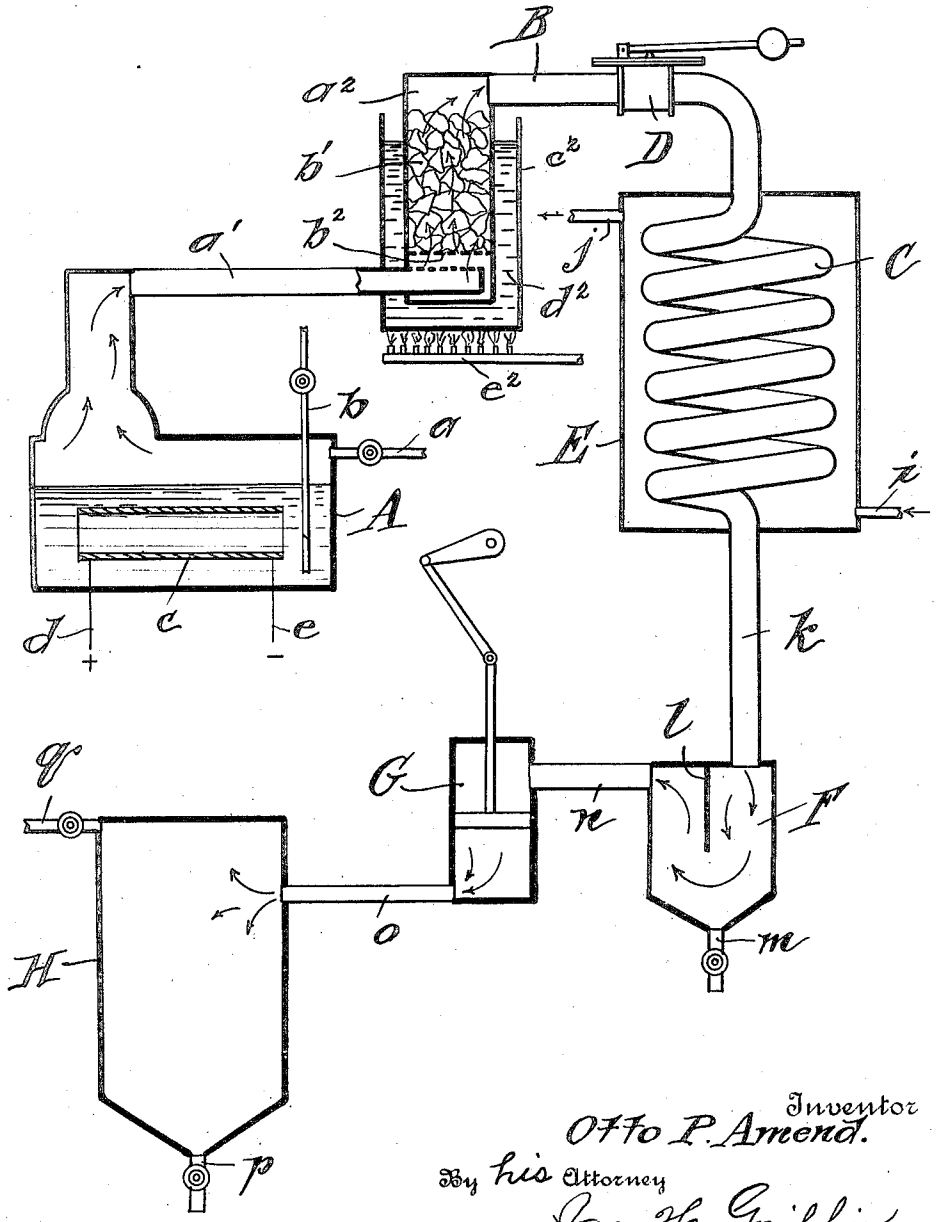
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CARBURETING LIQUID FUELS.

APPLICATION FILED JUNE 8, 1917.

1,423,064. Patented July 18, 1922.



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UNITED STATES PATENT OFFICE.

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CARBURETING LIQUID FUELS.

1,423,064. Specification of Letters Patent. Patented July 18, 1922.

Application filed June 8, 1917. Serial No. 173,665.

To all whom it may concern:

Be it known that I, OTTO P. AMEND, a citizen of the United States of America, and residing at New York city, New York, United States of America, have invented certain new and useful Improvements in Carbureting Liquid Fuels, of which the following is a specification.

The subjects of this invention are new hydrocarbon liquid fuels suitable for use in high speed internal combustion engines, and possessing the desirable qualities of the highest grade of gasoline, as well as certain other qualities that make them superior to the best saturated gasoline. The primary product is a "cracked" product, that is to say, it is produced by the cracking of high-boiling petroleum oils and distillates, preferably petroleum distillates boiling above 250° C., although distillates distilling between 150° C., and 250° C., may also be treated. It can be produced in unlimited quantities at a very low cost, from either kerosene or burning oil, gas oil, or fuel oil, and the product itself can either be used alone as a high grade motor fuel in internal combustion engines, or can be mixed with any desired percentage of naphtha or kerosene, or even higher boiling distillates, and when so mixed, forms a highly volatile desirable motor fuel that is both stable and uniform, and has none of the disadvantages that ordinarily result from the blending of a highly volatile saturated gasoline, such as casing-head gasoline, with a heavier hydrocarbon. When my product is so blended with a heavy naphtha, or kerosene, or burning oil, the resulting fuel can be burned in an internal combustion engine to the last drop, no deterioration takes place on standing, and no greater evaporation takes place than with ordinary 60° gasoline. It can also be blended with ordinary gasoline, in order to improve the volatility of the latter by adding to the latter a larger proportion of highly volatile hydrocarbons distilling below either 70° C., 80° C., 90° C., 100° C., or 120° C., as may be desired.

A great many different varieties of my new motor fuel can be produced, with a gravity varying between .82 and .72, or even lower. No matter what the specific gravity of my product may be within the limits say from 56° B. to 65° B., (.72 to .755 sp. g.) it is either equal to, or superior to, normal 76° B. saturated gasoline, both as regards lowness of flashing point, and as to the percentage of hydrocarbons contained therein boiling either below 70° C., 80° C., 90° C., 100° C., 110° C., or 120° C., or in the percentage of hydrocarbons boiling between 60° C. and 90° C., or between 60° C. and 100° C., or between 60° C. and 120° C., whichever basis of comparison is applied. As is well known, the percentage of high grade gasoline, say from 70° B. to 76° B. in gravity, produced by normal processes of fractional distillation, is comparatively small, and it is practically impossible to-day to purchase such high grade gasoline for motor fuel; the greater part of the gasoline of commerce having a gravity ranging from approximately 58° B. to 62° B. This is due to the fact that the increasing shortage of gasoline, in comparison to the rapidly increasing demand for the same for motor fuel, renders it necessary for manufacturers of gasoline to mix with the high grade gasoline an increasing proportion of low boiling hydrocarbons with a consequent impairment of the character of the resulting blend.

In other words, the 61° B. gasoline, that is practically the staple motor fuel to be had to-day in this country, contains less than one-third as much hydrocarbons volatile below 90° C., as 76° B. gasoline, only about 40% of the content of 76° B. gasoline volatile below 100° C., and less than one-half the content of hydrocarbons volatile below 110° C., that is contained in high grade 76° B. gasoline.

A comparative fractionation table of a sample of my product, compared with the above samples of 76° B. gasoline and 61° B. gasoline, shows conclusively the superior volatile qualities of my fuel to either of them.

Table A.

	Amend product, sample A.	76° B. gasoline from Eagle Works S. O. Co.	61° B. gasoline.
Baumé gravity at 60° F.	56.9°	77°	61°
Temperature distillation:			
Initial boiling point	43° C.	34° C.	45° C.
% off at 40° C		2	
% off at 50° C	2.5	11	1
% off at 60° C	19.5	25.5	2
% off at 70° C	42.5	42	6
% off at 80° C	63.5	56	12
% off at 90° C	82	68	20
% off at 100° C	90	77.5	30
% off at 110° C	93.5	84	41
% off at 120° C	95.5	88	54
% off at 130° C	97	90.5	66
% off at 140° C		92	70
% off at 150° C		93	84
% off at 180° C			97
	(Dry point 162° C.)	(Dry point 154° C.)	

It will be seen from the above table, that the initial boiling point of my product and of 61° B. gasoline is about the same, where-

as the initial boiling point of 76° B. gasoline is considerably lower. As to final boiling point, approximately 97% of my product distills below 130° C., as against 90.5% of the 76° B. gasoline, and as against 66% of the 61° B. gasoline.

As the great end sought in the cracking of heavy oils to produce a highly volatile motor fuel, is to obtain as large a percentage as possible of hydrocarbons boiling below 80° C., 100° C., or 120° C., respectively, my product in this respect is more than twice as good as ordinary gasoline, and is superior to 76° B, gasoline.

By adding, however, to the cracked distillate set out e. g. in sample A, additional amounts of heavier cuts of the cracked distillate, distilling above 80° C., the percentage of hydrocarbons or of the fuel volatile below 80° C., may if desired, be reduced to any desired percentage down to 40% or lower. In the same way, a cracked distillate can be obtained containing any desired lower percentage of the fuel volatile below 100° C., such as, for instance, either 70%, 60%, 50%, or lower.

Below is set forth a distillation table of my crude distillate from which the refined distillate (sample A), the distillation table of which has been given above, was produced:—

	Amend crude, Baumé gravity at 60° F.
Initial boiling point	56.5° B. / 40° C.
% off at 50° C.	6
% off at 60° C.	18
% off at 70° C.	33
% off at 80° C.	50
% off at 90° C.	66
% off at 100° C.	78
% off at 110° C.	85.5
% off at 120° C.	88.5
% off at 130° C.	92
% off at 140° C.	(Dry point 131° C.)

With regard to the percentage of recovery in this product that I can obtain from cracking a heavy oil, I am able to obtain of the above cracked distillate,—approximately 95% of which distills below 120° C.,—approximately 70% of the amount of heavy oil so treated. I obtain about 20% of gas and about 10% of heavier distillate, which can be rerun and converted into motor fuel,—thus making a total recovery of highly volatile motor fuel of about 80% of the amount of the original oil treated. As from 70% to 90%, approximately, of my motor fuel is volatile below 100° C., I convert from 56% to 72% of the original heavy oil treated, into hydrocarbons volatile between 50° C. and 100° C.

The primary product that I have obtained is also a highly homogeneous motor fuel, that contains substantially only hydrocarbons containing five, six and seven atoms of carbon, respectively, to the molecule. By cutting this distillate between 50° C. and 80° C., an absolutely homogeneous motor fuel is obtained containing practically only hydrocarbons having a content of 6 atoms to the molecule, such as the paraffin hexane (C_6H_{14}), the olefine hexylene (C_6H_{12}) and the naphthene or polymethylene hexamethylene or cyclo-hexane (C_6H_{12}), and a very small content, generally well under 5%, of benzenes.

By cutting my cracked distillate between say, 43° C. and 100° C., only hydrocarbons having a carbon content of from five to seven atoms of carbon to the molecule, are included therein, these hydrocarbons consisting substantially of paraffins, naphthenes and olefines, or substantially of naphthenes and olefines, with, in each case, a small percentage, generally not over five to eight per cent, and often much lower, of aromatic hydrocarbons, such as benzene and toluene.

The presence of a considerable percentage of olefine hydrocarbons in my distillate also enables the fuel to be subjected to higher compression without preignition.

Even when the entire distillate up to 130° C. or even 140° C., is taken, it contains substantially only hydrocarbons having between five and eight atoms of carbon to the molecule, and contains generally less than eight per cent of aromatic hydrocarbons.

One of the objections to a cracked motor fuel is generally the high percentage of aromatic hydrocarbons that it contains. These aromatic hydrocarbons, owing to their extremely high carbon content and low hydrogen content, are extremely difficult to oxidize completely, the incomplete oxidation and combustion resulting in heavy carbonization of the engine and smoking of the exhaust, as well as the producing of an evil smelling exhaust.

The percentage of olefines in the sample A set out above, is approximately 52%, the bromine absorption number for the distillate being about 131, and the sulphuric acid absorption number about 66. The naphthene content of the above distillate is nearly 40%.

The percentage of naphthenes in my cracked product may, however, be varied at will, within rather wide limits. For example, where a heavy naphthene hydrocarbon, such a California, Mexico, or Baku petroleum is subjected to my cracking process, a much higher content of naphthenes is obtained in the cracked distillate than where a paraffin hydrocarbon, such as Pennsylvania petroleum, or a mixed paraffin and naphthene hydrocarbon, such as Oklahoma petroleum, is subjected to the cracking operation. Where a heavy paraffin hydrocar-

bon is cracked, there will be present a considerable percentage of highly volatile paraffin hydrocarbons in the resulting cracked distillate. This percentage may be 20% or even more, and the percentage of naphthene hydrocarbons will generally be correspondingly reduced. The result of such an increase in paraffins present and the decrease in naphthenes is to make the specific gravity of the distillate correspondingly lighter, and also to increase somewhat the percentage of lower boiling hydrocarbons. This is due to the fact that the paraffin hydrocarbons have from about thirteen to eighteen degrees centigrade lower boiling points than the corresponding naphthene hydrocarbons of the same carbon content.

The characteristics of my fuel that distinguish it from ordinary gasoline, say 60° B., to 62° B., are:—

(1) It is a much cleaner burning fuel than gasoline and when used in the engine, will leave the spark plugs absolutely clean, when the use of gasoline will cause them to be covered with soot. In fact, my fuel when burned in an internal combustion engine, will burn sooty spark plugs clean in a very short time, thus showing that there is an absolutely perfect combustion;

(2) It has a much lower flashing point than gasoline, the flashing point ranging from about 10° F. down to about 25° below zero F., according to the percentage of low-boiling saturated open-chain hydrocarbons contained therein. As a result of this, my fuel will start a cold engine in cold weather instantaneously, where it is extremely difficult to start the engine with ordinary gasoline;

(3) An engine using my fuel, can run at lower speeds and be throttled down much lower without missing fire than when gasoline is used. The engine can therefore idle more easily and go slower in crowded traffic, which is a very great advantage;

(4) My fuel also accelerates more rapidly than ordinary gasoline, which is a distinct advantage in the stopping and starting in crowded traffic;

(5) As a result of the above advantages, it is a much more flexible fuel than ordinary gasoline. It has also a distinctive odor different from that of ordinary gasoline, but entirely free from the unpleasant cracked odor peculiar to other cracked gasolines;

(6) It has smokeless exhaust. The exhaust gases are also entirely free from the unpleasant odors of other cracked gasolines;

(7) Wider explosive range than gasoline; The air-gasoline vapor mixture must contain not less than 2.5% of gasoline vapor and not more than 4.8% to be properly explosive. In other words, the explosive range of gasoline is only over 2.3%. Any gasoline-vapor-air mixture containing less or more than this proportion of gasoline vapor is not satisfactorily explosive in an internal combustion engine.

The ethylene hydrocarbons, however, make explosive mixtures with air, when the ethylene-air mixture contains from 4.2% to 14.5% of ethylene vapor. The explosive range of the ethylene hydrocarbons is therefore over 10.3% or nearly five times as wide as gasoline. My fuel mixture containing about fifty per cent of ethylene hydrocarbons has therefore nearly three times the explosive range of gasoline; and where only twenty-five per cent of ethylene hydrocarbons are present the explosive range of my fuel is nearly double that of gasoline.

(8) Susceptibility to higher compression without preignition, than gasoline. My fuel can be subjected to a compression of 125 pounds to the square inch, or even higher, without preignition.

Owing to its very low flashing point, it is a peculiarly valuable motor fuel for use in aeroplanes where the engine is running at very high altitudes and at very low temperatures of the surrounding air.

The most distinctive characteristic of my fuel, resulting from the combination of qualities set out above, and the greatest commercial advantage resulting from it, consists in the fact that it can be blended with any desired proportion of ordinary gasoline, naphtha, kerosene, or burning oil, or alcohol, and when so blended, produces a homogeneous stable uniform motor fuel, the lighter parts of which do not evaporate to any extent, and that can be used up to the last drop without experiencing any difficulty in the engine.

The method by which I produce my new cracked distillate, is as follows:—

The high boiling hydrocarbons to be cracked,—whether kerosene, gas oil, fuel oil, etc., are preferably first heated and vaporized in a still, and these vapors then cracked in a cracking tube or retort, although they may be both vaporized and cracked in the retort,—the cracking temperature varying between 400° C. and a light red heat, according to the nature of the high boiling hydrocarbon to be cracked, but preferably using a cracking temperature with gas oil, or fuel oil, of between 500° C. and 700° C., and with kerosene, of between 650° C. and 850° C. No pressure is necessary in the cracking retort, although pressures may be used, but preferably not in excess of fifty pounds to the square inch. Kerosene vapors mixed with nitrogen gas or any inert gas passed through a cracking tube containing "bone-black," or animal charcoal, heated to between 650° C. and 850° C., and the resulting vapors mechanically cimpressed to from 250 to 350 pounds to the square inch and condensed, is converted into a distillate

containing a high percentage of highly volatile olefines. As catalytic material, animal or vegetable charcoal may be used, as well as granulated coke, or other finely divided carbon. In fact, while not necessary, any porous refractory material may be used, such as, for instance, broken pottery, meerschaum, pumice-stone, magnesia, lime, clays, broken brick, fire brick, etc., or iron, wire, shavings, or filings. In any case, there should preferably be a porous mass of heated metallic or refractory material, substantially filling the heated part of the cracking tube or retort. Finely divided metals produced by the reduction of their oxides or salts, preferably finely divided iron, may also be used. Such finely divided metals, may also be coated upon metallic wires, filings, or other porous material, or made into associations, preferably with refractory materials substantially free from silica, such as lime, magnesia, baryta, etc. The hydrocarbons may be passed over these metals or refractary substances either alone or mixed with a suitable inert gas. The cracking tube may be one inch in diameter or considerably larger, as desired, the limit of diameter being dependent upon the ability to heat the interior of the tube. Where the tube is filled with a porous metallic mass that is a good conductor of heat, much larger tubes may advantageously be used, such as from three to six inches in diameter. A large number of tubes may be inclosed in a reverberatory furnace. The cracking tube or retort need not be longer than ten feet and may be heated by gas, or electrically, or in any other suitable manner. The cracking tube or retort containing the refractory, or porous, or catalytic material, should preferably be vertical or inclined upward, and should be sufficiently high before the outlet for the vapors is reached, so that heavy hydrocarbon vapors not sufficiently cracked by their first passage through the refractory or catalytic material, should condense in the cooler upper part of the tube and fall back through the refractory or catalytic material, with the result of being cracked still further. In other words, the cracking tube or retort should preferably be roughly divided into two parts, the first or lower heated part filled with the porous, or refractory, or catalytic material, and the second or progressively cooler part, up which only the lighter hydrocarbon vapors will ascend to the outlet, the heavier vapors falling back into the heated part of the tube or retort. Where the cracking tube or retort is a vertical or an upward inclined one, the length of the tube filled with porous or refractory catalytic material, may be considerably shorter than where the cracking tube or retort is a horizontal one. Where it is a horizontal tube, from eight to ten feet in length filled with refractory or catalytic material is desirable, but where the cracking tube is a vertical or upward inclined tube, even five feet of refractory or catalytic material is sufficient.

The cracking temperature in the retort is preferably maintained at a temperature at which the minimum evolution of gas and deposition of carbon is produced,—that is to say, at a temperature of dissociation rather than of decomposition. I have found that decomposition,—and the resulting formation of considerable quantities of aromatic hydrocarbons, terpenes, terpene-like hydrocarbons and other asphaltic or easily oxidizable hydrocarbons, and tarry or resinous matter and gas and carbon,—is greatly reduced either by cracking the hydrocarbon vapors as they come over from the still or by using, as the raw material for cracking, a high-boiling hydrocarbon distillate within a very narrow range of distillation, preferably a range of not over fifty degrees centigrade,—that is to say, a high boiling hydrocarbon with as near as possible to a constant boiling point. The cracking temperature can be regulated in any given case, roughly by observing the amount of gas and carbon or tarry matter produced at any given cracking temperature. As soon as gas and carbon appear in quantity, the cracking temperature should be reduced.

The high-boiling hydrocarbons to be cracked, enter the retort either alone or mixed with nitrogen gas or other fixed inert or chemically neutral gases, such as carbon dioxide gas, which are present during the cracking operation and subsequently pass along with the cracked hydrocarbon vapors, first to a condenser and dephlegmator where the vapors are cooled and the high-boiling hydrocarbons above the desired point of cut are removed. The cut can be made at any desired point between say 150° C. and 200° C., but preferably below 200° C. The hydrocarbon vapors not liquefiable at the point of cut, along with the fixed gases, are then subjected to mechanical compression, being preferably drawn into the cylinders of a suitable compresser and are there compressed in two or more stages to a pressure of from 250 to 600 pounds to the square inch, according to the character of the product desired to be obtained. For instance, for the production of a cracked distillate of a gravity between .73 and .75, approximately, and a bromine absorption number in excess of 100, and containing over twenty-five per cent of highly volatile naphthene hydrocarbons, the hydrocarbon vapors should preferably be cracked at a temperature between 650° C. and 750° C., and a pressure of between 300 pounds and 350 pounds to the square inch should be maintained in the compresser, nitrogen gas or carbon dioxide,

or methane gas, being used as the compressible medium. The compressed vapors and gases are thereupon preferably allowed to cool by sudden expansion, passing through a suitable condenser, the pressure during condensation being preferably above atmospheric, and preferably about 30 to 35 pounds to the square inch.

The choice of fixed gas to be used during the cracking and compressing operation, depends entirely upon the character of the product which I may desire to produce. Where I desire to produce a product containing a high content of highly volatile ethylene hydrocarbons, I use preferably nitrogen gas or any other absolutely inert gas, such as carbonic acid gas (CO_2), which does not enter into the chemical reaction at the temperatures and pressures applied. Where, however, I desire to reduce the content of unsaturated hydrocarbons in the mixture and to increase the percentage of paraffin hydrocarbons in the mixture, I use preferably either hydrogen gas, or natural gas (which generally contains a considerable content of hydrogen (H_2)) or mixed hydrocarbon and hydrogen gases resulting from a previous cracking operation. By compressing the hydrocarbon vapors to a high pressure, viz, approximately from 400 to 500 pounds, in the presence of hydrogen gas, I have obtained a cracked distillate containing less than ten per cent of unsaturated hydrocarbons. My crude condensate contains a small percentage of asphaltic hydrocarbons, terpenes, hemi-terpenes, such as isoprene, polyterpenes, and other terpene-like hydrocarbons. These hemi-terpenes, terpenes and polyterpenes, and even more unsaturated hydrocarbons, take up oxygen very easily, and are easily converted into asphaltic or resinous or rubber-like colloidal bodies. Some of these colloidal bodies are yellowish in color, while others are colorless. Some of these hydrcarbon colloids are held in solution in the mixture and only oxidize gradually on exposure to light or air.

It is these bodies that are the most objectionable constituent of most unsaturated cracked distillates, and the chief reason why the latter are not used in internal combustion engines.

Either gasoline, naphtha, kerosene, or even light lubricating oils, or alcohol, may be used as a diluent of my motor fuel. Where alcohol is used, it may be either ethyl, propyl, butyl, or amyl or even higher alcohols of the $C_nH_{2n+1}OH$ series, or mixtures of two or more of such alcohols. Ethyl alcohol boils at about 78° C., propyl alcohol at about 97° C., and amyl alcohol at about 135° C. Mixtures of ethyl and propyl alcohol will generally boil below 90° C. I prefer, however, an alcoholic mixture consisting chiefly of ethyl and propyl alcohols to mix with the cracked distillate, these being the alcohols chiefly formed from the unsaturated cracked gases.

My cracked fuel can be blended also with ordinary 58° B. to 62° B. gasoline and even 5% to 10% of my cracked distillate when mixed with such ordinary gasoline, vastly improves the volatility of the gasoline. It can, however, be mixed in practically any proportions with gasoline, as well as naphtha or kerosene, or even heavier oils. A solvent action seems to take place with the heavier oils, and the highly volatile hydrocarbons contained in my cracked distillate are permanently retained in the blend, and do not work out or evaporate in the way in which a mixture of a light and heavy paraffin, such as casing-head gas gasoline and kerosene, does. The highly volatile and easily combustible light hydrocarbons, contained in my cracked distillate, carry complete combustion to the heaviest hydrocarbons contained in the kerosene or other heavy hydrocarbon distillate, so that a large percentage of hydrocarbons volatile over 200° C. or 250° C. can be present in my blended cracked distillate without at all affecting its value as a motor fuel, or its uniform combustion.

Alcohol is susceptible to a compression of as high as 150 pounds to the square inch without preignition and the olefines are susceptible to a compression of 125 pounds to the square inch, or over, without preignition. Taking ethyl alcohol as an example, although the heat units in a gallon of alcohol are only one-half of the heat units contained in a gallon of gasoline, the susceptibility to high compression of the alcohol enables it, when run in a high compression engine, to obtain an efficiency of about 35%, where gasoline will only result in an efficiency of about 18%, so that the power results derived from the use of alcohol in a properly constructed engine, are practically the same as those obtained from the use of gasoline. The susceptibility of my new fuel to this high compression without preignition, thus will enable it to develop much greater power in high compression engines than is obtained from it in the ordinary gasoline engines, which are adapted to only about 80 pounds of pressure to the square inch. Similarly, in a blend of my new fuel with kerosene, the susceptibility to high compression of my fuel more than offsets the inability to withstand high compression of the kerosene and results in a fuel that is as susceptible, if not more susceptible, to high compression than gasoline. In the same way, the very low flashing point of my fuel is uniformly distributed throughout in the blend with kerosene, producing a blended motor fuel that has even a lower flashing point than ordinary gasoline.

Below are set out two distillation tables, number one (1) of a blend of 50% of my primary cracked distillate (without alcohol) with 50% of ordinary 46° B. kerosene, obtained from the Standard Oil Works in New Jersey, and number two (2), a distillation table of a blend of one gallon of my cracked motor fuel (without alcohol) with three gallons of such export kerosene, together with brake horse power and fuel consumption tests made with each of these blended fuels. These two samples are only used as illustrations and not as limiting me to any specific percentage of blend. It is obvious that the percentage of the two constituents, that is, of my primary cracked distillate and gasoline, or naphtha, or kerosene, can be blended in any proportion desired, e. g. from say 10% of kerosene with 90% of my cracked fuel to 5% of my cracked fuel with ordinary gasoline, or ten per cent with ordinary kerosene. The range of specific gravity of the resulting blends will be extremely wide and may range from approximately 65° B. down to approximately 40° B., or from .72 specific gravity to .82. Any figures given herein, both as to gravity, boiling points, flashing points, absorption numbers, etc., are simply by way of illustration and not by way of limitation. The inflnite variety of the combination of my fuel with kerosene or with the heavier naphthas, or with alcohols, or alcoholic mixtures, is one of its distinguishing characteristics, as well as the fact that only a comparatively small percentage of it, when mixed with a high boiling distillate, such as kerosene, or with alcohol, produces a low-flashing motor fuel suitable for use in high speed internal combustion engines.

Another important characteristic of the blend of my cracked distillate with kerosene is that practically no different adjustment is required for the carbureter than with ordinary gasoline.

Sample distillation table of a blended mixture of 50% of amend motor fuel and 50% export kerosene and also of ordinary 60° B. to 62° B. gasoline.

NUMBER (1).

	Amend blend, 50% Amend product, 50% export kerosene.	60° B. to 62° B. gasoline (Eagle Works S. O. Co.).
Baumé gravity at 60° F.	51° B.	61° B.
Initial boiling point	43° C.	45° C.
Temperature distillations:		
% off at 50° C.	1	
% off at 60° C.	6	2
% off at 70° C.	14.5	6
% off at 80° C.	24	12
% off at 90° C.	31.5	20
% off at 100° C.	36.5	30
% off at 110° C.	41	41
% off at 120° C.	44	54
% off at 130° C.	47	70

Sample distillation table of a blended mixture of 50% of amend motor fuel and 50% export kerosene and also of ordinary 60° B. to 62° B. gasoline—Continued.

NUMBER (1).

	Amend blend, 50% Amend product, 50% export kerosene.	60° B. to 62° B. gasoline (Eagle Works S. O. Co.).
% off at 140° C.	49.5	
% off at 150° C.	51.5	84
% off at 160° C.	53	
% off at 170° C.	55	
% off at 180° C.	57	97
% off at 190° C.	60	
% off at 200° C.	64	
% off at 210° C.	68.5	
% off at 220° C.	72.5	
% off at 230° C.	76.5	
% off at 240° C.	81.5	
% off at 250° C.	85	
% off at 260° C.	88.5	
% off at 270° C.	91	
% off at 280° C.	93	
% off at 290° C.	94	
% off at 300° C.	95.5	
% off at 310° C.	97	
	(Dry point 320° C.—98.5%.)	(Dry point 180.)

NUMBER (2).

Test of motor fuel (50% Amend product and 50% export refd.). Object of test—horse power and fuel consumption. Type of brake—electric. Brake constant—.000746. Motor used—Massnick-Phipps, bore 3-1/8 inches, stroke 4 inches.

Time of run in minutes.	Revolutions per minute.	Horsepower.	Amount of fuel used in run (lbs.).	Lbs. fuel per B. H. P. per hour	Gallons fuel per B. H. P. per hour.
5	600	5.81	.52	1.07	.1660
5	800	7.75	.63	.97	.1505
5	1,000	9.69	.72	.88	.1366
5	1,200	11.63	.84	.86	.1335
5	1,400	13.57	.94	.82	.1273
5	1,600	15.51	1.01	.78	.1211
5	1,800	15.44	1.17	.83	.1288

Test of ordinary gasolene (60°–62° B.). Object of test—horsepower and fuel consumption. Type of brake—electric. Brake constant—.000746. Motor used—Massnick-Phipps, bore 3-1/2 inches, stroke 4 in.

Time of run in minutes.	Revolutions per minute.	Horsepower.	Amount of fuel used in run (lbs.).	Lbs. fuel per B. H. P. per hour.	Gals. fuel per B. H. P. per hour.
5	600	5.70	.49	1.02	.1661
5	800	7.9	.62	.94	.1531
5	1000	10.07	.73	.86	.1401
5	1200	12.08	.83	.82	.1336
5	1400	14.09	.94	.80	.1303
5	1600	14.92	1.00	.80	.1303
5	1800	15.10	1.05	.83	.1352

It will be seen by comparison of the above tests that at 1600 and 1800 revolutions per minute higher horse power was developed by my blended cracked fuel than by the gaso-

line, and at most of the speeds, considerably less of my blended cracked fuel was required per brake horse power per hour than for gasoline, the fuel economy being particularly noticeable at revolutions of over 1400 per minute. In other words, my blended cracked fuel is a more economical fuel for high speed engines than gasoline.

Where a blend is made of two parts of my cracked distillate boiling say below 120° C. with one part of kerosene, approximately sixty per cent of the blended cracked distillate will distill below 140° C., about 50% below 100° C., and about 40% below 90° C. The specific gravity of these blended fuels, that is, those in which my cracked product is blended with a higher boiling hydrocarbon, will generally range between .75 and .80 (57° B. to 44° B.) approximately.

In the accompanying drawing, the single figure shows, more or less diagrammatically, partly in section and partly in elevation, a substantially complete apparatus for carrying out the process and producing the products herein claimed.

Referring to the drawing, A is a still having an oil inlet a, and an inlet for inert gas b, extending to nearly the bottom of the still. The still is heated by means of a submerged carbon electrode c, preferably in tubular form, as shown, the said electrode being provided with suitable terminals d and e properly insulated from the walls of the still. The outlet a' for the vapors from the still leads to a cracking tube or retort a^2 containing animal or vegetable charcoal b', supported on a perforated false bottom b^2. Retort a^2 is preferably positioned in a chamber c^2 containing molten lead d^2, kept in a molten condition by means of a suitable heater such as gas-burner e^2, whereby the vapors from the still, entering retort a^2, are heated to the desired cracking temperature. The outlet B from the cracking retort a^2 connects with a cooling coil or condenser C, positioned within a cooling jacket or casing E, said jacket being provided with a suitable inlet i and outlet j for the cooling agent, such as water. Positioned in outlet pipe B is a pressure vlave D, whereby any desired pressure, preferably under 50 pounds, may be kept on the vapors within retort a^2 during the cracking operation. Outlet k from the condenser leads to a suitable trap or condensed liquid collector F, having a baffle l and a suitable draw-off pipe m. The trap is provided with an outlet n for non-condensed gases or vapors, said outlet leading to a suitable compressor G, diagrammatically shown, wherein said vapors or gases are compressed, whence they pass through the outlet o of the compressor into an expansion chamber H. The effect of expanding the mixture of compressed gases and vapors in chamber H results in the reduction of the temperature thereof to such extent that practically all the condensable vapors are liquefied in said chamber and may be drawn off through pipe p. The expansion chamber H is provided with a gas or vapor outlet q through which the residuary, uncondensed vapors or gases pass, whereupon they may be subjected to such further use or treatment as is found desirable.

The operation of the apparatus will be readily understood from the hereinbefore detailed description of the invention, but it may be briefly described as follows. The high boiling hydrocarbons to be cracked, e. g., kerosene, gas oil, fuel oil, etc., having been introduced into still A, are heated and vaporized by means of the heated carbon electrode c, whereupon the vapors pass into the cracking retort a^2. The temperature in this retort may vary between 400° C. and a light red heat, depending upon the nature of the high boiling hydrocarbon to be cracked, but, preferably, a temperature is employed between 500° C. and 700° C., when operating on gas oil or fuel oil, but, when operating upon kerosene, the temperature may be increased, say from 650° C. to 850° C. The desired temperature in the retort is readily secured by means of the lead bath described. No pressure is absolutely necessary in the cracking retort, although pressures may be used, but preferably not in excess of 50 pounds to the square inch. An inert gas, such as nitrogen, is introduced into still A through pipe b, and acts as a carrier in conducting the original oil vapors, or cracked products, through the system. The bone-black or animal charcoal b' employed in retort a^2 acts catalytically to assist the cracking operation. As heretofore stated, however, any suitable porous or refractory material may be employed in retort a^2. The subsequent treatment of the cracked vapors will be readily understood from the hereinbefore detailed description of the process and apparatus.

It will be understood that the products herein claimed may be produced in apparatus of a distinctly different type from that described, and that modifications may be made in the details of operation hereinbefore outlined, without departing from the spirit or substance of the invention.

What I claim as new and desire to secure by Letters Patent, is:—

1. A colorless refined motor fuel, made from petroleum, having a specific gravity above .72, a bromine absorption number in excess of 50, a flashing point below 10° F., not less than about fifty per cent of which fuel is volatile below 80° C., said fuel being substantially free from terpenes and easily oxidizable hydrocarbons and from resinous colloidal matter.

2. A colorless refined motor fuel, made

from petroleum, having a specific gravity above .72, a bromine absorption number in excess of 50, having a carbon to hydrogen ratio not in excess of 6.65 to 1, not less than seventy per cent of which fuel is volatile at temperatures below 100° C., said fuel being substantially free from terpenes and easily oxidizable hydrocarbons, and from resinous colloidal matter.

3. A colorless motor fuel, made from petroleum, having a specific gravity above .73, a bromine absorption number in excess of 100, a flashing point below zero F., not less than fifty per cent of which fuel is volatile at temperatures below 80° C., and not less than seventy per cent of which fuel is volatile below 100° C., said fuel being substantially free from terpenes and resinous colloidal matter.

4. As a new motor fuel, a cracked petroleum distillate having a specific gravity between .73 and .75, approximately, having a flashing point below zero, and a bromine absorption number above 100, over ninety per cent of said fuel distilling at temperatures below 125° C., and over fifty per cent of said fuel distilling below 80° C.

5. A colorless petroleum product having a specific gravity between .72 and .745, consisting substantially of saturated hydrocarbons and ethylene hydrocarbons, and containing between twenty per cent and sixty-five per cent of ethylene hydrocarbons, and having approximately the following distillation table:—

Temperature.	Fraction per cent.	Total over per cent.
Bet. 40 and 50° C.	5	5
Bet. 50 and 60° C.	33	38
Bet. 60 and 70° C.	30	68
Bet. 70 and 80° C.	32	100

6. As a new motor fuel, a cracked petroleum distillate having a specific gravity between .74 and .80, and a bromine absorption number in excess of 100, and containing over thirty per cent of naphthene hydrocarbons, over fifty per cent of which fuel is volatile between 50° C. and 80° C.

7. A colorless petroleum product having a specific gravity above .73, a bromine absorption number in excess of 50, a flashing point below 10° F., and a distillation range not less than between 60° C. and 120° C., not less than seventy per cent of which product is volatile below 100° C., and containing not less than twenty per cent of naphthene hydrocarbons volatile below 120° C., said product being substantially free from terpenes and resinous colloidal matter.

8. A motor fuel, made from petroleum, having a specific gravity above .74, and a bromine absorption number above 100, containing not less than thirty per cent of naphthene hydrocarbons volatile below 120° C., over ninety per cent of said fuel being volatile below 150° C., and not less than fifty per cent of said fuel being volatile at temperatures below 80° C., said fuel being substantially free from terpenes and easily oxidizable hydrocarbons, and from resinous colloidal matter.

9. A colorless motor fuel, made from petroleum, having a specific gravity above .74, a bromine absorption number in excess of 125, a flashing point below zero F., over fifty per cent of which fuel is volatile at temperatures below 80° C., containing not less than thirty per cent of naphthene hydrocarbons, and free from terpenes and resinous colloidal matter.

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

OTTO P. AMEND.