarbons, can be higher than the production cost of the oilgas and the cost of extracting and separating them. In this way it will be possible by selling these byproducts to obtain the gas at no production cost.

A gas produced without cost can give a large possibility of increase in the sale of gas by utilities allowing them to lower the gas rates. The high increase in gas consumption can be similar to the one experienced when natural gas was distributed in many cities at lower rates than coal gas or carburetted water gas.

When gas is available at no cost, electricity can be produced in generators driven by gas engines (approximately 11,000 B. t. u./H. P.) at much lower cost than any existing method of producing electricity. Considering the production of electricity from extracted oilgas, the value of the extracted hydrocarbons will be in excess of the production cost of oilgas, extraction cost, and amortization and operation cost of the electrical plant, so that electricity will be obtained at no cost whatsoever.

Having gas and electricity at no cost, it will have a great economical importance. Above economies can be extended at all uses of gas and/or electricity and/or heat and/or refrigeration and/or chemical process.

In the claims the term "oilgas" is used to denote a mixture of cracked hydrocarbons produced by highly heating a low grade petroleum distillate or residue rich in heavy hydrocarbons and having a heat content of from 950 to 1050 B. t. u./C. F. and a gravity of from 0.75 to 0.85, and the term "utility gas" is used to denote a mixture of permanent gases comprising essentially carbon monoxide, hydrogen and methane, nitrogen and small amounts of higher heat content hydrocarbons, having a heat content of about 525 B. t. u./C. F. and a gravity of about 0.6.

What I claim and desire to secure by Letters Patent is as follows:

1. The process of producing utility gas from petroleum derivatives containing heavy hydrocarbons which comprises heating said petroleum derivatives to a cracking temperature from 1500° F. to 1700° F. and gasifying them, using a hot blast produced by combustion to oxidize the carbon deposited, utilizing the heat of said hot blast gas and cracked gaseous products at least in part to produce steam, compressing said cracked gaseous products to 200 p. s. i. g. to 1200 p. s. i. g. and cooling them in successive stages from 0° F. to -120° F. to liquify low boiling constituents, removing the condensate and permitting it to vaporize and expand and utilizing it in cooling said cracked gaseous products, heating and fractionating said vaporized and expanded condensate by means of steam produced in the process, expanding the

stripped gaseous products to generate power and produce self-refrigeration, cooling a liquid at sub-atmospheric temperature by heat exchange with said expanded gaseous products and using it in cooling the cracked gaseous products in the stripping stages, and mixing sufficient hot blast gas with said stripped gaseous products to produce a satisfactory utility gas for distribution as such.

2. The process set forth in claim 1 wherein the gaseous products are purified to remove undesirable constituents before the removal of low boiling constituents.

3. The process set forth in claim 1 wherein carbon dioxide is removed from the gaseous product before the compressing and cooling steps for reducing gravity of gas and allowing easier extraction of hydrocarbons.

4. The process set forth in claim 1 wherein the removal of low boiling hydrocarbons is effected in successive stages, the condensate produced in each stage being separately fractionated to produce a series of hydrocarbon products.

5. A process of producing gas of high hydrogen content and low gravity from oil gas or refinery gas which comprises purifying the gas, then compressing and refrigerating the gas and extracting and separating higher hydrocarbons therefrom, then reforming the stripped gas catalytically so as to decompose the remaining hydrocarbons not fully extracted and including the methane to hydrogen and carbon oxide thereby obtaining a gas containing about 67% hydrogen having a gravity of about .38, reforming catalytically a portion of the separated higher hydrocarbons to obtain gas of low heat content and enriching said catalytically reformed portion with another portion of the separated higher hydrocarbons, thereby obtaining additional gas of desired heat content and gravity, blending said enriched gas and reformed stripped gas and utilizing for by-products the remaining high hydrocarbons previously extracted and separated from the gas.

6. A process for producing hydrogen and a gas of high

hydrogen content and low gravity from petroleum oils, especially from heavy fuel oil, comprising heating said oil to produce oil gas, treating said oil gas to purify, compress, refrigerate and extract higher hydrocarbons therefrom, reforming catalytically the stripped gas so as to decompose the remaining hydrocarbons into a gas containing a high percentage of H<sub>2</sub> and CO and thereupon increasing to about 95% the H<sub>2</sub> content of such gas by conversion of CO with steam into H<sub>2</sub> and CO<sub>2</sub> and removal of the CO<sub>2</sub>, thereby producing hydrogen for all purposes including ammonia synthesis, reforming catalytically a portion of the separated higher hydrocarbons to obtain gas of low heat content and enriching said catalytically reformed portion with another portion of the separated higher hydrocarbons, thereby obtaining gas of desired constant heat content.

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